The image is a composite. The top portion features a dark blue background with a faint, light-colored world map. Overlaid on this is the title text. The bottom portion is a high-angle, aerial photograph of a massive open-pit mine. The mine is characterized by numerous horizontal terraced levels, creating a stepped appearance. A network of dirt roads winds through the site, connecting different levels and areas. The rock faces of the mine are a mix of grey and brownish-yellow, showing signs of weathering and excavation. The overall scene conveys the scale and industrial nature of the mining operation.

Guidebook for Evaluating Mining Project EIAs

Guidebook for Evaluating Mining Project EIAs

1st Edition

July 2010



Environmental Law Alliance Worldwide (ELAW), Eugene OR 97403
© 2010 by Environmental Law Alliance Worldwide
All rights reserved

Cover image: Bingham Canyon Mine, U.S. Library of Congress, by Andreas Feininger
Page design and production by Joshua Keith Vincent

ISBN# 978-0-9821214-36

Environmental Law Alliance Worldwide (ELAW)
1877 Garden Avenue
Eugene, OR 97403
U.S.A.
Phone: 1-541-687-8454
Fax: 1-541-687-0535
www.elaw.org

Send inquiries to:
Mark Chernaik, ELAW Staff Scientist
mark@elaw.org

Contents

List of flowcharts	vii
Acknowledgements	ix
Introduction	1
1. OVERVIEW OF MINING AND ITS IMPACTS	3
1.1 Phases of a Mining Project	3
1.1.1 Exploration	3
1.1.2 Development	3
1.1.2.1 Construction of access roads	3
1.1.2.2 Site preparation and clearing	4
1.1.3 Active mining	4
1.1.3.1 Open-pit mining	4
1.1.3.2 Placer mining	5
1.1.3.3 Underground mining	5
1.1.3.4 Reworking of inactive or abandoned mines and tailings	5
1.1.4 Disposal of overburden and waste rock	5
1.1.5 Ore extraction	5
1.1.6 Beneficiation	6
1.1.7 Tailings disposal	6
1.1.8 Site reclamation and closure	7
1.2 Environmental and Social Impacts of Mining	8
1.2.1 Impacts on water resources	8
1.2.1.1 Acid mine drainage and contaminant leaching	8
1.2.1.2 Erosion of soils and mine wastes into surface waters	9
1.2.1.3 Impacts of tailing impoundments, waste rock, heap leach, and dump leach facilities	10
1.2.1.4 Impacts of mine dewatering	11
1.2.2 Impacts of mining projects on air quality	12
1.2.2.1 Mobile sources	12
1.2.2.2 Stationary sources	12
1.2.2.3 Fugitive emissions	12
1.2.2.4 Incidental releases of mercury	13
1.2.2.5 Noise and vibration	13
1.2.3 Impacts of mining projects on wildlife	13
1.2.3.1 Habitat loss	14
1.2.3.2 Habitat fragmentation	14
1.2.4 Impacts of mining projects on soil quality	14
1.2.5 Impacts of mining projects on social values	15
1.2.5.1 Human displacement and resettlement	15
1.2.5.2 Impacts of migration	15
1.2.5.3 Lost access to clean water	16

1.2.5.4	Impacts on livelihoods	16
1.2.5.5	Impacts on public health	16
1.2.5.6	Impacts to cultural and aesthetic resources	17
1.2.6	Climate change considerations	17
2.	OVERVIEW OF THE EIA PROCESS	19
2.1	What Is The Purpose of the EIA Process?	19
2.2	Who Prepares an EIA?	20
2.3	Stages of the EIA Process	21
3.	REVIEWING A TYPICAL EIA FOR A MINING PROJECT	25
3.1	Evaluating the Executive Summary	25
3.2	Evaluating the Project Description	26
3.2.1	Project alternatives	26
3.2.1.1	Alternative siting of mine facilities	26
3.2.1.2	Alternative ore beneficiation methods	26
3.2.1.3	Alternative methods of tailings disposal	29
3.2.1.4	The no-action alternative	31
3.3	Evaluating the Environmental Baseline	32
3.3.1	Characterization of mined materials	32
3.3.1.1	Mineralogy and whole rock analysis	32
3.3.1.2	Acid generation potential - static and kinetic testing	34
3.3.1.3	Contaminant leaching potential short- and long-term leach tests	34
3.3.1.4	Identification of contaminants of concern	34
3.3.2	Characterization of existing climate	35
3.3.3	Characterization of existing seismic conditions	35
3.3.4	Characterization of existing surface water quality	36
3.3.5	Characterization of existing surface and groundwater quantity	37
3.3.6	Characterization of existing air quality	37
3.3.7	Characterization of existing soil quality	38
3.3.8	Characterization of wildlife	38
3.3.8.1	Characterization of terrestrial species	38
3.3.8.2	Characterization of aquatic species	39
3.3.8.3	Characterization of habitats critical to ecological processes	39
3.3.9	Local socio-economic baseline	40
3.4.	Evaluating Potential and Predicted Environmental Impacts	41
3.4.1	How to understand and evaluate environmental impact matrices	41
3.4.2	Impacts on water quality and quantity	43
3.4.2.1	Water pollutant releases from pit lakes	46
3.4.2.2	Water pollutant releases from tailings impoundments	46
3.4.2.3	Water pollutant releases from waste rock dumps	47
3.4.2.4	Assessing the significance of water quality impacts	47
3.4.2.5	Impacts of surface water diversions	47
3.4.3	Impacts on air quality	48
3.4.4	Impacts on global climate	49
3.4.5	Impacts on ecological processes	49
3.4.5.1	Impacts on vegetation and soil quality	50
3.4.6	Impacts on wildlife	50
3.4.7	Social impacts	51

3.4.7.1	Cost-benefit analysis	52
3.4.8	Impacts on public safety	52
3.4.8.1	Dam break analysis	52
3.4.8.2	Traffic	53
3.4.9	Cumulative impacts	53
3.4.9.1	Impacts of related or connected actions	54
3.5	Evaluating Proposed Mitigation Measures and Contingency Plans	55
3.5.1	Protection of water resources	55
3.5.1.1	General measures regarding acid mine drainage	55
3.5.1.2	Water management	57
3.5.1.3	Stormwater, sediment and erosion control	58
3.5.1.4	Management of waste rock dumps	59
3.5.1.5	Management of open pits and pit lake prevention	60
3.5.1.6	Management of wet tailings impoundments	60
3.5.1.7	Management of leach facilities	60
3.5.2	Protection of air quality and noise levels	61
3.5.2.1	Control of fugitive dust emissions	61
3.5.2.2	Control of noise and vibrations	63
3.5.3	Management of hazardous materials	63
3.5.3.1	Cyanide use	63
3.5.3.2	Mercury management	64
3.5.3.3	Storage of fuel and liquid substances	65
3.5.4	Protection of wildlife	66
3.6	Evaluating the Environmental Monitoring Plan	67
3.6.1	Water quality monitoring	67
3.6.1.1	Surface water quality monitoring	68
3.6.1.2	Groundwater quality monitoring	68
3.6.1.3	Water quality monitoring parameters	68
3.6.2	Air quality monitoring	69
3.6.3	Vegetation and soil quality monitoring	69
3.6.4	Monitoring impacts on wildlife and habitat	69
3.6.4.1	Monitoring of key species	69
3.6.4.2	Monitoring habitat loss	69
3.6.5	Monitoring impacts on affected communities	70
3.6.5.1	Community health	70
3.6.5.2	Promised investments for socio-economic development	70
3.6.6	Monitoring of threats to public safety	71
3.7	Evaluating the Reclamation and Closure Plan	72
3.7.1	Conceptual versus actual plans	72
3.7.2	Post-mining land use and reclamation objectives	72
3.7.3	Reclamation schedule	73
3.7.4	Reclamation and closure of specific mine facilities	73
3.7.4.1	Overburden and waste rock piles	73
3.7.4.2	Open pits	75
3.7.4.3	Wet tailings impoundments	76
3.7.4.4	Leach and dump piles	78
3.7.5	Revegetation	79
3.7.6	Financial assurances for reclamation and closure	80
3.7.6.1	Timing of provision of financial assurances	81

3.7.6.2	Adequate forms of financial assurances	83
3.7.6.3	Adequate amounts of financial assurances	84
4.	HOW TO BE AN EFFECTIVE PARTICIPANT IN THE EIA PROCESS	85
4.1	Understanding the Regulatory Framework	86
4.2	Understanding Public Participation Rights and Opportunities	87
4.3	Access to Information and EIAs	88
4.4	The Importance of Participating as Early as Possible	88
4.5	How to Prepare Effective Written Comments	89
4.6	How to Participate Effectively at Public Hearings	89
4.7	Challenging Adverse Decisions Made During the EIA Process	90
4.7.1	Administrative review	90
4.7.2	Judicial review	91
4.7.2.1	Standing to sue	92
4.7.2.2	Scope of judicial review	92
4.8	Enforcing Promises, Commitments and Conditions Related to the Project	93
4.8.1	Promises contained in the EIA	93
4.8.2	Conditions contained in the grant of environmental clearance	93
	Glossary	95
	References	101
	Appendix - EIA Review Checklist	107

List of Flowcharts

Flowchart - Stages of the EIA process	21
Flowchart 3.1 - Project alternatives	27
Flowchart 3.2 - Evaluating the adequacy of the evaluation of acid-generating and contaminant leaching potential of mined materials	33
Flowchart 3.3 - Evaluating the adequacy of predicted impacts on water quality	45
Flowchart 3.4 - Evaluating the adequacy of measures for the protection of water resources	56
Flowchart 3.5 - Evaluating adequacy of measures for the management of hazardous materials	62
Flowchart 3.6 - Evaluating the adequacy of the Reclamation and Closure Plan	74
Flowchart 3.7 - Evaluating the adequacy of financial assurances	82

Acknowledgements

The *Guidebook for Evaluating Mining Project EIAs* reflects many years of experience evaluating the environmental impact assessments (EIAs) for proposed mining projects around the world. The Guidebook was produced by a team of experts at the Environmental Law Alliance Worldwide (ELAW), in collaboration with an international review committee. Many thanks to: Dr. Glenn Miller, ELAW Board Chair and Director of the Graduate Program in Environmental Sciences and Health at the University of Nevada at Reno; Isabela Figueroa, Attorney; Dr. Ann Maest, Managing Scientist, Stratus Consulting; Maria Paz Luna, Legal Consultant, Pusod Pilipinas; Dr. Mark Chernaik, ELAW Staff Scientist; Graciela M. Mercedes Lu, ELAW Environmental Research Scientist; Jennifer Gleason, ELAW Staff Attorney; Liz Mitchell, ELAW Staff Attorney; Lauren Ice, ELAW Office Manager; Maggie Keenan, ELAW Communications Director; Rita Radostitz, ELAW Outreach Director; Josh Vincent, graphic designer; and Eliana Villar Marquez, translator.

The Environmental Law Alliance Worldwide gives public interest lawyers and scientists, and the communities they work with around the world, skills and resources to protect the environment through law. These advocates, working in their home countries, know best how to protect the global environment. By giving grassroots advocates the tools and resources they need, ELAW helps protect the air, soil, water, and ecosystems, and builds a worldwide corps of skilled, committed advocates working to protect ecosystems and public health for generations to come. The key to our strategy at ELAW is locating strong advocates who are committed to protecting communities and biodiversity in their home countries. By collaborating with these advocates and providing legal and scientific tools, we achieve substantial impact around the globe at low cost.

Learn more at: www.elaw.org

Send inquiries to Mark Chernaik at: mark@elaw.org

Introduction

Most countries require an environmental impact assessment (EIA) before giving the green light to a mining project. EIA processes provide a valuable opportunity for citizens to participate in decisions about mines. The problem is, project proponents often submit long, complex EIA documents that are incomprehensible to lay people.

The *Guidebook for Evaluating Mining Project EIAs* will help public interest lawyers, grassroots advocates, and community members understand mining EIAs, identify flaws in mining project plans, and explore ways that mining companies can reduce the public health hazards associated with mining.

CHAPTER 1, *Overview of Mining and its Impacts*, provides an overview of large-scale metal mining practices and how these practices can harm the environment and public health.

CHAPTER 2, *Overview of the EIA Process*, describes the various stages of the EIA process and identifies opportunities for influencing decisions about proposed mining projects.

CHAPTER 3, *Reviewing a Typical EIA for a Mining Project*, focuses on EIA documents and how to critically assess different sections of an EIA.

SECTION 3.1 provides guidance on what constitutes an adequate Executive Summary.

SECTION 3.2 provides guidance on what constitutes an adequate Project Description, including project alternatives.

SECTION 3.3 examines what should be included in the Environmental Baseline, including discussion of tests for predicting the acid-generating and contaminant-leaching potential of mined materials and the information necessary

for adequate characterization of existing water and air quality, wildlife, and socio-economic characteristics of project areas.

SECTION 3.4 provides guidance on evaluating environmental impacts, including what constitutes an adequate assessment of impacts to water and air quality, wildlife, society, and public safety.

SECTION 3.5 looks at the Environmental Management Plan and what constitutes adequate mitigation measures and contingency plans.

SECTION 3.6 focuses on the Environmental Monitoring Plan and what constitutes an adequate plan for monitoring the impact of a proposed project on communities and the environment.

SECTION 3.7 looks at the Reclamation and Closure Plan, providing guidance on adequate plans for specific mine facilities (waste rock dumps, open pits, tailings dams, and leach facilities) and how to determine whether adequate funds are set aside to implement the Reclamation and Closure Plan.

CHAPTER 4, *How to be an Effective Participant in the EIA Process*, provides practical advice about how public interest lawyers and advocates can foster effective participation in the EIA process. This chapter will help readers understand the regulatory framework that applies to the EIA process, including: gaining full access to EIA documents and related information; commenting effectively during different stages of the EIA process; challenging adverse decisions; and enforcing promises made in the EIA and related documents.

The Guidebook includes references, a glossary, and an EIA Review Checklist.

1. Overview of Mining and its Impacts

1

Proposed mining projects vary according to the type of metals or materials to be extracted from the earth. The majority of proposed mining projects involve the extraction of ore deposits such as copper, nickel, cobalt, gold, silver, lead, zinc, molybdenum, and platinum. The environmental impacts of large-scale mining projects involving

these metal ores are the subject of this Guidebook. The Guidebook does not discuss the mining of ores that are extracted using strip mining methods, including aluminum (bauxite), phosphate, and uranium. The Guidebook also does not discuss mining involving extraction of coal or aggregates, such as sand, gravel, and limestone.

1.1 PHASES OF A MINING PROJECT

There are different phases of a mining project, beginning with mineral ore exploration and ending with the post-closure period. What follows are the typical phases of a proposed mining project. Each phase of mining is associated with different sets of environmental impacts.

1.1.1 Exploration

A mining project can only commence with knowledge of the extent and value of the mineral ore deposit. Information about the location and value of the mineral ore deposit is obtained during the exploration phase. This phase includes surveys, field studies, and drilling test boreholes and other exploratory excavations.

The exploratory phase may involve clearing of wide areas of vegetation (typically in lines), to allow the entry of heavy vehicles mounted with drilling rigs. Many countries require a separate

EIA for the exploratory phase of a mining project because the impacts of this phase can be profound and because further phases of mining may not ensue if exploration fails to find sufficient quantities of high-grade mineral ore deposits.

1.1.2 Development

If the mineral ore exploration phase proves that there is a large enough mineral ore deposit, of sufficient grade, then the project proponent may begin to plan for the development of the mine. This phase of the mining project has several distinct components.

1.1.2.1 Construction of access roads

The construction of access roads, either to provide heavy equipment and supplies to the mine site or to ship out processed metals and ores, can have substantial environmental impacts, especially if access roads cut through ecologically

sensitive areas or are near previously isolated communities. If a proposed mining project involves the construction of any access roads, then the environmental impact assessment (EIA) for the project must include a comprehensive assessment of the environmental and social impacts of these roads.



Erosion near a mining road, Pelambres mine, Chile
PHOTO: Rocio Avila Fernandez

1.1.2.2 Site preparation and clearing

If a mine site is located in a remote, undeveloped area, the project proponent may need to begin by clearing land for the construction of staging areas that would house project personnel and equipment. Even before any land is mined, activities associated with site preparation and clearing can have significant environmental impacts, especially if they are within or adjacent to ecologically sensitive areas. The EIA must assess, separately, the impacts associated with site preparation and clearing.

1.1.3 Active mining

Once a mining company has constructed access roads and prepared staging areas that would house project personnel and equipment, mining may commence. All types of active mining share a common aspect: the extraction and concentration (or beneficiation) of a metal from the earth. Proposed mining projects differ considerably in the proposed method for extracting and concentrating the metallic ore.

In almost every case, metallic ores are buried under a layer of ordinary soil or rock (called 'overburden' or 'waste rock') that must be moved or excavated to allow access to the ore deposit. The first way in which proposed mining projects differ is the proposed method of moving or excavating the overburden. What follows are brief descriptions of the most common methods.

1.1.3.1 Open-pit mining

Open-pit mining is a type of strip mining in which the ore deposit extends very deep in the ground, necessitating the removal of layer upon layer of overburden and ore.

In many cases, logging of trees and clear-cutting or burning of vegetation above the ore deposit may precede removal of the overburden. The use of heavy machinery, usually bulldozers and dump trucks, is the most common means of removing overburden. Open-pit mining often involves the removal of natively vegetated areas, and is therefore among the most environmentally-destructive types of mining, especially within tropical forests.



Open-pit mine in Cerro de Pasco, Peru
PHOTO: Centro de Cultura Popular LABOR, Peru

Because open-pit mining is employed for ore deposits at a substantial depth underground, it usually involves the creation of a pit that extends below the groundwater table. In this case, groundwater must be pumped out of the pit to allow mining to take place. A pit lake usually forms at some point in time after mining stops and the groundwater pumps are turned off.

1.1.3.2 Placer mining

Placer mining is used when the metal of interest is associated with sediment in a stream bed or floodplain. Bulldozers, dredges, or hydraulic jets of water (a process called 'hydraulic mining') are used to extract the ore. Placer mining is usually aimed at removing gold from stream sediments and floodplains. Because placer mining often occurs within a streambed, it is an environmentally-destructive type of mining, releasing large quantities of sediment that can impact surface water for several miles downstream of the placer mine.

1.1.3.3 Underground mining

In underground mining, a minimal amount of overburden is removed to gain access to the ore deposit. Access to this ore deposit is gained by tunnels or shafts. Tunnels or shafts lead to a more horizontal network of underground tunnels that directly access the ore. In an underground mining method called 'stopping' or 'block caving,' sections or blocks of rock are removed in vertical strips that leave a connected underground cavity that is usually filled with cemented aggregate and waste rock.

Although underground mining is a less environmentally-destructive means of gaining access to an ore deposit, it is often more costly and entails greater safety risks than strip mining, including open-pit mining. While most large-scale mining projects involve open-pit mining, many large underground mines are in operation around the world.

1.1.3.4 Reworking of inactive or abandoned mines and tailings

Some mining projects involve the reworking of waste piles (often tailings) from inactive or abandoned mines, or older waste piles at active mines. Typically, this is proposed when more efficient methods of metal beneficiation have made it economical to re-extract metals from old mining waste. The material from the piles may be sent to processing facilities on-site or

off-site. Mining projects that only involve the reworking of abandoned mine waste piles avoid the environmental impacts of open-pit mining and placer mining, but still entail environmental impacts associated with purification (beneficiation) of metals from the waste piles.

1.1.4 Disposal of overburden and waste rock

In almost every project, metallic ores are buried under a layer of ordinary soil or rock (called 'overburden' or 'waste rock') that must be moved or excavated to allow access to the metallic ore deposit. For most mining projects, the quantity of overburden generated by mining is enormous. The ratio of the quantity of overburden to the quantity of mineral ore (called the 'strip ratio') is usually greater than one, and can be much higher. For example, if a proposed mining project involves the extraction of 100 million metric tons of mineral ore, then the proposed mining project could generate more than one billion metric tons of overburden and waste rock.

These high-volume wastes, sometimes containing significant levels of toxic substances, are usually deposited on-site, either in piles on the surface or as backfill in open pits, or within underground mines. Therefore, the EIA for a proposed mining project must carefully assess the management options and associated impacts of overburden disposal.

1.1.5 Ore extraction

After a mining company has removed overburden, extraction of the mineral ore begins using specialized heavy equipment and machinery, such as loaders, haulers, and dump trucks, which transport the ore to processing facilities using haul roads. This activity creates a unique set of environmental impacts, such as emissions of fugitive dust from haul roads, which an EIA for a proposed mining project should assess separately.

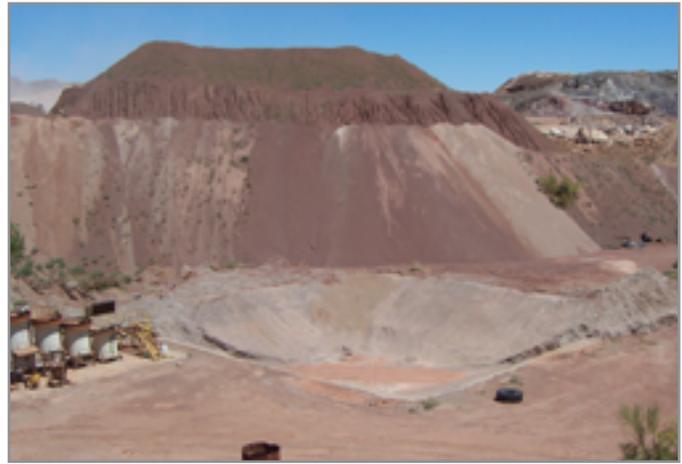
1.1.6 Beneficiation

Although metallic ores contain elevated levels of metals, they generate large quantities of waste. For example, the copper content of a good grade copper ore may be only one quarter of one percent. The gold content of a good grade gold ore may be only a few one-hundredths of a percent. Therefore, the next step in mining is grinding (or milling) the ore and separating the relatively small quantities of metal from the non-metallic material of the ore in a process called 'beneficiation.'

Milling is one of the most costly parts of beneficiation, and results in very fine particles that allow better extraction of the metal. However, milling also allows a more complete release of contaminants when these particles become tailings. Tailings are what remains following milling of the ore to fine particles and extraction of the valuable metal(s).

Beneficiation includes physical and/or chemical separation techniques such as gravity concentration, magnetic separation, electrostatic separation, flotation, solvent extraction, electrowinning, leaching, precipitation, and amalgamation (often involving the use of mercury). Wastes from these processes include waste rock dumps, tailings, heap leach materials (for gold and silver operations), and dump leach materials (for copper leach operations).

Leaching involving the use of cyanide is a kind of beneficiation process, usually used with gold, silver, and copper ores, that merits separate attention because of the serious environmental and public safety impacts. With leaching, finely ground ore is deposited in a large pile (called a 'leach pile') on top of an impermeable pad, and a solution containing cyanide is sprayed on top of the pile. The cyanide solution dissolves the desired metals and the 'pregnant' solution containing the metal is collected from the bottom of the pile using a system of pipes.



Heap leach, Bighorn gold mine, CA
PHOTO: Bender Environmental Consulting

1.1.7 Tailings disposal

As previously discussed, even high-grade mineral ores consist almost entirely of non-metallic materials and often contain undesired toxic metals (such as cadmium, lead, and arsenic). The beneficiation process generates high-volume waste called 'tailings,' the residue of an ore that remains after it has been milled and the desired metals have been extracted (e.g., with cyanide (gold) or sulfuric acid (copper)).

If a mining project involves the extraction of a few hundred million metric tons of mineral ore, then the mine project will generate a similar quantity of tailings. How a mining company disposes of this high-volume toxic waste material is one of the central questions that will determine whether a proposed mining project is environmentally acceptable. The key long-term goal of tailings disposal and management is to prevent the mobilization and release into the environment of toxic constituents of the tailings.

An entire section of this Guidebook is devoted to a detailed comparison of tailings disposal options (see Section 3.2.1.3). These options include: (1) the use of a wet tailings impoundment facility or 'tailings pond'; (2) dewatering and disposal of dry tailings as backfill; and (3) sub-marine tailings disposal.

The first option (a tailings pond) is by far the most commonly used option, but the second option

(dry tailings disposal) is, in most circumstances, the environmentally-preferable option. The third option (sub-marine tailings disposal) is sometimes proposed with mine sites located near deep sea environments, or in rare instances in freshwater lakes. Sub-marine tailings disposal has a poor environmental record in the few instances where it has been practiced.

Before the adoption of environmental laws and standards, many mining companies simply dumped tailings in the nearest convenient location, including nearby rivers and streams. Some of the worst environmental consequences of mining have been associated with the open dumping of tailings, a practice now nearly universally rejected. The International Finance Corporation (IFC)/World Bank Group explains:

“Riverine (e.g., rivers, lakes, and lagoons) or shallow marine tailings disposal is not considered good international industry practice. By extension, riverine dredging which requires riverine tailings disposal is also not considered good international practice.”¹



Wet tailings disposal at a mine in Peru
PHOTO: Centro de Cultura Popular LABOR, Peru

1.1.8 Site reclamation and closure

When active mining ceases, mine facilities and the site are reclaimed and closed. The goal of mine site reclamation and closure should always be to return the site to a condition that most resembles the pre-mining condition. Mines that are notorious for their immense impact on the environment often made impacts only during the closure phase, when active mining operations ceased. These impacts can persist for decades and even centuries. Therefore, the EIA for every proposed mining project must include a detailed discussion of the mine Reclamation and Closure Plan offered by the mining proponent.

Mine reclamation and closure plans must describe in sufficient detail how the mining company will restore the site to a condition that most resembles pre-mining environmental quality; how it will prevent – in perpetuity – the release of toxic contaminants from various mine facilities (such as abandoned open pits and tailings impoundments); and how funds will be set aside to insure that the costs of reclamation and closure will be paid for.

An entire section of this Guidebook is devoted to a discussion of how to evaluate whether the Reclamation and Closure Plan offered by a mining proponent is adequate (see Section 3.7).

¹ IFC/World Bank (December 2007) “Environmental, Health and Safety Guidelines for Mining.” [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

1.2 ENVIRONMENTAL AND SOCIAL IMPACTS OF MINING

The remainder of this chapter describes the most important environmental impacts of mining projects.

1.2.1 Impacts on water resources

Perhaps the most significant impact of a mining project is its effects on water quality and availability of water resources within the project area. Key questions are whether surface and groundwater supplies will remain fit for human consumption, and whether the quality of surface waters in the project area will remain adequate to support native aquatic life and terrestrial wildlife.

1.2.1.1 Acid mine drainage and contaminant leaching

The potential for acid mine drainage is a key question. The answer will determine whether a proposed mining project is environmentally acceptable. When mined materials (such as the walls of open pits and underground mines, tailings, waste rock, and heap and dump leach materials) are excavated and exposed to oxygen and water, acid can form if iron sulfide minerals (especially pyrite, or 'fools gold') are abundant and there is an insufficient amount of neutralizing material to counteract the acid formation. The acid will, in turn, leach or dissolve metals and other contaminants from mined materials and form a solution that is acidic, high in sulfate, and metal-rich (including elevated concentrations of cadmium, copper, lead, zinc, arsenic, etc.)

Leaching of toxic constituents, such as arsenic, selenium, and metals, can occur even if acidic conditions are not present. Elevated levels of cyanide and nitrogen compounds (ammonia, nitrate, nitrite) can also be found in waters at mine sites, from heap leaching and blasting.

Acid drainage and contaminant leaching is the most important source of water quality impacts related to metallic ore mining.



Acid mine drainage
PHOTO: SOSBlueWaters.org

As Earthworks explains:

“Acid mine drainage is considered one of mining’s most serious threats to water resources. A mine with acid mine drainage has the potential for long-term devastating impacts on rivers, streams and aquatic life.

“HOW DOES IT FORM? Acid mine drainage is a concern at many metal mines, because metals such as gold, copper, silver and molybdenum, are often found in rock with sulfide minerals. When the sulfides in the rock are excavated and exposed to water and air during mining, they form sulfuric acid. This acidic water can dissolve other harmful metals in the surrounding rock. If uncontrolled, the acid mine drainage may runoff into streams or rivers or leach into groundwater. Acid mine drainage may be released from any part of the mine where sulfides are exposed to air and water, including waste rock piles, tailings, open pits, underground tunnels, and leach pads.

“HARM TO FISH & OTHER AQUATIC LIFE: If mine waste is acid-generating, the impacts to fish, animals and plants can be severe. Many streams impacted by acid mine drainage have a pH value of 4 or lower – similar to battery acid. Plants, animals, and fish are unlikely to survive in streams such as this.

“TOXIC METALS: Acid mine drainage also dissolves toxic metals, such as copper, aluminum, cadmium, arsenic, lead and mercury, from the surrounding rock. These metals, particularly the iron, may coat the stream bottom with an orange-red colored slime called yellowboy. Even in very small amounts, metals can be toxic to humans and wildlife. Carried in water, the metals can travel far, contaminating streams and groundwater for great distances. The impacts to aquatic life may range from immediate fish kills to sub-lethal, impacts affecting growth, behavior or the ability to reproduce.

“Metals are particularly problematic because they do not break down in the environment. They settle to the bottom and persist in the stream for long periods of time, providing a long-term source of contamination to the aquatic insects that live there, and the fish that feed on them.

“PERPETUAL POLLUTION: Acid mine drainage is particularly harmful because it can continue indefinitely causing damage long after mining has ended. Due to the severity of water quality impacts from acid mine drainage, many hardrock mines across the west require water treatment in perpetuity. Even with existing technology, acid mine drainage is virtually impossible to stop once the reactions begin. To permit an acid generating mine means that future generations will take responsibility for a mine that must be managed for possibly hundreds of years.”²

1.2.1.2 Erosion of soils and mine wastes into surface waters

For most mining projects, the potential of soil and sediment eroding into and degrading surface water quality is a serious problem.

According to a study commissioned by the European Union:

“Because of the large area of land disturbed by mining operations and the large quantities of earthen materials exposed at sites, erosion can be a major concern at hardrock mining sites. Consequently, erosion control must be considered from the beginning of operations through completion of reclamation. Erosion may cause significant loading of sediments (and any entrained chemical pollutants) to nearby waterbodies, especially during severe storm events and high snow melt periods.

“Sediment-laden surface runoff typically originates as sheet flow and collects in rills, natural channels or gullies, or artificial conveyances. The ultimate deposition of the sediment may occur in surface waters or it may be deposited within the floodplains of a stream valley. Historically, erosion and sedimentation processes have caused the build-up of thick layers of mineral fines and sediment within regional flood plains and the alteration of aquatic habitat and the loss of storage capacity within surface waters. The main factors influencing erosion includes the volume and velocity of runoff from precipitation events, the rate of precipitation infiltration downward through the soil, the amount of vegetative cover, the slope length or the distance from the point of origin of overland flow to the point where deposition begins, and operational erosion control structures.

“Major sources of erosion/sediment loading at mining sites can include open pit areas, heap and dump leaches, waste rock and overburden piles, tailings piles and dams, haul roads and access roads, ore stockpiles, vehicle and equipment maintenance areas, exploration areas, and reclamation areas. A further concern is that exposed materials from mining operations (mine workings, wastes, contaminated soils, etc.) may contribute sediments with chemical pollutants, principally heavy metals. The variability in natural

² Earthworks Fact Sheet: Hardrock Mining and Acid Mine Drainage. http://www.earthworksaction.org/pubs/FS_AMD.pdf

site conditions (e.g., geology, vegetation, topography, climate, and proximity to and characteristics of surface waters), combined with significant differences in the quantities and characteristics of exposed materials at mines, preclude any generalisation of the quantities and characteristics of sediment loading.

“The types of impacts associated with erosion and sedimentation are numerous, typically producing both short-term and long-term impacts. In surface waters, elevated concentrations of particulate matter in the water column can produce both chronic and acute toxic effects in fish.

“Sediments deposited in layers in flood plains or terrestrial ecosystems can produce many impacts associated with surface waters, ground water, and terrestrial ecosystems. Minerals associated with deposited sediments may depress the pH of surface runoff thereby mobilising heavy metals that can infiltrate into the surrounding subsoil or can be carried away to nearby surface waters. The associated impacts could include substantial pH depression or metals loading to surface waters and/or persistent contamination of ground water sources. Contaminated sediments may also lower the pH of soils to the extent that vegetation and suitable habitat are lost.

“Beyond the potential for pollutant impacts on human and aquatic life, there are potential physical impacts associated with the increased runoff velocities and volumes from new land disturbance activities. Increased velocities and volumes can lead to downstream flooding, scouring of stream channels, and structural damage to bridge footings and culvert entries. In areas where air emissions have deposited acidic particles and the native vegetation has been destroyed, runoff has the potential to increase the rate of erosion and lead to removal of soil from the affected area. This is particularly true where the landscape is characterised by steep and rocky slopes. Once the soils have been removed, it is difficult for

the slope to be revegetated either naturally or with human assistance.”³



Overburden drainage at an Australian mine
PHOTO: Peripitus

Environment Australia summarizes the problem as follows:

“Potentially adverse effects of inadequate minesite water management and design include: unacceptably high levels of suspended solids (Non-Filterable Residue) and dissolved solids (Filterable Residue) in surface runoff [and] bed and bank erosion in waterways. It is self-evident that a Sediment and Erosion Control Plan is a fundamental component of a Minesite Water Management Plan.”⁴

1.2.1.3 Impacts of tailing impoundments, waste rock, heap leach, and dump leach facilities

The impacts of wet tailings impoundments, waste rock, heap leach, and dump leach facilities on water quality can be severe. These impacts include contamination of groundwater beneath these facilities and surface waters. Toxic substances can leach from these facilities, percolate through the ground, and contaminate groundwater, especially if the bottom of these facilities are not fitted with an impermeable liner.

