CHAPTER IX
ADDRESSING LEGACY SITES

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1. INTRODUCTION

Waste facilities are created to deal with inefficiencies in mining, mineral processing, and metallurgical extraction. These facilities comprise, for example, ponds and lagoons constructed for the 'disposal' of processing waste in slurry or paste form (including tailings, silt, and sludge ponds) and heaps for the 'disposal' of solid waste (e.g. spent ore and waste rock). Depending on where they are located, what they contain and how they are stored, tailings and other mine wastes have the potential to cause significant environmental contamination, take land out of productive use, and threaten the health, safety and livelihoods of nearby communities, .

This chapter focuses on the problems that can arise when a mine has ceased production and there is no owner who can be held accountable for the rehabilitation, stabilisation and safe management of the tailings and other waste that is left behind from mining. In the course of addressing these challenges, the chapter also engages with a larger set of issues relating to so-called 'orphaned' and 'abandoned mines' (as defined below). These are mines which are no longer under active management, have not been properly closed and rehabilitated, and generally are not subject to ongoing monitoring.

Legacy mining wastes can present major problems for governments, which generally end up having to bear the cost of, and responsibility for, dealing with contamination issues and community concerns. High profile 'problem sites' also damage the reputation of the mining industry because they detract from industry claims that mines can be operated and closed without causing harm to people or the environment. This was highlighted in the summary report of a workshop on Abandoned Mines convened by the United Nations Environment Programme (UNEP) and the Chilean Copper Commission in Santiago, Chile in April 2001. The report noted that: '[t]he orphan sites problem … continues to cast a shadow over all mining at the time when major operators are improving their operations and are trying to improve the image of their sites and their company' (UNEP 2001:p.16). Nearly 20 years on, this statement still holds true.

Concerns about the risks posed by old tailings facilities that had not been properly closed were frequently raised by stakeholders during the public consultation phase of the Global Industry Standard on Tailings Management ('the Standard') in November 2019. It was not possible to address these concerns within the framework of the Standard itself, in part because legacy sites generally do not have operators to whom responsibilities can be assigned. However, there is explicit recognition by the Co-convenors that more work needs to be done to address these issues, particularly by national and/or state level regulators.

This chapter of the volume was proposed by the Expert Panel as a means of responding to the wider consultation feedback. It serves to promote informed discussion, and to reinvigorate a more collaborative, coherent, and successful approach at global level to addressing what is recognised to be a major negative impact of the mining industry.

1.1 AIMS AND SCOPE

The chapter draws on published research studies, policy documents and guides, and the knowledge and expertise of people working in this area. It also engages with broader discussions about sustainable development, 'responsible mining' and the ethical responsibilities of companies. The overall aim is to promote informed discussion, and to reinvigorate a more collaborative, coherent, and successful approach at global level to addressing what is recognised to be a major negative impact of the mining industry.

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Specific objectives are to:

- present available data on the scale and nature of the problems posed globally by orphaned and abandoned mines, and demonstrate why these problems need to be addressed
- identify significant knowledge gaps and the actions required to fill these gaps
- provide an overview of initiatives that have been, or are being, taken at the international and national level to deal with the problems associated with legacy mines and legacy wastes in particular
- identify practical steps that can be taken to deal more effectively with existing legacies and reduce the likelihood of new negative legacies being created in the future
- explore the potential for applying existing and new technologies to address acute and chronic contamination and stability issues associated with tailings and other legacy mining wastes, extract residual value from these wastes, and realise opportunities to generate sustainable local and national socioeconomic benefits.

Some of the themes explored in the chapter are also addressed in other contributions to this volume. Chapters of particular relevance are those by David Williams (the role of technology in improving the management of tailings), Mark Squillace (strengthening the regulatory role of the state), and Gord McKenna and Dirk Van Zyl (improving closure practice).

A note on scope
The chapter focuses on land-based waste legacies, not those created by the deposition of tailings and rock material into rivers, lakes and marine environments. These other methods of waste management have caused significant environmental problems in some parts of the world and undoubtedly warrant attention. However, consideration of these matters falls outside the scope of this chapter, and of the Standard itself.

