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TOWARDS ZERO HARM

A COMPENDIUM OF PAPERS PREPARED FOR THE GLOBAL TAILINGS REVIEW

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CONTENTS

ACRONYMS

AA	Anglo American Technical Standard
AG	Advisory Group (for the Global Tailings Review)
ALARP	As low as reasonably practical
ANCOLD	Australian National Committee on Large Dams
APEC	Asia-Pacific Economic Cooperation
APELL	Awareness and Preparedness for Emergencies at Local Level
APRA	Australian Prudential Regulation Authority
AusIMM	Australian Institute of Mining and Metallurgy
BAT	Best available technologies
BAP	Best available/applicable practices
BC,CIM	British Columbia, Chief Inspector of Mines
BLM	Bureau of Land Management (US)
BRA	Brazilian Ordinance 70.389/17
CapEx	Capital Expenditure
CDA	Canadian Dam Association
CEO	Chief Executive Officer
CoE	Church of England
COI	Community of Interest
CRO	Chief Risk Officer
CTMC	Consortium of Tailings Management Consultants
DBM	Design Basis Memorandum
EP	Expert Panel
ESG	environmental, social, and governance
ESMS	Environmental and Social Management System
EU	European Union
FERC	Federal Energy Regulatory Commission (US)
FMEA	Failure Mode and Effects Analysis
FoS	Factor of Safety
FPIC	Free, prior and informed consent
GARD Guide	Global Acid Rock Drainage Guide
GIZ	German Corporation for International Cooperation
GTR	Global Tailings Review
HDTT	High Density Thickened Tailings
HRIA	Human Rights Impact Assessment
HSE	Health and Safety Executive
IBRAM	Brazilian Mining Association
ICMM	International Council on Mining and Metals
ICOLD	International Commission on Large Dams
IFC	International Finance Corporation
IGF	Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development
IIED	International Institute for Environment and Development
IM4DC	International Mining for Development Centre
INAP	International Network for Acid Prevention
IRP	International Resource Panel
ISO	International Organisation for Standardisation
ITRB	Independent Tailings Review Board
IUCN	International Union for Conservation of Nature
LDI	Landform Design Institute
m3	cubic metres
MAC	Mining Association of Canada
MEM	Ministry of Energy and Mines (British Columbia)
MEND	Mine Environment Neutral Drainage Program
MMSD	Mining, Minerals and Sustainable Development
NGO	Non-Government Organisation
NOAMI	National Orphaned/Abandoned Mines Initiative (Canada)
NPV	Net present value
OMS	Operation, Maintenance, and Surveillance
OpEx	Operational Expenditure
PAR	Pressure and Release Model
PBRISD	Performance-Based, Risk-Informed Safe Design
PMU	Project Management Unit
PRI	Principles for Sustainable Investment
PSI	Principles for Sustainable Insurance
QA	Quality Assurance
QC	Quality Control
RMI	Responsible Mining Initiative
RTFE	Responsible Tailings Facility Engineer
SANS	South African National Standards
SDGs	Sustainable Development Goals
SMART	specific, measurable, attainable, relevant and time-bound
SMI	Sustainable Minerals Institute (University of Queensland)
SMRCA	Surface Mining Control and Reclamation Act (U.S.)
TSF	Tailings Storage Facility
TSM	Towards Sustainable Mining
UN	United Nations
UNDRR	United Nations Office of Disaster Risk Reduction
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNGP	UN Guiding Principles on Business and Human Rights
USEPA	United States Environment Protection Authority
WISE	World Information Service on Energy
WMTF	World Mine Tailings Failures
USGS	United States Geological Survey
VET	Vocational and Educational Training
VSP	Verification Service Provider
WBCSD	World Business Council for Sustainable Development

FOREWORD FROM THE CHAIR

I would like to thank the whole Global Tailings Review team: the Expert Panel, the Advisory Group, the Co-Conveners and all authors and co-authors who have generously contributed their time and expertise to this volume. I trust that the papers contained herein add value to the ongoing public debate on safe management of tailings facilities and further reinforce the need for continued action to ensure that tragedies like the one in Brumadinho do not continue to happen.

Particular and special thanks to the co-editors of this volume; Emeritus Professor David Brereton of The University of Queensland, for his contributions, ongoing support and diligence; and to the GTR Project Manager, Antonia Mihaylova, who worked tirelessly to bring the volume to fruition.

Dr. Bruno Oberle
Chair of the Global Tailings Review

PREFACE

This collection of individually authored papers ('chapters') has been prepared to accompany the release of the Global Industry Standard on Tailings Management (the Standard). The volume performs two main functions:

1. It provides *context* to the Standard by informing readers about the reasons why the Global Tailings Review (GTR) was initiated, the process that was followed, and the considerations that guided the development of the Standard.
2. It goes *beyond* the Standard to review a wide range of issues related to the safe management of tailings facilities, for consideration by the different actors involved – including governments, investors, insurers, international organisations, educational institutions, and industry professionals.

All members of the Expert Panel, including the Chair, have contributed at least one chapter to the volume, either as sole or co-authors. The compilation also includes invited contributions from other experienced professionals and researchers working in the area. Several of these contributors were involved in the development of the Standard as members of the Multi-Stakeholder Advisory Group; some contributed in their capacity as representatives of one of the co-convening bodies; and others participated on an individual basis. As befits the breadth of the Standard, a broad cross-section of professional and academic disciplines is represented, including engineering, geology, environmental science, social sciences, risk management, law, public policy and finance.

The chapters are organised into six sections. Each section contains knowledge, learnings and insights that are relevant to advancing the ultimate goal of the Standard, which is to achieve zero harm to people and the environment, with zero tolerance for human fatalities.

Section One comprises two context-setting chapters. The first chapter, which was authored by the Chair and the Secretariat staff, provides a brief history and overview of the GTR. The second provides an overview of key research findings and organisational learnings on the frequency, type, location and impact of tailings facility failures and the factors that contribute to these failings.

Section Two focuses on the social performance and human rights issues involved in designing and operating tailings facilities and managing the consequences of facility failures. Social performance is a cross-cutting theme that links to most of the topics covered in the Standard, but in particular to Topic I (Affected Communities) and Topic V (Emergency Response and Long-term Recovery). The first chapter in this section explains how and why social performance work is critical to tailings facility management, and describes the logic that underpins the inclusion and integration of social performance elements throughout the Standard. The second chapter presents lessons for the mining industry from international disaster research.

Section Three links to Topics II and III of the Standard (Integrated Knowledge Base and Design, Construction, Operation and Monitoring of the Tailings Facility). The chapters in this section address different aspects of tailings management, from design through to closure. There is a strong focus on how outcomes can be enhanced through technological innovation and improved management and governance. Topics covered include: the benefits of taking a systems approach to tailings management; alternative technologies for storing and managing tailings; strategies for reducing the volume of tailings material generated; ensuring the safe closure of tailings facilities and their conversion to beneficial uses; and, dealing with tailings and other wastes associated with 'legacy' mining sites. The section includes a chapter that presents findings from the first detailed analysis of the data provided by companies in response to the Church of England disclosure initiative.

Section Four links to the theme of building organisational capability, which is also the focus of Topic IV of the Standard (Management and Governance). The first chapter in this section focuses on how mining companies can strengthen their internal accountability and risk management processes. The second chapter addresses the challenge of building technical and governance capability and improving knowledge management in the mining industry and regulatory bodies.

Section Five, which links to both Topic IV and Topic V (Disclosure of Information), engages with broader questions about the governance framework within which mining is conducted. It comprises: (1) a chapter on the role of the State in ensuring the safe design and management of tailings facilities (including a discussion of how this role can be enhanced); (2) a comparative study of relevant regulatory frameworks in a range of mining jurisdictions; (3) a comparison of the Standard with other standards, codes and guidelines relating to tailings management; and (4) a chapter focused on the role that the insurance industry can play in driving improved practices in the mining sector and promoting uptake of the Standard.

Section Six provides a brief overview of three other initiatives that are aimed at contributing to improved tailings management practices in the mining sector. These are: the Investor Mining and Tailings Safety Initiative; the United Nations Environment Assembly (UNEA) Resolution on Mineral Resource Governance; and the proposed Global Research Consortium on Tailings.

Section Seven lays out the different options and the Chair's recommendation for implementation of the Standard and the way ahead.

Disclaimer
The views expressed in individual chapters are those of the authors, or the organisations that they represent. Publication of this volume by the GTR does not constitute endorsement of these views by any of the co-conveners.

KEY MESSAGES

To provide guidance to readers, authors of most of the chapters have prepared a summary of the 'key messages' conveyed in their respective chapters. For ease of access, these messages are grouped together below, as well as being listed at the end of each chapter.

MINE TAILINGS FACILITIES: OVERVIEW AND INDUSTRY TRENDS

E. Baker, M. Davies, A. Fourie, G. Mudd, K. Thygesen

- Mine tailings are currently an unavoidable waste product of mining.
- There has been an increase in the volume of tailings produced for many mineral commodities, due to increased demand for minerals and the continuing decrease in ore grades.
- The precise number of active tailings facilities is currently unknown, although initiatives are underway to determine both the location and status of these facilities.
- Responsible mine closure is integral to mining companies' core business.
- Mining, conducted responsibly, is acknowledged as a key industry for achieving the United Nations Sustainable Development Goals (SDGs).
- Failures of tailings facilities are continuing to be reported across the globe. These failures are unacceptable to both the mining industry and society.
- The triggers for failures of tailings facilities are well documented and understood and, as such, should be anticipated and addressed, starting at the design phase and continuously during operation through to closure (and beyond if necessary).
- Communities potentially affected by mining hazards are entitled to information that allows an understanding of a broad range of risks, as well as being informed about operator risk reduction strategies.

SOCIAL PERFORMANCE AND SAFE TAILINGS MANAGEMENT: A CRITICAL CONNECTION

S. Joyce and D. Kemp

- Mining companies should avoid equating the social performance function solely with community engagement, and work to strengthen the scientific, organisational and legal dimensions of this function.
- Senior management should 'hard-wire' social performance into operational management practices to maximise the value of the function.
- Companies should review whether operational-level social performance functions are 'fit-for-purpose' (i.e. appropriate to both the tailings facility and the local context) and adequately resourced.
- A high level of interdisciplinary effort is required to support the safe management of tailings.
- Managers at all levels of a mining company should maintain a willingness to engage in and promote cross-disciplinary conversations on specialist topics such as tailings facility management, and actively support inter-disciplinary work.

LESSONS FOR MINING FROM INTERNATIONAL DISASTER RESEARCH

D. Kemp

- Mining companies could improve their 'contextual intelligence' by paying greater attention to the social, environmental and local economic context in which a project is situated, and the project's effects on that context.
- Including vulnerability as a relevant factor in root cause analysis would support mining companies to account for the structural and systemic aspects of disaster risk.
- Mining companies could consider utilising other relevant frameworks, such as the Sendai Framework for Disaster Risk Reduction 2015-2030.
- Better enabling of social specialists to contribute to tailings risk management (e.g. through participation in interdisciplinary processes) could help mining companies to avoid harm.
- Both public and private sector actors should consider broadening the 'circle of knowledge' on disaster prevention, to include the natural, physical and social sciences, and the lived experiences of affected people.

MINE TAILINGS – A SYSTEMS APPROACH

A. Kupper, D. van Zyl, J. Thompson

- Tailings facilities are complex entities that operate as a system within the broader context of mining operations, their external societal and environmental settings, and their potential to last in perpetuity.
- Tailings facilities are complex systems that need to be managed with a systemic approach for effective risk management.
- Although there are always immediate technical reasons for tailings facilities failures, the overarching technical and governance factors that allowed the facilities to approach a critical state are, in most cases, the root cause of the failure.
- The systematic management approach for tailings facilities involves vertical and horizontal integration of all functions (planning, design, construction, operation, management, oversight) that operate and collaborate within a broader framework.
- The resulting management framework must be supported by effective communication, transparent and robust data management, and information flows that builds knowledge and experience. Success also requires leadership, appropriate incentives and a culture of performance.
- Ultimately, the framework and resulting systems management has to be based on leadership that drives a culture of system-level performance

THE ROLE OF TECHNOLOGY AND INNOVATION IN IMPROVING TAILINGS MANAGEMENT

D. Williams

- If tailings facilities were built to a similar margin of safety to water dams, this would prevent many tailings facility failures.
- There is a commonly held perception in the mining industry that transporting tailings as a slurry to a facility is the most economic approach, but this fails to factor in the true cost of closing and rehabilitating the resulting tailings facility.
- A rethink is required about the way in which tailings management is costed. A substantial portion of global tailings practice still uses the Net Present Value (NPV) approach with a high discount factor. What is needed is a whole-of-life cost approach.
- In practice, not enough tailings facilities have been successfully rehabilitated, due to the difficulty of capping a 'slurry-like' (wet and soft) tailings deposit and the excessive cost involved, particularly at a time when the mine is no longer producing revenue.
- The implementation of existing and new technologies to tailings management could help to eliminate the risks posed by the nature of conventional tailings facilities that have been responsible for the failures that have occurred, possibly removing them altogether.
- A fundamental barrier to the implementation of innovative tailings management at those sites that would benefit from these technologies is people's resistance to change, which is often disguised as unsubstantiated claims about perceived high costs, technical obstacles and uncertainty.
- Change is more likely to be achieved in new mining projects than existing operations. Hence, change in tailings management for the industry as a whole will necessarily be generational.

LESSONS FROM TAILINGS FACILITY DATA DISCLOSURES

D. Franks, M. Stringer, E. Baker, R. Valenta, L. Torres-Cruz, K. Thygesen, A. Matthews, J. Howchin, S. Barrie

- The Investor Mining and Tailings Safety Initiative, as described in Chapter XVII, conducted the most comprehensive global survey of tailings facilities ever undertaken. The trends identified from this dataset highlight the value of information disclosure by companies.
- Analysis of company-disclosed data collected through the Initiative indicate that upstream facilities still make up the largest proportion of total reported facilities (37 per cent), although construction rates for upstream facilities have declined in recent years.
- The rate of reported past stability issues for facilities in the data base exceeded one per cent for most construction methods, highlighting the universal importance of careful facility management and governance.
- Over 10% of facilities in the database reported a stability issue, and the percentages for upstream, hybrid and centreline facilities were even higher. Statistical analysis provides a high level of confidence that the higher rate of reported stability issues for upstream facilities is not attributable to

'confounding' factors such as differences in facility age, the volume of material stored, or the level of seismic hazard.
- Based on company commissioned modelling, hybrid, upstream, downstream and centreline facilities are more likely than other types of facilities to be associated with a higher consequence of facility failure.
- Facilities with higher consequence of failure ratings were also more likely to report a stability issue.
- Based on the data provided by companies, the uptake of filtered and in-situ dewatering of tailings across the wider industry has not significantly increased over recent decades. This is notwithstanding that dry-stack (and in-pit/natural landform facilities) report fewer past stability issues and are typically associated with lower consequence of failure ratings.

CLOSURE AND RECLAMATION

G. McKenna, D. van Zyl

- Current practice at most mining operations largely divorces the long-term closure and reclamation of tailings facilities from the operational dam construction, tailings deposition, and geotechnical dam safety considerations. This artificial division leads to higher life-cycle costs, reduced performance and increased risk.
- Closing and reclaiming tailings facilities presents numerous challenges, especially if these challenges are overlooked during the initial design and construction of these mining landforms.
- Landform design provides a framework for inclusion of all aspects of the life cycle of a tailings facility. This is a multidisciplinary process for building mining landforms, landscapes, and regions to meet agreed-upon land use goals and objectives. The process ideally begins with the initial designs of tailings landforms (or in the case of most existing sites, adopted midstream) and continues long after operations have ceased.
- Tailings landforms are important features in the mine's closure landscape that will last for millennia and will serve as a major component of mines enduring legacy. Mines, by working with their regulators and local communities, can help establish a positive mining legacy by returning lands for use by local communities in a timely manner.

ADDRESSING LEGACY SITES

K. Nash

- Legacy mines and the wastes associated with them remain a significant problem for governments, industry and communities.
- 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.
- 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.

- 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.
- 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.
- There are significant economic opportunities to re-process legacy tailings to extract materials of value. Governments can facilitate this by creating supportive policy settings.

