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Environmental Assessment of Mining Projects

Expansion within the mining and metallurgical sector is central to the development and economic growth of many developing countries. The products of the sector (including metallic and non-metallic substances, construction materials or fertilizers) are not only essential to many industrial processes and for construction activities, but also are often a valuable source of foreign exchange earnings. However, mining operations frequently involve considerable environmental disturbance that can extend well beyond the area of mining developments.

The impacts of mining related activities commence with exploration, extend through extraction and processing of minerals, and may continue post-closure of the operation, with the nature and extent of impacts varying throughout the stages of project implementation. This Update *provides an introduction to the environmental issues associated with mining activities, the relevant contexts where the Bank might be involved with mining projects, and the extent to which environmental issues should be addressed by private or public sector organizations seeking Bank Group support for mining projects. While this* Update *briefly mentions certain social impacts, the primary focus is on physical environmental issues. This* Update *complements material in Chapter 10, pages 179–194 of the Environmental Assessment Sourcebook.*

Introduction

In comparison with many other sectors, the potential social and environmental issues associated with mining and mineral processing operations are both highly significant and complex to manage. The fixed location of the mineralized zone of interest imposes constraints on all aspects of mining developments, including the method of mining, location of mine facilities, requirements for new infrastructure and services (or conflict with existing infrastructure), and the suitability of waste management or disposal methods. This in turn profoundly influences the environmental, social and health impacts of mining developments, as well as the economic viability of developing a given mineralized zone.

The challenges posed to EA of mining projects are twofold. Firstly, to ensure that environmental, social and health costs are afforded adequate consideration in determining the economic viability and acceptability of alternative project scenarios. Secondly, to ensure that adequate control, mitigation or protection measures are incorporated into project design, implementation and decommissioning plans. This requires both effective environmental legislation and enforcement by regulatory institutions, and sound environmental management practices by private and public sector mine operators.

The International Conference on Development, Environment and Mining—jointly sponsored by the Bank, the International Council on Metals and the Environment (ICME), United Nations Environment Programme (UNEP) and the United Nations Conference on Trade and Development (UNCTAD)—held in Washington, D.C. in 1994 highlighted the following in relation to mining:

- Government approaches to environmental regulation are shifting from centralized decision making, detailed regulations, and command-and-control toward the setting of objectives, clear standards and provision of information.
- Environmental regulations do not act as a disincentive to investment, provided that the regulations are realistic, transparent and stable.
- Mining companies should take full account for social and cultural issues in promoting sustainable development.

Accordingly, the primary objectives of this *Update* are to:

- Provide Bank Group staff and borrowers with a brief overview of the environmental issues associated with mining and metallurgical processing
- Identify the types of Bank Group lending within the sector and describe the associated EA requirements (with reference to Bank policies and guidelines)
- Provide guidance on developing the institutional framework, and private sector environmental management capacity, to support sustainable development in the mining sector.

This *Update* is not intended as a detailed source of information on the environmental implications of the wide range of mining operations and project contexts. However, sources of such information are included on the last page of the *Update*.

Overview of environmental aspects of mining

Mining operations may generally be categorized as either surface or underground. Surface mining may be broadly defined to encompass open pit, open cast, quarry, strip, dredging, and placer (hydraulic) mining. Underground mining includes a range of methods such as cut-and-fill, pillar-and-stope, shrinkage stope, block caving, and longwall mining. Most mining operations (whether surface or underground) share a number of common stages or activities, each of which have potentially adverse impacts on the natural environment, social and cultural conditions, or the health and safety of mine workers, or communities in the environs of the mine. These adverse impacts may be especially severe when mining takes place in areas occupied or utilized by indigenous peoples. Mining and its related activities fall into the following categories:

- Exploration
- Extraction and disposal of waste rock, and so forth
- Ore processing and plantsite operations
- Tailings containment, treatment, and disposal
- Infrastructure, access, and energy
- Construction workcamps and operational townsites.

The potential adverse impacts of each of these activities (including impacts on air quality, hydrology and water quality, ecology and biodiversity, social and cultural conditions, human health, natural resources, and infrastructure) are illustrated in a simplified matrix in box 1, and briefly discussed below.

The identification of the area (and communities) potentially affected by a mining project is a key initial task. While the most obvious impacts may occur in the immediate vicinity of the mine and waste dumps, ecosystems and communities far distant may be impacted in the case of riverine disposal of waste and by the transportation and shipment of ores and coal over long distances. Such factors need to be taken into consideration in determining the aerial extent of any environmental and social studies.

Mining EA teams must determine the range, type, and duration of baseline data needed to make defensible and robust impact predictions. Where baseline information is lacking, as is often the case in developing countries, it is important to gather such data to support impact prediction and assessment. Additional guidance on baseline data is given in *Update* no. 16: *Challenges of Managing the EA Process.*

Exploration activities

Exploration activities encompass all actions in the field which precede feasibility studies. This might include initial reconnaissance flights and geophysical surveys, stream sediment studies and other geochemical surveys, construction of access roads, clearing of test drilling sites, installation of drill pads and drilling rigs, benching, trenching / pitting, erection of temporary accommodations, and power generation for exploratory drilling. The potential environmental implications of exploration depend on a number of factors, notably the following:

- Construction of new access routes
- Proximity of surface waters to drill sites (particularly those used for potable water abstraction)
- Ecological significance of affected habitat, and the extent to which access has been improved as a result of exploration
- Proximity to and intrusion upon existing settlements or resources utilized by local or indigenous people
- Extent to which local or indigenous communities are voluntarily isolated, or have been exposed to diseases prevalent among exploration workers.