2. OVERVIEW: DEFINING TERMS AND UNDERSTANDING THE PROBLEM

2.1 DEFINITIONS

A legacy site is one where '… mining leases or titles no longer exist, and for which responsibility for their rehabilitation cannot be allocated to any individual, company or organisation that has undertaken mining activities' (Unger 2017, p. 334). Legacy sites include old mines and associated waste facilities which are considered orphaned or abandoned. The former term is generally used to refer to mines 'for which the owner cannot be found' and the latter to those where the owner is known, but 'is financially unable or unwilling to carry out clean-up'.[1]

In practice, many mining sites can be in a perpetual state of 'limbo', neither 'relinquished', 'safely closed' nor actively under operation, with a range of intermediate possibilities. Some legacy sites may also exist within otherwise active mining tenures. In these situations, operators may be able to indefinitely defer addressing closure obligations and avoid dealing with significant long-term environmental liabilities.

2.2 WHAT IS THE SCALE OF THE PROBLEM?

In short, we do not know the answer to this question. At the country level many government agencies and some researchers have published limited inventories of abandoned mine sites, but in general (global) terms, these sites are largely unquantified (both in terms of absolute numbers and size – volume, area), poorly mapped and often in remote locations. In most cases site investigations are required to confirm the presence of abandoned mine features including tailings facilities.

Worrall *et al.* (2009), and Unger (2017) are among those who have tried to collate quantitative data on numbers of abandoned mine sites, but reliability of the data is variable. Estimated numbers in key mining jurisdictions range from 10,000 in Canada and 32,600 in Australia (both good quality data), to over half a million sites in the USA (relatively poor quality data). However, It is not clear how many of these sites produced ore and/or include tailings or other waste storage facilities.

Legacy mine sites are often also poorly documented with respect to their associated social, environmental and local economic impacts and liabilities. Further research and compilation of information on the

1. This definition is taken from the website of the Canadian National Orphan/Abandoned Mines Initiative (NOAMI). (https://www.abandoned-mines.org/en/ . Accessed 19 March 2020.

number, size and characteristic of abandoned and orphaned mines is necessary for sound decision-making, to enable the prioritisation of sites for attention, and to undertake cost-efficient planning and sustainable rehabilitation. Such information is also necessary to ensure transparency of decision-making and access to information by governments, civil society, industry and other stakeholders.

2.3 KEY ENVIRONMENTAL AND COMMUNITY ISSUES ASSOCIATED WITH LEGACY SITES

Mines have environmental and social impacts, which can be both positive and negative, throughout their lifecycle. These include impacts on the physical (e.g. air, water, soils, landscape,) and biological (e.g. fauna and flora) environment, and on people and their livelihoods (e.g. health and wellbeing, social structures, employment, heritage and human rights). During the normal process of impact assessment, these are identified and quantified, in terms of negative impacts (to be avoided, reduced and managed) and positive impacts (to be enhanced if possible, such as local economic benefits). When a mine ceases to operate however, the picture changes.

In an ideal situation, the process of decommissioning and closure is initiated and renders the mine and all its structures 'safe' in perpetuity. However, most legacy sites were created when there was little, if any regulatory oversight of the establishment, operation and closure of mines. Consequently, mines and the associated waste facilities were often abandoned without any consideration of potential risks to humans and the environments, nor with regard to visual impacts, landscape integration, alternative land uses or similar concerns.

Tailings and other mine wastes vary considerably in their chemical and physical characteristics and are stored in a range of social, environmental, and local economic contexts, so there is no 'one size fits all' description of environmental and health impacts. However, Table 1 gives an indication of the types of risks that they can present, both in the operational phase and after mining has ceased.

Table 1. Examples of potential risks from operating and closed mine waste storage facilities (including tailings)

Risk	Source	Pathway	Receptor(s)
Loss of structural integrity	Physical movement of waste, water, and construction material	Movement over land, transport by surface water, groundwater, and air (dust)	Humans, downstream environment (physical and biological), facility structures
Hazardous waste content (geochemical source)	The waste itself (dust, leachate)	Air, soil, groundwater, surface water, sediments	Humans and the environment (physical and biological)
Dangerous waste (chemical source)	The aqueous phase of the waste in tailings ponds	Soil, groundwater, surface water, sediments	Humans and the environment (physical and biological)
Incorrect closure (physical components)	Physical or chemical instability of the facility and/or the waste material	Air, soil, groundwater, surface water, sediments	Humans and the environment (physical and biological)
Incorrect closure (social components)	Management of post-closure land use	Access, land use, livestock, crops, soil, water	Human health and livelihoods

In some cases, as illustrated by the example in Box 1 below, failures in managing legacy mining wastes have given rise to significant public health concerns.