ADDRESSING THE ORGANISATIONAL WEAKNESSES THAT CONTRIBUTE TO DISASTER

A. Hopkins

- Accident analysis should always seek to identify the organisational causes of the accident.
- Shareholders should hold boards accountable for the on-going management of major accident risks.
- Boards should ensure that at least one of their members has expertise in the relevant major accident risks and is able to advise the board on the status of major accident risk management within the organisation and of the implications of board decisions for major accident risk.
- Mining companies should have an executive responsible for major accident risk (an Accountable Executive) answering directly to the CEO. This executive should also have a direct reporting line to the board and should be held to account by the board.
- Where a major part of an employee's role is to ensure compliance with standards and procedures, as is the case for the responsible tailings facility engineer, the employee should have dual reporting lines: a primary line that culminates with the Accountable Executive and a secondary line to the local site manager. Any performance review should be carried out by a supervisor in the line reporting to the Accountable Executive.
- Neither the Accountable Executive, nor staff in lines reporting to that position should be incentivised in relation to production, profit or cost reduction. This applies, in particular, to the Responsible Tailings Facility Engineer (RTFE).
- For employees whose primary role is to contribute to production, albeit safely, any bonuses paid should have a component for safety or facility integrity. This should not be based on quantitative metrics but on qualitative judgements about the employee's contribution to safety and operational integrity. It will be up to employees to make this case during performance reviews.
- Companies should incentivise the reporting of issues relating to major accident risk.
- Long term bonuses that vest after a period of years should be modified to take account of how well major accident risk is managed.

CREATING AND RETAINING KNOWLEDGE AND EXPERTISE

R. Evans and M. Davies

- Technical expertise in the design and management of tailings facilities is unevenly distributed across the globe, as is access to relevant education programmes.
- There is a need to go beyond a narrow engineering design focus and embed a multi-disciplinary approach within tailings-related education.
- The ability to understand and apply Risk Management frameworks is a critical capability for tailings governance and needs to be explicitly addressed in education initiatives.
- It is essential that all education and training programmes related to mine tailings, including university courses, have a strong practical as well as theoretical focus, and draw on experience and learning from case studies of failures.
- At a time of increased concern regarding the management of tailings facilities, our ability to educate specialists and those charged with managing such facilities is limited by a shortage of qualified and experienced educators.
- Globally, there are very few programmes that address the operational governance aspects of tailings facilities. The international development sector should be encouraged to support the development and deployment of such programmes in countries that cannot easily access this expertise.

THE ROLE OF THE STATE

M. Squillace

- States play a critical role in the success or failure of tailings facilities.
- The Standard offers a roadmap for States for how to establish an effective regulatory programme for tailings facilities.
- States have understandable concerns about their capacity to fund and implement a regulatory programme. Operators should therefore be expected to bear the cost of the programme, including the cost of training competent personnel.
- States bear a substantial part of the burden when people and the environment suffer from tailings facility failures. States should therefore embrace requirements for adequate performance bonds to assure full reclamation and safe closure, and for insurance to cover liability for injuries to third parties.
- States are uniquely positioned to monitor the performance of Operators and to take appropriate enforcement action where violations of tailings facility requirements occur.
- States that lack the capacity to adopt and implement a sound regulatory programme with well-trained staff should work with other countries and the international community to build that capacity.

COMPARATIVE ANALYSIS OF TAILINGS – RELATED LEGISLATION IN KEY MINING JURISDICTIONS

White & Case LLP

- A comparison of the laws and regulations from a cross-section of nine key mining jurisdictions indicates that many of the Principles of the Standard are well-reflected in the laws and regulations of some of these jurisdictions. However, overall the ambitions of the Standard, when compared to domestic law, set a higher threshold for achieving the degree of integrity, safety and community protection necessary for the development and management of tailings facilities.
- Where the research has identified certain areas in which the Standard sets a higher bar than legislation in Key Jurisdictions, this could provide the impetus for regulators to consider where changes could be made to address tailings facility safety and management.
- The overall results of the analysis of tailings safety legislation in the Key Jurisdictions, expressed as average scores, show how the Standard can be a catalyst for improving the regulation of tailings facilities. They also highlight the need for a consistent global approach to tailings facility management, safety and operation.
- The gap between the most and least aligned Key Jurisdictions draws out the need for more emphasis on catastrophic failure, accountability and engagement of communities as the starting point of tailings dams regulation. Working backward from a worst-case scenario informs the approach to permitting, approvals and enforcement from the beginning, which in turn sets the tone for iteration and improvement.
- While legislation is an essential tool for regulating tailings facility safety and management throughout the lifecycle, other forms of best practice exist and jurisprudence is also developing. Both of these may also be effective in helping to achieve the goals of the Standard.

SUMMARY OF EXISTING PERFORMANCE STANDARDS FOR TAILINGS MANAGEMENT

C. Dumaresq

- When development of the Standard was initiated, several other standards related to tailings management were already in place. Like the Standard, these standards address tailings management, governance, and community engagement and public disclosure.
- International Council on Mining and Metals (ICMM) Performance Expectations were introduced in 2020 and are being implemented by ICMM's 27 members. Commitments relevant to the Standard are described in:
    - Position Statement: Tailings Management (2016)
    - Position Statement: Indigenous Peoples (2013)
    - Position Statement: Partnerships in Development (2010)
    - Position Statement: Water Stewardship (2017)

- The Mining Association of Canada (MAC) *Towards Sustainable Mining® (TSM®)* was introduced in 2004 and is being implemented at over 60 facilities. TSM has also been adopted by industry associations in several other countries. Requirements relevant to the Standard are described in:
  - *Tailings Management Protocol* (2004, revised 2017 & 2019).
  - *Indigenous and Community Relationships Protocol* (2004, revised 2019).
  - *Water Stewardship Protocol* (2019).
- The Initiative for Responsible Mining Assurance (IRMA) *Standard for Responsible Mining* was launched in 2018 and is currently being implemented at two mines. Requirements relevant to the Standard are described in:
  - Environmental Responsibility Requirements
    - Chapter 4.1: Waste and Materials Management
    - Chapter 4.2: Water Management
  - Business Integrity Requirements (3 relevant chapters).
  - Planning for Positive Legacies Requirements (6 relevant chapters).
  - Social Responsibility Requirements (3 relevant chapters).
- There are no existing standards for technical design, which is a topic addressed in the Standard. However, guidance from organisations such as the International Commission on Large Dams (ICOLD) is frequently incorporated into legal requirements (e.g. site-specific permits for tailings dams).

INSURABILITY OF TAILINGS RELATED RISK

G. Becker

- Tailings facilities are integral to almost any mining activity. While the facilities themselves represent minor economic value compared to the remainder of the operation, their leakage or rupture can have considerable consequences for people, ecosystems and property.
- Even if the highest available standards for the safe construction, maintenance and operation of tailings facilities are strictly adhered to, it will never be possible to have full control over forces of nature such as extreme weather events or earthquakes; nor can human error be ruled out.
- The insurance industry stands ready to meet its role in alleviating the potentially catastrophic effects of a tailings facility failure on innocent third parties and the mining operators themselves. An indispensable prerequisite, however, is that the insured party undertakes whatever is humanly possible to prevent such an incident from occurring.
- What these precautions should include, in terms of technical to organisational measures, has been defined in the Standard. Adherence to the Standard must be seen as a premise for any insurance cover.
- Consideration should be given to organising insurance cover in the form of a pool, with a view to creating sufficient capacity to cover the risks of tailings facility failures.
- As the mining sector is a global industry, the Standard should likewise be applied globally. National governments, regulatory bodies, insurance associations and the like should actively promote the acceptance of the Standard within their respective spheres of influence.
- This support can be further enhanced by supranational organisations such as the UN and the World Bank, along with global initiatives such as the Principles for Responsible Investment (PRI) and the Principles for Sustainable Insurance (PSI).

INVESTOR MINING AND TAILINGS SAFETY INITIATIVE

S. Barrie, E. Baker, J. Howchin, A. Matthews

- A coalition of 112 international investors with over USD $14 trillion in assets under management was established in 2019 to improve understanding and transparency related to the social and financial risk associated with tailings dams.
- Investors are increasingly scrutinising company performance on environmental, social, and governance (ESG) criteria. Tailings storage facilities have implications for all three 'ESG' pillars.
- Investors have taken the view that tailings represent a systemic challenge for the mining sector and for other sectors linked to mining through the supply chain
- The Investor Mining and Tailings Safety Initiative has made a number of interventions, including calling for a Global Tailing Standard, asking for improved disclosure from 727 extractive companies, and collating and organising those disclosures in an accessible database: The Global Tailings Portal.
- The response to the disclosure request has been positive. As of March 2020, 152 companies have confirmed that they have tailings storage facilities (this includes both operator and joint venture interests). The 152 companies represent approximately 83% of the publicly listed mining industry by market capitalisation, and includes 45 of the 50 largest companies.
- The Initiative continues to work for safer, and more well understood tailings facilities. It is pursuing projects on insurance and disclosure, tailings monitoring, and the removal of the most dangerous dams.

GLOBAL RESEARCH CONSORTIUM ON TAILINGS

D. Franks, A. Littleboy, D. Williams

- Industry and public sector investment in research have expanded the approaches available to deal with tailings management challenges, but much of this learning remains underutilised.
- The University of Queensland, in partnership with a wide range of research and education institutions, is exploring the potential to establish a global research and education consortium to support improved tailings management.
- The overarching aim of the consortium would be to develop transdisciplinary knowledge-solutions (science, technology and practices) that address the technical, social, environmental and economic risks of tailings.
- The vision of the consortium is a multi-party collaborative initiative of the world's leading thinkers and practitioners in tailings and mine waste management: researchers, industry professionals, consultants, regulators, civil society and community representatives.
- A global research consortium on tailings could tackle a bold and globally significant agenda with the potential for meaningful impact.
- Members of the consortium would benefit from robust, transdisciplinary, game-changing research with partners that have deep knowledge of the sector.
- Discussions are currently underway with Amira Global, an independent minerals research management organisation with a long-track record in the sector, to develop the initiative.

SETTING THE SCENE

SETTING THE SCENE

CHAPTER I GLOBAL TAILINGS REVIEW AT A GLANCE: HISTORY AND OVERVIEW

Bruno Oberle, Chair of the Global Tailings Review
Antonia Mihaylova, Project Manager, Global Tailings Review
Audrey Hackett, Senior Adviser – Strategy and Delivery, Global Tailings Review

1. INTRODUCTION

The catastrophic failure of a tailings facility at Vale's Corrego do Feijão mine in Brumadinho in January 2019 was a tipping point for the mining sector. A month after this tragedy, on 26 February 2019, the International Council on Mining and Metals (ICMM) made a public commitment to establish a new standard for the safer management of tailings facilities. Having engaged on similar issues in the past, on 27 March 2019, a joint public announcement was made that the initiative would be co-convened by the ICMM, the United Nations Environment Programme (UNEP) and the UN-backed Principles for Responsible Investment (PRI), with each party having an equal stake and say in decision making. This marked the launch of the Global Tailings Review ('the Review').

The co-convened model of equal representation from industry, investor and government stakeholders was designed to give civil society and the public confidence that the initiative would have the necessary level of independence and not be subordinate to industry interests. It was also an acknowledgement that no single stakeholder can solve the problem and that community and investor trust in the mining sector needed to be restored in the wake of a number of such high-profile disasters. In addition, the tri-partite, co-convened, approach broadened the range of perspectives and specialist knowledge that could be drawn on to develop a credible, technically sound, fit-for-purpose standard.

This introductory chapter:

- outlines the governance arrangements that were put in place for the Review
- documents the timeline and trajectory of the Review, from establishment through to the finalisation of the Global Industry Standard on Tailings Management ('the Standard') and associated documents
- explains how the Review was conducted and the Standard formulated, focusing particularly on key roles
- provides an overview of the content and structure of the Standard
- presents some reflections on the process.

Parts A and B of the chapter provide an overview of the process and the Standard respectively. Part C contains observations and reflections on the process.

PART A: THE PROCESS

2. THE GOVERNANCE MODEL: ROLES AND RESPONSIBILITIES

Maintaining independence and taking a multi-stakeholder approach were at the core of the Review process.

2.1 CO-CONVENERS

In an increasingly globalised world, many of the challenges we face require a global response and coordinated effort. Mining is one of those sectors that is particularly reliant on multi-stakeholder engagement so that it can be undertaken responsibly and with minimal adverse impact on human life and the environment.

The multi-partite, co-convened, model is not unique. Shared power arrangements of this kind have been utilised on occasions in the past by the mining sector and other key actors, as a mechanism for developing a consensus approach to contentious issues. For such a model to be successful it requires a nurturing, adaptive and independent management approach which includes continuous dialogue, meaningful engagement and effective facilitation of consensus. The model also requires that the key participants have a level of mutual trust, are willing to share control and are prepared to accept outcomes that may not always appear to be optimal from their own perspectives.

The three co-conveners, UNEP, ICMM and PRI were each represented by two individuals:

1. UNEP: Ligia Noronha, Director, Economy Division and Elisa Tonda, Head of the Consumption and Production Unit
2. ICMM: Tom Butler, CEO and Aidan Davy, COO
3. PRI: Adam Matthews, Director of Ethics and Engagement for the Church of England and John Howchin, Secretary-General – The Council on Ethics Swedish National Pension Funds

The three parties had an equal say throughout the process. Key decisions were made by mutual agreement, beginning with the development of the foundational Scope and Governance document and the selection of the independent Chair.

In terms of input to the process, each of the co-conveners brought their areas of expertise and the perspectives of their constituents. The ICMM was also in a position to provide resourcing and administrative support to the Project Management Unit (PMU).

The Scope and Governance document established working assumptions, the overall scope of the Review and set certain parameters. It also retained flexibility for the Chair and the Expert Panel ('the Panel') to revisit the scope as the work progressed. The scope of the Standard was defined as including, but not limited to:

- a global and transparent consequence-based tailings facility classification system with appropriate requirements for each level of classification
- a system for credible, independent reviews of tailings facilities
- requirements for emergency planning and preparedness.

The full Scope and Governance document can be found on the Review website, here. The Terms of Reference for the Chair and the Panel, which were similarly co-developed and endorsed by the three co-conveners, can also be found in this document.

2.2 INDEPENDENT CHAIR

The selection of the independent Chair took approximately two months. The three co-conveners agreed that it was vital to select an individual who was not closely associated with any one of the three key sets of stakeholders within the mining sector: industry, government and civil society. Knowledge of the sector was therefore considered secondary to the ability to lead and facilitate consensus among highly diverse views. This proved prescient, as one of the most challenging aspects of the Chair's role was to facilitate consensus within the Expert Panel and amongst the co-conveners, while working towards a very ambitious timeline. In May 2019, Dr Bruno Oberle was appointed Chair of the Review (see Box 1).

Box 1: Brief Biography of the Chair of the Review, Dr Bruno Oberle

After completing his studies in environmental science, engineering and economics at the Swiss Federal Institute of Technology (SFIT), Dr Oberle founded and managed consultancy companies in the field of environmental management. In 1999, Dr Oberle was appointed Deputy Director of the Federal Office for the Environment, Forests and Landscape of Switzerland and, in 2005, Director of the newly established Federal Office for the Environment. Dr Oberle represented Switzerland in international negotiations as Secretary of State for the Environment. He also played a key steering role in the Global Environmental Facility (GEF) and in establishing the Green Climate Fund (GCF). Since 2016, Dr Oberle has been a Professor for Green Economy and Resource Governance and Director of the International Risk Governance Centre at L'Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland. He is also the President of the World Resources Forum Association.

The Scope and Governance document describes the Chair as a:

'*Senior, respected person who will be seen as independent. S/he will likely be a former employee of multilateral organisation, a former government minister, or some other person with demonstrated experience of chairing diverse groups to develop policy or standards, ideally complemented with senior (board level) experience in the private sector.*'

2.3 MULTI-STAKEHOLDER ADVISORY GROUP

A multi-stakeholder Advisory Group (AG) was assembled by the co-conveners in spring 2019. Following the first meeting in May, some members of the AG raised concerns about the lack of sufficient representation from civil society and affected communities. The Chair responded by collating recommendations from the AG membership and then inviting a number of additional advisers to join. The full and final list of the members is provided below (Table 1).

Note: Several proposed members could not accept due to unavailability, and one was only able to participate virtually due to inability to travel at the time.

Table 1. Composition of the Multi-stakeholder Advisory Group

Name	Organisation	Title
Antonio Pedro	UN Economic Commission for Africa	Director: Central Africa
Brian Kohler	IndustriALL	Director – Health, Safety and Sustainability
Bruno Milanez	Universidade Federal de Juiz de Fora, Brazil	Associate Professor
Charles Dumaresq	Mining Association of Canada	Vice President: Science and Environmental Management
Chris Sheldon*	World Bank	Practice Manager: Energy & Extractives
David Poulter	International Finance Corporation (IFC)	Principal Mining Specialist
Elaine Baker	University of Sydney/GRID Arendal	Director: Marine Studies Institute; UNESCO Chair: Marine Science
Günter Becker	Munich Re	Head of Mining
Harvey McLeod	Klohn Crippen Berger	Vice President: Strategic Marketing
Michael Davies	Teck Resources	Senior Advisor: Tailings & Mine Waste
Nuskmata Mack	Secwepemc & Nuxalk Indigenous Peoples	Member of Xat'sull (Soda Creek) First Nation
Paul Bateman	International Cyanide Management Code	President and Chair of the Board of Directors
Payal Sampat	Earthworks	Director: Mining Programme
Rebecca Campbell	White & Case	Partner: Global Head of Mining & Metals
Steve Edwards	International Union for Conservation of Nature (IUCN)	Senior Programme Manager: Business and Biodiversity Programme
Upmanu Lall	Columbia Water Center	Director

* *Note:* Due to limited availability, in the latter part of the process Chris Sheldon was replaced by Sven Renner, Manager of the World Bank's Extractives Trust Fund.

