Environmental, Health and Safety Guidelines for Mining

Introduction

The Environmental, Health, and Safety (EHS) Guidelines[*] are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)[1]. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Applicability

The EHS Guidelines for Mining are applicable to underground and open-pit mining, alluvial mining, solution mining, and marine dredging. Extraction of raw materials for construction products are addressed in the EHS Guidelines for Construction Materials Extraction.

This document is organized according to the following sections:

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[1] Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

1.0 Industry-Specific Impacts and Management

The following section provides a summary of EHS issues associated with mining activities (and including ore processing facilities) which may occur during the exploration, development and construction, operation, closure and decommissioning, and post-closure phases, along with recommendations for their management. Recommendations for the management of EHS issues common to most large industrial activities are provided in the **General EHS Guidelines**.

1.1 Environmental

Potential environmental issues associated with mining activities may include management of the following:

- Water use and quality
- Wastes
- Hazardous materials
- Land use and biodiversity
- Air quality
- Noise and vibrations
- Energy Use
- Visual Impacts

Water Use and Quality

Management of water use and quality, in and around mine sites, can be a significant issue. Potential contamination of water sources may occur early in the mine cycle during the exploration stage and many factors including indirect impacts (e.g. population in-migration) can result in negative impacts to water quality. Reduction of surface and groundwater availability is also a concern at the local level and for communities in the vicinity of mining sites, particularly, in arid regions, or in regions of high agricultural potential. Mining activities should therefore include adequate monitoring and management of water use, in addition to treatment of effluent streams including stormwater run-off from the mine property.

Water Use

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;
- Consultation with key stakeholders (e.g. government, civil society, and potentially affected communities) to understand any conflicting water use demands and the communities' dependency on water resources and/or conservation requirements that may exist in the area.

Water Quality

Recommended practices to manage impacts to water quality include:

- The quality and quantity of mine effluent streams discharged to the environment, including stormwater, leach pad drainage, process effluents, and overall mine works drainage should be managed and treated to meet the applicable effluent discharge guideline values in Section 2.0;
- In addition, discharges to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria outside a scientifically established mixing zone. Receiving water-body use and assimilative capacity, including the impact of other sources of discharges to the receiving water, should be considered with respect to acceptable contaminant loadings and effluent discharge quality as described in the **General EHS Guidelines**;
- Efficient oil and grease traps or sumps should be installed and maintained at refueling facilities, workshops, fuel storage depots, and containment areas, and spill kits should be available with emergency response plans;
- Water quality in open storage systems (e.g. leachate areas, solution ponds, and tailings ponds or impoundments) should be based on the results of a site-specific risk assessment with appropriate control measures put in place to mitigate the risk or meet the effluent guideline values in Section 2.0,
- Sanitary wastewater should be managed via reuse or routing into septic or surface treatment as described in the **General EHS Guidelines**.

Stormwater

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);
- Divert run-off 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);
- 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 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 non-mined 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, as discussed in the **General EHS Guidelines**. 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.

Acid Rock Drainage and Metals Leaching

Acid Rock Drainage (ARD) refers to acid formation that occurs when Potentially Acid Generating (PAG) materials with acid generating sulfide minerals in excess of acid neutralizing minerals, principally carbonates, oxidize in an environment containing oxygen and water. Acidic conditions tend to dissolve and release metals from their matrices (a phenomenon known as Metals Leaching or "ML") which then may be mobilized in surface and groundwater systems. ARD and ML should be prevented and controlled as described in the 'Solid Waste' section of this document. Management of PAG, ARD and ML should extend for as long as there is a need to maintain effluent quality to the levels required to protect the local environment, including where necessary, into the decommissioning, closure, and post-closure phases of the mine.

The ARD and ML issues apply to waste rock, tailing materials and any exposed rock surfaces such as road cuts and pit walls.

Groundwater Resource Protection

In addition to the prevention and control of effluents, wastes, and potential releases of hazardous materials, additional recommendations for the management of potential sources of groundwater contamination, primarily associated with leaching and solution mining activities as well as tailings management include the following:[2]

<u>Leaching:</u> Operators should design and operate surface heap leach processes with:

- Infiltration of toxic leach solutions should be prevented through the provision of appropriate liners and sub-

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[2] Additional information on groundwater protection measures in in-situ leaching and solution mining activities can be found at USEPA Guidance available at: http://www.epa.gov/safewater/uic/classv/pdfs/sol-fact.pdf; http://www.uic.com.au/nip40.htm ; and http://www.saltinstitute.org/12.html.

drainage systems to collect or recycle solution for treatment, and minimize ground infiltration;

- Pipeline systems carrying pregnant solutions should be designed with secondary bunded containment;
- Leak detection equipment should be installed for pipeline and plant systems with appropriate leak response systems in place;
- 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.

Solution Mining: Operators should design and operate solution mining projects with consideration of the following:

- Proper location and operating practices based on the characteristics of the confining strata, to ensure the movement of leaching solution is minimized beyond the extraction area and off-site aquifers are protected;
- Sufficient monitoring wells should be installed around cavities to enable monitoring of pressure levels, as well as water quantity and quality.

Wastes

Mines generate large volumes of waste. Structures such as waste dumps, tailing impoundments / dams, and containment facilities should be planned, designed, and operated such that geotechnical risks and environmental impacts are appropriately assessed and managed throughout the entire mine cycle.

Solid wastes may be generated in any phase of the mine cycle. The most significant waste generating mining activities will likely occur during the operational phases, which require the movement of large amounts overburden and creation of rock waste and tailings. Other types of solid wastes, depending on the type of mining undertaken, may include leach pad waste, workshop scrap, household and non-process-related industrial waste, as wells as waste oils, chemicals, and other potentially hazardous wastes.

Waste Rock Dumps

Depending on the stripping ratio (in open pit mines), large quantities of overburden or waste rock often need to be removed to expose the mineral to be mined. 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 below;
- 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.

Tailings

Tailings management strategies vary according to site constraints and the nature / type of the tailings. Potential environmental impacts may include groundwater and surface water contamination due to the generation of acid rock drainage (ARD) and metals leaching (ML) containing runoff / leachate, sedimentation of drainage networks, dust generation and the creation of potential geotechnical hazards associated with the selected management option. Tailings management strategies should consider how tailings will be handled and disposed of during operation, in addition to permanent storage after decommissioning. Strategies should consider the site topography, downstream receptors and the physical nature of tailings (e.g. projected volume, grain size distribution, density, water content, among other issues).[3]

Recommended tailings management strategies include:

- Design, operation, and maintenance of structures according to specifications of ICOLD3 and ANCOLD4, or other internationally recognized standards based on a risk assessment strategy. Appropriate independent review should be undertaken at design and construction stages with ongoing monitoring of both the physical structure and water quality, during operation and decommissioning;[4]
- 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;
- 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;
- 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 outlined elsewhere in this Section;
- 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;
- Where potential liquefaction risks exist, including risks associated with seismic behavior, the design specification

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[3] For additional information, refer to the Mining Association of Canada (MAC – www.mining.ca): A Guide to the Management of Tailings Facilities (1998), and Developing an Operations, Maintenance and Surveillance Manual for Tailings and Water Management Facilities (2003).

[4] International Commission on Large Dams (ICOLD) available at: http://www.icold-cigb.net, and Australian National Committee on Large Dams (ANCOLD) available at: http://www.ancold.org.au/

should take into consideration the maximum design earthquake;

- 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;
- Thickening or formation of paste for backfilling of pits and underground workings during mine progression.