Box 1: Impact of gold mining legacies around Johannesburg

'The legacy of gold mining activities around Johannesburg consists of enormous heaps of tailings dumps extending over many square kilometres. These sites must be considered as potential sources of mobile uranium to the biosphere. Gamma spectrometric analysis points to significant leaching of U … Very high concentrations were obtained in water bodies in the proximity of tailings dumps ... The processing of mine dumps has also contributed to enhancing acid drainage and probably oxidation of dump material, thus enhancing U mobility. Wetland sediments showed that they act as traps of sinks for U and other heavy metals .. It should be noted that the toxicity of U is not as a result of its radioactive nature, but rather its chemical nature. The kidney is considered as the target organ for uranium's chemical toxicity.'

Source: Tutu et al. 2003, p.147.

Legacy tailings facilities can adversely impact members of communities in different, sometimes gender-specific, ways (Box 2). These impacts are exacerbated when affected people are unwilling or unable to relocate for a variety of complex reasons. Apart from the obvious direct impacts on the people concerned, these situations represent a substantial cost to public authorities which are often expected to make the sites secure and prevent ongoing pollution.

The public is increasingly demanding action and this visible legacy of the past is producing growing community opposition to current mining activities (UNEP 2001). These sites are at the same time visible reminders of poor management and an invisible inheritance to be shouldered by subsequent generations. The historical legacy at a global scale appears to be one of 'out of sight, out of mind'.

3. THE WIDER CONTEXT: SUSTAINABLE DEVELOPMENT, COMMUNITY AND STAKEHOLDER EXPECTATIONS, AND 'RESPONSIBLE MINING'

Sustainable development was first clearly defined in 1987 as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland 1987). This highlights the issue of intergenerational equity. According to the International Council on Mining and Metals (ICMM), sustainable development for the mining sector means ensuring that investments are technically appropriate, environmentally sound, financially profitable, and socially responsible (ICMM 2016).

Box 2: Social and health impacts associated with tailings facilities in South Africa

Social factors that precipitate health issues in communities associated with management of South Africa's tailings dams include poverty, unemployment, poor housing and infrastructure, prostitution and a high influx of unaccompanied migrant labour. Major health-related issues among workers and residents related directly or indirectly to poor tailings handling include exposure to a toxic mix of radioactive elements, arsenic and heavy metals, loss of biodiversity, impairment of ecosystems services, respiratory illness, as well as contributions to ozone depletion and global warming.

Source: adapted from Cronje et al. 2013

By taking action to prevent, better manage, and reduce pollution at the regional, national, and local levels, governments and stakeholders can put themselves on a path to meeting the Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development (UNEP 2019). However, 'the commendable and necessary efforts to apply sustainable development in the mining sector […] are undermined by the existence of so many mining legacies globally' (Unger 2017, p.339).

An ethical approach to dealing with legacy issues in the mining sector would ensure respect for all stakeholder interests, as well as enhancing equity and transparency. An ethical mining culture should demand that companies commit not only to understand and uphold the applicable statutory requirements, but also guarantee that justice is done for all affected parties and in all circumstances. Such a culture applied by all stakeholders across the mining sector would promote the development of strategies that deal with and prevent unintended consequences (Poswa and Davies 2017). It would also address four key principles of accountability, compliance, justice and responsibility in equal measure (Table 2).

Table 2. Key principles for ethical tailings disposal practice

Principle	Key expectations
Accountability	• Take responsibility for actions, including unintended consequences • Apply the polluter pays principle • Be transparent
Compliance	• Uphold national legal standards and requirements • Follow international norms and standards – human rights, environmental and social performance, stakeholder engagement and participation
Justice	• Ensure fair and equal treatment • Avoid causing harm
Responsibility	• Exercise a duty of care • Take a precautionary approach

Source: adapted from Poswa and Davies 2017.

4. LEGISLATIVE AND GOVERNANCE APPROACHES TO ADDRESSING LEGACY SITES

There have been several, intermittent, initiatives to try to address the issue of legacy sites and their ongoing negative impacts. Nearly two decades ago, the Mining, Minerals and Sustainable Development (MMSD) Report suggested that:

one way to create a credit in the current natural capital account would be to deal with the worst environmental problems at abandoned sites. Improving these sites could create benefits, which could offset or perhaps even exceed any deficits attributable to current operations (International Institute for Environment and Development [IIED] 2002, p. 9) .