AG members played a critical role in maintaining the independence of the Review throughout the process and made several key contributions, both collectively and through bilateral and other engagements. The main contributions were:

1. **May 2019 – First AG meeting**
   The AG presented a list of individuals from which the Expert Panel was selected.
2. **August 2019 – Second AG meeting**
   The AG rejected Draft 1 of the Standard and, as a result, the Panel reshaped and developed Draft 2 of the Standard on which the AG provided detailed comments. The Panel responded in kind and the resulting Draft 3 reflected much of the AG feedback.
3. **November 2019 – Leveraging the AG network**
   The PMU sought the AG's advice and expertise in the execution of the public consultation workshops, including leveraging in-country contacts.
4. **February 2020 – Third AG meeting**
   The AG were provided with a post-consultation provisional draft ahead of an in-person meeting in early February 2020. Members' feedback was integrated into the following iteration of the Standard which was then submitted to the co-conveners for consideration.
5. **Contribution to GTR Papers**
   Several of the AG members contributed to the GTR Papers, either as authors or co-authors, or by providing contacts for contributors.
6. **Bilateral discussions with the Expert Panel**
   Throughout the process, AG members had the opportunity to engage bilaterally with individuals on the Expert Panel on matters relevant to their respective disciplines. These discussions often led to concrete wording suggestions for specific Standard Requirements.

2.4 EXPERT PANEL

The Panel was selected by the Chair. The co-conveners and, as mentioned above, the AG, put forward a list of experts from which the Chair selected a shortlist. He then conducted virtual interviews with the shortlisted experts and selected the final panellists.

The Panel comprised seven experts from a range of disciplines: geotechnical, social, environmental, organisational behaviour and legal. This composition broadly reflected the requirements of the co-conveners.

Table 2. Composition of the Expert Panel

Name	Organisation	Expertise
Prof Andrew Hopkins	Emeritus Professor of Sociology, Australian National University	Governance and organisational behaviour
Dr Angela Küpper	Director and Principal Geotechnical Engineer, BGC Engineering Inc.	Tailings engineering
Prof Deanna Kemp	Sustainable Minerals Institute (SMI), The University of Queensland	Community and human rights
Prof Dirk van Zyl	University of British Colombia	Tailings engineering
Karen Nash	Senior Associate, Behre Dolbear; Director, Environmental & Social Performance, MDS Mining & Environmental Services	Environment
Prof Mark Squillace	University of Colorado Law School	Legal
Susan Joyce	President, On Common Ground Consultants	Social performance and Human Rights

For more information on Panel members' backgrounds, readers should refer to the Review website, link here.

The Scope and Governance document describes the Expert Panel as:

'Representatives: no more than 7 technical experts with diverse range of disciplines (such as safety/risk analysis, tailings, organisational behaviour, (ex) regulator, community/social expert), selected in accordance with a pre-determined minimum list of qualifications.'

The multidisciplinary nature of the Panel was a key ingredient in delivering a trusted and credible standard underpinned by a holistic approach to tailings management.

2.5 PROJECT MANAGEMENT UNIT

Day to day management was undertaken by the PMU comprising Antonia Mihaylova, Project Manager, and Audrey Hackett, Senior Advisor – Strategy and Delivery. The PMU was likewise selected by the Chair based on a list of recommendations from the co-conveners. Key responsibilities of the PMU included:

- coordinating the Standard development process – consolidating, reviewing and editing inputs from the Panel
- oversight and editing of other deliverables including the GTR Papers and the Consultation Report
- day-to-day management, internal and external communications, planning and scheduling, execution of public consultation workshops and other events, and preparation of summary reports amongst other tasks.

3. DELIVERABLES

Below is a summary of the documents and resources developed as part of the Review.

- The **Standard** – the main output of the Review is the Global Industry Standard on Tailings Management. It contains a preamble, 15 principles and 77 requirements organised under six topic areas, a glossary and tables in annex.
- The accompanying volume – **Towards Zero Harm: A Compendium of Papers prepared for the Global Tailings Review** (formerly Recommendations Report) – a set of papers written from diverse disciplinary perspectives that address a number of issues, challenges and developments in the area of tailings management. Amongst other things, the papers provide background on the intent and evolution the Standard, and, where appropriate, draw out key messages and recommendations for the industry and other actors that go beyond the formal Requirements of the Standard.
- **Consultation Report** and publication of all submissions (with consent) – This report contains the specific suggestions, criticisms and requests of the individuals and organisations that participated in the public consultation. The summary and analysis of this feedback was prepared by an independent service provider Traverse, who managed the online consultation effort. The Consultation Report also outlines how this feedback was addressed in the final version of the Standard. In accordance with international best practice, and with the consent of those who provided feedback, we have published the submissions on the Review's website: www.globaltailingsreview.org.
- **Website** – The www.globaltailingsreview.org website has been the main source of information about the Review. Set up from the outset, the website is the repository of all governance documentation, published resources and news updates. The website content was handled by the Review's PMU, with IT and graphic design support provided by the ICMM.

4. TIMELINE

The Review process formally commenced in May 2019 following the appointment of an independent Chair (see above). A high-level retrospective timeline of the development of Standard is provided in Figure 1, below.

The tragedy in Brumadinho required an immediate response. The co-conveners' original intent was to complete the process by the end of 2019 and to launch the Standard on the one-year anniversary of the tragedy. Some considered this timeline to be very ambitious and expressed fears that the time pressures may unintentionally jeopardise quality. The counter-view was that a tight timeline reinforced the urgency of the issue, maintained momentum and allowed all parties to stay focused on the ultimate goal of the Review – to prevent catastrophic tailings facility failures.

Box 2: Related Initiatives

Underlining the urgent global response to the tragedy in Brumadinho and in parallel to the Review, there are now a number of other initiatives working towards the same objective. They include:

- UNEA-4: United Nations Environment Assembly Resolution on Mineral Resource Governance;
- ICMM's detailed technical guidance on tailings;
- PRI's Mining Safety and Tailings Initiative;
- Responsible Mining Initiative (RMI) 2020 report on tailings management.
- Establishment of a Global Research Consortium on Tailings.

More information about several of these initiatives can be found within this volume.

The multi-disciplinary approach to the development of the Standard provided layers of valuable reflection, but also added to the complexity of the effort. As a result, a number of iterations of the text were required, which translated into timeline extensions. The timeline of the Review was extended twice in response to feedback received from the Advisory Group and the co-conveners. The work was completed in July 2020.

The final phase of the Review was extended, as it coincided with the unprecedented global outbreak of COVID-19 in early 2020 and the ensuing pandemic. This resulted in a several month delay of the finalisation and release of the final draft of the Standard.

Figure 1 provides a visual representation of the main phases of the Review process. These were:

(i) Commitment and inception: The co-conveners committed to establishing a new standard on tailings management. As a result, the Global Tailings Review process was initiated, starting with the appointment of an independent Chair, a multi-stakeholder Advisory Group and the formation of the Expert Panel.

(ii) Review and drafting: The second phase included study trips by the Chair and members of the Expert Panel to Samarco, Brumadinho and Mount Polley, and other mines in Brazil and Canada. The Expert Panel reviewed existing standards and practices and developed a series of draft texts. The Advisory Group and the co-conveners subsequently provided feedback on these drafts. The full consultation draft was completed towards the end of October 2019.

(iii) Public consultation: This was undertaken both online and in person in a range of key mining jurisdictions.

(iv) Addressing public consultation feedback: This phase entailed integration of public consultation feedback, further engagement with the Advisory Group and the development of another iteration of the Standard.

(v) Co-conveners' consideration and endorsement: In this final stage, the Standard and accompanying documents were submitted to the co-conveners for discussion, negotiation, consideration and endorsement. As noted above, this phase was extended by approximately two months due to the global pandemic at the time.

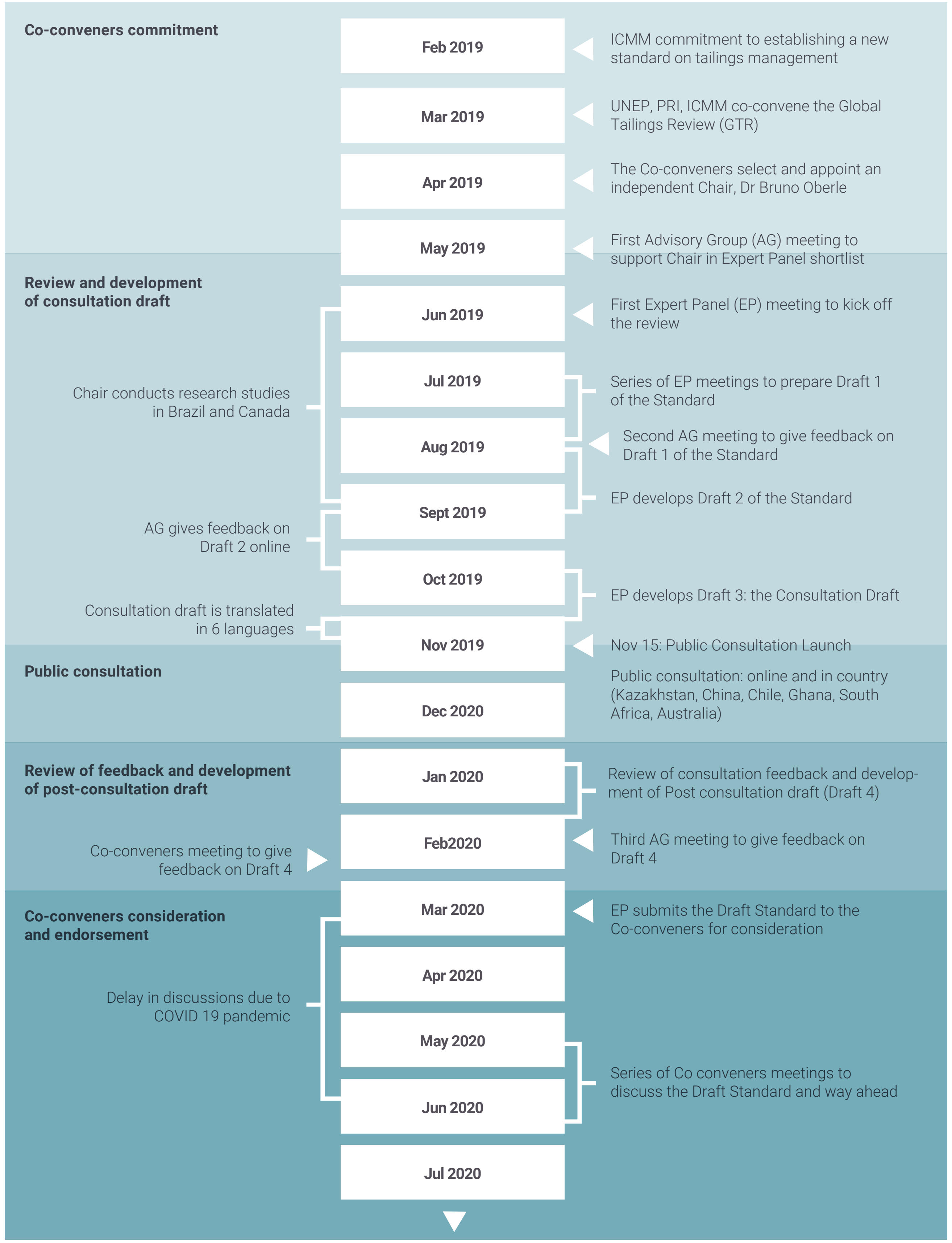

Figure 1: Global Industry Standard on Tailings Management Timeline

PART B:
OVERVIEW OF THE STANDARD

The Standard is directed at Operators[1] and applies to facilities. It makes clear that extreme consequences to people and the environment from catastrophic tailings facility failures are unacceptable. Operators must have zero tolerance for human fatalities and strive for zero harm to people and the environment from the earliest phases of project conception. To be compliant with the Standard, Operators must use specified measures to prevent the catastrophic failure of tailings facilities and to implement best practices in planning, design, construction, operation, maintenance, monitoring, closure and post closure activities. Overall, conformance is expected where there is no conflict with the legislative requirements of the jurisdictions where facilities are located.

In accordance with the Review's Scope and Governance document, the Standard does not:

- contain detailed technical design criteria for tailings facilities
- exclude or ban any technologies
- apply to riverine, deep sea and non-tailings related storage facilities
- cover standards for rehabilitation of affected areas.

The Standard's structure is logical, not chronological. It is underpinned by an integrated approach to tailings management which was the overarching objective of the Panel. To give the Standard structure, the Requirements are organised around six Topic Areas, 15 Principles and 77 specific Requirements. It is important to note that future development of implementation protocols would further clarify expected levels of performance.

Topic Area I focuses on project-affected people. In order to respect human rights, including the individual and collective rights of indigenous and tribal peoples, a human rights due diligence process is required to identify and address those rights that are most at risk from a tailings facility or its potential failure. To demonstrate this respect, project-affected people, must be afforded opportunities for meaningful engagement in decisions that affect them. The Requirements within Topic Area I are intended to be cross-cutting in terms of being addressed across all operational activities and ongoing throughout the tailings facility lifecycle.

Topic Area II requires Operators to develop knowledge about the social, environmental and local economic context of a proposed or existing tailings facility, and as part of this, to conduct a detailed site characterisation. It asks for a multi-disciplinary knowledge base to be developed and used by the Operator and key stakeholders in an iterative way to enable all parties to make informed decisions throughout the tailings facility lifecycle. These decisions will arise in the context of the alternatives analyses, the choice of technologies and facility designs, emergency response plans, and closure and post-closure plans, amongst others.

Topic Area III aims to lift the performance bar for designing, constructing, operating, maintaining, monitoring, and closing tailings facilities. Operators are asked to demonstrate the ability to upgrade a facility at a later stage to a higher consequence classification. For existing facilities, where upgrading is not feasible, the Operator must reduce the consequences of a potential failure. Recognising that tailings facilities are dynamic engineered structures, Topic Area III requires the ongoing use of an updated knowledge base, consideration of alternative tailings technologies, the use of robust designs and well-managed construction and operation processes to minimise the risk of failure. A comprehensive monitoring system must support the full implementation of the Observational Method and a performance-based approach must be taken for the design, construction and operation of tailings facilities.

Topic Area IV focuses on the ongoing management and governance of a tailings facility. It provides for the designation and assignment of responsibility to key roles in tailings facility management, including an Accountable Executive, an Engineer of Record and a Responsible Tailings Facility Engineer. Further, it sets standards for critical systems and processes, such as the Tailings Management System and independent reviews, which are essential to upholding the integrity of a tailings facility throughout its lifecycle. Cross-functional collaboration and the development of a learning organisational culture that welcomes the

1. The Standard defines 'Operator' as: an entity that singly, or jointly with other entities, exercises ultimate control of a tailings facility. This may include a corporation, partnership, owner, affiliate, subsidiary, joint venture, or other entity, including any State agency, that controls a tailings facility.

identification of problems and protects whistle-blowers are also included.

Topic Area V covers emergency preparedness and response in the event of a tailings facility failure. Operators must avoid complacency about the demands that would be placed on them in the event of a catastrophic failure. The Standard requires Operators to consider their own capacity, in conjunction with that of other parties, and to plan ahead, build capacity and work collaboratively with other parties, in particular communities, to prepare for the unlikely case of a failure. Topic Area V also outlines the fundamental obligations of the Operator in the long-term recovery of affected communities in the event of a catastrophic failure.

Topic Area VI requires public disclosure of information about tailings facilities to support public accountability, while protecting Operators from the need to disclose confidential commercial or financial information. The Standard concludes by requiring that Operators commit to transparency, and participate in global initiatives to create standardised, independent, industry-wide and publicly accessible information about tailings facilities.

EVOLUTION OF THE STANDARD

As mentioned above, there were a number of iterations of the Standard. However, there were certain aspects on which the Panel remained firm in their intention to lift the performance bar for the industry as a whole. As with any negotiated product, there were concessions and nuances added to the language as it evolved. However, the intent of the Panel was generally respected, and the resulting Standard contains, to one degree or another, 'step-changes' in all discipline areas.