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.

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.

Leach-pad Waste

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 in Section 2.0;
- 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;

Waste Geochemical Characterization

Mining operations should prepare and implement ore and waste geochemical characterization methods for proper routing of Potentially-Acid-Generating (PAG) materials and ARD management programs that include the following elements:

- Conducting a comprehensive series of accelerated leaching tests from feasibility study stage onwards, to evaluate the potential for ARD in all formations foreseen to be disturbed or otherwise exposed by the mine according to internationally recognized methodologies;[5]
- Conducting comprehensive ARD / metals leaching (ML) testing / mapping on an ongoing basis with decreasing block size as formations are transferred from long- to medium- and short-term mining plans;
- Implementation of ARD and ML preventive actions to minimize ARD including:
  - Limiting exposure of PAG 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

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[5] See U.S. Department of the Interior, Office of Surface Mining, *Acid Mine Drainage Prevention and Mitigation*, available at: http://www.osmre.gov/amdpvm.htm and *Policy for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia* (BC MEM 1998) available at: www.em.gov.bc.ca/Mining/MinePer/ardpolicy.htm

- Controlled placement of PAG materials (including wastes) to provide permanent conditions that avoid contact with oxygen or water including[6]:
    - 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 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.

General Non-Hazardous Waste

Recommended practices for the management of household and non-process related industrial waste include the following:

- Non-hazardous solid wastes should be managed according to the recommendations presented in the **General EHS Guidelines**;
- Non-hazardous solid waste should be collected for recycling or disposal at an approved sanitary landfill. External landfills should be audited by the mine to ensure appropriate waste management practices. When such a facility is not available within a feasible distance, the mine should establish and operate its own with appropriate regulatory permits and scientifically defensible studies that can demonstrate that the disposal of the hazardous waste will not impact human health and the environment;[7]
- Non-hazardous solid waste should not be disposed of together with waste rock or overburden except under exceptional circumstances to be fully documented in the environmental and social assessment of the project.

Hazardous Waste

Recommended practices for the management of hazardous waste include the following:

- Hazardous waste, including waste oils and chemicals, spent packaging materials and containers, should be managed as described in the **General EHS Guidelines**;
- Hazardous waste should be handled by specialized providers (in accordance with regulatory permits) of hazardous waste management facilities specifically designed and operated for this purpose. When such services are unavailable within a feasible distance of the mine, the mine should establish and operate its own waste facility with the necessary permits;
- Combustion of waste oils should preferably be undertaken as a supplementary fuel in power generation facilities and in accordance with emissions guidelines applicable to combustion sources (see the **General EHS Guidelines** and the EHS Guidelines for Thermal Power).

Hazardous Materials

Hazardous materials should be handled, stored, and transported so as to avoid leaks, spills or other types of accidental releases into soils, surface water, and groundwater resources. In order to minimize the risk associated with accidental spills from storage

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[6] Ibid (for additional information on placement).

[7] Detailed guidance on the design and operation of waste management facilities is provided in the EHS Guidelines for Waste Management Facilities.

tanks and pipelines (e.g. tailings pipelines) the recommended mitigation measures include:

- Providing secondary containment to restrict movement into receiving water bodies (e.g. sumps, holding areas, impermeable liners), for example:
    - Constructing pipelines with double-walled or thick-walled sections at critical locations (e.g. large stream crossings)
    - Installing shutoff valves to minimize spill volumes and to isolate flow in critical areas

Additional detailed guidance for hazardous materials management including spill prevention and control planning for the handling, storage, and transport of such materials as fuels and chemicals is provided in the **General EHS Guidelines**. .

Cyanide

Cyanide use should be consistent with the principles and standards of practice of the International Cyanide Management Code.[8] 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.

Land Use and Biodiversity

Habitat alteration is one of the most significant potential threats to biodiversity associated with mining. Habitat alteration may occur during any stage of the mine cycle with the greatest potential for temporary or permanent alteration of terrestrial and aquatic habitats occurring during construction and operational activities. Additionally, exploration activities often require the development of access routes, transportation corridors, and temporary camps to house workers which may all result in varying degrees of land-clearing and population in-migration.

Depending on the type of mining, development and construction activities often require land clearing for the mine as well as for the process plant, tailings facility, waste and stockpile areas, and infrastructure such as buildings, roads, construction camps, town sites, water management structures, power plant, transmission lines and access corridors to the mine site.

The protection and conservation of biodiversity is fundamental to sustainable development. Integrating conservation needs and development priorities in a way that meets the land use needs of local communities is often a critical issue for mining projects. Recommended strategies include consideration of the following:

- Whether any critical natural habitats[9] will be adversely impacted or critically endangered or endangered species reduced;
- Whether the project is likely to impact any protected areas;
- The potential for biodiversity offset projects (e.g. proactive management of alternative high biodiversity areas in cases where losses have occurred on the main site due to the mining development) or other mitigative measures;
- Whether the project or its associated infrastructure will encourage in-migration, which could adversely impact biodiversity and local communities;

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[8] International Cyanide Management Code available at: http://www.cyanidecode.org/

[9] As defined in IFC's Performance Standard (PS) 6 – Biodiversity Conservation and Sustainable Natural Resource Management. Readers should consult the definition and requirements applicable to Critical Habitat in the PS.

- Consideration of partnerships with internationally accredited scientific organizations to, for example, undertake biodiversity assessments, conduct ongoing monitoring, and manage biodiversity programs;
- Consultation with key stakeholders (e.g. government, civil society, and potentially affected communities) to understand any conflicting land use demands and the communities dependency on natural resources and / or conservation requirements that may exist in the area.

Terrestrial Habitats

Temporary and permanent terrestrial habitat alteration should be minimized to the extent feasible and be consistent with the requirement to protect and preserve critical habitat. Recommended management strategies include[10]:

- Siting access routes and facilities in locations that avoid impacts to critical terrestrial habitat, and planning exploration and construction activities to avoid sensitive times of the year;
- Minimizing disturbance to vegetation and soils;
- Implementation of mitigation measures appropriate for the type of habitat and potential impacts including, for example, post-operation restoration (which may include baseline inventories, evaluations, and eventual rescue of species), offset of losses, or compensation of direct users;
- Avoiding or minimizing the creation of barriers to wildlife movement, or threats to migratory species (such as birds) and providing alternative migration routes when the creation of barriers cannot be avoided;
- Planning and avoiding sensitive areas and implementing buffer zones;
- Conducting activities such that the risk of landslides, debris or mud flows, and bank or alluvial fan destabilization is minimized;
- Implementing soil conservation measures (e.g. segregation, proper placement and stockpiling of clean soils and overburden material for existing site remediation); key factors such as placement, location, design, duration, coverage, reuse, and single handling should be considered;
- Where topsoil is pre-stripped, it should be stored for future site rehabilitation activities. Topsoil management should include maintenance of soil integrity in readiness for future use. Storage areas should be temporarily protected or vegetated to prevent erosion;
- Conserving the quality and composition of growth medium for use (e.g. for capping) during site reclamation and closure activities;
- Ensuring that the growth medium is sufficient to support native plant species appropriate for the local climate and consistent with proposed future land uses. Overall thickness of the growth medium should be consistent with surrounding undisturbed areas and future land use;
- Manage vegetation growth along access roads and at permanent above-ground facilities. Remove invasive plant species and replant native species. Vegetation control should employ biological, mechanical and thermal vegetation control measures and avoid the use of chemical herbicides as much as possible.

