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Armenia

Sector Issues Paper

Second Thematic Paper: Enhancing Environmental and Social Sustainability of Mining in Armenia

Part I: Improved Environmental and Social Performance in Mining Sector

Part II: Environmentally and Socially Sound Management of Mine Tailings

Armenia: Enhancing Environmental and Social Sustainability of Mining—Sector Issues Paper

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Abbreviations

ADA	Armenian Development Agency
ARD	acid rock drainage
AMD	acid mine drainage
BAT	best available techniques
BREF	Best Available Technologies Reference
CIA	Cumulative Impact Assessment
CHMP	cultural heritage management plant
CSR	corporate social responsibility
DSTP	deep-sea tailings placement
EHS	Environment Health and Safety
EIA	Environmental Impact Assessment
EIP –RM	European Innovation Partnership on Raw Materials
EITI	Extractive Industries Transparency Initiative
EIT-KIC	European Institute of Innovation and Technology, Knowledge and Innovation Communities
EMP	Environmental Management Plan
EMS	Environmental Management System
ESIA	Environmental and Social Impact Assessment
ETP-SMR	European Technology Platform on Sustainable Minerals
ERA-MIN	Network on the Industrial Handling of Raw Materials for European Industries
GIIP	Good international industry practice
IBP	Integrated Benefits Package
IFC	International Finance Corporation
MT	metric tons
NEAP	National Environmental Action Plan
NGO	nongovernmental organization
PAG	Potentially Acid Generating
PS	Performance Standards (IFC)
R&D	research and development
RA	Republic of Armenia
RCRA	Resource Conservation and Recovery Act
SESA	Strategic Environmental and Social Assessment
TMF	tailings management facility
TSF	tailings storage facility
UNEP	United Nations Environment Programme
US EPA	United States Environmental Protection Agency

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Introduction

This report aims to guide the government of Armenia and other stakeholders in applying sustainability principles to the mining sector. The report is based on the premise that mining can significantly contribute to social and economic development, but that achieving positive impacts requires considering and integrating social, environmental, and economic concerns into mining policies and projects.

The principles of sustainability are present in all aspects of development, and are of great importance to the intensive and natural resource-based industries such as mining. The need to apply sustainability principles to ensure positive economic development has been widely acknowledged by governments and the mining industry. Globally, the governments, as well as the mining industry, have embraced the concept of sustainable development as defined in the Brundtland Report (World Commission on Environment and Development 1987), which summarizes the main pillars of sustainability as follows:

- enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations;
- provide for equity within and between generations; and
- protect biological diversity and maintain essential ecological processes and life support systems.

In recent years, these basic principles have been expanded to include equity, transparency, justice, accountability, and consultations. It is important to note that integrating sustainable principles is not a one-time event that can be completed; rather, it is a process that can lead to continuous improvements, and is being adopted by both developing and developed countries.

Sustainability requires strong coordination between various policy makers, implementing agencies, and other stakeholders that often have competing goals and opinions. As such, the key to implementing a sustainable approach involves open and participatory processes. With regards to the mining industry in particular, it is key to:

- ensure partnerships between government, mining companies, and communities, while focused on local development, rather than mining development; and
- maintain sustainability and revenue sharing as the key point of the dialogue

The first thematic paper, *Armenia: Sustainable and Strategic Decision Making in Mining*, prepared by the World Bank in 2014, highlights the importance of ensuring dialogue and strategic planning between the responsible ministries, companies, communities, and NGO sector, and has led to the preparation of the second thematic paper. It will contribute to enhanced awareness that application of global best practices in Armenia’s mining sector will set the sector on the road to sustainability. The overall goals and recommendations are presented in two separate sections of the paper: *Improved Environmental and Social Performance in the Mining Sector* and *Environmentally and Socially Sound Management of Mine Tailings*.

Organization of the paper and methodology

This thematic paper is the second produced under the World Bank's Environmental Sector Note aimed at strengthening the understanding of environmental and social sustainability principles in the development of Armenia's mining sector. The first paper, completed January 2014 and titled *Sustainable and Strategic Decision Making in Mining,* focused on higher-level regulatory strategic planning. It explored the use of SESAs as a policy instrument for making decisions and strategically developing the mining sector, and focused on the application of CIA as a tool for assessing area-wide risks, impacts, and mitigation responses that go beyond the regular, mine-specific EIA report. The findings of this paper also include recommendations on strengthening the dialogue among stakeholders and improving transparency, which also directly feed into the second paper.

This paper focuses on good practice management of the mining industry with respect to environmental and social sustainability, as a guidance tool for both regulators and operators. It is divided into two separate parts that are logically connected. The first part describes best available global practices, corporate systems, and examples of global legal mechanisms (laws, bylaws, guidance, and best practice notes) and requirements to enhance the overall sustainability of mining operations. The second part focuses on mine tailings and associated environmental and social issues while presenting good international practices in sound mine tailings management.

The second paper includes a literature review, analysis of existing data, and new data collection. However, certain limitations concerning availability and fragmentation of data, in particular on operating mines in Armenia and tailings depots that the authors experienced, may have affected the analysis and conclusions. The paper's intended audience includes policy makers and government officials involved in regulating the mining sector, as well as representatives from the private sector, NGOs, and civil society that could further benefit from its findings and recommendations.

A major constraint in the preparation of the first and second thematic paper was the lack of a readily available, organized, and regularly updated database. There is limited information available on the mine operations, mine tailings depots, and activities related to environmental management. Private companies lead this sector, especially international corporations that have an obligation to publish data and make information available on their websites. However, there is no formal registry that would provide an integrated and detailed overview of Armenia's mining sector that would be regularly revised, used, or produced by a government body.

The information used to draft this report was obtained from the Ministry of Energy and Natural Resources upon formal, written request. The request was also addressed to the Ministry of Nature Protection but the detailed information was only provided by the first ministry.

Part 1:

Environmental and Social Performance in Mining Sector

Best Practices to improve the Sustainability of Mining in Armenia

1. Background

Armenia's natural abundance in mineral and metal underground resources such as copper, gold, silver, zinc, cement, diatomite, gypsum, limestone, and perlite is a strong reason for the mining industry to be an economic driver in the country. The industry has helped maintain economic growth in times of crisis; makes up a large share of the country's exports; and is expected to contribute to social development by creating jobs and improving infrastructure. Certain mining sectors have grown particularly quickly and are now vital to the Armenian economy. In particular, during 2011, Armenia's production of gold increased by 30% from that in 2010, while production of copper metal increased by 16.12%; molybdenum concentrate by 11.12%;, molybdenum metal by 11.09%; zinc concentrate by 8.54%; copper concentrate by 8.16%; and ferromolybdenum by 7.78%. It is expected that investment in these sectors will continue to grow in the upcoming years, especially given that the demand for these products will be driven by prices in global markets, and prices are expected to continue to rise.

In 2011, the country's exports, which were valued at $1.33 billion, were much lower than the country's imports of $4.15 billion. Mineral commodities constituted a significant percentage of the country's exports. The main export commodities were diamond, energy, foodstuffs, nonferrous metals, pig iron, unwrought copper, and other mineral products. Overall, exports of ash, ores, and slag accounted for $287 million, or 21.5% of the country's export revenue; ferrous metals and articles made out of them accounted for $134 million (10%); and precious metals and precious stones contributed $196 million (14.7%). The main export partners of Armenia were Russia (which accounted for 16.7% of export revenue), Germany (11.8%), Bulgaria (11.4%), the Netherlands (8.8%), Iran (8.0%), the United States (7.5%), Spain (6.2%), Belgium and Canada (5.3% each), and Georgia (4.6%). In 2011, Armenia's imports of mineral products included diamond, natural gas, and petroleum. The main trade partners for imports were Russia (which provided 20.1%, by value, of Armenia's imports), China (8.2%), Ukraine (6.9%), Iran (6.5%), Germany (5.9%), Italy (4.7%), and Turkey (4.0%). (Source: National Statistical Service of the Republic of Armenia, 2012; and U.S. Central Intelligence Agency, 2012).

The mining sector's contributions to Armenia, and the potential for large-scale, short-term economic gains through investment in the sector, often overshadow the sector's potential impacts on the environment and society. Without a proper sustainability framework and plan in place, the impacts on the environment and local communities can indeed be significant. Mining operations are rightfully associated with a number of environmental and social hazards that include soil and water pollution, noise and dust, potentially toxic leaching of improperly disposed tailings, including large quantities of overburden rock and tailings, and other far-reaching impacts. Taking copper as an example, the average grade of copper ores in the 21st century is between 0.6% and 2% of the total volume of the ore rock. This means that in the best case scenario with a high strip ratio, for each ton of copper that is extracted, some 49 tons of waste rock and tailings are generated.

Ramping up the mining sector must therefore be accompanied by the institution of critical measures for socially and environmentally sustainable economic growth. Putting these measures in place could require far-reaching reforms in decision-making processes and supporting tools, even before the right policies are formulated. The first thematic paper in this series, *Strategic and Sustainable Decision Making in Mining*, provides a number of recommendations to the government of Armenia, which would need to follow the already ongoing reforms in the mining sector to ensure sustainability. These include (a) strategic planning of the sector with sustainability concerns, in particular through the use of a SESA; (b) reforming the legal and oversight practice to include better planning based on a CIA and SESA, and to ensure proper ecosystem valorization procedures; (c) facilitating dialogue and information sharing as well as increased transparency in the sector, in particular through the possibility of joining the EITI; all in order to (d) ensure shared prosperity and environmentally sound local development.

As a follow up, this thematic paper is meant to equally inform both policy makers and the private sector (representatives of the mining industry) of the global trends that ensure sustainability in mining, which include both trends in the legislative aspects, and practical implementation. A separate part of this paper includes analysis and recommendations that need to be put in place to achieve environmentally and socially sound management of mine tailings. Although the primary audience is policy makers, government officials, and mining industry representatives, the civil society groups could also use the recommendations to guide best practices in the sector.

2. Review of Legislative Provisions for Environmental and Social Sustainability

Environmental and social sustainability in the mining sector starts with sound regulations that allow for clear assessment, monitoring, and mitigation of social and environmental impacts, as well as provisions for transparency and benefit sharing. This section describes the measures currently in place in Armenia, their provisions for environmental and social sustainability, and areas for improvement. The section then compares these measures to those in place in other countries. This section makes it possible for Armenia's government to understand what kinds of mining sector regulations are available that can promote social and environmental sustainability. A more thorough analysis of the legislative provisions, and in particular the specific laws and codes is given in the first paper of this series, *Armenia: Sustainable and Strategic Decision Making in Mining.*

Legal requirements on sustainable mining in Armenia

Sustainability in the mining sector in Armenia is governed by several legal mechanisms. Mining planning, development, and operations are first and foremost governed through the Mining Code, which was developed and adopted in 2011. The Mining Code is linked to several pieces of legislation and regulations, including the Republic of Armenia Water Code, laws on geological exploration and the extraction of petroleum and gas, the Law on Urban Development, and the Environmental Impact Assessment Law.

As stated in its first article, the Mining Code "defines principles and order of mining throughout the territory of the Republic of Armenia, governs relations associated with protection of nature and environment from deleterious effects, ensures security of works during mining, as well as protection of rights and legitimate interests of state and individuals during mining." It includes provisions that promote sustainable development and strictly prohibits all activities that do not have a positive conclusion on the state expertise on environmental, geological, and technological safety. The Mining Code also requires application documents for mining licenses to include an environmental management plan, a mine closure plan, and a social program with a timetable of implementation. The code sets forth requirements for permanent monitoring. However, it needs to be further elaborated that environmental management comprises measures to dispose and store removed overburden and exhausted ore, as well as to restore and rehabilitate the damaged landscape.

The second most important legal mechanism for ensuring social and environmental sustainability in Armenia's mining sector is the EIA Law, which dates from 1995 and is being updated. The law requires EIA to be prepared and reviewed on a mine-by-mine basis. While the impacts of a single mining project could be manageable, the cumulative impacts of multiple mining developments in a given area or in a shared watershed could, in aggregate, significantly affect the quality of environmental services provided by the ecosystem. The Law on Targeted Use of Environmental Charges Paid by Mining Companies does not include provisions of fees for disposing mining residues and tailings dams.

The provisions of the Law on Targeted Use of Environmental Charges Paid by the Mining Companies is replaced by a mechanism of fees and royalties that are set forth in the Mining Code. Nonetheless, the system for collecting funds, along with their redistribution back to the affected communities, needs to be improved. Better investment planning is also needed to target the actual environmental damages for which the costs have been assigned. The process of calculating such costs also needs to be improved.[1]

Following up with a number of other legislative acts that deal with natural resources, and with a number of international treaties, reveals that there has been little development in improving the environmental legislation, and improving the overall process of legislation—that is, implementing, monitoring, and supervising. There are very limited, if any, inputs in the legislation and therefore few practices on valuation of ecosystem services, analyses of cumulative impacts, or development of strategic environmental and social impact assessments, which could be a very applicable strategic planning tool for Armenia's mining sector.

Legal requirements on sustainable mining in other countries

A number of countries are revising their mining laws and legal requirements as stated for a particular number of countries in the 2008 Mayer Brown Report, *Country Mining Law Updates*. The reasons for these reforms and aims are multifaceted. Most countries are attempting to promote foreign investments while safeguarding their natural riches; some, such as India, are also updating obsolete mining laws that date back all the way to the 1950s. Environmental and social sustainability play a major role in these revised laws. For example, the revised Indian laws would ensure that a sustainable development framework is being followed based on the International Council on Mining and Metals model.[2] As such, the mining companies would also be required to spend a percentage of profits on social infrastructure, in keeping with corporate social responsibility. Ecuador is proposing a mining law that has more stringent environmental controls and that also provides a stable environment for foreign mining companies in country. The existing laws and procedures in place in Russia also stipulate development of EIA (OVOS) reports with subsequent licensing, which include separate permits for mineral resources, water, waste management, waste generation and disposal, air emissions, and water discharge. Apart from this, the mine closure plan must be submitted for approval to regional authorities one year before mining activities cease.

In the Kyrgyz Republic, the main environmental laws that pertain to the mining industry are the ones that deal with Protection of the Environment and Environmental Expertise (both passed in 1999) that cover water and air quality, natural resources, land use, and ecological preservation. Unfortunately, given the limited capacities of the monitoring staff and few available resources, the companies are the ones that register their maximum emission or discharge values, which are frequently calculated rather than measured. The Kyrgyz Republic's legal requirements do state that the mine needs to be closed in an orderly fashion, but there are no detailed provisions regarding what the closure should entail or how it should be financed.[3] The legislation's proposed amendments needed to also focus on the financing mechanisms and guarantees for rehabilitation. The legislation also deals with the restoration and rehabilitation of the mining site, but does not include the tailings management. The example of the Kyrgyz Republic highlights a very relevant fact that may also be applicable in Armenia regarding historic environmental pollution and now-abandoned mines and tailings disposal areas that are leftover from previous operations.

Around the globe, the common denominator in improving sustainability in the mining sector is the EIA process, which is the first and foremost step in evaluating and managing environmental impacts at the individual mine or activity level. Even this process—which frequently has a standardized and internationally proposed table of contents—can vary greatly, in terms of the institutions that prepare

[1] World Bank, 2014.
[2] International Council on Mining and Minerals, 2014.
[3] World Bank, 2002b.

such reports, the bodies that review and authorize them, the follow up actions and their supervision, and the level of pertinence and technical details provided by the reports.

In Russia, the OVOS (EIA) differs from the Environmental and Social Impact Assessment (ESIA) reports that are prepared and submitted by international mining corporations in terms of its project footprint, level of technical detail for baseline studies, degree of public consultations and disclosure, labor, coverage of social issues, and preparation of Social and/or Environmental Management Plans (EMP) or Systems (EMS). In addition, the OVOS is only intended to inform a select group of experts.[4]

The most internationally recognized benchmarks and requirements for environmental and social activities assessment, including mining, are the ones associated with the World Bank and the IFC, or from countries with more developed, sustainable mining sectors, such as Canada, Australia, or Finland. As of 2012, the IFC, working with the private sector and the mining industry in particular, had developed a revised and refined set of Performance Standards (PS), which guide the environmental and social responsibilities of the activities in which the IFC is investing. The major and first PS is Assessment and Management of Environmental and Social Risks and Impacts, which includes, much like an ESIA process or report, identification of environmental and social risks and impacts, their avoidance, minimization, or mitigation, and community engagement and communication. The rest of the PSs include Labor and Working Conditions, Resource Efficiency and Pollution Prevention, Community Health, Safety and Security, Land Acquisition and Involuntary Resettlement, Biodiversity Conservation and Sustainable Management of Living Natural Resources, Indigenous Peoples and Cultural Heritage.[5]

The IFC also has a set of Environmental, Health, and Safety Guidelines[6] that serve as a technical reference document with general and industry-specific examples of GIIP. The industry-specific guidelines include mining and cover all aspects and areas impacted by mining activities. They provide succinct recommendations and guidance for each identified impact.[7]

Going beyond the EIA report, additional planning and management tools include higher-up SESA approaches that would be developed for the overall planned and strategic development of a sustainable mining sector, or review of CIAs. Capacity building and institutional strengthening, coupled with improved monitoring, availability of data and transparency, follow up and inspections, need to be implemented in a wider area than a simple EIA, and are further addressed in the World Bank thematic paper *Armenia: Sustainable and Strategic Decision Making in Mining* (2014).

Furthermore, there are numerous good examples of successful policies for decentralization and revenue sharing. These include but are not limited to: tax credits for local community expenditures (Placer Dome—Papua New Guinea) stabilization funds (Debswana, Botswana and Codelco, Chile), and intergenerational transfers of wealth (trust funds in Alaska, United States). Whichever of these (or other) instruments are used is a function of a project's economic viability as well as the prevailing circumstances in the country. An instrument of particular interest may be the financial sureties (or assurance) which is the most important instrument of modern mining. A company applying for a mining license needs to place the money into a financial surety, which is meant to be used for environmental remediation during the lifetime of the mine and post-closure. This surety can be used to cover associated environmental damages.

[4] Beare, 2009.
[5] IFC, 2012.
[6] IFC, 2007.
[7] IFC, 2007.

Comparison of environmental legislation and requirements in different countries

The range of the mining industry's industry-initiated mechanisms has largely been a result of international "soft law." Various United Nations international conferences, beginning with the Stockholm conference in 1972 and continuing with more recent, specific global mining initiatives, have directly influenced the range of self-regulatory tools that have been internally developed by the major mining companies, or more usually, in partnership with NGOs.

Environmental law is unlike most other areas of law. As a discipline it does not exist solely in jurisdictional isolation, whereas criminal law, taxation, and to a large extent commercial law clearly can. Since all global issues in environmental law have their genesis at the local level, and since local issues often resound in the international sphere, the field could correctly be viewed as a subset of public international law. Accordingly, environmental laws and regulations in any jurisdiction cannot be viewed in isolation from international factors. Understanding how these policies impact environmental law in general and the environmental regulation of mining in particular is essential to understanding the theoretical base on which domestic legislation is based and to predict future legislative trends.

A selection of four different countries has been made for the purposes of analyzing their mining and sustainability requirements. Table 1 provides an overview of the mining practice in Finland, Kyrgyzstan, and Australia.

Table 1: Review of legislative requirements related to mining

Mineral exploration			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
According to the Mining Act, all have the right to mineral exploration (i.e., doing geological measuring and observations and taking minor samples). Exploration may also be conducted in areas where the operator does not have ownership, provided that no damage is caused, or the harm or disturbance that is caused is only minor. An exploration license is needed from the mining authority if the exploration work does not comply with the legal requirements regarding the harm caused and the areas that are closed to mining, or if the landowner has not consented to the exploration activities. There are also other requirements stipulating conditions when an exploration license is needed; for instance, if the activities can cause harm to public health or general security.	Mineral exploration (except of small-scale artisanal mining activities) always needs a specific license. The license prescribes the maximum size of the licensed area and the minimum amount of annual investments for geological study per unit of licensed area. Furthermore, consent of the owner of land rights to conduct geological study is needed, this means obtaining temporary land-use rights.	Mineral and energy resources are owned by the Crown. According to the Mining Act, mining permits are issued by Government Department of Mines and Petroleum (DMP). Minerals are generally owned by the state, regardless of whether the minerals are on private land or Crown (public) land. However, minerals (apart from gold, silver, and precious metals) that are on land sold or granted by the Crown before January 1, 1899, may be owned by the private land owner. Most such land is in the southwest of WA.[8] The Mining Act allows people to apply for rights to explore for and extract minerals. These rights, including prospecting licenses, exploration licenses, retention licenses and mining leases, are known collectively as mining tenements.	Manmade mines remain an exclusive property of the Republic of Armenia, while mining fees are paid for the ability to mine on site. Two different permits are available, one for geological explorations, and one for extraction of minerals for industrial purposes. Only legal persons holding special permissions may apply for the mineral right for geological exploration. Such right is given based on an application for which a given set of information is required. The right (permit) is also supplemented with a contract and program for geological explorations.

[8] Further complexity arises from the differential treatment of specific resources. Some resources, for example coal and uranium, have separate legislative regimes in most jurisdictions.