Fifteen years after this was proposed, the issue appears to be just as intractable and challenging as it was then. As Unger observes, 'the inconsistent application of intervention measures to prevent the creation of future negative environmental legacies and the often-reactive approaches to the management of abandoned mine programmes, highlights the need for global leadership in this regard' (2017: pp. 339-340).

Problems associated with legacy sites can be the result of past actions of operators who were acting within the law at the time mining was being conducted. In more recent years, new legislative and governance approaches have been developed to address environmental concerns in a variety of ways. These include, for example, creating broad mechanisms for improving the overall quality of regulation and preventing the creation of future legacy sites, as well as specific requirements such as industry contributions for clean-up funds and extended liability provisions (see Box 3).

Of course, putting in place laws and regulations is only the first step in developing good approaches to existing and future legacy facilities. Measures to ensure adherence to these regulatory requirements, such as enforcement and compliance monitoring, must all be robust and transparent. Experience shows us that the level of success in this endeavour will vary considerably, depending on a range of national-level factors including the jurisdictional, political, economic and social contexts, as well as the technical and administrative capacities of regulators.

4.1 INITIATIVES AT THE GLOBAL LEVEL

UNEP in 2001 described abandoned mine sites as one of the major outstanding international environmental problems related to mining. Following this, in 2002 the MMSD (IIED 2002) *Breaking New Ground* project report noted different types of negative legacies, and observed that, while most countries with a long history of mining had little data on the environmental legacies of their mines, there was enough information to know that the problems were widespread.

A mining legacy roundtable convened in 2008 by the International Union for Conservation (IUCN), the ICMM and the Eden Project Post Mining Alliance identified important stakeholders for planning for the regeneration of legacy sites. These stakeholders included local communities, local government agencies and companies, Indigenous Peoples, state and provincial governments, national governments, industry bodies, and intergovernmental agencies.

In 2006, the European Union (EU) introduced its Mining Waste Directive (European Union 2006). Guidelines were issued in 2012 to support EU Member states in meeting Article 20 and 21 of the Directive relating to: (a) the development of closure and rehabilitation strategies and plans for closed and abandoned mining waste facilities; and (b) supporting bodies in charge of closed and abandoned extractive waste facilities to manage them effectively.

Box 3: Legislative and governance strategies for minimising long-term negative impacts of mine waste facilities

Broad approaches

- establishment of the authority to legislate on specific issues
- general prohibitions on pollutants
- management regimes and appeal regimes
- administrative and criminal provisions, offences, penalties and liabilities

Specific approaches that can be targeted at mine waste

- requirements for environmental assessment of proposed activities, including stakeholder engagement and participation
- imposition of thresholds and standards
- application and permitting procedures, approval or licensing for specific discharge contents
- requirements for environmental clean-up and remediation
- exemptions to approvals
- explicit obligations and liabilities in relation to uncontrolled discharges
- requirements for long term liability linked to permanent maintenance and controls
- extended liability provisions relating to asset transfer exemption of volunteers from being 'Responsible Persons' or limiting/eliminating liability under various laws when willing to carry out 'Good Samaritan' remediation.

The *MMSD +10 Report*, published in 2012, identified that the MMSD had been the impetus for collective action from the sector and that, ten years on, the ICMM had implemented many of the MMSD recommendations for industry. However, the report also noted that measures by governments, smaller-scale mining companies and local communities were lagging behind, and that there had been little advance in dealing with the environmental issues of legacy sites where legal responsibility remained unclear.

In late 2018 UNEP, through GRID-Arendal, convened a multi-stakeholder workshop to develop a *Roadmap for improved mine waste management.* The report on the workshop (UNEP 2019) provided an assessment of the market for mine waste and economic incentives for better mining and proposed the development of a global database of mine sites, tailings dams and mine waste volumes and characteristics.

In addition, there are now a number of multilateral environmental agreements and related frameworks that address broad issues of pollution directly or provide opportunities to prevent and reduce pollution (and thus are equally applicable to mine waste). Such agreements are an essential component of the pollution governance framework, providing for targeted, time-bound, action. Some also include compliance-related action, monitoring and reporting. In addition, these agreements and frameworks can enable the sharing of resources, technologies, guidelines and best practices for their implementation (UNEP 2019).