If it is demonstrated that the use of herbicides is required to control vegetation growth along access roads or at facilities, then personnel should be trained in their use. Herbicides that should be avoided include those listed under the World Health Organization (WHO) recommended Classification of Pesticides by Hazard Classes 1a and 1b, the WHO recommended

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[10] Additional information on biodiversity conversation strategies can be found at "Integrating Mining and Biodiversity Conservation – Case Studies from around the world" (IUCN and ICMM, 2004) and "Good Practice Guidance for Mining and Biodiversity" (ICMM 2006).

Classification of Pesticides by Hazard Class II (if the project host country lacks restrictions on distribution and use of these chemicals, or if they are likely to be accessible to personnel without proper training, equipment, and facilities to handle, store, apply, and dispose of these products properly), and Annexes A and B of the Stockholm Convention, except under the conditions noted in the convention.[11]

Aquatic Habitats

Aquatic habitats may be altered through changes in surface water and groundwater regimes, and resulting increased pressures on fish and wildlife communities. Earth-moving operations may mobilize sediment which can enter watercourses and disrupt water quality and quantity. Recommended management strategies include the following:

- Minimizing the creation and extent of new access corridors;
- Decommissioning and re-vegetating exploration access routes, and installing barricades to limit access;
- Maintaining, to the extent possible, natural drainage paths and restoring them if they are disrupted;
- Maintaining water body catchment areas equal or comparable to pre-development conditions;
- Protecting stream channel stability by limiting in-stream and bank disturbance, and employing appropriate setbacks from riparian zones;
- Attenuating surface runoff from high precipitation events using on-site storage and water management infrastructure (e.g. storage ponds, sumps, low gradient ditches, clean water diversions);
- Designing temporary and permanent bridges and culverts to manage peak flows depending on the associated potential risk;
- Constructing, maintaining, and reclaiming watercourse crossings that are stable, safe for the intended use, and that minimize erosion, mass wasting and degradation of the channel or lake bed.

Marine Habitats

Aquatic habitats in marine environments may be altered by marine dredge mining, deep sea mining, off-shore loading activities, port construction, and tailings disposal. Rivers and run off impacted by mining operations can also impact the marine environment. Key impacts of concern to the marine environment may include habitat disturbance and destruction, suspension of sediment in the water column, change in water temperature, and changed water quality. Project sponsors should engage the services of appropriate specialists to carry out marine impact assessments which also include socio-economic impacts (e.g. impacts on fishing grounds). Assessment and management of impacts should be in compliance with applicable host-country commitments to international conventions, including the United Nations Convention on the Law of the Sea.[12]

Air Quality

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

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[11] Stockholm Convention on Persistent Organic Pollutants (2001).

[12] The United Nations Convention on the Law of the Sea (1982) includes numerous requirements applicable to navigation, resource use, and resource protection in the territorial sea and contiguous zone of signatory states. The full text of the convention is available at: http://www.un.org/Depts/los/index.htm

equipment. Guidance on ambient air quality considerations is provided in the **General EHS Guidelines**.

Dust

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 all-weather 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.

Gaseous Emissions

The main sources of gaseous emissions are from combustion of fuels in power generation installations, mobile emissions, methane emissions and from drying, roasting, and smelting operations. Recommended emissions reduction and control strategies for stationary steam and power generation activities from sources with a capacity equal to or lower than 50 Megawatt thermal (MWth) and from mobile sources are addressed in the **General EHS Guidelines**. Power sources with a capacity greater than 50MWth are addressed in the EHS Guidelines for Thermal Power.

Smelting and Roasting

General recommendations related to smelting and refining may be found in the EHS Guidelines for Base Metal Smelting and Refining. However, there are a few issues which are specific to the roasting and smelting of precious metals.

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.

Operations that employ roasting of concentrates are often associated with elevated levels of mercury, arsenic and other metals as well as SO2 emissions. Recommended management strategies include:

- Operations at controlled temperature (higher temperature roasters generally cause more problems of contaminant control)
- Inclusion of an appropriate gas scrubbing system

Smelting of Platinum Group Metals (PGM) is similar to nickel and aluminum smelting. Care should be taken to avoid formation of nickel carbonyl and chromium VI during the smelting process. Where methane drainage (venting) is practiced, consideration should be given to beneficial utilization of the gas.

Noise and Vibration

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:

- Noise levels at the nearest sensitive receptor should meet the noise guidelines in the **General EHS Guidelines;**
- Where necessary, noise emissions should be minimized and controlled through the application of techniques which may 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.

Energy Use

Among the most significant energy consuming activities in mining are transport, exploration activities, drilling, excavation, extraction, grinding, crushing, milling, pumping, and ventilation processes. Recommended energy conservation measures include the following:

- Use of non-invasive technologies such as remote sensing and ground-based technologies to minimize exploratory digging and drilling;
- Correctly sizing motors and pumps used in the excavation, ore moving, ore crushing, and ore handling process, as well as using adjustable speed drives (ASDs) in applications with highly varying load requirements.

Visual Impact

Mining operations, and in particular surface mining activities, may result in negative visual impacts to resources associated with other landscape uses such as recreation or tourism. Potential contributors to visual impacts include highwalls, erosion, discolored water, haul roads, waste dumps, slurry ponds, abandoned mining equipment and structures, garbage and refuse dumps, open pits, and deforestation. Mining operations should prevent and minimize negative visual impacts through consultation with local communities about potential post-closure land use, incorporating visual impact assessment into the mine reclamation process. Reclaimed lands should, to the extent feasible, conform to the visual aspects of the surrounding landscape. The reclamation design and procedures should take into consideration the proximity to public viewpoints and the visual impact within the context of the viewing distance.[13] Mitigation measures may include strategic placement of screening materials including trees and use of appropriate plant species in the reclamation phase as well as modification in the placement of ancillary facilities and access roads.

1.2 Occupational Health and Safety

Mining activities should seek to provide an operation where people are able to work without being injured and where the health of the workforce is promoted. Facility-specific occupational health and safety hazards should be identified based on job safety analysis or comprehensive hazard or risk assessment using established methodologies such as a hazard identification study [HAZID], hazard and operability study [HAZOP], or a quantitative risk assessment [QRA]. As a general approach, health and safety management planning should include the adoption of a systematic and structured approach for prevention and control of physical, chemical, biological, and radiological health and safety hazards described in the **General EHS Guidelines**.