Licensing of mineral development			
• Authority			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
The Council of State (government) gives permission to redeem a mining site and determines a mining license for uranium and thorium. The mining authority (Finnish Safety and Chemicals Agency) determines all other mining license issues.	The State Agency for Geology and Mineral Resources is the main licensing authority. It issues mining licenses and executes license agreements. Other relevant instruments, such as mineral development or investment agreements, are negotiated and executed by the government. However, concession agreements can be concluded between the mining company and the empowered body, i.e., the State Agency. Local authorities have a role especially in smaller mining projects. Neither the identification or tasks of mining authorities nor their division of work is defined in the current Law on Subsoil.	A prospecting license entitles a person to enter land to prospect for minerals and to undertake activities necessary for that purpose, such as drilling bores, digging trenches and pits, taking samples for testing and taking water. A prospecting license covers a maximum area of 200 hectares. An exploration license, such as a prospecting license, authorizes a person to enter land and to undertake exploration activities. In order to commence commercial mining production, a person must have a mining lease. The holder of a mining lease can extract minerals and conduct any other operations that are necessary.	The Mining Agency under the Ministry of Energy and Natural Resources issues and awards mining permits and licenses, keeps records of permits issued in a registrar, manages implementation of government programs, considers mining project applications, and applies for initial environmental assessment and examination. The Mineral Resources Agency checks the feasibility assessment of deposits and their reevaluation during mining operations.
• Public Participation			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
The Mining Act holds that stakeholders must be given an opportunity to make recorded comments before a decision on a mining-related license is taken. Actors other than stakeholders must be given an opportunity to express their opinions. The main legal instrument regulating public participation in mining projects is the Act on EIA Procedure, that lays down detailed requirements for information sharing, public hearings, and accounting of public inputs in the final decision making. The EIA procedure is set to include also the relevant social impacts of projects	The Law on Subsoil does not address public participation in the licensing procedure at all. Recently however, an advisory board has been established and civil society participation is also allowed in the licensing commission. However, the State Agency for Geology and Mineral Resources has the ultimate power to decide about licenses, and public participation may sometimes be more *pro forma*. EIA reports are legally required to be carried out on new mining projects, and in line with the Aarhus Convention on public's environmental rights. Public participation is mandatory at all stages of the EIA procedure. The EIA procedure also includes a requirement for social assessment within the EIA. Despite the advanced guidelines, these practices have been criticized for not ensuring the proper engagement of public.	Public notification of the application for an exploration license is required in all jurisdictions except Queensland, usually by notification in the government gazette or in a local newspaper. In relation to onshore minerals, all jurisdictions other than New South Wales and Queensland provide for public comment on the granting of an exploration license or permit. However, there are a variety of arrangements for when comment is permitted and how the comments are taken into account.	There are no specific provisions on public participation and consultations in the scope of the Mining Act. There is a separate article on transparency, which only states that the dissemination of information regarding activities related to mining shall be carried out in accordance with the laws of the Republic of Armenia. The EIA process, which is carried out in parallel with the mining permit process, does have requirements for public participation and public consultations process.

Reasons to not issue a mining license			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
If there are significant reasons to suspect that the applicant has no means or intention to start mining activities or the applicant has previously seriously neglected obligations related to the Finnish mining law, an application for a mining license may be rejected. Even if the legal requirements for a mining license were fulfilled, a license cannot be issued if the mining activity will cause danger to public security, cause significant harmful environmental impacts, or significantly weaken the living and industrial conditions of the area and if these risks and impacts cannot be removed by license conditions.	The Law on Subsoil lays down the conditions on the basis of which a license application may be rejected. These are: if the applicant has produced erroneous data about itself; if the applicant does not have the required financial resources for effective, technically and ecologically safe development of the subsoil allotment; or if a license has been already issued or an application has already been registered for the allotment.	If there is no objection to granting a prospecting license or miscellaneous license, the Mining Registrar can grant these. If there is no objection to an exploration license or mining lease, the Mining Registrar makes a recommendation to the Minister for Mines, who makes the final decision whether or not to grant the license. Where an objection is lodged to a mining tenement application, the matter will go before the Mining Warden for hearing. The hearing before the Mining Warden is quite formal. Any witnesses who are called may be cross-examined. The Warden usually gives each party an opportunity to make submissions at the opening and closing of the hearing. At the conclusion of the hearing, the Warden will prepare a recommendation to the Minister. Normally, each party bears its own costs of hearings before the Warden's Court. However in exceptional cases, the Warden does have power to order one party to pay all or part of another party's costs. This will only occur if the Warden finds that one party has acted in a way that was "frivolous or vexatious," or delayed the proceedings unreasonably, or failed to comply with the Court's directions. Reasons for rejection can be various, such as in case of endangered public security, etc.	The Mining Act prohibits mining activities in areas with a cemetery, natural, historical or cultural monuments, endangered plants or animals, or protected areas. The application for license for exploration will be rejected by the authorized body if the documents are false or untrue; the subsoil allotment for which the application is made cannot be subject to individual mining right; the allotment exceeds the territory indicated in the brief business plan of geological exploration; incompliance of applicant's information on financial and technical capacities and resources with the requirements set out by the legislation; provision of geological exploration right contradicts the requirements of RA laws, national security of RA as well as international treaties that RA is signatory to, any mining right held by the applicant in the past has been suspended based on grounds indicated in the code; or that the mining activity proposed is located in areas where mining is not allowed.

Duration of licenses			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
An exploration license may be issued for up to four years. The duration may be prolonged for up to three years at a time, for the total maximum time of 15 years per license. A mining license is valid for an indefinite time. The mining authority must check the conditions of the license every ten years at a minimum. A mining license may also be issued for a certain period of time if that is reasonable. Such a license may be	An exploration license is initially issued for the period of up to 2 years, with the following extension for up to 10 years, provided that the conditions of the license agreement are observed. A license to develop mineral deposits (mining license) is granted for a period established on the grounds of a technical project document, but for no longer than 20 years with the subsequent extension pending the depletion of mineral stocks.	The duration of a prospecting license is 4 years, with the possibility of a further four-year extension in certain circumstances. The initial term of a exploration license is 5 years, however if the DMP is satisfied that grounds exist, it may be extended once for 5 years, and by further periods of two years. A mining lease may be granted for a term of up to 21 years and is renewable for further 21-year periods.	Geological exploration permission for the purpose of mining shall be provided for a period not exceeding 3 years, which may be extended for 3 consecutive times, each time not exceeding 2 years.

issued for the maximum of ten years. The validity of the license may be prolonged by ten years at a time. A license for gold washing is issued for the maximum period of four years. The license's validity may be prolonged for the maximum of three years at a time.			
Issuing of licenses			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
The process is in principle very simple: an operator sends in a license application, after which the appropriate authorities determine whether to grant a license. The license will contain all the conditions placed on the exploration or mining activity.	After operators have submitted license applications, the subsoil use rights are granted by a tender and by direct negotiations. However, if the applying company has discovered a deposit after a legal exploration, it has an exclusive right to obtain a license for its mining (i.e., no tender process is needed). A license agreement to be negotiated between the mining operator and the appropriate authority is an integral part of the license, which is not valid without it. Mining companies may also enter into more negotiable investment or concession agreements with the government.	Before submitting application for a mining lease for minerals and coal, following permits/constraints need to be obtained: • land constraints, such as restricted areas, wild rivers, native title exclusive land, reserve land and strategic cropping land. • landholder communication, including gaining access to private land, seeking written consent from land holders and understanding your obligations. • environmental authorities that assess the impact that your work will have on the environment and restoring the land during and after your operations. • public objections. Local governments and landholders need to be notified of mining activity in their areas and you will need to comply with public objection requirements.	The application for geological exploration right for the purpose of mining (not exploration) is submitted to the authorized entity and includes a number of details including the description of the area, work plan, data on mining rights that the applicant has, information on financial and technical resources and capacities available to applicant. A specific list of attached documents is also required, and includes a business and work plan, that is submitted for a preliminary assessment of the nature and environmental impact.
Fees			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
The holder of a mineral exploration license must pay annual compensation to the owners of the real property in the exploration area. The holder of a mining license must pay annual quarry compensation to the owners of the real property in the mining area. In addition, compensation payments should be made based on the value of the excavated and utilized minerals and other mining material. Also gold washers are	A number of specific fees and taxes need to be paid by a mining company in different phases of operations in Kyrgyzstan. According to the Tax Code, a mining company is subject to bonus and royalty payments. The former are one-off payments for the right to use the subsurface for the purpose of a geological survey and the exploration of mineral deposits. The rate for the bonus is set by the government using a classification chart for all kinds of mineral resources depending on the exploration stage and size of the	In accordance with annual indexation, the fees under the Mining Regulations 2011 have been updated. There are number of fees and taxes that mining company needs to pay. Fees are determined under the Mining Act 1971, and the Mining Regulations 2011.	Under the Mining Code of Armenia, a number of fees need to be paid for the use of minerals. These fees include: environmental fees for protection measures, contribution to the nature and environmental protection fund, fee for monitoring of program in particular health and safety and disposal and storage of industrial waste, fee for use of minerals, royalty for metallic minerals, state duty for provision of mining authorization.

required to pay annual compensation to the authority that controls the area.	deposit. According to the Tax Code, mining companies once they have started the extraction pay a monthly royalty. The royalty is essentially a tax on mineral production. The rate of the royalty is set for each type of mineral resource per unit of volume or as a percentage of the proceeds. The land tax or land-use fee is to be paid on top of the bonus or licensing fee. It is a kind of annual payment for license rights. The land use fee has different rates for exploration and production. Other taxes or fees related to mining include an emergency fund payment of 1.5 per cent of gross revenues. In addition to the official tax regime, the tax rates of mining companies operating in Kyrgyzstan may be determined by the arrangements in mining development agreements. As these agreements are negotiated between the company and the government, they may be made to contain a scheme of special treatment with regard to the tax (mining-related and other) system for the company. Note: small-scale artisanal mining is exempted from the payment of taxes on use of subsurface.		

Mine closure			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
When applying for a license, a mining operator must also provide information concerning the termination of the activity and the related measures. The mining operator is required in the design and construction of the mine as well as in its operation to prepare for the safe termination of the mining activities and closure of the mine. At the latest after two years after the mining activities have stopped, the mining operator must bring the mining area and the supporting area to the condition that is required by public safety, take measures of repair, cleanup and landscaping and take measures that are in this respect required in the mining and mining security licenses. The mining authority must conduct a final inspection after it has received a notification from the mining operator that it has completed the measures for mine closure. After mining activities have stopped, the mining operator continues to be responsible for monitoring the area, and for the needed reparative measures and their costs that are due to the requirements in the mining license or in the decision on the termination of mining activities. The mining authority takes the final decision on the termination of mining activities.	Once a company has completed mining works, it is legally obliged to close the mine. The Law on Subsoil states that subsoil users must “bring land plots and other natural objects disturbed during the subsoil use into the state that is suitable for further use thereof in compliance with the normative requirements.” The Land Code requires that the mining operator must at his own expense bring the land plots as close as possible to their initial condition, and where impossible, indemnify the land owner/user for any damages caused by the reduction of the value of the land plot. The subsoil users who operate under a license are required to present their financial guarantees for restoration of the damaged environment. Furthermore, licensing agreements for exploitation of deposits typically require the miner to environmentally restore the mine site after use. Generally, mine closure includes mandatory rehabilitation of the land. A recultivation plan is required from the companies, which shall be approved by the environmental protection and mining supervisory authorities. In addition, mining companies must make environmental rehabilitation payments. However, it has been reported that in practice such guarantee is not provided due to the absence of established terms and conditions of providing such payments. The authority responsible for mine closure is the Kyrgyz State Agency for Geology and Mineral Resources.	As of July 1, 2011, the DMP requires all new mining proposal applications to contain a Mine Closure Plan. Existing mining operations with a mining proposal or notice of intent will also be required to submit a revised Mine Closure Plan to the DMP by June 30, 2014. All mine closure plans are required to be reviewed every 3 years. Mine Closure Plans must now be prepared in accordance with the Guidelines for Preparing Mine Closure Plans (June 2011), which has been jointly prepared by the DMP and EPA, to satisfy the requirements of both agencies. These changes mean that the EPA will no longer assess mine closure as part of its environmental impact assessment process for mining proposals, unless they are concerned that mine closure will present a particularly high environmental risk.	The agreement on mining that is signed between the authorized body and the applicant company also needs to include provisions related to mine closure. The mining operator, as such, is obliged to dismantle the mining complex in accordance with the mine closure program. The mine closure plan must incorporate a program on monitoring if mining operation areas and tailings as well as the health and safety of population of nearby communities.

Mine tailings management			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
The management of the tailings storage facility begins after dam construction. The dam management starts with the commissioning of the dam (in relation to the plans and construction work descriptions, etc.), and after that the filling of the impoundment basin can start. The management and supervisory personnel should have sufficient experience in carrying out demanding earthworks, and the persons responsible for these works should have previous experience on embankment dams. The dam owner/holder is obliged to store all the dam safety documents in a special safety file. This also includes the control and measurement documents, which must be registered in the same dam safety file. The Finnish procedure for reducing the risks of dam damage includes a safety monitoring program for each dam referred to in the Dam Safety Act. A seasonal surveillance of the dam is to be carried out by the schedule required in the safety surveillance program.	Different management plans are developed mainly in accordance with policies of the financiers (WB; EBRD, etc.). There are no specific issues listed in any Kyrgyz legislation or policy. The country's legislation also makes provisions for environmental research to be conducted at several stages throughout mining activities. Kyrgyzstan developed its legislation to conform to the Aarhus Convention requirements, which include provision on the public's environmental rights. Environmental impact assessments are legally required to be carried out on new mining projects. Despite these measures, this has not always worked as envisaged and community members have complained that they were not included, as the legislation had intended.	According to the Australian Guidelines, "continuous management is a fundamental principle in the planning of tailings storage systems. Any TSF is a system, which is developed and maintained over a long period of time in a dynamic environment. This requires a commitment to management at the appropriate level during all phases of its life". To this end, the Australian Guidelines on Tailings Dam Design, Construction and Operation, 1999 suggest that the tailings management plan be subdivided into Short (month to month), Medium (3-5 years), and Long Term (rest of the project life). The TSF has been designed in accordance with the applicable edition of the "Guidelines on the Safe Design and Operations Standards for Tailings Storages" issued by the Department of Minerals and Energy, Western Australia.	The Mining Code defines the term "manmade mine" as an accumulation of minerals on the earth surface or in rock holes or tailings facilities formed as a result of exploration, extraction, processing and enrichment of minerals, which in compliance with the established regulations have received geological and economical assessment. As such, the mine tailings are considered to be a secondary mine and source of minerals, rather than waste. These manmade mines are the exclusive property of RA and may be provided for extraction of minerals in line with the mining provisions of the code. This includes fees for remining, while the ownership over the industrial dumps remains with the Operator for the duration of the licenses.

Mine tailings management—environmental management during and after closure			
Finland	**Kyrgyzstan**	**Australia**	**Armenia**
The planning and implementation of mine closure are constrained by legislative requirements that define criteria and objectives for closure, as well as dictate responsibilities and sanctions. In addition to legislation, principles of sustainability, good practice and environmental management systems provide guidelines for closure. The selection of methods employed is dependent on e.g. the nature of the deposit and the production process, the type and properties of the byproducts and the environmental conditions at the site. As a result of a three-year national technology project, the Green Net Mining (GNM) group produced a comprehensive mine closure handbook. The handbook is designed to assist mine operators and environmental agencies in developing strategies for closure planning in accordance within European Union jurisdictions. Topics covered in detail include regulatory requirements, potential types of impacts and their assessment, risk management, economic considerations, best practice procedures and instructions for preparing a successful closure plan.	Once a company has completed mining works, it is legally obliged to close the mine. The Law on Subsoil states that subsoil users must "bring land plots and other natural objects disturbed during the subsoil use into the state that is suitable for further use thereof in compliance with the normative requirements." The Land Code requires that the mining operator must at his own expense bring the land plots as close as possible to their initial condition, and where impossible, indemnify the land owner/user for any damages caused by the reduction of the value of the land plot. The subsoil users who operate under a license are required to present their financial guarantees for restoration of the damaged environment. Furthermore, licensing agreements for exploitation of deposits typically require the miner to environmentally restore the mine site after use. Generally, mine closure includes mandatory rehabilitation of the land. A recultivation plan is required from the companies, which shall be approved by the environmental protection and mining supervisory authorities. In addition, mining companies must make environmental rehabilitation payments. However, it has been reported that in practice such guarantee is not provided due to the absence of established terms and conditions of providing such payments. The authority responsible for mine closure is the Kyrgyz State Agency for Geology and Mineral Resources.	As of July 1, 2011, the DMP requires all new mining proposal applications to contain a Mine Closure Plan. Existing mining operations with a mining proposal or notice of intent will also be required to submit a revised Mine Closure Plan to the DMP by June 30, 2014. All mine closure plans are required to be reviewed every 3 years. Mine Closure Plans must now be prepared in accordance with the Guidelines for Preparing Mine Closure Plans (June 2011), which has been jointly prepared by the DMP and EPA, to satisfy the requirements of both agencies. These changes mean that the EPA will no longer assess mine closure as part of its environmental impact assessment process for mining proposals, unless they are concerned that mine closure will present a particularly high environmental risk.	The application for the mining right needs to include a mine closure plan, which is made up of a physical mine closure plan, reclamation of lands, workforce social mitigation plan, program for monitoring disposal of industrial dumps, and confirmation for the preparation of the final mine closure plan two years prior to the end of operations, along with financial guarantees for the implementation of the said plan. With the financial resources contributed by the Mining Operator within the timelines set for mine closure, the Authorized Entity shall conduct on-going monitoring, for prevention of future disasters and development of preventive measures to ensure the safety and health of the people in communities close to the industrial area, placement of industrial dumps emerged during the extraction as well as in neighboring communities.

Although the four countries analyzed in the above table have very distinct and different approaches to mining, a common factor in all of the sections analyzed is the need for public involvement and the fact that post-closure activities are envisaged, as one of the basic sustainability practices. In all four countries the environmental impact assessment with a proper public consultations mechanism supplements the initial review of the mining application and a number of mechanisms exist why the mining licenses can be revoked. For the particular in-depth analysis of the Armenian legislative requirements on mining and environmental sustainability, please refer to the first paper of the series, *Armenia: Sustainable and Strategic Decision Making in Mining.*

3. Transparency and Information Sharing

With the development of the new Mining Code, and revisions being made to the EIA Law, the integration of sustainability principles in Armenia's mining industry has been under a lot of scrutiny and pressure from NGOs and civil society. One of the key elements of sustainability that has attracted the most attention is transparency, or the present lack there of. Among the key shortcomings are a general lack of available information, decision making without the involvement of a broader stakeholder audience, inadequate information sharing, and a lack of information about how environmental and social impacts are identified and addressed.

Since Armenia is a signatory to the Aarhus Convention on the Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters,[9] it is obligated to provide information to all interested stakeholders. The mechanism established under this convention ensures that the civil society has access to environmental information, is able to participate in the decision-making processes, and has access to justice.

Depending on proposed project complexity and associated impacts, the EIA procedure requires a series of public consultations, where comments received need to be used to further develop and expand the report and the follow up monitoring practices. In addition, the SESA is built upon and deeply rooted in stakeholder participation and involvement.

Armenia could adopt several other mechanisms and international best practices on transparency. For example, the EITI ensures transparency in governance of the mining sector, including revenues from oil, gas, and mineral resources. The initiative is developed and overseen by a multistakeholder coalition of governments, companies, investors, and civil society organizations. Benefits for implementing the EITI include improved investment climate, strengthened accountability, and greater economic and political stability. This in turn is beneficial for business, since investments are capital intensive and dependent on long-term stability to generate returns. Armenia could also recommend that its companies follow the guidance of the International Council on Mining and Metals, which makes public reporting one of the three steps that are required for membership. The other two are commitment to 10 principles of sustainable development and independent assurance, or audits conducted by independent parties.

[9] Armenia signed the Aarhus Convention in 1998 and ratified it in 2001.

One of the core principles and mandatory requirements in establishing and certifying an EMS at the corporate or mine level is also making data publically available, as well as instituting a feedback mechanism through which affected populations can provide their comments, grievances, and feedback.[10]

Transparency and availability of information is not just the obligation of the mining companies. The regulatory agencies must also ensure that the information is available to the public and that the public is included and consulted with during the entire decision-making process. The consultation mechanism needs to be well integrated into the EIA process, while information on environmental monitoring, noted impacts, mitigation measures, and mitigation projects financed by the fees collected, and the number and mitigation of technogenic accidents also needs to be available. Figure 1 shows how the information that is either formally submitted or voluntarily disclosed can impact the public knowledge and also solicit inputs and feedback in a continuously open dialogue.