The potential significance of the environmental and social disruption associated with exploration has often not been recognized, although experience suggests that this is increasingly the first point of conflict on many such issues. Exploration impacts may be controlled by measures such as restricting land clearance to the minimum required, removal or disabling of access infrastructure, use of helicopter access for personnel and equipment wherever practicable, developing plans for managing contact with local communities, and rehabilitation of abandoned exploration sites.

Ore extraction and disposal of overburden and waste rock

Overburden and waste rock include non-mineralized strata overlying or interleaving mineralized zones,

Box 1. Potential environmental and social impacts of mining activities

MINING ACTIVITIES	Exploration and ore extraction	Exploration drilling	Resettlement (if necessary)	Extraction and waste rock removal/disposal	Rock blasting and ore removal	Mine dewatering	Placer and dredge mining	Small-scale artisanal mining	Ore processing and plantsite	Plant site, materials handling, etc.	Stockpiling	Beneficiation	Phytometallurgical processing	Hydrometallurgical processing	Water usage (all industrial and domestic)	Use & storage of process chemicals	Tailings containment/disposal	Infrastructure, access & energy	Access roads, rail & transmission lines	Wastewater treatment and disposal	Pipelines for slurries or concentrates	Power sources & transmission lines	Construction camps, town site	Decommissioning	Regrading and recontouring	Stabilization of waste dumps and tailing	Mine closure
POTENTIAL IMPACTS																											
Air quality																											
Increased ambient particulates (TSP & PM-10)				●	●					●	●		●				●		●			●	●		●		
Increased ambient Sulfur dioxide (SO_2)													●									●	●				
Increased ambient Oxides of Nitrogen (NO_x)													●									●	●				
Increased ambient heavy metals				●	●					●	●		●				●		●			●	●				
Hydrology, hydrogeology & water quality																											
Altered hydrologic regimes				●		●	●	●		●				●	●		●		●	●		●	●		●		
Altered hydrogeological regimes						●								●	●												
Increased heavy metals, acidity or pollution			●	●		●	●	●		●	●			●		●	●		●	●		●	●		●	●	
Increased turbidity (suspended solids)			●	●			●	●		●	●			●			●		●	●	●	●	●		●	●	
Risk of groundwater contamination			●	●	●	●		●						●		●	●			●						●	
Ecology and biodiversity																											
Loss of natural habitats & biodiversity (OP 4.04)			●	●			●	●		●							●		●		●	●	●				
Loss of rare and endangered species				●			●	●		●							●		●		●	●	●				
Effects of induced development on ecology			●					●											●				●				
Effects on riverine ecology and fisheries				●		●	●	●			●				●	●	●			●	●		●				
Impacts due to effluents or emissions			●	●			●	●				●	●	●			●			●					●	●	
Social concerns																											
Resettlement issues (OD 4.30)				●	●		●			●							●		●			●	●				
Effects on indigenous peoples (OD 4.20)			●	●	●		●	●		●							●		●			●	●				
Loss of cultural heritage or religious sites			●	●	●		●			●							●		●			●	●				
Loss of livelihood				●													●					●	●				●
Induced development issues			●	●															●			●	●				
Effects on aesthetics and landform				●			●	●		●							●					●	●				
Noise issues				●	●		●			●												●	●				
Occupational & public health concerns																											
Occupational health and safety concerns												●										●	●				
Hazards from process chemicals or explosives					●			●				●				●						●					
Potential increase in disease vectors				●				●															●				
Increased potential for respiratory disorders					●			●				●	●			●						●					
Resource issues																											
Effects of subsidence on surface resources						●																					
Agricultural land losses			●	●	●			●			●							●		●			●	●				
Loss of forestry resources (OP 4.36)					●			●	●		●							●		●			●	●				
Effects on surface water resources (OP 4.07)					●	●	●	●	●			●	●		●	●		●		●	●		●	●				
Effects on ground water resources (OP 4.07)						●	●		●				●		●	●		●			●		●	●				
Disruption to infrastructure					●			●												●								
Effects on fisheries					●		●	●	●			●			●	●		●			●		●	●				

and low-grade mineralization which can not be economically processed. The key issues to consider in determining the magnitude and significance of environmental impacts include:

- The extent and depth of the mineralized zone
- The quantities of material to be mined and disposed of and the effects on dump locations and designs
- The possible inherent toxicity of the wastes
- The potential for acid drainage from or erosion of mineralized stockpiles or waste rock dumps and requisite environmental controls

- Health and safety issues relating to transportation, storage, use of explosives and toxic materials, radioactive materials in mine workings, and dust inhalation
- Geotechnical competence of materials and suitability for remedial or civil works (such as landscaping, road fill or aggregate, tailings dam or bund construction, or clay liners for tailings disposal areas or settlement ponds)
- Management (containment, control, and disposal) of slurries (for overburden disposal from dredging or placer mining)
- Surface damage and subsidence resulting from underground mining
- Release of methane from underground coal mines.

The potential adverse environmental implications of these activities include impacts on water quality or hydrology, plant and animal life, loss of natural habitats, resettlement, loss of cultural heritage or religious sites, effects on visual amenity, noise nuisance, and loss of agricultural land or forestry resources (see box 1).