PART C: OBSERVATIONS AND REFLECTIONS ON THE PROCESS

DECISION MAKING AND WAYS OF WORKING

CO-CONVENERS

The co-conveners had a series of meetings and checkpoints throughout the process. The most extensive engagements came at the beginning, in the lead up to the public consultation, and towards the end of the process during the consideration and endorsement phase.

Each co-convener also presented their respective positions on key issues formally as part of the public consultation. All of the minor issues and a number of more substantial disagreements were resolved in the resulting post-consultation iterations of the Standard. Key points of divergence were left to be resolved during the negotiations amongst the co-conveners in the final consideration and endorsement phase.

WITHIN THE PANEL

The general approach was to endeavour to reach consensus on all issues. However, there were times when this was not possible. In these cases, the Chair assumed responsibility for the final decision, taking account of both the views of the Panel member with expertise in the area in question and the objectives of the co-conveners.

THE 'OWNERSHIP' DIVISION WITHIN THE PANEL

Each expert was assigned responsibility for a sub-set of Requirements that linked to their areas of expertise. This work involved drafting the Requirements, consulting on and addressing feedback from other members of the Panel. Some of this work was done remotely, but at all key stages of the Review the full Panel convened to examine all Requirements together. In addition, sub-groups of the Panel were formed to problem-solve, engage bilaterally with the AG and work on cross-cutting topics such as the integrated management system.

While wordsmithing and improvements were sometimes discussed bilaterally or in smaller working groups, when it came to finalising the Standard, every single edit to the text was collectively considered and endorsed by all seven Panel members and the Chair. This process, while time consuming, helped to maintain the integrated approach and delivered an end product which was coherent, technically sound and credible.

A good example of how this process facilitated the integration of a discrete topic is the approach taken by the Panel to the issue of climate change. Instead of drafting a stand-alone requirement for Operators to consider climate change impacts, the Panel identified multiple decision points where these impacts needed to be addressed, along with other considerations. This approach ensures that climate change remains in scope for all risk management and review activities, and that information is shared systematically across the operation.

POST-CONSULTATION DECISION-MAKING

The Consultation Draft of the Standard was released in mid-November 2019 and stakeholders were given until the end of December to provide feedback. The consultation process was conducted both online, and in-person in several key mining jurisdictions globally. Respondents were asked to provide comments on individual Requirements and on the Standard more generally, and were also invited to make suggestions for re-wording.

The consultation responses were collated and provided to the Panel on an ongoing basis throughout the consultation period. Two weeks after the consultation closed, the Panel was provided with a single consolidated file containing all comments in a structured way, based on 'coding' or categorisation of key terms and themes. Overarching and cross-cutting comments were considered by the Panel at their first post-consultation in-person meeting.

Due to the volume of feedback, and in the interest of saving time, each Panel member was tasked with: (i) presenting a summary of the feedback on the Requirements for which they had responsibility; and (ii) proposing a rewording if this was deemed necessary. These proposals were then discussed and agreed by the full Panel. A **triage process** was applied to facilitate decision-making.

Triage process to addressing public consultation feedback

1. Is the intent of this Requirement clear?
2. Does the Panel want to keep or remove this Requirement?
3. Does the Panel want to keep it as is or reword it?

As to be expected, there was both a lot of duplication and plenty of divergence in the views that were expressed. Naturally, individuals and organisations within the same stakeholder group often made similar comments while, conversely, different stakeholder groups had different views across a broad range of issues. This required making iterative adaptations, looking for points of commonality, assessing the practicality of proposals, and testing the logic and content of the Standard against the objectives of the Review on an ongoing basis. Overall, the majority of the feedback was focused on a limited number of specific controversial themes which are explored in more detail in the Global Tailings Review Consultation Report released alongside this report.

REFLECTIONS

There are a number of reflections and lessons from the Review process that are worth capturing for any future initiatives of this nature. The governance model, the ambitious timeline and the multidisciplinary Panel were aspects of the Review that gave it external credibility, but, at the same time, made the process particularly challenging.

Below are some key overarching takeaways from the Chair and PMU:

1. **Scope and governance.** The scope of the Review was frequently discussed throughout the process and there were conflicting views between stakeholders concerning the breadth of scope required to achieve the ultimate objective of the Review. This made it difficult to maintain focus on some of the detail of the proposed Requirements throughout the process. The Scope and Governance document was intentionally drafted by the co-conveners to allow for flexibility to amend the parameters should public feedback or the Chair's assessment point to the need to adjust the scope. Ultimately, this allowed the Chair and Panel to maintain control over the process.
2. **Schedule**. The ambitious work plan from the outset, along with the dispersed geographical spread of the Panel, proved challenging at a number of critical junctures. The schedule also forced part of the Review to be conducted in parallel to the drafting effort (e.g. the comparative

assessment of tailings management legislation across a number of mining jurisdictions).
To address these challenges, strong project management controls were required. Technology also played a big part in keeping people connected and the information flowing.

3. **Challenges with logistics.** Related to the point above, the geographical spread often made it logistically challenging to accommodate the experts' working times and availability. This proved particularly difficult in terms of arranging in-person meetings. Having a quorum of 100 per cent also often led to delays even with virtual meetings. Early calendar sharing and the advance block-booking of dates allowed a level of certainty around some aspects of planning.

4. **Managing the Advisory Group and co-conveners.** The second AG meeting, in August 2019, was scheduled so that it overlapped with one of the co-conveners' checkpoints. The joint meeting, which was attended by representatives from two of the three co-conveners, proved to be problematic due to this being perceived by some members of the AG as undermining the independence of the process. This was therefore the last combined meeting held. The timing and sequencing of meetings needed to be planned carefully so that information was shared evenly and participants were adequately informed in advance of key decision points.

5. **Managing the consultation process**. Additional iterations during the pre-consultation drafting phase resulted in the delay of the consultation timeline. Unintentionally, this led to the consultation being conducted from mid-November until the end of December 2019, coinciding with end-of-the-year processes and seasonal holiday festivities. Some perceived this as a benefit and utilised the quieter period to prepare a thorough submission; however, for the in-person consultation it was impossible to visit a jurisdiction for more than three days, which made attendance for participants difficult in some circumstances. Additional effort was made around communications, and resources were drafted in to support invitations to the in-country consultations. Reminders were also issued to virtual participants to ensure the public consultation remained on their radar.

6. **Translations.** The translation period allowed under the revised pre-consultation schedule was two weeks. This proved to be insufficient for delivering technically-sound translations that reflected linguistic and structural nuances. The need to wait for translated versions also shrunk the amount of time available to in-country consultees to review the draft and engage with their constituencies. The draft Standard made it clear that the English version should be considered as the definitive version, and this was reiterated during the consultation process.

7. **Dealing with information asymmetry.** A challenge with taking a multi-stakeholder approach to addressing an issue that is largely specific to one industry is that, by definition, the industry was better placed to provide detailed technical input on the draft Standard as it developed. This risked creating a perception from the outside that the process was overly influenced by the industry who were seeking to self-police. To combat this potential imbalance the Chair, in his role as facilitator, maintained consistent communication with all three parties. He also allowed additional time for the non-industry co-conveners to engage within their respective constituencies, particularly on technical aspects, and made himself available as and when requested to discuss specific issues.

8. **Finding the right language within the Expert Panel.** The multi-disciplinary composition was not without its challenges. As with the establishment of any team, the Panel went through a period of learning, adapting and familiarisation both with each other in terms of ways of working, and with those disciplines outside their area of expertise. Over time, trust was built, and a working 'language' emerged through which all experts, regardless of background, could engage. An example of this is the different interpretations of the term 'management systems' which can imply different types of activities for the technical teams compared with the environmental and social teams. Much effort was therefore expended in carefully clarifying the boundaries and the areas of intersection between these different understandings.

9. **Finding widely understood terminology globally.** As mentioned previously, independence was a core tenet of the Review. This gave the Panel the freedom to think innovatively and not be constrained by what had or had not worked in the past. However, and in connection with comments on the need for a common language among the experts, one challenge which arose was to find a language that adequately covered the multitude of processes, systems and terminologies that are used at an operational level across the world. To this end, the Panel took efforts to engage further with industry professionals across a range of disciplines to ensure that the Requirements and Glossary terms were easily understood and aligned with currently accepted mining-industry parlance.

10. **Balancing the objectives of three disparate parties with distinct interests and perspectives.** For the co-conveners, it was important that their positions were respected and that their objectives were positioned in an amenable way so as to not exclude the other co-conveners. For the Chair, keeping the views of the co-conveners at the back of mind throughout the process was vital to ensure equitable representation of the co-conveners.

5. CONCLUSION

The Review took just under a year and half to complete: from the public commitment by the three co-conveners to jointly assemble an independent review on tailings management, up until the public launch of the Standard. Using an open and honest dialogue and consensus building throughout the entirety of the process, the co-conveners managed to reach agreement and deliver the best possible product to help improve the way tailings facilities are designed, built, monitored, managed and closed. Looking ahead, it will be critical for all stakeholders involved to date to remain as committed during the next phase – the implementation of the Standard.

SETTING THE SCENE

CHAPTER II
MINE TAILINGS FACILITIES: OVERVIEW AND INDUSTRY TRENDS

Elaine Baker*, Professor, The University of Sydney, Australia and GRID Arendal, Arendal, Norway
Michael Davies*, Senior Advisor – Tailings & Mine Waste, Teck Resources Limited, Vancouver, Canada
Andy Fourie, Professor, University of Western Australia, Australia
Gavin Mudd, Associate Professor, RMIT University, Australia
Kristina Thygesen, Programme Group Leader, Geological Resources and Ocean Governance, GRID Arendal, Norway

1. INTRODUCTION

This chapter provides an overview of mine tailings and mine tailings facilities. It illustrates why and how mine tailings are produced, and the complexity involved in the long-term storage and management of this waste product. The call for a global standard for mine tailings management is a response to recent catastrophic facility failures. Mining companies, governments and communities all recognise the potential for unacceptable loss of life, livelihoods and long-term environmental damage that can result from such failures. There are lessons to be learned from past failures but if we cannot integrate these lessons throughout the industry, we will likely continue to witness these tragic events. The United Nations Sustainable Development Goals (SDGs) should underpin the mining industry's social licence to operate, ensuring that benefits from mining to society are not achieved at the expense of local communities or the environment. To realise this, the entire industry needs to commit to a standard of design, operation and innovation that solves the problem of tailings facility failures.

2. MINE TAILINGS AND TAILINGS FACILITIES: AN OVERVIEW

Mine tailings are the waste material that remains after the economic fraction has been extracted from the mineral ore. Tailings consist of a slurry of ground rock, and water and chemical reagents that remain after processing. The composition of mine tailings varies according to the mineralogy of the ore deposit and how the ore is processed.

The tailings are most commonly stored on site in a tailings storage facility. Storage methods for conventional tailings include cross-valley and paddock (ring-dyke) impoundments, where the tailings are behind a raised embankment(s) that then, by many definitions, become a dam, or multiple dams. However, a tailings facility can have an embankment function like a dam during some portion of its life cycle but not during another (e.g. closure). For this reason, it is more correct to refer to the entire tailings facility when discussing mine tailings. The tailings still exist during all life-stages but the 'dam(s)' may not, as there may no longer be a function for embankment(s) of that nature.

Raised embankments can be constructed using upstream, downstream or centreline methods (Figure 1) and even a combination thereof. The embankment needs to be designed, constructed and operated to withstand the loading conditions expected during the life of the mine, including post-closure.

While impoundment storage of tailings slurry is currently the most common storage method, tailings can also be deposited into a previously mined pit when available, filtered to produce dewatered stacked tailings, placed underground after adding a binder such as cement, or less commonly deposited into rivers or offshore (though the latter is increasingly limited due to jurisdictional and/or owner restrictions on the use of such practices). The approach taken in the design, construction, operation and decommissioning of the tailings facility will depend on many factors, including the owner's own governance approach, government regulations, nature of the ore, the local topography and climate, site geology, seismic risk and cultural context.

*Member of the GTR Multi-stakeholder Advisory Group

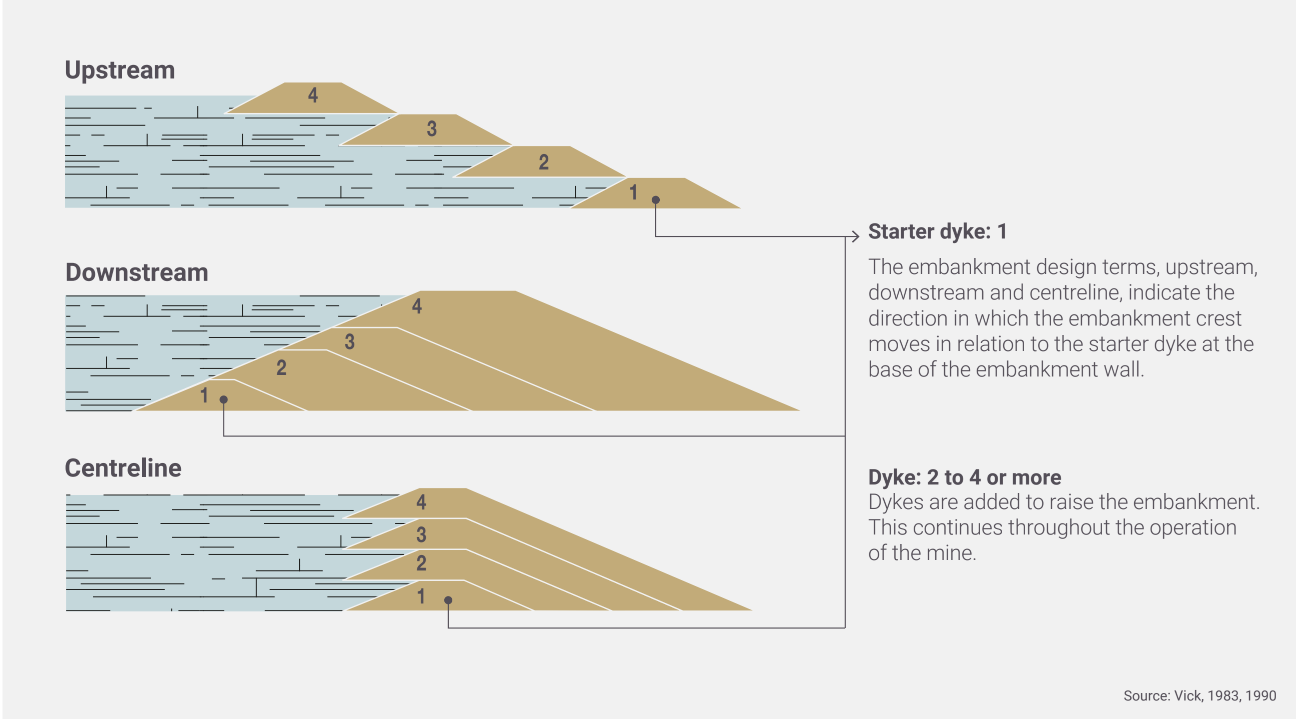

Figure 1. Common methods of tailings embankment construction

Mine tailings management is a long-term process that starts well before any tailings are produced (Figure 2). It can be difficult to estimate the 'typical' cost of building, operating and closing a tailings storage facility as it depends on many factors, but examples suggest up-front capital costs can be around 15 per cent of mine development, with ongoing operational costs generally less than 5 per cent of the total cost of mine production.

There is increasing scrutiny being placed on mine closure, with expectations of improved land rehabilitation and comprehensive water management planning (McCullough et al. 2018). A key take-out from Figure 2 is that by far the longest portion of a tailings life cycle (closure/post-closure) also occurs at the time when the mine is not generating revenue. For larger mining owners with multiple operations this may be addressed through sharing of resources, but for most tailings facilities it is critical that the facility is sufficiently prepared for closure/post-closure through investment during the operational phase.