4.2 INITIATIVES AT THE NATIONAL LEVEL

In many countries, the mining industry, governments, and local communities clearly recognise that historically mined areas, including associated waste facilities, can pose ongoing environmental, health, safety and economic problems (e.g. Castrilli 2007). There is also increasing recognition of the longer-term benefits of the effective rehabilitation and reuse of these sites. Some examples of these initiatives are given below. Ultimately, however, the key questions which remain are: (a) who is responsible for management and rehabilitation; and (b) how much will it cost, and who pays? To give an indication of how these challenges have been assessed at the country level, the following discussion focuses on four countries in particular: Australia, the United States, Canada and China.

Australia
In Australia, audits of contaminated land programmes and environmental regulation have drawn attention to liabilities and inadequate governance of mining operations at all stages of the mine life cycle. Several strategic initiatives have been undertaken in response to these findings (Box 4). However, writing in 2017 Unger observed that '[i]n Australia, the dialogue on mine closure at a national level has ground to a halt' (Unger 2017:350). Unger concluded that the record to date of 'unimplemented recommendations on abandoned mines suggests that the challenges are too complex and long-term in nature for governments to manage alone' (2017, p. 358).

United States
The funding mechanisms for reclamation of abandoned mines in the US are administered by various federal legislated and regulated agencies. The longest running and most successful programme is that of the Office of Surface Mining Reclamation and Enforcement of the Department of the Interior. This programme requires companies to return land to agricultural productivity, with a requirement to backfill open cut mine voids. The relevant legislation also addresses funding for abandoned mines and associated research but focuses only on abandoned coal mines and the funding is provided by a fee on coal production. This federal programme has resulted in the establishment of abandoned mines agencies in all states where coal is produced (D. van Zyl 2020, pers. comm. 10 February 2020).

Another long-standing program is Superfund, which is administered by the United States Environmental Protection Agency (USEPA). This is the federal government's programme to clean-up the nation's uncontrolled hazardous waste sites, including selected mine sites with extensive water quality concerns. The programme places an emphasis on recovery of costs from previous present owners. Superfund projects are often also subject to Natural Resource Damage claims (which cover the loss incurred from natural resources being damaged and the cost of restoring those resources). Unfortunately, rather than being focused on positive outcomes from a sustainability perspective, Superfund clean-up projects have sometimes become heavily politicised.

Reclamation of abandoned mine lands is also conducted by federal land management agencies including the Bureau of Land Management and the National Forest Service. These activities are based on the prioritisation of the sites and careful budgeting and implementation. The budgets for abandoned mine reclamation for these agencies are limited and decided on an annual basis, thus limiting the scope to achieve longer term sustainable outcomes.

Box 4: Initiatives to address legacy facilities in Australia 2003-2015

- Australia forum on 'Management and Remediation of Abandoned Mines' held in 2003.
- Australia Abandoned Mines Working Group established in 2005-6 under the Ministerial Council on Mineral and Petroleum Resources.
- 2010 Australia Strategic Framework for Managing Abandoned Mines in the Minerals Industry.
- A forum on 'Managing Mining Legacies' was held in July 2012 at the University of Queensland prepared a value proposition to establish a national hub for abandoned mines in Australia.

Source: C. Unger (2020, pers.comm.13 January)

Canada
The National Orphaned/Abandoned Mines Initiative (NOAMI) is a cooperative Canadian programme, guided by an advisory committee and comprising the mining industry, government (federal, provincial and territorial), environmental NGOs, and First Nations peoples. The Advisory Committee has created several task groups to address different aspects of the issue, including:

- information gathering
- community engagement and participation
- legal and regulatory barriers to voluntary collaboration on clean-up measures
- liability issues
- funding model and approaches
- guidelines for legislative reviews.

A survey conducted in 2010 on issues related to mine closure and post-closure site management found that processes of closure planning and provision of financial assurance are well-developed and consistently applied across Canada, but that policy around long-term management of sites beyond closure, including methods of returning mining lands to the Crown, was almost non-existent. The resulting report presented a policy framework, together with recommendations for preventing further accrual of abandoned mine hazards (Cowan, Mackasey and Robertson 2010).

China
In China, pressure for land has raised the profile of land reclamation and environmental issues. Mining waste stockpiles are estimated to cover over 2 million hectares (20,000 square km) of potentially useful land.

China currently plans to promote investment in repairing the environmental damage caused by mining and the Ministry of Natural Resources is seeking a mixture of public and private entities to support the initiative. It is reported that, until now, restoration has been delayed by a lack of effective policies to stimulate investment (Reuters 2019). The country's 'Market-Oriented Way' for the restoration process aims to encourage the repair and re-use of mined land, including the sustainable use of abandoned soil and waste rock.