Ore processing and plantsite operations

Depending on the type of mine, ore processing may involve beneficiation—where mined ore is either concentrated for further processing or graded for sale—followed by metallurgical processing and refining. For some ores beneficiation consists of: preparation by crushing and/or grinding, concentration by gravity or magnetic separation or flotation, followed by dewatering and filtration. The outputs from such processes are ore concentrates and waste materials, in the form of tailings (which may include process chemicals and heavy metals) and dust emissions.

Metallurgical processing typically involves the isolation of metal substances from ore concentrates by pyrometallurgical, hydrometallurgical or electrometallurgical methods, singly or in combination. Pyrometallurgical processes such as roasting and smelting result in atmospheric emissions (for example, sulfur dioxide, particulates, and heavy metals) and slag containing toxic substances. Hydrometallurgical methods typically retain pollutants in the aqueous phase, and those which are not recycled are usually discharged to tailings ponds. Wind entrainment of dry tailings can result in airborne pollution. Some of the chemicals used in processing (such as cyanide, mercury, and strong acids) are inherently hazardous, and their transportation, handling, use, storage, and disposal should be carefully controlled in the interests of health and safety, and the environment.

In the case of coal, its preparation may include removal of waste and rocks by hand or mechanical methods, as well as, coal washing to produce a product of higher and more consistent quality. Impacts to be assessed include the disposal of rejects and waste material, dust containment, and disposal of waste waters.

Tailings containment, treatment and disposal

Management of tailings is one of the most significant environmental aspects of mining operations. Failure of tailings containment, treatment or disposal operations is of great concern, particularly in regions of seismic activity. It can have serious adverse environmental consequences, and may also be the focus of attention by the media and NGOs. Examples include the accidental release of tailings at a copper operation on the Island of Marinduque in the Philippines in March 1996, which resulted in leakage of 2.4 million tons of tailings into the Boac river. Similarly, the failure of a tailings dam in August 1995 at a gold mine in Guyana, resulted in the release of tailings to the Omai and Essiquibo rivers.

The important issues to consider in evaluating alternative tailings disposal options include:

- The geochemical characteristics of the area to be impounded/inundated by tailings, and potential for leachate migration from tailings
- Seismicity of the area, or other natural hazards and risks that might affect the suitability of potential disposal areas or influence the engineering design
- Other siting issues including conflict with sites of ecological, cultural heritage, agricultural, or other importance, and protection of livestock, wildlife, and people
- Chemical characteristics of sands, slimes, and pond water, and requirements for treatment
- The water management regime and requirement to discharge effluents (if any) and the degree of treatment required
- The reclamation potential of the site, based on the above factors.

The options for tailings disposal include backfilling into mined-out areas, damming valleys, construction of a retaining bund (in relatively flat areas), and disposal to river, lake, or sea. The latter options are generally resorted to only where land-disposal options are seriously constrained. For example, some uranium operations in Northern Canada employ deep lake disposal in the anoxic zone to overcome tailings management difficulties related to long term frost conditions. Similarly, the Lihir Gold Mine project in Papua New Guinea is using deep ocean disposal, due to physical constraints imposed by the island landform.

Pollution control from tailings disposal during operation should address prevention of seepage, the treatment/return of decant waters, prevention of wind erosion, and effects on wildlife. The World Bank

Box 2. Environmental and social policies, procedures and guidelines relevant to mining

A number of Bank environmental and social policies and procedures are applicable to mining projects considered for financing by the World Bank. IFC and MIGA follow procedures that are fully consistent with these:

OD 4.01 Environmental Assessment (to be issued as OP/BP/GP 4.01): Policy and procedures for EA, whereby potential impacts are taken into account in selecting, siting, planning, and designing projects.

OP/BP/GP 4.02 Environmental Action Plans: Policy to encourage and support borrowers to prepare, implement, and maintain environmental action plans, which should be reflected in Bank operations.

OP/BP 4.04 Natural Habitats: Policy to support the protection, maintenance, and rehabilitation of natural habitats. The Bank does not finance projects that involve the conversion of designated critical natural habitats.

OP 4.07 Water Resources Management: Policy to promote economically viable, environmentally sustainable, and socially equitable water management.

GP 4.11 Cultural Property: The Bank's general policy regarding cultural properties is to assist in their preservation and avoid significant damage or elimination of irreplaceable cultural property.

OD 4.20 Indigenous Peoples (to be issued as OP/BP/GP 4.10): Policy to ensure that indigenous peoples benefit from development projects, and that projects' potentially adverse effects are avoided or mitigated.

OD 4.30 Involuntary Resettlement (to be issued as OP/BP/GP 4.12): Policy and procedures on Bank staff and borrower responsibilities towards displaced persons in operations involving involuntary resettlement.

In addition, a number of World Bank guidelines outlined in the *Pollution Prevention and Abatement Handbook* are also of relevance, including the following:

Guidelines on Mining and Milling (Open Pit and Underground), Coal Mining, Mineral Processing, Coal Washing, etc.,: Guidelines relating to, *inter alia*, liquid effluents; air emissions; management of tailings, erosion and reclamation; and occupational health and safety.

Group's *Pollution Prevention and Abatement Handbook* details the maximum liquid effluent limits that borrowers are required to meet for mining projects.