Engaging civil society in Armenia

Many companies hesitate to engage civil society. In Armenia, civil society is relatively young, but it has a significant impact on management of environmental impacts related to mining. In Armenia, civil society has raised awareness of potential negative impacts of mining,

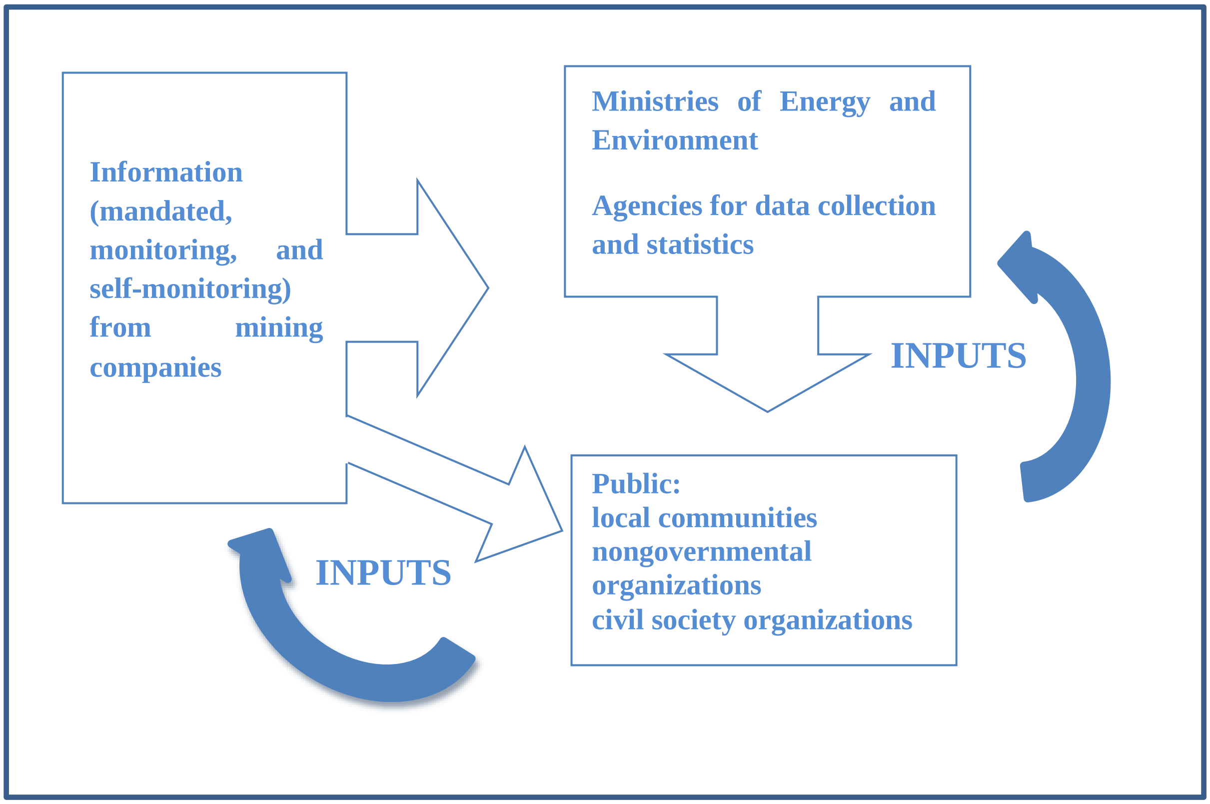
Engaging civil society can lead to several benefits for companies:

- Civil society can help inform the public of positive environmental and social actions taken on by a mining company, and therefore help to spread good practices and improve the reputation of environmentally and socially responsible actors.
- Civil society can encourage the participation of citizens affected by mining, and can therefore lead to companies better understanding social impacts. This can lead to better design of mitigation measures.
- In cases where mining activities are funded by actors with strong grievance redress mechanisms (such as the World Bank's inspection panel) engaging civil society can help reduce the chances that these groups or affected populations recur to these third party GRMs.
- Civil society can inform the public about revenues paid by companies to the government, and therefore hold the government accountable for providing services and using mining revenues to benefit communities.

As part of their communications and outreach strategies, companies that operate in sustainable ways may want to engage civil society. Companies may want to engage several types of civil society, including civil society that can help local communities engage, ones that can help the company understand when activities have been carried out in ways that are not environmentally sustainable, and ones that have technical capacity to help the companies develop activities for social and environmental sustainability. Companies may also want to engage civil society as partners in tracking the use of mining funds for the benefit of Armenia and for the environmental sustainability of communities.

[10] US Environmental Protection Agency, 2013.

Figure 1: Diagram of information sharing



Source: Authors.

4. Best Practices from International Mining Corporations

With the growing investments in the developing countries and their mining industry, there is also growing scrutiny and potential for allegations that international corporations seek countries with less stringent environmental regulations that would allow profit maximizing at the cost of environmental impacts and damages. Much like the international financing institutions with their own, globally applicable environmental and social mechanisms, international corporations are also a powerful vector in sharing sound environmental and social practices across the globe, while spreading their business and investments. International corporations, in particular the ones that deal with mining, have adopted corporate-level policies that they apply wherever they are engaged in mining operations. Community outreach programs, environmental management systems, and corporate responsibility are just some of the practices that the international corporations may bring to countries years before such requirements are introduced or required by the local legislation. Improved, more detailed and more elaborate environmental and social impact assessments may also be prepared by such corporations, or by other, independent international consultants, or are required by international financing institutions, and often surpass the local legislation requirements. Some of the more positive examples yielded from the experiences and practices of a number of international mining corporations are provided below.

Environmental Management Systems (EMSs)

One of the key and core elements in properly identifying and managing environmental and social risks, and the impacts of one's activities at the company level, is establishing a properly functioning EMS. These systems are often based on the requirements and certification as per ISO 14001 series or other international standards, membership in international organizations that promote sustainable mining. However, the EMS can and should be fully operational prior to being certified, and should be based on a given standard. The benefits of having an EMS in place include the company's superior environmental performance, potential cost savings and improved efficiency, lower insurance costs, and improved public relations. The main benefits of an EMS include the responsibility of a company beyond mere compliance with the regulations and improved process efficiencies. The EMS should be in place for all environmental aspects of all activities and operations that a company has control over or can reasonably influence. The general and required elements of an EMS include:

- setting a clearly defined objective and target and overall company policy regarding environmental impacts
- supporting procedures to implement the actions needed to meet the objectives
- accountability for environmental action across the company
- monitoring and review of the impacts and overall system to insure continuous development

An EMS within the mining industry can be used to manage all of the associated environmental impacts throughout the life cycle of the mine, in a manner that is fully integrated with all of the other management considerations. The EMS provides a structured approach through continuous planning, implementation, review and checking, corrective action, and management review. The EMS provides a more focused and structured approach than simply responding to an environmental impact or issue as they appear. This continuous review and development process can also help better adjust the mitigation and planning actions to the changing work of the mine. In addition, the EMS would also include data on monitoring, social, health, and safety aspects of the operation and would include measures for making all relevant information publically available. By better organizing the data and making it readily available, the EMS also ensures a positive and transparent image of a company’s sound environmental planning and management. With proper data collected and published, it offers a set of benchmarks against which to measure progress, and improves staff morale and public image.

Environmental auditing

Although environmental auditing—environmental review and reporting conducted by an independent third party—is one of the requirements of a functioning EMS, it can also be done regardless of an EMS or its certification. Environmental audits should be conducted to determine (a) whether the site is operating in compliance with applicable regulatory requirements and appropriate nonregulatory and corporate requirements; and (b) whether the EMS and other environmental plans have been properly implemented and maintained. Each audit should take into consideration the results of previous environmental audits and be carried out by qualified expert teams. The scope of an environmental audit will vary depending upon the type and size of mine and the objectives of the audit, which usually are to identify and assess potential liabilities, risks, and hazards. The results may be used to identify areas for improvement in environmental management and to identify costs associated with reducing environmental risks and liability to acceptable levels.

Self-monitoring

Monitoring is essential to assessing environmental performance, and monitoring results may be used to help ensure continual improvement in environmental performance and also to keep track of related social issues. Environmental monitoring is the process of checking, observing, or tracking a mine’s environmental releases and any environmental impacts potentially associated with the mine. Some environmental monitoring is required by regulatory agencies. However, voluntary monitoring, beyond that required by regulatory agencies, may help prevent pollution and will continually improve performance by identifying risks and avoiding problems before they occur.

Besides the legally mandated environmental monitoring process, companies should also self-monitor both on- and off-site impacts, including air emissions, releases to water and land, water management and wastewater treatment facilities, containment and storage facilities, waste handling and disposal, acid leakage, and effects on water quality from the mining disposal areas and tailings dams. Self-monitoring should be based on documented procedures and plans, together with schedules and follow-up procedures. Reporting should be carried out both in-house to management and to external, regulatory agencies as mandated. Monitoring is used to determine whether facilities are operating as designed, and inspection is used to verify the condition of facilities and to provide early warning of any deterioration of the facilities. Environmental monitoring establishes control over emissions from the site, and helps monitor impacts on surrounding natural areas and biodiversity. Environmental monitoring should include specific plans to measure and verify all effects and endpoints that were predicted in the environmental assessment.

One of the additional positive examples in monitoring comes from monitoring cumulative environmental impacts; that is, impacts that go beyond the activity’s physical footprint, or those that may arise from additional interactions with other activities in the area. Monitoring plans developed by the companies and regulatory agencies need to include measures to assess such impacts. Overall, monitoring should begin as early as possible in the mine development and should always have a proper and clear baseline against which the measurements need to be made. In particular, the monitoring plan needs to account for the applicable legislative requirements, potential other activities in the vicinity, and any existing monitoring activities. Some examples of how cumulative impacts may arise in a given mining location depend on:

- the number of mining facilities operating in close proximity;
- whether a mining facility is operating near another industrial facility, such as a pulp and paper mill; or
- whether a mining facility is operating in an area of historical industrial activity.

When environmental monitoring activities identify an effect or a change not predicted or not deemed acceptable in the environmental assessment, additional monitoring measures should be implemented to investigate the cause of the effect.

The issue of self-monitoring and self-reporting will also have to respect the provisions and requirements of the Republic of Armenia's Law on Self-Reporting on the Requirements of the Environmental Legislation. This law has been drafted and is currently undergoing the adoption procedure with the Armenian government, and is pending Parliament's approval (third reading).

Grievance redress mechanisms (GRMs)

Regardless of how meticulous a company is in its operations, there are likely to be cases where its activities impact surrounding communities. Sometimes these impacts may be direct, such as by displacing individuals, households, or their livelihoods, and sometimes impacts may be indirect, such as when mining activity results in overcrowded health facilities or landfills. These impacts may result in grievances that need to be addressed to ensure that impacted individuals and communities are not worse off as a result of mining and to avoid conflict between mining companies and communities. GRMs are also increasingly recognized as a critical tool for promoting transparency and accountability.

Effective GRMs typically have common building blocks and characteristics: multiple grievance uptake locations and multiple channels for receiving grievances; fixed service standards for grievance resolution; clear processing guidelines; and an effective and timely grievance response system to inform complainants of the action taken. The best GRMs are managed by independent third parties, such that all parties feel that the outcome of the system is fair.

Setting up an effective GRM requires the following steps.

1. Identifying areas where more common grievances are likely to arise and the populations that are more likely to be affected.
2. Design mechanisms for uptake of grievances, such as hotlines, complaints boxes, etc. It is important to design a system that can be anonymous if necessary (such as when individuals want to point out cases of corruption), but where individuals can also identify themselves (such as when individuals need compensation for environmental damages to their lands.) Ensure that this mechanism is accessible to people that may be more vulnerable, including people in more remote areas, people with low income or limited education, etc.
3. Communicate to potential affected populations about the setup of GRMs and how they are used. Encourage the use of these mechanisms for grievances as well as for any feedback or suggestions on the operation of the company.
4. Design a mechanism for sorting and processing feedback. Feedback should be received by the individual or unit that can act on the feedback and acknowledge receipt to the feedback provider, if the feedback provider is not anonymous.

5. Create a system to verify, investigate, and act on grievances and feedback. The system should be set up so that grievances are addressed as quickly as possible, especially when grievances have significant impacts.
6. Communicate to communities about the type of grievances received and measures taken to address grievances. This can help communities and companies have more positive interactions and can encourage communities to continue to provide feedback that can improve the impact of mining.

Corporate social responsibility

Companies often carry out activities to benefit the communities in and around mining areas. These corporate social responsibility (CSR) activities serve multiple purposes, including showing communities that the company intends to improve the surrounding areas; meeting local benefit-sharing regulations; and indirectly improving the lives of mining workers and their families. Companies can benefit greatly from such endeavors, since they can increase the good will of communities towards companies, which reduces the potential for conflict between companies and citizens.

Companies often use CSR funds for highly visible activities. Community building activities such as sports tournaments and cultural events are commonly funded. Companies also fund infrastructure that benefits both the company and communities, such as roads. In other cases, companies support social infrastructure, such as schools and health centers.

The Juruti Mine project in Brazil is being helped by WorleyParsons consultancy of Australia to achieve world's best practice environmental standards. Since 2001, a year after the project began, an Environment, Social, and Health Impact Assessment (ESHIA) has been published and 35 environmental and social programs are being implemented. Key programs include the Support for Family Agriculture Program.

CSR benefits communities most when it is tied to medium-long term development programming. Companies can work closely with communities and local governments to understand the priorities that have been set. Local governments and communities need to understand the companies, their plans, and infrastructure needs. Together, local governments, communities, and companies can then develop a plan for using CSR funds in a way that furthers local development and benefits the company. For example, building access roads could benefit both communities and companies; increasing the capacity of schools and health centers could benefit communities while serving mining sector workers; coordinating with local technical schools could mean that more local people obtain jobs and offer the mining company greater access to skilled workers.

The Lihir gold mine on the Lihir Group of Islands in Papua New Guinea started operations in 1995, after an Integrated Benefits Package (IBP) was been agreed upon between the community, government, and mining company. In 1998 the LMC mining company established a Cultural Information Center that documented major sacred sites and cultural practices and organized various cultural festivals. In 2009 a Lihir-wide cultural heritage committee was formed to develop a draft cultural heritage management plant (CHMP) aligned with international standards.

Good CSR is based on the principles of partnership, transparency, and accountability. Companies and local governments need to work together and establish clear channels of communication and decision-making processes. Communities need to understand how funds are used and who they benefit: this increases trust between communities and the government and also prevents intra-community conflicts. Contracts issued with CSR funds need to be allocated fairly and transparently, which promotes responsible use of resources and furthers the community's understanding of how investments are financed and procured. If grievances arise because of CSR activities, clear grievance redress mechanisms need to be in place.

Proper planning and practices beyond mine closure

According to the Armenia Mining Code (2011), and the EIA practice of Environmental Impact Assessment, the practice of mine closure and remediation needs to be stated and identified up-front, before the company is granted rights to exploit a given mineral reserve. A mine closure program needs to be an integrated part of the a company's contract with the given company. Even though this approach of reviewing the whole "cradle-to-grave" process of mining development is in line with all international standards, but it leaves a lot of questions and issues that could arise in the practical implementation, mostly related to planning of financing mine closure financing, and the responsibilities and liabilities and associated with post--closure monitoring. Closure plans should be considered and incorporated into all aspects of mine planning, construction, and operation so that key aspects of the closure are anticipated throughout the mine's life cycle. Plans should identify measures to be undertaken during the operations phase that are aimed at progressive reclamation of disturbed or developed areas of the mine site.[11] Figure 2 shows the relationship between cumulative efforts and investments throughout the stages of the mine development life cycle, including the decommissioning and closure phases.

Managing social impacts

While CSR and GRMs are good practices for improving social impacts, companies need to have in place systematic processes to manage social impacts. Many of the social impacts that may arise from mining are due to environmental impacts. For example, contamination of water sources or impacts on biodiversity ultimately have an impact on the people who use these natural resources. Mining also has a great deal of direct social impacts, however, including displacement from lands and impacts on livelihoods. Mining can also have positive impacts through the sharing of benefits.

Managing social impacts is one of the most difficult tasks of a mining company. Good practice states that mining companies need to mitigate against all negative social impacts, including indirect and downstream impacts. This means that companies need to have good mechanisms for establishing who the affected populations are, costing out losses, and compensating populations for their losses. In many cases, affected populations need assistance establishing new sources of livelihoods, especially when the mining activity means that a community can no longer engage in traditional livelihood activities.

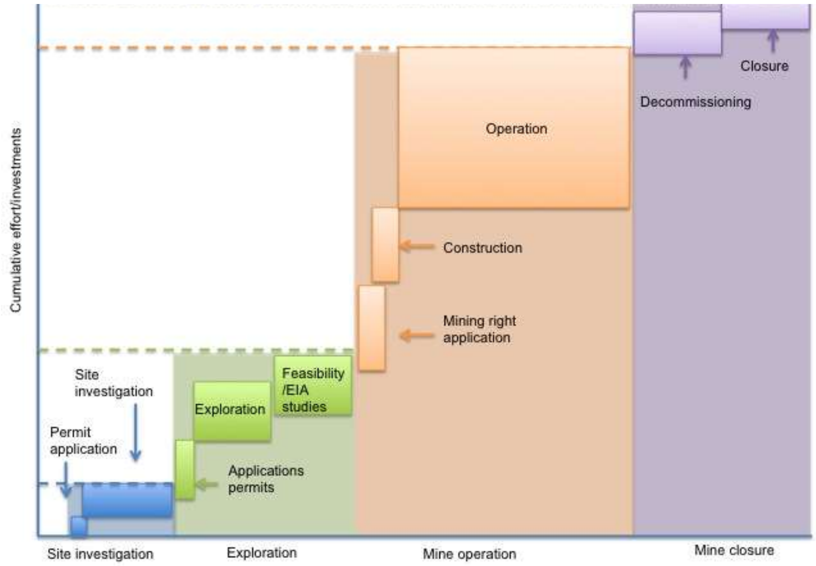
When managing social impacts, the participation of affected populations is essential. Populations, their representatives, and civil society can participate in helping the company establish potential impacts (positive and negative) and affected populations. Most importantly, affected populations are more likely to be satisfied with mitigation measures that they themselves design in collaboration with the company. These measures are likely to lead to more sustainable outcomes.

Mining can have a great role in reducing poverty in a country, and especially at the local level. This positive social impact should also be managed. Putting in place benefit sharing mechanisms is essential, and goes

[11] Environment Canada, 2013.

beyond a company's corporate social responsibility activities and involves working closely with populations and their governments to help revenues impact the lives of those affected by mining.

Figure 2: Level of investments within life cycle of mining project



Source: Environment Canada.

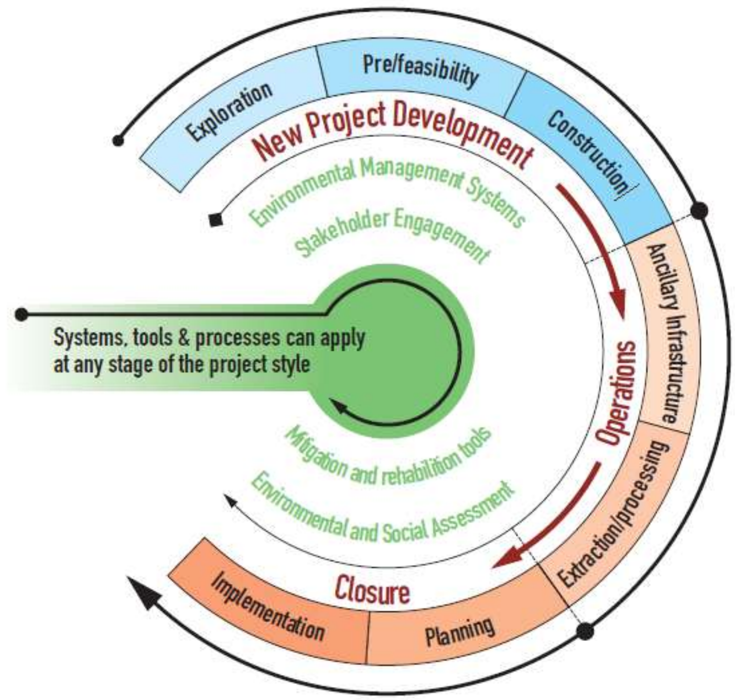
Mine closure should be carried out in a way that prevents or minimizes impacts and risks to the environment and human health. Closure plans should identify site-specific objectives for closure and how the land plans to be used post-closure. Closure plans should detail the processes that will be used to decommission and reclaim all aspects of the mining facility, including:

- mining and ore-processing facilities;
- site infrastructure; and
- water and waste management facilities, including waste rock piles and tailings management facilities.

Mine closure planning is a key tool in preventing or limiting post-closure environmental problems. The sooner in the mine's life cycle designing for mine closure begins, the greater the likelihood that closure measures will be effective. In many cases, early planning also means the mine closure process will be less costly. In addition, the early development of closure plans can facilitate progressive reclamation activities during the mine operations phase, and this can help in preventing pollution during operations.

Apart from early identification of potential issues and recommended mitigation measures, it is proposed that the environmental management plans, mine closure plans, and waste management plans be regularly updated during the mine's operation; these should be adjusted based on the monitoring results that are obtained from regular monitoring processes, ongoing reclamation activities results, changes in mine operations, public reactions, or other factors that influence mining operations. The final use of rehabilitated areas after mining should be compatible with—or complemented by—adjacent land uses, which may have changed over time. Figure 3 shows a schematic of the systems, tools, and processes that can be applied at any stage of the project cycle, as well as the different stages of mine development and exploitation.

Figure 3: Mining development process and planning tools and processes



Source: www.iccm.com.

Social issues must also be considered when planning for mine closure. A large number of individuals in local communities will probably need to find alternative work, and may need help developing skills to transition to a different industry. In addition, community demographics may change, as the health and education systems see individuals leave the community. Local development activity funding may be impacted if firms were contributing to these plans. Social issues in mine closure therefore also need to be updated throughout a mine's life span.

A separate issue is the management and reclamation including clean-up of legacy pollution and old and/or abandoned mining sites. The ownership over such mines may be an issue, as well as privatization or foreign investments into old mines, where environmental and social issues have not been determined up-front. Nonetheless, the potential and actual contamination of old mines and abandoned sites in particular tailing dams, still pose a significant environmental risk and pollution source and need to be managed.

5. Technological Advances—Costs and Benefits

The constant need for development and technological advances primarily hinges on improved efficiency of a given process. The first and foremost aim of improving efficiency is indeed to lower associated costs and raise economic benefits. With growing concern being rightfully paid to environmental issues, scientific and technological advances are increasingly geared towards minimizing undesired environmental impacts, including emissions, pollution, water use and wastewater release, and waste generation. Technological developments and new practices span the entire mining and metal processing branch, and are aimed at different segments of processing, including mines, related beneficiation, smelting facilities, and even mine tailings reprocessing. Research behind the technological advances and development is focused first on understanding the underlying processes that give rise to environmental impacts and then builds on this foundation to provide new, cost-effective solutions. The challenge is to develop environmentally sound mining and processing techniques that can also contribute to more widespread mitigation of historic environmental problems.