Occupational health and safety issues occur during all phases of the mine cycle and can be classified according to the following categories:

- General workplace health and safety
- Hazardous substances
- Use of explosives
- Electrical safety and isolation
- Physical hazards
- Ionizing radiation
- Fitness for work
- Travel and remote site health
- Thermal stress
- Noise and vibration
- Specific hazards in underground mining (Fires, explosions, confined spaces and oxygen deficient atmospheres)

General Workplace Health and Safety

Recommended strategies to manage general workplace safety hazards include the following:

- Mining exploration and development activities should manage occupational health and safety hazards as part of a comprehensive health and safety management plan incorporating the following aspects:
  - Preparation of emergency response plans specifically applicable to exploration and production activities (considering the often geographically isolated nature of mining sites) and including the provision and

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[13] An example of a visual impact assessment methodology that can be used to help prioritize prevention and mitigation measures includes the United States Bureau of Land Management's Visual Resource Contrast Rating system (http://www.blm.gov/nstc/VRM/8431.html)

  maintenance of necessary emergency response and rescue equipment;
  - Sufficient number of first aid trained employees to respond to emergencies;
  - Implementation of specific personnel training on work-site health and safety management including a communication program with a clear message about corporate management's commitment to health and safety. The communication program should also include regular meetings such as daily talks prior to initiation of work shifts;
  - Integration of behavioral considerations into health and safety management, including on-the-job behavioral observation processes;
  - Training of employees on the recognition and prevention of occupational hazards specifically applicable to work in remote areas such as safety with respect to wildlife; protection against the elements; thermal stress; acclimatization; disease exposure; and navigational aids to avoid becoming lost;
- Illumination systems should be adequate and safe[14] for the planned working conditions in travel paths, mine working areas, and within and around surface facilities and dumpsites of mines (see the illumination guideline values presented in Section 2.0). Additional illumination guidance includes adherence to local standard requirements for illumination for mobile equipment operating above ground and on public roads;[15]
- Signage in hazardous and risky areas, installations, materials, safety measures, emergency exits, and other such areas should be in accordance with international standards (including standards of cleanliness, visibility and reflectance in areas of potentially poor illumination or sources of dust and pollution), be known and easily understood by workers, visitors, and as appropriate the general public;
- To the extent that alternative technologies, work plans or procedures cannot eliminate or sufficiently reduce a hazard or exposure, the mine operators should provide workers and visitors with the necessary personal protective equipment (PPE), and provide instruction and monitoring in their appropriate maintenance and use. Applicable PPE include, at a minimum, safety helmets and footwear, in addition to ear, eye, and hand protection devices.
- Occupational health assessments should be conducted for employees on a regular basis, based on exposure to risk. Medical records should be retained for at least 20 years.

Hazardous Substances

Working areas should be provided with adequate ventilation and dust/ fume extraction systems to ensure that inhalation exposure levels for potentially corrosive, oxidizing, reactive or siliceous substances are maintained and managed at safe levels as described in the **General EHS Guidelines**. In addition eye wash and emergency shower systems should be provided in areas where there exists the possibility of chemical contamination of workers and the need for rapid treatment. Materials Safety Data Sheets (MSDSs) should be available for all hazardous materials held on site.

Use of Explosives

Blasting activities that may result in safety impacts are typically related to accidental explosion and poor coordination and communication of blasting activities. Recommended explosives management practices include:

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[14] Considering the need to avoid such things as glare or potential sources of ignition.

[15] As a general rule, mobile equipment should produce an illumination level of 50 Lux across the passage at a distance of 1.5 times the stopping distance.

- Using, handling, and transporting explosives in accordance with local and / or national explosives safety regulations;
- Assigning certified blasters or explosives experts to conduct blasts;
- Actively managing blasting activities in terms of loading, priming, and firing explosives, drilling near explosives, misfired shots and disposal;
- Adoption of consistent blasting schedules, minimizing blast-time changes;
- Specific warning devices (e.g. horn signals, flashing lights) and procedures should be implemented before each blasting activity to alert all workers and third parties in the surrounding areas (e.g. the resident population). Warning procedures may need to include traffic limitation along local roadways and railways;
- Specific personnel training on explosives handling and safety management should be conducted;
- Blasting-permit procedures should be implemented for all personnel involved with explosives (handling, transport, storage, charging, blasting, and destruction of unused or surplus explosives);
- Blasting sites should be checked post-blast by qualified personnel for malfunctions and unexploded blasting agents, prior to resumption of work;
- Specific audited procedures should be implemented for all activities related to explosives (handling, transport, storage, charging, blasting, and destruction of unused or surplus explosives) in accordance with relevant national or internationally recognized fire and safety codes;
- Qualified security personnel should be used to control transport, storage, and use of explosives on site.

Electrical Safety and Isolation

Electrical safety and isolation of all sources of hazardous energy and hazardous substances should be undertaken in accordance with the **General EHS Guidelines**. Recommended management practices for mining operations include:

- Development of electrical competency standards and safe work procedures for all electrical work, including construction, decommissioning and demolition of electrical equipment;
- Use of electrical safety devices on all final distribution circuits, and appropriate testing schedules applied to such safety systems;
- All sources of hazardous energy or hazardous substances should have written procedures for isolation, identifying how the system, plant or equipment can be made and kept safe.

Physical hazards

Physical hazards in mining activities may include: the threat of landslides, rockfalls, face slumping, or land collapse in aboveground or underground mining environments; hazards related to transport (e.g. trucks, elevated haul roads, and railways), hazards related to height and falling, and use of fixed and mobile equipment, lifting and hoisting devices, and moving machinery.. Recommended prevention and control strategies include:

Geotechnical Safety

- Planning, designing, and operating all structures such as open pits, waste dumps, tailing dams, containment facilities and underground excavations such that geotechnical risks are appropriately managed throughout the entire mine cycle. Additional levels of safety should be applied in active seismic areas and those potentially exposed to extreme climatic events. Systematic monitoring and regular review of geotechnical stability data should be carried out Long term stability of worked-out sites should be adequately addressed for both surface and underground mines;

- For waste dumps, fills and other containment structures, static safety factors should be established based on the level of hazard for the operational phase of a facility and at closure;
- Potential change of geotechnical properties in dumps due to chemical or biologically catalyzed weathering should be considered. 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;
- Accurate assessment of worksite safety from rockfall and/or landslide should be conducted. Particular attention should be given after heavy rainfall, seismic events and after blasting activities. Risks should be minimized by appropriate bench and pit slope design, blast pattern design, rock scaling, protective berms and minimizing traffic.
- Assessment of the natural topography around the mine site, as well as mine related infrastructure such as cut slopes, road alignments should be included in geotechnical stability analyses. Especially in tropical climates or seismic zones with deeply weathered soils and high precipitation, natural geotechnical risks may exist even before the start of mining activities. These conditions can be especially hazardous for settlements / housing related to mining activities. Especially underground, but also for surface features, modern topographical 3D deformation measurements and related specific processing and evaluation software should be the standard method for stability monitoring.

Machine and Equipment Safety

To prevent and control hazards related to machine and equipment use, measures for the enhancement of visibility should be applied throughout the mine. Specific visibility management practices may include the following:

- Use of contrast coloring on equipment / machinery, including the provision of reflective markings to enhance visibility;
- Use of moving equipment / machinery equipped with improved operator sight lines;[16]
- Issuing workers high visibility clothing;
- Use of reflective markings on structures, traffic junctions, and other areas with a potential for accidents (e.g. walls in static locations should be whitewashed for improved reflectance);
- Use of appropriate illumination for the immediate operating areas of frequently turning and reversing equipment / machinery;
- Installing safety barriers in high-risk locations of internal roads / transport corridors. Barriers may be constructed with refuse or other materials capable to stopping vehicles.

Recommendations for the management of work in confined spaces or excavations, and work at heights, are provided in the **General EHS Guidelines.**

Ionizing Radiation

Where natural radiation hazards exist, the recommended mitigation measures include the following:

- Implementing a radiation dosimetry monitoring program for any areas where workers may be expected to receive

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[16] Sight lines of new equipment should be assessed using tools such as the United States National Institute of Occupational Safety and Health (NIOSH) Visibility Analysis Software available at: http://www.cdc.gov/niosh/mining/mining/illum/.

whole body doses of greater than 6 millisieverts in a 12-month period (see Effective Dose Limits for Occupational Ionizing Radiation presented in Section 2.0). The program should include workplace assessments as well as personal monitoring.