4.3 NATIONAL CAPACITY TO ADDRESS LEGACY SITES

As noted previously, there is already keen awareness of the need to address the adverse environmental and public health impacts of historically mined areas. Translating this awareness into practical action requires a fundamental level of sustained capacity – human resources, funding, and governance structures – in order to succeed.

Notably, little information is available about how low-income countries are dealing with the problem of abandoned and orphaned sites. For some countries, this could reflect the absence of any historic mine sites requiring government and industry attention. However, the more likely interpretation is that this reflects a lack of state capacity to effectively regulate the mining sector and to address legacy sites in particular. For example, of the 20 countries with the lowest Human Development Index scores in 2019, seven (Burkina Faso, Mali, Eritrea, Liberia, DR Congo, Sierra Leone and Guinea) were highly dependent on mining, as measured by the revised Mining Contribution Index (see Ericsson and Lof 2019).

This brings into striking focus the potential gaps in capacity of national governments to effectively manage their mining industries and to deal effectively with the problems associated with legacy sites. This issue has also been captured in the report by the United Nations Development Programme (UNDP) *Managing Natural Resources for Human Development in Low Income Countries* (2011) which describes the dilemma faced by governments and industry in trying to find the balance between enabling national development and making operators responsible for preventing harm to people and the environment, both in the present and the future.

5. PREVENTING FUTURE LEGACY ISSUES

Until such time as mines become 'zero-waste', there will be a need for consideration of management of mine waste during and after closure in order to ensure continued good governance and to reduce or avoid ongoing environmental and social impacts. The importance of safe closure and rehabilitation of sites to prevent future legacy issues is clear and this is discussed briefly below. That said, current guidance on closure and rehabilitation could go much further to address the potential for reduction of the volume and impact of tailings at source. This could ultimately reduce the need for costly rehabilitation, and possibly ongoing management of closed sites, in the future.

5.1 ENSURING EFFECTIVE CLOSURE AND REHABILITATION

A lack of effective management of closure and rehabilitation is a key cause of ongoing legacy impacts on people and the environment. Even with a good 'closure plan', closure requirements can change over time, as the mine plan evolves in response to economic conditions, and – in the best case – to take account of changes in climatic, environmental and social conditions in which the mine operates. There is, in addition, a need for regular updates to the budgetary plan to ensure provision for any additional financial assurance to cover associated costs.

Numerous guidelines on mine closure and mine closure planning now exist, both at national scale and the industry sector level (e.g. ICMM 2019). In addition, some larger mining companies have developed their own company-specific guidelines for mine closure planning, implementation and follow-up. However, most existing guidance on mine closure is devoted to planned or operating mines and does not address approaches to remedial closure and rehabilitation. Furthermore, the guidance typically covers the entire mine site and pays only limited attention to the management of tailings and other forms of mine waste.

Overcoming the significant and complex challenges relating to closure and rehabilitation requires clear direction and investment by all stakeholders across a number of areas. Key priorities are listed below

(adapted from IUCN-ICMM 2006, IUCN-ICMM and Post-Mining Alliance 2008, Unger 2017). In some cases, these challenges may be seen to cut across traditional boundaries of responsibility and may need to be addressed equally by government, industry, or indeed by potentially innovative public-private partnerships.

Legal & funding

- Commit to effective enforcement of legislation.
- Implement mechanisms to ensure that the mining company will meet all of its closure commitments.
- Ensure that compliance with regulatory requirements will lead to effective closure.
- Ensure that good closure planning and bonding includes surety calculation and provision.
- Clarify and, if appropriate, limit legal liability for those willing to address legacy concerns.
- Address the need for a remediation fund both for when new mines are established and to encourage regional cooperation among companies and local governments.

Company policy & strategy

- Encourage peer pressure within the industry to 'do the right thing'.
- Ensure public availability of information on the cost of tailings management to support effective future tailings strategy decision making.
- Hold companies accountable for poor planning and lack of commitment.
- Incentivise approaches that prioritise long term value creation over short term financial gains.
- Encourage and provide incentives to invest in remedial actions.

Closure planning & resourcing:

- Devise realistic closure objectives and assumptions.
- Strengthen closure risk assessments (ensure adequacy of data, including climate change considerations; utilise cross-disciplinary expertise).
- Undertake timely and up-to-date planning to identify and implement efficiencies in waste management solutions (e.g. prevention of double handling of waste materials for major landform design changes).
- Ensure that proper budgetary provision is made for closure and that closure costs and related budgetary provisions are periodically reviewed.