Developing more efficient and cost-effective approaches for handling mining-related environmental impacts is desirable, particularly if the approaches promote the widespread cleanup of old mining sites. Innovative methods for preventing and mitigating mining impacts will also help ensure cost-effective development of future mines and the continued supply of minerals and metals. Environmentally sound mining and metal production practices should meet the key challenges of:

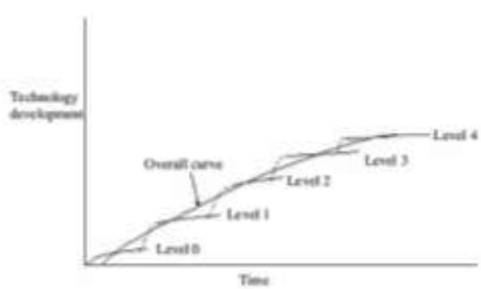
- *Reclamation*—includes reestablishing viable soils and vegetation at the mine site. Although regulatory agencies and general recommendations may require more complex reclamation designs, modifying sloped (and other) surfaces and planting vegetation are simple ways to help stabilize the soil and prevent erosion and surface water infiltration. Although simple, this can still cost a few thousand dollars per acre to implement. As such, the challenge remains to decrease costs and develop reclamation and mitigation approaches that will yield better results. A potential and promising reclamation option may include using sludge, or "biosolids," from municipal waste water treatment processes as an organic soil amendment and growing plant species that are more tolerant to acidic conditions, which would fit with the acidic conditions of tailings depots.
- *Soil treatment*—a common approach is to physically move soil to specially designed repositories. Future approaches may include using chemical methods to stabilize metals in soils, making them less mobile and biologically available; using bactericides that stop bacterial growth that promotes oxidation of pyrite and the accompanying formation of sulfuric acid; or using bio-liners (such as low permeability and compacted manure) as barriers at the base of waste piles.
- *Water treatment*—the most common treatment for acidic and metal-bearing waters is to add a neutralizing material, such as lime, to reduce the acidity. This "active" treatment process, which causes dissolved metals to precipitate from the water, usually also requires construction of a treatment facility. The operational maintenance that such a plant requires makes this treatment technique very expensive. Some possible alternatives could include using a "passive" wetland systems to treat metal-bearing waters (used where the volumes and acidity of the water are not too high); using in-situ treatment zones, where reactive materials or electric currents are placed in the subsurface so that water passing through them is treated; or combining treatment with the recovery of useful materials from contaminated water.
- *Prevention of acid rock drainage*—the potential for ARD needs to be identified early on and prevention must be addressed during exploration activities, prior to the start of newly planned mining operations. In some cases, it may even be possible to prevent or reduce ARD even in old or abandoned

mining areas. Possible measures to prevent or significantly reduce ARD include flooding old underground mine workings to cut off the oxygen supply necessary for the sustained generation of acidic waters; sealing exposed surfaces in underground workings with a nonreactive or impermeable coating that inhibits the oxidation process; backfilling mine workings with reactive materials that can neutralize and treat waters that pass through them; adding chemicals to the water in flooded surface and underground mine workings that can inhibit acid-generating chemical reactions and precipitate coatings that will seal off groundwater migration routes; and isolating contaminated waters at depth by stratification, which allows viable habitat to develop near the surface in the water that fills large open pits.

- *Control of gas and airborne emissions*—including the particulates that are being emitted into the air from the mining operations and the gas emissions from the mines themselves.
- *Recycling*—recycling used metal components can be an alternative source of metals that reduces the need for new metal mines. Developing technologies may make recycling become a significant source or metals; however, recycling facilities themselves are new and stand-alone industrial developments and therefore have their own set of environmental impacts.
- *Innovative mine backfilling*—for example, alternative Binder technology that reduces greenhouse gas emissions, diminishes smelter footprint, and decreases environmental effects and long-term liability.
- *Management of waste rock and tailings*—tailings and waste rock being considered for use as mine backfill should be assessed to ensure that the material will be suitable for this purpose, particularly if the material is to be used to provide structural support in underground mines.
- *Mine closure*—mine closure activities should address the underground and open pit mine workings; ore-processing facilities and site infrastructure; waste rock piles and TMFs; sludge disposal areas, as well as ongoing sludge disposal requirements post-closure; water management facilities; landfill and waste disposal facilities; and exploration areas.

New technological advances, and research and development (R&D) in general, need to be in constant development. This is to not only follow trends and changing variables, but also to be able to build on one set of advances and ensure continuous development and improvement. For example, in the United States, mine health issues are certain to be paramount in the coming decades. Noise, dust, and diesel emissions, as well as heat and humidity, will continue to be targets for improved technology. But others may arise as mining and overall global variables change. Some of these concerns come about from the increasing depth of mineral operations and the growth of operations. Others arise from the use of new equipment, potential health problems, and the small size of operations.

Figure 4: Technology development as a function of time



Source: Automation and productivity increases at LKAB, 1998.

Figure 4 indicates diminishing returns on the overall curve as it relates to a specific area of technology, with gradual improvements as individual breakthroughs are made, and then improvements that occur at specific points. An example of this could be the introduction of mechanized tunneling rigs. Level 0 would represent manual drilling, with the first and major breakthrough to level 1 being the semi-mechanized pneumatic rig. This technology would be improved and made more mine-worthy until the next breakthrough to level 2, with the introduction of the rail-bound hydraulic drifter. The next breakthrough could be the trackless, diesel hydraulic rig, and the level 4 technology, the fully automated electrohydraulic rig. The overall technological developments need to stem from an R&D strategy, which would be based on not only the available technology but also on how appropriate and applicable that technology is to a given operation.[12]

New technologies at the company level

In order to improve safety, environmental protection, or operational effectiveness, many mining companies view the introduction of new technology as a strategic necessity. Most mining companies worldwide have experienced the difficulty in successfully implementing new technologies in the mining industry.[13] Often, failure is not caused by the technology itself, but by the overall operational system into which the technology is introduced. Such failures may come with a significant opportunity cost, and have a detrimental effect on future development, simply because the system has not been adequately engineered and the risks have not been adequately assessed and managed. Technology initiatives often fail because the technology was not appropriate for the work system into which it was introduced; perhaps it was too technically advanced for the level of skill available, or it may have required too radical a change in workflow, or there was a lack of skilled personnel to operate.

New technology or new operational methods involve doing work differently. Such a statement immediately implies change, which, unless managed adequately, will foment resistance. Thus, a change in management process, which is applicable to the introduction of new technology and methods, is necessary. Lessons to be learnt from large-scale interventions are that firstly, the change process goes through a series of phases that, in total, usually require a considerable length of time. Skipping steps creates only the illusion of speed and never produces a satisfying result. A second lesson is that crucial mistakes in any of the phases can have a devastating impact, slowing momentum and negating hard-won gains. The holy grail of optimum performance is not found in technology—technology is merely an information tool.

Numerous research studies and cases suggest that new technologies are best implemented through a series of steps that are required to properly change and upgrade a working technological process into something new and different. As a starting point, any plan for a new technology's implementation must offer the business a quantifiable purpose and benefit, whether in terms of economics, health, safety, or environment. Within the visioning process, it is important to identify risks and derailers. This is essential, because many of these will be identified and raised by the team members and stakeholders during the change process. The risks include:

- premature application of unproven technology
- resistance to change from the workforce and supervisors
- fear of job loss as a result of the technology
- suspicion of management motives in introducing the technology
- poorly engineered work systems
- inadequate training and skill to operate the equipment

[12] Hustralid and Nilsson, 1998.
[13] Hudson, Fox, and Plumlee, 1999.

- new health and safety risks created by the technology or work system
- poor implementation, planning, and control

New technologies must be introduced through a process that should ensure the implementation program includes:

- a strategic component, such that the program supports the strategic intent of the company
- a carefully developed feasibility study
- an inclusive change management process
- an understanding of the technology's appropriateness
- a risk assessment and risk management program
- an ongoing performance management system for people and technology

Introducing new technology to an existing operation is a complex and multilayered process that may require substantial resources to be harmonized with the operation's other segments. Hence, greenfield development that allows for early introduction of most recent technologies has an advantage in this scenario, but also requires that sufficient research and design is done during the exploration and planning phases to support such technological decisions. Some companies may actually prefer to use already tested and tried processes, while others may prefer to obtain the benefits of newer technologies.

New technologies at the regulator or government level

Developing and using new technologies in any industry, including mining, is welcome if a company experiences immediate economic benefits. If the aim of the new technology is predominantly to improve environmental impacts and concerns, however, then companies may see little incentive to adopt processes that can be cumbersome and even unnecessary, if judged solely from an economic and market value perspective. Hence the government needs to support the development and implementation of such technologies. This means that government agencies and institutions need to employ experts who will undertake and promote research and technology development, and transfer and cooperate with the companies that operate in a given industrial branch such as mining. Doing so will ensure that a country's resources are optimally used for overall development of the country and that the industry remains competitive. Furthermore, the private sector tends to underfund R&D, particularly for high-risk projects and projects with long-term benefits.

The government needs to have an appropriate, clear, and critical role in funding mining technology R&D. Successful R&D produces new technologies that reduce production costs; enhance the quality of existing mineral commodities; reduce adverse environmental, health, and safety impacts; and create or make available entirely new mineral commodities. In order for government institutions to track and support new technologies and their application, expert teams must follow global trends and cooperate with other teams that provide licenses for mining operations and the EIA procedures. The R&D geared at new mining technologies should be two-fold: (a) interact with the regulatory system that governs current mining operations; and (b) focus on the cleanup, remediation, or even reuse of the historic mining or mining-related pollution sites.

The government's role in this process is essential. For example, when determining the value of R&D, private firms tend to only consider the benefits they expect to capture. Therefore, society as a whole is best served when R&D expands to the point at which the expected benefits of additional expenditures just equal the costs, appropriately discounted for time and risk.[14] The expected benefits include internal benefits to the firm carrying out the R&D, as well as external benefits realized by consumers and other producers. Because the external benefits of exploration, mining, and mineral processing often constitute a large portion of the total benefits, the market will not support the optimal amount of R&D, possibly by a wide margin, without government support.

As states move to reclaim their roles in community and economic development, there will be opportunities for improved partnerships between governments, mining companies, and local communities. These new partnerships will be critical to ensure that mining contributes to local and national development in an environmentally sustainable way. Studies show that countries with a positive history of new technology implementation are mostly those that have strong institutions and well-formed policies.[15] Revenue flows from the mining sector have helped finance public sector investments that have supported overall economic growth.

A number of recommendations can be made based on the example of Australia's industry policy, which is a relatively noninterventionist instrument that rests first and foremost on providing general economic settings that foster efficiency. Recent policy has emphasized innovation as the basis for continuing competitive advantage, including a focus on commercialization of Australian research.[16] The developed programs that can provide services to the industry include:

- Small Business Assistance Program—a competitive grants program made up of three components: Small Business Incubators, Small Business Enterprise Culture, and Small Business Answers.
- Commercial Ready—a competitive merit-based program that offers industry a single entry point to grants for early stage commercialization activities, R&D with high commercial potential, and proof-of-concept activities.
- Commercializing Emerging Technologies (COMET)—a grants program that targets management skills of businesses and individuals to increase the commercialization of innovative products, processes, and services.
- The Pooled Development Fund (PDF) Program—designed to increase the supply of equity capital for growing Australian small and medium-sized enterprises (SMEs). PDFs raise capital from investors and use it to invest in Australian companies.
- The Innovation Investment Fund (IIF) Program—designed to promote the commercialization of Australian R&D, through the provision of venture capital to small, high-tech companies at the seed, start up or early expansion stages of their development.
- *Industry Techlink*—gives companies looking for technology solutions access to technology consultants who can help them diagnose their problem and provide a suggested way forward.
- *Invest Australia*—in the course of attracting direct foreign investment, builds capacity by creating leading edge customers for the industry.

Companies can take several actions to improve their mining sectors. Companies in developing countries should:

- closely cooperate with government and innovators, as well as participate in any research and support it
- formulate their strategy for the gradual changes within the company itself and mining approach

[14] Committee on Technologies for the Mining Industries, Board on Manufacturing and Engineering Design, Board on Earth Sciences and Resources, and National Research Council. 2002.
[15] Macfarlane, 2011.
[16] Australian Government, 2001.

- evaluate the current situation (environmental, safety, economic) and determine the best methodology for choosing improvement technologies
- introduce an appropriate performance management system to enhance and motivate technology implementation
- identify strategic thrusts and establish a common mindset among the implementation team
- identify risks and derailers
- adopt organizational structure
- coordinate with local governments and contribute to local development planning
- assess the profile of the workforce required for the technology or new work method, and work on skill development
- invest in R&D programs that target the next wave or breakthrough noted in your development strategy or plan

Policymakers can also take action to improve their mining sectors. Policymakers in developing countries concerned with strengthening the economic management and institutional competency in their mining sectors might want to:

- formulate a strategy for the sustainable development of the minerals and metals sector
- pursue reform and capacity building for government agencies and ministries, in particular with regard to economic management and fiscal administration (this includes strengthening the independence and competence of fiscal and monetary authorities so that they can resist pressures to spend any windfalls on suboptimal investments, and promoting the independence and competence of tax collection authorities)
- pursue partnerships with industry, the provinces and territories, and others in addressing issues within its jurisdiction
- build legal and fiscal frameworks to attract private mining investment
- improve social and environmental frameworks to support responsible mining
- enunciate the government's support of the principle of safe use of minerals and metals and engage the government to advance this principle both domestically and internationally
- privatize parasternal mining and industrial enterprises, including closing unprofitable state-run mines
- regulate small-scale and artisanal mining
- strengthen partnerships with important stakeholders
- require transparent and accountable practices in the mining sector
- inform communities of their rights when new mining investments enter an area
- set up processes for communications and grievance redress that operate throughout the life of an investment

6. Main Risks, Bottlenecks, and Obstacles

One of the first issues identified in developing these two thematic papers is the need for stronger coordination and cooperation between the Ministry of Energy and Natural Resources (as the body responsible for the development of mining) and the Ministry of Nature Protection (as the body responsible for ensuring sound environmental practices across the board of all development activities). Although generally perceived as having different and opposing agendas, the two ministries need to work together to develop compromise solutions that would lead to environmentally and socially sustainable mining development. The first thematic paper (*Sustainable and Strategic Decision Making in Mining*) concluded that there is a need for strategic planning in mining, and stressed the use of a number of instruments that would help ensure the overall sustainability of the mining development process. In particular, based on the analysis made regarding the R&D and technological advances (Chapter 5), it is essential to have professional staff dedicated and able to track the global development of technologies, and be able to apply and/or review their practical application in Armenia. The designated staff can also help influence the regulative requirements coming out of the ministries, particularly the Ministry of Nature Protection.

In addition, the lack of formally required and organized data was a major constraint in the development of this paper, and will also be an obstacle to the management of the environmental and social impacts associated with mining activities. A registry of data needs to be developed based on a set of parameters that will be unified for all mining activities. This dataset will be regularly updated based on formal monitoring and will allow for easier and readily available tracking of all given parameters against either a baseline (which may be impossible to generate for already operating mines) or the earliest available data for a given mine. The data can also be separated into sections ready for public disclosure, along with threshold values and data interpretation that can be beneficial to raising awareness and for the public's general knowledge, in particular the local communities that are the most impacted by the mining operations. Furthermore, having a formal registry will also help build the practice of formal monitoring conducted for the mines and strengthen the regular communication channels between the operators and regulators.

7. Recommendations and Conclusions

Building on the recommendations made in the first paper, this paper offers a series of more in-depth and specific recommendations to enhance strategic and sustainable planning; integrate SESA processes in strategic mining development; include CIA to supplement the EIA procedure; and enhance transparency in mining. These recommendations are aimed at ensuring better and stronger support and coordination between the regulating agencies, and to ensure better data collection and monitoring practices. All of this should lead to improved data availability and disclosure of available data and monitoring results.

For each of the recommendations there is an assigned responsibility between the two ministries that are primarily involved in mining development and impact assessment. . In addition, priority recommendations are ranked as “high” or “medium”. . A high priority may identify issues that need to be urgently dealt with, or for which the preconditions have been met. A medium priority may mean that the activity includes an ongoing and longer-term process, or that the recommendation may need to have one or a few preconditions in place prior to its commencement. The priorities are, as such, based on their need and the ability to be implemented rapidly.

Recommendation 1: enhance cooperation and better staffing practices in the responsible ministries

***Responsibility**: Ministry of Energy and Natural Resources and Ministry of Nature Protection*
***Level of Priority**: high – (long-term process)*

Having professional and dedicated staff to follow global development and improvements in the environmental management practices related to mining is critical for making sure Armenia is implementing the most up-to-date and enhanced environmental protection measures. Furthermore, the Ministry of Energy and Natural Resources and the Ministry of Nature Protection need to engage in continuous dialogue so as to achieve the synergy necessary for developing environmentally and socially sustainable mining solutions. This cooperation can only benefit from having a designated staff member, or even a whole unit, to handle mining issues in particular. Once a staff member or unit is fully dedicated to one industrial branch (mining) they can build their own professional expertise, easily follow the most recent global technological developments, and fully view the economic, social, and environmental impacts of such developments. Furthermore, the cooperation will be strengthened by tracking global developments and new practices and technologies to help mitigate the associated impacts.

Recommendation 2: improve monitoring practices, enforcement and data collection, analysis and disclosure

***Responsibility**: Ministry of Nature Protection and Ministry of Energy and Natural Resources*
***Level of Priority**: high – (long-term process)*

A main constraint to developing this thematic paper was the lack of available and up-to-date information and data. In particular, similar requests often resulted in different values of data provided, often citing the same source. The limited data, measurements, and figures that are available come from relevant government agencies, private mining companies, international companies that are involved in Armenia’s mining industry, and from articles and analyses conducted by independent experts or nongovernmental organizations (NGOs). Armenia lacks a central registry of data on the operating mines, which would include general items related to the location and operation of the mine, linked with environmental measurements, and data for example on the management of tailingsThe existence of such a register would help ensure regular monitoring practices and help enforcement agencies conduct inspections. The register should feature well-organized and structured databases; certain sections of it would ideally be made available to the public, which would boost public awareness and knowledge of mining-associated impacts, ways these are measured, and how they are mitigated. Increased public awareness can also help generate more constructive dialogue between all stakeholders, in particular for drafting strategic documents hinged on sustainability, such as the SESA. Joining the EITI (one of the recommendations from the first paper) will help increase the public disclosure and availability of the data to the public as well.

Armenia has already taken certain steps, for example through the RA Government Decree from January 2013 that establishes monitoring procedures of the mining areas and tailings dams with respect to the safety and health of the population in the neighboring communities. The provisions of this decree need to be enforced, and the regularly updated data needs to be made available in a consistent manner.

Recommendation 3: develop specific guidelines

***Responsibility**: Ministry of Nature Protection with Ministry of Energy and Natural Resources*
***Level of Priority**: medium – (long-term process already initiated)*

Substantial guidelines and sound practices exist to guide all of the individual mining processes, as well as overall mining development. In particular, countries such as Australia and Canada have very strong and well-established guidance notes and literature, which have been used to develop this paper. A general conclusion of the literature is that strong expert presence needs to be ensured on the ground, so as to custom tailor the guidance to a given mine in a given country, and to make sure the technological solutions are a good fit for a given operation. This recommendation can developed by a strong expert staffing or a dedicated unit within the two ministries, and can only be implemented once the first recommendation is fully implemented and the second is partially implemented.

First steps in this general direction are being made by the Government of Armenia, in particular with the guidelines that will be further developed and are aimed at supplementing the Mining Code, but also through the Operational Manual that the Ministry of Nature Protection had drafted in 2011, tackling a number of mining-related issues and impacts.

The key point of this recommendation, as well as the overall paper is to ensure harmony between various requirements and to ensure proper compliance with the legal provisions.

Part 2:

Environmentally and Socially Sound Management of Mine Tailings

I. Mine Tailings and Associated Impacts

Mine tailings is a term for the materials (or *residue)* left over from the process of separating the valuable fraction from the uneconomic fraction of a given ore. Since separation processing requires large quantities of rock to be mined, crushed, pulverized, and processed, the resulting mine tailings are usually enormous, especially if the extraction process is not very efficient. Furthermore, the tailings usually take up more physical space than the area from which they were mined. The definition of mine tailings does not include the *overburden* materials, which are the waste rock or inert materials that have been removed from the mining area prior to extraction of the ore.

In most cases, mine tailings are kept close to the mining site so as to decrease transport costs, or in some cases, are transported to a site displaced from the actual mine. The tailings usually represent the external cost of mining; they are the industry's single most important environmental impact. The associated environmental and health impacts of mine tailings depots are far-reaching and require a number of financially substantial steps to render the areas environmentally safe both during their lifetime and after a mine closes. The tailings depots are often the most significant environmental liabilities for mining development projects. Because tailings have no financial value to the mine operator at that particular point in time,[17] they are typically stored in the most cost-effective manner that meets the bare minimum of regulations. As such, the tailings are disposed (or stored) at dams, embankments, and other types of low-cost containments that are also prone to catastrophic failures. Hence, it is important to examine not only the environmental impacts associated with inadequately storing and managing tailings, but also the risks associated with catastrophic and accidental events.

In general, the tailings from base metal mining activities can be characterized as follows:

- they are usually a slurry
- they contain metals;
- they contain sulphides;
- large amounts are produced;
- slurried tailings are managed in ponds; in some underground mines, the coarse tailings are used as backfill material;
- sulfide in tailings and waste rock can oxidize when water and air have access and an acidic leachate is generated. This phenomenon is called Acid Rock Drainage (ARD). Due to ARD, not only is the physical stability of the tailings ponds and dams an issue, but so is the chemical stability of the acid generating tailings, both during operation and after the mine closure;
- waste rock is stacked on heaps and can also have a high environmental impact if it has a net acid generating potential.