³ MINEO Consortium (2000) “Review of potential environmental and social impact of mining” <http://www2.brgm.fr/mineo/UserNeed/IMPACTS.pdf>

⁴ Environment Australia (2002) “Overview of Best Practice Environmental Management in Mining.” <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMOverview.pdf>

Tailings (a by-product of metallic ore processing) is a high-volume waste that can contain harmful quantities of toxic substances, including arsenic, lead, cadmium, chromium, nickel, and cyanide (if cyanide leaching is used). Although it is rarely the environmentally-preferable option, most mining companies dispose of tailings by mixing them with water (to form a slurry) and disposing of the slurry behind a tall dam in a large wet tailings impoundment. Because the ore is usually extracted as a slurry, the resulting waste contains large amounts of water, and generally forms ponds at the top of the tailings dams that can be a threat to wildlife. Cyanide tailings in precious metals mines are particularly dangerous.

Ultimately, tailing ponds will either dry, in arid climates, or may release contaminated water, in wet climates. In both cases, specific management techniques are required to close these waste repositories and reduce environmental threats.

During periods of heavy rain, more water may enter a tailings impoundment than it has the capacity to contain, necessitating the release of tailings impoundment effluent. Since this effluent can contain toxic substances, the release of this effluent can seriously degrade water quality of surrounding rivers and streams, especially if the effluent is not treated prior to discharge.

Dozens of dam breaks at wet tailings impoundments have created some of the worst environmental consequences of all industrial accidents. When wet tailings impoundments fail, they release large quantities of toxic waters that can kill aquatic life and poison drinking water supplies for many miles downstream of the impoundment.

1.2.1.4 Impacts of mine dewatering

When an open pit intersects the water table, groundwater flows into the open pit. For mining to proceed, mining companies must pump and discharge this water to another location. Pumping and discharging mine water causes a unique set of environmental impacts that are well described

in a study commissioned by the European Union:

“Mine water is produced when the water table is higher than the underground mine workings or the depth of an open pit surface mine. When this occurs, the water must be pumped out of the mine. Alternatively, water may be pumped from wells surrounding the mine to create a cone of depression in the ground water table, thereby reducing infiltration. When the mine is operational, mine water must be continually removed from the mine to facilitate the removal of the ore. However, once mining operations end, the removal and management of mine water often end, resulting in possible accumulation in rock fractures, shafts, tunnels, and open pits and uncontrolled releases to the environment.

“Ground water drawdown and associated impacts to surface waters and nearby wetlands can be a serious concern in some areas.

“Impacts from ground water drawdown may include reduction or elimination of surface water flows; degradation of surface water quality and beneficial uses; degradation of habitat (not only riparian zones, springs, and other wetland habitats, but also upland habitats such as greasewood as ground water levels decline below the deep root zone); reduced or eliminated production in domestic supply wells; water quality/quantity problems associated with discharge of the pumped ground water back into surface waters downstream from the dewatered area. The impacts could last for many decades. While dewatering is occurring, discharge of the pumped water, after appropriate treatment, can often be used to mitigate adverse effects on surface waters. However, when dewatering ceases, the cones of depression may take many decades to recharge and may continue to reduce surface flows Mitigation measures that rely on the use of pumped water to create wetlands may only last as long as dewatering occurs.”⁵

⁵ MINEO Consortium (2000) “Review of potential environmental and social impact of mining” <http://www2.brgm.fr/mineo/UserNeed/IMPACTS.pdf>

1.2.2 Impacts of mining projects on air quality

Airborne emissions occur during each stage of the mine cycle, but especially during exploration, development, construction, and operational activities. Mining operations mobilize large amounts of material, and waste piles containing small size particles are easily dispersed by the wind.

The largest sources of air pollution in mining operations are:

- Particulate matter transported by the wind as a result of excavations, blasting, transportation of materials, wind erosion (more frequent in open-pit mining), fugitive dust from tailings facilities, stockpiles, waste dumps, and haul roads. Exhaust emissions from mobile sources (cars, trucks, heavy equipment) raise these particulate levels; and
- Gas emissions from the combustion of fuels in stationary and mobile sources, explosions, and mineral processing.

Once pollutants enter the atmosphere, they undergo physical and chemical changes before reaching a receptor (Figure 1). These pollutants can cause serious effects to people’s health and to the environment.

Large-scale mining has the potential to contribute significantly to air pollution, especially in the operation phase. All activities during ore extraction, processing, handling, and transport depend on equipment, generators, processes, and

materials that generate hazardous air pollutants such as particulate matter, heavy metals, carbon monoxide, sulfur dioxide, and nitrogen oxides.

1.2.2.1 Mobile sources

Mobile sources of air pollutants include heavy vehicles used in excavation operations, cars that transport personnel at the mining site, and trucks that transport mining materials. The level of polluting emissions from these sources depends on the fuel and conditions of the equipment. Even though individual emissions can be relatively small, collectively these emissions can be of real concern. In addition, mobile sources are a major source of particulate matter, carbon monoxide, and volatile organic compounds that contribute significantly to the formation of ground-level ozone.

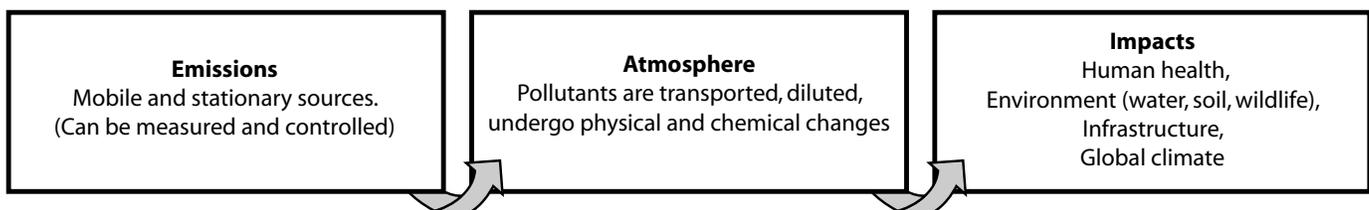
1.2.2.2 Stationary sources

The main gaseous emissions are from combustion of fuels in power generation installations, and drying, roasting, and smelting operations. Many producers of precious metals smelt metal on-site, prior to shipping to off-site refineries. Typically, gold and silver is produced in melting/fluxing furnaces that may produce elevated levels of airborne mercury, arsenic, sulfur dioxide, and other metals.

1.2.2.3 Fugitive emissions

The U.S. Environmental Protection Agency defines ‘fugitive emissions’ as “those emissions which could not reasonably pass through a stack, chimney, vent or other functionally-equivalent

Figure 1.



opening.”⁶ Common sources of fugitive emissions include: storage and handling of materials; mine processing; fugitive dust, blasting, construction activities, and roadways associated with mining activities; leach pads, and tailing piles and ponds; and waste rock piles. Sources and characteristics of fugitive emissions dust in mining operations vary in each case, as do their impacts. Impacts are difficult to predict and calculate but should be considered since they could be a significant source of hazardous air pollutants.

1.2.2.4 Incidental releases of mercury

Mercury is commonly present in gold ore. Although concentrations vary substantially, even within a specific ore deposit, mercury is found in gold ore and associated waste materials. If the content of mercury in a gold ore is 10 mg/kg, and one million tons of ore is processed at a particular mine (not unusual concentrations), 10 tons of mercury are potentially released to the environment. This is a major source of mercury and should be controlled.

In some gold mining projects, gold-containing ore is crushed and then, if necessary, heated and oxidized in roasters or autoclaves to remove sulfur and carbonaceous material that affects gold recovery. Mercury that is present in the ore is vaporized, particularly in roasters, which are some of the largest sources of mercury emitted to the atmosphere.

Following roasting or autoclaving, the ore is mixed with water and reacted with a cyanide leach solution, where gold and mercury are dissolved and solids removed via filtration. The purified solution is sent to an electrowinning process, where the gold is recovered. In this process, mercury must also be recovered and collected. If not collected by air pollution control devices, this mercury could be released to the atmosphere and impact the environment and public health.

⁶ U.S. Environmental Protection Agency, Title 40 Code of Federal Regulations, Section 70.2. <http://www.gpo.gov/fdsys/pkg/CFR-2009-title40-vol15/xml/CFR-2009-title40-vol15-part70.xml>

Volatilization of mercury from active heaps and tailings facilities has recently been identified as another substantial source of mercury emitted to the atmosphere. This process should be assessed and controlled. Overall, mercury present in gold ore may be released to the land (in disposed air pollution control wastes and spent ore tailings), to the air (not removed by air pollution control devices, or from tailings or heaps), or in the gold product (i.e., as an impurity).

1.2.2.5 Noise and vibration

Noise pollution associated with mining may include noise from vehicle engines, loading and unloading of rock into steel dumpers, chutes, power generation, and other sources. Cumulative impacts of shoveling, ripping, drilling, blasting, transport, crushing, grinding, and stock-piling can significantly affect wildlife and nearby residents.

Vibrations are associated with many types of equipment used in mining operations, but blasting is considered the major source. Vibration has affected the stability of infrastructures, buildings, and homes of people living near large-scale open-pit mining operations. According to a study commissioned by the European Union in 2000:

“Shocks and vibrations as a result of blasting in connection with mining can lead to noise, dust and collapse of structures in surrounding inhabited areas. The animal life, on which the local population may depend, might also be disturbed.”⁷

1.2.3 Impacts of mining projects on wildlife

Wildlife is a broad term that refers to all plants and any animals (or other organisms) that are not domesticated. Mining affects the environment and associated biota through the removal of vegetation and topsoil, the displacement of fauna, the release of pollutants, and the generation of noise.

⁷ MINEO Consortium (2000) “Review of potential environmental and social impact of mining” <http://www2.brgm.fr/mineo/UserNeed/IMPACTS.pdf>

1.2.3.1 Habitat loss

Wildlife species live in communities that depend on each other. Survival of these species can depend on soil conditions, local climate, altitude, and other features of the local habitat. Mining causes direct and indirect damage to wildlife. The impacts stem primarily from disturbing, removing, and redistributing the land surface. Some impacts are short-term and confined to the mine site; others may have far-reaching, long-term effects.

The most direct effect on wildlife is destruction or displacement of species in areas of excavation and piling of mine wastes. Mobile wildlife species, like game animals, birds, and predators, leave these areas. More sedentary animals, like invertebrates, many reptiles, burrowing rodents, and small mammals, may be more severely affected.

If streams, lakes, ponds, or marshes are filled or drained, fish, aquatic invertebrates, and amphibians are severely impacted. Food supplies for predators are reduced by the disappearance of these land and water species.

Many wildlife species are highly dependent on vegetation growing in natural drainages. This vegetation provides essential food, nesting sites, and cover for escape from predators. Any activity that destroys vegetation near ponds, reservoirs, marshes, and wetlands reduces the quality and quantity of habitat essential for waterfowl, shore birds, and many terrestrial species.

The habitat requirements of many animal species do not permit them to adjust to changes created by land disturbance. These changes reduce living space. The degree to which animals tolerate human competition for space varies. Some species tolerate very little disturbance. In instances where a particularly critical habitat is restricted, such as a lake, pond, or primary breeding area, a species could be eliminated.

Surface mining can degrade aquatic habitats with impacts felt many miles from a mining site. For

example, sediment contamination of rivers and streams is common with surface mining.

1.2.3.2 Habitat fragmentation

Habitat fragmentation occurs when large areas of land are broken up into smaller and smaller patches, making dispersal by native species from one patch to another difficult or impossible, and cutting off migratory routes. Isolation may lead to local decline of species, or genetic effects such as inbreeding. Species that require large patches of forest simply disappear.

1.2.4 Impacts of mining projects on soil quality

Mining can contaminate soils over a large area. Agricultural activities near a mining project may be particularly affected. According to a study commissioned by the European Union:

“Mining operations routinely modify the surrounding landscape by exposing previously undisturbed earthen materials. Erosion of exposed soils, extracted mineral ores, tailings, and fine material in waste rock piles can result in substantial sediment loading to surface waters and drainage ways. In addition, spills and leaks of hazardous materials and the deposition of contaminated windblown dust can lead to soil contamination.”

“SOIL CONTAMINATION: Human health and environmental risks from soils generally fall into two categories: (1) contaminated soil resulting from windblown dust, and (2) soils contaminated from chemical spills and residues. Fugitive dust can pose significant environmental problems at some mines. The inherent toxicity of the dust depends upon the proximity of environmental receptors and type of ore being mined. High levels of arsenic, lead, and radionuclides in windblown dust usually pose the greatest risk. Soils contaminated from chemical spills and residues at mine sites may pose a direct contact risk when these materials are misused”

as fill materials, ornamental landscaping, or soil supplements.”⁸

1.2.5 Impacts of mining projects on social values

The social impacts of large-scale mining projects are controversial and complex. Mineral development can create wealth, but it can also cause considerable disruption. Mining projects may create jobs, roads, schools, and increase the demands of goods and services in remote and impoverished areas, but the benefits and costs may be unevenly shared. If communities feel they are being unfairly treated or inadequately compensated, mining projects can lead to social tension and violent conflict.

EIAs can underestimate or even ignore the impacts of mining projects on local people. Communities feel particularly vulnerable when linkages with authorities and other sectors of the economy are weak, or when environmental impacts of mining (soil, air, and water pollution) affect the subsistence and livelihood of local people.

Power differentials can leave a sense of helplessness when communities confront the potential for change induced by large and powerful companies. The EIA process should enforce mechanisms that enable local communities to play effective roles in decision-making. Mineral activities must ensure that the basic rights of the individual and communities affected are upheld and not infringed upon. These must include the right to control and use land; the right to clean water, a safe environment, and livelihood; the right to be free from intimidation and violence; and the right to be fairly compensated for loss.

1.2.5.1 Human displacement and resettlement

According to the International Institute for Environment and Development:

“The displacement of settled communities is a significant cause of resentment and conflict associated with large-scale mineral development. Entire communities may be uprooted and forced to shift elsewhere, often into purpose-built settlements not necessarily of their own choosing. Besides losing their homes, communities may also lose their land, and thus their livelihoods. Community institutions and power relations may also be disrupted. Displaced communities are often settled in areas without adequate resources or are left near the mine, where they may bear the brunt of pollution and contamination. Forced resettlement can be particularly disastrous for indigenous communities who have strong cultural and spiritual ties to the lands of their ancestors and who may find it difficult to survive when these are broken.”⁹

1.2.5.2 Impacts of migration

According to the International Institute for Environment and Development:

“One of the most significant impacts of mining activity is the migration of people into a mine area, particularly in remote parts of developing countries where the mine represents the single most important economic activity. For example, at the Grasberg mine in Indonesia the local population increased from less than 1000 in 1973 to between 100,000 and 110,000 in 1999. Similarly, the population of the squatter settlements around Porgera in PNG, which opened in 1990, has grown from 4000 to over 18,000.¹⁰ This influx of newcomers can have a profound impact on the original inhabitants, and disputes may arise over land and the way benefits have been shared. (These were among the factors that led to violent uprisings at Grasberg in the 1970s and the 1990s.)

“Sudden increases in population can also lead to pressures on land, water, and other

8 Ibid.

9 International Institute for Environment and Development (2002) “Breaking New Ground: Mining, Minerals and Sustainable Development: Chapter 9: Local Communities and Mines. Breaking New Grounds.” <http://www.iiied.org/pubs/pdfs/G00901.pdf>

resources as well as bringing problems of sanitation and waste disposal.

“Migration effects may extend far beyond the immediate vicinity of the mine. Improved infrastructure can also bring an influx of settlers. For instance, it is estimated that the 80- meter-wide, 890-kilometre-long transportation corridor built from the Atlantic Ocean to the Carajas mine in Brazil created an area of influence of 300,000 square kilometres.”¹⁰

1.2.5.3 Lost access to clean water

According to scientists at the University of Manchester (UK) and the University of Colorado(U.S.):

“Impacts on water quality and quantity are among the most contentious aspects of mining projects. Companies insist that the use of modern technologies will ensure environmentally friendly mining practices. However, evidence of the negative environmental impacts of past mining activity causes local and downstream populations to worry that new mining activities will adversely affect their water supply. ...

“There are major stakes in these conflicts, affecting everything from local livelihood sustainability to the solvency of national governments. Fears for water quantity and quality have triggered numerous and sometimes violent conflicts between miners and communities.”¹¹

1.2.5.4 Impacts on livelihoods

When mining activities are not adequately managed, the result is degraded soils, water, biodiversity, and forest resources, which are critical to the subsistence of local people. When contamination is not controlled, the cost of the

contamination is transferred to other economic activities, such as agriculture and fishing. The situation is made worse when mining activities take place in areas inhabited by populations historically marginalized, discriminated against, or excluded.

Proponents of mining projects must insure that the basic rights of affected individuals and communities are upheld and not infringed upon. These include rights to control and use land, the right to clean water, and the right to livelihood. Such rights may be enshrined in national law, based on and expressed through a range of international human rights instruments and agreements. All groups are equal under the law, and the interests of the most vulnerable groups (low-income and marginalized) need to be identified and protected.

1.2.5.5 Impacts on public health

EIAs of mining projects often underestimate the potential health risks of mining projects. Hazardous substances and wastes in water, air, and soil can have serious, negative impacts on public health. The World Health Organization (WHO) defines health as a “state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity.”¹²

The term ‘hazardous substances’ is broad and includes all substances that can be harmful to people and/or the environment. Because of the quantity, concentration, or physical, chemical or infectious characteristics, hazardous substances may (1) cause or contribute to an increase of mortality or an increase in serious irreversible or incapacitating illness; or (2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

¹⁰ Ibid.

¹¹ Bebbington, A., & Williams, M. (2008) “Water and Mining Conflicts in Peru.” Mountain Research and Development. 28(3/4):190-195 http://snobear.colorado.edu/Markw/Research/08_peru.pdf

¹² World Health Organization. 1946. Preamble to the Constitution of the World Health Organization. Official Records of the World Health Organization No. 2, p. 100.

Frequent public health problems related to mining activities include:

- Water: Surface and ground water contamination with metals and elements; microbiological contamination from sewage and wastes in campsites and mine worker residential areas;
- Air: Exposure to high concentrations of sulfur dioxide, particulate matter, heavy metals, including lead, mercury and cadmium; and
- Soil: Deposition of toxic elements from air emissions.

Mining activities can suddenly affect quality of life and the physical, mental, and social well-being of local communities. Improvised mining towns and camps often threaten food availability and safety, increasing the risk of malnourishment. Indirect effects of mining on public health can include increased incidence of tuberculosis, asthma, chronic bronchitis, and gastrointestinal diseases.

1.2.5.6 Impacts to cultural and aesthetic resources

Mining activities can cause direct and indirect impacts to cultural resources. Direct impacts can result from construction and other mining activities. Indirect impacts can result from soil erosion and increased accessibility to current or proposed mining sites. Mining projects can affect sacred landscapes, historical infrastructures, and natural landmarks. Potential impacts include:

- Complete destruction of the resource through surface disturbance or excavation;
- Degradation or destruction, due to topographic or hydrological pattern changes, or from soil movement (removal, erosion, sedimentation);
- Unauthorized removal of artifacts or vandalism as a result of increased access to previously inaccessible areas; and

- Visual impacts due to clearing of vegetation, large excavations, dust, and the presence of large-scale equipment, and vehicles.

1.2.6 Climate change considerations

Every EIA for a project that has the potential to change the global carbon budget should include an assessment of a project's carbon impact. Large-scale mining projects have the potential to alter global carbon in at least the following ways:

Lost CO₂ uptake by forests and vegetation that is cleared. Many large-scale mining projects are proposed in heavily forested areas of tropical regions that are critical for absorbing atmospheric carbon dioxide (CO₂) and maintaining a healthy balance between CO₂ emissions and CO₂ uptake. Some mining projects propose long-term or even permanent destruction of tropical forests. EIAs for mining projects must include a careful accounting of how any proposed disturbance of tropical forests will alter the carbon budget. The EIA should also include an analysis of the potential for the host country to lose funding from international consortiums that have and will be established to conserve tropical forests.

CO₂ emitted by machines (e.g., diesel-powered heavy vehicles) involved in extracting and transporting ore. The EIA should include a quantitative estimate of CO₂ emissions from machines and vehicles that will be needed during the life of the mining project. These estimates can be based on the rate of fuel consumption (typically diesel fuel) multiplied by a conversion factor that relates units (typically liters or gallons) of fuel that is consumed and units (typically metric tons) of CO₂ that is emitted.

CO₂ emitted by the processing of ore into metal (for example, by pyro-metallurgical versus hydro-metallurgical techniques). An example is found in an assessment by CSIRO minerals of Australia which used the Life Cycle Assessment methodology to estimate the life cycle emissions of greenhouse gases from copper and nickel

production, including mining. This assessment found that Life Cycle greenhouse gas emissions from copper and nickel production range from 3.3 kilograms (kg) of CO₂ per kg of metal for copper produced by smelting to 16.1 kg of CO₂ per kg of metal for nickel produced by pressure acid leaching followed by solvent extraction and

electrowinning.¹³ The bottom line is that metal mining generates *more than 1 kg of greenhouse gas for every 1 kg of metal that is produced*, and this does not take into account lost carbon uptake of cleared forests.

13 T. E. Norgate and W. J. Rankin (2000) "Life Cycle Assessment of Copper and Nickel Production, Published in Proceedings, Minprex 2000, International Conference on Minerals Processing and Extractive Metallurgy, pp133-138. http://www.minerals.csiro.au/sd/CSIRO_Paper_LCA_CuNi.htm

2. Overview of the EIA Process



2.1 WHAT IS THE PURPOSE OF THE EIA PROCESS?

The environmental impact assessment (EIA) process is an interdisciplinary and multi-step procedure to ensure that environmental considerations are included in decisions regarding projects that may impact the environment. Simply defined, the EIA process helps identify the possible environmental effects of a proposed activity and how those impacts can be mitigated.

The purpose of the EIA process is to inform decision-makers and the public of the environmental consequences of implementing a proposed project. The EIA document itself is a technical tool that identifies, predicts, and analyzes impacts on the physical environment, as well as social, cultural, and health impacts. If the EIA process is successful, it identifies alternatives and

mitigation measures to reduce the environmental impact of a proposed project. The EIA process also serves an important procedural role in the overall decision-making process by promoting transparency and public involvement.

It is important to note that the EIA process does not guarantee that a project will be modified or rejected if the process reveals that there will be serious environmental impacts. In some countries, a decision-maker may, in fact, choose the most environmentally-harmful alternative, as long as the consequences are disclosed in the EIA. In other words, the EIA process ensures an informed decision, but not necessarily an environmentally-beneficial decision.

BENEFITS OF THE EIA PROCESS

- Potentially screens out environmentally-unsound projects
- Proposes modified designs to reduce environmental impacts
- Identifies feasible alternatives
- Predicts significant adverse impacts
- Identifies mitigation measures to reduce, offset, or eliminate major impacts
- Engages and informs potentially affected communities and individuals
- Influences decision-making and the development of terms and conditions

2.2 WHO PREPARES AN EIA?

Depending on the EIA system, responsibility for producing an EIA will be assigned to one of two parties: (1) the government agency or ministry, or (2) the project proponent. If EIA laws permit, either party may opt to hire a consultant to prepare the EIA or handle specific portions of the EIA process, such as public participation or technical studies.

Some EIA laws recognize the inherent conflict of interest produced when a mining company or other project proponent hires a consultant to prepare an EIA. Using a consultant carries the risk that the document will be biased in favor of proceeding with the project. If a consultant is hired by the mining company, conflicts may arise

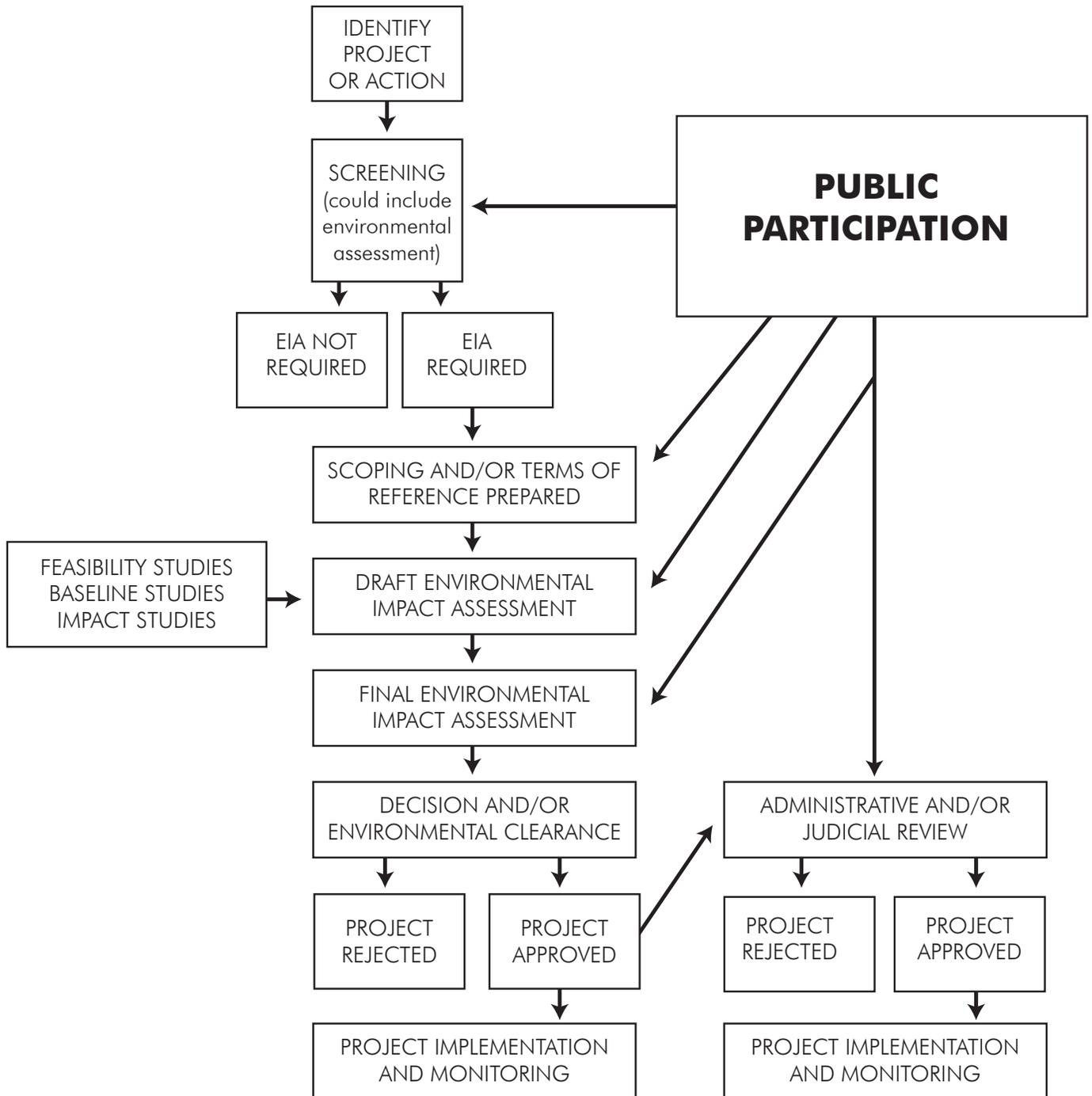
if the consultant believes it will receive future work if the project is approved, or even indirect benefits from related activities (e.g., consulting work for a port where ore will be exported). Some laws require consultants to be registered with the government and/or professionally accredited in EIA preparation. In some instances, a consultant may be required to file a statement disclosing any financial or other interest in the outcome of the project.¹⁴

¹⁴ For example, in the Rosemont Copper Project on the Coronado National Forest in the United States, the U.S. Forest Service prepared a statement outlining its rationale for selecting a particular contractor to prepare an environmental impact statement (EIS) for the project. The agency and the mining company also executed a memorandum of understanding that defined each party's respective role in preparing the EIS. The document is available at www.fs.fed.us/r3/coronado/rosemont/documents/swca-selection-reply-061308.pdf.

2.3 STAGES OF THE EIA PROCESS

The EIA process, while not uniform from country to country, generally consists of a set of procedural steps culminating in a written impact assessment report that will inform the decision-maker whether to approve or reject a proposed project.

THE FLOWCHART BELOW DEPICTS THE BASIC ELEMENTS OF GOOD EIA PRACTICE:



Identifying and Defining the Project or

Activity: Although this step may seem relatively simple, defining a “project” for the purposes of an EIA can become complex and even controversial if a mining project is large, has several phases, or involves multiple sites. The goal of this step is to define the project with enough specificity to accurately determine the zone of possible impacts and to include activities that are closely connected with the proposal so that the entire scope of environmental impacts is evaluated.

Screening: The screening process determines whether a particular project warrants preparation of an EIA. The threshold requirements for an EIA vary from country to country – some laws provide a list of the types of activities or projects that will require an EIA, others require an EIA for any project that may have a significant impact on the environment or for projects that exceed a certain monetary value. In some cases, particularly if the possible impacts of a project are not known, a preliminary environmental assessment will be prepared to determine whether the project warrants an EIA.

Scoping: Scoping is a stage, usually involving the public and other interested parties, that identifies the key environmental issues that should be addressed in an EIA. This step provides one of the first opportunities for members of the public or NGOs to learn about a proposed project and to voice their opinions. Scoping may also reveal similar or connected activities that may be occurring in the vicinity of a project, or identify problems that need to be mitigated or that may cause the project to be canceled.

Preparing Terms of Reference: The Terms of Reference serve as a roadmap for EIA preparation and should ideally encompass the issues and impacts that have been identified during the scoping process.

GENERALLY THE TERMS OF REFERENCE WILL INCLUDE THE FOLLOWING:

- A description of the project
- A list of the agencies or ministries responsible for overseeing the EIA process and making decisions
- The geographic area to be studied (also called the ‘impact zone’)
- EIA requirements in applicable laws or regulations
- Impacts and issues to be studied
- Mitigation and/or monitoring systems to be designed
- Provisions for public involvement
- Key stakeholders
- Timeframe for completing the EIA process
- Expected work product and deliverables
- Budget for the EIA

A draft Terms of Reference may be made available for public review and comment. Public review at this early stage of the process provides a key opportunity to ensure that the EIA is properly framed and will address issues of community concern.

Preparing Draft EIA: A draft EIA is prepared in accordance with the Terms of Reference and/or the range of issues identified during the scoping process. The draft EIA must also meet the content requirements of the overarching EIA law or regulations. This step will ideally engage a wide range of technical specialists to evaluate baseline conditions, predict the likely impacts of the project, and design mitigation measures.

Public Participation: Best EIA practice involves and engages the public at numerous points throughout the process with a two-way exchange of information and views. Public participation may consist of informational meetings, public hearings, and opportunities to provide written comments about a proposed project. However, there are no consistent rules for public participation among current EIA systems. Even within a particular country, there can be variations in the quality and extent of public involvement in the EIA process, depending on the type of project being

considered, the communities that may be affected, or government agencies that are overseeing the project.

Preparing Final EIA: This step produces a final impact assessment report that addresses the viewpoints and comments of the parties that reviewed the draft EIA. These comments may prompt revisions or additions to the text of the draft EIA. In some cases, the final EIA will contain an appendix summarizing all of the comments received from the public and other interested parties and provide responses to those comments.

Decision: A decision to approve or reject a mining project is generally based on the final EIA, but in some instances, an environmental clearance may be just one step in the mine permitting process. The decision may be accompanied by certain conditions that must be fulfilled, such as posting a reclamation bond or filing an Environmental Management Plan.

Administrative or Judicial Review:

Depending on the jurisdiction, there may be opportunities for a party to seek administrative and/or judicial review of the final decision and the EIA process. An appeal may address procedural flaws in the EIA process, such as a failure to hold any required public hearings, or may point

to substantive issues that the decision-maker failed to consider. A country's judicial review or administrative procedure act, or sometimes the EIA law itself, will usually identify the kinds of issues that can be raised in an appeal and the type of relief that may be granted.

Project Implementation: Provided all regulatory requirements are met and permits are obtained, mine development will proceed following the project decision and once opportunities for administrative and/or judicial review are exhausted.

Monitoring: Monitoring is an important part of project implementation. Monitoring serves three purposes: (1) ensuring that required mitigation measures are being implemented; (2) evaluating whether mitigation measures are working effectively; and (3) validating the accuracy of models or projections that were used during the impact assessment process.

3. Reviewing a Typical EIA for a Mining Project

Reviewing EIA documents can be daunting. Project proponents submit reports that include complex and obscure technical terms. Sometimes only the Executive Summary is made available to the public. The purpose of an EIA is to provide clear and impartial information about a project's potential environmental and social impacts. Questions to consider when reviewing an EIA include:

- Does the EIA fulfill requirements for the proposed activity, as set out in the relevant EIA guidelines or Terms of Reference?
- Does the EIA focus on the issues that most concern the community?
- Does the description of the existing environment reflect actual conditions? Is the information sufficient?
- Has the EIA defined the area of direct and indirect influence of the project?
- Is the impact analysis clear about the extent and significance of the impacts? Is the analysis rigorous enough?
- What sources support the conclusions? Can they be verified?
- Is there enough information about alternatives to the project?
- Is the EIA clear and easy to understand? Does it acknowledge limitations and difficulties?
- Does the EIA describe how the project would implement proposed mitigation and management measures (including pollution control measures and closure)?

3.1 EVALUATING THE EXECUTIVE SUMMARY

The Executive Summary of an EIA provides decision-makers and the public with a concise presentation of the most significant issues contained in the body of an EIA. The Executive Summary is critical because an EIA may be several hundred pages long and decision-makers may read the Executive Summary, and nothing else.