Rehabilitation practice:

- Avoid delaying progressive rehabilitation.
- Carry out trials to develop effective and sustainable methods and techniques relevant to the local context.
- Undertake robust and timely stakeholder engagement to ensure alignment between local perceptions and expectations of remediation and post-mining land use.
- Work to provide clarity on post-mining land uses, closure outcomes, objectives and completion criteria, even when these are challenging to define.

Despite the challenges, successful initiatives to safely close and rehabilitate abandoned mines have been taken worldwide. More than 20 – 30 years of experience can be drawn from these projects and their methodologies. In many cases the technologies already exist; what is needed is a strengthened framework (legislative, financial, political) to ensure that they are deployed and effectively implemented.

5.2 AVOIDING FUTURE LEGACIES THROUGH REDUCING THE VOLUME AND IMPACT OF MINE TAILINGS: REDUCE, REUSE, REPROCESS, RECYCLE

For existing tailings facilities (and hence also legacy sites), timely consideration of reuse, recycling, and reprocessing options can maximise opportunities to generate additional income or make significant cost savings for the overall mine operation, by eliminating or reducing the need for costly long-term rehabilitation. More generally, an integrated approach is needed to optimize environmental, social and economic outcomes of tailings management across the value chain through integrated resource characterisation, mine planning, processing, disposal, reprocessing, recycling and reuse (Edraki *et al.* 2014).

Climate change is creating opportunities for innovation as well as increasing demands for resilience in the face of future uncertainties. This is driving the development of low carbon business strategies, 'climate-proofing' of operations, and an openness to investigating opportunities to find added value by investigating new approaches to tailings and mine waste management. There are similarly increased incentives for diversification, and for moving towards a more integrated, holistic, multidisciplinary approach to land use. Another important driver is the need to demonstrate to a wide stakeholder base the implementation of responsible mining, which promotes the more efficient use of resources and the minimisation of harm to people and the environment.

Recycling, where resource components are extracted from existing waste, or the waste is used as a feedstock, can potentially result in conversion of much, or even all, of a mine's waste into valuable new products after additional processing (Lottermoser 2010). Recycling systems in practice can involve metal retrieval, decontamination, backfill, and development of new 'soil' properties. The recycling system can be based on the economic principle that the costs of excavating and transporting the tailings are spread over a number of different processes, all of which can be designed to provide additional income or significant cost saving to the overall mine operations, as well as reducing – and ultimately eliminating – the need for tailings rehabilitation in the longer term.

There is a growing need to develop more innovative and sustainable approaches to mineral processing operations (e.g. McLellan *et al.* 2009) and to change from reactive pollution control to proactive pollution prevention and cleaner production (see e.g. Edraki *et al.* 2014). Higher metal prices, combined with higher expectations associated with the management of environmental and social impacts, are also likely to make reprocessing of old tailings more cost-effective, as well as being the more responsible, sustainable option (see Box 5).

Box 5: Recovery of metals from old mining waste in Europe

The increase in demand and metal prices has led to renewed interest in historical mining wastes … Old wastes can be considered as significant reserves of valuable metals when economically recoverable metals remain … A current project run by the French Geological Survey (BRGM) is aimed at identifying interesting old mining waste deposits at the national level and assessing their metal recovery potential. This is being driven in part by the incentive of the European Raw Materials Initiative (November 2008) which itself has triple aims to (1) secure sustainable access from outside Europe (2) improve framework conditions for extracting minerals within Europe and (3) promote the recycling and resource efficiency of such materials.

Source: adapted from Bellenfant *et al*. 2013

While technologies already exist, or are under development, to manage tailings differently, there are some specific factors – political, technical and economic – that can limit their uptake (see e.g. Figueiredo *et al* 2019). These include market supply and demand, costs, and lack of technical expertise. This is particularly the case when the financial models applied to calculate the potential return on investment are the same as those used for development of the original resource (i.e. is there sufficient valuable resource to be extracted at sufficient scale to justify the financial investment and deliver attractive returns?).

Policy drivers are needed to support initiatives such as the circular economy (e.g. OECD 2019) in order to incentivise tailings reuse and to provide protection against potential liabilities for addressing existing 'waste resources'. An effective combination of financial initiatives, innovation, data, and policy is needed. In this regard, the United Nations Environment Assembly (UNEA) 2019 Mineral Resource Governance resolution specifically '[u]nderlines the need to share knowledge and experience with regard to regulatory approaches, implementation practices, technologies and strategies for the sustainable management of metal and mineral resources, *including over the whole life of the mine and the post-mining stage*' (emphasis added).