Fitness for work

Mining operations often have a number of activities where fatigue or other causes of impaired fitness for work could produce potential for serious injury, equipment damage or environmental impact. A risk assessment should be conducted to identify roles where "fitness for work" (including personal fitness) is required to ensure that the activity is completed with minimized risk. The recommended mitigation measures could include:

- Review of shift management systems to minimize risk of fatigue among employees;
- Tailoring of pre-placement medical exams to the requirements expected of an employee (i.e. good eyesight for a driver);
- Development of an alcohol and other drugs policy for the operation.

Travel and remote site health

Mining operations are often located in very remote regions, with limited access to high quality emergency or general medical services. To minimize risk from health impacts associated with frequent travel (as seen in exploration teams) and remote sites, the following mitigation measures can be recommended:

- Development of programs to prevent both chronic and acute illnesses through appropriate sanitation and vector control systems;
- Identification of risks associated with operating at altitude;
- Where food is prepared at a mining operation, food preparation, storage and disposal should be reviewed regularly and monitored to minimize risk of illness.

Thermal stress

Mining operations can require exposure of workers to extreme weather conditions. High temperature conditions generated by industrial processes can also result in thermal stress and should be considered. Thermal stress related to underground operations is discussed later in the document.

Noise and Vibration

Noise and vibration sources should be managed as described above in Section 1.1. Additional recommendations for the management of occupational exposures to noise and vibrations include:

- Reduction of noise to acceptable occupational exposure levels as described in the **General EHS Guidelines**;
- Ensuring that large equipment (e.g. excavators, dumpers, dozers, wagon-drills, and other automated equipment that requires an operator) is equipped with a soundproof cab;
- After all other options have been explored and implemented, use of personal hearing protection, as described in the **General EHS Guidelines**;
- Exposure to hand-arm vibration from hand and power tools or whole-body vibration from surfaces on which the worker stands or sits should be adequately controlled through the selection and maintenance of equipment which meets occupational vibration exposure standards.

Specific Hazards in Underground Mining

The following occupational health and safety hazards are specific to underground mining. As a general safety rule, a tagging system should be implemented to account for all persons traveling underground.

Ventilation

- Ventilation and air cooling systems should be appropriate for the workplace activities and be able to maintain work area temperatures and concentrations of contaminants at safe levels. Ventilation is considered an integral and essential part of the overall mine project and should be treated as such. Ventilation operators and maintenance personnel should undergo adequate training with respect to issues such as explosive atmospheres, products of combustion, dust (particularly if silica is present) and diesel fumes;
- Underground mines should ensure a safe and clean source of air for all areas expected to be occupied by workers. Recommended management strategies include:
  - Ensuring surface ventilation units and associated auxiliary equipment are located and managed to eliminate hazards that could jeopardize ventilation equipment performance or ventilation air quality (e.g. emissions sources and inflammable or explosive materials should not be stored near air intakes);
  - Operating auxiliary fans to avoid the uncontrolled recirculation of air;
  - Removing all persons from the mine, or moving them to a refuge area (properly stocked with water and food), if the main ventilation system is stopped other than for a brief interruption;
  - Barricading all areas that are not being ventilated and posting warning signs to prevent inadvertent entry.
  - All transformers, compressors, fuel bays and other high hazard areas should be ventilated direct to return airways;

- As appropriate, thermal conditions should be monitored to identify when persons could be adversely affected by heat and cold stress, and protective measures should be implemented. Temperatures should be maintained at levels reasonable and appropriate for the activities undertaken. Other practices should include heat tolerance screening, acclimatization, water breaks, and adoption of suitable work-rest regimens.

Dust

- Over and above the risks associated with dust identified earlier in this document and in the General EHS Guidelines, dust control should be fully integrated into underground operating procedures, particularly associated with blasting, drilling, and material transport and dumping. Minimization of dust is key to improved visual clarity in an underground setting, and also to the improvement of worker health.

Fires and Explosions

Underground mines should prepare and implement plans to prevent, detect, and combat the outbreak and spread of fires. Fire and explosion prevention and control strategies include:

- Conducting fire hazard assessments on a recurrent basis for early identification and minimization of areas where risks of “rapidly escalating fires” occur (e.g. areas using trackless diesel powered machinery);
- Identifying fire hazard areas using warning signs, and prohibiting all persons from smoking, using open flame lamps, matches or other types of ignition sources in the designated fire hazard areas, unless under strict protocols (e.g. welding protocol);
- Avoiding use of oil filled transformers underground;
- Inflammable materials should be stored in fireproofed facilities equipped for containment of leaks and spills. An appropriate fire detection and extinguishing system should be installed at each such storage location;

- Any storage for inflammable or hazardous materials including explosives should be located, designed, equipped and operated in accordance with relevant national or internationally recognized fire and safety codes. Explosives stores should be placed on surface except where local conditions justify (e.g. security or extreme cold);
- Avoid and control conveyor belt fires by ensuring fire hoses are operational and readily available along conveyor lines.

In underground mines classified as 'gassy' (which include most coal mines) additional precautions should include:

- Preventing ignitions by installing automatic gas detectors where electrically powered equipment is used, and other gas detectors throughout the underground working areas (e.g. at coal faces);
- Preventing ignition by restricting items made of, or containing, aluminum, magnesium, titanium, or light metal alloy unless there is no possibility of friction or impact, or they are adequately coated with non-sparking material;
- Hand-held tools should be placed in a non-sparking storage and appropriate permits obtained before use;
- Use of fire resistant hydraulic fluids in all underground equipment;
- Management of inflammable and explosive gasses in active and worked-out parts of underground mines unless such sections have been completely sealed and possible sources of ignition removed. When = 1 percent of methane is present, all electrical and mechanical equipment should be switched off. When = 1.5 percent of methane is present everyone except for those equipped, trained, and required for normalizing the situation should be evacuated and all potential sources of ignition should be deactivated and disconnected at the power source. Where methane emission occurs, monitors and alarms should be installed, as appropriate;
- Installing and using fire doors.

Refuge Bays and Self Rescuers

- Underground mines should be designed and developed with secondary or auxiliary exits and with mine refuge chambers that are:
    - Clearly identified
    - Within 15 minutes traveling time from anywhere in the mine for workplaces that are more than 300 m from a mine portal or shaft station that is used to access the workplace
    - Constructed of non-combustible material, with a sealing mechanism to prevent entry of gas, and of sufficient size to accommodate all persons working in the local vicinity
    - Equipped with independent connections to the surface for supply of air, communication (e.g. telephone), water, and first aid facilities
- Based on an assessment of potential risk of encountering oxygen deficient atmospheres (e.g. mines operating trackless diesel powered equipment), underground mining workers should be equipped and trained in the use of self-contained self-rescue devises (SCSRs) providing at least double the time needed to reach a refuge bay or mine exit (minimum 30 minutes). The SCSRs should be carried at all times or be readily accessible and within reach of the worker.

Illumination

Illumination systems should be adequate and safe[17] for the planned working conditions in travel paths and mine working areas (see the illumination guideline values presented in Section

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[17] With due consideration of the need to avoid such things as glare or potential sources of ignition.

2.0). Additional illumination guidance specific to underground mining includes:

- Underground illumination should be adequate for the safe performance of all work functions and the safe movement of workers and equipment;[18]
- Permanent lighting that provides adequate illumination in the following locations: all workshops, service garages, and other places with moving machinery or where equipment could be a hazard; underground main shaft stations and active shaft landings; first aid stations; and conveyor galleries, drives, and transfer stations;
- Separate and independent emergency light sources should be provided at all places where a hazard could be caused by a failure of the normal lighting system. The system should turn on automatically, should be adequate to allow the workers to conduct an emergency shutdown of machinery, and should be tested on a regular basis;
- Underground workers should have an approved cap lamp in their possession at all times while underground. The peak luminance should be at least 1500 lux at 1.2 m from the light source throughout the shift.