Summary, material from the body of the EIA that describes serious environmental and social impacts may be softened or omitted entirely from the Executive Summary. Statements in the Executive Summary that are favorable to the project proponent must be carefully compared with related material in the body of the EIA.

Since project proponents understand that decision-makers may only read the Executive

3.2 EVALUATING THE PROJECT DESCRIPTION

The Project Description is one of the most important sections of the EIA. The crucial issue is whether this section describes each and every aspect of the proposed mining project in sufficient detail to enable citizens to understand the project's true environmental and social impacts.

For example, the Project Description in a poor EIA might state: "A wet tailings impoundment shall be constructed for disposal of tailings from the mining project." This statement is missing details that are essential to predicting what the environmental and social impacts of the tailings impoundment might truly be.

In this case, a good Project Description would answer questions like: Where would the tailings impoundment be located and what surface waters would it connect with? What would be the dimensions of the tailings impoundment? What materials would be used to construct the tailings dam? Would the mining company treat effluent from the tailings impoundment before releasing it to surface water? If so, how? Would the tailings impoundment include an impermeable liner to protect groundwater?

Each of these questions should be answered in detail, accompanied by large-scale technical drawings, in the Project Description.

3.2.1 Project alternatives

The Project Description should analyze alternative ways to undertake the project and identify the least environmentally-damaging practical alternative. The following are a few examples of alternatives that a good EIA would consider.

3.2.1.1 Alternative siting of mine facilities

Alternative locations for the mine itself are usually not up for discussion, because the ore deposit exists where it is. However, a mining company may be able to change from an open-pit

extraction method to an underground extraction method, to preserve surface resources. An underground mine might displace fewer human inhabitants and better protect surface waters, groundwater, or ecologically important wildlife habitat.

The alternatives section of an EIA should answer the question: Is the preferred alternative the least environmentally-damaging practical alternative?

The location of key mine facilities can also be discussed. These include the location of ore processing facilities (e.g., beneficiation plants) and the location of waste disposal facilities, including facilities for the disposal of overburden and tailings. The location of these facilities should be chosen to protect public safety and minimize impact on critical resources, such as surface waters, groundwater, or ecologically important wildlife habitat.

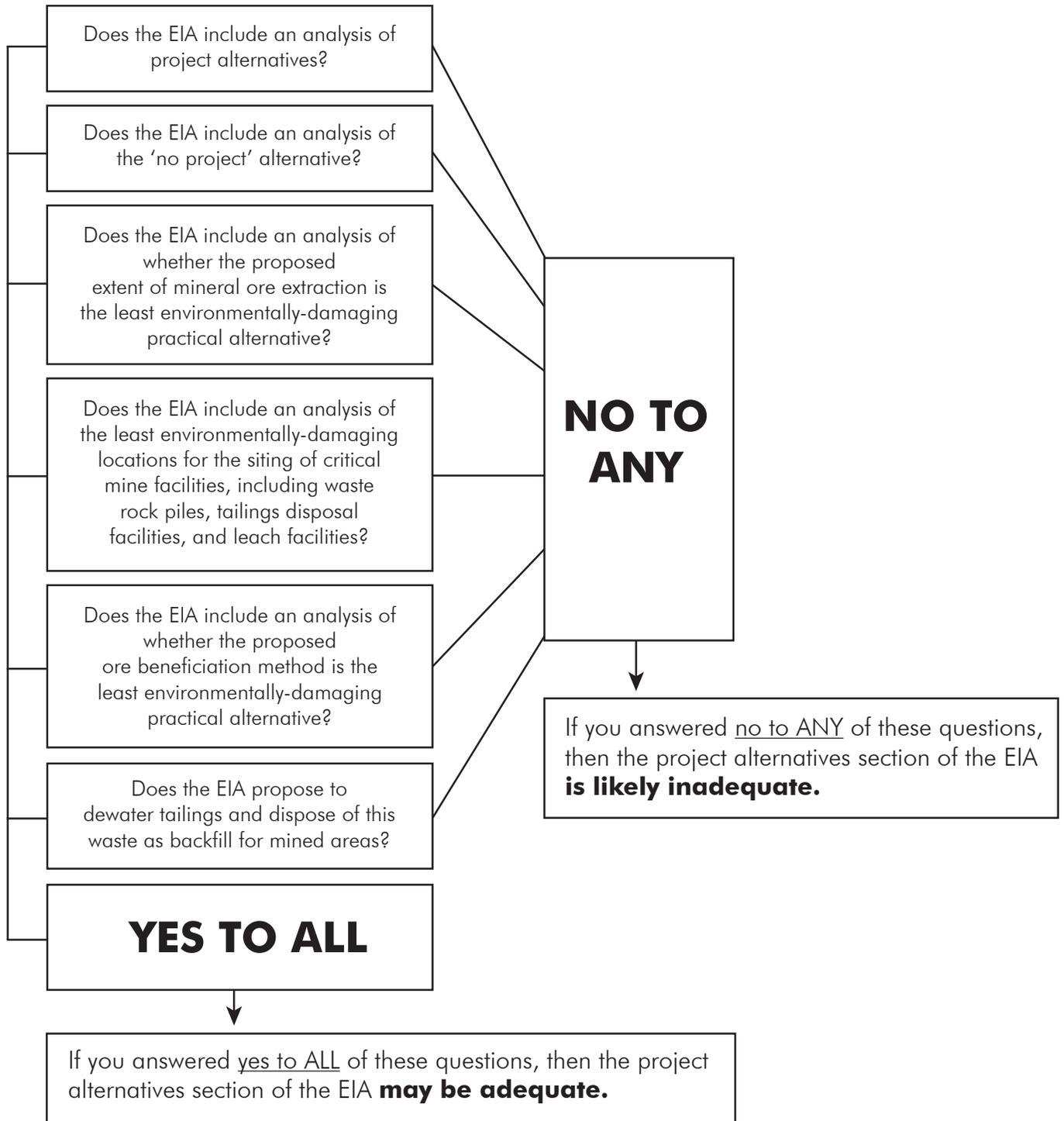
For example, if a wet tailings impoundment facility is the least environmentally-damaging practical alternative for tailings disposal, then its location should be carefully considered. A tailings impoundment should not be located near critical water resources and should be located at a safe distance (called a 'setback' or 'buffer zone') from residences and public buildings.

The alternatives section of an EIA should answer the question: Are mine facilities located in the least environmentally-damaging locations?

3.2.1.2 Alternative ore beneficiation methods

Mining companies often have a choice of 'beneficiation' methods to concentrate the desired metals in the metallic ore they have mined. Some ore beneficiation methods have less serious impacts than others. For example, gravity concentration of gold ore has less potential to contaminate the environment and threaten public

FLOWCHART 3.1 - Project Alternatives



health than cyanide leaching. However, few types of gold ore are amenable to gravity concentration.

The U.S. EPA cites the following as the most common beneficiation methods for specific ore types.

“The most common beneficiation processes include gravity concentration (used only with placer gold deposits); milling and floating (used for base metal ores); leaching (used for tank and heap leaching); dump leaching (used for low-grade copper); and magnetic separation. Typical beneficiation steps include one or more of the following: milling; washing; filtration; sorting; sizing; magnetic separation; pressure oxidation; flotation; leaching; gravity concentration; and agglomeration (pelletizing, sintering, briquetting, or nodulizing).

“Milling extracted ore produces uniform-sized particles, using crushing and grinding processes. As many as three crushing steps may be required to reduce the ore to the desired particle size. Milled ore in the form of a slurry is then pumped to the next beneficiation stage. ...

“Flotation uses a chemical reagent to make one or a group of minerals adhere to air bubbles for collection. Chemical reagents include collectors, frothers, antifoams, activators, and depressants; the type of reagent used depends on the characteristics of a given ore. These flotation agents may contain sulfur dioxide, sulfuric acid, cyanide compounds, cresols, petroleum hydrocarbons, hydrochloric acids, copper compounds, and zinc fume or dust.

“Gravity concentration separates minerals based on differences in their gravity. The size of the particles being separated is important, thus sizes are kept uniform with classifiers (such as screens and hydrocyclones).

“Thickening/filtering removes most of the liquid from both slurried concentrates and mill tailings. Thickened tailings are discharged to

a tailings impoundment; the liquid is usually recycled to a holding pond for reuse at the mill. Chemical flocculants, such as aluminum sulfate, lime, iron, calcium salts, and starches, may be added to increase the efficiency of the thickening process.

“Leaching is the process of extracting a soluble metallic compound from an ore by selectively dissolving it in a solvent such as water, sulfuric or hydrochloric acid, or cyanide solution. The desired metal is then removed from the “pregnant” leach solution by chemical precipitation or another chemical or electrochemical process. Leaching methods include “dump,” heap,” and “tank” operations. Heap leaching is widely used in the gold industry, and dump leaching in the copper industry.

“Beneficiation of copper consists of crushing and grinding; washing; filtration; sorting and sizing; gravity concentration; flotation; roasting; autoclaving; chlorination; dump and in situ leaching; ion exchange; solvent extraction; electrowinning; and precipitation. The methods selected vary according to ore characteristics and economic factors; approximately half of copper beneficiation occurs through dump leaching, while a combination of solvent extraction/froth flotation/electrowinning is generally used for the other half. Often, more than one metal is the target of beneficiation activities (silver, for example, is often recovered with copper).

“Copper is increasingly recovered by solution methods, including dump and in situ leaching. Because most copper ores are insoluble in water, chemical reactions are required to convert copper into a water-soluble form; copper is recovered from a leaching solution through precipitation or by solvent extraction/electrowinning (SX/EW). Solution beneficiation methods account for approximately 30 percent of domestic copper production; two-thirds of all domestic copper mines use some form of solution operations. Typical leaching agents used in solution beneficiation are hydrochloric

and sulfuric acids. Microbial (or bacterial) leaching is used for low-grade sulfide ores, however this type of leaching is much slower than standard acid leaching and its use is still being piloted. ...

“Beneficiation of lead and zinc ores includes crushing and grinding; filtration; sizing; flotation; and sintering of concentrates. Flotation is the most common method for concentrating lead-zinc minerals.

“Three principal techniques are used to process gold and silver ore: cyanide leaching, flotation of base metal ores followed by smelting, and gravity concentration. ... Gravity concentration is used primarily by gold and silver placer operations.

“Cyanide leaching is a relatively inexpensive method of treating gold ores and is the chief method in use. In this technique, sodium or potassium cyanide solution is either applied directly to ore on open heaps or is mixed with a fine ore slurry in tanks; heap leaching is generally used to recover gold from low-grade ore, while tank leaching is used for higher grade ore.”¹⁵

The EIA should demonstrate that the beneficiation method preferred by the mining company is the least environmentally-damaging practical alternative.

3.2.1.3 Alternative methods of tailings disposal

Mine tailings are a high-volume waste that often contain toxic substances in high concentrations. There are three main alternatives for the disposal of tailings: (1) use of a wet tailings impoundment facility or ‘tailings pond’; (2) dewatering and disposal of dry tailings as paste backfill or ‘dry tailings disposal’; and (3) the release of tailings

into the deep sea via a long pipeline or ‘submarine tailings disposal.’

Of these alternatives, the clear choice for the environment is dry tailings disposal. Even mining industry representatives understand the advantages of dry tailings disposal. It may cost more in the short-term, but it has long-term cost advantages.



*Dry tailings disposal method, La Coipa mine, Chile
PHOTO: Tailings.info*

The following is an explanation of the environmental and cost-advantages of dry tailings disposal, by Rens B.M. Verburg, a scientist with a U.S. mining industry consultant, Golder Associates:

“In recent years, use of paste fill has evolved from an experimental backfill method with limited application to a technically viable and economically attractive alternative. This is primarily due to the development of dewatering and transportation systems that allow for controlled and consistent production and delivery of paste in a cost-effective manner. In addition, it has been recognized that underground backfill provides for a mechanism to safely dispose of mine wastes such as tailings, which results in cost savings and reduced immediate and long-term liability. Minimizing this liability through a reduction in surface disposal will have a beneficial effect on the feasibility of any mining venture.

“In addition to the use of paste for underground backfill, the improvements in

¹⁵ United States Environmental Protection Agency (1995) “Office of Compliance Sector Notebook Project: Profile of the Metal Mining Industry.” <http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/metminsn.pdf>

dewatering and transport technology have generated industry interest in so-called “dry” disposal of tailings as a paste. This interest is further stimulated by increased regulatory pressure on hydraulic structures (dams) and other aspects (e.g., liners) of the more traditional subaerial tailings management methods. The public perception of tailings impoundments as being generally unsafe structures is another driving force behind the current revival of alternative tailings management concepts. ...

“Of all potential advantages associated with disposal of tailings in paste form, the environmental benefits are among the most promising. In particular as regulatory and societal demands on the mining industry continue to increase, use of paste technology may provide an avenue for minimizing or even eliminating various environmental issues.

“The environmental benefits of surface disposal of paste can be divided into two main categories; those that stem from the physical and chemical characteristics of paste itself, and those that are more operational in nature.

“... First, very little free water is available for generation of a leachate, thereby reducing potential impacts on receiving waters and biological receptors. In addition, the permeability of a poorly sorted, run-of-mill paste is significantly lower than that of classified, well-sorted tailings. In a surface scenario, this limits infiltration of rainfall and snowmelt, which also results in a reduction of the seepage volume. When placed underground, the paste may represent a hydraulic barrier to groundwater flow, thereby limiting generation of a potentially onerous leachate. Furthermore, the saturated conditions within the paste minimize the ingress of oxygen, thereby reducing the potential for generation of acid rock drainage. Second, the paste production technology allows for production of an engineered material by modifying the paste geochemistry in such a manner that environmental benefits result. For

instance, addition of Portland cement has been shown to be very effective in reducing metals mobility. In addition, acid generation in the tailings can be markedly curtailed by mixing with alkaline materials. Third, co-disposal of other waste materials with paste is made feasible by the paste production technology. In particular, encapsulation of acid generating waste rock in appropriately designed paste may provide significant benefits in terms of environmental control and waste management.

“There are additional, operational aspects of surface disposal of paste that benefit the mine owner and the environment. The placement of pastes on the surface allows for increased flexibility in both facility siting and disposal strategy. The absence of a pond affords the use of management strategies that are much less restrictive, thereby opening the way for siting and disposal options that are least detrimental to the environment. In addition, the footprint of a paste facility will generally be smaller than that of an impoundment designed for an equivalent amount of tailings. A second operational benefit results from the improved recovery of water. In particular in arid regions, the reduced water use may represent an important economic incentive. A third benefit stems from the potential for concurrent reclamation and creation of a true “walk-away” facility at closure. As reclamation strategies can be incorporated into the placement options, land disturbance can be minimized during operation. This results in a reduction of visual impacts and operational hazards (e.g., dust generation). In addition, unnecessary loss of pre-mining land uses (agriculture, timber, wildlife habitat, etc.) can be prevented.”¹⁶

If the EIA does not propose dry tailings disposal, which is almost always the environmentally-preferable alternative, then the EIA must clearly demonstrate that dry tailings disposal is not

16 Verburg, R.B.M (2001) “Use of Paste Technology for Tailings Disposal: Potential Environmental Benefits and Requirements for Geochemical Characterization.” IMWA Symposium 2001. <http://www.imwa.info/docs/BeloHorizonte/UseofPaste.pdf>

feasible in the specific instance and, if feasible, that a wet tailings impoundment has clear, site-specific environmental advantages over dry tailings disposal.

The third alternative for disposal of mine tailings is sub-marine tailings disposal. This is only possible when mines are located near deep sea environments. Sub-marine tailings disposal is illegal in several jurisdictions and has a poor environmental record. The IFC/World Bank Group explains:

“Deep sea tailings placement (DSTP) may be considered as an alternative only in the absence of an environmentally and socially sound land-based alternative and based on an independent scientific impact assessment. If and when DSTP is considered, such consideration should be based on detailed feasibility and environmental and social impact assessment of all tailings management alternatives, and only if the impact assessment demonstrates that the discharge is not likely to have significant adverse effects on marine and coastal resources, or on local communities.”¹⁷

If an EIA proposes sub-marine tailings disposal, then the EIA must explain why this alternative should be considered when it has been prohibited

in many jurisdictions and caused significant environmental damage in places where it has been practiced.

3.2.1.4 The no-action alternative

An EIA is not complete without a comparative analysis of the environmental and social impacts of the ‘no-action’ alternative (a future in which the proposed project does not take place). The laws and regulations of many countries explicitly require that an EIA contain a separate assessment of the ‘no-action’ alternative.

An assessment of the environmental and social impacts of a future, in which the proposed mining project does not take place, is important to understanding what benefits might be lost if the project does not move forward.

For example, if a proposed mining project would be located in a tropical forest with high-biodiversity, and the project does not take place, then tourism to the area may greatly expand, providing employment and income to local communities. These benefits may only come to light if the EIA assesses the environmental and social impacts of the ‘no-action’ alternative.

¹⁷ IFC/World Bank (December 2007) “Environmental, Health and Safety Guidelines for Mining.” [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

3.3 EVALUATING THE ENVIRONMENTAL BASELINE

The section of an EIA that details existing conditions (often called the 'environmental baseline') demonstrates whether the project proponent truly understands the environmental and social conditions that the proposed mining project may disturb. For example, if the EIA does not include details about existing surface water quality, air quality, and the abundance and distribution of threatened and endangered species, then it simply is not possible for the project proponent to formulate accurate predictions about how the project would impact water quality, air quality, and threatened and endangered species.

The section of an EIA that describes the environmental baseline may often contain misleading information. For example, it is in the interest of the project proponents to describe environmental conditions as already degraded or impaired, or to minimize the extent to which local communities inhabit and make use of the project area.

If the environmental baseline contains claims that the environment is degraded or uninhabited, then those claims should be questioned and evidence to the contrary provided.

The following is a more detailed discussion of the specific kinds of environmental baseline data that an EIA for a proposed mining project needs to contain, and how to evaluate whether the information provided adequately characterizes baseline conditions.

3.3.1 Characterization of mined materials

The environmental baseline should begin with a detailed characterization of the geological environment, including the metallic mineral ore reserve and materials comprising the overburden. These materials must be managed properly because they give rise to the high-volume waste

that a mining project generates. Mined materials must be carefully characterized for concentrations of toxic substances and the potential to become acidic at any future time (creating the potential for acid mine drainage).

3.3.1.1 Mineralogy and whole rock analysis

Maest et al. (2005) provide the following guidance about the kind of geochemical analysis a mining project proponent must include to predict possible water quality impacts, including the release of contaminants and acid drainage:

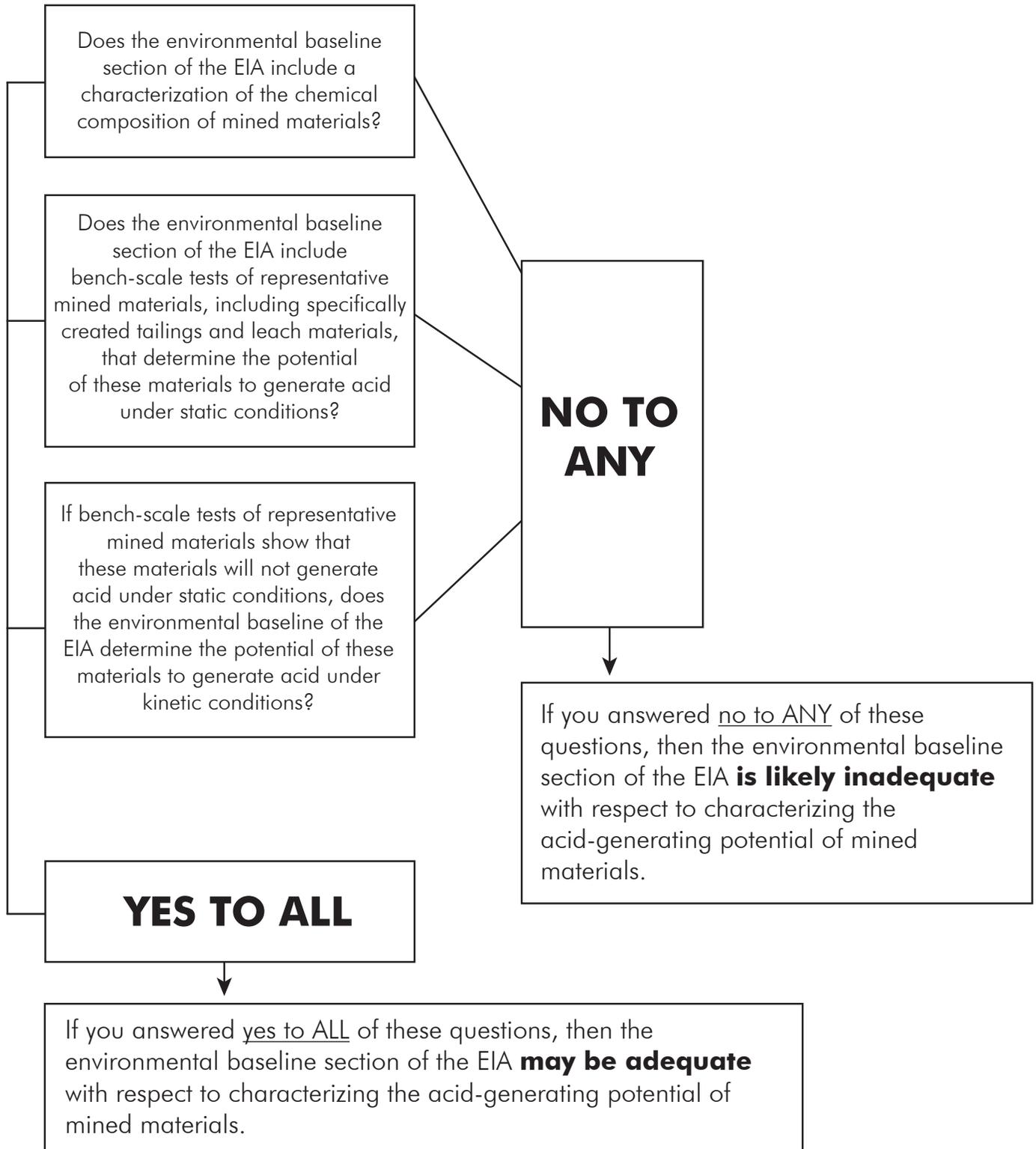
"The first step in characterizing mined materials is to determine the geology and mineralogy of the rocks at the mine site. Such analyses include the determination of rock type, alteration, primary and secondary mineralogy, the availability of acid-producing and - neutralizing and metal-leaching minerals (liberation, e.g., veins, disseminated, encapsulated, etc.), and the locations and dimensions of oxidized and unoxidized zones for all waste types, pit walls, and underground workings. ...

"The next step in the geochemical characterization of mined materials is defining the geochemical test units. Geochemical test units are rock types of distinctive [physical and chemical characteristics]...

"Depending on the results of the characterization, some of the test units may be grouped together in the mine waste management plan. Alternatively, if an initial unit designation provides a wide range of test outcomes, it may be necessary to subdivide the unit for waste management purposes...

"The third step in characterizing mined materials is to estimate the volumes of each type of material to be generated and the

FLOWCHART 3.2 - Evaluating the adequacy of the evaluation of acid-generating and contaminant leaching potential of mined materials



distribution of types of material in waste, pit, and underground workings... The information on geochemical test units should be coordinated with the mine waste management plan.

"The fourth step in characterization is conducting bench-scale testing of the ore, which involves creating tailings and/or heap leach materials in a laboratory... The general categories of geochemical testing that will be performed on the geochemical test units are whole rock analysis, static testing, short-term leach testing, and kinetic testing."¹⁸

3.3.1.2 Acid generation potential - static and kinetic testing of mined materials

To determine the acid generation potential of mined materials and mine project wastes, an EIA should include the following test results:

Static testing

"Static testing [should be] performed on potential sources of acid drainage, including waste rock, pit wall rock, underground working wall rock, tailings, ore, leached heap materials, and stockpile materials. The number of samples for each unit will be defined by the volume of material to be generated. For acid-generation potential (AGP), the modified Sobek method using total sulfur is recommended. The mineralogy and composition of the sulfides should be confirmed using mineralogic analysis."

Kinetic testing

"The objectives of kinetic testing should be clearly defined. Kinetic testing should be conducted on a representative number of samples from each geochemical test unit. Special emphasis should be placed on kinetic testing of samples that have an uncertain ability to generate acid. Column tests are

recommended over humidity cell tests for all aerially exposed mined materials, including natural on-site construction materials, with the exception of tailings. However, either type of kinetic test can be useful depending on the objectives of the testing and if the available surface areas for reaction are determined in advance of the testing."¹⁹

3.3.1.3 Contaminant leaching potential short- and long-term leach tests

Scientists recommend the following analyses to determine the potential of mined materials and mine project wastes to release toxic substances:

"Results from short-term leach tests can be used to estimate the concentrations of constituents of concern after a short event (e.g., a storm event) but are not appropriate to use for estimation of long-term leaching. Standard short-term leach tests with a lower liquid:solid ratio can be conducted on samples from each geochemical test unit. However, using first flush results from longer-term kinetic testing will help coordinate the short-term and longer-term weathering results and will allow the determination of weathering on a per mass basis. The leachate samples should be analyzed for constituents of concern (based on whole rock analysis and known contaminants of concern) using detection limits that are at least ten times lower than relevant water quality standards (e.g., for arsenic, which has a drinking water standard of 10 µg/L, the detection limit should be 1 µg/L or lower). Major cations and anions should also be determined on the leachate samples, and the cation/anion balance should be checked for each sample."²⁰

3.3.1.4 Identification of contaminants of concern

The section of an EIA that characterizes the mined materials should include quantitative predictions of the concentrations of contaminants of concern

18 Maest, A.S., et al. (2005) "Predicting Water Quality at Hardrock Mines: Methods and Models, Uncertainties, and State-of-the-Art. http://www.swrcb.ca.gov/academy/courses/acid/supporting_material/predictwaterqualityhardrockmines1.pdf

19 Ibid.
20 Ibid.

(e.g., arsenic, lead, cadmium, nickel, chromium, and mercury). These would be found in polluted water that a mining project may, at any future point in time, release into the environment. These quantitative predictions should then be used to anticipate potential changes in groundwater and surface water quality.

3.3.2 Characterization of existing climate

Rainfall is a major concern at mine sites. In fact, rainfall can determine the environmental acceptability of a proposed mining project. In the tropics, high rainfall generates large quantities of runoff. In contrast, mines in arid areas need only cope with small quantities of runoff. Mining projects in many tropical areas are fraught with environmental risk. These projects not only threaten pristine ecosystems, but high rainfall and heavy storms overwhelm mining facilities and mitigation measures for preventing environmental disasters. An especially rainy climate can, by itself, deem a proposed mining project environmentally unacceptable.

The following should be included in the description of the existing climate at the proposed mine site:

“Rainfall patterns including magnitude and seasonal variability of rainfall must be considered. Extremes of climate (droughts, floods, cyclones, etc.) should also be discussed with particular reference to water management at the proposal site.”²¹

“Climatic conditions (precipitation, evaporation, climate type, seasonal/long-term climatic variability, dominant wind directions, typical storm events, temperature) for locations at or close to mine.”²²

21 Queensland Environmental Protection Agency (2001) “Generic Terms of Reference for Environmental Impact Statements for Non-Standard Mining Projects.” <http://www.derm.qld.gov.au/register/p00443aa.pdf>

22 Maest, A.S., et al. (2005) “Predicting Water Quality at Hardrock Mines: Methods and Models, Uncertainties, and State-of-the-Art.” http://www.swrcb.ca.gov/academy/courses/acid/supporting_material/predictwaterqualityhardrockmines1.pdf

3.3.3 Characterization of existing seismic conditions

If a mining project involves a wet tailings impoundment, the EIA must adequately characterize existing seismic conditions, including the risk of a major earthquake which could damage mine facilities and cause catastrophic consequences, such as a tailings dam failure. The U.S. EPA recommends the following analysis:

“The design of tailings impoundments usually has to consider potential seismic activity at the site. This requires the selection of a design earthquake for the site in question. A method commonly used to determine the effects of the design earthquake on a particular site is to assume that the earthquake occurs on the closest known possibly active fault. The fault is selected on the basis of the geological studies previously conducted in the area. Attenuation tables are then used to estimate the magnitude of the earthquake forces reaching the site as a result of the design earthquake occurring on the selected fault.”²³

The EIA should include a description of the design earthquake for the mine site and assess its potential impact on mine facilities, including the wet tailings impoundment (if one is proposed). The description of the design earthquake should be based on the most complete and recent seismic data.

The IFC/World Bank Group explains that:

- *“Where structures are located in areas where there is 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 the design is such that during seismic events there will be no uncontrolled release of tailings;*

23 United States Environmental Protection Agency (1994) “Technical Report: Design and Evaluation of Tailings Dams.” <http://www.epa.gov/epawaste/nonhaz/industrial/special/mining/techdocs/tailings.pdf>

- *Design of tailings storage facilities should take into account the specific risks/ 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;*
- *Where potential liquefaction risks exist, including risks associated with seismic behavior, the design specification should take into consideration the maximum design earthquake;"²⁴*

3.3.4 Characterization of existing surface water quality

Characterizing existing surface water quality provides detailed information on the location, distribution, quantity, and quality of all water resources that could be affected by a project and its alternatives. The data and analysis should have a reasonable level of detail, to help understand the conditions of the environmentally-significant geographic areas.

Baseline studies about water quality should consider the local and regional uses of water (domestic, industrial, urban, agricultural, recreational, others) and assess water quality as part of the ecosystem (in relation to the life of plant and animal communities). Water quality studies should be compared to water standards and other legal guidelines for each water use. Quantity must reflect several aspects such as watershed distribution, hydrological processes, and the availability for different water uses at local and regional levels.

The characterization of existing surface water quality should address:

- Hydrology: Description and location of the physical, chemical, biological, and hydrological characteristics of all surface water resources in the project area and in the area of influence (including seasonal variations). Maps, location, and characterization of river basins, lakes, and streams. Identification of existing water pollution sources; location, volume flows, minimum flows.
- Identification of wetland areas, flood zones, minimum flow rates, speed, direction.
- Applicable water quality standards.
- Common water quality parameters: Physical, chemical: pH, turbidity, suspended solids, temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Solids, salinity, conductivity. Common contaminants of concern include ammonia, arsenic, cadmium, copper, chromium, cyanide, iron, lead, manganese, mercury, molybdenum, nickel, nitrate/nitrite, sulfate, thallium, uranium, vanadium, and zinc. When baseline water quality (surface water or groundwater) samples are collected, they should be analyzed for the full suite of parameters and contaminants of concern listed above, and any others that are known to be common in the area or specific to the proposed extraction and beneficiation methods.
- Relevant information of the relationship between input and output of water in the project location; environmental scientists and hydrologists call this 'water budget and balance.' This allows people to know whether or not there are periods when there is plenty of water available and when there is not enough, and why. This information is important for water quality

²⁴ IFC/World Bank (December 2007) "Environmental, Health and Safety Guidelines for Mining." [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

because it can let people know if there are times of the year when the concentration of water pollutants would be higher.

Surface water quality data should be supported by methodological and analytical data. In other words, an EIA must include a clear description of water sampling methods, and the number and exact location of sampling points. These should be representative of the area of influence of a project and of all the surface water resources that would be affected by a project. Also, water quality data should include the results of laboratory analysis. Frequently, this information in an EIA is presented in tables and figures and the laboratory reports are included as annexes.

As mentioned, surface water quality data must be compared to existing water quality standards, according to the uses categorized in national laws or international guidelines.

3.3.5 Characterization of existing surface and groundwater quantity

Groundwater resources are very complex systems. Depending on the area, groundwater can be located at low depth with strong interaction with surface waters, or deep with much less or no interaction with surface water. Groundwater can also have different uses, such as agricultural, human consumption, and industrial.

An EIA should include the following basic information about groundwater resources:

- Depth to groundwater under different seasonal conditions
- Geology and locations of aquifers, thicknesses, and their hydraulic conductivity ranges
- Groundwater flow directions
- Locations/flows of springs and seeps
- Groundwater discharge locations in streams
- Groundwater uses

3.3.6 Characterization of existing air quality

Air quality conditions in a project area are critical to evaluating the potential distribution of air pollutants and their effects in the area of influence. Air pollutants can travel long distances, so baseline air quality information should be considered in relation to meteorological conditions, wind patterns, geological formations, and anything else that might influence the distribution of air pollutants.

Baseline air quality data should:

- Identify air basin
- Describe local climate and topography
- Identify national and local air quality standards
- Describe historical air quality trends
- Describe air quality of the proposed mining area and/or air basin
- Identify sensitive receptors
- Describe the exact location of air monitoring and/or sampling stations

Baseline air quality analyses should include measurements of these common parameters:

- Particulate matter (PM10 and PM2.5)
- Carbon monoxide (CO)
- Nitrogen oxides (NOx)
- Lead (Pb), cadmium (Cd), arsenic (As), mercury (Hg)
- Total Suspended Solids (TSS)
- Sulfur dioxide (SO₂)

Baseline air quality information should be supported by methodological and analytical data. In other words, the EIA must include a clear

description of the air sampling methods, and number and exact location of sampling points. These should be representative of the project's area of influence. Frequently, this information is included in tables and figures and the laboratory reports are included as annexes. Results of air water quality data must be compared to existing air quality standards or international guidelines.

3.3.7 Characterization of existing soil quality

Soil is defined as the top layer of the land surface of the Earth and is composed of small rock particles, humus (organic matter), water, and air. Soil is a major factor affecting plants, including agricultural crops and plants that provide the food and habitats for animals. Avoiding major impacts on soil can prevent the degradation of a whole ecosystem.