The EIA should evaluate the risks associated with an impoundment failure and the borrower should commit to preparing an emergency response plan accordingly. This plan should identify the actions to be taken in the event of various emergency scenarios, both to prevent and control the release of tailings and to alert and assist communities at risk. Responsibilities for such actions should be clearly identified.

Infrastructure, access and energy

This encompasses the means of gaining access to proposed mines, for operating such mines and associated facilities, for accommodating labor, for obtaining power (both during construction and operation) and for exporting finished products. It also includes material handling systems within the mining area (including in-pit crushers, conveyors, railroads, elevated tramways, pipelines for conveying tailings or mineral concentrates), and construction of railhead or port facilities.

The environmental, social, and health impacts of these ancillary activities can be very significant and are influenced by factors such as:

- Proximity of the mine to suitable access infrastructure and energy sources
- Number of construction and operational staff required, and level of in-migration
- Proximity of mine concession to and influence on: protected areas and natural habitats, potable water sources and other water bodies, existing communities or lands used by indigenous peoples
- The relative extent to which existing communities and mine workers are affected by communicable diseases such as malaria, AIDS, or schistosomiasis.

Construction workcamps and operational townsites

The demand for labor and qualifications required at industrial mining operations often exceeds local supply, thereby creating a need to 'import' the requisite skills. The impacts of recruiting and providing the necessary infrastructure for large numbers of migrant workers can be very significant.

Where the availability of natural resources or other environmental factors have effectively constrained human settlement, large influxes of mine workers can rapidly degrade environmental resources and result in severe social conflicts. For example, mining communities have been linked to degradation of forests (including protected areas), contamination and reduction of water supplies, local extinction of wildlife and trade in endangered species, and transmission of communicable diseases and sexually transmitted diseases, notably AIDS. In addition, the EIA should address provisions for solid and sanitary waste arising from the mine site and camps; sewage effluent discharge standards are detailed in the *Pollution Prevention and Abatement Handbook.*

Decommissioning and closure plans

At some point, the ore either becomes exhausted or uneconomic to mine and closure becomes inevitable. Historically, due to a lack of emphasis on environmental matters, many mine sites were abandoned without any attempt at rehabilitation. In principle however, the areas or resources affected by mining should be returned to a safe and productive condition through rehabilitation, which may or may not involve a return to pre-mining conditions. This is not to suggest that rehabilitation commences once mining ceases—reclamation should be an ongoing activity throughout the life of the operation.

Rehabilitation techniques include: regrading, recontouring, and revegetation of degraded land surfaces; containment of toxic or acid generating wastes through the use of physical (either solid or liquid) or vegetative barriers to prevent erosion or acid drainage; and long term water management measures through recontouring or physical barriers to help contain wastes. Issues to consider in developing a reclamation plan include:

- Long term stability of impoundments, slopes, and surface materials
- Safety issues relating to open pits, shafts, subsidence, toxic, or radiological hazards
- The physical characteristics, nutrient status, and inherent toxicity of tailings or waste rock which may constrain revegetation
- The potential for acid drainage from abandoned pits and shafts, tailings, and waste rock dumps (as a consequence of oxidation of sulfides contained in the ore or wastes)
- The potential for methane generation in and emission from coal mines
- The costs of ongoing and post decommissioning rehabilitation.

The socioeconomic aspects of decommissioning are also important, particularly where the existence and economic survival of large communities may depend on a mine. Aside from loss of incomes, the provision of services—such as water, sewerage, electricity, and health care—may be directly linked to the mine. All these issues should be factored into post-closure plans which are adequately costed.

Small-scale or artisanal mining

Most of the activities and associated impacts described above relate to industrial mining operations. However, in some countries, such as Brazil and the Philippines, small-scale mining is also important and may dominate the sector—for example, in Tanzania less than 3,000 people are employed in industrial mining operations compared with more than 500,000 in small-scale mining using artisanal techniques. These typically involve rudimentary methods of ore extraction and processing. Measures to safeguard the health and safety of workers or the environment are generally crude or nonexistent. This issue is discussed further in the sections below.

Relevant project contexts and application of the Bank's EA policy

Summarized in box 3 are the five categories of mining project types in which the Bank Group is involved. It also indicates the EA classification which will typically apply and the recommended approach (for example, environmental audit of sectoral EA), consistent with the Bank's Operational Directive on Environmental Assessment (OD 4.01 soon to be reissued as OP / BP / GP 4.01).

Sector adjustment lending is usually linked to large scale restructuring or privatization activities, such as the Russia Coal Sector Restructuring Project or the Peru Privatization Project. Such projects frequently involve mine closures or layoffs with attendant social and environmental issues. Sector reform and privatization projects are designed to result in industries that are financially stronger, more efficient and less polluting. Sector investment lending typically involves strengthening institutional capacity in support of mining and / or support for environmental and social improvements at operations. For example, the Coal Sector Environmental and Social Mitigation Project in India, aims to improve Coal India Limited's capacity to manage the social and environmental issues associated with its operations (see box 4).

A Category A or B rating will normally apply to sector adjustment or sector investment projects, as failure to adequately address important issues could result in significant adverse environmental or social consequences during implementation; consequently, Bank assistance often includes measures to mitigate these impacts. Strategic EA can offer considerable benefits to the planning and implementation of such projects. Where Bank projects promote sector reforms aimed at encouraging environmentally sound investment within the mining sector, strategic EAs of existing conditions in the sector can help to formulate environmental management strategies (see box 5). Another application of strategic EA is to help governments demarcate concessions, while excluding areas where social and environmental concerns would present overriding constraints. Several other generic advantages applicable to mining are outlined in Update numbers 4 and 15 dealing with sectoral and regional EA respectively.