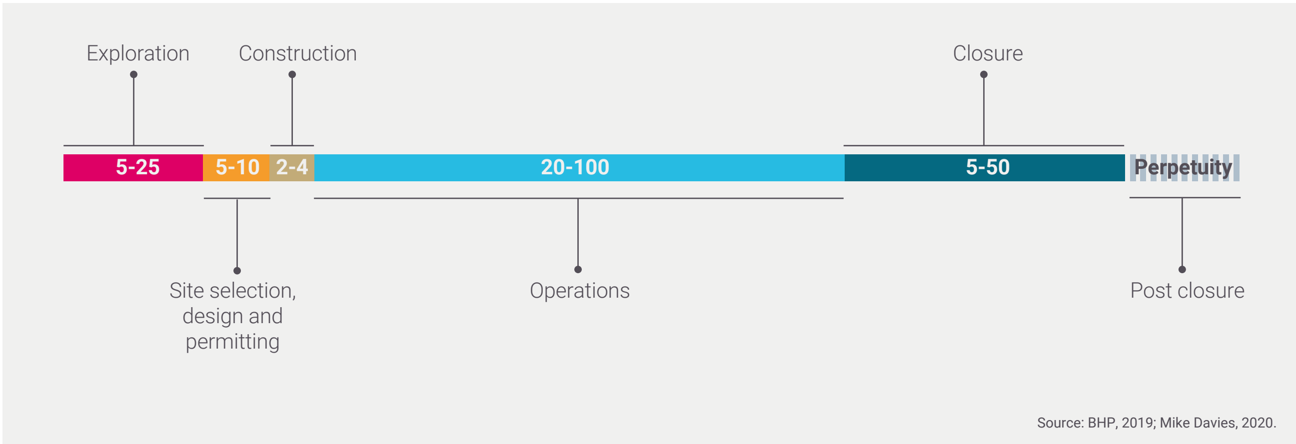

Figure 2. Life of a mine with a tailings storage facility – in average years

Tailings, other than perhaps waste rock dumps in some instances, generally have the single largest mine site footprint, both spatially and temporally (Werner *et al.* 2020). This is but one of the reasons why managing TSFs can be extremely complex. The volume of waste material produced per unit of commodity is increasing due to declining ore grades (Mudd 2007; 2010), so the challenges of operating and maintaining traditional tailings facilities are increasing. The largest facilities can have embankments designed to contain more than a billion m^3 of tailings. In 2016 it was estimated that more than 8 billion tonnes of tailings were produced from the extraction of metals and minerals (Figure 3). The largest volume of tailings, 46 per cent, is produced from copper mining (Figures 4 and 5).

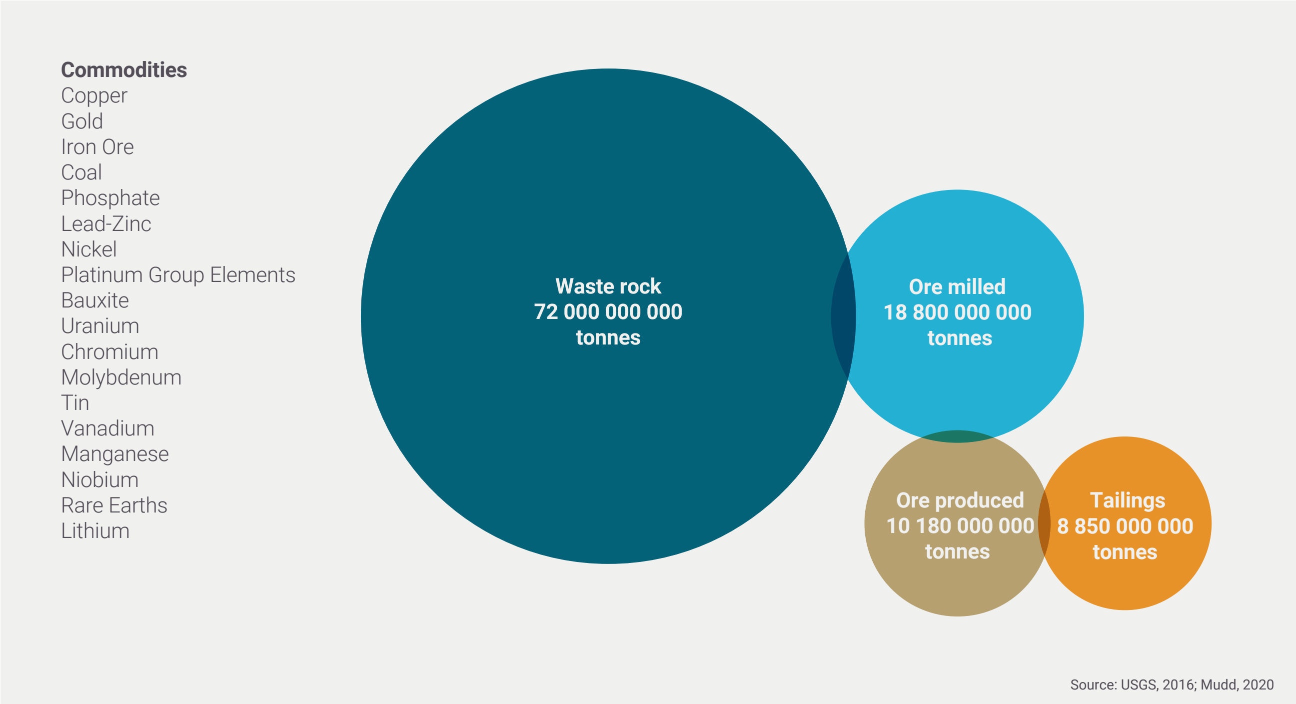

Figure 3. Estimate of the volume of tailings and waste rock produced in 2016 in relationship to ore production (c.f. plastic waste weight and volume)

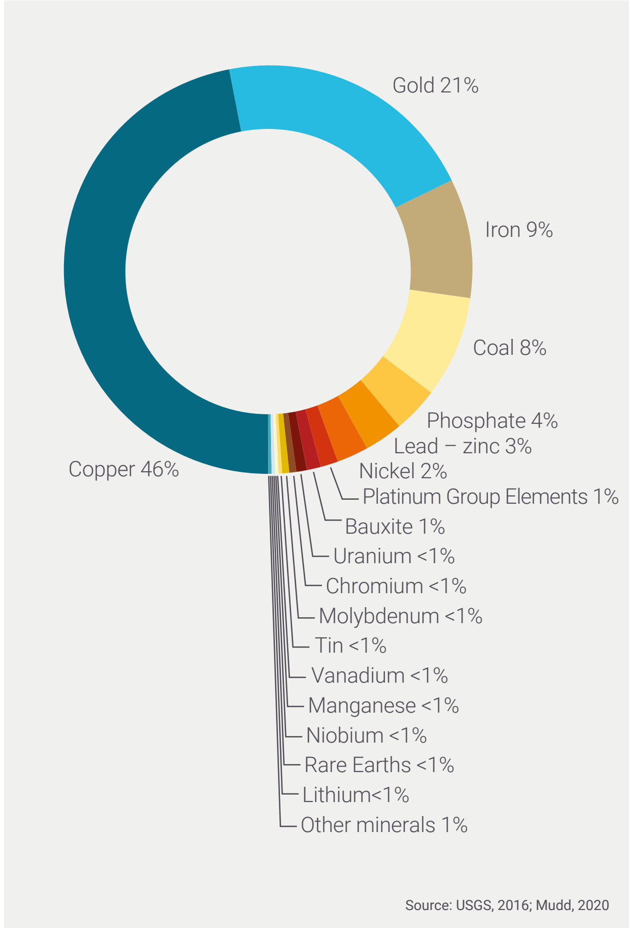

Figure 4. Percentage of global tailings volume per commodity in 2016

The precise number of active tailings storage facilities is currently unknown. Although incomplete, the Global Tailings Portal (see the chapters by Franks *et al.* and Barrie *et al.*, this volume), which includes information provided by publicly listed companies, currently records 724 active tailings facilities. More than half of these (364), were constructed in the last 10 years. The actual total of tailings facilities in the world is likely at least an order of magnitude greater than the 724 noted above when all of the active and legacy (closed) facilities are taken into account (see Franks *et al.* this volume, who estimate there are approximately 8,500 sites world-wide or which around 3,250 are active sites). Many of these other facilities may be quite small and relatively inconsequential, but that presumptive assumption should be confirmed over coming years.

The growth in resource consumption as a result of population increase and the continual expansion of the global economy has seen a steady increase in the extraction of metals and minerals (Figure 6). Mining of metal ores has grown on average by 2.7% per year since the 1970s, a reflection of the growth in infrastructure and manufacturing (International Resource Panel [IRP] 2019). Metals and minerals are essential to society and have a major impact on 11 of the 17 Sustainable Development Goals (UNDP and UN Environment 2018). The reduction in poverty in many parts of the world is underpinned by mineral resources and the move towards a low carbon economy points towards increasing demand for metals. For example, the shift to renewable energy, outlined in the scenarios developed to achieve the Paris Climate Agreement target, requires increased use of many metals, including copper, lithium, cobalt, aluminium, iron, manganese and silver. Increased material efficiency and recycling may offset some of this demand, but for many currently important metals the projected demand far exceeds the current production rates (Giurco *et al.* 2019).

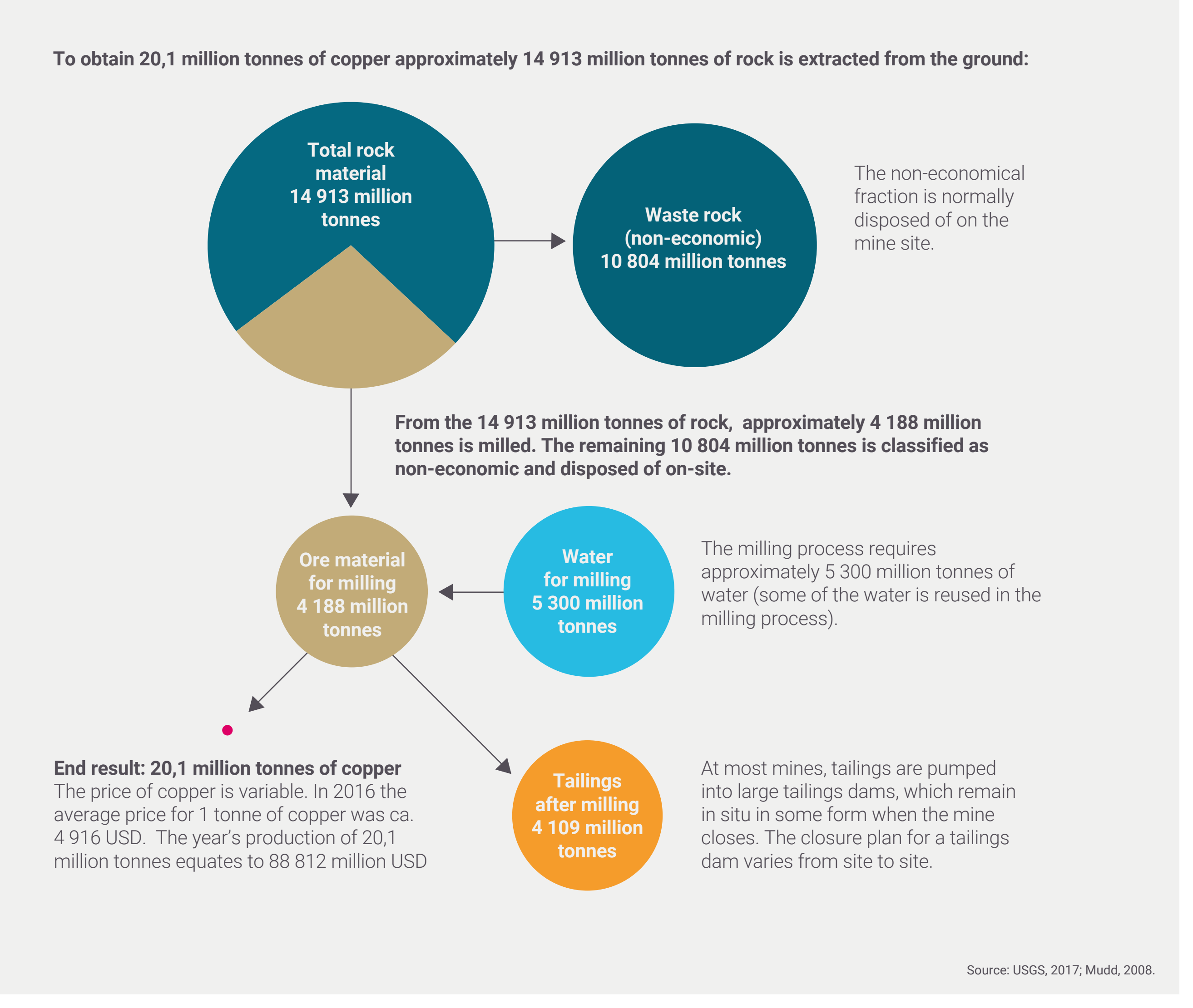

Figure 5. The relationship between copper, waste rock, tailings and water usage – Global footprint of copper production, 2016

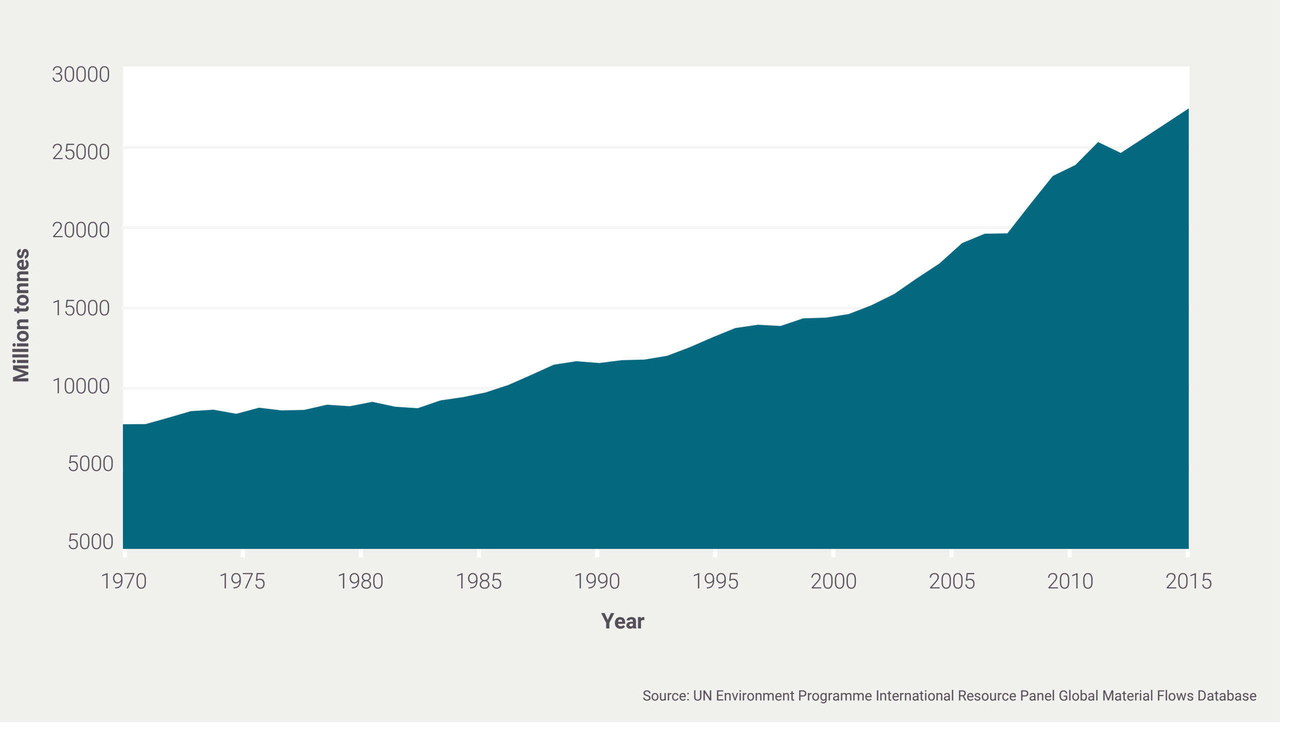

Figure 6. The global extraction of metal ores (includes copper, iron, aluminium and other non-ferrous metals) from 1970 to 2017.

3. TAILINGS FACILITY FAILURES

The UNEP Rapid Response Assessment on mine tailings safety (Roche *et al.* 2017) noted that in the previous 10 years, significant failures of tailings facilities had been reported across the globe, including in jurisdictions with comprehensive regulatory regimes. The key point is that despite numerous interventions, failures continue to occur at an unacceptable rate. Various groups around the world have analysed and presented data on aspects of tailings facility failures, failure rates and consequences (e.g. WISE 2019; WMTF 2019; Owen *et al.* 2020) and all of these make useful contributions to highlighting the problem. The Global Tailings Portal (2020) provides a significantly updated database of tailings facilities and their consequence of failure. While not exhaustive, it illustrates the enormous volume of tailings that need to be safely managed.

In 2001 Davies reviewed tailings facility failures up to that time and observed that all were predictable in hindsight and could have been prevented during the design and/or operational phase. This is still the case for the many failures that have occurred in the intervening period, indicating that there has unfortunately not been sufficiently uniform commitment to the fundamentally sound design and operating concepts that were outlined in the review.

At the same time, while failures do continue to occur, and the rate and nature of those remain wholly unacceptable, on a per tonne basis the world's largest facilities have performed well and are not contributing to these events. Further, an increasing number of countries have adopted governance programmes and many owners, regulators, communities of interest (COIs) and designers continue to advocate for their use more broadly (e.g. Mining Association of Canada [MAC] 2017; MAC 2019a). Finally, we can say that failure modes remain within a tight band of technical root causes that have known engineering solutions (see below).