5.3 REGENERATION AND BETTER POST-MINING LAND USE

Legacy sites, in addition to their negative environmental impacts, also reduce the social and economic value of the land to the surrounding community. Programmes that deal with post-mining lands, and alternative economic and livelihoods options in the longer term, can be developed to address many of these negative legacies. Indeed, examples of novel approaches to considering post-closure, post-mining, land use can now be found across the industry.

Community buy-in is critical for the success of these initiatives. As Bennett notes, '[r]egardless of proposed future use, stakeholder consultation is a fundamental part of identifying values and developing appropriate (and acceptable) management options' (2016: p. 250). In some cases, local communities themselves are demanding faster rehabilitation through pressure for earlier public access to reclaimed areas (Ashton & Evans 2005).

While un-remediated environmental impacts may make a site unsuitable or unattractive for many

potential uses by humans and livestock, there are other options for post-mining land use. These include mining heritage tourism (Box 6), creating recreational spaces and establishing alternative businesses such as renewable energy production.

Box 6: Innovative re-use of a mining site: The Eden Project

The Eden Project UK is a charity and tourist attraction focusing on education and sustainable development. Established within a reclaimed kaolinite pit in Cornwall, it is an example of successful rehabilitation of a mine site. Its success has been attributed to several key attributes:

- development of local solutions to fit local circumstances
- leadership, vision and commitment
- creative partnerships for funding, development and implementation
- collaboration with 'unusual suspects' to explore and develop shared interests
- community involvement and consultation at all stages to develop shared responsibility and ownership
- good design and uniqueness of the site attributes

Source: Pearman 2009; ttps://www.edenproject.com/

6. A FUTURE PATHWAY

Einstein: 'We cannot solve our problems with the same thinking we used when we created them.'

The launch of the Standard provides an opportunity to re-focus our efforts on tackling the problem of legacy tailings and mining waste more generally, not just with the aim of improving how we deal with current liabilities, but in order to prevent the creation of future liabilities. Key objectives should be to:

1. clean up existing legacy sites to remove threats of harm to people or the environment
2. aim for a positive and sustainable legacy for previously mined lands
3. prevent new negative legacies from being created that will be borne by future generations.

Past failures to effectively engage with and address the issue of legacy sites attest to the complexity and perceived intractability of this issue. Action will be required at the level of intergovernmental organisations, national governments, industry, and society to provide an effective response to these complexities. The key elements of such actions are already well-known from previous initiatives – the challenge now is to ensure that they are implemented.

Looking to the future, we should aim to move beyond the narrow focus on avoiding or mitigating the negative impacts that can result from the cessation of mining and strive instead to close mines in ways that leave positive long-term legacies. Within the broad context of sustainable development, the goal must be to ensure that current and future approaches fully consider design for sustainability to ensure that economic gains (for companies, communities and society) can be balanced with zero human and environmental harm and enhanced social benefits in the post-mining context. It will

take time and energy to establish effective and sustainable mechanisms at national and local levels to address this issue while ensuring respect for local community expectations, norms and capabilities. If these mechanisms can be put in place, in combination with full cradle-to-grave waste management, then there is great potential to improve environmental and social outcomes and reduce future risk exposure. This, in turn, will help to ensure that the benefits of resource extraction can continue to be shared collectively by current and future generations.

KEY MESSAGES

1. Legacy mines and the wastes associated with them remain a significant problem for governments, industry and communities.
2. This problem has been recognised for a long time, but only intermittent and limited progress has been made in addressing it. A stronger regulatory and governance response is required globally to achieve a stepwise change.
3. Closure and site remediation practice should aim to: (a) better protect public and environmental health and safety; and (b) establish conditions which maximise beneficial post-mining land use options in the longer term.
4. To avoid future problems, industry should focus on: (a) reducing the volume of tailings and other waste produced from current operations; and (b) developing new projects with tailings elimination in mind from the outset.
5. Mining companies should work towards zero tailings impoundment by considering tailings to be a product that may have value for both mining and other industries. Companies should also contribute to the development of a resource-efficient circular minerals economy.
6. There are significant economic opportunities to re-process legacy tailings to extract materials of value. Governments can facilitate this by creating supportive policy settings.

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