1.3 Community Health and Safety

Community health and safety issues that may be associated with mining activities include transport safety along access corridors, transport and handling of dangerous goods, impacts to water quality and quantity, inadvertent development of new vector breeding sites, and potential for transmission of communicable diseases, e.g., respiratory and sexually transmitted infections resulting from the influx of project labor. In addition, there can be significant household and community level effects on the social determinants of health, e.g., drug, alcohol, gender violence, and other psychosocial effects, associated with the rapid influx of labor during construction and operational phases. The rapid influx of labor and their associated extended family members may also place a significant burden on existing community health facilities and resources. Finally, because of their large and generally positive economic impacts, large mining developments can rapidly move local communities from a pattern of infectious diseases, e.g., malaria, respiratory and gastrointestinal infections, to a pattern of non-communicable diseases, e.g., hypertension, diabetes, obesity and cardiovascular disorders. The medical infrastructure in many developing countries is often poorly equipped or experienced in dealing with non-communicable diseases. .

Recommendations for the management of these issues are described in the **General EHS Guidelines**. Additional concerns specific to mining activities, with community health and safety implications, and also broader EHS implications are considered under the following headings:

Tailings Dam Safety

Dams, wet tailing impoundments, and other major wet containment facilities represent a potential risk depending on their location with regards to human settlements and other community resources. Tailings dam health, safety and environment considerations are covered earlier in this document.

Water Storage Dams

Water storage dams can potentially create and change the existing pattern of vector breeding sites. In areas where malaria is common, the shorelines of the WSD may create a mosquito breeding site because of the presence of a large, shallow, and vegetated shoreline. In addition, the WSD may also create a

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[18] As a general rule, underground workers should have cap lamps with a mean intensity of 1 candela (12.57 Lumens) and 10-hours battery capacity. Mining vehicles and transport equipment of all types should provide at least 10 Lux 20 m ahead of the device and 10 Lux 5 m behind it when reversing.

new breeding site for the snail host of schistosomiasis, an important parasitic disease that is common in many tropical climates.

Land Subsidence

Land subsidence may occur as a result of underground or solution mining activities. Land subsidence may leave land prone to flooding and may otherwise damage property if it leaves farmland unsuitable for further use. To minimize and / or control changes in terrain due to land subsidence, recommended management measures include the following:

- Developing the mine with consideration of the location / size of the ore body, overlying strata, and required well depths for extraction (e.g. there is generally less potential for subsidence associated with increased extraction depths);
- Monitoring the size and shape of mined caverns using well logging devices and operating techniques (e.g. solution pressures and pumping rates over time, flow volumes, temperatures, and specific gravities);
- Filling shafts, raises, stope openings, adits, and drifts opening to the surface with reinforced concrete or with other material to prevent or reduce subsidence in high risk areas.;
- Subsidence areas should be managed to ensure adequate drainage and re-established to previous land use or other use acceptable to the community. Roads in such areas should be adequately sign-posted.

Emergency Preparedness and Response

Emergency preparedness and response arrangements should be commensurate to the potential for emergency situations, reflecting the measures described in the **General EHS Guidelines.** An Emergency Response Plan should be prepared in accordance with the guidance of the UNEP APPEL for Mining: Awareness and Preparedness for Emergencies at the Local Level[19] process.

Communicable Diseases

The nature of mining projects (e.g. location in remote areas with long material / product supply chains) requires proactive and sustained interventions to minimize the incidence and transmission of communicable diseases caused by the influx of migrant workers, associated extended family members and other service workers at the site. Long haul transport activities may serve as disease conduits particularly for sexually transmitted infections. At the mine site, good international industry practice for solid waste management, surface water drainage, and sanitary wastewater management are usually effective in reducing vector borne and water related communicable diseases.

Project housing and catering facilities and services should be designed and maintained according to internationally accepted standards. Worker living quarters that are designed and maintained to prevent over-crowding can reduce the transmission of communicable respiratory diseases that may transfer to local communities. Catering facilities and services that are designed, maintained and operated according to internationally accepted Hazard Analysis Critical Control Point (HACCP) standards reduce the potential for transmission of food related illnesses from the project to the community.

In many parts of the world the key threat to the viability of the mining operation and the health of local communities are the potential negative impacts on key social determinants of health (i.e. drug, alcohol, sexually transmitted infections, and gender violence).

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[19] APELL for Mining, Awareness and Preparedness for Emergencies at Local Level, Technical Report No. 41, UNEP 2001. The report provides a framework for preparation of an Emergency Response Plan involving the mine, emergency response agencies, local authorities and communities.

In many developing countries, there are significant pre-existing burdens of all STIs including HIV, however, the potential of triggering a new upsurge in these trends should be considered when developing a mining project. The hallmark of this situation is the "Four M's":

- Men – labor influx;
- Money – surge in disposable cash;
- Movement – development of new transport routes facilitating access to rural communities;
- Mixing – interface of high prevalence rate groups (i.e. police, security, truckers and sex workers) with local low prevalence rate men and women.

Over time, the spread of HIV / AIDS is not only the cause of immense human misery and suffering, but can also negatively affect the company in terms of staff turnover, declining productivity, increasing costs, changing markets, and access to contracts and procurement opportunities. Mining operations should define and understand the potential effect of HIV / AIDS, and design an appropriate management response, including use of:[20]

- Strategies to manage the impact of diseases through assessment, surveillance, actions plans, and monitoring;
- A workplace program to prevent new HIV infections and provide care and support for infected and affected employees;
- Outreach activities within the community, sector and / or broader society.

Typical measures undertaken to reduce communicable disease incidence involve:

- Preventing illness among workers and their families and in local communities by:
    - Undertaking health awareness and education initiatives
    - Training health workers in disease treatment
    - Providing treatment through standard case management in on-site or community health care facilities (e.g. immunization programs)

Specific Vector Control and Prevention Strategies

Reducing the impact of vector-borne disease (e.g. malaria) on the long-term health of workers and in local communities is best accomplished through implementation of an integrated set of interventions aimed at eliminating the factors that lead to disease. Therefore there are significant roles for both project engineering and medical staffs. Project sponsors, in close collaboration with community health authorities, should implement an integrated control strategy for mosquito and other arthropod-borne diseases that should generally involve:

- Implementation of an integrated vector control program;
- Engineering design reviews including careful scrutiny of roads, water storage and control facilities and surface water management strategies;
- Collaboration and exchange of in-kind services with other control programs in the project area to maximize beneficial effects, particularly distribution of treated bed nets;
- Development of the "A-B-C-D" program for all project workers where A= awareness, B=bite control, C=chemoprophylaxis for non-immune personnel and D= diagnosis and treatment;
- Selective use of residual indoor spraying (IRS) for project housing. IRS programs are complex and involve careful design review, particularly a clear understanding of the local mosquito vectors and their pre-existing resistance to available insecticides;

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[20] For additional information refer to the IFC's HIV/AIDS Resource Guide for the Mining Sector available at: http://www.ifc.org/ifcext/enviro.nsf/Content/HIVAIDS

- Development of an effective short and long-term monitoring and evaluation program for both workers and potentially affected communities.