Poor governance practices (operating or regulatory) that contribute to failures can be addressed through more rapid adherence to frameworks like MAC's *Towards Sustainable Mining* (see MAC 2019b) or, where a jurisdiction does not have a sound governance model, the Global Industry Standard on Tailings Management ('the Standard'). When addressing the governance issues that can contribute to catastrophic failures, these frameworks are entirely consistent and are based upon the premise that eliminating catastrophic failures is the ultimate goal. In this respect there are similarities with how the mining industry approaches workplace safety. There are likewise parallels with other industrial sectors, such as the airline, and hydroelectric industries, where the aim is also zero fatalities and zero major incidents that cause severe public and environmental impacts.

In terms of what causes a tailings facility to fail, there are a number of design and/or operational flaws that can trigger a failure event. These triggers are well-represented in the failure case history record and, as such, are well known and commensurately should be able to be anticipated and addressed prior to any failure event. These common triggers include:

- **Operating and/or regulatory failures of governance.** A lack of attention to the key performance indicators that are required for the facility to perform as intended can lead to any of the common triggers that follow. While inadequate designs have occurred, in the majority of all case histories available there was clearly a failure of either operating governance or regulatory oversight which was at odds with adequate tailings facility management. Even the best designs may not be able to withstand poor governance.
- **Overtopping**, where the capacity of a tailings facility without a sufficiently sized spillway is insufficient to safely store water during operational upsets and/or extreme storm events. When this occurs in the most extreme cases, water eventually overtops a low point on the facility perimeter, often resulting in significant erosion and perhaps even, ultimately, catastrophic release of tailings.
- **Foundation failure**, where the soil and/or rock beneath the tailings facility is not sufficiently strong to safely bear the imparted stresses from the weight of the overlying embankment that forms the retention portion of the facility.
- **Piping**, which is initiated by excessive seepage through the embankment or the foundation of the tailings facility, which leads to sufficient erosion of embankment or foundation particles resulting in the development (sometimes very rapidly) of an erosion void that may ultimately facilitate extremely rapid discharge of tailings and process water. This is a more common failure mode in conventional (non-tailings) water reservoirs but has occurred for some tailings facilities as well.
- **Slope failure**, including where tailings are used to construct some or all of the tailings facility embankment(s). This type of failure can occur where the material used for any embankment(s) developed lacks the strength required for the loading conditions, inclusive of the slope of the embankment. Where tailings are used for embankment construction and they are not sufficiently compacted, a very sudden loss of strength called 'liquefaction' can occur and a catastrophic release of tailings can follow.

The triggering mechanisms mentioned here are certainly not exhaustive and there are many examples of less well-recognised triggering events, such as development of a sinkhole beneath the tailings facility sited in a karstic environment due to dissolution of underlying limestone or dolomite (e.g. Yang *et al.* 2015) or the upstream failure of another structure, such as a beaver dam (e.g. McKenna *et al.* 2009) that leads to a cascade failure event.

As evident from World Mine Tailings Failures (WMTF) database (2020), the number of tailings facility failure events is unacceptable to both the mining industry and society in general. Whenever a failure occurs, there tends to be a rush to investigate whether other facilities have a similar flaw to that identified in the forensic investigation of the most recent failure, whatever that might be. As an example, in the aftermath of the failure of the Mount Polley tailings facility in Canada, extensive field investigations were carried out around the world to determine if the possibility of the primary mechanism identified as being responsible for this failure (in this case related to inadequate shear strength of the foundation soils) could be a problem at other sites. Such reactive approaches can add some value but are prone to miss a number of key issues:

- It is very rare that a tailings facility failure is attributable to a single, isolated cause. Earthquake-induced failure may be an exception to this statement, but even these failures are now avoidable, as evidenced by the excellent performance of many large tailings facilities in Chile since the 1960s through many large seismic events including the very large (magnitude 8.8) earthquake in 2010. Rather, forensic investigations of tailings facility failures often point to a failure of governance as well as technical issues. Focussing on just the event that finally triggers a failure will likely only serve to ensure that failures that are more a function of poor governance will continue to happen. Good governance, for example the management approaches outlined by MAC (2017; MAC 2019a), is clearly defined yet not universally applied, as evidenced by the nature of failures that have continued to occur.
- Focussing on single cause mechanisms may disguise a deeper underlying malaise, which includes inadequate governance and inadequate or insufficient technical training of responsible personnel. Achieving the goal of sound tailings facility governance towards a future with zero catastrophic failures requires: (1) proper training in personnel management, regulatory management, engineering principles, facility operation and other roles that are key to ensuring that a facility is designed and operated safely; and (2) management systems to ensure that appropriate monitoring, surveillance and governance systems are in place and are adequately resourced.
- A single cause focus can also lead to the erroneous conclusion that solutions to ensuring stability are simple, e.g. 'if failure occurs due to overtopping, all that is needed is monitoring of water levels'. Unless responsible personnel, including the designer, the facility owner and the regulator, are adequately trained and suitably skilled to recognise an evolving problem, monitoring protocols alone may well prove to be inadequate.

4. PREVENTING TAILINGS FACILITY FAILURES

The vast majority of active tailings facilities – and many that have been closed, – have operated without any issues of concern for society. However, the number of failures that continue to occur is rightfully deemed unacceptable by both those who own/operate them and by society in general. As described above, there has been a wide variety of facilities across broad geographies that have failed over the past 100 years (although record keeping has been sporadic and incomplete). The specific causes and triggers for the documented failures have varied, but there are similarities in each case in terms of fundamental loss of governance at some point to the degree that a failure did occur. 'Governance', as used here, includes the responsibilities of the owner and/or operator, the core competencies of the designer, the core competencies and role provided for any independent senior review and the competency/capacity of the regulatory processes within the jurisdiction of the facility involved. Certainly not all of these aspects of governance were lacking for each incident, but in all cases systems and processes in at least one or more of those areas were insufficiently robust.

The Standard provides recommendations that address largely the owner/operator but also has clear requirements related to engagement of appropriate design and independent review competence/capacity commensurate with the subject facility. Though far from a certainty, given the nature of the failures that have occurred, it appears a logical conclusion that if the recommendations in the Standard on governance issues related to design, operation and review had been followed, many of the failures that occurred in the past may not have happened, or at least would have had less severe impacts. This observation is necessarily speculative and is not intended in any way to address any single incident, either explicitly noted above or implied through connection. However, it broadly aligns with the published findings of incidents and the examples of best practices from well-governed facilities that together were used to inform the development process of the Standard; to that extent the conclusion appears well-justified.

5. CONCLUSION

The mining industry is extremely good at determining the cause of tailings facilities failures, and to date there have been no unexplained failures reported. The problem is that the events or conditions that lead to failures, although clear in hindsight, have not always been observed and/or are miscommunicated during the lead-up to the failure. There needs to be greater effort to identify high risk tailings facilities with a focus on preventing failures. Recent catastrophic failures have increased community awareness of mining risk. Communities which may potentially be impacted by the failure of a tailings facility deserve access to disclosure information that provides an understanding not only of the risk status of the facility, but also the broader risks to communities and the environment. Tailings facilities owners and their regulators that do prioritise safety and provide appropriate risk information need to be acknowledged and rewarded for their combined efforts to operate existing facilities and/or design new ones with no credible failure modes.

KEY MESSAGES

1. Mine tailings are currently an unavoidable waste product of mining.
2. There has been an increase in the volume of tailings produced for many mineral commodities, due to increased demand for minerals and the continuing decrease in ore grade.
3. The precise number of active tailings facilities is currently unknown, although initiatives are underway to determine both the location and status of these facilities.
4. Responsible mine closure is integral to mining companies' core business.
5. Mining conducted responsibly, is acknowledged as a key industry for achieving the United Nations Sustainable Development Goals (SDGs).
6. Failures of tailings facilities are continuing to be reported across the globe. These failures are unacceptable to both the mining industry and society.
7. The triggers for failures of tailings facilities are well documented and understood and, as such, should be anticipated and addressed, starting at the design phase and continuously during operation through to closure (and beyond if necessary).
8. Communities potentially affected by mining hazards are entitled to information that allows an understanding of a broad range of risks, as well as being informed about operator risk reduction strategies.

REFERENCES

BHP (2019). ESG Briefing: Tailings Dams June 2019. https://www.bhp.com/-/media/documents/media/reports-and-presentations/2019/190607_esgbriefingtailingsdams.pdf?la=en Accessed 6 May 2020.

Davies M. P. (2020). Personal communication. May 2020.

Davies, M. P. (2001). Impounded mine tailings: what are the failures telling us? CIM Distinguished Lecture 2000-2001. *The Canadian Mining and Metallurgical Bulletin* 94(1052), 53-59.

Giurco, D., Dominish, E., Florin, N., Watari, T. and McLellan, B., (2019). Requirements for minerals and metals for 100% renewable scenarios. In *Achieving the Paris Climate Agreement Goals.* Teske, S. (ed.). Switzerland: Springer, 437-457.

Global Tailings Portal (2020). https://tailing.grida.no/

IRP (2019). *Global Resources Outlook 2019: Natural Resources for the Future We Want:* Report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

IRP (2020). Global Material Flows Database. International Resource Panel. United Nations Environment Programme. https://www.resourcepanel.org/global-material-flows-database. Accessed 6 May 2020.

Martín-Crespo, T., Gómez-Ortiz, D. and Martín-Velázquez, S., (2019). Geoenvironmental Characterization of Sulfide Mine Tailings. In *Geochemistry*. IntechOpen.

McCullough, C.D., Harvey, B., Unger, B.C.J., Winchester, S., McCarthy, B. and Coetzee, J. (2018). From start to finish–a perspective on improving sustainable development aspects of life-of-mine practices. *From Start to Finish: Life of Mine Perspective, Spectrum*, *24*.

McKenna, G., Keys, M., van Meer, T., Roy, L. and Sawatsky, L. (2009). The impact of beaver dams on the design and construction of reclaimed mine sites. *Proceedings of the 24th Annual British Columbia Mine Reclamation Symposium*, Williams Lake, BC, 2000. The Technical and Research Committee on Reclamation.

MAC (2017). *Third Edition of a Guide to Tailings Management, October 2017*. Ottawa: Mining Association of Canada. https://mining.ca/documents/a-guide-to-the-management-of-tailings-facilities-version-3-1-2019/

MAC (2019a). *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities (Second Edition).* Ottawa: Mining Association of Canada. https://mining.ca/our-focus/tailings-management/

MAC (2019b). *Towards Sustainable Mining. 2019 Highlights*. Ottawa: Mining Association of Canada. https://mining.ca/wp-content/uploads/2019/12/TSM-Booklet-EN-Web.pdf

Mudd, G.M. (2007). Global trends in gold mining: Towards quantifying environmental and resource sustainability. Resources Policy, 32(1),4 2-56.

Mudd, G.M. (2008). Sustainability reporting and water resources: a preliminary assessment of embodied water and sustainable mining. *Mine Water and the Environment*, *27*(3), 136-144.

Mudd, G M. (2010). The Environmental Sustainability of Mining in Australia: Key Mega-Trends and Looming Constraints. *Resources Policy*, 35(2), 98-115.

Mudd G.M. (2020). Personal communication April 2020.

Owen, J.R., Kemp, D., Lèbre, É., Svobodova, K. and Murillo, G.P. (2020). Catastrophic tailings dam failures and disaster risk disclosure. *International Journal of Disaster Risk Reduction,* 42, p.101361.

Pepper, M., Roche, C.P. and Mudd, G.M. (2014). Mining legacies—Understanding life-of-mine across time and space. In *Proceedings of the Life-of-Mine Conference* (pp. 449-465). Brisbane, Australia: Australasian Institute of Mining and Metallurgy.

Roche, C., Thygesen, K., Baker, E. (eds) (2017). *Mine Tailings Storage: Safety Is No Accident. A UNEP Rapid Response Assessment*. Nairobi and Arendal: United Nations Environment Programme and GRID-Arendal.

UNDP and UN Environment (2018). *Managing Mining for Sustainable Development: A Sourcebook*. Bangkok: United Nations Development Programme.

USGS (2016). USGS Mineral Commodity Summaries 2016. https://www.usgs.gov/centers/nmic/mineral-commodity-summaries Accessed 6 May 2020.

USGS (2017). USGS Mineral Commodity Summaries 2017. https://www.usgs.gov/centers/nmic/mineral-commodity-summaries Accessed 6 May 2020.

Vick S.G. (1983). *Planning, Design, and Analysis of Tailings Dams*. John Wiley & Sons.

Vick S.G. (1990). *Planning, Design, and Analysis of Tailings Dams*. Vancouver: BiTech.

Werner, T. T., Mudd, G .M., Schipper, A. M. and Huijbregts, M. A .J. (2020). Global-Scale Remote Sensing of Mine Areas and Analysis of Factors Explaining Their Extent. *Global Environmental Change*, 60: doi.org/10.1016/j.gloenvcha.2019.102007, 10 p.

WISE (2019). Chronology of Major Tailings Dam Failures. World Information Service on Energy. https://www.wise-uranium.org/mdaf.html. Accessed May 2020.

World Bank (2016). What a Waste 2.0. A Global Snapshot of Solid Waste Management to 2050. https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html. Accessed 6 May 2020.

WMTF(2019). World Mine Tailings Failures. https://worldminetailingsfailures.org/. Accessed 6 May 2020.

Yang, Y.Y., Xu, Y.S., Shen, S.L., Yuan, Y. and Yin, Z.Y., (2015). Mining-induced geo-hazards with environmental protection measures in Yunnan, China: an overview. *Bulletin of Engineering Geology and the Environment, 74(1), 141-150*.

THE SOCIAL DIMENSION

CHAPTER III
SOCIAL PERFORMANCE AND SAFE TAILINGS MANAGEMENT: A CRITICAL CONNECTION

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1. INTRODUCTION: IS SOCIAL PERFORMANCE RELEVANT TO TAILINGS FACILITIES?

The starkest indicator of a catastrophic tailings facility failure is loss of human life. There is no more devastating outcome. If a tailings facility has a significant flow failure in a locality where people live or work, where protections are absent, and local capacity to respond is low, tragedy is likely to unfold. While the loss and damage from a catastrophic failure can be forensically documented, quantified and classified, the lived experience for affected people is one of trauma and distress. These considerations provided the backdrop to our work as communities and social performance specialists on the Expert Panel for the Global Industry Standard on Tailings Management (the 'Standard').

Preventing loss of life and responding to worst case scenarios involves anticipating what might unfold under different circumstances. This requires an understanding of the social norms, rules and protocols that would apply in the event of a failure event. This knowledge offers the much needed insight into people's ownership and use of land and territory, systems of social and political organisation, livelihood systems, and human exposure to credible failure modes and potential impacts. It follows, therefore, that this knowledge must be available to developers, regulators and local people before a facility is built, and before a failure occurs. Early access to data and information may even enable decisions that entirely avoid the possibility of harm to people.

A catastrophic tailings facility failure is not solely defined by loss of life. Though lives were not lost at Mount Polley, traditional custodians characterised the tailings facility failure at this operation as catastrophic. First Nations groups have expressed, quite publicly, that the damage to places of cultural and ecological significance and the associated loss and trauma from this event was catastrophic for their communities, with lasting effect.

Box 1: Global Industry Standard on Tailings Management Glossary definition of 'catastrophic failure'

A tailings facility failure that results in material disruption to social, environmental and local economic systems. Such failures are a function of the interaction between hazard exposure, vulnerability, and the capacity of people and systems to respond. Catastrophic events typically involve numerous adverse impacts, at different scales and over different timeframes, including loss of life, damage to physical infrastructure or natural assets, and disruption to lives, livelihoods, and social order. Operators may be affected by damage to assets, disruption to operations, financial loss, or negative impact to reputation. Catastrophic failures exceed the capacity of affected people to cope using their own resources, triggering the need for outside assistance in emergency response, restoration and recovery efforts.

Some dam specialists have argued that the Mount Polley event should not be described as catastrophic because the consequences of the failure did not meet the necessary threshold in the engineering Consequence Classification tables. In their view, any application of the descriptor 'catastrophic' where lives were not lost serves no function other than to invoke unnecessary emotion. By contrast, we argue that the way a tailings facility failure is described or classified must be understood as a function of position, privilege, and perspective. Our experience of working in the area of mining and social performance is that there are often differences in how actors understand and interpret a supposedly 'common' event. Reconciling the professional and the personal, the cultural and the commercial, and the differences between local and global understandings of 'development' and 'disaster' is, we would argue, the essence of social performance work.