Conflicting views over how mine tailings are perceived mostly hinge on the associated costs of their sound environmental management and on who has ownership over them. As is the case in Armenia, tailings are considered a valuable resource due to the potential to reprocess them and extract the remaining valuable ore.[18]

[17] One of the main reasons behind mine tailings being "stored" and not permanently managed as waste is the fact that they could be reprocessed sometime in the future. At a given point in time, when the further extraction of smaller fractions of ore from tailings is not economically viable, the tailings have no value to the mining operator.

[18] By far the larger proportion of ore mined in most industry sectors ultimately becomes tailings that must be disposed of. In the gold industry, for example, only a few hundredths of an ounce of gold may be produced for every ton of dry tailings generated. Similarly, the copper industry (and others) typically mine relatively low-grade ores that contain less than a small percentage of metal values;

As such, ownership over the tailings (or manmade mines) is transferred to the government of Armenia once the mine is closed. The tailings are not defined as a waste material in the Law on Wastes (2004), are not required to be listed in state registers, and are not issued a "waste passport" as mandated by the Decree on Procedures of Issuing Passports to the Wastes. There are also no fees associated with storage or final disposal. Yet another issue to take into account is whether the mine tailings are a historic remnant of previous mining, or if the tailings are being presently generated by an active mine.

Disposal methods

In almost every project, metallic ores are buried under a layer of ordinary soil or rock (called *overburden* or *waste rock*) that must be moved or excavated to access the metallic ore deposit. Most mining projects generate enormous overburden. The ratio of the quantity of overburden to the quantity of mineral ore (the *strip ratio*) is usually greater than one, and can be much higher. For example, if a proposed mining project involves the extraction of 100 million metric tons of mineral ore, the project could generate more than one billion metric tons of overburden and waste rock. These high-volume wastes, which sometimes contain significant levels of potentially toxic substances, are usually deposited on-site, either in piles on the surface or as backfill in open pits, or within underground mines. Therefore, the EIA for a proposed mining project must carefully assess the management options and associated impacts of overburden disposal.

The crushed ores are also usually concentrated to free the valuable mineral and metal particles from the less valuable rock. Beneficiation processes include physical/chemical separation techniques such as gravity concentration, magnetic separation, electrostatic separation, flotation, solvent extraction, electrowinning, leaching, precipitation, and amalgamation. Conventional beneficiation processes generate tailings, which generally leave the mill as a slurry that consists of 40–70% liquid and 30–60% solids.

There are several methods for disposing tailings. These include dry or thickened tailings disposal in impoundments or free-standing piles; backfilling underground mine workings and open pits; subaqueous disposal; and the most common method, disposing tailings slurry in impoundments. Modern tailings impoundments are engineered structures for permanently disposing the fine-grained waste from mining and milling operations. At some projects, tailings embankments stand several tens of meters high and the impoundments cover several square kilometers. Historically, tailings were disposed where convenient and most cost-effective, often in flowing water or directly into drainages. As local concerns arose about sedimentation in downstream watercourses, water use, and other issues, mining operations began impounding tailings behind earthen dams, which were often constructed of tailings and other waste materials. The impoundments served the dual purpose of containing the tailings and, particularly in the arid areas, allowing scarce water to be reused.[19]

Tailings contain toxic constituents, and the key long-term goal of tailings disposal and management is to prevent the mobilization and release of these toxic materials into the environment. The disposal options include: (a) the use of a wet tailings impoundment facility, or *tailings pond*; (b) dewatering and disposal of dry tailings as backfill; and (c) submarine tailings disposal. The first option (a tailings pond) is by far the most commonly used option, but the second option (dry tailings disposal) is, in most circumstances, the environmentally-preferable option. The third option (submarine tailings disposal) is sometimes proposed for mine sites located near deep-sea environments, or in rare instances in freshwater lakes. Submarine tailings disposal has a poor environmental record in the few places where it has been practiced. Before the adoption of

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the residue becomes tailings. Thus, tailings disposal is a significant part of the overall mining and milling operation at most hard rock mining projects. (Source: US Environmental Protection Agency, 1994.)

[19] US Environmental Protection Agency, 1994.

environmental laws and standards, many mining companies simply dumped tailings in the nearest convenient location, including nearby rivers and streams. Some of the worst environmental consequences of mining have been associated with the open dumping of tailings, a practice that is now nearly universally rejected.[20]

Environmental, social, and health impacts of poorly managed mine tailings

The first and most visible impact of mine tailings is the aesthetic appearance of an area in which tailings are disposed, and also the land footprint of the tailings, as they occupy large portions of land. However, the risks associated with mine tailings go beyond the simple physical impacts.

The second most common concern and issue with the tailings depots is the erosion of soils and tailings, which especially needs to be assessed in the event of a catastrophe or dam failure. Erosion is a specific issue, as large areas of land are disturbed by mining operations; this continues to be an issue that must to be managed throughout the mine's life cycle, from the planning and start of operations through reclamation. Erosion may cause sediments (and any entrained chemical pollutants) to be unloaded to nearby water bodies, especially during severe storm events and high snow melt periods. A further concern is that exposed materials from mining operations (mine workings, wastes, contaminated soils, etc.) may contribute sediments with chemical pollutants, principally heavy metals. The variability in natural site conditions (for example, geology, vegetation, topography, climate, and proximity to and characteristics of surface waters), combined with significant differences in the quantities and characteristics of exposed materials at mines, preclude any generalization of the quantities and characteristics of sediment loading.[21]

The composition of mine tailings varies greatly and depends on the type of ore mined, the geological composition that would include other elements in the tailings, and finally, the process that has been used to extract the valuable ore. In particular, the extraction process that may use chemicals and other extraction compounds would in turn characterize the tailings as hazardous waste. Even when chemicals are not used, tailings contain a number of trace elements in the form of complex compounds, and present waste that is bulky and difficult to manage. Even though mine tailings contain naturally occurring elements that have been extracted from the ground, the mining and grinding process may uncover and liberate compounds that are not a standard part of the ecological systems (either by form, concentration, or simply presence at the soil's surface layers).

For example, most mining and processing wastes contain minerals, such as sulfides, which are formed at the higher temperatures and pressures found at geological depths. Once such elements are processed and therefore exposed to aerobic, surficial conditions, the minerals may break down and release elements (including acids) that are not a common or natural part of the surrounding environment.[22] As such, when such compounds are leached, it changes the soil composition in the surrounding areas and renders them useless for agriculture or other human uses. It also negatively impacts the surrounding flora, fauna, and ecosystems. Leaching increases with precipitation, which further spreads the polluting constituents to nearby rivers, lakes, and groundwater. These water bodies are mostly used as a water supply source for settlements, where water quality monitoring, if conducted at all, may not test for all of the constituents that may leach from tailings piles.[23]

[20] IFC, 2007.
[21] Environmental Law Alliance Worldwide, 2010.
[22] Franks, Boger, Côte, and Mulligan, 2011.
[23] Ramírez-Andreotta, Henry, Hillenbrand, Maier, Figueroa, and Williams, 2011.

Commonly called acid mine drainage (AMD) or acid rock drainage (ARD), acid drainage primarily depends on the mineralogy of the rock material and the availability of water and oxygen. Acid drainage is generated at both abandoned and active mine sites. The potential for a mine or its associated waste to generate acid and release contaminants depends on many site-specific factors. AMD occurs at mine sites when metal sulfide minerals are oxidized. Once acid drainage has occurred, controlling the releases is a difficult and costly problem, so prediction is becoming an important tool for regulators and operators.

Both water and oxygen are necessary to generate acid drainage. Other factors that affect acid drainage are the physical characteristics of the material, the placement of the acid-generating materials, the presence of any acid-neutralizing materials (whether naturally occurring in the material or supplemental), and the climatologic and hydrologic regime in the vicinity. Once formed, the acid will leach or dissolve metals and other contaminants from mined materials and form a solution that is acidic, high in sulfate, and metal-rich (including elevated concentrations of cadmium, copper, lead, zinc, arsenic, etc.) Toxic constituents, such as arsenic, selenium, and metals, can be leached even if acidic conditions are not present. Elevated levels of cyanide and nitrogen compounds (ammonia, nitrate, and nitrite) can also be found in waters at mine sites, from heap leaching and blasting. Acid drainage and contaminant leaching is the most important source of water quality impacts related to metallic ore mining.

Acid mine drainage is mostly associated with metal mines, and in particular with metals such as gold, copper, silver, and molybdenum, all of which are relevant to the Armenian mining industry. These metals are often found in rock with sulfide minerals. When exposed to air and water, the sulfides will form sulfuric acid. The acid will in turn dissolve other harmful metals in the surrounding rock. If uncontrolled, the acid can reach ground or surface water bodies and severely impact fish and other aquatic life. Once a stream has a pH value of 4 or lower, its plants, animals, and fish cannot survive. Beyond the acidic conditions, the toxic characteristics of the leachate also severely impact the aquatic life. AMD also dissolves toxic metals such as copper, aluminum, cadmium, arsenic, lead, and mercury from the surrounding rock. These metals, particularly the iron, may coat the stream bottom with an orange-red colored slime called *yellowboy*. Even in very small amounts, metals can be toxic to humans and wildlife. Carried in water, the metals can travel far, contaminating streams and groundwater over great distances. The impacts to aquatic life may range from immediate fish kills to sublethal impacts that affect growth, behavior, or reproductive ability. Metals are particularly problematic because they do not break down in the environment. They settle to the bottom and persist in a stream for long periods of time, constituting a long-term source of contamination to the aquatic insects that live there and the fish that feed on them.[24]

Due to processing and grinding, tailings particles decrease in size and can easily become airborne, especially with wind. As such, the dust that is spread may contain fine particulates along with other compounds found in the tailings. All of these can spread far beyond the local tailings depot area. This issue can persist over decades, as low pH and lack of soil content at a tailings depot prevents plant cover from developing. Exacerbating the problem is population growth, which has led to increasing proximity of some mine sites to developing communities. Thus, there are both human and ecological health consequences from exposure to dust that originates from these sites.

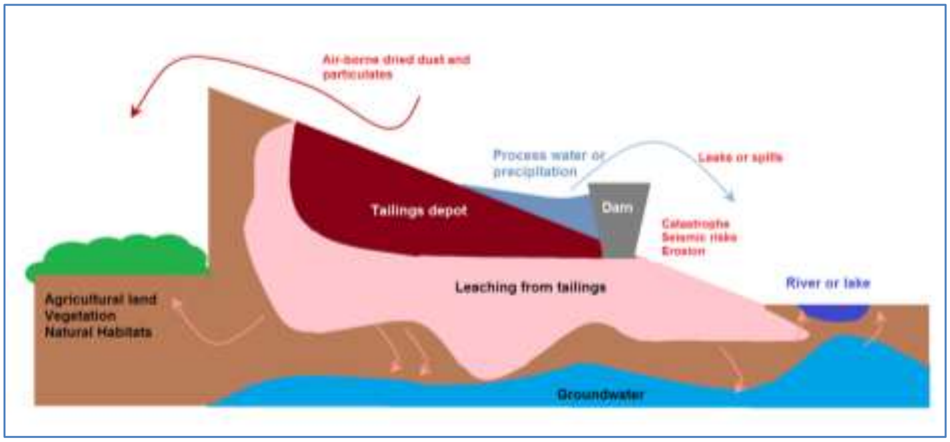
The health-related impacts go beyond the site's workers. The airborne particles may interfere with the respiratory system (of both humans and animals) and may settle on the surface of the plants and/or soil. The acid and other leached compounds impact the quality of the soil and surface and groundwater beyond the

[24] Environmental Law Alliance Worldwide, 2010.

project site. Since soil is used for agriculture and to sustain the population, and ground and surface waters are used for water supply, the health impacts, especially those that accumulate over years of consumption, may be very serious.

The underlying social impacts that can arise from poorly organized and uncontrolled mining operations and mining sites include possible illegal access to the sites and artisanal mining. Such practices can expose artisanal miners to great risks of accidents on site. Figure 5 provides an overview of the main environmental impacts associated with the mine disposal areas or tailings sites.

Figure 5: Schematic overview of the main environmental impacts associated with mine tailings



Source: Authors.

The main challenge, and therefore purpose of this paper, is to provide guidance on sound environmental management practices for the tailings, regardless of whether the tailings would be processed or disposed of in the long run. From a practical aspect, these guidelines would include minimizing the physical footprint, managing dust, controlling leaching of hazardous elements, and controlling access to the site; meanwhile from an enforcement aspect, the guidelines would need to include the necessary steps required for self-monitoring, third-party monitoring, ensuring compliance with relevant laws and permits, and, most importantly, deliberating a cut-off date by which the tailings would need to be reprocessed in order to avoid being considered waste material.

II. Situation with Mine Tailings in Armenia

According to information collected in 2011 by the Armenian Development Agency—Research and Information Department,[25] some 30 base metal and precious metals mines exist in Armenia, out of which 22 were being exploited in 2011. Seven are copper-molybdenum, three are copper, thirteen are gold and gold poly-metallic mines, and two are iron ore mines. Apart from the operating mines, an additional 115 deposit sites have been discovered. According to the ADA, the biggest concentration of the mines is in the Lori, Kotayk, and Syunik marzes, with mines also present in the marzes of Gerharkunik, Vayots Dzor, and Aragatsosn.

[25] Mining Industry in Armenia 2011

According to the letter and information received from the Ministry of Energy and Natural Resources, there are 17 existing tailings ponds for disposal of residue; these cover an area of almost 700 hectares. The details on specific sites are provided in Table 2.

Table 2: Information on the existing locations of the mine tailings depots

No.	Company in charge	Geographic location or name	Planned volume (mln. m^3)	Area (ha)	Operation mode
1	Closed Joint Stock Company “Zangezur Copper Molybdenum Combine”	River Davazam	3		Conservation
2		River Pokhrot	3.2	10	Conservation
3		River Vogji	35	92	Conservation
4		River Artsvanik	310	227	In operation
5	Closed Joint Stock Company “Agarak Copper Molybdenum Combine”	River Davazam	35	75	In operation
6		River Hovit 1	9.08	35	In operation
7		River Hovit 1	17		In operation
8	“Dundee Precious Metals” Kapan	River Geghanush	8.7	32	In operation
9	Dastakert Community	River Airiget	2.1	9.5	Conservation
10	Closed Joint Stock Company “GeoProMining Gold”	Ararat Valley	12	134	In operation
11	Closed Joint Stock Company “Akhtala Mountain Enrich Combinat”	River Nakhtak	3.1	16	In operation
12		Kilisa Province	2.1	12	In operation
13	Closed Joint Stock Company “Multi Group Concern”	Neighboring area to “Mghut” gold mine	0.03		Conservation
14			0.02		Conservation
15			0.05		In operation
16	Closed Joint Stock Company “Mego Gold”	Neighbouring area to “Tuchmanuk” gold mine		2	Conservation
17				2	In operation

Source: Ministry of Energy and Natural Resources, formal letter, 2014.

However, according to the data of Ministry of Emergency Situations there were 19 tailing dumps in Armenia by March of 2012[1] (presented in map in Figure below). The area of land allocated to the mining companies makes 8275 hectares including 1400 hectares used for tailing dumps with the volume of accumulated tailings equal to 220 million m3.[2]

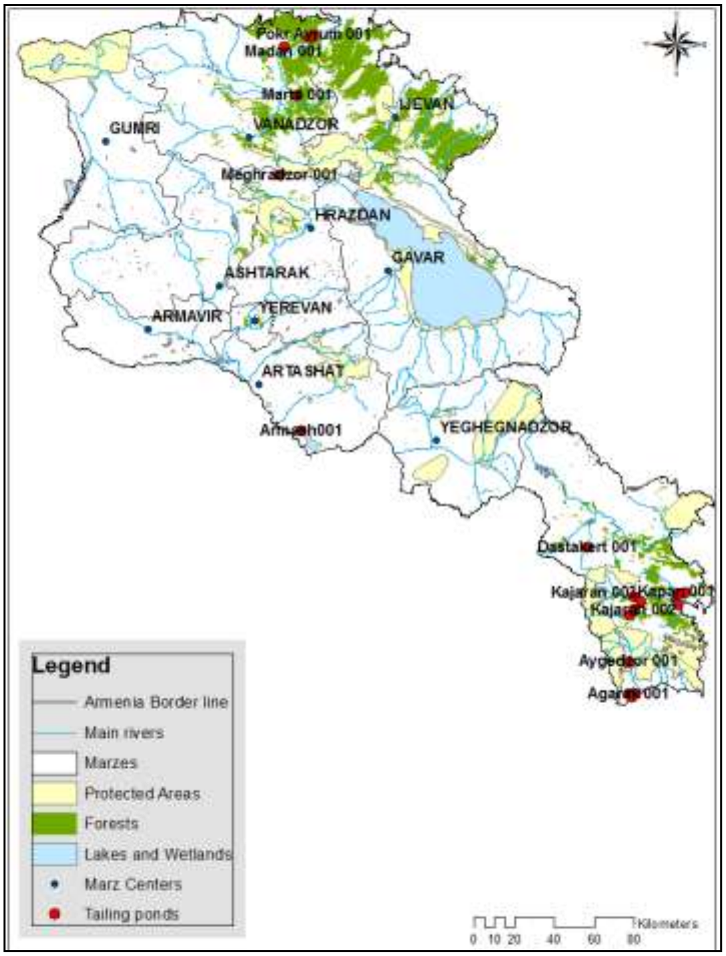


Figure 6: Map of Tailings Depot Locations in Armenia

Large amounts of concomitant ore components remain unutilized in the disposed overburden. Most of the tailings are poorly managed, with little oversight to limit the exposure of such sites to weather conditions. A Toxic Site Identification Program—a joint effort led by the Blacksmith Institute, the American University of Armenia, the World Bank, the European Commission, and other development partners—evaluated sites where toxic pollution may impact human health. The investigated sites included 7 mines, 12 active or abandoned tailings depots and one abandoned smelter. Thirteen impacted communities in five marzes were interviewed. Water and soil samples were taken and analyzed in a licensed laboratory in the United Kingdom. Among many other observations, the Toxic Site Identification Program points out that the most significant impacts on the environment and human health originating from the tailings leachate include contaminated soil, groundwater, and surface water, and children's exposure to contaminated soils and bodies of water. Toxic chemicals such as cadmium, chromium, arsenic, and lead get into the food chain when abandoned tailings are used as pastures or cultivated land and polluted rivers for irrigation. Local communities use tailings residues as construction materials. Valuable species are disappearing in polluted rivers.

According to the available information, the most predominant mine tailings dam sites are those associated with primarily gold and then copper mining. These include the Mghart gold mine in Lori, the Sotk gold mine in Gegharkunik, and the Amulsar gold mine in Jermuk, Vayots Dzor. The tailings dams of the copper mines are registered at Teghut and Akhtala in Lori, Kajaran and Hankasar mines in Syunik, while the Agarak mine in Syunik has multiple tailings dams that have been or are currently being used. In most cases, the registries may not include the mines that have previously been operational but are now shut down, but the tailings dams still exist.

One of Armenia's most substantial mining operations is the copper-molybdenum mine in Kajaran, which is considered to be one of the country's industrial giants. Operational since 1951 the plant is estimated to produce some 10 million tons of copper and molybdenite concentrates per year. The copper concentrate is transported to the Alaverdi metallurgical plant and Armenian Molybdenum Production Company in Yerevan for further processing, while final treatment of molybdenite takes place at the Yerevan Clean Iron Plant. The mine in Kajaran employs 3,800 people.

The Alaverdi Copper Smelter was founded in 1770, and had benefited from the regional investments in the metallurgical sector through Russian and French support through the 19th century. By 1903, the amount of copper produced in Alaverdi equaled 13% of the total copper produced in the entire Russian Empire. Along with the development of the hydropower plant of the Debed River to supply energy to the metallurgical plants, the Alaverdi area expanded into a large town of 16,500 population (as of 2009). The smelter employs approximately 500 people.

Across the country, mine tailings are located fairly close to settlements, in particular in small towns that have grown around the mines and mine processing, such as Alaverdi. The predominant part of the country is rich in cultural-historical heritage and natural areas, including forests. For example, in Alaverdi, the Odzun church dates back to 5th century and the Horomayr monastery dates back to the 7th; natural areas within the high mountains include the Debed River canyon and forests. One of the most drastic examples of the proximity of a mine tailings pond to an urban area is in Akhtala, Lori marz, which is a particular valued cultural heritage site; a tailings dam is located in a gorge right next to a monastery from the 13th century.

Although there is a general notion that metals mining has been the driving economic force in many of these mining communities (for example in the area of Agarak, where use of the copper and lead mines date back to ancient times), some areas, such as Jermuk, may also have other development options which can be endangered by unsustainable mining practices. Jermuk's mineral water and spa tourism industry offers a substantial development option, and it is essential to preserve the quality of the groundwater being bottled and used in spas.

The fact that water accumulates on top of the tailings depots is further evidenced in the Geghi rivulet and Voghji River, where direct disposal in the riverbanks or river canyons occurs. Meanwhile, the Kajaran tailings dam has water stored on top of the tailings dump and is used to meet the plant's water needs.