Bank technical assistance lending (TAL) to the mining sector in the past decade has primarily been

Box 3. EA classification of Bank Group mining projects

Project type	*Bank Group institution typically involved*	*EA Classification and recommended EA approach*
Sector adjustment loans (SECALs)	World Bank (IBRD / IDA)	Category A or B, depending on the degree of environmental sensitivity associated with the mining sector. Sectoral EA examining potential impacts of the reforms is normally appropriate (a future Update will provide guidance on EA for SECALs).
Sector investment loans	World Bank (IBRD / IDA)	Category A or B. A programmatic EA approach is appropriate, normally involving sectoral EA to address sector-wide issues, and environmental audits and EIAs as needed at individual mine sites.
Sector technical assistance loans	World Bank (IBRD / IDA)	Normally Category C unless the loan is intended to facilitate major new investments, in which case category B or perhaps A is more appropriate. A sectoral EA is then ideally suited to examine key environmental issues associated with such investments.
Greenfield investment project (loan, equity or guarantee)	IFC and MIGA	Category A. A comprehensive EIA is normally required. For particularly large projects or projects likely to affect sensitive areas, a regional EA is recommended.
Rehabilitation, upgrading, or privatization of existing mining operation (loan, equity or guarantee)	IFC and MIGA	Category A or B depending on the environmental risks associated with the existing operations and proposed new investments. An environmental audit and / or risk assessment of existing operation is almost always necessary, sometimes followed by an EIA.

linked to developing the public sector policy and institutional framework to support investment (often by the private sector) in the mining sector. Examples include the Tanzania Mineral Sector Development Technical Assistance Project and the Argentina Mining Development Technical Assistance Project. Once

Box 4. Managing social and environmental issues of coal production, India

Approximately two-thirds of India's coal comes from large highly mechanized opencast mines which often have severe environmental and social impacts. During implementation of a number of Bank supported coal investments in India, social and environmental issues—particularly those related to land acquisition and involuntary resettlement—have often resulted in crippling delays and increased project costs. Domestic opposition to opencast coal mining in India is growing as a direct consequence of past failures by Coal India Limited (CIL) to adequately address such issues.

The overall objective of the Coal Sector Environmental and Social Mitigation Project is to improve management of the environmental and social issues associated with production of coal by CIL.

The specific objectives are to:

- Enhance the capacity of Coal India to deal with environmental and social issues
- Implement appropriate policies for environmental mitigation, resettlement, and rehabilitation (R & R) of project affected people, and community development, in particular tribal communities
- Test these policies in 25 mines, due to receive support under a proposed Coal Sector Rehabilitation Project.

The project will support CIL's compliance with Bank's policies in relation to environment and resettlement. In particular, the project will support the development of institutional capacity within (and actions by) CIL to implement environmental action plans, resettlement action plans, and indigenous peoples development plans (IPDPs). The rehabilitation and mitigation projects are linked through cross-conditionality—satisfactory progress with implementing these plans at each of the 25 mines is a condition for continued Bank support for rehabilitation.

CIL's revised R & R policy self-imposes responsibilities which greatly exceed minimum legal requirements. CIL have used a participatory approach in developing the various plans. Implementation of both projects should safeguard rehabilitation of 9,260 people, resettlement of 10,000 people, and improve the lives of 188,000 people through community based infrastructure development. All project specific environmental and social mitigation costs are fully accounted for.

Box 5. Sectoral EA of mining activities, Argentina

The Mining Development Project in Argentina is aimed at supporting mining sector reforms which encourage environmentally sound private sector investment in mining. For example, the absence of a clearly defined legal environmental framework within Argentina was perceived as both a constraint to sound environmental management in the sector, and a disincentive to private sector investment, since most private investors prefer clearly defined rules and standards. To address such concerns, a sectoral EA assessed the environmental conditions within the mining sector, which encompassed the following:

- Policy and legal environmental framework for mining, including the applicability of EIA procedures, and regulations related to health and safety
- The institutional framework for environmental management at the federal and provincial levels, and interfaces with mining trade associations and NGO interests
- Baseline environmental data for the 6 participating provinces, including information on water resources, protected areas and natural habitats, population distribution, and indigenous peoples
- An analysis of the impact of current mining activities on the environment
- Predictions of possible future environmental and social impacts
- Recommended priority actions for inclusion in an environmental management plan (EMP).

The sectoral EA formed the basis for developing an environmental subcomponent for the project aimed at implementing a preventive environmental protection system for mining activities in Argentina at the national, provincial and project level. This included developing and implementing environmental legislation and the regulatory framework for mining activities at the provincial level, strengthening environmental management capacity at the national and provincial levels, and undertaking targeted baseline studies on the physical and social conditions in potential mining areas to support sound environmental management.

again, support for environmentally sustainable development within the sector is an increasingly common objective of such projects (see box 6). This may be achieved through modernizing the mining codes to incorporate environmental and social provisions, and strengthening the monitoring and enforcement capabilities of ministries and government agencies.

As most TALs exclude financing of investments and do not directly result in impacts, they have been ranked Category B or C for environmental review purposes. However, TA projects that include initiatives to regularize informal mining may lead to increased small-scale mining and associated environmental impacts. Experience has shown that convincing informal miners to improve mining practices is fraught with difficulties. Consequently, in certain cases, for example the Ecuador Mining Technical Assistance Project, it may be appropriate to assign mining TALs a category A rating.