This chapter explains how and why social performance work is critical to tailings facility management. It describes the logic that underpins the inclusion and integration of social performance elements throughout the Standard, and our work to ensure that these elements were stabilised during the various rounds of consultation and feedback. It also provides our perspective on what is needed to ensure the effective participation of social performance in the Standard's implementation into the future.

1.1 DEFINING SOCIAL PERFORMANCE

We use the term 'social performance' to refer to how a company handles its commitments, interactions and activities as they relate to local communities. The practical tasks involved in this work include, amongst other things: scoping and overseeing applied, field-based, studies and surveys; gaining access to land; negotiating agreements, compensating for loss and disruption; mitigating and managing impact and benefit streams; and ensuring that project-affected people receive timely and accessible information and that their grievances are investigated and remedied where needed. Effective social performance practice prioritises respect for human rights, harm avoidance and equitable benefit sharing.

This arena of work is often mischaracterised as a one-dimensional activity encompassed solely by the concept of 'community engagement'. This characterisation misses the vital role that the social performance function can play in using field-based data to influence how a mining project is configured and managed throughout its lifecycle. Community engagement remains a priority but equating social performance work with relational work 'outside the fence' does not adequately describe this field of practice (Kemp 2010). Social performance work also involves engaging internally within companies, to influence how mining takes place. Such work, done properly, involves relational, scientific, organisational and legal dimensions, with the latter anchored in instruments of international human rights law.

The Standard's Glossary defines a 'stakeholder' as any affected or interested party, located anywhere, with an interest in any aspect of tailings facility management. Social performance work, by contrast, primarily involves engaging with a local set of stakeholders, many of whom will be directly affected by operational activities. These stakeholders have a distinctly situated set of rights, interests, obligations and entitlements that cannot be de-linked from the context within which they are ascribed and exercised (Joyce 2019).

The place-based focus of social performance differentiates this practice domain from:

- public relations, which is primarily concerned with protecting and enhancing a company's reputation
- government relations, which is concerned with maintaining a certain equilibrium with the state, and
- investor relations, which focuses on assuring investors that they will profit financially from their engagement with the company.

While a mining company's supply chain raises an important set of social performance and human rights considerations, social performance in mining is largely anchored to the point of extraction. It is here that waste is generated and stored, and where tailings facilities are located.

2. WHERE DO THE 'SOCIAL' ELEMENTS FEATURE IN THE STANDARD?

Social performance spans all six Topic Areas of the Standard, with specialist components defined in 14 (18 per cent) of the Standard's 77 Requirements, with a further 18 Requirements (23 per cent of the Standard) requiring operators to integrate social performance inputs into processes, systems and decisions about tailings facility management.

The first sub-section below describes the placement and position of the specialist, and more obvious, social performance components. The second sub-section draws connections between these and other parts of the Standard. As we explain, the level of depth and breadth in this Standard differentiates it from other voluntary standards and schemes relating to either tailings management or social performance.

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2.1 SPECIALIST SOCIAL PERFORMANCE COMPONENTS

Four social performance Requirements are bundled under Topic I Affected Communities. The upfront positioning of these components provides a strong signal that the catastrophic failure of a tailings facility is a salient human rights issue, and requires respect for human rights, including human rights due diligence, from the very outset of a project and throughout the tailings facility lifecycle (1.1)[1].

The Standard also requires operators to work to obtain and maintain free, prior and informed consent from indigenous and tribal peoples, where circumstances warrant it (1.2). Meaningful engagement (1.3) is fundamental to the Standard's goal of achieving zero harm to people, as is the requirement for an operational-level, non-judicial grievance mechanism that effectively handles issues relating to the tailings facility and its potential failure (1.4). The sharing of information to support these and other local-level processes is explicitly required.

Social performance components also feature prominently in Topic II, Integrated Knowledge Base. Under this topic, social, environmental, and local economic considerations are packaged together, given the often inextricable link between these aspects at the operational level. The Standard requires that knowledge is developed from the outset of project planning, and that operators build an understanding of the context within which a tailings facility exists or may exist in the future (2.1). This must include knowledge of downstream areas. Similarly, the knowledge base provisions include a requirement to understand human exposure and vulnerability in the event of a credible flow failure (2.4).

Operators are also required to conduct impact assessments and develop mitigation plans where material adverse impacts are anticipated (3.3). These assessments are to be updated, both periodically and when there is a material (adj.) change to the tailings facility or the social, environmental and local economic context (3.4). Such changes may include, for instance: the closure or commencement of another major project; a radical change in land use (e.g. from farming to an urban settlement); water or food shortages following a major climatic event (e.g. drought or flood); increased in or out-migration; or a major conflict or security event.

Topic III, Design, Construction, Operation and Monitoring of the Tailings Facility, may appear to be an exclusively technical section, written for engineers and tailings facility specialists. However, while this section is certainly weighted to this audience, it does not exclude other disciplines, and in fact encompasses a range of social performance elements. For example, following the provision requiring the operator to consider additional steps to minimise consequences (5.7), the Standard requires the operator to follow international standards if involuntary resettlement is pursued to achieve this aim (5.8).

Another important feature of the Standard is that it includes requirements for both risk reduction and consequence minimisation. Operators are required to reduce risk, which includes both probability and consequences, to as low as reasonably practicable (ALARP). They are also expected to decouple these two concepts and to think solely about the consequences of the event, without considering the probability of that event occurring; that is, to take additional reasonable steps to minimise consequences to people and the environment. This, in effect, reinforces the requirement to reduce risk to ALARP, but compels Operators to consider impacts to people and the environment as a priority.

Topic V, Emergency Preparedness and Recovery is critically important from a social performance perspective. Requirement 13.1 anticipates meaningful engagement with employees and contractors in the development of Emergency Preparedness and Response Plans, and 'locks in' the role of project-affected people in the co-development of community-focused emergency preparedness measures. Requirements 14.1 to 14.5 cover the long-term recovery of people and the environment in the event of a catastrophic failure event – a topic that is not covered in any other tailings or social performance standard.

Requirement 14.1 asks operators to take reasonable steps, before a failure event, to meaningfully engage with public sector agencies and other organisations that would participate in medium- and long-term social and environmental post-failure response strategies. These agencies are likely to be quite different to the first responder groups engaged for Requirement 13.1. Requirements 14.2 to 14.5 apply after a catastrophic failure and would involve post hoc impact assessments, and stakeholder engagement to develop and implement plans that enable the participation of affected people in restoration and recovery works and ongoing monitoring activities.

1. Numbers in parentheses refer to the relevant requirement of the Standard.

2.2 EMBEDDED INTERDISCIPLINARY CONNECTIONS

The Standard embeds social performance in ways that may not appear obvious on first pass. For instance, in Topic II, Integrated Knowledge Base, the Standard calls for social performance knowledge to be included in early technical decisions given that these decisions determine, to a large extent, how a facility will affect people and the environment. Typically, this knowledge is not generated until the regulatory approvals or environmental permitting stage, which is often not early enough to support key decisions about tailings facility management. Decoupling the generation of social knowledge from regulatory requirements, and 'front end loading' that process, means that mine planners and tailings facility designers are better placed to minimise negative consequences to people and the environment from the very outset of project planning. Early access to information may even enable planners to identify sensitive or 'no go' areas, potentially saving time, resources and unnecessary conflict down the track.

To provide a specific example: under Topic II, Knowledge Base, the multi-criteria alternatives analysis (3.2) should be iterative and apply diverse criteria for the selection of sites, technologies and management strategies (e.g. upstream, downstream, centre line, in-pit and so forth). Having robust and relevant information available means that social performance can contribute to deliberations and actively influence outcomes. Successive reviews of alternatives will flag the need for more granular or different data and information, with each stage of the analysis building on new inputs. Through this iterative process, in conjunction with other disciplines, social performance inputs can be scaled up as options are narrowed down.

Throughout the Standard, social performance is positioned as integral to tailings facility management. This includes a series of requirements under Topic III, Design, Construction, Operation and Monitoring of the Tailings Facility. For instance, numerous social performance aspects from Topic II, Integrated Knowledge Base, would be used to inform the Consequence Classification. Topic III also includes requirements to use social management (6.1) and social monitoring (7.1) systems in the management of a tailings facility, as appropriate to the data and information that becomes available. The Expert Panel carefully built these types of evidence-based interconnections throughout the Standard, as an underlying logic.

Topic IV, Management and Governance requires the establishment of a tailings governance framework and confirms the Environmental and Social Management System (ESMS) as an integral component (8.2). This topic nominates one or more Accountable Executive(s) as responsible for, amongst other matters, avoiding or minimising the consequences of a tailings facility failure for local people (8.4). Other requirements include multi-disciplinary risk assessments (10.1), and the review (10.2) and audit (10.3) of the ESMS as it relates to the tailings facility.

Accountable Executives will need to rely on social performance knowledge and expertise in order to discharge their duty to minimise adverse social consequences (8.4). In the same way, the Standard specifies that a Responsible Tailings Facility Engineer (RTFE) should liaise not only with operations and mine planners, but also with social and environmental teams on matters that are relevant to the tailings facility (8.5). This may include, for instance, being involved in processes of stakeholder engagement and information sharing, responding to grievances or concerns about the facility, or changes in downstream land use about which the RTFE may not be immediately aware. These changes could include, for instance, an increase or decrease in human settlements, the influx of artisanal miners into areas identified in the dam breach analysis as potentially impacted, or damage to downstream engineering measures through community activity. In this way, the social performance footprint extends well beyond the more 'obvious' elements of the Standard.

Public accountability for tailings facilities must respond to a set of discernible local-level concerns for public health and safety. While the documents listed under Topic VI, Public Disclosure and Access to Information will likely be in the hands of other functions, such as external affairs and legal, many of these concerns fall within the purview of social performance. Regularly publishing and updating information (15.1) and responding to reasonable requests for additional information (15.2) is fundamental to meaningful engagement at the local-level, and for generating trust across the stakeholder spectrum.

2.3 GAPS AND OMISSIONS

The Standard sets a new benchmark for integrating social performance considerations into a deeply technical area. Nonetheless, there are some aspects that were not fully resolved by the Expert Panel and at this point are not integrated into the Standard. For instance, the Standard does not confirm the rights of project-affected people to *participate* in tailings-related decisions that affect their lives. This language sat uncomfortably with some tailings facility specialists, reflecting the gap that still exists in understanding how social performance work supports rather than undermines technical decision-making. The essence of the concept (i.e. 'participation') is addressed, such as through the glossary definition for 'meaningful engagement'. In our view, this need not have been a contested term, and will be one of a number of concepts that is likely to become part of the Standard as it evolves.

It is also the case that we were not always familiar, or comfortable, with the terminology and concepts used in other disciplinary areas, and other disciplines adjusted some of their language to account for our preferences and understandings. For instance, the use of 'material' in a sustainability reporting sense is well established, whereas to engineers, 'material' is a physical substance or object. Finding agreement on these terms was often difficult. In our view, deep and sustained engagement between experts from different disciplines would help to build mutual understanding in other similarly complex and contested topic areas. The imperative created by the Standard to move beyond comfortable disciplinary 'streams', and engage in interdisciplinary work is a significant undertaking, with potential upsides for people and the environment and ultimately mining companies themselves.

Acknowledging the challenges, our priority in this process has been to put forward a workable and technically accurate Standard that included critical social performance components that were well integrated with the technical aspects of the standard. While we certainly support the version of the Standard that has been endorsed by the co-conveners, we are also of the view that it should not be regarded as an immutable document, but rather, as the basis for interdisciplinary discussion that will continue to evolve over time.

3. WHAT IS DIFFERENT ABOUT THIS STANDARD?

In its initial phase of work, the Expert Panel was tasked with reviewing international standards and guidelines about tailings facilities to understand coverage of our respective disciplinary areas. We were also tasked with reviewing standards and guidelines within our own areas of specialisation for coverage of tailings facilities. This process of review continued throughout the Standard drafting process. While there are many voluntary standards and schemes in active use, we focused on those in which a connection was expected or was identified. These are listed in Table 1.

The best example of a voluntary standard that is beginning to forge some connections between tailings facility management and social performance can be found in the Tailings Management Protocol and the Indigenous and Community Relationships Protocol for the Mining Association of Canada's (MAC's) Towards Sustainable Mining scheme. Both of these protocols were updated following the Mount Polley failure. Key aspects of social performance are addressed in the tailings-specific protocol, with some cross reference to the community-specific protocol. That said, social performance is not integrated to the degree that has been achieved in the Standard. In regard to the numerous other sustainability standards that we reviewed, but that are not in the table, our principal observation is that the connections between the technical aspects of tailings facility management and social performance are absent.

In this sense, we confirm that, from a social performance perspective, the 'step change' in the Global Industry Standard on Tailings Management is that it connects leading practice social performance to the topic at hand and demonstrates the criticality of integrating social performance into this high-stakes field of practice. There is no equivalent standard in this respect.

Table 1. Voluntary standards: social performance strengths and opportunities to strengthen

Standard	Scope	Social performance strengths	Opportunities to strengthen
Tailings Management Protocol, as part of MAC's Towards Sustainable Mining (TSM) scheme.	Tailings-specific standard. Facility focused. Supported by the Guide to the Management of Tailings Facilities, and the guide to Developing and Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities.	Requirements to understand community expectations about tailings facility management through local-level engagement. Requires community engagement in emergency planning.	No requirement to respect human rights with reference to the UNGP. No requirement for participation of project-affected people in decisions about public safety. No coverage of long-term recovery after a failure. No requirements for public disclosure.
Position Statement Tailings Governance Framework, ICMM.	Tailings-specific position statement.	Nil.	No coverage. Excludes ICMM Principle 9 on Social Performance.
Standard for Responsible Mining, Initiative for Responsible Mining Assurance.	Comprehensive sustainability standard with a waste-specific chapter and social performance chapters. Applies site-wide.	Focus on preventing harm to people and the environment. Disciplinary depth within chapters.	Few explicit cross references between social performance and tailings facilities. No coverage of long-term recovery after a failure or public disclosure in the Waste and Materials Management Chapter. No coverage of waste or tailings in the Human Rights Chapter.
International Finance Corporation's (IFC) Environmental and Social Performance Standards, IFC.	Comprehensive social and environmental performance standards. Applies project-wide.	Focus on minimising risk to people and the environment. Disciplinary depth and systems focus.	No substantive cross-references between social performance and tailings facilities.
TSM Indigenous and Community Relationships Protocol, Mining Association Canada (MAC).	Applies site-wide. Broad focus on building local-level relationships, and managing impacts and benefits throughout the mine lifecycle.	Disciplinary depth. Includes a list of tailings-related issues that may be of interest to people at the local-level.	Use of tag clause: '…including those associated with tailings management (as applicable)', but few substantive points of connection back to the Tailings Management Protocol.
The International Council on Mining and Metals' social performance-related principles, performance standards, guidance materials and tools.	Broad focus on building local-level relationships, and managing impacts and benefits throughout the mine lifecycle.	Disciplinary depth. Reference to a range of leading practice standards.	Across the ICMM's full suite of 'social performance' documents, few explicit connections are made between social performance and tailings facilities.

4. WHAT WAS INVOLVED IN INTEGRATING SOCIAL PERFORMANCE INTO THE STANDARD?

We use the analogy of a 'push-pull' dynamic to describe our efforts at integrating social performance into the Standard. A 'push' dynamic occurs when a producer or supplier works to convince a consumer to use their product or service. A 'pull' dynamic occurs once a consumer is convinced and begins to request that service because they see inherent value in it. In this section, we take social performance as an available service, and tailings facility engineers, specialists and other accountable persons as potential consumers of that expertise and knowledge. We sought to create an inherent 'pull' for social performance, to avoid social performance practitioners having to routinely justify their role at the operational level.

The inclusion of social performance aspects in the Standard was logical for some stakeholders, and the composition of the Expert Panel suggests that its inclusion was part of the ambition from the very outset of the GTR. Nonetheless, we encountered strongly held arguments from some of those who made public submissions, some members of the advisory group, and others from within industry, that social performance should be removed from the Standard or relegated to guidance material. The reason given for excising social performance from the Standard was that it diverted attention away from the physical integrity of tailings facility and detracted from the important task of preventing catastrophic failures. Our argument that context is crucial to preventing catastrophic outcomes and minimising consequences was not accepted by all. As a result, we found ourselves working to make the case that social performance is critical to preventing catastrophic failures.

Take the example of the process of determining the consequence classification for a facility. Ideally, when dam designers classify a facility, they call upon social performance knowledge and expertise in determining potential loss of life and other consequences across health, social, cultural, infrastructure and economic categories in their tables. Engineers should expect that information about human exposure is available and accurate, and that expertise is on hand to assist with deliberations about the classification, should this be necessary. They should also expect that the information is appropriate to the site and the context in which they are operating, recognising that in some cases, significant effort will be required to collect and collate that information. Engineers should not assume that they have this knowledge, or just rely on guess-work to estimate life and loss in the external context. Instead, they should expect to work in an environment where social performance knowledge and expertise is available to them when they, and others, need it.