Soil baseline studies are based on three major sources of information: desk study, fieldwork, and laboratory analysis. Baseline studies should include soil survey maps, tables documenting the levels of chemical components, methods of analyses, literature review, soil sampling, and the results of laboratory analysis. Maps should be accompanied by explanatory information, with information on local geology, vegetation, and land use.

Soil sampling information should comprise a reasonable number of sampling points representative of the mining concession area. Samples must include each horizon encountered in soil profiles. The maximum depth to which a soil profile is dug is usually one meter. In general, samples are taken systematically using a sampling grid, but random sampling or sampling particular areas of interest may be appropriate. The layout and number of samples required can vary, but the number of samples should be representative of the project area.

Laboratory analysis should provide information about soil composition, soil strength (resistance to crushing), mineral content, and pH. Some

measure of water content, organic content, soil texture, particle size, and bulk density should also be included. Soil chemistry is important in mining projects because problems with naturally occurring toxic elements are a real possibility. Baseline soil quality analyses should include measurements of these common parameters:

- pH
- Cation exchange capacity (the total number of cations absorbed on soil colloids gives some indication of potential fertility)
- Soil nutrient status: potassium, calcium, magnesium, nitrogen, and phosphorus
- Heavy metals: lead, copper, zinc, cadmium, mercury, and chromium

3.3.8 Characterization of wildlife

Wildlife comprises all living things that are undomesticated. This includes plants, animals (vertebrates, birds, fish), and other organisms (invertebrates). Baseline information about wildlife must include a list of wildlife species within the project area and interactions between species. An EIA should include a description of the region, species maps, relationships, population densities, and species distribution. All endemic flora and fauna in the project area that have a special conservation status – for example, listed by the International Union for Conservation of Nature (IUCN) or by national legislation as a threatened or endangered species – should be surveyed for their distribution and abundance in the project area.

3.3.8.1 Characterization of terrestrial species

Plants are one of the most important indicators of environmental conditions because they reflect the overall state of life conditions in an area and the state of all other species in an ecosystem. Plants are relatively easy to identify and map through fieldwork and remote sensing. An inventory

of plant species should include information about: composition, density, distribution, status, vegetative cover, and dominant, protected, foreign, threatened, and vulnerable species, as well as noticeable effects of human presence in the ecosystem. Some areas have endemic and rare plant species that are of special interest.

Inventories of fauna species are more difficult to obtain, but should include: diversity, distribution, and density, including information about the presence of endemic, protected, threatened, and endangered species. The EIA should discuss biomes, indicator species, and relevant interrelations between communities of species. Depending on the project, other relevant baseline information about migration routes, breeding grounds, nesting sites, wildlife corridors, and uniqueness of fauna habitat should be discussed.

3.3.8.2 Characterization of aquatic species

Aquatic environments include not only fish and amphibians, but also aquatic plants, and invertebrates (snails, bivalves, crustaceans, insects, worms). Information on aquatic species should include details on the abundance and distribution of endemic, protected, and endangered species; detailed data on the abundance and distribution of fisheries of commercial importance or relied on for sustenance; and impact on migratory aquatic species (such as fish) and breeding grounds.

3.3.8.3 Characterization of habitats critical to ecological processes

At the level of a landscape or region, certain natural habitats are especially important for ecological functioning or species diversity in an ecosystem. Unusual climate or edaphic (soil based) conditions may create local biodiversity hotspots or disproportionately support ecological processes such as hydrologic patterns, nutrient cycling, and structural complexity. For these reasons, preservation of specific habitats (usually the remaining natural areas within the landscape) should be a priority.

Within a landscape, certain habitats are vital for ecosystem functioning. In general, these are the remaining natural areas, especially those that integrate the flows of water, nutrients, energy, and biota through the watershed or region. This concept is analogous to that of 'keystone species' that are essential for a community structure. Forests, rangelands, and aquatic ecosystems all have unique or critical habitats that support the provision of ecosystem services within the landscape.

Around the world, identifying critical or endangered ecosystems has become more important. An EIA for a large-scale metal mining project must consider and be consistent with national and international classifications of endangered ecosystems. An EIA should include consultations with state natural heritage programs for a more detailed assessment of flora and fauna of special concern.

3.3.9 Local socio-economic baseline

The socio-economic environment is defined as all activities, and social and economic processes, that could be influenced directly or indirectly by the mining project. In most cases, there is a defined socio-economic environment that will be affected. The community impact assessment is of particular importance. The range of topics (scope) and level of detail can be highly variable.

The section of an EIA that includes the socio-economic baseline data should explain how the scope of the analysis was defined and how the study area was delineated. The section should include information about:

- Location of the local population in relation to the proposed project area
- Population size, age composition, growth
- Economic activities, employment, income (inventory of present economic environment without the project)
- Quality of life
- Housing quality and quantity (this is particularly important if people are to be relocated)
- Community organizations, representative institutions, neighborhood cohesion (usually measured with surveys and interviews)
- Public safety (police, fire)
- Education (average level, access, public and/or private)
- Health services
- Recreation (public, private)
- Existence of local development or well-being plans
- Access to public services and sanitation
- Maps with location and quantity of farmlands
- Maps with existing land-use patterns
- Attitudes towards the project

3.4. EVALUATING POTENTIAL AND PREDICTED ENVIRONMENTAL IMPACTS

3.4.1 How to understand and evaluate environmental impact matrices

There are several methods for identifying environmental effects and impacts. Some of the most common are:

- Checklists
- Matrices
- Flow diagrams
- Batelle environmental evaluation systems

Checklists

Checklists are based on a list of special biophysical, social, and economic factors that may be affected by a project. Checklists are easy to use and found in nearly all EIAs. Checklists do not usually include direct cause-effect links to project activities.

Sample checklist for a large-scale mining project:

Sources of Potential Environmental Impacts	
Project Phase	Activity
Construction	Road construction for mineral transportation and access to waste sites
	Preparation of area for the solid waste deposit. Storage of the production plant and leach waste deposit
	Construction of deviation channels
	Construction of the foundations for the production plant
	Preparation of area for heap leach

Sources of Potential Environmental Impacts	
Project Phase	Activity
Construction	Top soil removal and storage
	Preparation of area for domestic wastes disposal
	Preparation of area for domestic waste water treatment facility
	Installation of campsites, offices, workshops, storage facilities.
	Preparation of open pit area
Operation	Exploitation of open pits
	Transportation of mineral to the leach pad
	Expansion and elevation of the leach pad
	Mineral leaching
	Transportation and disposal of materials in waste sites
	Reception and storage of mineral in the production plant
	Management of solutions at the production plant
	Storage of ground mineral at the production plant
	Process of mineral recovery at the production plant
	Waste disposal from the production plant
	Management of industrial and domestic waste water
	Management of hazardous materials
	Closure and post-closure
Closure of solid waste piles	
Closure of heap leach pads	
Backfill waste dump sites	
Closure of storage sites	
Closure of water and electricity sources	
Land reclamation	
Restoration of internal roads	
Revegetation	

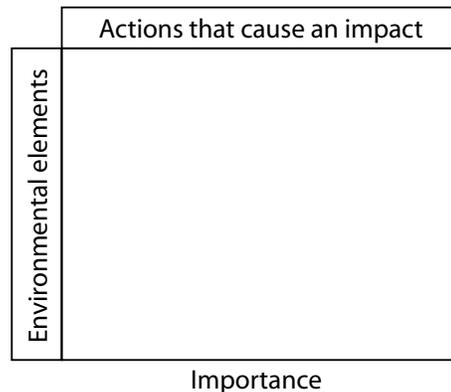
Matrices

A matrix is a grid-like table for identifying the interaction between project activities (displayed on one axis) and environmental characteristics (displayed on the other axis). Environment-activity interactions can be noted in the appropriate cells or intersecting points in the grid. Matrices organize and quantify the interactions between human activities and resources of concern. Once numerical data is obtained, matrices combine values for the magnitude and significance or importance in individual cells to evaluate multiple actions on individual resources, ecosystems, and human communities.

Matrices have values for “magnitude” and “significance.” Magnitude refers to the extension or scale while significance is related to the importance of potential consequences of a previewed impact. Commonly, matrices represent magnitude and significance on a scale of 1-10, with 10 representing the highest value.

Simple interactive matrix (Leopold interaction matrix)

A series of matrices at each stage of a project can be an effective way of presenting information. Each matrix can be used to compare options rated against select criteria. The greatest drawback of matrices is that they can only effectively illustrate primary impacts. Sometimes an EIA complements matrices with tables, checklists, or network diagrams to illustrate higher-order impacts and to indicate how impacts are inter-related.



Sample of a simple interaction matrix:

Regional Characteristics \ Activities		General Alterations														Infrastructures					
		Flora	Fauna	Hydrological Structure	Drainage	River Flows	Land Parcelling	Joint Property	Deforestation	Arborization	Urbanization	Civil Construction	Flying Field	Marine	Highways	River Bed	Canals	Sewer	Electric Net	Via Access	
Land	Soil				4/3				2/4											3/1	
	Relief				3/3				2/4											3/1	
Water	Sea	Surface																8/3			
		Quality							2/4									8/3			
		Temperature																8/8			
	River	Waterfall																		3/1	
		Waterflow				3/1														3/1	4/1
		Spring																	5/1		
		Quality								3/1								8/1			
Air	Quality								4/5								8/8				
	Pluviality								4/5												
	Temperature								3/5												
	Humidity								4/5												

Pan American Center for Sanitary Engineering and Environmental Sciences [CEPIS] (1981) “Environmental impact assessment methodologies description and analysis and first approach to environmental impact assessment methodologies application.” <http://www.cepis.ops-oms.org/bvsair/e/repindex/rep151/environ/environ.html>

Another example of a simple matrix of interactions of activities and environmental effects:

Environmental Effects Development	Social Environment	Physical Environment	Biological Environment
	Treatment	Recreation Landscape/Visual Historical/Cultural Personal/Social Values Risks and Anxieties Existing Land Uses Land Value Settlement Employment Public Participation	Landform Nuisance (noise, dust, smell) Climate/Atmosphere Foundation Materials Agricultural Soil Ground Water Surface Water Sedimentation Erosion/Land Stability River Regime
Sedimentation Millscreening Circulation Ponds Activated Sludge Trickling Fiber Nutrient Removal Chlorination Further Treatment Offsite			
Disposal - Land			
Rapid Infiltration Surface Flooding Spray Irrigation			
Disposal - Inland Water			
River Lake			
Disposal - Marine Water			
Estuary Inland Marine Offshore Marine Deep Well Injection			

EIA e-Course Module, U.N. University, United Nations Environmental Programme (UNEP)
http://eia.unu.edu/wiki/index.php/Assessment_Matrix

3.4.2 Impacts on water quality and quantity

The section of the EIA that assesses the predicted impacts of a mining project on water quality should be quantitative, not just qualitative. That means the EIA should predict how much the surface and groundwater baseline levels would change as a result of contaminants from the mine. Numerous computer models and tools exist to provide these kind of quantitative analyses. The following are general steps to predicting water-quality:

“The prediction of water-quality in a mine facility and in downgradient groundwater and

surface water involves the following general steps. Depending on the modeling objectives, not all steps may be required:

“1. Develop site-specific conceptual model: Develop a conceptual model for prediction of water quality from the mine unit of interest. Identify all significant processes and pathways that could influence water quality. Also determine the end point of modeling (e.g., composition of pore fluid in tailings impoundment vs. concentrations of constituents at a receptor). The modeling end point will determine which of the following steps need to be implemented.

"2. Characterize hydrogeologic and chemical conditions:

"3. Determine mass fluxes into the facility: Determine water balance for the facility using basic meteorological data and numerical or analytical models. Determine chemical releases to the unit from mined material outside of the facility, using short-term and/or long-term leaching data (depending on objectives) or water quality samples. ...

"4. Determine water quality in the facility: If water quality samples are available, and the modeling endpoint is downgradient of the facility, modeling of water quality in the facility may not be required. If water quality in the facility is a modeling endpoint (e.g., pore water quality for waste rock, tailings, leach dumps; pit or mine water quality for pit lakes and underground workings), use inflowing water chemistry (if relevant), releases from mined material, and water balance information. A mass-balance geochemical code (e.g., PHREEQE) can be used to mix waters and calculate concentrations of constituents, taking precipitation and adsorption into account. Include an uncertainty analysis in the prediction of water quality. Consider physical, chemical, and biological processes that can change the water quality within the facility.

"5. Evaluate mass fluxes out of the facility: Evaluate migration of contaminants from the mine unit. For waste rock, tailings, or dry pits, this could require estimating water and chemical mass fluxes discharging from the bottom or toes of the dump or tailings impoundment, or infiltrating through the floor of the dry pit.

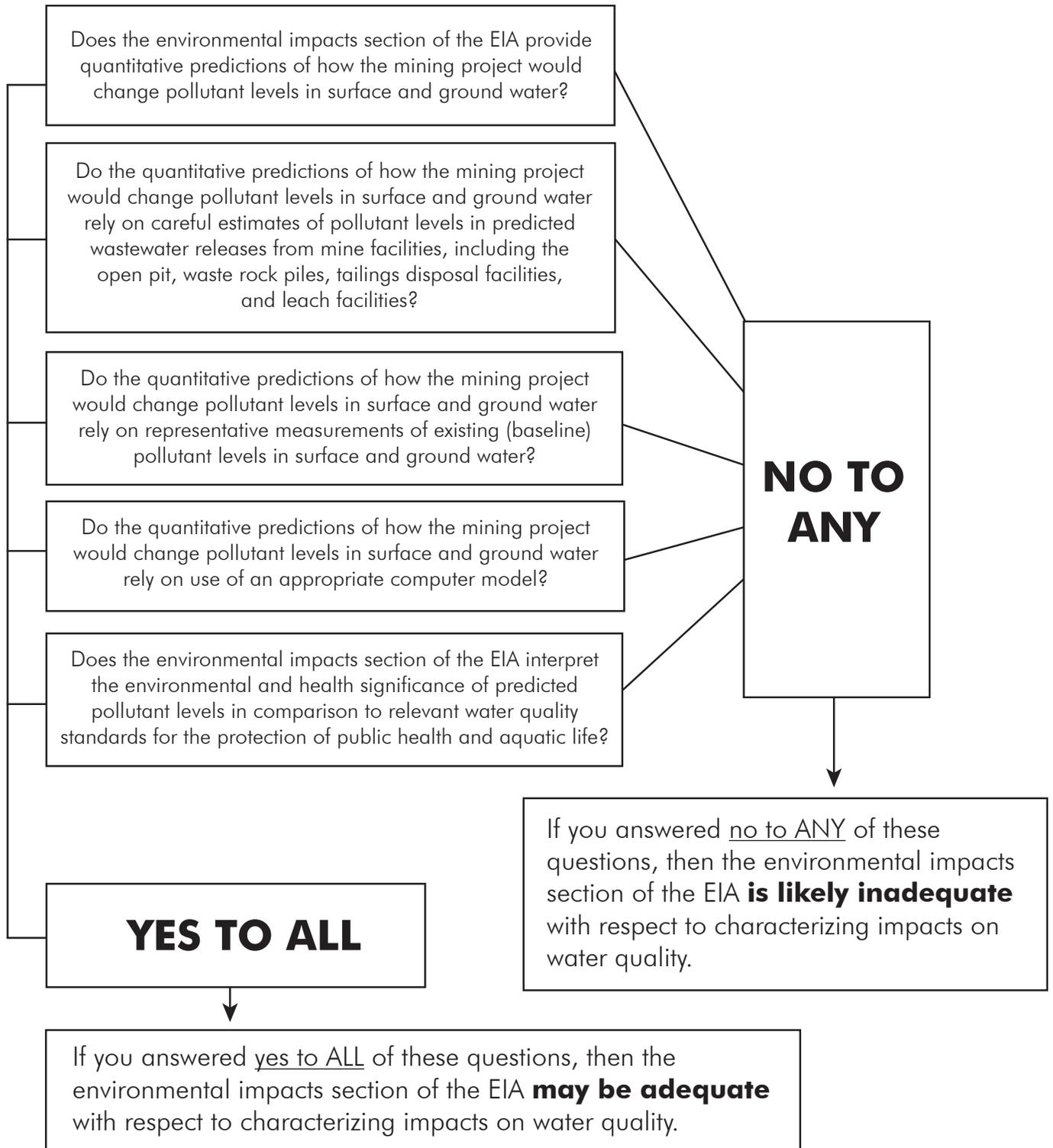
"6. Evaluate migration to environmental receptors: Environmental receptors include groundwater and surface water resources where water will be used by humans or wildlife, or where water quality standards are relevant (e.g., points of compliance).

"7. Evaluate effects of mitigation: Assessing the effects of mitigations on the predicted water quality at downgradient locations may require creating a conceptual model for mitigations. Based on the conceptual model, values for releases of water and constituents from or to the facility can be modified. For example, if a cover will be added to a tailings impoundment at Year 10, the infiltration rates to the impoundment would need to be decreased after Year 10 in the model. Decreasing infiltration rates will affect the flux of constituents leaving the facility and migrating to receptors."²⁵

If an EIA does not use a similar approach to predicting water quality, then it lacks essential information for determining whether the mining project is environmentally acceptable.

25 Maest, A.S., et al. (2005) "Predicting Water Quality at Hardrock Mines: Methods and Models, Uncertainties, and State-of-the-Art. http://www.swrcb.ca.gov/academy/courses/acid/supporting_material/predictwaterqualityhardrockmines1.pdf

FLOWCHART 3.3 - Evaluating the adequacy of predicted impacts on water quality



3.4.2.1 Water pollutant releases from pit lakes

A mining company should not propose a project that allows for the formation of a pit lake. Open pits should be backfilled, recontoured, and revegetated to create a final surface that is consistent with the original topography of the area. If a mining company does propose the creation of a pit lake, then the following additional considerations are necessary to accurately predict water quality impacts caused by pit lake water contamination:

“For pit lakes, estimate precipitation and evaporation from lake surface, runoff from pit high walls, groundwater flow rate into and out of the pit (if relevant), discharge rate of any surface water entering or leaving the pit. The water balance can be used to predict rate of inundation of pit walls with groundwater.

“Determine chemical releases to the unit from mined material outside of the facility, using short-term and/or long-term leaching data (depending on objectives) or water quality samples. For pits, these releases may be derived from oxidized wall rock, runoff from pit high walls, and possibly waste rock backfill.

Oxidation of sulfide minerals in the walls of underground workings and dry pits may also release metals and acid to the environment.

“For a pit lake or flooded underground workings, the chemical mass flux out of the facility would be the amount of water and quantity of constituents released to groundwater or the vadose zone.

“If considering vadose zone transport to groundwater (mass flux from facility initially enters vadose zone rather than groundwater), use an unsaturated zone flow and transport analytical or numerical code. Downgradient transport of constituents in groundwater can be

evaluated using a groundwater flow and solute transport code, or a reaction path code.”²⁶

3.4.2.2 Water pollutant releases from tailings impoundments

The environmentally-preferable option for the disposal of tailings is dewatering and use as backfill (dry tailings disposal). If an EIA for a mining project calls for the creation of a wet tailings impoundment, then analysis of water quality impacts of tailings impoundments should include the following quantitative predictions:

“Tailings pore water quality; Potential for and quality of seepage from impoundments; Downgradient groundwater quality; Surface water quality (if tailings seepage impacts seeps, springs, streams, lakes).”²⁷

These quantitative predictions should be based on the following inputs:

“Tailings mineralogy (sulfide content); Contaminant release rates from tailings; Dimensions of tailings impoundment; Tailings impoundment water management during mining and postclosure (presence of pool, degree of saturation); Sulfide mineral oxidation rates; Liner specifications (release/zero discharge); Surface water proximity; Distance to water table over time; Infiltration rate through unsaturated zone; Characteristics of vadose zone and aquifer that affect hydraulics and transport; Groundwater transport characteristics, if tailings seepage impacts groundwater; and Surface water characteristics, if tailings seepage discharges to surface water.”²⁸

26 Ibid.
27 Ibid.
28 Ibid.

3.4.2.3 Water pollutant releases from waste rock dumps

The analysis of water quality impacts of waste rock dumps should include the following quantitative predictions:

“Potential for and quality of seepage from waste rock dumps; Downgradient groundwater quality; and Surface water quality (if waste rock seepage impacts seeps, springs, streams, lakes).”²⁹

These quantitative predictions should be based on the following inputs:

*“Waste rock mineralogy (sulfide content); Oxidation rate of sulfides in waste rock; Chemical release rates from waste rock; Quantity and quality of waste rock seepage; Infiltration rates through unsaturated zone; Runoff (amount and chemistry); Dump dimensions; Physical composition of waste rock dump; Mitigations (cover, liners, etc.); Upgradient groundwater quality; Distance to water table over time; Distance to surface water; Characteristics of vadose zone and aquifer that affect hydraulics and transport; Groundwater transport characteristics, if waste rock seepage impacts groundwater; and Surface water characteristics, if waste rock seepage discharges to surface water.”*³⁰

3.4.2.4 Assessing the significance of water quality impacts

After an EIA specifies the numerical extent to which contaminants the mining project may release would elevate the levels of these contaminants in surface and groundwater (when added to baseline levels), the next step is to interpret the environmental and health significance of these quantitative predictions. Focus should be placed on toxic substances that are contaminants of concern (e.g., arsenic, lead, cadmium, nickel, chromium, and mercury) but should include other substances that may have harmful effects (e.g., salinity, pH, total dissolved solids).

29 Ibid.
30 Ibid.

The interpretation of the environmental and health significance of predicted levels of pollutants will require the comparison of these levels to water quality standards. For predicted levels of pollutants in groundwater, the relevant water quality standards for comparison are standards for clean drinking water found in domestic legislation and (especially if domestic clean drinking water standards are lax or absent) the World Health Organization’s Guidelines for Drinking Water Quality.³¹

For predicted levels of pollutants in surface water, the relevant water quality standards for comparison are standards for clean drinking water (for surface waters used for human consumption) and standards for the protection of fish and aquatic life found in domestic legislation and (especially if domestic standards are lax or absent) U.S. EPA recommended water quality criteria.³²

3.4.2.5 Impacts of surface water diversions

Some mining projects propose to alter the course of rivers, streams, and other surface waters. For example, if a river or stream runs above the ore deposit, a mining company may propose diverting the flow via a pipeline or artificial canal, to gain access to the ore deposit during open-pit mining operations.

If a mining project includes a proposal to divert surface water, then the EIA should include a thorough assessment of the impacts. This includes how the proposed diversion would affect the quality and availability of other surface and groundwater resources (a diverted stream might be a source of groundwater replenishment), and the aquatic species that might rely on existing conditions in the stream proposed to be diverted.

31 World Health Organization (2006) “Guidelines for drinking-water quality, third edition, incorporating first and second addenda.” http://www.who.int/water_sanitation_health/dwa/gdwq3rev/en/

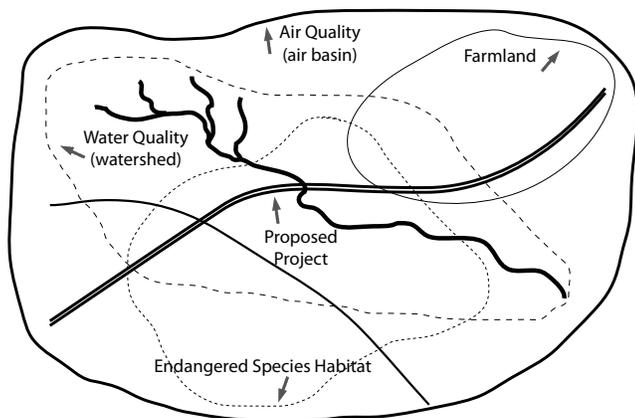
32 United States Environmental Protection Agency (2005) “National Recommended Water Quality Criteria.” <http://www.epa.gov/waterscience/criteria/wqtable/>

3.4.3 Impacts on air quality

Air quality impacts of a mining project are not limited to the mining concession area. Assessing potential impacts requires examining a larger region, including adjacent lands. The following factors must be considered:

- How are the areas of direct and indirect influence of the project defined?
- Does the study include documented data of the magnitude and direction of winds?
- What information is included to support statements about the dispersion of air pollutants?

The figure below shows an example of the extension of an air basin (compared to a watershed), the location of a proposed project, and areas with different use categories. The extension of an air basin could be significantly larger than the proposed project area.



California Department of Transportation (2008) *Guidance for preparers of Cumulative Impact Assessments*. http://www.dot.ca.gov/ser/cumulative_guidance/defining_resource.htm

Air quality affects human health, wildlife (plants and animals), and the water quality in large areas. An EIA for a project that potentially affects air quality should include:

1. Identification (what kind?) and estimated amount of air pollutants that would be produced during all stages of the project.

2. Estimated amount and the effects caused by particulate matter that will be produced during excavations, blasting, transportation, wind erosion (more frequent in open-pit mining), fugitive dust from tailings facilities, stockpiles, waste dumps, haul roads, and infrastructure construction.

3. Identification (what kind?) and estimated amount (how much?) of gases released as emissions from the combustion of fuels in stationary sources (ore processing facilities, main camp, energy generators) and mobile sources (vehicles, equipment, mobile campsites) and blasting.

The following is a list of common potential emission sources:

- Gas exhaust from equipment used in perforation, loading, and transportation of materials
- Gases from explosives used in blasting operations
- Dust from excavation, loading materials, and other operations in an open-pit mine
- Dust from grinding and segregation of materials
- Sulfides, hydrocarbons, and other gas emissions from vents in underground mining operations
- Gas emissions from drying operations in ore processing (drying of pulp and/or sediment materials during ore processing)
- Fugitive emissions during ore processing (uncontrolled leaks in equipment such as valves, pump seals, and others that enter the air without going through a smokestack and is not routed to a pollution control device)

The impacts analysis section of the EIA must integrate the baseline data (environmental conditions before the project) with the assessment of potential impacts on air quality in all project

phases. The assessment must consider the influence of industries already existing in the project area (and area of influence), relevant meteorological data (trends of wind direction) and the impacts of particulates and gas emissions on water, wildlife, soil, and human health.

The EIA should include estimated amounts of air pollutants, identify the most significant pollutants (particulates, gas emissions from stationary and mobile sources), and include modeling studies and dispersion analysis of these pollutants.³³

Sometimes air pollutants interact with each other, creating what are called 'secondary' pollutants (e.g., ground level ozone and particulate matter formed from gaseous primary pollutants). EIAs usually present rough estimates of the percentage of air emissions generated by each source. These values must be considered with baseline information and meteorological data to assess the dispersion of air pollutants.

3.4.4 Impacts on global climate

Large-scale mining projects have the potential to alter the global carbon budget in at least the following ways: (1) Lost CO₂ uptake by forests and vegetation that is cleared in order for mining to begin; (2) CO₂ emitted by machines consuming fossil fuels that are involved in extracting and transporting ore (e.g., diesel-powered heavy vehicles); and (3) CO₂ emitted by the processing of ore into metal (e.g., by pyro-metallurgical versus hydro-metallurgical techniques).

The impacts analysis section of the EIA should include quantitative estimates of each of the above three ways a mining project could potentially affect the global carbon budget. Quantitative estimates of the second two components should be relatively simple projections, based on expected rates of fossil fuel consumption.

A quantitative estimate of the first component will require a more complicated, site-specific analysis

³³ An EIA must include references of the methods used to predict impacts of the project in the air quality such as computer modeling analysis of the dispersion

of the CO₂ uptake rates by local forests that will be impacted by the proposed mining project. This analysis is essential because for many proposed mining projects in tropical areas, lost CO₂ uptake by forests and vegetation would be the largest factor determining the project's potential impact on the global climate.

3.4.5 Impacts on ecological processes

It is useful for analysts to begin their evaluation by investigating discrete ecological processes. There are 10 ecological processes that effectively capture ecosystem functioning and should be evaluated for adverse effects:

1. Habitats critical to ecological processes
2. Pattern and connectivity of habitat patches
3. Natural disturbance regime
4. Structural complexity
5. Hydrologic patterns
6. Nutrient cycling
7. Purification services
8. Biotic interactions
9. Population dynamics
10. Genetic diversity

Loss and degradation of forest habitat is common to many projects. While forests have been recognized as habitat for wildlife species, the value associated with different forest types has only recently been considered. Specific forest communities, particularly old-growth stands, support sensitive species and ecological processes that cannot be sustained in other forest types.

"The degree of impact caused by mining activities varies both within and among the phases of mining projects and the different kinds of activities. The level of impact is determined both by the intensity and extent of the activity, and by the specific type of impact on the habitat of concern. The impacts to habitats, and to their values and functions, falls into three general categories: (1) Destruction of habitat, (2) Fragmentation of habitat, and (3) Degradation of habitat.

“The nature of these impacts depends on the specific stress created by each activity. In most cases, a single activity will include several stressor processes that impact habitat. For example, the activity of opening a mining pit includes removal of vegetation, erosion and sedimentation of nearby streams, and disturbance from noise and human activity. The major stressor processes affecting habitats include the following: Vegetation removal; Erosion, sedimentation, and soil compaction; Acidification; Contaminant toxicity; and Noise and visual disturbance.

“These stressor processes can result in the following effects on habitat: Direct mortality of resident species; Physiological stress and decreased reproduction; Disruption of normal behavior and activities; Segmentation of interbreeding population; and Modified species interactions.

“At greatest risk are the following groups of species: large terrestrial mammals, bats, hole- and ground-nesting birds, amphibians, snails, trees, herbs, grasslands, freshwater stream organisms, river fishes and mollusks, and aquatic vegetation.”³⁴

3.4.5.1 Impacts on vegetation and soil quality

Mining projects can contaminate soils over a large area, potentially affecting nearby agricultural activities. Spills and leaks of hazardous materials and the deposition of contaminated windblown dust can lead to soil contamination. “High levels of arsenic, lead, and radionuclides in windblown dust usually pose the greatest risk.”³⁵ The impacts analysis section of the EIA should include quantitative estimates of how the deposition of contaminated windblown dust could elevate

levels of soil contaminants and impact nearby agricultural activities.

3.4.6 Impacts on wildlife

The impact analysis section must provide clear, “big picture” information of the aquatic and terrestrial ecosystems and wildlife species, and how these would be affected by the mining project. This section must also contain references to the national and/or international legal bodies protecting species or providing frameworks regarding their status.

What to look for in the wildlife impact analysis section

- Changes in natural vegetation
- Disturbance of aquatic life, river, streams, lake alterations
- Changes in species population
- Species relocation
- Changes in birds, fish, and mammal food web nutrient cycling
- Threatened species evaluation
- Effects on migratory birds, mammals, fish
- Impacts on breeding areas and other considerations regarding species reproduction
- Scope of the areas of analysis (should consider not only the mining concession area but other potential areas of direct and indirect influence)

Key questions in the valuation of impact assessment on wildlife

- Has the impact analysis section considered substantial adverse effects, either directly or through habitat modifications, on species identified as sensitive or special status species in local or regional plans, policies, or regulations?
- Does the section provide a rigorous analysis of the adverse effects on riparian habitat or other sensitive natural communities identified in local or regional plans, policies, or regulations?

³⁴ United States Environmental Protection Agency (1993) “Habitat Evaluation: Guidance for the Review of Environmental Impact Assessment Documents.” <http://www.epa.gov/compliance/resources/policies/nepa/habitat-evaluation-pg.pdf>

³⁵ MINEO Consortium (2000) “Review of potential environmental and social impact of mining” <http://www2.brgm.fr/mineo/UserNeed/IMPACTS.pdf>

- Does the analysis consider long-term and cumulative substantial adverse effects during all the mining project cycles?

3.4.7 Social impacts

Large-scale mining projects can cause severe and even permanent social impacts. Changes in the physical environment, the presence of hundreds of workers, the building of new access roads, increased demands on services, changes to land use, access to water, and environmental contamination can permanently affect local people's lives.

Most EIA guidelines require a social impact analysis. Social impacts can differ substantially, depending on the duration of the project, the location of populated areas in relation to the project area, and potential mine expansion plans. Factors that should be included in the social impact analysis are:

- Characteristics of local populations in the project area and areas of influence: population location, age distribution, population growth rate, and ethnic group composition
- Relevant information about access to education and health services
- Sanitation
- Development trends (some communities have community life plans and/or local development plans)
- Employment and income
- Social-economical stratification
- Housing (infrastructure, number of houses)
- Land use and land property
- Presence of indigenous communities, customary land uses, territorial rights
- Relevant health data (most prevalent diseases, causes of death)
- Access to information and knowledge about the project, attitudes towards the project
- Infrastructure (roads, transportation)
- Migration
- Rural/urban population distribution
- Urban development trends

What to look for in the social impact assessment

The social impact assessment should consider baseline information related to at least the four following areas:

1. Changes in access to and power over local resources (land, water). Increased competition between local people and productive activities for energy, basic services (health, education, sanitation), and access to water resources.
2. Changes in the characteristics of a population (size, composition, traditions, productive activities).
3. Divergent perceptions between decision-makers, the mining company, and local people about the distribution of economic benefits and social/environmental costs of a large mining operation.
4. Land (property), land use.

Involuntary relocation of a population is a major social problem. In this case, the EIA must include detailed information about compensation, relocation plans, alternative relocation sites, and information about conditions that would guarantee people the same quality of life. Another special situation is when areas have little apparent presence of human activity, but are used by local people for hunting (not recreational), fishing, and gathering wildlife products necessary for their subsistence and livelihood.

Key questions in the valuation of social impacts

- How is land use and access to environmental resources (land, water) valued?
- Does the analysis consider changes in subsistence and income? How does the study assess short, medium, and long-term effects on local population income and the local economy?