1.4 Mine Closure and Post-Closure

Closure and post-closure activities should be considered as early in the planning and design stages as possible. Mine sponsors should prepare a Mine Reclamation and Closure Plan (MRCP) in draft form prior to the start of production, clearly identifying allocated and sustainable funding sources to implement the plan. For short life mines, a fully detailed Mine Reclamation and Closure Plan (with guaranteed funding) as described below should be prepared prior to the start of operations. A mine closure plan that incorporates both physical rehabilitation and socio-economic considerations should be an integral part of the project life cycle and should be designed so that:

- Future public health and safety are not compromised;
- The after-use of the site is beneficial and sustainable to the affected communities in the long term;
- Adverse socio-economic impacts are minimized and socio-economic benefits are maximized.

The MRCP should address beneficial future land use (this should be determined using a multi-stakeholder process that includes regulatory agencies, local communities, traditional land users, adjacent leaseholders, civil society and other impacted parties), be previously approved by the relevant national authorities, and be the result of consultation and dialogue with local communities and their government representatives.

The closure plan should be regularly updated and refined to reflect changes in mine development and operational planning, as well as the environmental and social conditions and circumstances. Records of the mine works should also be maintained as part of the post-closure plan.

Closure and post closure plans should include appropriate aftercare and continued monitoring of the site, pollutant emissions, and related potential impacts. The duration of post-closure monitoring should be defined on a risk basis; however, site conditions typically require a minimum period of five years after closure or longer.

The timing for finalization of the MRCP is site specific and depends on many factors, such as potential mine life, however all sites need to engage in some form of progressive restoration during operations. While plans may be modified, as necessary, during the construction and operational phases, plans should include contingencies for temporary suspension of activities and permanent early closure and meet the following objectives for financial feasibility and physical / chemical / ecological integrity.

Financial Feasibility

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. 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. Mine closure requirements should be reviewed on an annual basis and the closure funding arrangements adjusted to reflect any changes.

Physical Integrity

All structures (e.g. tailings impoundments) should remain stable such that they do not impose a hazard to public health and safety as a result of physical failure or physical deterioration. Tailings structures should be decommissioned so that water accumulation on the surface is minimized and that any water from the surface of the structure can flow away via drains or spillways and these can accommodate the maximum probable flood event. Spillways, drains and diversion ditches must continue to be maintained as required after closure, as they can easily become choked after storm events. Structures should not erode or move from their intended location under extreme events or perpetual disruptive forces. Consideration should be given to backfilling of mine workings.

Physical hazards such as unguarded roads, shafts, and other openings should be effectively and permanently blocked from all access to the public until such time that the site can be converted into a new beneficial land use based on changed conditions at the site, as well as alternative uses by local communities or other industries for roads, buildings and other structures. Where there is a risk of methane emanating from disused shafts and other workings, passive venting systems should be considered.

Chemical Integrity

Surface water and groundwater should be protected against adverse environmental impacts resulting from mining and processing activities. Leaching of chemicals into the environment should be prevented, so as to avoid endangering public health or safety or exceed water quality objectives in downstream surface water and groundwater systems.

Ecological Habitat Integrity

While ecological habitat integrity is partially determined by the above factors (e.g. physical issues such as slope stability) and chemical issues (e.g. such as metal contaminants), it is also addressed with consideration towards replacement of habitat that is beneficial for future ecological use. The Mine Reclamation and Closure Plan (MRCP) should contain comprehensive measures for concurrent reclamation during the operating life of the mine according to a plan approved with the environmental and mineral authorities and with the engagement of local government and communities.

2.0 Performance Indicators and Monitoring

2.1 Environment

Emissions and Effluent Guidelines

Table 1 presents effluent guideline values for this sector. Guideline values for process effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks. These guidelines should be achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques discussed in the preceding sections of this document.

Effluent guidelines should be applicable for site runoff and treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the **General EHS Guideline.**

Table 1. Effluent Guidelines

Pollutants	Units	Guideline Value
Total Suspended Solids	mg/L	50
pH	S.U.	6 – 9
COD	mg/L	150
BOD_5	mg/L	50
Oil and Grease	mg/L	10
Arsenic	mg/L	0.1
Cadmium	mg/L	0.05
Chromium (VI)	mg/L	0.1
Copper	mg/L	0.3
Cyanide	mg/L	1
Cyanide Free	mg/L	0.1
Cyanide WAD	mg/L	0.5
Iron (total)	mg/L	2.0
Lead	mg/L	0.2
Mercury	mg/L	0.002
Nickel	mg/L	0.5
Phenols	mg/l	0.5
Zinc	mg/L	0.5
Temperature	°C	<3 degree differential

Note: Metals concentrations represent total metals.

These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels in consideration of specific, local project conditions should be justified in the environmental assessment.

Combustion source emissions guidelines associated with steam- and power-generation activities from sources with a capacity equal to or lower than 50 MWth are addressed in the **General EHS Guidelines** with larger power source emissions addressed in the EHS Guidelines for Thermal Power. Guidance on ambient considerations based on the total load of emissions is provided in the **General EHS Guidelines**.

Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project. In some mining projects monitoring should extend for a minimum period of three years after closure or longer if site conditions warrant.

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

2.2 Occupational Health and Safety Performance

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of

Governmental Industrial Hygienists (ACGIH),[21] the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),[22] Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),[23] Indicative Occupational Exposure Limit Values published by European Union member states,[24] or other similar sources. Table 2 provides illumination guidelines for mining activities. Table 3 provides ionizing radiation exposure guidelines for mining workers.

Table 2. Minimum average illumination for designated mine locations and activities.[25]

Location / activity	Minimum Illumination (Lux)
Emergency lighting	5
Walkways and passages	5 -10
Dynamic locations - production and development areas.	5 - 50
Areas with occasional and simple manual tasks	50 -100
Workstations and areas with medium to high precision manual tasks	150 – 400

Table 3. Effective Dose Limits For Occupational Ionizing Radiation Exposure.[26]

Five consecutive years average – effective dose	20 mSv/year
Single year exposure – effective dose	50 mSv/year

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)[27].

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals[28] as part of an occupational health and safety monitoring program with recognition for post-closure long term health concerns. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

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[21] Available at: http://www.acgih.org/TLV/ and http://www.acgih.org/store/

[22] Available at: http://www.cdc.gov/niosh/npg/

[23] Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992

[24] Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/

[25] The Role of illumination in Reducing Risk to Health and Safety in South African Gold and Platinum Mines, GAP 804, 2001 provides detailed recommendations for a variety of underground places of work.

[26] ICRP 60 by the International Commission on Radiological Protection and IAEA Safety Series No. 115.

[27] http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm

[28] Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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Annex A: General Description of Industry Activity

Mining operations are defined primarily by the type and method of the mining (e.g. hard rock mining, coal mining, solution mining, marine mining, underground, open pit). Conventional hard rock mine operations combine large scale ore and waste rock extraction, beneficiation [which involves comminution (e.g. crushing / grinding ore) and mineral concentration], and large scale waste storage and treatment facilities. Metallurgical processing involves geochemical changes to refine the metals, and is typically conducted off-site from the mine. Metallurgical processing is considered a separate industry sector, and is discussed in the EHS Guidelines for Smelting and Refining.

The overall objective of a mining operation is to extract the valued ore, and complete preliminary processing (e.g. beneficiation), while at the same time manage the much larger volumes of mine waste (e.g. waste rock, tailings, wastewater, process and hazardous wastes) in a manner that protects environment, human health and safety under a range of present and future conditions and timelines.