The World Bank Group's involvement in mining investment projects is typically through the IFC and MIGA which both provide support for specific mining development proposals. IFC cofinances both *greenfield* mining projects and expansion projects such as the Ashanti Goldfields development in Ghana. MIGA typically provides investment guarantees against political risks for either greenfield or expansion projects. Greenfield mining operations require a category A rating, and the potential environmental impacts are addressed within a comprehensive EA which addresses all relevant policies and guidelines. The major issues to be addressed have been described in the overview section above.

Bank Group involvement, investments in, or guarantees for, existing mining operations should be preceded by an environmental audit. The audit should determine the:

- Environmental performance of the operations (with respect to all applicable legislation and Bank policies and guidelines)
- Environmental management capacity and capability within the operation
- Terms of reference for any EA requirements with respect to the proposed expansion (where relevant, and subject to screening under OP 4.01).

Where the environmental audit identifies noncompliance with legislation or Bank Group policies and guidelines, an environmental management plan (EMP) should be prepared which provides for implementation of appropriate corrective actions. These might include strengthening environmental management capacity through employment of environmental technologists and rehabilitation specialists. Depending on the extent and severity of such noncompliance, the Bank Group may decide not to proceed with its participation, or to require initiation or completion of remedial actions in advance of disbursement or signing of loan guarantees.

Analysis of alternatives

OP 4.01 requires a systematic comparison of design, site, technology and operational alternatives. In practice, comparative evaluations of mining development alternatives are severely constrained by the fixed location of the mineralized zone, and by the absence of alternatives to meet market demands for precious met-

Box 6. Promotion of environmentally sustainable mining in the private sector, Tanzania

Despite its diverse natural resource base and history of mining, Tanzania's mining sector has declined during recent decades of public ownership and management. In parallel, the inadequate legal, regulatory, and fiscal regimes governing private mining did not attract investment by the private sector, and resulted in informal mining with attendant social and environmental issues. The ongoing Mining Sector Development Technical Assistance Project aims to promote environmentally sustainable investment by the private sector through:

- Establishing a development policy and strategy for the mining sector
- Revising the legal and regulatory framework for the sector, including the establishment of an environmental management framework
- Strengthening the capacity of the Ministry of Mines and sectoral agencies to carry out their responsibilities (with particular emphasis on promoting investments in the sector, monitoring, inspection, and enforcement functions, etc.)
- Promoting environmentally sound practices within small-scale and informal mines.

The project has been developed using a participatory approach involving a series of workshops. To strengthen the framework for environmental management and the regulatory role of the MRD, modern environmental, health and safety regulations were collaboratively developed by the ministries responsible for mining and environment. This framework was underpinned by increased staffing, training and budget for field inspection and monitoring by the MRD.

The small-scale mining sector, comprising an estimated 500,000 artisanal (primarily gold) miners, presents specific challenges including poor safety practices in badly ventilated working areas (as deep as 100 meters); uncontrolled use of mercury; unprotected and inherently dusty methods of ore crushing and grinding; and poor water and sanitation leading to communicable diseases. Initiatives supported by the project to address these issues included:

- Detailed assessments of the extent of environmental and social problems in the sector and development of action plans (which also identify policy, legal and institutional issues) to address these concerns
- On-site demonstration of the environmental and health benefits of simple low-cost technology and approaches (such as mercury retorts, mechanical crushers, submersible pumps, and pit protection measures) to managing these issues
- Gradual regularization of illicit informal mining, and progressive enforcement of environmental and safety standards.

als and other minerals. The economic viability of developing a mine is primarily a function of the magnitude, grade, and proximity to the surface of the ore body, and the infrastructure required to link the mine to its markets. It is those factors which determine whether proposed mining developments proceed to the detailed feasibility stage.

Despite these constraints, the potential environmental and social impacts of mines can be profoundly influenced by the design and location of mine facilities. For example, metallurgical processing of sulfide gold concentrates can use high temperatures, which results in release of sulfur dioxide and heavy metals, or leaching methods—heap leaching or carbon-in-pulp leaching—which generates a liquid effluent containing sulfates and cyanide. Aside from technical and economic factors, the choice of such methods should also reflect the assimilative capacities of the receiving environment.

Analysis of alternatives for EAs of mining projects should extend to:

- The method of mining and processing options
- Options for conveying ore and tailings (conveyors, road, rail, or pipelines)
- Sources of water and water management strategies
- Tailings management alternatives
- Locations of, *inter alia*, the plantsite, tailings disposal area, waste rock dump, construction workcamps, permanent accommodation, power supply, and access routes.

For additional guidance on this subject, see *Update* no. 19 on *Analysis of Alternatives in EA*.

Socioeconomic aspects and public involvement in EA

While technically robust approaches to managing and mitigating the environmental impacts of mining are well developed, socioeconomic issues associated with mining present significant unresolved challenges. Many mining companies are struggling with the management of social issues, which are not dealt with in great detail within this *Update*. These may be broadly defined as:

- Compensating for loss of land and / or access to resources on such lands (including customary land rights), as well as potential loss of economic / cultural livelihood
- Managing impacts related to the mine operations, such as the influx of migrants and camp followers, potential for increasing income inequality, poten-

tial impacts on water and other resources used by communities, etc.
- Realizing development benefits of the mine, such as employment opportunities, and mechanisms to distribute social benefits more widely among local communities.