- What sources are used to support the social impact assessment? Did the study use surveys? Who participated in the surveys? What questions were asked? How were the questions developed?
- Has the study included the concerns of local people?
- If the study mentions surveys and interviews, were people informed about the use and purpose? What methods were used? Is the population sample representative?
- How are the positive and negative findings described?
- Does the social impact assessment consider long-term impacts (including post-closure)?

3.4.7.1 Cost-benefit analysis

Some laws and/or mining industry guidelines require an EIA to contain a cost-benefit analysis. There are different opinions about what should be included in a cost-benefit analysis. Typically, a cost-benefit analysis means the “economic” cost-benefit, but the definition has expanded to include the “social” cost-benefit and some EIAs have sections dedicated to this. Socio-economic cost-benefit analyses explore the relationships between socio-economic benefits of mining (jobs, infrastructure, land compensation, royalties, tax revenue) and the social cost of environmental damage to quality of life.

3.4.8 Impacts on public safety

3.4.8.1 Dam break analysis

Some EIA guidelines do not require an analysis of the impacts of a failure of a tailings dam (‘dam break analysis’), despite the major risks and often irreversible damage this poses to the environment

and public health.³⁶ In most tailings dam failures, mine tailings liquefy and flow substantial distances, with the potential for extensive damage to property and life. To assess the potential for damage in the case of a dam break, it is necessary to predict the characteristics of the flow and the possible extent of flood movement.³⁷

According to Danihelka and Cervenanova,³⁸ the most common causes of mine tailings dam breaks are:

- Inadequate mine tailings management
- Lack of control of hydrological system
- Error in site selection and investigation
- Unsatisfactory foundation, lack of stability of downstream slope
- Seepage
- Overtopping
- Earthquake

Does the impact analysis section include a risk analysis of tailings dams? If the answer is no, local people can request that a tailings dam risk analysis be included. If the answer is yes, pay attention to the following issues:

Dam stability, infrastructure and design considerations

- Does the analysis consider the influence of weather conditions (rain, snow, freeze)?
- Does the analysis consider earthquakes and induced seismicity factors?

36 United Nations Environmental Programme and International Commission on Large Dams (2001) “Tailings Dams, Risk of Dangerous Occurrences, Lessons Learnt From Practical Experiences,” Bulletin 121. <http://www.mineralresourcesforum.org/docs/pdfs/Bulletin121.PDF>

37 Jeyapalan, J. (2005) “Effects of fluid resistance in the mine waste dam-break problem.” International Journal for Numerical and Analytical Methods in Geomechanics. Vol 7:1 <http://www3.interscience.wiley.com/journal/110559848/abstract?CRETRY=1&SRETRY=0>

38 Danihelka, P. and Cervenanova, E. (2007) “Tailings dams: risk analysis and management.” UNECE Workshop on Tailings Dams Safety. Yerevan, Armenia. http://www.unece.org/env/teia/water/tailingdams/presentations/DanihelkaRISK_ANALYSIS_OF_TAILING_DAMS_F.ppt

- How are geologic conditions defined and which ones are considered?
- How was the tailings dam location selected?
- Does the analysis comprise all stages of the project (including post-closure)?

Indirect causes, including human error

- What control measures are considered?
- What materials are considered? (You may need to contact an expert about this issue if the information is not clear.)
- Does the study include a tailings dam maintenance plan?

Consequences

- Is the proposed tailings dam near populated areas?
- Is the location of a proposed tailings dam near a major source of surface water?
- Is airborne particulate matter considered (impact on surface water, agricultural lands, local people's houses, recreational use areas)?
- Is environmental and human toxicity considered?

3.4.8.2 Traffic

Large-scale mining involves the intensive transportation of significant materials, products, equipment, workers, supplies, etc. (emissions from motor vehicles, including fugitive dust emissions, are addressed in section 3.5.2.) However, transportation of materials, equipment, and more in mining operations entail other risks that need to be addressed in the Environmental Management Plan (EMP).

Key issues include:

- Transportation of hazardous materials; The EMP should establish routes, calculated amounts, and responsibilities in case of contingencies or accidents.
- Detailed measures to control and reduce accidents in all reasonable foreseeable transportation links (train, road, port transfer, marine).
- How is the project in accordance with state and national regulations and requirements?

3.4.9 Cumulative impacts

Cumulative impacts are defined by the International Association of Impact Assessment as those that result from combined, incremental impacts of an action in a particular place and time. According to the U.S. EPA:

"Cumulative impacts result when the effects of an action are added to or interact with other effects in a particular place and within a particular time. It is the combination of these effects, and any resulting environmental degradation, that should be the focus of cumulative impact analysis. While impacts can be differentiated by direct, indirect, and cumulative, the concept of cumulative impacts takes into account all disturbances since cumulative impacts result in the compounding of the effects of all actions over time. Thus the cumulative impacts of an action can be viewed as the total effects on a resource, ecosystem, or human community of that action and all other activities affecting that resource no matter what entity (federal, non-federal, or private) is taking the actions."³⁹

There is no standard method to assess cumulative impacts, but given their importance, national

³⁹ United States Environmental Protection Agency (1999) "Consideration Of Cumulative Impacts In EPA Review of NEPA Documents." <http://www.epa.gov/compliance/resources/policies/nepa/cumulative.pdf>

guidelines for EIAs should require the assessment of cumulative impacts. According to the U.S. EPA:

“The assessment of cumulative impacts is not substantially different from the assessment of direct or indirect impacts. The same type of considerations are made to determine the environmental consequences of the alternatives for direct, indirect, or cumulative impacts. One possible difference is that cumulative impact assessment entails a more extensive and broader review of possible effects. Reviewers should recognize that while no “cookbook” approach to cumulative impacts analysis exists, a general approach is described in the CEQ handbook. As with the review of direct or indirect impacts, EPA review of cumulative impacts analysis is most effective if done early in the process, especially in the scoping phase.”⁴⁰

One possible difference is that the cumulative impact assessment entails a more extensive and broader review of possible effects.

As mentioned, it is necessary to review the legal requirements of including cumulative impacts. It is expected that large-scale mining projects consider cumulative impacts as a significant issue in an EIA. The U.S. EPA states, “The analysis should be commensurate with the potential impacts, resource affected, project scale and other factors.”⁴¹

Key issues include

- Does the EIA address short and long-term environmental and social effects caused by more than one source?
- Does the EIA assess the possible effects on the human environment that may be impacted by other productive activities in the area (e.g., the presence of a smelter)?

- Are the significance and magnitude of impacts on water, air, and soil evaluated based on one pollution source at a time?
- Is any particular resource (soil, water, air) especially vulnerable to incremental effects of pollutants?
- How is the geographic area identified? Does it include the resources potentially affected by the project?

3.4.9.1 Impacts of related or connected actions

Some EIA laws require an assessment of connected actions, such as railways for transporting ore, highway construction to a new mine, and transmission lines to a processing facility. There is controversy over the fragmentation of EIAs and whether they should include related or connected actions. Ideally, an EIA for a large-scale mining project would assess connected actions and their potential impacts on the project.

40 Ibid.
41 Ibid.

3.5 EVALUATING PROPOSED MITIGATION MEASURES AND CONTINGENCY PLANS

According to the U.S. EPA:

“Mitigation of mining impacts involves siting issues, technological solutions to eliminate contamination, and restoration programs. Most important for ... mineral mining is the siting of mining operations and tailing ponds to avoid habitats of concern, wetlands, riparian areas, and recharge areas. Specific mitigation measures depend on the type of mining and the specific process causing impacts. It is generally best to minimize the area affected as it is unlikely that even the disrupted soils and sediments can be restored. In addition to minimizing the area disturbed, activities should be timed to avoid disturbing nearby plants and animals during crucial periods of their life cycle.”⁴²

3.5.1 Protection of water resources

3.5.1.1 General measures regarding acid mine drainage

EIAs for proposed mining projects must include a comprehensive examination of all possible measures to avoid grave consequences, such as acid mine drainage.

Acid mine drainage and contaminant leaching prevention versus treatment

It is important to distinguish between measures that are designed to prevent acid mine drainage (AMD) from starting (by preventing sulfides in wastes and exposed geological materials from being converted to sulfuric acid) and measures that are designed to minimize the impacts of AMD by treating it after it occurs.

AMD is like a genie in a bottle: once it is out, it is nearly impossible to put back! Once AMD starts, it feeds on itself and is nearly impossible to extinguish. Treatment of AMD must go on forever. Therefore, EIAs should emphasize mitigation measures that prevent acid mine drainage from ever starting. The IFC/World Bank Group recommends the following measures for the prevention of AMD:

“Implementation of ARD and ML [metal leaching] preventive actions to minimize ARD including:

“Limiting exposure of PAG [potentially acid-generating] materials by phasing of development and construction, together with covering, and/or segregating runoff for treatment:

“Implementation of water management techniques such as diverting clean runoff away from PAG materials, and segregating “dirty” runoff from PAG materials for subsequent treatment; grading PAG material piles to avoid ponding and infiltration and removing pit water promptly to minimize acid generation.

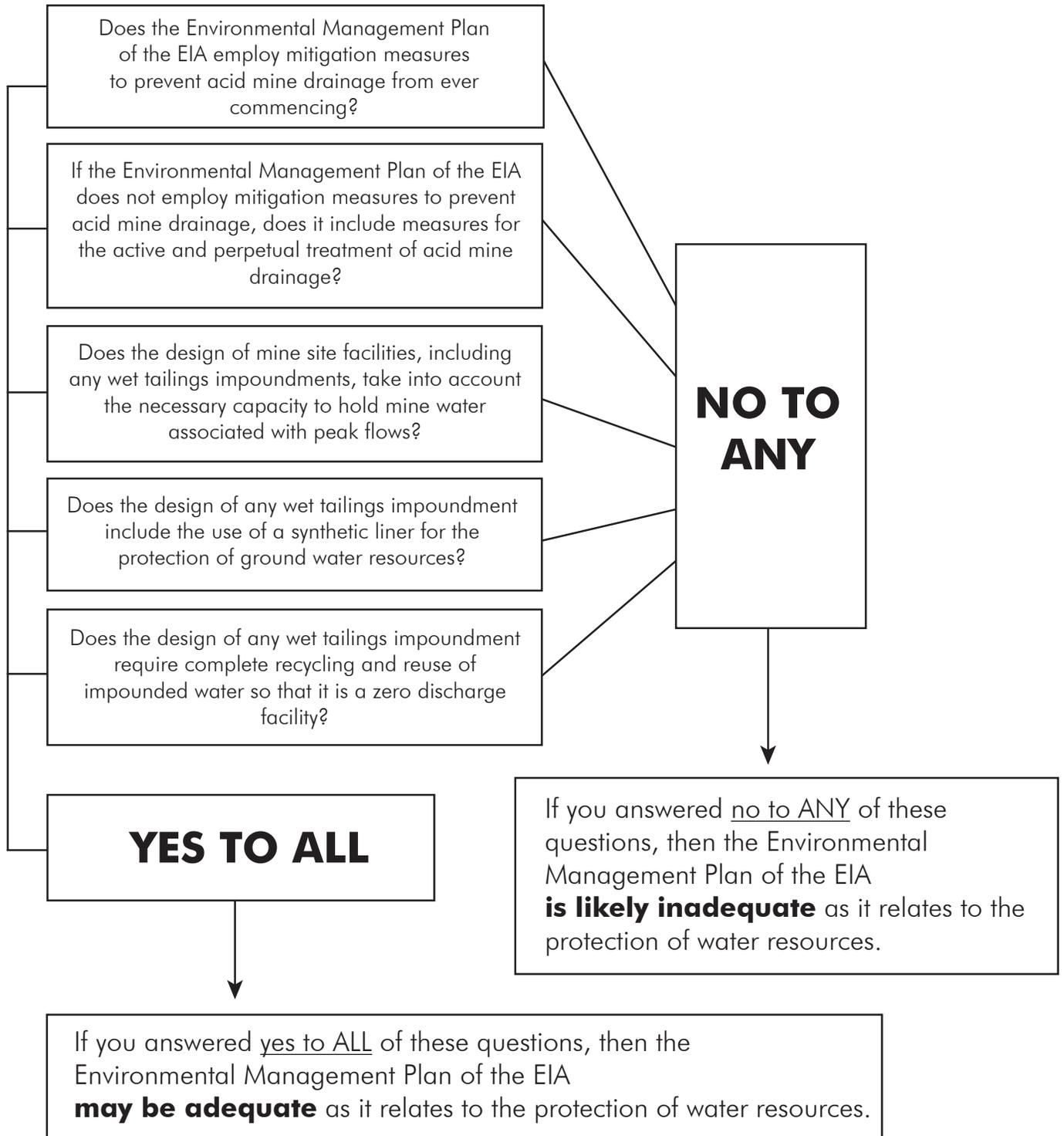
“Controlled placement of PAG materials (including wastes) to provide permanent conditions that avoid contact with oxygen or water including:

“Submerging and/or flooding of PAG materials by placing PAG materials in an anoxic (oxygen free) environment, typically below a water cover;

“Isolating PAG materials above the water table with an impermeable cover to limit infiltration and exposure to air. Covers are typically less of a concern in arid climates where there is limited precipitation, and should be

42 United States Environmental Protection Agency (1999) “Considering Ecological Processes in Environmental Impact Assessments.” <http://www.epa.gov/compliance/resources/policies/nepa/ecological-processes-eia-pg.pdf>

FLOWCHART 3.4 - Evaluating the adequacy of measures for the protection of water resources



appropriate for local climate and vegetation (if any)

“Blending of PAG materials with non-PAG or alkaline materials can also be employed to neutralize acid generation, as appropriate. Blending should be based on full characterization of each of the blended materials, the ratio of alkaline materials to acid generating materials, the case histories of failed operations, and the need for static and long-term kinetic tests.”⁴³

3.5.1.2 Water management

A mining company must demonstrate in the EIA that it has a comprehensive and accurate understanding of meteorological and hydrological conditions that determine the nature of water movement throughout the mine site. As Environment Australia explains:

“Water is integral to virtually all mining activities and typically the prime medium, besides air, that can carry pollutants into the wider environment. Consequently, sound water management and practice are fundamental for most mining operations to achieve environmental best practice.”⁴⁴

The IFC/World Bank Group explains that:

“Mines can use large quantities of water, mostly in processing plants and related activities, but also in dust suppression among other uses. Water is lost through evaporation in the final product but the highest losses are usually into the tailings stream. All mines should focus on appropriate management of their water balance. Mines with issues of excess water supply, such as in moist tropical environments or areas with snow and ice melt, can experience peak flows which require

careful management. Recommended practices for water management include:

“Establishing a water balance (including probable climatic events) for the mine and related process plant circuit and use this to inform infrastructure design;

“Developing 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;

“Minimizing 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.”⁴⁵

Regarding the establishment of water balance, the EIA for a proposed mining project must use design criteria that can accommodate peak flows (the amount of water that might enter and leave specific locations at the mine site during a maximum foreseeable rainfall event). According to Environment Australia:

“Rainfall intensity-frequency-duration data are necessary to estimate peak discharges for drainage and flood analyses. ...

“Various hydrological models are available to estimate ‘discharge hydrographs’, or the variation of discharge with time at a location of interest within a catchment. Such models include ‘RORB’, ‘RAFTS’ and ‘URBS’, and are referred to as ‘runoff-routing’ models. Typically, these models would be used to estimate peak flood discharges in creeks and rivers as part of

43 IFC/World Bank (December 2007) “Environmental, Health and Safety Guidelines for Mining.” [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

44 Environment Australia (2002) “Overview of Best Practice Environmental Management in Mining: Water Management.” <http://www.ret.gov.au/resources/Documents/LPSPD/BPEMWater.pdf>

45 IFC/World Bank (December 2007) “Environmental, Health and Safety Guidelines for Mining.” [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

minesite flood studies, and to estimate peak spillway design flows from a minesite water storage on a creek or river.

“Runoff-routing models simulate the rainfall-runoff process for a selected storm event over the catchment of interest. The catchment is divided into a number of sub-areas on the basis of the drainage network. An appropriate rainfall intensity and temporal pattern is selected for the storm event of interest (see above), together with rainfall loss parameters that reflect the loss of rainfall by infiltration. The storm event is divided into a suitable number of time increments. For each time increment, the model estimates the surface runoff from a sub-area (i.e., the rainfall excess) and ‘routs’ that runoff out of the sub-area and into the next downstream sub-area, where it is combined with runoff from that sub-area. In this way, surface runoff is progressively routed from sub-area to sub-area down the catchment over the duration of the storm, so allowing discharge hydrographs to be generated at locations of interest.”⁴⁶

Further sections of this Guidebook discuss water management measures with respect to specific, individual facilities at mines. An EIA for a proposed mining project should show that the design of mine site facilities that would hold mine water incorporate accurate information about peak flows.

3.5.1.3 Stormwater, sediment and erosion control

The erosion of soils and mine wastes into surface waters is a serious, adverse environmental consequence of mining projects. The IFC/World Bank Group explains that:

“Key issues associated with management of stormwater include separation of clean and dirty water, minimizing run-off, avoiding

erosion of exposed ground surfaces, avoiding sedimentation of drainage systems and minimizing exposure of polluted areas to stormwater. Recommended stormwater management strategies have been broadly categorized into phases of operation (although several measures span more than one phase including the decommissioning and closure phase). As such; from exploration onwards, management strategies include:

- Reducing exposure of sediment-generating materials to wind or water (e.g., proper placement of soil and rock piles);
- Diverting runoff from undisturbed areas around disturbed areas including areas that have been graded, seeded, or planted. Such drainage should be treated for sediment removal;
- Reducing or preventing off-site sediment transport (e.g., use of settlement ponds, silt fences);
- Protecting stormwater drains, ditches, and stream channels should be protected against erosion through a combination of adequate dimensions, slope limitation techniques, and use of rip-rap and lining.
- Temporary drainage installations should be designed, constructed, and maintained for recurrence periods of at least a 25-year/24-hour event, while permanent drainage installations should be designed for a 100-year/24-hour recurrence period. Design requirements for temporary drainage structures should additionally be defined on a risk basis considering the intended life of diversion structures, as well as the recurrence interval of any structures that drain into them.

“From construction onwards, recommended management strategies include:

- Establishing riparian zones;
- Timely implementation of an appropriate combination of contouring

⁴⁶ Environment Australia (2002) “Overview of Best Practice Environmental Management in Mining: Water Management.” <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMWater.pdf>

techniques, terracing, slope reduction / minimization, runoff velocity limitation and appropriate drainage installations to reduce erosion in both active and inactive areas;

- Access and haul roads should have gradients or surface treatment to limit erosion, and road drainage systems should be provided;
- Facilities should be designed for the full hydraulic load, including contributions from upstream catchments and nonmined areas;
- Stormwater settling facilities should be designed and maintained according to internationally accepted good engineering practices, including provisions for capturing of debris and floating matter. Sediment control facilities should be designed and operated for a final Total Suspended Solids (TSS) discharge of 50 mg/l and other applicable parameters and guideline values in Section 2.0, taking into consideration background conditions and opportunities for overall improvement of the receiving water body quality. Discharge water quality should also be consistent with the receiving water body use.

"From operations onwards, recommended management strategies include:

- Final grading of disturbed areas, including preparation of overburden before application of the final layers of growth medium, should be along the contour as far as can be achieved in a safe and practical manner;
- Revegetation of disturbed areas including seeding should be performed immediately following application of the growth medium to avoid erosion."⁴⁷

The EMP should include a detailed discussion of how it would employ the above strategies to

47 IFC/World Bank (December 2007) "Environmental, Health and Safety Guidelines for Mining." [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

prevent the erosion of soils and mine wastes into surface waters.

3.5.1.4 Management of waste rock dumps

The IFC/World Bank Group recommends the following measures for the management of waste rock dumps for protection of water quality.

"The overburden and waste rock is often disposed of in constructed waste rock dumps. Management of these dumps during the mine life cycle is important to protect human health, safety and the environment. Recommendations for management of waste rock dumps include the following:

"Dumps 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;

"Management of Potentially Acid Generating (PAG) wastes should be undertaken as described in the guidance.

"Potential change of geotechnical properties in dumps due to chemical or biologically catalyzed weathering should be considered. This can reduce the dumped spoils significantly in grain size and mineralogy, resulting in high ratios of clay fraction and a significantly decreased stability towards geotechnical failure. These changes in geotechnical properties (notably cohesion, internal angle of friction) apply especially to facilities which are not decommissioned with a proper cover system, which would prevent precipitation from percolating into the dump's body. Design of new facilities has to provide for such potential deterioration of geotechnical properties with higher factors of safety. Stability / safety assessments of existing facilities should take these potential changes into account."⁴⁸

The EMP should include a detailed discussion of

48 Ibid.

how it would incorporate the above measures to prevent water quality impacts of overburden and waste rock dumps.

3.5.1.5 Management of open pits and pit lake prevention

Because pit lakes can cause substantial environmental impacts, mining companies should not allow a lake to form in an open pit. Instead, open pits should be backfilled (see Section 3.7.4.2). The EMP should include a discussion of how the open pit would be managed in a manner that would allow for its backfilling and eventual recontouring and revegetation, to re-create pre-mining conditions.

3.5.1.6 Management of wet tailings impoundments

Dewatering of tailings and their use as backfill (Section 3.2.1.3) is the environmentally-preferable disposal option. As such, the EMP would not need to discuss the management of a wet tailings impoundment. However, if the EIA calls for the creation of a wet tailings impoundment, then the IFC/World Bank Group recommends the following management strategies to protect water quality:

- *“Any diversion drains, ditches, and stream channels to divert water from surrounding catchment areas away from the tailings structure should be built to the flood event recurrence interval standards...;”*
- *“Seepage management and related stability analysis should be a key consideration in design and operation of tailings storage facilities. This is likely to require a specific 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;

- *Design specification 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;*
- *On-land disposal in a system that can isolate acid leachate-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;”⁴⁹*

The EMP should include a discussion of how the wet tailings impoundment (if one is proposed) would be managed, consistent with the above principles.

3.5.1.7 Management of leach facilities

The IFC/World Bank Group recommends the following measures for the management of leach facilities for protection of water quality:

“Operators should design and operate surface heap leach processes [such that]:”

- *Infiltration of toxic leach solutions should be prevented through the provision of appropriate liners and sub-drainage systems to collect or recycle solution for treatment, and minimize ground infiltration;*
- *Pipeline systems carrying pregnant solutions should be designed with secondary banded containment;*
- *Leak detection equipment should be installed for pipeline and plant systems with appropriate leak response systems in place;*

49 Ibid.

- Process solution storage ponds and other impoundments designed to hold non-fresh water or non-treated leach process effluents should be lined, and be equipped with sufficient wells to enable monitoring of water levels and quality. ...

“ Recommended practices for the management of leach-pad waste include the following:

- Leachate collection and treatment should continue until the final effluent criteria are consistent with guideline values

...

- Decommissioned leach pads should utilize a combination of surface management systems, seepage collection, and active or passive treatment systems to ensure post closure water resource quality is maintained ...”⁵⁰

The EMP should include a discussion of how any leach facilities would incorporate the above-recommended practices.

3.5.2 Protection of air quality and noise levels

The IFC/World Bank Group explains:

“Management of ambient air quality at mine sites is important at all stages of the mine cycle. Airborne emissions may occur during each stage of the mine cycle, although in particular during exploration, development, construction, and operational activities. The principal sources include fugitive dust from blasting, exposed surfaces such as tailings facilities, stockpiles, waste dumps, haul roads and infrastructure, and to a lesser extent, gases from combustion of fuels in stationary and mobile equipment.”⁵¹

The EMP should discuss measures for the control of air pollution, including specific measures to control fugitive dust, noise, and ground vibrations.

50 Ibid.
51 Ibid.

3.5.2.1 Control of fugitive dust emissions

The IFC/World Bank Group recommends the following measures for the control of fugitive dust emissions from mining operations:

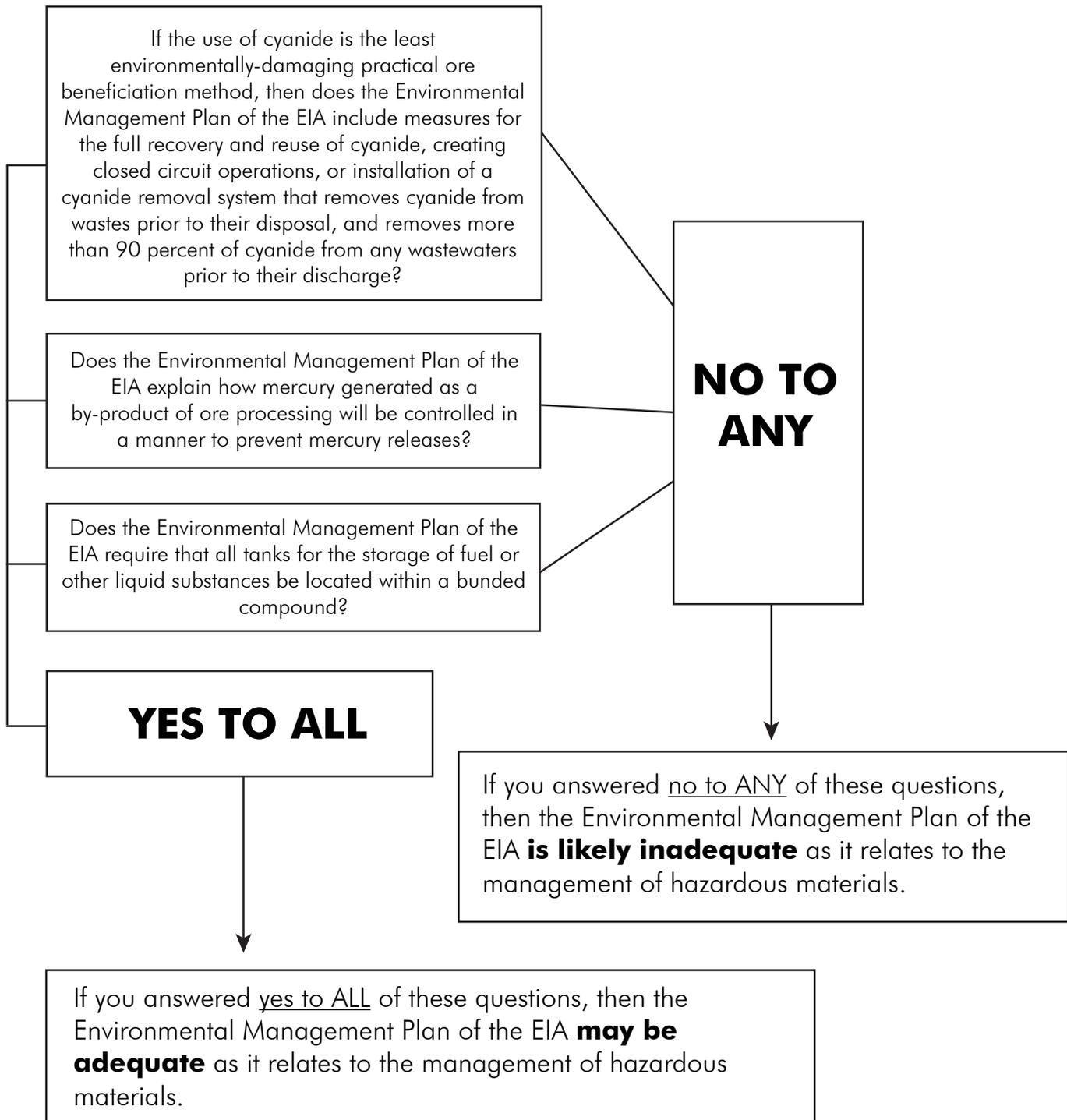
“Fugitive dust emissions from the dry surfaces of tailings facilities, waste dumps, stockpiles and other exposed areas should be minimized. Recommended dust management strategies include:

- Dust suppression techniques (e.g. wetting down, use of allweather surfaces, use of agglomeration additives) for roads and work areas, optimization of traffic patterns, and reduction of travel speeds;
- Exposed soils and other erodible materials should be revegetated or covered promptly;
- New areas should be cleared and opened-up only when absolutely necessary;
- Surfaces should be re-vegetated or otherwise rendered non-dust forming when inactive;
- Storage for dusty materials should be enclosed or operated with efficient dust suppressing measures;
- Loading, transfer, and discharge of materials should take place with a minimum height of fall, and be shielded against the wind, and consider use of dust suppression spray systems;
- Conveyor systems for dusty materials should be covered and equipped with measures for cleaning return belts.”⁵²

The EMP should include these measures as appropriate for the control of fugitive dust emissions.

52 Ibid.

FLOWCHART 3.5 - Evaluating the adequacy of measures for the management of hazardous materials



3.5.2.2 Control of noise and vibrations

The IFC/World Bank Group explains:

“Sources of noise emissions associated with mining may include noise from vehicle engines, loading and unloading of rock into steel dumpers, chutes, power generation, and other sources related to construction and mining activities. Additional examples of noise sources include shoveling, ripping, drilling, blasting, transport (including corridors for rail, road, and conveyor belts), crushing, grinding, and stockpiling. Good practice in the prevention and control of noise sources should be established based on the prevailing land use and the proximity of noise receptors such as communities or community use areas. Recommended management strategies include...

- *Implementation of enclosure and cladding of processing plants*
- *Installation of proper sound barriers and / or noise containments, with enclosures and curtains at or near the source equipment (e.g., crushers, grinders, and screens)*
- *Installation of natural barriers at facility boundaries, such as vegetation curtains or soil berms*
- *Optimization of internal-traffic routing, particularly to minimize vehicle reversing needs (reducing noise from reversing alarm) and to maximize distances to the closest sensitive receptors*

“The most significant vibrations are usually associated with blasting activities; however vibrations may also be generated by many types of equipment. Mines should minimize significant sources of vibration, such as through adequate design of crusher foundations. For blasting-related emissions (e.g., vibration, airblast, overpressure, or fly rock), the

following management practices are recommended:

- *Mechanical ripping should be used, where possible, to avoid or minimize the use of explosives;*
- *Use of specific blasting plans, correct charging procedures and blasting ratios, delayed / microdelayed or electronic detonators, and specific in-situ blasting tests (the use of downhole initiation with short-delay detonators improves fragmentation and reduces ground vibrations);*
- *Development of blast design, including a blasting-surfaces survey, to avoid overconfined charges, and a drill-hole survey to check for deviation and consequent blasting recalculations;*
- *Implementation of ground vibration and overpressure control with appropriate drilling grids;*
- *Adequately designing the foundations of primary crushers and other significant sources of vibrations.”⁵³*

The EMP should include these measures as appropriate for the control of noise and vibrations.

3.5.3 Management of hazardous materials

All mining operations involve the use of liquid petroleum fuels. Many mining operations involve the use of cyanide and the co-production of mercury. The EMP should include well-designed measures for preventing serious impacts that releases of cyanide, mercury, and petroleum fuels have on the environment.

3.5.3.1 Cyanide use

Cyanide is potently toxic to humans and wildlife. Section 3.2.1.2 describes mining activities, chiefly gold and copper ore concentration operations,

53 Ibid.

that involve the use of large quantities of cyanide solutions. The IFC/World Bank Group recommends:

“Cyanide use should be consistent with the principles and standards of practice of the International Cyanide Management Code. The Cyanide Code includes principles and standards applicable to several aspects of cyanide use including its purchase (sourcing), transport, handling/storage, use, facilities decommissioning, worker safety, emergency response, training, and public consultation and disclosure. The Code is a voluntary industry program developed through a multi-stakeholder dialogue under the auspices of the United Nations Environment Programme and administered by the International Cyanide Management Institute.”⁵⁴

The International Cyanide Management Code is considered a weak set of measures to protect public safety and aquatic life from cyanide at mines. Nevertheless, it is generally consistent with cyanide use protocols in most countries.

Another problem with cyanide is that it mobilizes mercury as mercury cyanide complexes (as well as other metals that can be complexed with mercury), and these concentrations can be very high in process fluids and ponds.

Mercury should be measured on a regular basis and wildlife, workers, and surrounding residents protected from exposure to mercury, either in process fluids, or from volatilization of mercury from tailings facilities and heap leach operations. Arsenic and antimony are also commonly observed in high pH process fluids and should be measured and reported on a monthly basis.

The EMP should include a commitment that the mining company will use cyanide consistent with the principles and standards of practice of the International Cyanide Management Code. However, this commitment is often not sufficient to protect public safety and aquatic life. Cyanide

management should include treatment options to remove cyanide to concentrations that are not acutely or chronically toxic.

The EMP should also, when feasible, create closed circuit operations (zero discharge processes), or install a cyanide removal system that removes cyanide from wastes prior to their disposal and removes cyanide to well below 50 mg/L WAD (weak acid dissolvable) cyanide in the process ponds, and removes cyanide well below 0.05 mg/L from any wastewaters prior to their discharge, with sufficient flow in the stream such that the concentrations are less than 0.005 mg/L following a short mixing zone.

The concerns regarding cyanide do not end when mining is discontinued. Cyanide is generally oxidized to nitrate following mine closure, and high nitrate concentrations are often observed in process fluids that drain from tailings facilities and heaps, in addition to other salts. These fluids should be managed in such a manner that nitrate, in particular, and salts, in general, are not released to receiving waters, or have been treated to remove the salts, prior to release.

3.5.3.2 Mercury management

Most gold mining projects, and some mining projects involving other metals, have the potential for releasing mercury into the environment. U.S. mining experts explain:

“Mercury release to the environment is related to the co-incidence of mercury in many gold ores in Nevada, and release during ore processing. Mercury is produced as a byproduct from gold mines in Nevada, and is the largest source of new mercury in the U.S. ... Both the gold and mercury cyanide complexes are trapped on carbon and recovered during processing. Mercury is distilled (retorted) from the gold and collected

⁵⁴ IFC/World Bank (December 2007) “Environmental, Health and Safety Guidelines for Mining.” [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

as liquid mercury and sold by the flask (76 lbs).⁵⁵

These mining experts recommend:

“More consistent and more mercury measurements should be required. Because of the complexity of the mercury emission sources, a systematic evaluation of the methods used to determine mercury emissions rates and concentrations should be undertaken.