Mining operations are generally classified into four principal categories based on commodity: precious metals, base metals, and energy and industrial minerals (see Table A.1).

The principle components of a typical mine include:

- Mine pits and / or underground workings;
- Waste storage areas and tailings facilities;
- Rock and ore stockpiles;
- Plant and processing facilities (e.g. mills);
- Water management infrastructure (e.g. treatment ponds, dams, ditches, piping);
- Other infrastructure (e.g. roads, power lines, airstrips)

Mine operations are invariably located on or adjacent to the ore body to minimize operation and preliminary processing costs as well as potential for unwarranted land disturbance. Mine locations are diverse, including virtually all bio-geoclimatic zones (e.g. temperate, tropics, polar, desert, high altitude, coastal, surface and subsurface). Processed products are transported for further processing or to market as economic and logistical considerations dictate using a combination of truck, barge, rail, and slurry pipeline, among other methods. Typical surface mine operations range from about 100 ha to 1,000 ha in size, but can exceed 5,000 ha for exceptionally large developments.

Exploration

Exploration activities are likely to progress through increasing levels of site activity, namely preliminary, detailed and advanced exploration. Preliminary exploration studies frequently do not include extensive site work. However, detailed and advanced exploration sites require site investigations usually involving ground disturbance for access roads, drill sites and underground exploration tunnels.

Development, Construction, and Decommissioning

Proactive planning of the mining strategy should be undertaken with the objective of reducing environmental risks. This may range from major issues that determine the mine plan, such as the sequencing of pits and the selection of a materials handling strategy, to locating soil and overburden stockpiles up-wind from tailings and other potential sources of dust.

Operation Phase

Operation is signified by startup of the mill and processing unit(s). The operational life of the mine is a function of the amount of ore available in the deposit. Waste rock from the mine workings and tailings from the processing plant are produced daily as the mine advances and these materials are deposited on land in waste storage areas until mining ceases. Additional ore body reserves may be discovered during operations resulting in dynamic changes to the overall mine exploitation strategy. Temporary closure may be required during operations (e.g. due to unfavorable economics or labor disputes), during which time care and maintenance is required to ensure there are no risks to public health and safety and the environment.

During the operation phase, the mine evolves physically and geochemically, resulting in the potential need for additional environmental, social and health impact assessment and management, Upset conditions may occur (e.g. accidental release of tailings pond water, or breach of tailings dam), and such events, although rare, would also potentially necessitate further impact assessment and management

Final Closure and Decommissioning

Typically during the last five years of forecasted operations, a final closure plan is developed with the objective of leaving the mine area in a functioning ecological (to the extent possible), and physically-chemically stable, state, thereby making it available for future land uses. 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. Ongoing rehabilitation work will typically include:

- Demolishing buildings and physical infrastructure;
- Closing open pits;
- Stabilizing and preventing public access to underground workings and shafts;
- Reclamation of slopes;
- Ensuring that water draining from the mine site and waste deposits are not a risk to human health and the environment.

Post- Closure Care

The extent of care required after closure of mining and processing activities falls into two basic levels:

- *Active care*: Requires ongoing operation, maintenance, and monitoring to ensure there is minimal (acceptable) risk to public health and the environment
- *Passive care*: Requires ongoing need for occasional monitoring and periodic maintenance to ensure there is minimal (acceptable) risk to public health and the environment.

A third level of care, the concept of a "walk away" solution, infers that no additional monitoring or maintenance is needed. Experience shows that some parts of a mine site or mine components may be left in a "walk away" condition. However, it is rare that an entire mine site can be left in a "walk away" condition.

Mining Methods and Activities

Open Pit Mining

Large, near-surface ore bodies are excavated by forming an open pit. The ore and non-ore materials (which include topsoil, overburden and rock) are excavated using surface mining equipment, generally trucks and shovels. The dimensions and size of each open pit are unique and depend upon the ore grade and geometry, geologic structures, rock strength and topography. The pit slopes are commonly designed in a system of steep slopes, typically up to 30 meters high, between horizontal benches. The height of each individual slope is principally dependent upon the size of excavation equipment, geologic structures, and rock strength.

Many open pits are excavated below the water table causing changes to the groundwater flow pattern during operation and in some instances during post-closure of mines. Surface drainage patterns may also be disrupted. Often an underground mine is developed below the open pit and there may be connections to underground mine workings. Open pits are typically partially filled with water from surface and groundwater following completion of mining operations.

Underground Mining

Underground mining generally requires a complex system of access, service and stoping excavations to recover the ore. Ore bodies can be continuous or discontinuous, occurring in small volumes with large barren (no ore) zones in between. Mines generally attempt to remove as much of the economical ore material as possible and this can result in very large underground excavations. These excavations will have different levels of stability. The larger excavations may be backfilled or allowed to collapse. Most underground mining methods fall within the following broad categories:

Concurrent caving: Ore is extracted and the underground workings are allowed to collapse, and the overlying rock therefore must cave (collapse) concurrently with extraction of the ore. Consequently, surface disturbances are likely to occur rapidly, depending upon the depth of the mine workings.

Post caving: Extraction of the ore takes place without backfill and caving could occur at some time after the ore has been extracted. Surface disturbances are likely to occur in the future.

Open stopping with pillars: Pillars are left to maintain stability while ore is extracted. Collapse and surface disruption could occur in the future.

Fill mining: The openings left by the extraction of the ore are backfilled with material, which may be waste rock, tailings or tailings paste. Fill mining greatly reduces the potential for surface disturbances.

Other Mine Types and Methods

Industrial Mineral Mining

The term “Industrial Mineral” is often used to refer to non-fuel, non-metal minerals such dimension stone (e.g. limestone, granite, slate, among others); crushed and broken stone; sand and gravel; clay, ceramic, and refractory minerals (e.g. kaolin, bentonite, shale); and chemical and fertilizer materials (e.g. potash and phosphate). This wide range of materials can be mined using a variety of techniques.

Solution Mining and In Situ Leaching

Solution mining is sometimes referred to as *In-situ* leaching because of the common feature of dissolving and collecting the valued mineral (e.g. salt, potash, sulfur, uranium, copper, and gold) in solution form. Solution mining focuses on the dissolution of salts through injection of water into the deposit and creation of a pressurized subsurface cavern of brine that is returned to the surface. *In situ* leaching involves addition of various reagents to water and a network of injection wells to inject the solution into a subsurface mineral deposit to effect dissolution, followed by pumping to recapture the dissolved minerals (pregnant solution) via a network of collection wells. *Heap leach* extraction is yet another variation of the dissolution strategy, whereby the desired minerals are dissolved from ore that has already been brought to surface by conventional means (e.g. by surface or underground mining).

Marine Dredge Mining

Marine dredge mining involves removing minerals from the ocean floor by dredging. This method may result in disruption to the seabed and loss of habitat and its associated biota. High levels of suspended sediment may also occur in the water column from activities related to capturing the material, raising it to the surface, transporting, and placing or storing it for further processing. Dredging can be conducted by stationery, self-propelled, or land-based approaches, and typically involves mechanical, hydraulic, or combined-technology machinery.

Deep Sea Mining

Deep sea mining involves mechanized excavation equipment together with large pumps, mining superficial deposits on the sea floor. The pumps propel the mineralized material to a ship on the surface, using a riser. This mining method may result in disruption to the seabed, changing water temperatures, and development of a sediment plume.