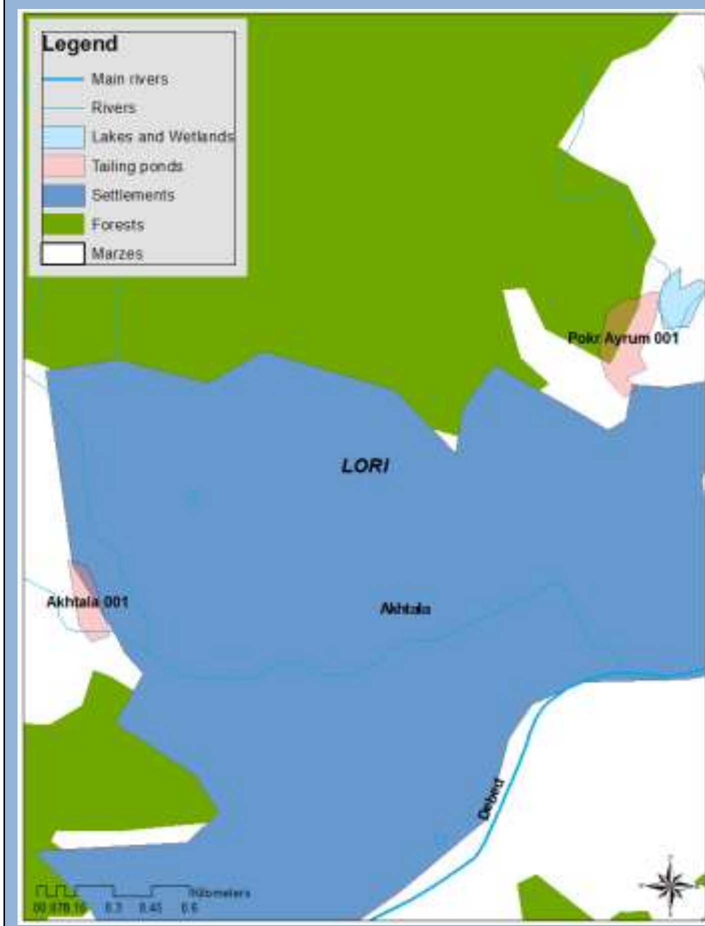
Improperly managed mining areas and in particular tailing dams and depots present a number of environmental threats and concerns. In particular, it is very important to note that improperly managed historical mining areas, whether they are still operational or abandoned, are a deterrent to any new mining developments. Any plans and agreements made for a new mine cannot be acceptable to the general public if the remnants of old mining processes and their environmental impacts are still visible. A combined approach needs to be made for ensuring sustainable development of new mining areas but also clean-up and remediation of the old sites.

Tailing depots of "Akhtala Mountain Enrich Combinat" Ltd

There are 3 tailing depots adjacent to Akhtala town. "Nazik" tailing depot has an area of 2 hectares, 40 meters height, and designed volume of 0.5 mln m^3. [1] By March 2012 0.4 mln m^3 was full. "Canyon of explosive materials" tailing depot has an area of 3.6 hectares, 40 meters height, and designed volume of 0.45 mln m^3 with 0.3 mln m^3 being full. [1] The "Martir" tailing depot has an area of 8 hectares, 60 meters height, and designed volume of 3 mln m^3 (1.1 is full).[1] The materials of the construction for all three dams are clay-sand.[1] All three dams lack basic environmental protection measures including diversion of surface water, circulation of waste water and rehabilitation of the land.[3] All tailing depots were established during Soviet time.[3] In 2010, two out of three tailing depots were actively used by the company although they have been closed due to reaching designed maximum capacity.[3] According to 2012 data the first two tailing depots have been conserved while "Martir" continues to be active.[1]

The closest human habitats to tailing depots are Akhtala with population of 2400, Mets Ayrum with population of 986, and Jojkan with population of 2138.[4] [5] Akhtala Monastery is located in Akhtala town just next to "Nazik" tailing depot.[6] There are houses next to the tailing depots in "Svinets" and "Transport" district of the town (see figure below). In addition to the tailing depots from the other side of the Monastery yard tailings can be seen across the river bank[6].

Figure Box1. Location of tailing depots in vicinity of Akhtala town.



The "Martir" tailing depot that is currently active is located in the gorge between Mets Ayrum and Jojkan villages.[1] [6] This tailing depot has exhausted its capacity during the Soviet time and demonstrates structural issues.[3] Livestock was found grazing in the close proximity of the depot.[6] Residents of those two villages complain of a headaches, hypertension and nausea stressing the worsening of such effects after opening of the tailing depot.[6] The village administration receives insignificant amount from environmental fees.[6]

The soil examined in Akhtala shows some contamination with lead and arsenic. In Akhtala 11% of yard soil samples and 17% of loose soil samples taken from the front of the building entrances exceeded the Maximum Allowable Concentration (MAC) for lead and 58% of all soil samples exceeded the MAC for Arsenic.[7]

Tailing Depots of "Multi Group" Concern

"Multi Group" Concern owns the open pit gold mine adjacent to Mghart and Koghbes villages.[6]

In the area of "Mghart" mine there are three tailing depots with designed volumes of 0.03, 0.02 and 0.05 mln m^3, respectively.[1] As of March 2012 the first tailing depot was full by 0.026 mln m^3 out of 0.03 mln m^3, the second depot was full by 0.01 mln m^3 out of 0.02 mln m^3 and the third was full by 0.043 mln m^3

out of 0.05 mln m^3.[1] The current heights of the dams of three tailing depots are 5m. The designed height of the first dam was 2m, and for the next two the designed heights are equal to the current heights (5m). The materials used are clay-sand, rocks and gravel.[1] The area of these tailing depots are 0.15, 0.064 and 0.023 hectares, respectively.[1] Two of these tailing depots are conserved and the last one is in operation.[1] The owner of these tailings depots is “Multi Group” Concern.[1]

Villagers of the abovementioned communities reported continuous disturbance due to explosions.[6] Since the mining operations started the quality and quantity of the drinking water suffered. As a result villagers have to collect water from the spring located in the center of the village since their taps are no longer providing drinking water.[6]

A Tailing Depot of “ACP” Ltd

The ACP (Armenian Copper Programme) operates since 1997 and owns Copper Smelter in Alaverdi and Teghut Mine.[9]

A tailing depot that belongs to “ACP” Ltd is located next to Alaverdi town.[1] The designed volume is 0.5 mln m^3 out of which 0.4 was full by March, 2012.[1] The area of the tailing depot is 1.32 hectares.[1] The dam was constructed with mineral wastes accumulations.[1] The designed and current heights of the dam were 59.7 m and 40 m, respectively.[1] At current the tailing depot is conserved.[1]

SYUNIK MARZ

There are 9 tailing depots in Syunik marz.[1]

Tailing Depots of "Zangezur Copper-Molybdenum Combine" Ldt

The "Zangezur copper-molibdenum combine" was established in 1951. It was privatized in 2004 by an international consortium led by a German mining company.[1, 3] Currently it is one of the biggest mining companies in Armenia. Zangezur mine is an open pit copper-molibdenum mine with annual 12.8 megatons of copper ore; part of which is processed in Alaverdi and part in sent abroad.[1, 3] According to the Kajaran's Mayor's office 60 % of available workforce in Kajaran work in the Combine. Kajaran has around 10 000 inhabitants.[3] The "Zangezur Copper-Molybdenum Combine" Ldt owns four tailing depots.[1]

The first tailing depot is located in Kajaran town on the right stream of Voghji river (see figure below). It has designed volume of 3.0 mln m^3.[1] It has a dam constructed with stone-pudding materials materials with designed height equal to 60 m and current height equal to 58 m.[1] According to the data of March 2012 it is completely full and conserved.[1]
Most of the people expressed concern about pollution of air since the dust is blown to the city during explosions as well as concern about drinking water.[6]
Analysis of soil samples taken from Kajaran showed that molybdenum exceeded the Maximum Allowable Concentration by 10.2 times, Nickel 8.2 times, Cobalt 2.6 times and Copper 1.7 times.[10] In addition, mercury was high in vegetables in the boundaries of the city.[11]

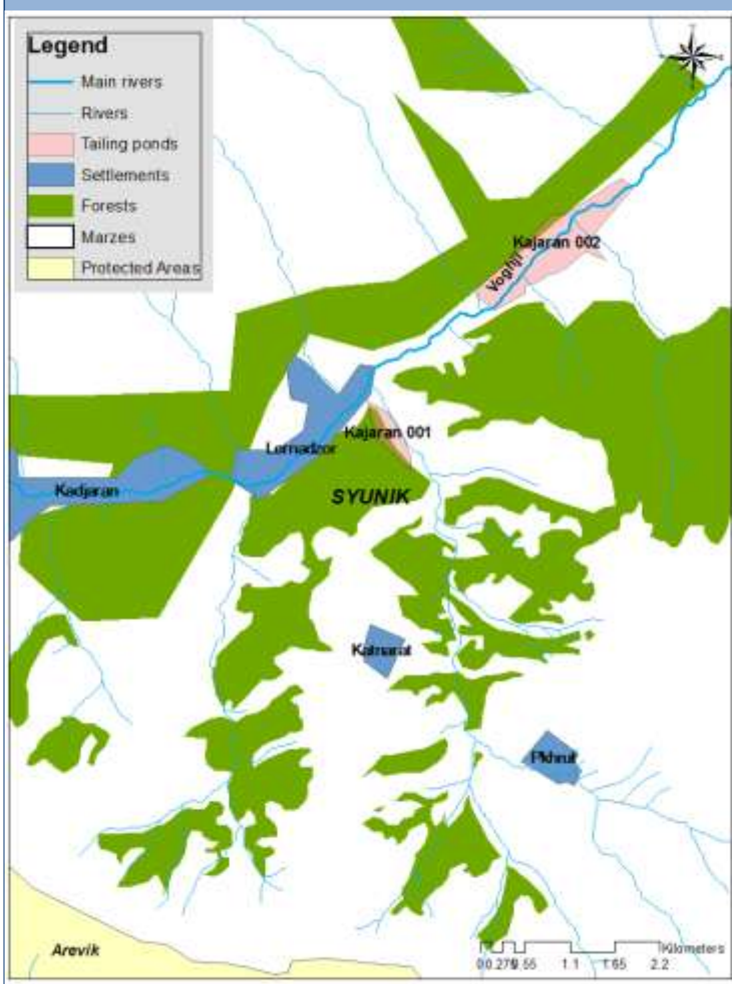


Figure Box2. Location of tailing depots in vicinity of Kajaran town.

The second tailing depot in on Voghji river in Lernadzor village (with community of 465 people) across the Kapan-Karajan highway (see figure 3).[1] The designed volume is 30 mln m^3.[1] The designed and current heights of the dam are 112 m and 100 m, respectively.[1] The area of the tailing depot is 53 hectares.[1] Materials used for the construction of the dam include sand and stone-pudding materials.[1] It is also conserved though only 10 mln m^3 is full with tailings.[1]

The third tailing depot is located near Pkhrut village on the right stream of Voghji river with total volume of 3.2 mln m^3, designed height equal to 50 m and current height equal to 46 m.[1] The area of the tailing depot is 11.2 hectares.[1] Its dam has been constructed with stone-pudding materials.[1] The tailing depot is fully used and conserved.[1] The tailing depot is not fenced, and it smoothly passes to the neighboring surroundings.[6] Observations during the Toxic Site Identification Program revealed vegetation on the tailing depot, grazing, and traces of cars wheels on the surface. [6]

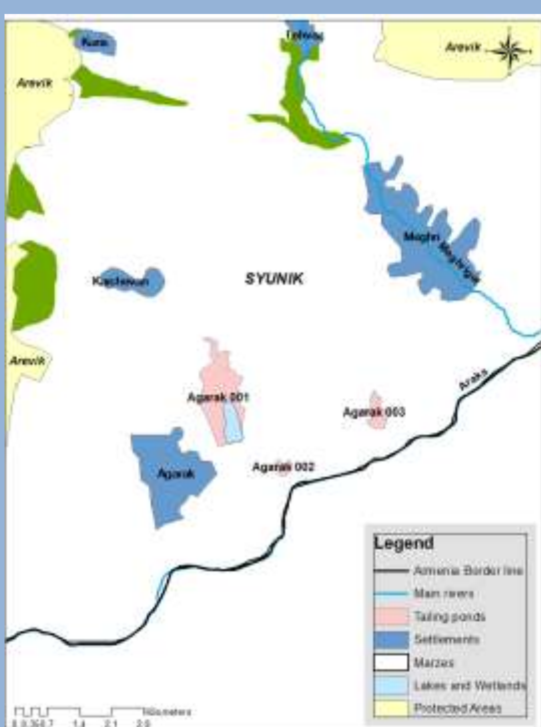
The fourth tailing depot is located on Artsvanik river with the designed volume of 310 mln m^3.[1] The designed and current heights of the dam are 112.7 m and 53.6 m, respectively.[1] The tailing depot has designed area equal to 24 hectares.[1] In 2006 and 2011, 102 hectares and 180 hectares were added, respectively.[6] The dam constructive materials are clay, mountain rocks and crushed stone.[1] At current it is in operation with the used volume of 95 mln m^3.[1] The Artsvanik tailing depot is the largest in Armenia.[6] The tailings from Kajaran flow through pipelines to “Artsvanik” tailing depot.[6] The adjacent human habitats include Syunik, Artsvanik, Ajanan, Chapni, Sevakar, Norashenik villages and Kapan town.[6] These villages have grazing lands, vegetable and tree gardens next the tailing depot.[6] The wheat fields of Artsvanik village are located in close proximity of the depot.[6]

Villagers from Artsvanik, Syunik and Ajanan have been reporting cancer, diabetes, hypertension, headaches, cardio-vascular diseases, infertility, diarrhea and general weakness as common health problems for the communities.[6] A young age mortality is detected.[6] People also reported air pollution by dust of the tailing depot due to general wind direction, and pollution of rivers and springs during accidents.[6] Report of the villagers include information about number of fruits and vegetables (such as cucumbers, peppers, tomatoes, etc.) that no longer grow well in these areas.[6]

Tailing Depots of “Agarak Copper-Molybdenum Combine” Ltd

“Agarak copper-molybdenum combine” has three tailing depots (see figure below).[1] The Agarak Copper-Molybdenum Mine is an open-pit copper-molybdenum deposit that was originally established in 1958.[12] It was privatized by a Russian company in 2003.[3] The Mine is using conventional methods to dig out the pit which later is processed at the adjacent processing plant into an end-product of concentrate.[12]

Figure box3. Location of tailing depots in vicinity of Agarak town.



One is located on Darazami river with designed volume of 40.9 mln m^3.[1] As of March 2012 38.6 mln m^3 was full.[1] The designed and current heights of the dam are 125 m and 120 m, respectively.[1] The tailing depot has an area of 20 hectares.[1] The dam construction materials are clay, mountain rocks and crushed stone.[1] The depot is currently in operation being used by “Agarak Copper-Molybdenum Combine” Ltd.[1]

The second tailing depot is called Valley 1.[1] It has capacity of 9.08 mln m^3 and as of March 2012 only 0.9 mln m^3 is occupied by tailings.[1] The designed and current heights of the dam are 51 m and 5 m, respectively.[1] The tailing depot has an area equal of 24 hectares.[1] The dam was constructed with sand and clay.[1] Currently it is an active tailing depot used by “Agarak Copper-Molybdenum Combine” Ltd.[1]

The third tailing depot is Valley 2 with the designed volume of 17.9 mln m^3.[1] The designed and current heights of the dam are 43 m and 4 m, respectively.[1]

The construction materials of the dam are sand, clay and mountain rocks.[1] The tailing depot has an area of 8.2 hectares.[1] Currently it is being used by “Agarak Copper-Molybdenum Combine” Ltd with the used volume of 3.5 mln m^3.[1]

One of the closest human habitats adjacent to the tailing depots is Agarak town (previous name Banavan).[3] It was founded on the basis of mining activities in 1949.[3] The river Araks flows below Agarak town forming border between Armenia and the Islamic Republic of Iran.[3] The water from Araks river is used for irrigation in local agricultural farmlands in Agarak town and other villages downstream.[3] The tailing discharge from the three tailing depots as well as from the waste storage facilities flows into the river.[3] Currently 1000 people from around 1200 households are working in the mine.[3]

In the frame of Toxic Site Identification Program, in-depth interviews with general population and healthcare providers revealed that in the past there was a crucial problem with pollution of the irrigation water.[6] As a result, during the recent years the water is being double filtered before it flows to Araks.[6] However, the population is still concerned with the quality of irrigation water since no test have been implemented.[6] The incidence of cancer has risen during the last years, however, there is no evidence to link this with pollution of heavy metals; Chronic lung diseases and hypertension is among the most prevalent diseases among people living near mine.[6] Local people reported that some fruit trees (e.g. apricot) no longer grow in this area.[6]

A Tailing Depot of “Dino Gold Mining Combinat” Ltd

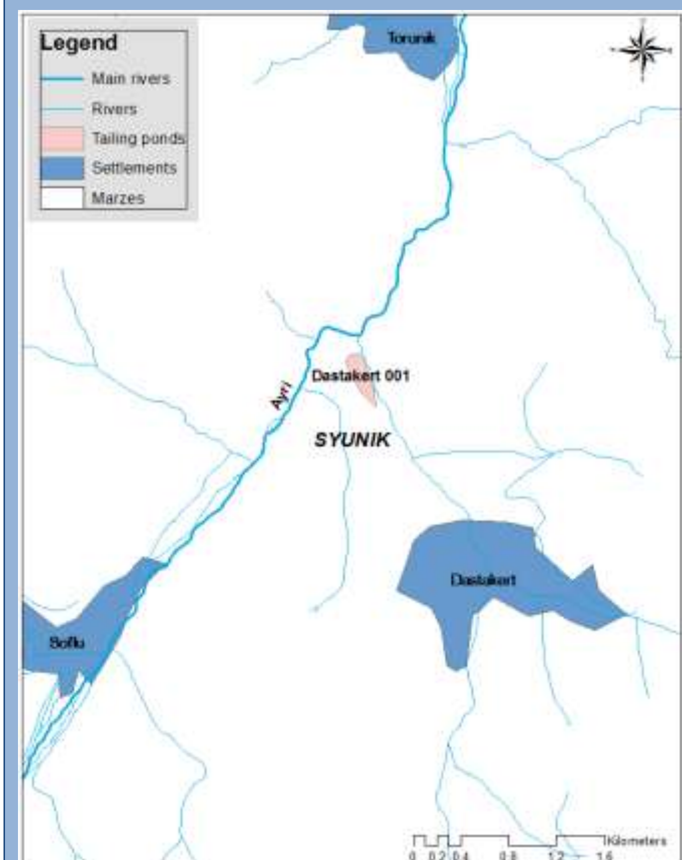
Kapan town has gold, silver, copper and zinc mine production.[3] The local mining facilities, including one underground mine, tailing storage facilities, many mining legacy sites belong to the Canadian “Dino Gold Mining Combinat” Ltd.[3]

A tailing depot that belongs to “Dino Gold Mining” Ltd is located near Kapan town and is named “Geghanush”.[1] It has a designed capacity of 4.6 mln m^3 and by March 2012 the used volume was estimated to be 2.5 mln m^3.[1] The designed and current heights of the dam are 56 m and 45 m, respectively.[1] The area of the tailing depot is 12.8 hectares.[1] The construction materials of the dam are stone-pudding materials.[1] “Geghanush” is currently active tailing depot.[1]

The site observation found that the “Geghanush” tailing depot is located in the hills directly next to Kapan.[6] The depot is active with visible borders, at an elevation of 834 meters above sea level.[6] Observations show livestock grazing in adjacent fields.[6] During the interviews residents reported that tomatoes and some fruit trees no longer grow well in their gardens.[6]

An Abandoned Tailing Depot of the Former “Dastakert Copper-Mining Combinat”

There is a tailing depot located near Dastakert village on Ayriget river (see figure below).[1] The designed capacity was 3.1 mln m^3 with used volume of 1.5 mln m^3 (by March, 2012).[1] The dam has a designed height of 40 m and current height of 30 m.[1] The area of the depot is 54 hectares.[1] The dam was constructed with clay, mountain rocks and crushed stones.[1] The depot is conserved and abandoned.[6]



Dastakert village was established on the basis of copper-molybdenum mining operations which were conducted from 1953-1975 during Soviet times by “Dastakert Copper-Molybdenum Factory”.[6] Currently the village has 300 residents. The abandoned tailing pond is not fenced. In the past the river was isolated from the tailing depot via canal.[6] However, since the canal was eroded over time the river returned to its original rout.[6] Consequently the tailing depot opens into the flow of Ayri river which later falls into Tolors water reservoir near Sisian town.[6]

Figure box4. Location of tailing depot in vicinity of Dastakert village.

ARARAT MARZ

There is one tailing depot in Ararat marz.[1]

A Tailing Depot of "Ararat Gold Recovery Combine" Ltd

The "Ararat Gold Recovery Company" owns a gold processing plant in Ararat town, an open pit gold mine in Sotk near the border between Armenia and Azerbaijan and the tailing depot in Ararat town.[3] The gold ore form Sotk is transported to Ararat where it is processed in processing plant. Since 2008 the company belongs to Russian investors.[3] It was planned to build a new gold processing facility on Lake Sevan to reduce the costs related to transportation of ore from Sotk to Ararat but the plan was failed because of potential hazards.[3]

There is a tailing depot located in Ararat valley near Ararat town (see figure below).[1] Its designed volume is 12 mln m^3 and as of March 2012 10 mln m^3 was already occupied.[1] The area of the tailing depot is 134 hectares.[1] The materials used for the construction of the dam are soil, clay and mountain rocks; the designed and current heights of the dam is 17 m and 19 m, respectively.[1] The tailing depot is in operation and belongs to the "Ararat gold recovery plant" Ltd.[1]

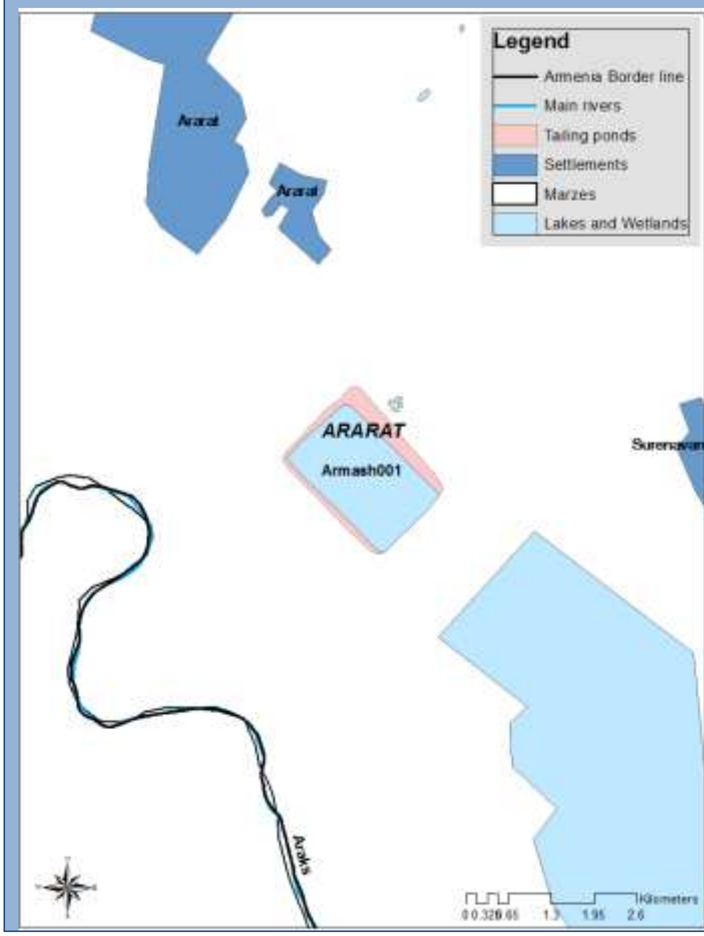


Figure Box5. Location of tailing depots in vicinity of Ararat town.