“New systems for better mass balance are recommended for accurate assessments of mercury release. This includes more precise measurements of mercury in the ore, mercury in the process fluids, and mercury sent out to the tailings facilities. The amount of mercury in the ore should be accounted for in a life-cycle assessment. Byproduct mercury production and sales should be reported.”⁵⁶

The IFC/World Bank Group recommends:

“Many producers of precious metals smelt metal on site prior to shipping to off site refineries. Typically gold and silver is produced in small melting / fluxing furnaces which produce limited emissions but have the potential for mercury emissions from certain ores. Testing should be undertaken prior to melting to determine whether a mercury retort is required for mercury collection.”⁵⁷

The EMP for any mining project that has the potential to generate mercury must include special measures for preventing the release of mercury to the environment. If the ore being mined contains significant trace amounts of mercury, then the EMP should explain how mercury generated as a by-

55 Miller, G. & Jones, G. (2005) “Mercury Management in Modern Precious Metals Mines” Glenn Miller and Greg Jones - Department of Natural Resources and Environmental Science, University of Nevada, Reno. <http://wman-info.org/resources/conferencepresentations/Mercury%20and%20Mining%20%28Glenn%20Miller%29.ppt>

56 Ibid..

57 IFC/World Bank (December 2007) “Environmental, Health and Safety Guidelines for Mining.” [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

product of ore processing will be controlled in a manner to prevent mercury releases.

In recent years, the State of Nevada in the U.S. has implemented a program that requires measurement of mercury emissions from many individual units involved in gold processing. Significant emissions sources include heap process ponds and tailings ponds, roasters, autoclaves, carbon regeneration furnaces, electrowinning circuits, retorts, and other units of the refinery. A variety of mercury capture systems are available.

For mining projects involving the processing of ores using cyanide, the mercury that is recovered should be reported and sold only to reputable buyers. Recovered mercury from precious metal mines should not be sold into a market where it has the potential to be used for mercury amalgamation of precious metals, due to the high probability that this mercury would simply be released into aquatic ecosystems or otherwise evaporated as part of a gold recovery scheme.

3.5.3.3 Storage of fuel and liquid substances

The Australia Water and Rivers Commission describes the following potential impacts of poor practices involving the storage of fuel and liquid substances by mining companies.

“Chemical substances, including corrosives, poisons, brines and hydrocarbons, may escape from storage facilities through various means including:

- *absence of containment facilities;*
- *poor construction or deterioration of containment facilities;*
- *inappropriate equipment maintenance operations;*
- *poor ‘housekeeping’ practices;*
- *accidental damage;*
- *deliberate vandalism.*

“The release or leakage of tank contents to the environment may adversely impact on the quality of water resources.”⁵⁸

To prevent these impacts, the Australia Water and Rivers Commission recommends the following measures for the storage of fuel and liquid substances at mine sites.

“Tank siting: Above-ground storage facilities should not be constructed: in wellhead and reservoir protection zones within a Public Drinking Water Source Area; on seasonally inundated land unless fill is placed to protect the tanks against flooding and the footings against erosion; on floodplains i.e., areas that may be affected by a 1-in-20 year flood; within 30 metres of the bank of any seasonal water body or surface water drainage line; and within 100 metres of the bank of any permanent waterbody.

“All facilities should have a one-metre clearance between the finished ground surface and the historical maximum groundwater level.

“Tank design: All tanks should be constructed and located within a bunded compound to Australian Standards AS 1940 – The storage and handling of flammable and combustible liquids and AS 1692 – Tanks for flammable and combustible liquids.

“Bunded compound design: All storage tanks should be located within a bunded compound. The bunded compound should extend sufficiently beyond the plan perimeter of the tank (when projected down to the bund) so that a jet of liquid from any perforation of the tank or process equipment will be contained. The bunded compound should be lined with low permeability (less than 10–9 m/s) material that is not adversely affected by contact with stored fuels or chemicals. Where permitted in Public Drinking Water Source

Areas, the bund should be constructed of waterproof reinforced concrete or an approved equivalent. The bunded compound should be constructed or protected in a manner that permits full recovery of contents spilt from the tank and ensures that the lining material is not damaged. The bunded compound should have sufficient capacity to fully contain leakage from storage tanks and not be overtopped during extreme rainfall events. This capacity should equate to not less than 110% of the capacity of the largest contained tank system and at least 25% of the total capacity of all tanks for a multiple tank system that do not have manifolded connections between tanks. Consideration must be given to the volume of any additional objects stored inside the bund. The compound should also contain, where it is uncovered, sufficient freeboard to contain incident rainfall from a 1-in-20 year return frequency 72-hour storm event and 110% of tank content. All process equipment subject to routine maintenance (valves, meters, pumps, gauges), should be situated within the bunded compound. Suitable security measures should be installed to prevent deliberate contamination of groundwater by intruders when the site is unattended.”⁵⁹

The EMP should include these measures for the storage of fuel and liquid substances.

3.5.4 Protection of wildlife

The best measures for the protection of wildlife are those measures that avoid impacts to wildlife habitat. There is nothing that compels a mining company to extract the full extent of the ore deposit. Mining projects should not infringe upon protected areas or other critical or sensitive ecological areas, even if it means leaving some of the ore deposit in the ground.

Mitigation measures, such as wildlife relocation projects, are seldom effective and the EMP should not assume that wildlife relocation projects would be successful.

⁵⁸ Australia Water and Rivers Commission (2000) “Water Quality Protection Guidelines for Mining and Mineral Processing – No. 10: Above-ground fuel and chemicals storage.” <http://www.water.wa.gov.au/PublicationStore/first/10142.pdf>

⁵⁹ Ibid.

For mining projects that generate toxic waste piles or impoundments of toxic waters, the EMP should call for the use of barriers, such as fences and netting, to prevent animals and birds from suffering exposures to toxic substances in mining wastes.

3.6 EVALUATING THE ENVIRONMENTAL MONITORING PLAN

Every promise in an EIA runs the risk of being an illusion unless the EIA sets out measures by which the mining company and/or responsible government officials will monitor performance of the mining project and its impact on the environment. As Conservation International explains:

“The monitoring program should be a part of the company’s overall environmental management system, and should respond directly to the environmental issues identified in the EIA performed before operations began. The monitoring program should be developed using a set of objectives, the commitments of the company and existing conditions. The program should spell out the work plan, responsibilities of the mine staff, monitoring arrangements and reporting systems. Monitoring programs begin with baseline sampling programs performed to characterize the pre-development environment. Environmental issues addressed in and managed by the plan generally relate to issues such as land-clearing and topsoil, water, waste rock, tailings, hazardous wastes, biology (species, health risks, biodiversity), dust, noise and transportation.”⁶⁰

The Environmental Monitoring Plan (EMP) needs to provide more than details about where, when, what, and how often a mining company will monitor the quality of the water, air, and soil in the vicinity of the mining project, and the quantity of pollutants in effluents and emissions

being released. The Environmental Monitoring Plan must also specify how this information will be provided to government decision-makers and to the general public in a manner that enables decision-makers and the general public to ascertain if the mining company is complying with all of its promises and relevant environmental regulations and standards.

Therefore, it is important that the Environmental Monitoring Plan specify that it will report *all* monitoring data promptly to the public in a user-friendly format. It is also important to insure that citizens from affected communities are part of any teams assembled to monitor a mining company’s environmental performance. These monitoring teams might be compromised if they include only industry and/or government agency representatives.

3.6.1 Water quality monitoring

Monitoring the extent to which water quality is changing within a mine site is essential for the protection of water quality. An adequate water quality monitoring program can insure that the mining company is fulfilling promises in its Environmental Monitoring Plan and is responding to water quality problems before it is too late. According to the Department of Minerals and Energy, Western Australia:

“Monitoring of minesite water quality is an essential part of the environmental management of a mining and mineral processing operation. It enables water quality and chemical containment performance to be

⁶⁰ Conservation International (2000) “Lightening the Lode: A Guide to Responsible Large-scale Mining.” <http://www.conservation.org/sites/celb/Documents/lode.pdf>

assessed. *Undesirable impacts can thus be detected at an early stage and remedied.*"⁶¹

The water quality monitoring section of the EIA should adhere to the following principles.

3.6.1.1 Surface water quality monitoring

For mining projects in Ontario, Canada:

"Surface water chemical monitoring shall be conducted for the following:

1. Discharge or seepage exiting on-site sources.
2. Discharge or seepage exiting the property boundary.
3. On-site water bodies and water bodies downstream from the site.
4. Background reference sites."⁶²

According to the IFC/World Bank Group: "Monitoring frequency should be sufficient to provide representative data for the parameter being monitored."⁶³

3.6.1.2 Groundwater quality monitoring

According to the Australia Water and Rivers Commission:

"Monitoring is one of the most important aspects of protecting groundwater resources. This is best achieved by constructing a network of bores. Assessing groundwater quality before an operation commences can set the environmental management needs of a project. Monitoring undertaken during

the Environmental Impact Assessment (EIA) process can also establish the baseline data by which the environmental performance of an operation can be assessed. Undesirable environmental impacts can thus be detected at an early stage and remedied effectively.

"Bores are normally required upstream and downstream (in the direction of groundwater flow) to monitor changes in water level and quality across a site and to monitor the performance and stability of tailings facilities."In hard rock areas, bores must be located within geological features that are most likely to transmit groundwater (e.g. along fault lines, within weathered zones with coarse granular soil or in alluvial sand).

"Monitoring bores should be sampled at least three-monthly for key likely pollution indicators associated with the project."⁶⁴

3.6.1.3 Water quality monitoring parameters

In Ontario, Canada, monitoring of water quality impacts from mining projects should include analysis of the following parameters:

"(a) pH; (b) conductivity; (c) total suspended solids; (d) total dissolved solids; (e) alkalinity; (f) acidity; (g) hardness; (h) cyanide; (i) ammonium; (j) sulphate; (k) aluminum (Al); (l) arsenic (As); (m) cadmium (Cd); (n) calcium (Ca); (o) copper (Cu); (p) iron (Fe); (q) lead (Pb); (r) mercury (Hg); (s) molybdenum (Mo); (t) nickel (Ni); and (u) zinc (Zn)."⁶⁵

Unless a mining company can demonstrate that a particular parameter is not relevant to the mining project, the Environmental Monitoring Plan should require monitoring of surface and groundwater for all of the above parameters.

61 Australia Water and Rivers Commission (2000), "Water Quality Protection Guidelines for Mining and Mineral Processing," - No. 5: Minesite Water Quality Monitoring.

62 ONTARIO REGULATION 240/00: Mine Development and Closure under Part VII of the Mining Act. http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_000240_e.htm

63 IFC/World Bank (December 2007) "Environmental, Health and Safety Guidelines for Mining." [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

64 Australia Water and Rivers Commission (2000) "Water Quality Protection Guidelines for Mining and Mineral Processing - No. 4: Installation of minesite groundwater monitoring bores" <http://www.water.wa.gov.au/PublicationStore/first/10137.pdf>

65 ONTARIO REGULATION 240/00: Mine Development and Closure under Part VII of the Mining Act. http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_000240_e.htm

3.6.2 Air quality monitoring

A mining operation must have an air quality monitoring plan to record the emissions of the most significant air pollutants. The selection and location of monitoring equipment should comply with technical assessments and specifications. Weather conditions, topography, residential areas, and wildlife habitat help determine the best location of air quality monitoring equipment.

Key issues include:

- Does the EIA have a detailed air quality monitoring plan?
- What equipment and methods are used?
- What are the criteria that were used to select the location of the monitoring points?
- How frequently will data be collected?
- Is an independent agency going to assess the calibration and implementation of the air quality monitoring plan?
- Will the results be available to the public?

3.6.3 Vegetation and soil quality monitoring

Key issues include:

- How would alterations of land be reported?
- Which methods would be used to quantify the excavated and/or disturbed lands?
- How would erosion and disturbance to surface soils be recorded and reported?

3.6.4 Monitoring impacts on wildlife and habitat

Key issues include:

- How are primary effects on fauna, flora, and habitats going to be monitored?
- Is an independent agency going to assess the potential (including cumulative) effects on terrestrial and aquatic wildlife and habitat?
- What methods would be used to report and organize the monitoring data? Is that information available to the local authorities and to the public?

3.6.4.1 Monitoring of key species

Large-scale mining operations entail activities that could significantly affect the natural functions of terrestrial and aquatic ecosystems. Ideally, an Environmental Monitoring Plan for a large-scale mining project would include periodic assessments of impacts on key wildlife species, with support from an independent group of qualified professionals. The baseline section of the EIA should identify wildlife species listed by national or local authorities and/or endemic species.

Key issues include:

- Evaluation of habitat loss.
- Key species should be previously identified in the baseline section.
- Conduct surveys to assess the reduction or alteration of key species populations.
- Overview of changes in the ecosystem and potential exposure of key species to hazardous pollutants.

3.6.4.2 Monitoring habitat loss

An Environmental Monitoring Plan must include plans to perform regular surveys to assess the

state of the habitat. These plans must include previous mapping of the surveyed areas, to define in advance the scope of habitat monitoring.

Key issues include:

- Habitat types should have been adequately identified and mapped previously.
- Who will perform the habitat monitoring? This activity requires qualified independent experts.
- Surveys must determine habitat density changes in several locations.
- Assessments of the current status of key species based on field work (count and observe species, population densities).

3.6.5 Monitoring impacts on affected communities

Mineral development can cause serious disruption in local communities, related to benefits and costs that may be unevenly shared. The economic gains of a national or foreign mining corporation do not necessarily result in local development. Meanwhile, environmental degradation affects the livelihood of local people.

3.6.5.1 Community health

Key issues include:

- Incidence of pollution related diseases and deaths.
- Assessment of water quality and availability for domestic use, agriculture, and other productive activities.
- Results of air quality assessments in populated areas.
- Records of regular or episodes of high air pollution (check compliance with the local, national, or international guidelines and standards).

- Incidence of alcoholism, prostitution, and sexually transmitted diseases related to the presence of mining workers in the area.

3.6.5.2 Promised investments for socio-economic development

Frequently, large-scale mining takes place in areas of extreme poverty with weak social capital, few job opportunities, and economically depressed conditions. The presence of a large company offering jobs and promising to improve living conditions causes great expectation and also anxiety among local people. Often, local people are socially or culturally marginalized with limited capacity to negotiate with government and company representatives. All of these circumstances generate mistrust and tension.

Key issues include:

- Transparency: Local community members must participate in the decision-making processes affecting the allocation of financial contributions to local development programs, and in the audits or assessments of these allocations.
- Communication: Representatives of the local community, the mining company, and authorities must create communication procedures/strategies from the earliest stages of decision-making and throughout project implementation.
- Access to information: The community must have free access to information related to environmental quality as well as to financial reports and investments in socio-economic development made by the mining company.
- Land acquisitions and land-use changes: Local people must be consulted and informed.
- Local development plans: The authorities and the mining company must create official procedures to define and execute local development plans,

according to a community's prioritized needs (health, education, productive activities, transportation, infrastructure, recreation, etc.)

- Cultural impacts of proposed local investment projects.

3.6.6 Monitoring of threats to public safety

If a mining project chooses to dispose of its tailings in a wet tailings impoundment, then failure of the impoundment would constitute one of the most serious threats to public safety. For this reason, the Environmental Monitoring Plan should include details about how the operation and structural integrity of the tailings impoundment would be monitored to promptly detect possible structural problems and prevent potential disasters.

Mining experts recommend the following measures for monitoring a wet tailings impoundment:

"During mining operations, daily recordings should be taken of the following characteristics of tailings waste: consistency (water content), particle size distribution of incoming tailings, quantity of tailings deposited and volumes of water removed. These recordings allow a constant source of information about tailings quality, which will allow operators to predict and prevent potential disasters such as spills, dam failures and high toxicity."

"A continuous program of inspection and maintenance is necessary from the beginning of deposition throughout the life of the dam. Through careful monitoring, areas of concern may be noted and quickly repaired, thereby preventing failure. In addition to monitoring

the stability of the dam, the performance of liners and drainage systems can be evaluated. Monitoring wells are useful in monitoring seepage.

"Inspections are critical to effective implementation of a dam safety program. The frequency of inspection and the items for inspection will be set out in the Operation, Maintenance and Surveillance Manual. Inspections are most effective if they are carried out by the same group of staff over a period of time. Digital photography also assists in tracking the changes in a structure, if the photographs are properly annotated and filed for future reference.

"(By site personnel): Routine inspections on a weekly or monthly basis; Daily to weekly during wet season or during snow melt; and Monthly during dry season

"(By designer): Engineering inspections on a semi-annual to annual basis, Special inspections after significant events

"(By designer and site personnel): Following earthquakes and floods

"(By independent engineer [not the designer]) A dam safety review every 5 to 10 years"⁶⁶

The Environmental Monitoring Plan should include plans as least as detailed as those above for the monitoring of wet tailings impoundments.

66 Hewlett, L. (2007) "Tailings Dam Safety And Implementation Of Safety Guidelines By A Tailings Dam Operator." http://www.unece.org/env/teia/water/tailingdams/presentations/DE-NODam_Safety.ppt

3.7 EVALUATING THE RECLAMATION AND CLOSURE PLAN

As discussed in Chapter 1, the most serious and far-reaching environmental consequences of mining projects occur after mining ceases, during the closure period. Waste rock piles, open pits, tailings impoundments, and leach piles left behind and unattended by the mining company can begin generating and releasing highly toxic wastewaters that can cause immense damage to water resources and aquatic life.

As Conservation International explains:

“Although reclamation is often viewed as something to be done after mining activity ends, reclamation techniques cover a wide range of activities that should begin in the earliest planning phases of a mining project. Mining companies should include reclamation plans in their initial production development reports as well as in their environmental impact assessments (EIAs). Mining companies should plan for and incorporate reclamation activities concurrently with the mining of the site, in order to reduce waste early on and prevent expensive cleanup after the site has been closed.”⁶⁷

A mining project should not be approved unless the mining company has put forward a detailed, workable, and adequately funded plan to prevent environmental impacts for decades after mining ceases, and restore the ecology of the mine site as closely as possible to pre-mining conditions.

3.7.1 Conceptual versus actual plans

Many mining companies submit EIAs containing only a ‘conceptual’ Reclamation and Closure Plan, not an actual plan. The ‘conceptual’ plan may state very broadly what the mining company

might do to prevent environmental impacts during the closure period, but lack key details necessary to evaluate whether the plan would work. Some EIAs present a conceptual plan that is only a few pages long, lacking essential details.

Although it is important to acknowledge that conditions may change during the period of active mining (necessitating changes to the Reclamation and Closure Plan), the plan presented in an EIA – whether it is labeled ‘conceptual’ or not – must contain enough specific information to allow an independent appraisal of whether the plan in the specific context of the proposed mining activities is workable and adequately funded.

3.7.2 Post-mining land use and reclamation objectives

At its outset, the Reclamation and Closure Plan should specify the desired land uses for the site, post-mining. Post-mining land uses should resemble as closely as possible pre-mining conditions.

As Conservation International explains:

“Mine site reclamation, also called rehabilitation, refers to either the restoration of mined land to its pre-mining conditions, or alteration to make it available for another productive use. Specific goals of mine-site reclamation include the prevention of water contamination and sedimentation, the restoration of wildlife habitat and ecosystem health, and aesthetic improvement of the landscape. Although it will be impossible to fully restore pre-mining levels of diversity in an ecosystem such as a tropical rain forest, reclamation projects should have the ultimate goal of a post-mining landscape that is as close to the pre-mining landscape, physically and biologically, as possible.”⁶⁸

⁶⁷ Conservation International (2000) “Lightening the Lode: A Guide to Responsible Large-scale Mining.” <http://www.conservation.org/sites/celb/Documents/lode.pdf>

⁶⁸ Ibid.

The adequacy of specific measures included in the Reclamation and Closure Plan is judged on whether they attain the post-mining land uses specified in the plan.

3.7.3 Reclamation schedule

The Reclamation and Closure Plan must include a schedule of when reclamation and closure activities will commence and how long they will continue. It is important that mining companies begin to reclaim land damaged by mining activities as soon as possible. This means that mining companies should reclaim portions of mined land from which all ore has been extracted and other areas of the mine site that will no longer be used during the period of active mining (called 'progressive restoration'), and not wait until mining operations cease.

Environment Australia explains:

*"Best practice demands that mining is a tEnvironmental Monitoring Planorary user of land and that the land should be returned to some beneficial use for the community after mine closure. Landform design is critical to achieving this objective. Traditional mining activity either left the land with no shaping, or left any shaping until the end when the size of the problem and low cash flows generally resulted in a minimalist program of landscaping works. This approach also often meant that the best options for placement of contaminated or other hazardous materials such as rock with acid-forming potential to reduce long-term risk were no longer available."*⁶⁹

The IFC/World Bank Group explains:

"A key part of the closure plan is a commitment to progressive rehabilitation of the mine area, taking advantage of available personnel and equipment, minimizing the potential for

*contamination, and reducing final closure costs or the need for complex or sizable financial assurance."*⁷⁰

The Reclamation and Closure Plan must firmly commit the mining company to a reclamation schedule in which portions of mined land are reclaimed as soon as is practical during mining operations. In addition, it is important that the schedule for reclamation and closure disclose and discuss long-term activities that will be necessary to insure that reclamation and closure are successful.

For example, if an EMP for a mine facility calls for the treatment (rather than the prevention) of acid mine drainage (see Section 3.5.1.1) then the schedule for the Reclamation and Closure Plan should discuss how the mining company would insure that such treatment of acid mine drainage lasts for perpetuity.

3.7.4 Reclamation and closure of specific mine facilities

The Reclamation and Closure Plan should specify measures for the reclamation of key mine facilities, as follows:

3.7.4.1 Overburden and waste rock piles

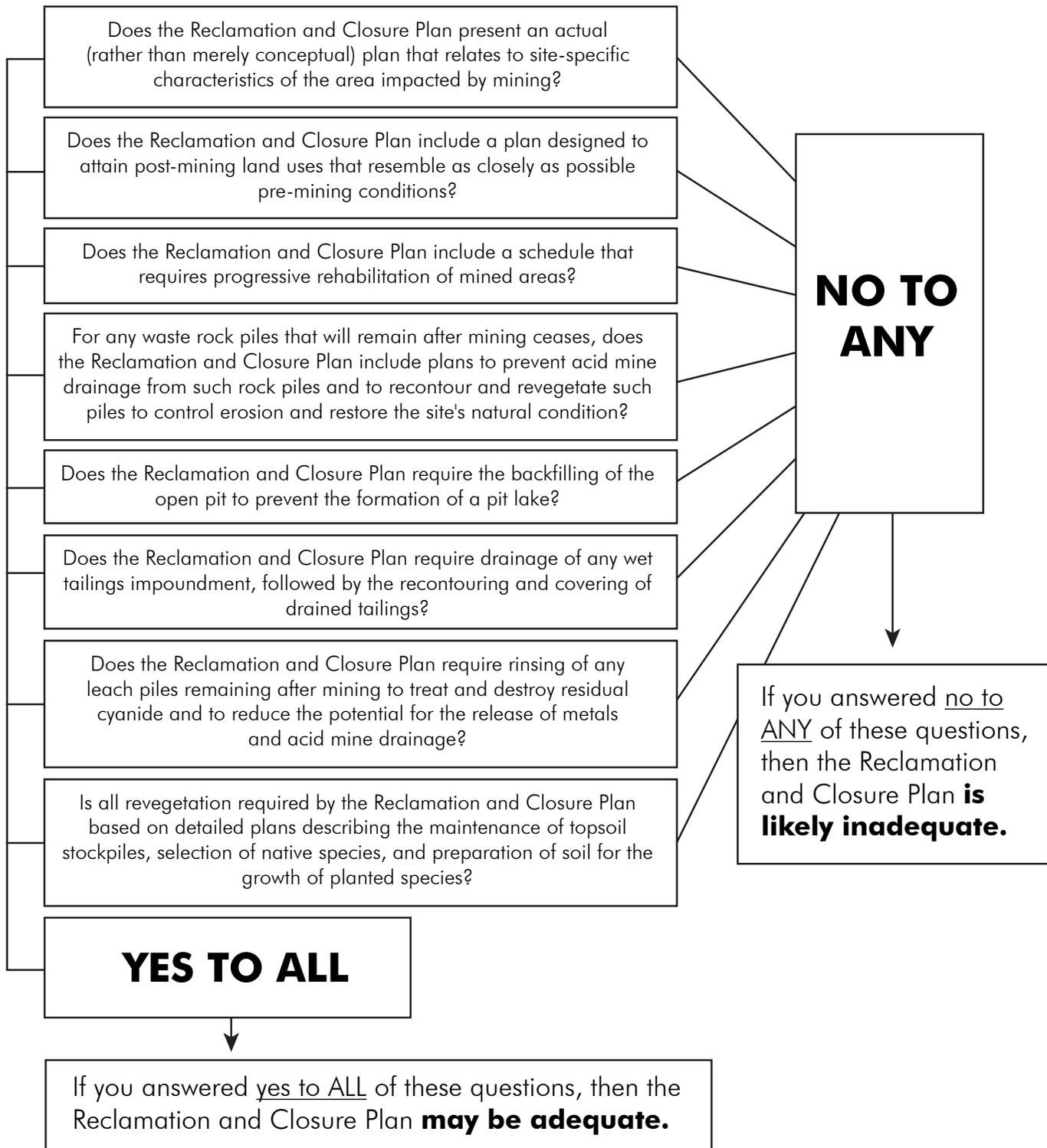
Overburden and waste rock are materials that a mining company should consider returning to open pits as backfill, to prevent pit lake formation. If a Reclamation and Closure Plan calls for return of overburden and waste rock, then reclamation and closure of these areas would simply require revegetation of these former waste disposal sites.

However, if the Reclamation and Closure Plan calls for leaving piles of overburden and waste rock in place after mining ceases, then the plan must provide detailed information about the final conditions of these waste piles. Most importantly, measures must be put in place to prevent any

⁶⁹ Environment Australia (2002) "Overview of Best Practice Environmental Management in Mining." <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMOverview.pdf>

⁷⁰ IFC/World Bank (December 2007) "Environmental, Health and Safety Guidelines for Mining." [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

FLOWCHART 3.6 - Evaluating the adequacy of the Reclamation and Closure Plan



potentially acid-generating materials in piles of overburden and waste rock from becoming acidic. These measures might include the construction of runoff diversion structures and the placement of caps of low-permeability material over the piles, to prevent water from infiltrating the waste piles. These measures might also involve addition of materials to the waste piles to prevent the initiation of acid-generating chemical reactions. A Reclamation and Closure Plan for overburden and waste rock piles should never call for allowing waste piles to generate acid mine drainage, which would necessitate long-term treatment.

As the Government in Quebec, Canada, explains:

“Waste rock pile rehabilitation must allow the chemical reactions generating acid water to be controlled at the source, prevent contaminated water flows, and allow contaminated water to be collected and treated. Use of effluent-treatment facilities (including diversion and collection ditches) does not constitute rehabilitation, but a temporary measure to be used while striving to meet ... standards or develop technically and economically viable rehabilitation methods.”⁷¹

After measures for the prevention of acid mine drainage at any piles of overburden and waste rock are left in place, the Reclamation and Closure Plan should specify the manner in which such piles would be contoured and revegetated to control erosion and restore the site’s natural condition.

3.7.4.2 Open pits

Open pits should normally be backfilled, recontoured, and revegetated to create a final surface that is consistent with the original topography of the area. The following are regulations from the Surface Mining and Reclamation Act (SMARA) of the California State Mining and Geology Board U.S. :

⁷¹ Ministère des Ressources naturelles et de la Faune (1997) “Guideline for preparing a mining site rehabilitation plan and general mining site rehabilitation requirements.” <http://mrnf.gouv.qc.ca/english/publications/mines/environment/guianmin.pdf>

“(a) An open pit excavation created by surface mining activities for the production of metallic minerals shall be backfilled to achieve not less than the original surface elevation, unless the circumstances under subsection (h) are determined by the lead agency to exist. ...

“(d) Backfilling, recontouring, and revegetation activities shall be performed in clearly defined phases to the engineering and geologic standards required for the end use of the site as stipulated in the approved reclamation plan. All fills and fill slopes shall be designed to protect groundwater quality, to prevent surface water ponding, to facilitate revegetation, to convey runoff in a non-erosive manner, and to account for long term settlement.

“(h) The requirement to backfill an open pit excavation to the surface pursuant to this section using materials mined on site shall not apply if there remains on the mined lands at the conclusion of mining activities, in the form of overburden piles, waste rock piles, and processed or leached ore piles, an insufficient volume of materials to completely backfill the open pit excavation to the surface, and where, in addition, none of the mined materials has been removed from the mined lands in violation of the approved reclamation plan. In such case, the open pit excavation shall be backfilled in accordance with subsections (b) and (d) to an elevation that utilizes all of the available material remaining as overburden, waste rock, and processed or leached ore.”⁷²

The Reclamation and Closure Plan should not allow for the formation of a pit lake. If the plan allows for the formation of a pit lake, the plan should include a detailed discussion of the efficacy and feasibility of all possible options for the prevention of acid mine drainage within the pit lake, the potential characteristics of pit lake

⁷² Surface Mining and Reclamation Act (SMARA) regulations of the California State Mining and Geology § 3704.1 Performance Standards for Backfilling Excavations and Recontouring Lands Disturbed by Open Pit Surface Mining Operations for Metallic Minerals <http://www.conservation.ca.gov/omr/smara/Documents/010107Note26.pdf>

effluent, and its impact on groundwater and adjoining surface waters.

3.7.4.3 Wet tailings impoundments

As discussed in Section 3.2.1.3, dewatering of tailings and their use as backfill (dry tailings disposal) is the environmentally-preferable option for tailings disposal. Therefore, the Reclamation and Closure Plan of a good EIA would not need to discuss reclamation and closure of a wet tailings impoundment because no such facility would be created. If the EIA calls for the creation of a wet tailings impoundment, then the Reclamation and Closure Plan should also call for dewatering (or draining) of the tailings impoundment during closure; although allowing tailings to remain perpetually submerged under a layer of water might be environmentally-preferable at mine sites with very high rainfall amounts.

The following discussion presented by Canadian mining engineers illustrates the pitfalls of allowing tailings to remain perpetually submerged under a layer of water.

“Considering the ‘collect and treat’ (long-term treatment phase) vs. the ‘water cover’ (closure phase) option for decommissioning of a tailings impoundment may present a serious dilemma. In general, while ‘no long-term treatment’ objective is preferred, the fact is that in general a tailings dam supporting water cover will be more hazardous in the very long-term as compared with a dam where the tailings pond is partially or fully drained. This is particularly evident when comparing a semi-pervious (e.g., ‘upstream’) or highly pervious (e.g., rockfill) tailings dam with allowance for long-term treatment, and a low permeability dam designed to support a water cover throughout the closure phase.

“Some confusion in this regard appeared in the late 1980s and 1990s in conjunction with considerations given to the ‘collect and treat’ vs. ‘water cover’ closure options for sites where tailings had the potential to impact runoff geochemistry, for instance, the potential

to generate ARD [acid rock drainage]. Some mine owners and regulators were under the impression that providing a permanent water cover supported by one or more dams, which would relieve the owner and, potentially, the public from the obligation to treat the tailings impoundment runoff in the long-term. It is understandable how the water cover gained appeal as at first glance it was clearly a highly desirable closure option. Besides significant technical and economic problems with flooding of some tailings deposits, this judgment was flawed since an implicit assumption was made that a flooded tailings impoundment would essentially be ‘care and maintenance’ free as long as an adequate spillway is provided. This certainly is not the case. While a water cover can indeed create a low oxygen diffusive environment, from a geotechnical perspective a flooded impoundment is certainly of higher risk with regard to essentially every nature of possible physical failure mode and needs to be considered as such for impoundments with a flooding plan for the closure condition. An allowance for long-term inspections, monitoring and maintenance must be made wherever a dam is left to support a water cover. In general, such an allowance will be less for dams where the tailings pond is partially or fully drained (and the residual risk of dam failure will be less as well).”⁷³

For this reason, under standards promulgated by the California State Surface Water Resources Control Board U.S., at mine closure, wet tailings impoundments must be drained and then subject to the following reclamation and closure measures: placement of a cover over the tailings; recontouring of the tailings to prevent ponding, erosion, and runoff; the maintenance of leachate collection and removal systems; and the performance of monitoring tests to prevent and detect groundwater contamination.

73 Szymanski, M.B & Davies, M.P. (2004) “Tailings dams : design criteria and safety evaluations at closure” British Columbia Mine Reclamation Symposium 2004. <http://www.infomine.com/publications/docs/Szymanski2004.pdf>



Aerial photo of Flambeau open pit mine before and after successful backfill operation
 PHOTO: Applied Ecological Services

See:

“(a) Closure Performance Standard — New and existing Mining Units shall be closed so that they no longer pose a threat to water quality. No post closure land uses shall be permitted that might impair the integrity of containment structures.

“(l) Tailings Pond Closure Standards — New and existing Group A and B tailings ponds shall be closed in accordance with the provisions ...

“(a) Remove Free Liquids — All free liquid remaining in a surface impoundment at the time of closure shall be removed and discharged at an approved waste management unit (Unit). All residual liquid shall be treated to eliminate free liquid.