For example, large-scale mining operations require large construction and operational workforces. Where mining development takes place in sparsely populated areas from which a workforce can't readily be recruited, the social, environmental and health impacts of large influxes of mine workers can be very significant.

Large-scale mining projects may result in involuntary resettlement. Where the communities to be resettled have no land rights and are involved in informal mining (sometimes several thousand people), the social issues are even more complex and difficult to manage. Ironically, there are also opportunities for environmental gains by controlling impacts from the informal sector. The apparent "win-win" solution of employing informal miners within the formal operation may not be straightforward — mine operators may be unwilling to employ informal miners for various reasons, in which case alternative income generating opportunities should be evaluated. Another related issue is how to deal with opportunistic in-migration in anticipation of development.

Managing social issues is particularly difficult in relation to indigenous people where their dependency on environmental resources is both intimate and complex. The Bank's requirements relating to resettlement and indigenous people are specified in Operational Directives 4.30 and 4.20 respectively. The management of such issues is integral to the India Coal Sector Environmental and Social Mitigation Project (see box 4), and to a lesser extent at the privatized Tarkwa gold mine in Ghana.

Due to the significance of potential environmental, health and social impacts of mining operations, the effective involvement of stakeholders is essential to the EA process. The challenge for Bank Group staff is to assist client countries and borrowers to understand Bank policies and encourage the adoption of a comprehensive decision-making approach, following timely and adequate consultation with affected stakeholders. There are many examples of where consultation has been too little and too late or with the wrong groups of people. Well-designed consultation should ensure the identification of groups likely to be impacted by, or benefit from, mining projects. For additional guidance, refer to *Update* no. 5 on *Public Involvement in the Environmental Assessment Process* and the Bank's *Participation Sourcebook*.

Further information on the management of social issues related to mining operations is contained in *Integrating Social Concerns into Private Sector Decision Making: A review of Corporate Practices in the Mining and Oil and Gas Sectors*. This document presents a series of recommendations which form the basis for developing a social issues management framework. These include the adoption of a policy on social and community issues, identifying stakeholders and acknowledging the legitimacy of their perspectives, addressing social equity issues, and developing mechanisms for conflict resolution.

Health and safety aspects of mining

The principal health concerns associated with mining projects relate to: occupational injury (much of it traffic related); increases in non-communicable diseases resulting from poor occupational health and safety conditions or environmental pollution; occupational injury; increases in communicable diseases and disease vectors such as mosquitoes; and the risks of structural failure of tailings dams or waste dumps.

Non-communicable diseases which include respiratory disorders or heavy metal poisoning are frequently associated with mining operations. For example, chronic lung disease is common amongst migrant underground mine workers in South Africa. Mine workers and adjacent communities may also suffer chronic exposure to heavy metals. This problem is particularly associated with informal and small-scale operations involved in gold extraction, where mercury is extensively used in the final gold recovery process by amalgamation, for example in Ecuador. The risks of injury is also high in informal mines, where inadequate protection of pit walls and underground workings is commonplace—for example, the fatality rate amongst informal miners in Tanzania is reputed to be 5 percent per annum. Industrial mining facilities frequently make personal protective equipment available, such as boots, hard hats, ear defenders, and dust masks. However, enforcement of the use of personal protective equipment is less common.

Mining projects have sometimes been associated with an increased incidence of malaria, partly due to increases in breeding areas for mosquitoes, and partly due to the influx of non-immune mine workers. The known or likely presence of endemic water-related disease vectors (such as mosquitoes and water snails), should provide an indication of potential increases in related communicable diseases such as malaria and schistosomiasis.

Early screening of mining projects for risks to health is strongly recommended, supported by appropriate measures to adequately address these risks during project preparation, implementation, and beyond (see *Update* no. 18 on *Health Aspects of EA*).

Building capacity for improved environmental management

Capacity building for improved environmental management involves activities ranging from development of appropriate environmental, safety and health standards within the ministries of mining or environment or equivalent, to ensuring that responsibilities are allocated for undertaking specific actions to prevent or control accidental releases of process chemicals from a mining operation. The principles which guide development of environmental management capacity should include the following:

- The development of a regulatory framework and environmental, health and safety guidelines and standards, should take due account of accepted international practices, the availability and cost of the associated technological controls in-country, and the baseline environmental conditions.
- Effective environmental regulation is critically dependent on government monitoring and enforcement capacity, the availability of injunctive measures to help enforce compliance, the use of such measures where appropriate, and the ability of the mining sector to finance the costs of compliance.
- Regulation of the informal sector is fraught with practical difficulties. The first priority should be to formalize small-scale artisanal operations as the basis for managing the associated environmental issues.
- It is imperative to ensure that disincentives related to formalization (such as taxes or land titling fees) do not outweigh perceived benefits. This will require educating informal miners of the benefits of formalization, perhaps through grant assisted access to environmentally sound low-cost technologies (such as retorts for ore recovery of mercury) or guidance on sustainable mining techniques. In practice, there are benefits in ensuring that environmental improvement costs to informal miners are minimal (at least initially), as the hidden costs of environmental degradation, social and health impacts of informal mining are likely to be very high.
- The interrelated nature of the social, health and environmental impacts of mining should be recognized, and maximum advantage gained from the complimentary nature of measures aimed at mitigating adverse impacts.
- In managing the ongoing environmental, social and health impacts of private and public sector industrial mining operations, an environmental management system (EMS) approach to systematically manage these aspects is strongly recommended. An EMS should encompasses the organizational structure, responsibilities, and procedural controls to ensure sound environmental and safety management.
- While the responsibility for managing environmental, social and health programs of industrial mining operations is likely to be placed at several levels (from senior management to mine workers), the manager(s) with the prime responsibility for these issues should be allocated sufficient authority and budget to effectively manage the issues, for example hiring or contracting specialists to develop a reclamation plan. The employment of community liaison officers to act as the focal point for community issues and concerns is strongly recommended.