Ararat Gold Recovery Combine is located next ot Surenavan and Ararat villages and Ararat town. Surenavan is the closest to the Combine.[6] The factory has been working since 1970s.[6] Surenavan, Yeraskh and Armash villages take irrigation water from Kakhanov canal which is located adjacent to the tailing depot.[6] In addition, a fish farm with the area of 584 hectares is located to the south of the tailing depot.[6]

The interviews with local healthcare providers identified increased rated of infertility, cancer and congenital abnormalities during the recent years; presumably as mutli-factorial diseases and not direct result of environmental pollution.[6]

ARAGATSOTN MARZ

There is one tailing depot in Aragatsotn marz.[1]

A Tailing Depot of "Mego-Gold" Ltd

In Aragatsotn marz there is one tailing depot that is located 2 km to west from Meliqgyugh village.[1] The designed volume of the tailing depot is 90 000 m^3; by March of 2012 the half of the designed volume was full with tailings (45 000 m^3).[1] The current height of the dam is 10 m and the materials used for the construction is clay-sand.[1] The area of the tailing depot is 2 hectares.[1] The tailing depot is currently active and it belongs to the "Mego-Gold" Ltd.[1]

"Mego-Gold" Ltd owns the Tukhmanuk open pit gold mine near Melikgyugh village.[6] The village has 350 houses with 1260 residents.[6] Kasakh river flows next to the tailing depot down to the village.[6] The river water is used for irrigation.[6] The air pollution is possible due to general direction of wind from the tailing depot to the community.[6] Livestock grazing was observed in close proximity of the tailing depot.[6] During the interviews local people reported high level of river pollution due to direct flow of the tailings in past.[6] Also local inhabitants reported sharp decline of health of population since the mining operations have started.[6] The main concerns are hypertension, loss of teeth, stomach diseases, stroke.[6]

GEGHARKUNIK MARZ

In Gegharkunik marz near Sotk village a small tailing depot is located. It is an abandoned tailing depot with no authority responsible for its management.

Health risks and implications associated with heavy metals and mining residues

Although human health, and an area population's general health, reflects a combination of different factors and elements, it has been proven that long-term exposure to certain elements may endanger human health and be linked to serious and life-threatening illnesses. Some elements and compounds may also simply be toxic when ingested by people or animals. Some such metals and/or elements and their health implications include:

- Cadmium (Cd)—often found in zinc-concentrate after mineral processing; removed at smelter. Lead and copper ores may contain small amounts of cadmium. Cd is always a byproduct in smelters.

- Copper (Cu)—mostly found in nature in association with sulfur. Recovered in a multistage process.

- Lead (Pb)—ores occur primarily as sulphides or, nowadays, more commonly in complex associated compounds with zinc and small amounts of silver and copper. Usually the lead concentrate is achieved by selective flotation. The metal is recovered from the concentrate by smelting.

- Gold (Au)—occurs in native form (free-gold) or is locked in other minerals (pyrite, quartz, etc.). It can contain a variable amount of silver in solid solution. Gold-silver tellurides can also be a minor addition in commercial gold deposits. The use of cyanide (CN) to leach gold has been a much discussed issue in recent years. Due to cyanide's high toxicity, special attention must be given to the tailings management where this process is applied. When exposure occurs (for example, via inhalation or ingestion), cyanide interferes with many organisms' oxygen metabolism and can be lethal in a short time. Overall, cyanide can cause three major types of environmental impacts. First, ponds and ditches contaminated with cyanide can pose an acute hazard to wildlife and birds. Tailings ponds present similar hazards, but less frequently (because of lower cyanide concentrations). Second, spills can cause cyanide to reach surface water or groundwater and cause short-term (for example, fish kills) or long-term (for example, contamination of drinking water) impacts. Finally, cyanide in active heaps, ponds, and in mining wastes—primarily spent ore heaps, dumps, and tailings impoundments—may be released and present hazards to surface water or groundwater. Geochemical changes can also affect the mobility of heavy metals.

Overall, leached heavy metals and other potential contaminants can reach surface waters. From there they form sediments that may become a persistent source of toxins and pose a chronic threat to aquatic organisms. In addition, consuming fish or coming into direct contact with the sediments or drinking water puts human health at risk. Bioaccumulation of toxic pollutants in aquatic species may limit their use for human consumption. Accumulation in aquatic organisms, particularly benthic species, can also cause acute and chronic toxicity to aquatic life.

Table 3 presents the effects of some of these metals on humans, animals, and plants (Vick 1990).

Table 3: Impact of various metals on environment and health

Metal	Effect
Arsenic (As)	Highly poisonous and possibly carcinogenic in humans. Arsenic poisoning can range from chronic to severe and may be cumulative and lethal.
Cadmium (Cd)	Cadmium is concentrated in tissue and humans can be poisoned by contaminated food, especially fish. Cd may be linked to renal arterial hypertension and can cause violent nausea. Cd accumulates in liver and kidney tissue. It depresses growth of some crops and is accumulated in plant tissue.
Chromium (Cr)	Cr^{+6} is toxic to humans and can induce skins sensitizations. Human tolerance of Cr^{+3} has not been determined.
Lead (Pb)	A cumulative body poison in humans and livestock. Humans may suffer acute or chronic toxicity. Young children are especially susceptible.
Mercury (Hg)	Mercury and its compounds are highly toxic, especially to the developing nervous system. The toxicity to humans and other organisms depends on the chemical form, the amount, the pathways of exposure, and the vulnerability of the persons exposed.
Copper (Cu)	Small amounts are considered nontoxic and necessary for human metabolism. However, large doses may induce vomiting or liver damage. Toxic to fish and aquatic life at low levels.
Iron (Fe)	Essentially nontoxic but causes taste problems in water.
Manganese (Mn)	Affects water taste and may stain laundry. Toxic to animals at high concentrations.
Zinc (Zn)	May affect water taste at high levels. Toxic to some plants and fish.

Source: Vick 1990.

III. International Best Practices—Legal Requirements and Guidelines

Mining legislation varies across the world, and even in developed countries could be more stringent. Globally, environmental legislation that deals with mining practices was put into place after a number of operations were already ongoing and impacting the environment. After that, the environmental requirements needed to be ensured both in future operations as well as those that are already ongoing. For the purposes of comparison, the legislation, acts, guidelines, and best available techniques from the United States, Canada, and the European Union will be reviewed in this chapter, with attention paid to the most environmentally sound provisions of each. Furthermore, the practices that are promoted under the Environment, Health, and Safety guidelines of the International Finance Corporation (IFC) are used to additionally supplement the reviewed legislation.

United States Environmental Protection Agency

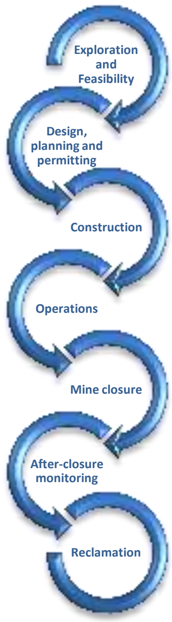
The United States Environmental Protection Agency's (US EPA) Resource Conservation and Recovery Act (RCRA) of 1976 and Hazardous and Solid Waste Amendments of 1984 define all discarded materials as solid waste, regardless of whether the material is solid, liquid, or gas. US EPA's definition of solid waste also includes materials that are "abandoned," "recycled," or "inherently waste-like," all of which are defined in separate regulations. The same US EPA legislation was amended in 1980 to require that all extraction and beneficiation wastes, as well as 20 large-volume mineral-processing wastes, be regulated as nonhazardous waste. This exception is known as the Bevill Exclusion to RCRA, and has a number of provisions that need to be met before the waste can be considered under it. The exclusion specifically lists the origins, processing, or activities from which the waste can be considered. The Bevill exclusion primarily considers the fact that these wastes are usually generated in very high volumes, and does not consider tailings to be hazardous, though nonetheless a waste. The US EPA Hardrock Mining Framework offers provisions to predict acid mine drainage and stability of tailings ponds and dams. Moving down to state levels of environmental management, certain states tackle mining waste through reclamation programs. Others do so through the water pollution program, while some states do a combination of both.[26]

Environment Canada

The Canadian environmental agency, Environment Canada has issued an Environmental Code of Practice for Metal Mines. The code includes recommended environmental management practices that fully encompass mitigation of environmental impacts and sound environmental practices in the entire life cycle of a mine. The code and the recommended practices include items as simple as an Environmental Policy Statement of the mining company, through starting and implementing an Environmental Management System, through public participation, emergency planning, monitoring, and adaptive management. The practices are grouped into the exploration and feasibility, planning and construction, mine operation, and mine closure phases. The mine closure phase also includes recommendations that go beyond the formal closure date and include monitoring and site inspections, and as such cover a mine's full life cycle. A mine's typical life cycle is shown in Figure 7.

[26] www.cfpub.epa.gov/npdates/indpermitting/mining.cfm

Figure 7: Stages in the life cycle of a mine



Source: Environment Canada, reformatted by authors.

The following parameters need to be considered when designing TMFs:

- physical and chemical characteristics of the tailings material, including its metal and acidic leaching potential;
- hydrology and hydrogeology, including local climate conditions and extreme weather events;
- geology, geotechnical considerations, and seismic data, including seismic risk; and
- topography of the TMF and adjacent areas.

The code provides guidance on the earliest possible planning and design of the waste rock piles and the tailings management facilities (TMF). TMFs are key elements of the environmental management infrastructure at most mine sites, especially since at least 90% of the material that is sent for ore processing typically ends up as tailings. TMFs include all components and facilities functionally pertaining to tailings management, including dams, spillways, decant structures, tailings lines, as well as settling and polishing ponds. Frequently, effluents such as mine water and site runoff are directed to the TMF for treatment prior to release into the environment. Issues to consider when locating a TMF are shown in Figure 8.

Figure 8: Issues to consider when siting a new tailings management facility

Source: Environment Canada, reformatted by authors.

The code recommends that the most stringent engineering standards are employed for the containment structures and monitoring practices, and that TMF design and planning is carried out as early as possible in the planning stages. The cost of implementing mine tailings management practices during operation or at a later stage of the mine life cycle could have substantially increased costs.

During the mine's operation, a different approach is taken for waste rock and tailings. The waste rock is regarded as inert waste and stored separately, to be reused at a later time. The main concern with piling the waste rock is instability and possible landslides, while its reuse can be facilitated during the gradual filling in of the mining areas and reclamation during operation of the mine.

The waste rock and tailings can also be used for mine backfill, but only if it is determined that the material will be suitable for such use. In particular, it must have appropriate structural properties and be determined that the chemical alteration of the material will not pose risk to the environment. In the event that potentially acid-generating (PAG) materials are used as mine backfill, monitoring measures should be implemented to assess impacts of the material on the quality of mine water and to predict potential impacts after mine closure. Potential impacts on the groundwater also need to be tracked by carefully planned monitoring programs

TMFs need to be regularly inspected during mine operations to ensure that the construction and stability measures are sound, that the planned and designed measures are implemented, that procedures for dust suppression are in place, and that monitoring is regularly conducted, including taking samples and keeping and registering data. In addition, the Mining Association of Canada has developed a document titled *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities (2011).*

A monitoring plan needs to be developed based on the environmental permitting requirements, assumptions made in the design, and the EIA report. The monitoring plan and monitoring practice need to be conducted in order to:

- assess the potential of tailings for acid drainage and metal leachate
- make sure predictions made during the planning phase are true
- collect data required for modeling
- assess the level of acid generation
- evaluate the effectiveness of mitigation measures
- identify potential contamination of water, soil, or groundwater
- identify possible threats to stability[27]

European Union Legislation—BREF

The European Waste Catalogue and Hazardous Waste List dedicates its first chapter to the *Waste Resulting from Exploration, Mining, Quarrying, and Physical and Chemical Treatment of Minerals.* Under the code of 01 01 01, wastes from mineral metalliferous excavation are considered nonhazardous, as this predominantly deals with waste rock generated during excavation. However, under section 01 03 04*, acid-generating tailings from processing of sulphide ore is considered hazardous, and so is 01 03 07* or other wastes containing dangerous substances from the physical and chemical processing of metalliferous minerals.

A separate directive has been drafted to distinguish wastes from extractive industries from those that are considered under the Landfill Directive. Directive 2006/21/EC applies to wastes from extraction, treatment and storage of mineral resources, and working of quarries. This particular extractive waste, as per the directive, needs to be managed in specialized facilities and in compliance with specific rules. The operators of such facilities need to obtain a permit prior to operation, which shall set forth the basic parameters of the facility such as: its location, how its stability is ensured, how pollution prevented, whether it is monitored and inspected by competent persons, what arrangements are made for its closure, and how land is to be rehabilitated in the post-closure phase. After closure, the operator needs to stay on site and is responsible for all monitoring activities for as long as the competent authority considers necessary. This means that all associated costs are borne by the operator.

Apart from the permit, the operator must also produce a waste management plan that is reviewed every five years. This plan needs to ensure that waste is reduced or prevented and must encourage recycling and reclaiming and safe short- and long-term waste disposal. At a minimum the plan must contain a description of waste and its characterization, the control and monitoring procedures, planned measures for closure and post-closure, and measures to prevent soil and water pollution. The competent authority must also be satisfied with the steps taken to evaluate leachate generation, preventing leachate generation, and treating contaminated water and leachate. The directive also introduces specific measures aimed at limiting cyanide concentrations in tailings ponds and waste waters. One of the requirements of the directive is that all extractive wastes be handled in accordance with the Best Available Techniques Reference Document (BREFs) for Management of Tailings and Waste Rock in Mining Activities (January 2009).

The BREF document also defines the TMF as a pond, dam, system, backfill, heap, or any other kind of tailings management. The BREF further proposes that proper design and planning be undertaken early in the mine's

[27] Environment Canada, 2013.

life cycle. The BREF document is very specific to the countries of the EU, as it first analyzes the metals that are most pertinent and the mining activities that are the most represented in the EU. The BREF then defines in detail the types of mining activities and follow up activities for processing, as well as the currently applied techniques for disposing mine tailings at locations throughout the EU. The techniques that define the core of the BREF document are first and foremost aimed at preventing or reducing emissions and preventing or mitigating accidents. As such, good management of tailings and waste rock includes evaluating alternative options for:

- minimizing the volume of tailings generated in the first place by proper choice of mining method; and
- maximizing opportunities for the alternative use of tailings and waste rock such as in aggregate, restoration of mine sites, backfilling, conditioning of mine tailings, and waste rock to minimize any environmental or safety hazard.

The most common methods for managing mine tailings and waste rock, as reviewed and defined in the BREF document, are:

- discarding slurried tailings into ponds
- backfilling tailings or waste rock into underground mines or open pits
- dumping dry tailings onto waste-rock heaps or hill sides
- using the tailings and waste rock as a product for land use, aggregates etc.
- dry stacking thickened tailings
- discarding tailings into surface water or groundwater

Recommendations for TMFs are centered on preventing ARD, accidental bursts and collapses of the ponds or dams, the contamination of water and soil, and health threats. The BREF document's recommendations are very detailed; they include suggestions to start planning and implementing tailings management as early as possible in a mine's life cycle, and to include defined technical practices or good operating practices in tailings management. The best available techniques (BAT) defined in this document is based on reducing reagent consumption, preventing water erosion, preventing dust generation, developing a water management plan based on a water balance, applying free water management, and monitoring groundwater around all tailings and waste rock areas. ARD needs to be first determined and then prevented, controlled, or have treatments applied. These treatments include adding limestone, hydrated lime, or quicklime to neutralize acids, adding caustic soda for ARD with high manganese content, or include passive treatment options such as constructed wetlands, open limestone channels, or diversion wells. A number of sound engineering recommendations are made for the design of tailings dams to ensure safety and stability. In particular, the BREF includes recommendations on limiting cyanide use in gold mining. At the end, a number of emerging techniques are noted in order to raise awareness for any future revisions to the BREF document, as they are only in the R&D phase.

IFC Environmental, Health, and Safety Guidelines for Mining

The IFC EHS Guidelines for Mining are a technical reference with general and industry-specific examples of GIIP. The guidelines are mandatory for all investment projects that the World Bank Group supports, but can also be a useful document for all other activities in a given sector. For the mining sector, the EHS Guidelines include industry-specific impacts and their management, performance indicators and monitoring, references, and additional sources. The guidelines separate management of waste rock dumps and management of tailings. Recommendations for managing waste rock dumps include:

- to minimize erosion and reduce safety risks, dumps should be planned with appropriate terrace and lift height specifications based on the nature of the material and local geotechnical considerations;
- management of 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 significantly reduce the dumped spoils 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 that are not decommissioned with a proper cover system, which would prevent precipitation from percolating into the dump's body. New facilities must be designed so as to provide for such potential deterioration of geotechnical properties with higher safety factors. Stability/safety assessments of existing facilities should take these potential changes into account.

The guidelines acknowledge that the tailings management strategies vary according to site and nature/type of tailings, but that the general impacts include groundwater and surface water contamination, ARD and metals leaching, sedimentation of drainage networks, dust generation, and the potential for geotechnical hazards associated with the selected management option. The guidelines suggest that the management of tailings needs to include not only operation aspects, but permanent or long-term storage requirements, too. Strategies should consider the site topography, downstream receptors, and the physical nature of tailings (for example, projected volume, grain size distribution, density, water content, among other issues). Apart from leach-pad waste and geochemical mapping of the tailings, the 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;
- where structures are located in areas at risk for high seismic loadings, the independent review should include a check on the maximum design earthquake assumptions and the structure's stability to ensure there will be no uncontrolled release of tailings during seismic events;
- tailings storage facility design 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. The use of natural or synthetic liners should be considered 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 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 (for example, rivers, lakes, and lagoons) or shallow marine tailings disposal is not considered good international industry practice; nor is riverine dredging, which requires riverine tailings disposal. 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.

IV. International Best Practices—Technology, Development, and Practice

In order to keep track of the best available technologies, R&D, as well as practical approaches to environmental and social sustainability, it is common to follow available data and information, but also to take part in a number of international organizations and cooperation platforms that could help share experiences and link the less developed mining countries and corporations with more developed and sustainable ones. For example, the EU has the European Innovation Partnership on Raw Materials (EIP-RM) and the European Technology Platform on Sustainable Minerals (ETP-SMR). In addition, the Network on the Industrial Handling of Raw Materials for European Industries (ERA-MIN) and the European Institute of Innovation and Technology, Knowledge and Innovation Communities (EIT KIC) can also be helpful platforms. One of the key international initiatives is the Extractive Industries Transparency Initiative, membership in which is one of the recommendations of the first thematic paper in this series and which directly feeds into the conclusions and recommendations made by this paper.

In Finland, within the Sustainability Action Plan, one of the greatest potentials for recycling is found in the waste rock heaps from mines and natural stone quarries, and the ever-growing and developing recycling industry needs to keep this waste stream in mind. The only issue remains with the cost-effective recovery of small quantities of metals in the rock heaps and further development of such technologies. In Romania, the mine closure and rehabilitation works are subject to monitoring of technical solutions meant to ensure environmental protection. The coordinating engineers, residents, and the rest of the staff monitor all aspects and in line with FIDIC provisions on behalf of the beneficiary. The designer of the mine closure and environmental rehabilitation works is obliged to monitor from a technical point of view how the approved solutions are put into practice. Following closure, the line ministry allocates funds for each mining site to be monitored for environmental issues and works completion. These also include monitoring for erosion and landslides, sampling groundwater and gas samples beyond the tailings dams, monitoring soil quality, monitoring tailings depots, and so on. The monitoring phase is concluded with a report on the field observations and findings.