“Closure and Post-Closure Maintenance Requirements for Solid Waste Landfills...

“(a) Final Cover Requirements — Final cover slopes shall not be steeper than a horizontal to vertical ratio of one and three quarters to one, and shall have a minimum of one fifteen-foot wide bench for every fifty feet of vertical height...

“(b) Grading Requirements. (1) Prevent Ponding, Erosion, and Run-On. (2) Steeper-Sloped Portions — Areas with slopes greater than ten percent, areas having surface drainage courses, and areas subject to erosion by water or wind shall be protected from erosion or shall be designed and constructed to prevent erosion. (3) Precipitation & Drainage Plan — The final closure plan for the Unit shall incorporate a precipitation and drainage control plan for the closed landfill...

“(c) General Post-Closure Duties — Throughout the post closure maintenance period, the discharger shall: (1) maintain the structural integrity and effectiveness of all containment structures, and maintain the final cover as necessary to correct the effects of settlement or other adverse factors; (2) continue to operate the leachate collection and removal system as long as leachate is generated and detected; (3) maintain monitoring systems and monitor the ground water, surface water, and the unsaturated zone [and]... (4) prevent erosion and related damage of the final cover due to drainage...”⁷⁴

74 California State Water Resources Control Board, Mining Waste Management Regulations. 22510. SWRCB - Closure and Post Closure Maintenance of Mining Units. (C15: Section 2574) <http://www.calrecycle.ca.gov/Laws/Regulations/Title27/ch7sb1.htm>

3.7.4.4 Leach and dump piles

Mining projects that involve cyanide heap leaching or copper dump leaching leave behind mine waste piles (leach piles) that require special consideration. After active mining ceases, huge piles of waste nearly always contain excessive levels of a variety of contaminants (salts, metals, cyanide) that require detoxification to prevent acid mine drainage.

The U.S. EPA explains:

“There are three fundamental approaches to the decommissioning of cyanide-contaminated ore heaps. The first is to leave the heap alone and allow the cyanide to degrade, perhaps slowly, but without any human intervention. The second is to dismantle the heap and treat the ore in smaller batches. This approach may be necessary when sections of the heap have become impermeable or when it is desired to reclaim the leach pad area for other uses. The third approach is to rinse the heap to flush out cyanide, with the rinse solution then being treated by any of the methods described below. Ore heaps may be rinsed with fresh water or with recycled rinse water that has been treated so that it contains little cyanide. The rinse medium may or may not contain chemicals designed to oxidize the residual cyanide as it trickles through the heap.”⁷⁵

A publication by U.S. mining engineers explain how rinsing of heap piles is a requirement in U.S. State environmental standards:

“Closure regulations... require rinsing of the heap until the WAD cyanide level is reduced to 0.2 mg/l or less, pH is in the range of 6 to 9, and other contaminants are at levels which will not degrade waters of the State... this regulation allows alternate methods of chemical stabilization to be used, if the operator can demonstrate that the resulting

effluent will not degrade waters of the State. Therefore, detoxification with chemicals such as hypochlorite or hydrogen peroxide may be approved. Biological detoxification is also being approved with the use of cyanide consuming bacteria. In addition, technologies are available which provide a bio-reduction of metals in the heap. There are currently a number of proven and developing technologies that are available to provide adequate stabilization of spent heap ore.”⁷⁶

Unfortunately, while this suggestion appears reasonable, it is rarely sufficient to render a heap “detoxified”. Rinsing with fresh water requires very large amounts that will also require treatment and is rarely (if ever) currently done in arid locations. In most cases, the goal is to economically reduce the amount of water that needs to be treated, and this involves recirculating the water draining from the heap to the top of the heap, where a portion of it evaporates.

Following months of recirculating the water, the pH will be reduced to less than pH 9, the cyanide will be oxidized or evaporate, and a portion of the residual cyanide will be converted to nitrate. However, the salts will be concentrated and retained. Further rinsing with fresh water can remove a portion of the salts, but is rarely done, since arsenic and antimony are effectively impossible to completely rinse from a heap.

Thus, most mines simply recirculate the very contaminated water until the volume of residual water draining from the heap is dramatically lowered, or in some cases, completely stopped. In wetter climates or during wet periods in dry climates, water from rain or snow will re-initiate drainage and plans for management of that water must be implemented and planned for the very long-term. Unfortunately, rinsing of heaps is problematic, and even when caps are placed on the top of heaps, drainage remains a long-term concern.

⁷⁵ United States Environmental Protection Agency (1994) “Technical Report: Treatment of Cyanide Heap Leaches and Tailings.” <http://www.epa.gov/epawaste/nonhaz/industrial/special/mining/techdocs/cyanide.pdf>

⁷⁶ Burkhalter, C.J. et al (1999) “Precious Metals Heap Leach Facilities Design, Closure and Reclamation.” http://www.unr.edu/mines/mlc/conf_workshops/book1/chapter29.pdf

Even after heap piles have been rinsed and treated to destroy residual cyanide and reduce the potential for the release of metals and acid mine drainage, the reclamation and closure of heap piles presents similar problems as the reclamation and closure of overburden and waste rock piles.

Thoroughly rinsed leach piles are materials that a mining company should consider returning to any open pits as backfill to prevent pit lake formation. If a Reclamation and Closure Plan calls for the backfilling of leach pile materials to open pits, then reclamation and closure of these areas would simply require revegetation of these former waste disposal sites. For any leach piles that are left in place, the Reclamation and Closure Plan must impose measures for the prevention of acid mine drainage and should specify the manner in which such piles would be contoured and revegetated to control erosion and restore the site's natural condition.

3.7.5 Revegetation

Revegetation is an essential and oft-promised element of mine Reclamation and Closure Plans. Actual revegetation is easy to describe on paper, but very difficult to accomplish in practice. It requires attention to details such as maintenance of topsoil stockpiles, selection of native species, and preparation of soil for the growth of planted species.

As Conservation International explains:

"Because the reclamation objective is usually the restoration of native vegetation, the species of vegetation are pre-determined. Companies need to be careful about possible changes that mining operations may have caused in the soil, and should make sure that native species would thrive if this were the case.

"In restoring tropical forest ecosystems, the goal is to develop an ecosystem that will move through the stages of succession and facilitate the accumulation of biomass. The diversity of plants and their physical requirements (shade,

humidity, lower temperatures) in a mature system are such that colonizing plants should be used to condition the soil and provide a more appropriate habitat for the later stage plants. Colonizers can be identified during the operation of the mine and then used in the initial rehabilitation of the land.

"The timing of seeding is important for successful revegetation. Usually seeding should take place immediately before rains begin or early on in the rainy season. In tropical areas, seeding should take place during the wet season. Fertilizer is commonly used to speed up natural processes by increasing species number, plant cover and density, and growth rates. Companies should be careful when using fertilizers, however, to avoid the destruction of seedlings and the growth of unwanted vegetation."⁷⁷

In light of the difficulty of achieving successful revegetation of mined areas, the Colorado Department of Natural Resources, Division of Minerals and Geology (U.S.), requires the following information to be part of a mining company's reclamation plan:

"(1) In those areas where revegetation is part of the Reclamation Plan, land shall be revegetated in such a way as to establish a diverse, effective, and long-lasting vegetative cover that is capable of self-regeneration without continued dependence on irrigation, soil amendments or fertilizer, and is at least equal in extent of cover to the natural vegetation of the surrounding area. Except for certain post-mining land uses approved by the Board or Office, the use of species native to the region shall be emphasized. Greater emphasis on non-native species may be proposed for intensively managed forestry and range uses.

...

"(4) The revegetation plan shall provide for the greatest probability of success in plant

⁷⁷ Conservation International (2000) "Lightening the Load: A Guide to Responsible Large-scale Mining." <http://www.conservation.org/sites/celb/Documents/lode.pdf>

establishment and vegetation development by considering environmental factors such as seasonal patterns of precipitation, temperature and wind; soil texture and fertility; slope stability; and direction of slope faces. Similar attention shall be given to biological factors such as proper inoculation of legume seed, appropriate seeding and transplanting practices, care of forest planting stock, and restriction of grazing during initial establishment.

“(5) To insure the establishment of a diverse and long-lasting vegetative cover, the Operator shall employ appropriate techniques of site preparation and protection such as mechanical soil conditioning by discing and ripping; mulching; soil amendments and fertilizers; and irrigation. ...

“At a minimum, the Operator/Applicant must include the following information:

“(b) the estimated depth to which soil, suitable as a plant growth medium, will be salvaged for use in the reclamation process. ... Sufficient soil must be salvaged to meet the vegetation establishment criteria... If plant growth medium is not reapplied on a graded area immediately after salvage, then the Operator/Applicant must specify how the topsoil will be stockpiled and stabilized with a vegetative cover until used in reclamation. Plant growth medium stockpiles must be located separate from other stockpiles, out of the way of mine traffic and out of stream channels or drainageways. The location of plant growth medium stockpiles must be shown...”⁷⁸

This model shows that the Reclamation and Closure Plan must contain similar details about how revegetation would succeed under prevailing conditions at the mine site.

3.7.6 Financial assurances for reclamation and closure

Sadly, reclamation often begins at the end of mining, when the mining company does not have the money or interest in proper reclamation. Without an adequate bond for reclamation, the promises of a mining company for reclamation go unmet. A bond for full reclamation by a third party contractor provides an incentive for the mining company to fully reclaim the site.

One of the most important questions an EIA for a proposed mining project must address is: Who will pay to reclaim the mine site and/or cleanup a mess if things go wrong? Unless a responsible government has made steadfast, prior provisions for the mine owner to pay, the government will be left with the choice of paying staggering reclamation and cleanup costs or leaving its citizens to suffer. The National Wildlife Federation describes the experience in the U.S.:

“For more than 150 years, America’s quest to locate and extract copper, lead, silver, gold and other precious metals from the mountains of the West dramatically influenced the way the region was settled and developed.

“While Americans have enjoyed short-term economic prosperity from mining, we now know that it has come at a terrible cost. Once teeming with big game and sage grouse, the majestic mountains and rolling grasslands of the West have been ravaged by hard rock mining. The sight of waste rock dumps, tailings piles, mined pits, and tunnels into mountainsides is all too common. While these sights are alarming, historic and even present day mining operations have another less obvious, but far more ominous legacy: air and water pollution that threatens human health.

“Despite more than 25 years of progress under the Clean Water Act, many Western waters remain dangerously polluted from active, inactive and abandoned mine runoff. Mining companies too often walk away from the

⁷⁸ Colorado Department of Natural Resources, Division of Minerals and Geology - Hard Rock Rules Effective October 1, 2006 <http://mining.state.co.us/rulesregs/HR%20and%20Metal%20adopted%20Aug%209%202006%20indexed.pdf>

pollution they've created, without restoring or "reclaiming" the land they've damaged, forcing taxpayers to pick up the tab for the clean-up. ...

*"Reclamation bonding is meant to serve as an "insurance policy" against pollution problems. It is a cache of money that mining companies are required to put down before beginning work, and which can be used for clean-up down the road, if needed."*⁷⁹

The International Institute for Sustainable Development describes the situation more broadly:

"There are real and significant financial considerations with respect to mine closure and site rehabilitation, especially given that closure and rehabilitation occur at a time when the operation is no longer financially profitable. Among others, 'this is one major reason why governments are increasingly requiring companies to provide guarantees for mine closure, sometimes referred to as reclamation funds prior to a mine opening and it is important that these funds be established in accordance with both best accounting practices and in accordance with the tax provisions in the mine's jurisdiction.'

"In many countries with underdeveloped economies, the lack of implementation of mine closure programs has resulted in significant adverse environmental impacts. As Nazari suggests, 'in contrast to countries that have already implemented 'good international mining practices', these Economies in Transition have yet to develop a similarly sophisticated corporate governance, regulatory framework or financial and insurance market to address mine closure and secure its funding.'

"It seems that it is a good idea to demand a financial guarantee for newly permitted mines. The financial guarantee should consist of enough money to assure reclamation of the

*site at an agreed upon 'worst case scenario'. This encourages better mine operation and closure planning since generally mine planning becomes more efficient when money is involved."*⁸⁰

3.7.6.1 Timing of provision of financial assurances

The IFC/World Bank Group cautions that:

*"The costs associated with mine closure and post-closure activities, including post-closure care, should be included in business feasibility analyses during the planning and design stages. Minimum considerations should include the availability of all necessary funds, by appropriate financial instruments, to cover the cost of closure at any stage in the mine life, including provision for early, or temporary closure."*⁸¹

According to the World Bank Group Oil, Gas and Mining Policy Division:

*"Public involvement: Since the public runs the risk of bearing the environmental costs not covered by an inadequate or prematurely released bond, the public must be accorded an essential role in advising authorities on setting and releasing of bonds. Therefore, regulators must give the public notice and an opportunity to comment both before the setting of a bond amount and before any decision on whether to release a bond."*⁸²

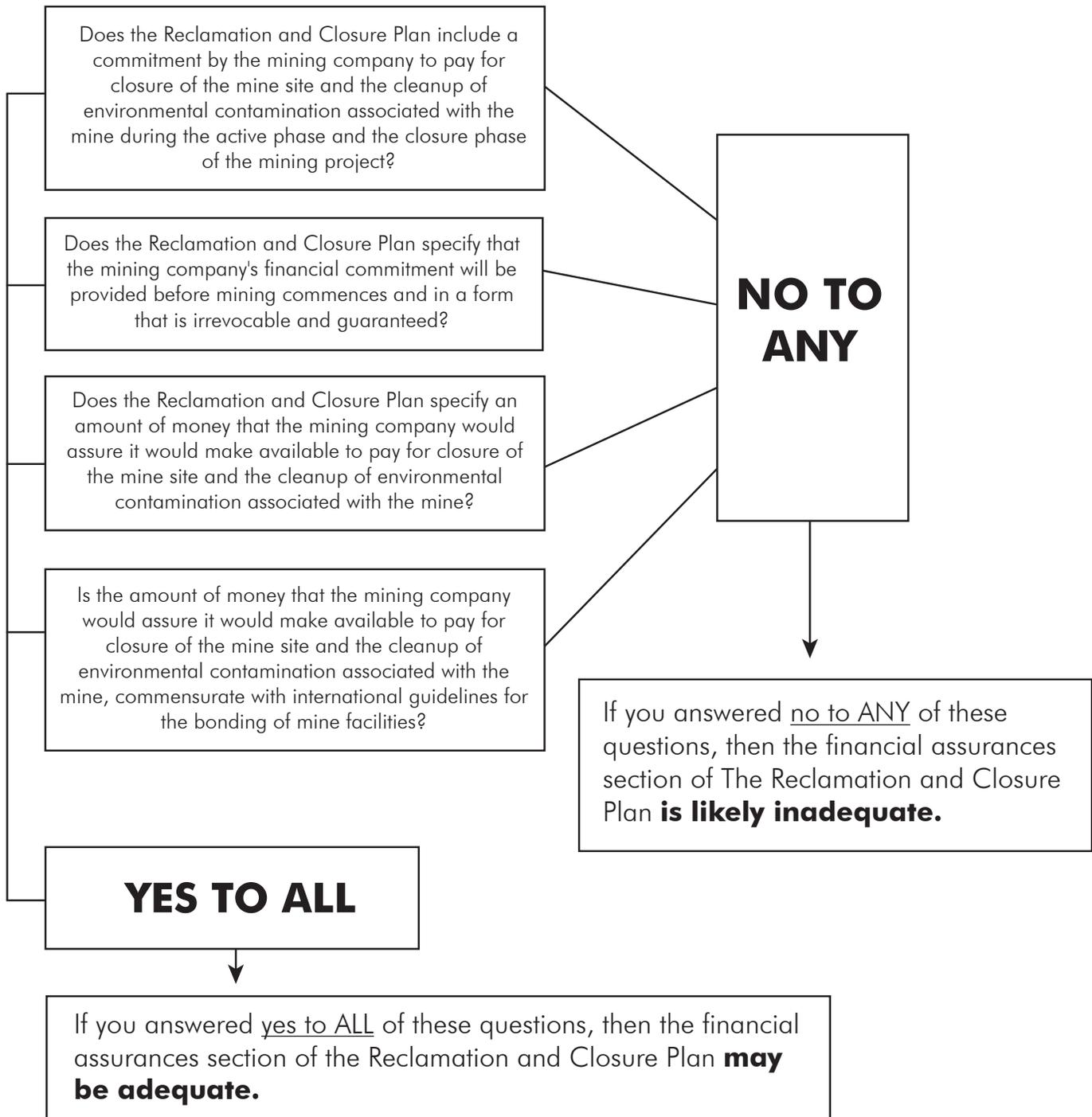
⁷⁹ National Wildlife Federation (February 2000) "Hardrock Reclamation Bonding Practices in the Western United States." http://www.earthworksaction.org/pubs/hardrock_bonding_report.pdf

⁸⁰ International Institute for Sustainable Development (January 2002) "Research on Mine Closure Policy" http://www.iiied.org/mmsd/mmsd_pdfs/044_cochilco.pdf

⁸¹ IFC/World Bank (December 2007) "Environmental, Health and Safety Guidelines for Mining." [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

⁸² World Bank Group, Oil Gas and Mining Policy Division (2008) "Guidance Notes for the Implementation of Financial Surety for Mine Closure." http://siteresources.worldbank.org/INTOGMC/Resources/financial_surety_mine.pdf

FLOWCHART 3.7 - Evaluating the adequacy of financial assurances



3.7.6.2 Adequate forms of financial assurances

The IFC/World Bank Group recommends that:

“Funding should be by either a cash accrual system or a financial guarantee. The two acceptable cash accrual systems are fully funded escrow accounts (including government managed arrangements) or sinking funds. An acceptable form of financial guarantee must be provided by a reputable financial institution.”⁸³

The State of Colorado (U.S.) imposes the following requirements:

“All Financial Warranties shall be set and maintained at a level which reflects the actual current cost of fulfilling the requirements of the Reclamation Plan; and for Designated Mining Operations, fulfilling the applicable requirements of the reclamation and Environmental Protection Plans during site closure and reclamation.

“Proof of financial responsibility may consist of any one or more of the following, subject to approval by the Board: ...

“Cash or Certified funds assigned to the Board ...

“A fund of cash or cash invested in [specified securities, time deposits or repurchase obligations]

“A Surety Bond issued by a corporate surety authorized to do business in this state.

“An Irrevocable Letter of Credit issued by a bank authorized to do business in the United States; the Operator/Applicant must provide evidence that the bank issuing the Letter of Credit is in good financial standing and

condition, as may be evidenced by its rating by an appropriate rating system.

“A Certificate of Deposit assigned to the Board.

“A Deed of Trust or security agreement encumbering real or personal property and creating a first lien in favor of the State.

“Self-insurance through credit rating or net worth...

“A trust fund which shall be funded by periodic cash payments representing a fraction of total receipts, providing assurance that the funds required for reclamation will be available.
“Credit for the Salvage Value of project-related fixtures and equipment (excluding rolling stock) owned or to be owned by the Financial Warrantor within the permit area, represented by a security agreement creating an equipment lien, less the value of any encumbrances of higher priority, which encumbrances shall be limited to government encumbrances. ...

“A Deed of Trust or security agreement encumbering specific project-related fixtures and equipment that must remain on-site upon completion of mining operations, or that must be demolished or removed in order for the Reclamation Plan to be performed, creating a first priority lien in favor of the State [and]

“A Treasury note backed by the full-faith and credit of the United States Government.”⁸⁴

One form of bond that should not be acceptable is a “corporate” bond, where a percentage of the cost of reclamation is not required as an actual financial instrument, simply because a company has large resources available. Substantial problems have occurred in Nevada (U.S.) because of this. A corporate bond is not a guarantee that the mining company will reclaim mined lands.

83 IFC/World Bank (December 2007) “Environmental, Health and Safety Guidelines for Mining.” [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

84 Colorado Department of Natural Resources, Division of Minerals and Geology - Hard Rock Rules Effective October 1, 2006 <http://mining.state.co.us/rulesregs/HR%20and%20Metal%20adopted%20Aug%209%202006%20indexed.pdf>

3.7.6.3 Adequate amounts of financial assurances

The cost of reclaiming the mine should be based on the cost of the agency contracting with a third party to conduct the reclamation. This should include the administrative costs by the regulatory agency to contract with the third party reclamation firm to conduct the reclamation. In nearly every case, the cost of a third party contractor to conduct the reclamation will be much larger than the cost of the mining company performing the reclamation, due to costs of studying the mine and mobilization of equipment.

According to the World Bank Group Oil, Gas and Mining Policy Division:

“Closure costs for environmental issues range from less than US\$1 million each for small mines in Romania to hundreds of millions of dollars for large lignite mines and associated facilities in Germany. More typically, closure costs will range in the tens of millions of dollars. Preliminary research indicates that medium-size open pit and underground mines operating in the past 10 to 15 years cost US\$5-15 million to close, while closure of open pit mines operating for over 35 years, with large waste and tailings facilities, can cost upwards of \$50 million.”⁸⁵

In Western Australia:

“The [unit performance bond] UPB is determined using the area of disturbance information provided in the mining proposal. The amount is calculated using rates from a minimum of A\$3,000 per hectare for simple rehabilitation on level ground (and low mobilisation costs) to more than A\$30,000 per hectare for areas with major rehabilitation challenges, or where a full cost recovery bond is deemed as being warranted.

“The UPB covers all land disturbed by mining and where rehabilitation is required but with the total amount apportioned over each tenement i.e. separate pro rata bond amount are lodged for each tenement affected by the mining proposal. Common bonded areas include: waste dumps, tailings facilities, stockpile areas, backfilled pits, hardstand areas, plant sites, camp sites, haul roads, hard stand and laydown, areas, airstrips, accommodation areas and the safety zone around any abandoned open pit.”⁸⁶

In Western Australia, tailings facilities are bonded at a minimum rate of A\$12,000 per hectare, and waste rock piles are bonded at a rate of A\$10,000 per hectare.⁸⁷

85 World Bank Group, Oil Gas and Mining Policy Division (2008) “Guidance Notes for the Implementation of Financial Surety for Mine Closure.” http://siteresources.worldbank.org/INTOGMC/Resources/financial_surety_mine.pdf

86 Western Australia Department of Industry and Resources (DoIR) (December 2006) “Review of Environmental Performance Bonds in Western Australia.” http://www.dmp.wa.gov.au/documents/ED_Min_GL_ReviewOfEnvPerformanceBonds_Dec06.pdf
87 Ibid.

4. How to be an Effective Participant in the EIA process

Principle 10 of the Rio Declaration states “[e]nvironmental issues are best handled with participation of all concerned citizens”⁸⁸ and outlines three essential elements to public involvement: access to information; opportunity to participate in the decision-making process; and effective access to administrative and judicial proceedings.

These elements are often referred to collectively as “public participation.” Each participatory element strengthens environmental decision-making by facilitating information exchange and understanding, increasing transparency, and improving accountability.

People living near the site of a proposed project know best about the possible impacts of a project on the local environment or community resources, and may introduce new ideas or identify possible impacts that may not have otherwise been considered. Public participation can also forge lines of communication among communities, the project proponent, and the government, that will

continue through to project implementation or other future projects. For these reasons, it is very important to understand and use every opportunity to engage in the EIA process.

PRINCIPLE 10

Environmental issues are best handled with participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

⁸⁸ Rio Declaration on Environment and Development, Principle 10 (1992). United Nations Environmental Programme (UNEP) Goals and Principles of Environmental Impact Assessment, Principle 7(1987). <http://www.unep.org/Documents.Multilingual/Default.asp?documentid=78&articleid=1163>

4.1 UNDERSTANDING THE REGULATORY FRAMEWORK

Public participation encompasses many different activities – from seeking information about a project, to writing comments on a draft EIA, to filing a court case challenging a decision. These opportunities will frequently be explained in different laws within a jurisdiction where a proposed mine may be located.

The first step should be to identify the laws that apply to a proposed mining project and what obligations are created on the part of the government and the project proponent by these laws. Although this Guidebook focuses on the EIA process, there may be other permitting steps that occur before, during, or after the EIA process. These permitting procedures may include additional opportunities for public participation. For example, a mining company may need to apply for pollution discharge permits, acquire water rights, seek permission to build roads, or obtain a source of electrical power for operations, any of which may be authorized in a distinct procedure separate from the EIA process.

Therefore, it is important to review the general regulatory landscape in a particular country where a mining project is being proposed. In addition to a mining law, laws governing forests, protected areas, wildlife, wetlands, cultural resources, or customary land tenure may contain requirements that apply to mining projects.

Turning back to the EIA process, laws governing the EIA process might be found within a general environmental law, sometimes known as a framework law or an umbrella law, or there may be a specific EIA law. As outlined in the following, access to information and administrative procedure laws are also important to the EIA process. Some countries' constitutions may be part of the regulatory framework if they create rights to environmental information or have other provisions that might be implicated in decisions about a proposed mine. Some EIAs may even be prepared in the absence of a law that requires one.⁸⁹

⁸⁹ See, e.g., *Save Guana Cay Reef Association Ltd. v. The Queen & Ors* (Bahamas) [2009] UKPC 44, at para. 12 (“The preparation of the EIA in this case, and its submission to The Bahamas Environment, Science and Technology Commission (BEST Commission) was in accordance with what has become the usual practice, but it is not a practice required by statute.”).

4.2 UNDERSTANDING PUBLIC PARTICIPATION RIGHTS AND OPPORTUNITIES

Public participation requirements and implementation vary widely, depending on the particular EIA system. Some laws require extensive public involvement as part of the EIA process,⁹⁰ while others make it discretionary, or are silent on the matter. There is growing recognition that the public has the right to meaningfully participate in the EIA process. Some courts have even ruled that the public must be properly consulted, even when there is no law specifically governing the process.⁹¹

The terminology used in EIA systems to describe public involvement can be confusing. Terms such as “inform,” “consult,” and “participate” may seem similar, but in fact have very different implications

for public involvement. Agencies, ministries, and project proponents may take advantage of this ambiguity to minimize or even eliminate public participation in the decision-making process.

Depending on the term used, public participation will fall in a range from passive to active.

“Inform” represents the most passive form of public involvement. To “inform” means the flow of information is generally one way, from the government or the project proponent to the public. In this case, information can even be given after a decision has been made. “Consult” or “consultation” is less passive, and means that there is an exchange of information and opinions among the public, the government, and the project proponent. In this case, citizens and other interested parties may be asked questions or given opportunities to provide their views. Depending on the EIA system, the decision-maker may be required to take these views into consideration. “Participate” is more active and means that the public has a substantive role in the EIA process, including opportunities to influence the project design and permitting decision.⁹²

Regardless of the terminology used, citizens should strive to engage as fully and effectively as possible in the EIA process.

90 Examples of EIA systems with more detailed public participation provisions include China, the European Union (through the Aarhus Convention), and the United States. See, e.g., The Provisional Measures on Public Participation in Environmental Impact Assessment, 2006 (China); Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (1998) (“Aarhus Convention”); 40 C.F.R. §§ 1502.19, 1503, 1506.6 (United States). See also the European Commission’s legislation implementing the Aarhus Convention, which is listed at <http://ec.europa.eu/environment/aarhus/#legislation>.

91 *The Northern Jamaica Conservation Association v. The Natural Resources Conservation Authority & Anor* [2006] HCV 3022 of 2005 (available at <http://www.elaw.org/node/1629>). See also *Regina v. North and East Devon Health Authority, ex parte Coughlan* [2001] QB 213, 258 (“It is common ground that, whether or not consultation of interested parties and the public is a legal requirement, if it is embarked upon it must be carried out properly. To be proper, consultation must be undertaken at a time when proposals are still at a formative state, it must include sufficient reasons for particular proposals to allow those consulted to give intelligent consideration and an intelligent response; adequate time must be given for this purpose; and the product of the consultation must be conscientiously taken into account when the ultimate decision is taken.”).

92 For an example of how public participation terminology is defined, see Part 1 of the Public Participation Guide published by the Canadian Environmental Assessment Agency. The guide is available online at <http://www.ceaa.gc.ca/default.asp?lang=En&n=46425CAF-1&offset=4&toc=show>

4.3 ACCESS TO INFORMATION AND EIAs

Under most systems, EIA documents must be made available for public review. There is likely to be at least one designated public place where an EIA will be made available. This might be an agency office, on the internet, or at public libraries.

Some EIA laws require that the public have access to background information or supporting documents used to prepare the EIA. If it is not clear, citizens should insist that they have the right to access these documents, especially documents

that are referenced in the EIA itself. Note that other laws, particularly access to information laws, may govern what documents the public has the rights to access.

It is not uncommon to find discrepancies between the EIA and the underlying scientific and technical documents. These discrepancies can be used to demonstrate that the statements and conclusions contained in the EIA are flawed.

4.4 THE IMPORTANCE OF PARTICIPATING AS EARLY AS POSSIBLE

Ideally, citizens should participate in an EIA process as early as possible – even at the screening stage. In many EIA systems, however, the first opportunity for public involvement is during the scoping process. At this point, it is important to ensure that significant issues are identified and alternative ways of implementing the project are considered.

As soon as an EIA process is underway for a proposed mining project, citizens need to find a way to get involved in the process, to insure that the EIA includes accurate information that adequately reflects environmental concerns and concerns of local communities.

The earlier that citizens can get involved in the process, the more likely they will be able to influence decisions about the project. It is easier to change a project while it is being designed than after studies are completed and the EIA is already drafted. Also, it is easier for the decision-maker or project proponent to dismiss or ignore public comments if they are received late in the process.

If a community learns about an ongoing EIA process and has missed the opportunity to comment during the screening or scoping phases, the community should not give up hope. Public participation is critical at all stages in the EIA process and, in some systems, it is required to have participated in the review process before one can challenge the EIA in court.

4.5 HOW TO PREPARE EFFECTIVE WRITTEN COMMENTS

In outlining the goals and principles of the EIA process, UNEP determined that “government agencies, members of the public, experts in relevant disciplines and interested groups should be allowed appropriate opportunity to comment on the EIA” before a decision is made on an activity that is likely to significantly affect the environment.

Laws governing the EIA process will likely specify a period of time for the public to review a draft EIA and submit written comments. If the law does not specify, the agency or ministry may issue a notice indicating the date when comments are due. If an EIA is particularly long or involves complex issues, consider seeking an extension of time to file written comments.⁹³

⁹³ United Nations Environment Programme (UNEP), *Goals and Principles of Environmental Impact Assessment*, Principle 7 (1987).

Rather than making generalized statements about how the project will affect you, your community, or the surrounding environment, your comments will be more effective if they specify provisions of domestic laws and regulations that the EIA or proposed project violate. If your constitution guarantees access to clean water or guarantees a right to live in a healthy environment, it is recommended that these legal rights be highlighted in your written comments if they are likely to be affected by a proposed mining project.

Submitting written comments is important for demonstrating, in later stages, that you participated in the EIA review. If you decide to appeal the approval of an EIA for a particular mine project, your case will be stronger if your written comments cover all the issues you may later want to raise in court.

4.6 HOW TO PARTICIPATE EFFECTIVELY AT PUBLIC HEARINGS

Before participating in a public hearing, it is important to consider the target audience. Are you only trying to inform the decision-makers or are you also trying to engage the public and the media? Most participants in public hearings are trying to address both audiences. Therefore, while your written comments may have tied most of your concerns to the legal duties of the agencies involved, your oral testimony at a public hearing should highlight impacts that will affect the community at large and explain why others should share your concerns.

If there are issues of particular importance, consider putting these on paper in a simple, bulleted form and handing them out at the beginning of the hearing. This will encourage others to address your points as well.

Before a hearing, it is a good idea to find respected experts, such as medical doctors or toxicologists, who understand the likely impact of a proposed project and are willing to testify at the hearing. It is also a good idea to make sure that members of the local community who may be affected by the project are there, in large numbers, to testify about their concerns.

At some public hearings it is a good idea to get on the agenda for the hearing as early as possible. If the media is covering the event, they may not stay for the whole hearing and may be influenced by what takes place early on. It is also important to alert the media, to make sure they cover the hearing.

4.7 CHALLENGING ADVERSE DECISIONS MADE DURING THE EIA PROCESS

The opportunity to seek administrative or judicial review of substantive and procedural outcomes of the EIA process is an important measure for maintaining fairness and transparency. The prospect of having an independent arbiter review a decision imposes an element of accountability on the decision-maker. The availability of administrative and judicial review also enables citizens to enforce their participatory rights and right to access environmental information.

4.7.1 Administrative review

For parties who disagree with a decision made during the EIA process, or if the process itself was flawed, the next step will often be to seek administrative review of the decision. In general, this means that the decision will be reviewed by a higher-level official within the agency or ministry that made the decision, or by an administrative court. In many jurisdictions, courts of law will not accept a petition for judicial review if a party has not sought administrative relief first.

Administrative appeals can be useful because they tend to be less expensive and quicker than judicial proceedings and provide an opportunity to refine arguments that may be made later in a court of law. Agency officials or administrative courts may be more familiar with the subject matter and issues of law. But administrative appeals can be equally

frustrating if there is corruption or delay due to improper outside influence or a backlog of cases.

Many jurisdictions guarantee citizens the right to administratively appeal a decision made by a public authority. There are three basic principles of administrative law that guide decision-making:

1. The decision-maker must take into account all relevant considerations and may not be influenced by outside information or demonstrate bias;
2. Discretionary powers must be exercised within the bounds of the legislation that grants the authority (e.g., a decision cannot be ultra vires); and
3. People affected by an administrative decision are entitled to procedural fairness.

If one or more of these principles is violated, there may be grounds to seek administrative review of the decision. It is very important to be aware of appeal deadlines, which are usually much shorter than civil statutes of limitation. The EIA law or a general administrative procedure law will set out these deadlines, stating that an appeal or petition must be filed within a certain number of days of the decision being made.