Boxes 4, 5 and 6 contain specific examples of institutional capacity development within the sector. In addition, the *EA Sourcebook* deals with such issues in detail in Chapter 5.

Monitoring and supervision

A monitoring plan should be prepared for projects involving development or expansion of industrial mining, as part of or separate to an environmental management plan (EMP). This should set the framework for assessing the acceptability of impacts from ongoing operations and the need for additional mitigation. The level of detail will depend on the scale and complexity of the mining project.

The monitoring plan should define monitoring objectives which clearly identify the questions to be answered by measurement activities. It should include a description of monitoring to be performed and linkages to impacts and mitigation measures identified in the EA. The parameters to be measured, sampling locations, methods to be employed, frequency of measurements, detection limits (where appropriate) and definition of thresholds that will trigger remedial actions should also be specified.

The basic framework within which supervision occurs is project conditionality in accordance with Bank policies and guidelines. It is vital to link measures in the EMP to the project legal agreement in the form of environmental conditions and covenants the borrower and Bank Group agree on. To reinforce the legal documents it is recommended that a monitoring

summary be prepared that is linked to the project's legal agreements. Where an environmental management system has been instituted, this should be of great assistance in setting the framework for supervision. Detailed guidance on monitoring and supervision of projects is contained in *Update* no. 14: *Environmental Performance Monitoring and Supervision*.

For further reading

Biller, D. (1994). *Informal Gold Mining and Mercury Pollution in Brazil.* Policy Research Working Paper 1304. World Bank. Washington, D.C.

Birley, M. H. (1995). *The Health Impact Assessment of Development Projects.* HMSO, London.

Environment Department. (1996). *Industrial Pollution Prevention and Abatement Handbook.* The World Bank. Washington, D.C.

Marcus, J. J. (Ed.) (1997). *Mining Environment Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining.* Imperial College Press, London.

McPhail, K. and A. Davy. (1998). *Integrating Social Concerns into Private Sector Decisionmaking: A Review of Corporate Practices in the Mining, Oil, and Gas Sectors.* The World Bank. Washington, DC.

Ripley, E. A., R. E. Redmann, and A. A. Crowder. (1996). *Environmental Effects of Mining.* St. Lucie Press. Florida.

UNEP (1995). Environmental Impact Assessment Training Resource Manual. Available at following Web-site: http://www.environment.gov.au/portfolio/epg/eianet/manual.html.

EA Sourcebook Updates

Number and Title	*Date*
1 The World Bank and Environmental Assessment: An Overview	Apr. 93
2 Environmental Screening	Apr. 93
3 Geographic Information Systems for Environmental Assessment and Review	Apr. 93
4 Sectoral Environmental Assessment	Oct. 93
5 Public Involvement in Environmental Assessment: Requirements, Opportunities and Issues	Oct. 93
6 Privatization and Environmental Assessment: Issues and Approaches	Mar. 94
7 Coastal Zone Management and Environmental Assessment (also in Arabic)	Mar. 94
8 Cultural Heritage in Environmental Assessment (also in Arabic)	Sep. 94
9 Implementing Geographic Information Systems in Environmental Assessment	Jan. 95
10 International Agreements on Environment and Natural Resources: Relevance and Application in Environmental Assessment (*second edition*)	Mar. 96
11 Environmental Auditing	Aug. 95
12 Elimination of Ozone Depleting Substances	Mar. 96
13 Guidelines for Marine Outfalls and Alternative Disposal and Reuse Options	Mar. 96
14 Environmental Performance Monitoring and Supervision	Jun. 96
15 Regional Environmental Assessment	Jun. 96
16 Challenges of Managing the EA Process	Dec. 96
17 Analysis of Alternatives in Environmental Assessment	Dec. 96
18 Health Aspects of Environmental Assessment	Jul. 97
19 Assessing the Environmental Impact of Urban Development	Oct. 97
20 Biodiversity and Environmental Assessment	Oct. 97
21 Environmental Hazard and Risk Assessment	Dec. 97
22 Environmental Assessment of Mining Projects	Mar. 98

This *Update* was prepared by Aidan Davy. Extensive review and comments have been provided by Peter van der Veen, John Strongman, Leo Maraboli (IENIM), and Meredith Sasson, a mining consultant. The *EA Sourcebook Updates* provide guidance for conducting environmental assessments (EAs) of proposed projects and should be used as a supplement to the *Environmental Assessment Sourcebook.* The Bank is thankful to the Government of Norway for financing the production of the *Updates.* Please address comments and inquiries to Colin Rees and Aidan Davy, Managing Editors, *EA Sourcebook Updates*, Environment Department, The World Bank, 1818 H St. NW, Washington, D.C., 20433, Room No. MC-5-105, (202) 458-2715.