Good practice and sustainable environment techniques common to the analyzed legislative and practical requirements or guidelines from the U.S., Canada, the EU, and the international IFC Guidelines include:

- life cycle assessment and planning of a mine
- early planning of all stages, including mine closure
- TMFs
- siting, design, and stability of a tailings dam
- prevention or control of ARD
- water control management
- improved cyanide control
- post-closure monitoring and follow up

Life cycle of the mine and rehabilitation

Mining represents a transient land use, and the aspiration should always be to restore land used for mining to some "productive" use. In broad terms, rehabilitation refers to the measures undertaken to return land on which mining has taken place to the agreed post-closure uses. Implicitly, this requires that rehabilitation measures are not undermined in the longer term by residual pollution (such as the presence of toxins in soils used for revegetation or of ARD). Proper mine closure should:

- include operational waste management planning, which includes overburden rock, tailings, and toxic materials (such as cyanide);
- include mine tailings sites rehabilitation or proper management and monitoring;
- involve local community and various stakeholders;
- start as early as possible in the process of mine development; and
- account for management of all types of waste, including potential sludge that may be generated from treating acidic drainage with lime in order to neutralize acidic conditions. In some cases, the volume of the sludge may exceed the volume of tailings. These sludges may also release additional metals.

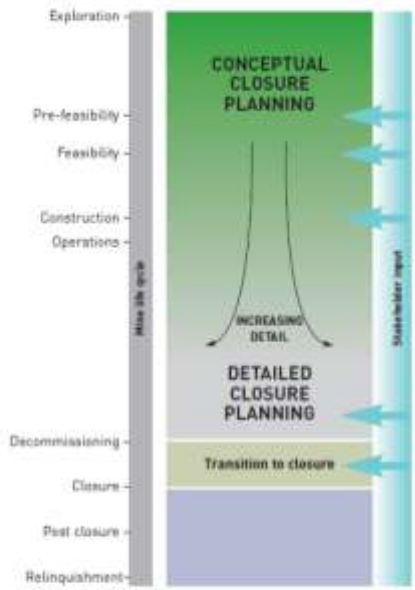
Planning of mine closure and tailings management

Effective closure planning involves bringing together the views, concerns, aspirations, efforts, and knowledge of various internal and external stakeholders to achieve outcomes that are beneficial to the operating company and its host community. One of the most beneficial recommendations to the mining company and also to the regulatory agencies is to have the mine closure and also waste management planning decided and developed early in the mining operation. The process should be open and conducted in cooperation with the local community. Overall planning and initial siting should be guided by the concerns of the population, and the protection and integration of biodiversity. Mine closure activities should address the following environmental aspects:

- underground and open pit mine workings;
- ore-processing facilities and site infrastructure;
- waste rock piles and TMFs;
- sludge disposal areas, as well as ongoing sludge disposal requirements post-closure;
- water management facilities;
- landfill and waste disposal facilities; and
- exploration areas.

The planning for mine closure is depicted in Figure 9 throughout the mining development phases.

Figure 9: Closure planning



Source: Planning for Integrated Mine Closure: Toolkit.

The concept of continuous closure planning is not the same as concurrent rehabilitation. The former is a process that extends throughout the life of the mine. The latter is only one part of the closure planning process that is usually accounted to operations only. Table 4 presents a summary of components to be addressed in the mine closure plan.

Table 4: Mine components to be addressed in the closure plan

Components	Issues to be addressed
Underground mines	• sealing shafts, inclines and declines, or ventilation raises to prevent unauthorized access • effects of seepage from backfill • mine water drainage • formation of potentially unstable ice plugs
Open pit mines	• slope and bench stability • groundwater and rainwater management • security and unauthorized access • wildlife entrapment • effects of drainage into and from the pit
Ore-processing facilities	• removing buildings and foundations • cleaning up workshops, fuel, and reagent • disposing scrap and waste materials • reprofiling and revegetation of site
Waste rock piles	• slope stability • effects of leaching and seepage on surface and groundwater • dust generation • visual impact • special considerations for certain mines, such as uranium mines

Components	Issues to be addressed
Tailings Management Facilities	• dam stability • changes in tailings geochemistry • effects of seepage past the dam and from the base of the facility • surface water management and discharge • dust generation • access and security • wildlife entrapment • special considerations for certain types of mines, such as uranium mines
Water management facilities	• restoring or removing dams, reservoirs, settling ponds, culverts, pipelines, spillways, or culverts that are no longer needed • surface drainage of the site and discharge of drainage waters • maintaining water management facilities
Landfill/waste disposal facilities	• disposing or removing hazardous wastes from the site • disposing and stabilizing treatment sludge • removing sewage treatment plant • preventing groundwater contamination • preventing illegal dumping • security and unauthorized access
Infrastructure	• removing power and water supply • removing haul and access roads • reusing transportation and supply depots

Source: Environment Canada.

Tailings management facilities

In order to better manage tailings that are a byproduct of mining, a TMF or a tailings storage facility (TSF) should be established in lieu of the tailings depots or dumps. Based on the European Commission BAT document, the following tailings characteristics will need to be established in order to facilitate a tailings storage facility's design requirements:

- chemical composition (including changes to chemistry through mineral processing) and its ability to oxidize and mobilize metals
- physical composition and stability (static and seismic loading)
- behavior under pressure and consolidation rates
- erosion stability (wind and water)
- settling, drying time, and densification behavior after deposition
- hard pan behavior (for example, crust formation on top of the tailings)

The engineering characteristics of tailings are in most instances influenced by the degree of thickening and the method of deposition. It is therefore essential that while investigating the properties of tailings that the physical characteristics and material parameters (for example, beach slope angles, particle size segregation, water recovery) that can occur as a result of varied deposition techniques be identified (SANS 1998). This is particularly true when considering high density tailings disposal and its associated transportation and deposition challengers.

Once the potential site specific parameters (for example, environmental, social, geotechnical, cost) and the characteristics of the tailings and their behavior upon deposition are determined, the process of deciding a suitable storage method can begin.

A number of technological or design solutions can be included in the TSF design to minimize the facility's environmental impact. For example, tailings that have a potential to generate acid[28] can be controlled by preventing or minimizing oxygen and water from contacting the material, as well as ensuring that an adequate amount of natural or introduced material is available to neutralize the acid produced. Oxygen and water contact can be controlled through techniques such as subaqueous disposal, covers, waste blending, hydrologic controls, bacterial control, and treatment.

Impounding slurry tailings is one of the most common methods for the disposal or storage of mine tailings. Impoundment is largely favored due to the low economic costs and the fact that they are relatively easy to operate. If properly designed, the impoundments can be developed to perform a number of functions:

- remove suspended solids by sedimentation
- precipitate heavy metals as hydroxides
- permanently contain settled tailings
- equalize wastewater quality
- stabilize some oxidizable constituents (thiosalts, cyanides, flotation reagents)
- manage water, including runoff and recycled water from the process[29]

However, tailings impoundments have a number of disadvantages that require attention in design, such as:

- difficulty in achieving good flow distribution
- difficulty in segregating drainage from uncontaminated areas
- difficulty in reclamation, particularly with acid-generating tailings, because of the large surface area and materials characteristics
- inconsistent treatment performance due to seasonal variations in bio-oxidation efficiency
- costly and difficult collection and treatment of seepage through impoundment structures
- potentially serious wind dispersion of fine materials unless the surface is stabilized by revegetation, chemical binders, or rock cover

Siting of a tailings management facility

Once the site screening criteria of mill or mine location, topography, and hydrology have been conducted, the number of siting options is usually considerably reduced. Geologic considerations then assume a critical role. In particular, site geology affects the foundation of the embankment, seepage rates, and the availability of borrow materials for embankment construction. Soft foundations, for example, may limit the allowable rate of embankment build-up in order to allow for adequate pore pressure dissipation. Sloping foundations and the presence of weak layers will need to be investigated, since these may contribute to slope failure of the embankment.

Although geologic details are critical to siting and design, they often play a secondary role in actual siting decisions. This is because there are usually a limited number of sites available at this stage (the rest having

[28] Acid generation prediction tests are increasingly relied on to assess the long-term potential of a material, or waste, to generate acid. Mineralogy and other factors affecting the potential for AMD formation are highly variable from site to site, which can result in difficult, costly, and questionable predictions. In general, methods used to predict the acid-generation potential are classified as either static or kinetic. These tests are not intended to predict the rate of acid generation, only the potential to produce acid. Static tests can be conducted quickly and are inexpensive compared with kinetic tests. Kinetic tests are intended to mimic the processes found in the waste unit environment, usually at an accelerated rate. These tests require more time and are much more expensive than static tests.

[29] Environment Canada, 2013.

been eliminated by considering mill location, topography, and hydrology). In addition, the lack of detailed information often precludes any meaningful comparisons of alternative sites. The tendency is to try to engineer around any geologic problems. If, following the site investigation, a "fatal" geologic problem is discovered, the site must be abandoned at that time. The search will then continue for one or more suitable sites.

Groundwater conditions are usually related to geology, and also affect siting conditions. A high water table limits the amount of dry borrow material available for construction, and shortens the distance for seepage to enter the groundwater system. In addition, shallow groundwater can infiltrate tailings and increase the amount of water in the impoundment.

Initially, various observations and assessments can assess broad geologic factors, including the availability of construction materials, special construction problems with respect to nearby structures, drainage conditions at the site, and apparent ground stability of the site (such as slumping, evidence of weak planes within the rock, faulting, etc.). An area’s vegetation can indicate subsoil characteristics. Test pits and trenches may be dug and test holes may be drilled to obtain soil and/or rock samples. In situ permeability tests also may be run in holes drilled at the site of the proposed tailings impoundment area.

A proposed site will undergo a geotechnical site investigation. The investigation will assess site geology, including the depth, thickness, continuity, and composition of the strata; site hydrogeology; geotechnical properties of soil and rock affecting design; and availability of suitable construction materials for building dams, dikes, drains, and impervious liners.

Design and stability of a tailings management facility or tailings dam

A very significant concern regarding tailings dams involves stability, and therefore the environmental performance of such sites. The risk of seismic activity, earthquakes, erosion, or simply any natural or manmade event that may lead to the tailings impoundment’s collapse may cause substantial and irreversible environmental damages. The stability concerns arise from the materials used for tailings dams or embankments and the fact that a certain amount of seepage is usually necessary to keep the embankments stable.

The impoundments or tailings dams need to be clearly marked, fenced, and guarded, with adequate provisions to minimize seepage and drainage, and with appropriate water and dust management and monitoring in place. The most stringent requirement in design is stability.

Prevention or control of acid rock drainage

The first step in planning disposal and storage of waste rock or overburden and tailings is to establish the risks of metal and acid leaching drainage, and then develop design and siting of the waste rock piles and TMFs. In the event of potential acid leaching, one of the most commonly used disposal methods is the subaqueous disposal, which helps avoid oxidation reactions and therefore acidic generation. Such disposal would require tailings dam facilities to be properly designed. Stability and accidental events management must be carefully considered, and under no circumstances should tailings be disposed in water bodies, but rather a layer of water must be present on the tailings. If it is impossible to prevent acidic drainage, several methods may be used alone or in combination to control or limit it. These include:

- dry covers consisting of alternating layers of material of different porosity to limit water infiltration
- dry covers using innovative materials, such as sewage sludge stabilized by lime or sludge from pulp and paper mills
- impermeable geo-membrane liners to prevent infiltration of acidic drainage into underlying materials

- waste rock or tailings maintained in a frozen state (in permafrost areas)
- direct addition of lime or other alkaline substances
- raising the water table to inhibit acid generation of materials disposed of below the water table
- use of tailings as mine backfill, or disposing of tailings in mined-out open pits[30]

Water control and management

One of the most significant aspects of tailings impoundment design and operations, as well as environmental concern, is water management and control. Water disposed of in the impoundment, as well as the collected atmospheric precipitation, play an important role in leaching. They spread contamination from the site, but also play the most significant role in the stability and failure of the impoundments or embankments. Leaching various constituents from the mining tailings, including acid, degrades the quality of the surrounding soil, groundwater, and surface water. Containing seepage that would fully control water in impoundments is considered to be "an elusive goal" (Vick 1990).

Looking at a mining impoundment in a strict mass-balance approach, the inflows would include precipitation and process water, while the outflows from the impoundment would include overflows, evaporation, water recycling, and seepage. Overflow is directly related to the dam's storage capacity and precipitation volume. Evaporation rates are a function of the climate and surface area of the pond and saturated tailings, while the amount of water recycled back into the impoundment or the transport system depends on the operation's capacity and needs. Seepage can leave the containment as groundwater or seep from under the embankment.

In general, the inflow plus the storage available has to equal the outflow from the dam. The maximum storage occurs when the inflow equals the outflow.

The principal methods for controlling run-on are catch basins and check dams, and diversion ditches (channels and pipes). Catch basins stop surface water from entering the tailings impoundment area but generally require some method of bypassing the tailings impoundment, such as decant systems or diversion ditches. Catch basins may be expensive because of labor and fill material, but can be cost-effective for small runoff volumes. It may not be necessary to treat the water, because the water never enters the tailings impoundment itself.

Improved cyanide regulations

In the IFC EHS on mining's section on cyanide, it is stated that the use of cyanide should comply and be consistent with the principles and standards of practice of the International Cyanide Management Code. This code includes principles and standards applicable to cyanide purchase (sourcing), transport, handling, storage, use, facilities decommissioning, worker safety, emergency response, training, and public consultation/disclosure. The code is a voluntary industry program developed through multi-stakeholder dialogue under the auspices of the United Nations Environment Programme (UNEP) and administered by the International Cyanide Management Institute.

The country-specific regulations targeting cyanide use should also address the design of facilities that use cyanide (requiring or recommending liners and site preparation for heap leach piles or tailings impoundments); operational concerns (monitoring of solutions in processes and in ponds, treatment of cyanide-containing wastes); and closure/reclamation requirements (rinsing to a set cyanide concentration in rinsate, before reclamation can begin). Operators are generally required to take steps either to reduce/eliminate access to cyanide solutions or to reduce cyanide concentrations in exposed materials to below lethal levels. Regulatory

[30] Environment Canada, 2013.

requirements and guidelines for the allowable concentration of cyanide in exposed process solutions are widely variable (when numeric limitations are established, they generally range around 50 mg/l), as are the means by which operators comply. Operators reduce access in several ways, including covering solution ponds with netting or covers, using cannons and other hazing devices (for example, decoy owls) to scare off waterfowl and other wildlife, and/or installing fencing to preclude access by large wildlife.[31]

Post-closure monitoring and follow up

A proper mine closure and tailings rehabilitation or management plan needs to include adequate monitoring procedures. The monitoring system should be able to monitor the environmental impacts that are associated with a given operation and also detect whether pollution containment methods are effective. The monitoring plan needs to include the parameters to be monitored, the procedure by which they will be monitored, legally prescribed thresholds, and most importantly, baseline conditions against which all monitoring results will be compared. The environmental monitoring will rely more on sampling and testing, while socioeconomic monitoring will be more qualitative.

Mine closure costs

Proper mine closure needs to account for the associated costs, which need to be reevaluated throughout the planning stages and adjusted accordingly. The funds also need to be made available either through guarantees or funds established for such purposes. Since the establishment of such funds can be mandated very early in the mine development stage, it is necessary to review the applicability and costs associated with the available funds. The mine owner/operator should ensure that adequate funds are available to cover all closure costs, and the amounts of any security deposits should be adjusted accordingly.

Cost estimating, from prefeasibility through to construction, should be owned at the project or site level, with projected expenditures being factored into annual operating activities. As a closure plan evolves, it should have ownership at the site level, both technically and financially (versus simply higher level accounting entry). Such ownership can spur more accountability for accurate estimates. At the conceptual stage, the closure costs are expected to be broad estimates only. The earlier that risks and unknowns are reduced, the greater the potential for meeting specific objectives. This is one reason that planning for closure should begin at the earliest opportunity.

[31] Environment Canada, 2013.

V. General Guidelines for Environmentally and Socially Sound Management of Mine Tailings

The purpose of this section of the paper is to provide sufficient information on the key environmental and social concerns as related to the management of mine tailings and the current practices in Armenia. Based on the current practices and on the Mining Code (2011) the mine tailings are considered as a "manmade mine" and can become a secondary source of valuable minerals upon further processing. This process of "recycling" and promoting high-efficiency use of natural resources is rather encouraging. However, first and foremost a final time frame needs to be established, by when such attempts at reprocessing will be carried out, so that the tailings are not stored permanently and indefinitely.
Furthermore, one of the key constraints is the lack of sufficiently advanced processing techniques, which would help balance the economic aspects and associated costs with the potential mineral gains and extraction from the tailings. As such, the tailings can be stored on- or off-site for a long period of time, exposed to the natural elements, which can lead to the spread of a number of hazardous or potentially hazardous constituents. As a result, improperly managed tailings piles or ponds present a direct threat to human health and the environment, but can also have other far-reaching impacts.

Overall recommendation: establish sound environmental management of tailings facilities or depots

The overall recommendation of this paper is to ensure sound environmental management of mine tailings depots, ponds, or simply TMFs, coupled with regular and thorough monitoring practices that would be established and carried out for the mine's lifetime by the operator. After closure, monitoring and supervision would be conducted by the regulating agencies (ministries) to ensure minimal if any environmental impact as the tailings await processing. The associated costs and responsibilities need to be defined in the mining rights contracts, as included in the pertinent legislation.

A great step in this direction has already been taken through the general provisions of the Mining Code, as well as the supplemental secondary legislation, such as the RA Government Decree from January 2013 on establishing monitoring procedures for the area of mining operations and tailings dams in particular to ensure safety and health of the population of the neighboring communities. In addition, with the assistance of GEF, a framework for surveying the mining areas and establishing a monitoring framework is also going to be pursued.

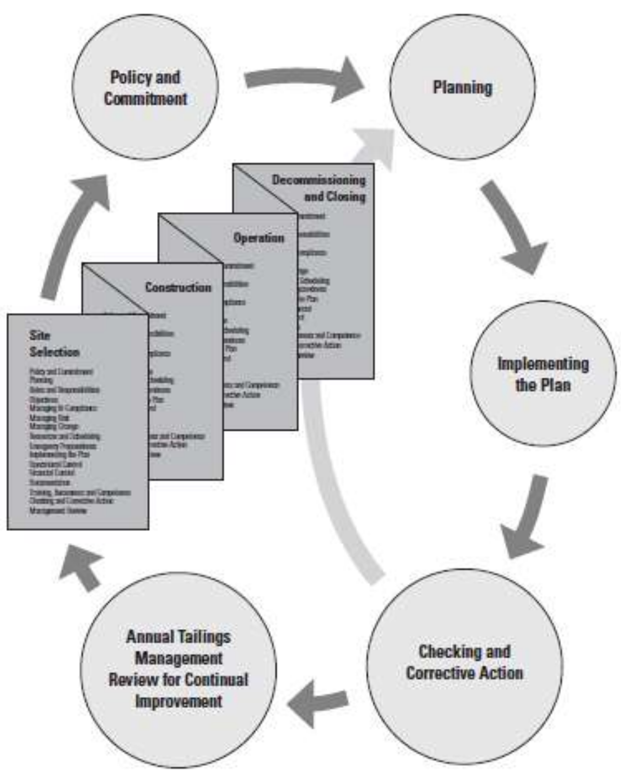
Within the guidelines that supplement the Mining Code, as well as the Operational Manual drafted by the Ministry of Nature Protection in 2011 on secure management of tailings in Armenia, the legislative framework may be close to complete. The next steps should include: (i) establishing implementation of such guidelines in the field and enforcement, (ii) obtaining monitoring results (set of established values over an established period of time) that would be publically disclosed and (iii) differentiating the approach for new mining developments as opposed to the legacy pollution sites, abandoned mines, or old operational mines that have been privatized.

Develop mine tailings facility or depot registry

The data made available from the Ministry of Energy and Natural Resources needs to be continuously updated and revised to reflect the situation on the ground. The existing sites need to be adequately assessed and reviewed based on the existing environmental impacts. Future mines need to incorporate sound tailings management practices in their EIAs and ensure that such sites/facilities are properly monitored. Baseline data for any new development is an essential requirement, against which all subsequent monitoring measurements will be conducted. The information for existing, new, and yet-to-be-developed tailings facilities will be combined into one registry that will be equally managed and reviewed by the Ministry of Energy and Natural Resources and the Ministry of Nature Protection. The first ministry needs to ensure adequate treatment of the potential secondary resource, while the second ministry needs to be involved to ensure minimal if any associated environmental impacts, as proven by the monitoring results.

Among the key elements for developing this registry is (a) to adequately staff and delegate responsibility in the ministries; (b) establish presence in the field, coupled with on-site assessments, documentation preparation, quantities estimates, and clear delineation of locations using GPS coordinates; and (c) provide expert assessment of the major environmental issues and potential risks associated with the tailings depots. Based on this information, a mine-specific Tailings Management Framework will be developed. Figure 10 shows the application of such a framework through the life cycle of a mine. The framework needs to be somewhat adjusted for the already existing and non-managed mine tailings facilities.

Figure 10: Application of the Tailings Management Framework through the life cycle of a mine



Source: Mining Association of Canada.

Ensure implementation of monitoring plans and develop remediation plans for existing facilities

Based on the registry of mine tailings facilities or depots, a number of remediation actions can be proposed. These should have the goal of properly managing the mine tailings facility and decreasing its environmental impact, as well as mitigating any environmental damages that have already been sustained. The monitoring needs to be made subject to public disclosure and be regularly updated. A lack of current information can serve as a red flag to make sure monitoring is being conducted and that the results are satisfactory.

Obviously, management of mine tailings is the most important segment of any mining operation. Throughout this paper a number of recommendations have been made but mostly related to implementing measures and legal requirements from day one of planning a mining operation. The situation in Armenia is more complex, as a number of mines have been operational for a long time, and have started operating prior to any environmental requirements were in place. Some of these old mines have attracted foreign investors and have expanded their operations. Even if the tailings from current operations are managed in the most environmentally sound approach, the historic tailings still remain. Any approach to be taken towards environmentally sustainable management of mine tailings needs to include both, the new mining developments and the legacy sites. The legacy sites, due to different ownership issues and the associated clean-up costs may present a more long-term priority, while setting up new mining developments on a sound and sustainable base is a key priority that the Government of Armenia has started to address.

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