Typical Appeal Points

- Failure to disclose certain adverse environmental impacts
- Lack of or inadequate opportunities for public participation
- Omissions in the required content of the EIA (e.g., inadequate range of alternatives, lack of mitigation measures, failure to evaluate cumulative impacts)
- Improper or lack of adequate notice of availability of EIA for public review

Administrative review, as the name implies, typically involves a review of the documents that were gathered or prepared during the EIA process (also called a “record”) to determine whether the decision was proper. Usually, there is no opportunity to introduce new information and a party will be limited to providing a statement of reasons supporting the appeal. Because the scope of review is limited, administrative appeals will be most successful if they point to errors or flaws in the EIA process or to specific examples where the EIA does not satisfy the content requirements set forth in applicable law.

4.7.2 Judicial review

If the decision-maker acts improperly or if the decision does not meet substantive requirements of the EIA law, then the decision may be reviewed by a court, provided that the jurisdiction permits judicial review. Although Principle 10 of the Rio Declaration and other international laws recognize a citizen’s right to access effective judicial proceedings and to obtain redress and remedy in environmental matters, not all countries acknowledge this right and have insulated ministerial decisions from judicial review.

Even when judicial review is available, courts are generally not permitted to exercise *de novo* review of an administrative decision. Rather, the court will look to see whether the EIA process was followed correctly and, in some cases, whether the decision meets substantive requirements in the EIA law. The court’s authority and permitted grounds for review will be described by a statute – such as an administrative procedure, civil procedure, or judicial review act. Some jurisdictions have specialized courts to review administrative decisions. It is important to understand the bounds of the court’s discretion and what issues it may review so that the claims may be properly stated. A court case will not be successful, or may even be dismissed, if a party raises issues that the court does not have authority to review.

Judicial review may be complicated by certain legal and practical limitations, such as the high

cost of obtaining legal representation and expert witnesses, the possibility of costs being awarded against an unsuccessful petitioner, and standing requirements that severely restrict the scope of possible plaintiffs. Some jurisdictions have enacted provisions to reduce costs for public interest cases or have softened standing requirements, but litigation is still expensive. Even if a party is able to get through the courthouse door to challenge the approval of a mining project, judges are often reluctant to overturn or even scrutinize administrative decisions, particularly when a dispute centers on technical issues that are within an agency or ministry’s realm of expertise.⁹⁴ Despite these obstacles, judicial review can be a very effective tool.⁹⁵

In early 2010, an administrative judge in the U.S. Department of Interior overturned a controversial surface coal mining permit issued in the state of Arizona because the agency overseeing the mining project, the Office of Surface Mining (OSM), failed to prepare a supplemental environmental impact statement (EIS) after the mining company changed the project. A coalition of tribal and environmental groups challenged the permit. The administrative law judge concluded: “As a result [of the OSM not preparing a supplemental EIS], the Final EIS did not consider a reasonable range of alternatives to the new proposed action, described the wrong environmental baseline, and did not achieve the informed decision-making and meaningful public

94 See, e.g., *Otadan v. Rio Tuba Nickel Mining Corp.*, G.R. No. 161436 (2004) (Philippines) (<http://sc.judiciary.gov.ph/resolutions/2nd/2004/2Jun/161436.htm>) (“This Court has consistently held that the courts will not interfere in matters which are addressed to the sound discretion of the government agency entrusted with the regulation of activities coming under the special and technical training and knowledge of such agency.”).

95 In April 2010, Bulgaria’s Supreme Administrative Court revoked a permit for a proposed metals processing facility in Chelopech because: (1) there was a two and one-half year delay between the public hearings on the EIA and the date the EIA resolution was issued; (2) the affected communities were incorrectly identified by the Environment Ministry; and (3) the proposed technology was deemed not to be based on best available techniques for an industrial scale operation. See “Bulgarian Court blocks Dundee Precious Chelopech plant,” Reuters, April 16, 2010 (<http://www.reuters.com/article/idUSSGE63F0H120100416>).

comment required by [the National Environmental Policy Act].”⁹⁶

4.7.2.1 Standing to sue

One significant hurdle that potential environmental litigants may face is establishing “standing” (or *locus standi*) to bring a case before a court. Standing means that a party has a sufficient legal interest in the outcome of a case or may suffer impairment of a legal right. An interest in protecting the environment or in having public authorities comply with the law is viewed in some jurisdictions as insufficient to establish standing to sue.

In many jurisdictions, associations or NGOs formed for the protection of collective interests of the public (such as protecting the environment) are not deemed to have sufficient legal interest because the group’s members cannot assert individual claims. This concept is generally called “associational standing.” In such jurisdictions, individuals who have a direct legal interest at stake must file the case and bear the risks and costs.

On the other hand, certain countries (particularly in Latin America) have open standing rules that allow judicial review of government action at the behest of any member of the public. These cases are known as “*acciones populares*.”⁹⁷

Similarly, India has very broad standing requirements and a robust system that encourages public interest litigation to protect environmental rights.⁹⁸

4.7.2.2 Scope of judicial review

As mentioned previously, most jurisdictions follow general principles of administrative law and do not allow a court to substitute its own decision for that of an administrator or minister. Instead, the court will evaluate the “reasonableness” of the agency or ministry’s decision and whether all of the relevant information was considered before the decision was made. Courts will also review the EIA process to make sure that required steps, such as proper notice or public participation, have been met.

96 In re *Black Mesa Complex Permit Revision*, DV 2009-4-PR (Jan. 5, 2010), at p. 36.]

97 An example is Article 88 of the Constitution of the Republic of Colombia, which states: “The law will regulate *acciones populares* for the protection of collective rights and interests related to property, space, security and public safety, administrative ethics, the environment, free economic competition and issues of similar nature defined therein. It will also regulate the actions originating in damage to a plural number of persons, without prejudice to the relevant individual stocks. Also, it will determine the cases of strict liability for damage caused to the collective rights and interests.”

98 *S.P. Gupta vs. Union of India*, AIR 1982 SC 149, at para. 19A (“It is for this reason that in public interest litigation -- litigation undertaken for the purpose of redressing public injury, enforcing public duty, protecting social, collective, ‘diffused’ rights and interests or vindicating public interest, any citizen who is acting bona fide and who has sufficient interest has to be accorded standing.”); *State of Uttaranchal v. Balwant Singh Chauhan & Ors* [2010] INSC 54 (describing history of public interest litigation in India and relaxed standing requirements).

4.8 ENFORCING PROMISES, COMMITMENTS AND CONDITIONS RELATED TO THE PROJECT

In some legal systems, the EIA itself is an enforceable document and citizens can bring a court case to enforce an EIA.

4.8.1 Promises contained in the EIA

As described in earlier sections, an EIA for a mine is likely to include mitigation plans and perhaps plans for restoring the area after the mine closes. The EIA may include specific commitments to use certain technologies to protect groundwater from contamination or restrict the hours of operation to maintain the livability of the area near the mine. If the mine violates commitments made in the EIA, citizens in some countries will be able to challenge those violations in court.

4.8.2 Conditions contained in the grant of environmental clearance

In some countries, the environmental clearance that is based on the information provided in the EIA is an enforceable document. The environmental clearance will generally include conditions on which the mine was approved. In many jurisdictions, these conditions are enforceable in court.

GENERAL TIPS FOR EFFECTIVE PARTICIPATION IN THE EIA PROCESS

- Identify the ministries or agencies that have decision-making authority over the proposed project.
- Identify the key individuals who will be responsible for the decisions that concern you.
- Collaborate and join forces with organizations or groups that share a similar interest in the issues that concern you.
- Monitor local newspapers for official announcements or articles about a proposed project and opportunities to submit comments or attend hearings.
- Participate at every possible opportunity provided by the government or project proponent, whether by submitting written comments or attending a public hearing.

Abandonment plan

See closure plan.

Acid Mine Drainage (AMD)

The outflow of acidic water from metal mines. After being exposed to air and water, oxidation of metal sulfides (often pyrite, which is iron-sulfide) within the surrounding rock and overburden generates acidity.

Acid Rock Drainage (ARD)

See Acid Mine Drainage.

Acute exposure

A single exposure to a toxic substance which may result in severe biological harm or death; acute exposures are usually characterized as lasting no longer than a day.

Aggregate

Coarse material in the earth, such as sand, gravel, and limestone, that is mined for use in the construction industry.

Alluvium

Relatively recent deposits of sedimentary material laid down in river beds, floodplains, lakes, or at the base of mountain slopes (adj. alluvial).

Assay

A chemical test performed on a sample of ores or minerals to determine the amount of valuable metals contained.

Backfill

Mine waste or rock used to refill voids in mined areas, including open-pit and underground mines.

Base metal

Any non-precious metal (e.g., copper, lead, zinc, nickel).

Basic rocks

Igneous rocks that are relatively low in silica and composed mostly of dark-colored minerals.

Beneficiation

The concentrating or enriching of the valuable minerals in an ore.

Borehole

A vertical shaft drilled in ground, usually for the purpose of collecting soil samples, groundwater samples, or rock cores,

Chronic exposure

Continuous exposure to a toxin over an extended period of time, often measured in months or years.

Closure plan

Set of measures designed to ensure that mining operations are developed and operated with a sound strategy and the financial resources necessary for the eventual closure of the operation. A closure plan must include a guide to deactivate, stabilize, and perform long-term surveillance of waste management units or facilities.

Contamination

Action of introducing hazardous substances (or excessive amounts of substances not usually hazardous) to the environment, causing negative environmental impacts.

Contingency plan

A strategy and set of actions for responding to a specific situation in which something goes wrong (spill, fire, natural disaster, and other emergencies). Contingency plans prepare companies to respond to all possible worst-case scenarios.

Cyanide

Any chemical compound that contains the cyano group (CN), which consists of a carbon atom triple-bonded to a nitrogen atom. Inorganic cyanides are generally salts of the anion CN^- . There are many cyanide compounds - some are gases and others are solids or liquids. Those that can release the cyanide ion CN^- are highly toxic.

Cyanidation

Extracting exposed gold or silver grains from crushed or ground ore by dissolving it in a weak cyanide solution (in tanks inside a mill or in heaps of ore, outdoors).

Degradation

Reduction or loss of the overall environmental quality, or of one environmental component (e.g., water quality).

Deposit

A natural occurrence of a useful mineral ore in sufficient extent and concentration to be profitably mined.

Dry Tailings Disposal

A method for the disposal of tailings in which tailings are first dewatered and then disposed of on land as a paste in a landfill or as backfill.

Effluent

The discharge of a pollutant from a facility or industrial process in a liquid form (also called liquid waste).

Emission

The act of emitting, releasing, or discharging a substance to the natural environment (e.g., air pollutant emissions from a stationary or mobile source).

Extraction

The process of mining and removal of ore from a mine.

Fugitive emission

Unintended or irregular releases of gases, vapors, or dust, not from a discrete point source.

Groundwater Drawdown

The lowering of the groundwater level as a result of the overuse (over abstraction) of groundwater.

Habitat

The natural physical environment that surrounds, influences, and is utilized by a species.

Hazardous material

Harmful solids, liquids, or gases that impact people, other living organisms, property, or the environment (e.g., materials which are explosive, poisonous, chemically active (including acids and other corrosives), radioactive, or biologically active (including medical wastes)).

Heap Leach Pad

A lined, relatively flat, constructed area with solution containment features, on which ore is loaded and then leached with a solution to dissolve and recover minerals.

Heavy metal

Elements that exhibit metallic properties. Many different definitions have been proposed – some based on density, some on atomic number or atomic weight, and some on chemical properties or toxicity. The term heavy metal has been called a “misinterpretation” by the International Union of Pure and Applied Chemistry (IUPAC), due to the contradictory definitions and its lack of a “coherent scientific basis.” There is an alternative term “toxic metal,” for which there is also no consensus on a definition.

Hydrometallurgical

Referring to a process or method in which metals are extracted or purified from their source using water-based chemicals.

Impact

Change (positive or negative) in the natural or human environment, as a direct or indirect result of an action or proposal.

In situ

In mining, in situ refers to the extraction of minerals from ore that is left in place in the ground.

Kinetic Testing

In mining, a chemical test in which a sample is examined for its potential to cause Acid Mine Drainage by subjecting the sample to conditions (e.g., humidity and exposure to air) that approximate natural weathering of the sample.

Leaching

In mining, the use of cyanide in water, or other chemical, that is applied on top of finely crushed ore to dissolve and extract the desired metal (typically gold or copper).

Metal

Chemical element, compound, or alloy characterized by high electrical conductivity. Metal is a good conductor of heat and forms cations and ionic bonds with non-metals.

Mineral

An inorganic compound occurring naturally in the earth's crust, with a distinctive set of physical properties, and a definite chemical composition.

Mitigation measure

Measures considered necessary to prevent, reduce and, where possible, remedy or offset any significant adverse impact on the environment.

Monitoring plan

Set of measures designed to continuously or repeatedly collect comparative information or measurements in the environment, to evaluate whether the performance of a mining project adheres to required standards and does not adversely impact the environment.

Operator

Company or group conducting a project's activities. The operator could be the owner or one of the owners in a collective business project.

Open pit

A mine pit that is entirely open to the surface. Also referred to as open-cut or open-cast mine.

Ore

The naturally occurring material from which a mineral or minerals can be extracted. The term is generally used to refer to metallic material, and is often modified by the names of the valuable constituent (e.g., iron ore).

Overburden

Layers of soil and rock covering an ore deposit. Overburden is removed prior to surface mining and should be replaced after the metallic ore is taken from the ground.

Placer

A deposit of sand and gravel containing valuable metals such as gold, tin, or diamonds.

Pyrometallurgical

Referring to a process or method in which metals are extracted or purified from their source using very high temperatures (e.g., smelting or roasting).

Reclamation

The reconstruction of the landscape in which a mine operated in order to make it possible for the landscape to be once again safely used for other purposes.

Rehabilitation

Cleanup process to return an area to acceptable conditions, but not necessarily to the original condition.

Restoration

The act of repairing damage to a site caused by human activity, industry, or natural disasters. The ideal environmental restoration is to restore the site as closely as possible to its natural condition before it was disturbed.

Sampling (mineral)

Cutting a representative part of an ore deposit, which should truly represent its average value.

Shaft

A primary vertical or non-vertical opening through mine strata used for ventilation or drainage and/or for hoisting of personnel or materials; connects the surface with underground workings.

Static Testing

In mining, a chemical test in which a sample is examined for its potential to cause Acid Mine Drainage by accounting for the ratio of acid and alkaline components in the sample.

Suspended Solids

When referring to water quality, very small solid particles that remain suspended in the water. Excessive levels of suspended solids impair the drinkability and suitability of water for aquatic life.

Stripping ratio

The unit amount of overburden that must be removed to gain access to a similar unit amount of mineral material.

Surface mine

A mine in which the ore lies near the surface and can be extracted by removing the covering layers of rock and soil.

Tailings

Material rejected from a mill after most of the recoverable valuable minerals have been extracted.

Tailings pond

A low-lying depression used to confine tailings from the mine operation, the prime function of which is to allow enough time for heavy metals to settle out or for cyanide to be destroyed before water is either recycled back into the mill operation or treated before discharge into the local watershed.

Toxicity

The degree to which a substance is able to damage an exposed organism. Toxicity can refer to the effect on a whole organism, such as an animal, bacterium, or plant, as well as the effect on a substructure of the organism, such as a cell (cytotoxicity) or an organ (organotoxicity), such as the liver (hepatotoxicity).

Underground mine

Also known as a “deep” mine. Usually located several hundred feet below the earth’s surface. An underground mine’s ore is removed mechanically and transferred by shuttle car or conveyor to the surface.

Waste

Barren rock or mineralized material that is too low in grade to be economically processed.

Water Balance

The net sum of liquid inflows and outflows for a given system.

References

Chapter 1

Bebbington, A., & Williams, M. (2008) "Water and Mining Conflicts in Peru." Mountain Research and Development. 28(3/4):190-195. http://snobear.colorado.edu/Markw/Research/08_peru.pdf

Earthworks Fact Sheet: Hardrock Mining and Acid Mine Drainage. http://www.earthworksaction.org/pubs/FS_AMD.pdf

Environment Australia (2002) "Overview of Best Practice Environmental Management in Mining." <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMOverview.pdf>

IFC/World Bank (December 2007) "Environmental, Health and Safety Guidelines for Mining." [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

International Institute for Environment and Development (2002) "Breaking New Ground: Mining, Minerals and Sustainable Development: Chapter 9: Local Communities and Mines. Breaking New Grounds." <http://www.iied.org/pubs/pdfs/G00901.pdf>

MINEO Consortium (2000) "Review of potential environmental and social impact of mining." <http://www2.brgm.fr/mineo/UserNeed/IMPACTS.pdf>

T. E. Norgate and W. J. Rankin (2000) "Life Cycle Assessment of Copper and Nickel Production, Published in Proceedings, Minprex 2000, International Conference on Minerals Processing and Extractive Metallurgy, pp133-138. http://www.minerals.csiro.au/sd/CSIRO_Paper_LCA_CuNi.htm

U.S. Environmental Protection Agency, Title 40 Code of Federal Regulations, Section 70.2. <http://www.gpo.gov/fdsys/pkg/CFR-2009-title40-vol15/xml/CFR-2009-title40-vol15-part70.xml>

World Health Organization. (1946) Preamble to the Constitution of the World Health Organization. Official Records of the World Health Organization No. 2, p. 100. http://www.who.int/governance/eb/who_constitution_en.pdf

Chapter 2

Food and Agriculture Organization (1995) "Environmental impact assessment of irrigation and drainage projects," 53 FAO Irrigation and Drainage Paper. <http://www.fao.org/docrep/V8350E/v8350e00.htm#Contents>

United States Environmental Protection Agency (1998) "Principles of Environmental Impact Assessment Review." Publication No. 315B98012 600. <http://www.epa.gov/nscep/>

United Nations Environment Program (UNEP) (2002) "Environmental Impact Assessment Training Resource Manual, Second Edition." http://www.unep.ch/etu/publications/EIAMan_2edition.htm

Chapter 3

Australia Water and Rivers Commission (2000) "Water Quality Protection Guidelines for Mining and Mineral Processing - No. 4: Installation of minesite groundwater monitoring bores." <http://www.water.wa.gov.au/PublicationStore/first/10137.pdf>

Australia Water and Rivers Commission (2000) "Water Quality Protection Guidelines for Mining and Mineral Processing," - No. 5: Minesite Water Quality Monitoring.

Australia Water and Rivers Commission (2000) "Water Quality Protection Guidelines for Mining and Mineral Processing - No. 10: Above-ground fuel and chemicals storage." <http://www.water.wa.gov.au/PublicationStore/first/10142.pdf>

Burkhalter, C.J. et al (1999) "Precious Metals Heap Leach Facilities Design, Closure and Reclamation." http://www.unr.edu/mines/mlc/conf_workshops/book1/chapter29.pdf

California State Water Resources Control Board, Mining Waste Management Regulations. 22510. SWRCB - Closure and Post Closure Maintenance of Mining Units. (C15: Section 2574) <http://www.calrecycle.ca.gov/Laws/Regulations/Title27/ch7sb1.htm>

CEPIS (1981) "Environmental impact assessment methodologies description and analysis and first approach to environmental impact assessment methodologies application." <http://www.cepis.ops-oms.org/bvsair/e/repindex/rep51/environ/environ.html>

Colorado Department of Natural Resources, Division of Minerals and Geology – Hard Rock Rules Effective October 1, 2006 <http://mining.state.co.us/rulesregs/HR%20and%20Metal%20adopted%20Aug%209%202006%20indexed.pdf>

Conservation International (2000) "Lightening the Lode: A Guide to Responsible Large-scale Mining." <http://www.conservation.org/sites/celb/Documents/lode.pdf>

Danihelka, P. and Cernanova, E. (2007) "Tailing dams: risk analysis and management." UNECE Workshop on Tailings Dams Safety. Yerevan, Armenia. http://www.unece.org/env/teia/water/tailingdams/presentations/DanihelkaRISK_ANALYSIS_OF_TAILING_DAMS_F.ppt

Environment Australia (2002) "Overview of Best Practice Environmental Management in Mining: Water Management." <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMWater.pdf>

Hewlett, L. (2007) "Tailings Dam Safety And Implementation Of Safety Guidelines by a Tailings Dam Operator." http://www.unece.org/env/teia/water/tailingdams/presentations/DENODam_Safety.ppt

IFC/World Bank (December 2007) "Environmental, Health and Safety Guidelines for Mining." [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/\\$FILE/Final+-+Mining.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf)

International Cyanide Management Institute. <http://www.cyanidecode.org>

International Institute for Sustainable Development (January 2002) "Research on Mine Closure Policy" http://www.iied.org/mmsd/mmsd_pdfs/044_cochilco.pdf

Jeyapalan, J. (2005) "Effects of fluid resistance in the mine waste dam-break problem. International Journal for Numerical and Analytical Methods in Geomechanics." Vol 7:1. <http://www3.interscience.wiley.com/journal/110559848/abstract?CRETRY=1&SRETRY=0>

Maest, A.S., et al. (2005) "Predicting Water Quality at Hardrock Mines: Methods and Models, Uncertainties, and State-of-the-Art." http://www.swrcb.ca.gov/academy/courses/acid/supporting_material/predictwaterqualityhardrockmines1.pdf

Miller, G. & Jones, G. (2005) "Mercury Management in Modern Precious Metals Mines" Glenn Miller and Greg Jones - Department of Natural Resources and Environmental Science, University of Nevada, Reno. <http://wman-info.org/resources/conferencepresentations/Mercury%20and%20Mining%20%28Glenn%20Miller%29.ppt>

MINEO Consortium (2000) "Review of potential environmental and social impact of mining." <http://www2.brgm.fr/mineo/UserNeed/IMPACTS.pdf>

Ministère des Ressources naturelles et de la Faune (1997) "Guideline for preparing a mining site rehabilitation plan and general mining site rehabilitation requirements." <http://mrnf.gouv.qc.ca/english/publications/mines/environment/guianmin.pdf>

Moran, R.E. (2002) "De-coding Cyanide: An Assessment of Gaps in Cyanide Regulation at Mines." <http://www.earthworksaction.org/pubs/DecodingCyanide.PDF>

National Wildlife Federation (February 2000) "Hardrock Reclamation Bonding Practices in the Western United States." http://www.earthworksaction.org/pubs/hardrock_bonding_report.pdf

ONTARIO REGULATION 240/00: Mine Development and Closure under Part VII of the Mining Act. http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_000240_e.htm

Queensland Environmental Protection Agency (2001) "Generic Terms of Reference for Environmental Statements for Non-Standard Mining Projects." <http://www.derm.qld.gov.au/register/p00443aa.pdf>

Surface Mining and Reclamation Act (SMARA) regulations of the California State Mining and Geology § 3704.1 Performance Standards for Backfilling Excavations and Recontouring Lands Disturbed by Open Pit Surface Mining Operations for Metallic Minerals. <http://www.conservation.ca.gov/omr/smara/Documents/010107Note26.pdf>

- Szymanski, M.B & Davies, M.P. (2004) "Tailings dams : design criteria and safety evaluations at closure," British Columbia Mine Reclamation Symposium 2004. <http://www.infomine.com/publications/docs/Szymanski2004.pdf>
- United Nations Environmental Programme and International Commission on Large Dams (2001) "Tailings Dams, Risk of Dangerous Occurrences, Lessons Learnt From Practical Experiences," Bulletin 121. <http://www.mineralresourcesforum.org/docs/pdfs/Bulletin121.PDF>
- United States Environmental Protection Agency (1993) "Habitat Evaluation: Guidance for the Review of Environmental Impact Assessment Documents." <http://www.epa.gov/compliance/resources/policies/nepa/habitat-evaluation-pg.pdf>
- United States Environmental Protection Agency (1994) "Technical Report: Design and Evaluation of Tailings Dams." <http://www.epa.gov/epawaste/nonhaz/industrial/special/mining/techdocs/tailings.pdf>
- United States Environmental Protection Agency (1994) "Technical Report: Treatment of Cyanide Heap Leaches and Tailings." <http://www.epa.gov/epawaste/nonhaz/industrial/special/mining/techdocs/cyanide.pdf>
- United States Environmental Protection Agency (1995) "Office of Compliance Sector Notebook Project: Profile of the Metal Mining Industry." <http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/metmins.pdf>
- United States Environmental Protection Agency (1999) "Consideration Of Cumulative Impacts In EPA Review of NEPA Documents." <http://www.epa.gov/compliance/resources/policies/nepa/cumulative.pdf>
- United States Environmental Protection Agency (1999) "Considering Ecological Processes in Environmental Impact Assessments." <http://www.epa.gov/compliance/resources/policies/nepa/ecological-processes-eia-pg.pdf>
- United States Environmental Protection Agency (2005) "National Recommended Water Quality Criteria." <http://www.epa.gov/waterscience/criteria/wqtable/>
- Verburg, R.B.M (2001) "Use of Paste Technology for Tailings Disposal: Potential Environmental Benefits and Requirements for Geochemical Characterization." IMWA Symposium 2001. <http://www.imwa.info/docs/BeloHorizonte/UseofPaste.pdf>
- Western Australia Department of Industry and Resources (DoIR) (December 2006) "Review of Environmental Performance Bonds in Western Australia." http://www.doir.wa.gov.au/documents/environment/ED_Min_GL_ReviewOfEnvPerformanceBonds_Dec06.pdf
- World Health Organization (2006) "Guidelines for drinking-water quality, third edition, incorporating first and second addenda." http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/
- World Bank Group, Oil Gas and Mining Policy Division (2008) "Guidance Notes for the Implementation of Financial Surety for Mine Closure." http://siteresources.worldbank.org/INTOGMC/Resources/financial_surety_mine.pdf

Chapter 4

Rio Declaration on Environment and Development, Principle 10 (1992). United Nations Environmental Programme (UNEP) Goals and Principles of Environmental Impact Assessment, Principle 7(1987). <http://www.unep.org/Documents.Multilingual/Default.asp?documentid=78&articleid=1163>

Additional References

Australian Department of Minerals and Energy (1999) "Guidelines on the Safe Design and Operating Standards for Tailings Storage." <http://www.elaw.org/node/1671>

Australia EPA (1995) "Best Practice Environmental Management and Mining Community Consultation and Involvement." <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMCommunity.pdf>

Australia EPA (1995) "Best Practice Environmental Management and Mining: Rehabilitation and Revegetation." <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMRehab.pdf>

Australia EPA (1995) "Best Practice Environmental Management and Mining: Tailings Containment." <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMTailings.pdf>

Australia EPA (1994) "Best Practice Environmental Management and Mining: Cleaner Production." <http://www.ret.gov.au/resources/Documents/LPSDP/BPEMCleanerProduction.pdf>

Bolton, B.R, et al (2003) "Acid Rock Drainage Management at the Ok Tedi Mine, Papua New Guinea." http://www.oktedi.com/attachments/209_ARD_BOLT.PDF

British Columbia Ministry of Energy and Mines, (1998) "Policy for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia." www.em.gov.bc.ca/Mining/MinePer/ardpolicy.htm

European Integrated Pollution Prevention and Control Bureau (EIPPCB) (2009) "Best Available Techniques (BAT) Reference Document for Management of Tailings and Waste-Rock in Mining Activities." ftp://ftp.jrc.es/pub/eippcb/doc/mmr_adopted_0109.pdf

Hamor, Tamas (2004) "Sustainable Mining in the European Union: The Legislative Aspect," *Environmental Management*, 33: 252-261. <http://www.springerlink.com/content/ywkj6nfnwhy418y4/>

International Union for the Conservation of Nature (IUCN) and International Council for Mining and Metals (ICMM), 2004. "Integrating mining and biodiversity conservation: Case studies from around the world." London, UK. <http://www.icmm.com/publications/767BiodiversityReport.pdf>

Miranda, M., Chambers, D. & Coumans, C. (2005) "Framework for Responsible Mining: A Guide to Evolving Standards." http://www.frameworkforresponsiblemining.org/pubs/Framework_20051018.pdf

Moran, R.E. "Cyanide in Mining: Some Observations on the Chemistry, Toxicity and Analysis of Mining-Related Waters." <http://www.earthworksaction.org/pubs/morancyanidepaper.pdf>

United Nations Department of Economic and Social Affairs (UNDESA) and United Nations Environmental Programme Industry and Development (UNEP) "Environmental Guidelines for Mining Operations." http://commdev.org/files/814_file_UNEP_UNDESA_EnvGuidelines.pdf

United States Environmental Protection Agency. 40 CFR Part 440 - Effluent Limitation Guidelines for Metallic Mineral Mining <http://www.elaw.org/node/2841>

United States Environmental Protection Agency (1994) "Technical Report: Design and Evaluation of Tailings Dams." <http://www.epa.gov/osw/nonhaz/industrial/special/mining/techdocs/tailings.pdf>

United States Environmental Protection Agency (1994) "Background for NEPA Reviewers: Non-Coal Mining Operations." <http://www.epa.gov/compliance/resources/policies/nepa/non-coal-mining-background-pg.pdf>

Western Australia Department of Minerals and Energy (2000) "Water Quality Protection Guidelines No. 1 Water Quality Management in Mining and Mineral Processing: An Overview." <http://www.water.wa.gov.au/PublicationStore/first/44631.pdf>

World Bank (1998) "Environmental Assessment of Mining Projects." <http://www.elaw.org/system/files/22.pdf>

Zorilla, Carlos (2009) "Protecting Your Community Against Mining Companies and other Extractive Industries: A Guide for Community Organizers." <http://www.culturalsurvival.org/files/Guide%20for%20Communities.pdf>

Appendix

EIA REVIEW CHECKLIST				
No.	Review Question	Yes	No	Notes
1. General				
1.1	Is the need for the project and its objectives explained?			
1.2	Are the main components of the project described?			
1.3	Is the location of each project component identified, using maps, plans, and diagrams?			
1.4	Are all activities involved in all of the project's phases described (exploration, development, exploitation, mineral processing, closure, reclamation)?			
1.5	Are all activities involved in the ore beneficiation and other processing described?			
1.6	Does the EIA describe additional components that are required for the project (roads, water, leach pads, tailings impoundments, mine waste dumps, sanitation facilities, campsites)?			
1.7	Are any developments likely to occur as a consequence of the project?			
1.8	Will the project involve widespread land disturbance, site clearance, or extensive earthworks?			
1.9	Will the project involve the storage, handling, use, or production of toxic hazardous substances? Are these substances identified and quantified?			
1.10	Has the project assured a reclamation fund with the necessary financial warranties?			
1.11	Does the EIA include a detailed assessment of project alternatives?			
1.12	Does the area experience high levels of pollution or other environmental damage?			

EIA REVIEW CHECKLIST cont'd

No.	Review Question	Yes	No	Notes
2. Aspects of the environment				
Air				
2.1	Will the project generate emissions of air from fuel combustion, production processes, materials handling, construction activities, or other sources?			
2.2	Will the project involve disposal of waste through burning (slash, construction debris)?			
2.3	Will the storage of wastes or raw materials affect air quality?			
2.4	Will the project release noise, vibration, light, or heat to the environment?			
2.5	Will the project be located in an area subject to adverse atmospheric conditions (temperature inversions, fogs, extreme wind)?			
Water				
2.6	Will the project require large volumes of water or disposal of large volumes of sewage or industrial effluent?			
2.7	Will the project involve disturbance of drainage patterns, such as dams or relocation of watercourses, or increased flood potential?			
2.8	Will the project require channel dredging or straightening or crossing of streams?			
2.9	Will the project involve the alteration of coastal features with the construction of infrastructure?			
2.10	Will the project be located near a relevant watercourse (freshwater or groundwater) or wetlands?			
2.11	Will use of water affect the availability of existing local supplies?			
2.12	Will the project cause significant changes in wave action, sediment movement, erosion, or water circulation?			
Land				
2.13	Will the project result in widespread disturbance of land surface?			
2.14	Will the project conflict with present zoning or land use policy?			
2.15	Will the project conflict with indigenous territories?			

EIA REVIEW CHECKLIST cont'd

No.	Review Question	Yes	No	Notes
Land				
2.16	Will the project be located on lands of high agricultural value?			
2.17	Is the project likely to cause erosion?			
2.18	Could the use of erosion controls result in other adverse impacts?			
Ecology				
2.19	Will the project be located in the vicinity of important or valuable habitat?			
2.20	Are there rare or endangered species in the area?			
2.21	Will the project be located on or near a coastline susceptible to erosion?			
2.22	Will the project be located in an area susceptible to earthquakes or seismic faults?			
2.23	Will the project be located in an area of steep topography that may be susceptible to erosion?			
2.24	Is the project located in or near protected areas or a place with unique natural features?			
3. Wastes				
3.1	Will the project require disposal of spoil, overburden, or mine effluents?			
3.2	Will the project require disposal of municipal or industrial wastes?			
3.3	Will the project have the potential to contaminate groundwater?			
4. Hazards				
4.1	Will the project (construction, operation, decommissioning) involve the storage, handling or transport of hazardous substances (flammable, explosive, toxic, radioactive, carcinogenic, mutagenic)?			
4.2	Will the project involve the regular use of pesticides, fertilizers?			

EIA REVIEW CHECKLIST cont'd

No.	Review Question	Yes	No	Notes
5.	Social			
5.1	Will the project involve employment of large numbers of workers?			
5.2	Will the project make significant demands on facilities and services?			
5.3	Will the project result in changes in health conditions?			
5.4	Will the project affect the income of other productive sectors or communities?			
5.5	Will the project be located in an area of high population density?			
6.	Historic and cultural features			
6.1	Will the project be located in the vicinity of important or valuable historic or cultural resources?			