Social performance specialists should likewise expect that they will have access to the resources they need to commission and conduct the necessary studies and build accurate and accessible information. It is sometimes the case that financial and human resources are available, but that the lead time for conducting studies is inadequate. Studies conducted in remote areas with difficult transportation routes, across language groups, and in situations where consent is required to proceed with data collection, need to be scheduled and planned to ensure that adequate time is allowed, with in-built flexibility and contingencies.

All these factors need to be considered in making this knowledge available for the purposes of supporting safe tailings facility management. The outcome required by the Standard will not be achieved if the social performance function is unable to furnish engineers and other specialists with quality data, information and analysis. The Standard seeks to address this by 'front-end loading' the study process by insisting that social performance knowledge is built from the outset of project planning (alongside other types of knowledge), and pulled into the decision-making process, as needed, throughout the tailings facility lifecycle.

Leading companies already require the early development of a robust knowledge base to use in their engagement processes, studies, and planning and management processes. One area where even leading companies may not have ventured is in re-thinking the composition of Independent Tailings Review Boards (ITRBs). Most ITRBs are comprised of engineers and other technical specialists as needed for specific site conditions. With the Standard's focus on the context in which a facility is located, we would expect that the ITRB will, from time to time, include social performance in their review processes. This may involve, for instance, a review of the operator's assessment of human exposure and vulnerability to confirm that it interfaces adequately with the dam breach analysis. As an important line of defence, the ITRB should be 'pulling' social performance into the review processes whenever circumstances warrant.

In practice, the push-pull dynamic that we describe here is fluid and can range from open collaboration to a more reluctant, even combative, type of engagement. There is a risk that some technical specialists will remain unconvinced that social performance knowledge is relevant to the prevention of catastrophic failure and the safe management of tailings facilities. Thus, despite what the Standard requires on paper, it is possible that critical data about the social and local economic context will not be documented, and that information about social change over time will become de-linked from tailings facility management. Our aim has been to bring social performance to the forefront of the conversation about the safe management of tailings facilities, and to make the connection between social performance and technical aspects as explicit as possible. In doing so, we seek to extend what is currently understood to be 'best practice' in this arena.

5. DOES THE SOCIAL PERFORMANCE FUNCTION NEED TO BE STRENGTHENED?

If the Standard is immediately taken up, there will likely be a shortage of qualified and experienced professionals to meet demand. This problem exists across multiple disciplines, including in mine engineering and other specialist areas. In some companies, work will be required to build both social performance competency and organisational functionality to support the Standard. In this section, we consider some of the challenges that need to be overcome for social performance to contribute to the ongoing success of the Standard.

5.1 CHALLENGES AT THE PROFESSIONAL LEVEL

Social performance emerged as a specialized field in mining more than 20 years ago. Initially referred to as 'community relations' (Zandvliet and Anderson 2009; Kemp and Owen 2013), the field has developed in response to evolving stakeholder expectations and international standards. Leading companies have progressively incorporated these standards into their corporate policy frameworks. Most social performance practitioners are site-based, reflecting the grounded and characteristically place-based nature of the work. This means, however, that these practitioners tend to have relatively limited opportunities to interface with the global initiatives that are defining best practice in their field. The nature of the work also means that specialists spend much of their time engaging externally and can become disconnected from the business. Opportunities for peer-learning, and career development, remain relatively limited.

The field of social performance has many points of entry. Anecdotal evidence suggests that practitioners have a diversity of qualifications and experience, which can range from geology to environment, and from health services to security and policing. Some will have knowledge gaps in the technical aspects of mining, whereas others will have gaps in technical aspects of social performance. Locally hired practitioners may have deep knowledge of the context, but no formal training in either mining or social performance. Yet, there are few structured professional development pathways that enable social performance practitioners to address competency gaps.[2] At the time of writing, several university-based postgraduate programs had been disbanded due to low enrolments. Short courses and specialised forums are available but tend not to form part of a professional or formal qualification. The social aspects of mining have gained increased visibility at industry conferences; however, the emphasis tends towards showcasing company activities and achievements, rather than reflecting the needs of the cohort for professionalisation.

While there is a need to strengthen the competency of social performance practitioners, there is a parallel need to strengthen competencies in other disciplines. Practitioners and leaders from other disciplines that are active in the company-community interface should understand how social performance relates to their work. For instance, tailings facility specialists would ideally understand what is involved in a social baseline, an impact assessment and a human rights due diligence process, and in turn what they might utilise as outputs from these processes. Where social performance competency is built across an organisation it can harness collective capability to meaningfully engage project-affected people, communicate about risks and consequences, avoid or mitigate impacts, and contribute to safe tailings facility management over the long term. Interdisciplinary work involves both deep disciplinary expertise, and a structured approach to working across disciplines on cross-cutting issues.

5.2 STRUCTURAL AND SYSTEMIC ISSUES

Researchers have raised issues about how companies are configuring their social performance functions and

2. While there have been various attempts to do so, social performance competencies have not been systematically defined at an industry level – either for social performance generalists or those who may be working in a sub-field such as indigenous relations or resettlement.

whether they are 'fit-for-purpose' (Owen and Kemp 2017). It is common, for instance, for projects that involve resettlement, or mining on indigenous peoples' lands, to have limited access to specialist expertise. Where expertise is procured from other sectors, specialists are not always 'on-boarded' in terms of understanding the technical aspects of mining, such as the design and operation of tailings facilities. It is essential that social performance expertise is geared to the mining project, and the context in which it is situated. This same logic applies to tailings facilities. Expertise must be geared towards the facility, the local operating context and the expectations of affected and interested stakeholders.

Another consideration is alignment with the Standard's goal of zero harm to people. Global mining companies are readily prioritising strategies aimed at enhancing their reputation and demonstrating 'benefit'. However, a predominant focus on building up reputation can inadvertently skew an operator's focus towards appearance, rather than performance. The Standard has a clear focus on risks to people, rather than risk to the operator's reputation. Consider a mine with a tailings facility in a context where an urban majority realises benefits through direct employment, business opportunities, and community investment, while downstream settlements carry the burden of risk in terms of the potential consequences of failure. The Standard aims to avoid this scenario by requiring operators to focus on both probability and consequences. An enhanced corporate reputation may be the outcome of such measures, but it should not be the driver.

Finally, we observe that the social performance function is at a disadvantage in terms of its position in most corporate hierarchies. Over the past few years, many of the largest mining companies have brought their social performance functions under communications or external affairs, and many are now represented at the executive and board level under this banner. We see the function being re-orientated towards reputation-enhancing initiatives that have little bearing on how a mining complex is designed or configured, including how waste is managed and how tailings facilities are designed and operated. The priority should be on installing a social performance function with the resources and influence it needs to operate effectively. As we have outlined, this should involve the social performance function being 'pulled' into decisions on the basis that interdisciplinary work is critical to preventing catastrophic failure, rather than the function having to 'push' its way into conversations in order to contribute to operational decisions.

6. CONCLUSION: WHAT LIES AHEAD FOR SOCIAL PERFORMANCE IN THIS ARENA?

The Standard is a next generation regulatory framework, in which social performance is integrated, not separated, from consequential decisions at the operational level. Social performance is not symbolically positioned alongside the technical aspects of tailings management, but rather, positioned to influence outcomes. If the Standard is broadly adopted, effort will be needed to increase industry capacity in social performance. Industry capacity is currently low, and specialist knowledge and expertise are not widely available. Moreover, the position of the social performance function within corporate hierarchies may not be aligned to the task. Appropriate organisational structures, disciplinary diversity and an inclusive approach to managing risk to people and the environment are keys to 'moving the needle' to a level that satisfies stakeholder expectations in this arena.

The challenging process of getting to an agreed standard reflects the tensions present across the industry between disciplines, and with different stakeholder groups. There have been constructive conversations during the Global Tailings Review and some progress made towards building mutual understanding. We hope that the current appetite for difficult conversations continues into the future. Tailings facilities require precision in design, construction and management. As complex engineered structures, they must apply robust design criteria to maintain physical integrity throughout their lifecycle. At the same time, there is a recognition that both engineered structures and human systems are fallible. The Standard supports industry efforts to move beyond purely technical solutions to bolster safeguards, enhance public accountability, and position the goal of zero harm to people and the environment, with zero tolerance for human fatality as a clear priority.

KEY MESSAGES

1. Mining companies should avoid equating the social performance function solely with community engagement, and work to strengthen the scientific, organisational and legal dimensions of this function.
2. Senior management should 'hard-wire' social performance into operational management practices to maximise the value of the function.
3. Companies should review whether operational-level social performance functions are 'fit-for-purpose' (i.e. appropriate to both the tailings facility and the local context) and adequately resourced.
4. A high-level of interdisciplinary effort is required to support the safe management of tailings.
5. Managers at all levels of a mining company should maintain a willingness to engage in and promote cross-disciplinary conversations on specialist topics such as tailings facility management, and actively support inter-disciplinary work.

REFERENCES

Joyce, S. (2019). Challenges and strategies for meaningful rights-holder participation in company-commissioned HRIA. In Götzmann, N. (ed.) *(2019), Handbook on Human Rights Impact Assessment*. Edward Elgar: Cheltenham, UK.

Kemp, D. (2010). Community relations in the global mining industry: exploring the internal dimensions of externally orientated work. *Corporate Social Responsibility and Environmental Management*, 17 (1), 1-14.

Owen, J.R. and Kemp, D. (2017). *Extractive Relations: Countervailing Power and the Global Mining Industry*. Greenleaf Publishing/Routledge: Sheffield, UK.

Zandvliet, L. and Anderson, M. (2009). *Getting It Right: Making Corporate-Community Relations Work*. Routledge: Oxfordshire.

CHAPTER IV LESSONS FOR MINING FROM INTERNATIONAL DISASTER RESEARCH

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1. INTRODUCTION

When there is a major industrial disaster, there are a number of common reactions. People express shock or anger, empathise with victims, and applaud rescue efforts. Losses and damages are calculated, and forensic investigations ensue. Many people will ask how the disaster happened. However, while legal charges may be laid against individuals and organisations, and moral disapproval expressed towards those seen as responsible for the disaster, rarely do we insist that investigators look beyond immediate events and probe for deeper underlying causes. In the aftermath of a disaster – and before public interest wanes – popular media tends to centre on the drama, the tragedy, and the crimes of those who failed to fulfil their corporate responsibilities.

This sequence mirrors what has occurred after devastating failures of mine tailings facilities. Most recently, the world expressed shock at the torrent of sludge that wiped out villages and ecosystems in Brazil, watched in horror as the death count of employees and community members rose, and empathised with the families whose lives and livelihoods were shattered. Forensic studies of the tailings facilities were commissioned, examining their design, integrity and stability. The decisions that immediately preceded the failures and the sudden release of slurry were also scrutinised and flaws exposed. As prosecutors identified who was responsible, fines were issued, damages paid, and charges instituted against corporate executives.

There is a growing movement in contemporary disaster research that asks not only why a particular event occurred, but why it resulted in disaster. This approach pushes towards a deeply structural and systemic analysis on the basis that conventional investigations of catastrophic events provide only a partial explanation. The approach pivots away from conceptualising disaster as a spatially and time-bound event, and towards seeing the broader context as a potential cause of the disaster, and not simply as the backdrop against which disaster plays out. Re-framing disasters in this way has important practical implications, as it significantly broadens the focus of efforts to prevent catastrophic outcomes in the future.

In this chapter I draw on this body of work to demonstrate the value of viewing tailings disasters as resulting from a set of factors and forces that produce conditions of vulnerability that create or contribute to disasters, rather than a disaster being attributable solely to the hazard; or in the case of a tailings facility, the failure of an engineered structure. I also examine the challenges associated with mobilising forensic, broad-based research to conduct this form of analysis, and explore the implications for the global mining industry of viewing disasters from a perspective that includes people's vulnerability as a causal factor.

The first part of the chapter defines 'disaster' and 'disaster risk', and then reviews developments in international disaster research and practice. I then briefly elaborate five principles that define this contemporary approach to understanding and explaining disasters. In the concluding section I reflect on the benefits of taking a broad-based approach to analysing disaster risk in mining and discuss the challenges associated with changing how the industry views – and therefore seeks to explain – the causes of a tailings disaster.

A key aim of the chapter is to demonstrate that social, cultural, political and historical factors must be considered if the goals of the Global Industry Standard on Tailings Management (the 'Standard') are to be realised. Deeply technical knowledge from

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the physical sciences is crucial to the safe design, construction, management, and closure of tailings facilities. However, while such knowledge is essential, it is not sufficient for understanding and addressing the myriad underlying causes that give rise to tailings facility disasters. The Standard has succeeded in positioning other, non-technical considerations as relevant to risk reduction (e.g. local-level engagement, organisational management systems and internal culture), but further shifts in the mining industry's approach will be required to achieve the ultimate goal of preventing catastrophic tailings facilities failures.

2. DEFINITION AND KEY INTERNATIONAL INSTRUMENTS

The outcomes associated with recent tailings dam failures are commonly described as 'catastrophic'. This term features prominently on the Global Tailings Review (GTR) website. The ICMM likewise states that it is committed to achieving 'the safe and secure management of tailings facilities that *prevents catastrophic failures'* (emphasis added).

In common parlance, 'disaster' and 'catastrophe' are often used interchangeably, although they have different etymological roots, with the term catastrophe tending to signal a more far reaching, or permanent, disruption.[1] In this chapter I have opted to use 'disaster' as the key term, largely because it is grounded in an established literature, utilised by global bodies, and embedded in international instruments of policy and practice.

The United Nations Office of Disaster Risk Reduction (UNDRR), defines a disaster as:

A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.[2]

According to this definition, a cyclone that remains off-shore in an unpopulated area is not a disaster; it only warrants this label once it makes landfall and causes widespread damage. If we apply the same approach to the mining industry, structural failures to tailings facilities become disasters when there

Box 1: The Components of Disaster Risk

The foundational definition of 'disaster risk' is DR = H x V. This formulation (Blaikie et al. 1994) represents disaster risk (DR) as a function of hazard exposure (H) and people's vulnerability to hazard (V). Later versions (Wisner et al., 2003), include other elements, such as people's capacity to cope (C), which is linked to the concept of 'disaster resilience'.

$$DR = \frac{H \times V}{C}$$

are major long-term consequences for people and the environment. It is these 'disastrous' failures that have garnered public attention and provided the impetus for commissioning a global review of the industry's approach to managing tailings facilities.

As the UNDRR definition indicates, contemporary disaster studies are mainly concerned with hazards and hazardous events that cause, or have the potential to cause, significant harm and disruption to people, either directly or indirectly.[3] In a similar vein, Oliver-Smith and Hoffman (2002, p.4), in the opening chapter to their volume *Catastrophe and Culture*, define disaster as:

A process/event combining a potentially destructive agent/force from the natural, modified or built environment, and a population in a socially and economically produced condition of vulnerability, resulting in a disruption of the customary relative satisfactions of individual and social needs for physical survival, social order and meaning.

From this perspective, disasters are defined not only by hazards that carry the potential for loss of life, injury or damage, but also by those processes that set hazards in motion, exposing them to people and places.

Since the 1990s, the United Nations (UN) has been working to change the prevailing paradigm of disaster research by challenging the notion of a 'natural disaster'. A new way of conceiving of disaster and disaster risk is now embedded in international instruments of the UN. This perspective holds that

1. In engineering, the term 'catastrophic failure' is often used to describe 'a rapid and irreversible structural failure'. This is a narrower formulation that characterises the failure event itself, rather than its consequences.
2. See: UNDRR's knowledge platform for disaster risk reduction, *PreventionWeb*. https://www.preventionweb.net/terminology/view/475

3. This is not to discount the significance of impacts on other types of populations (e.g. the widespread loss of wildlife as a result of a massive wildfire) but that is not the primary focus of disaster studies, or of this chapter.

disasters are, in fact, created and are not at all a natural outcome. This way of thinking about disaster is encapsulated in the *Sendai Framework for Disaster Risk Reduction (2015–2030)*, which was adopted by member states in early 2015 at the World Conference on Disaster Risk Reduction held in Sendai, Japan and endorsed by the UN General Assembly later that same year.[4] The first goal of the framework is to ensure that disaster risk reduction policy and practice is based on understanding of people's vulnerability to hazards, and how that vulnerability comes about. The framework also recognises the constructive role that the private sector can play in this arena.

The *Sendai Framework* applies to a full range of disaster risks, including small and large-scale disasters, frequent and infrequent events, rapid and slow-onset disasters, as well as tectonic, climatic, technological, engineered, chemical, and biological hazards and risks. In effect, the framework recognises that smaller, isolated and remote mining communities can be devastated by a tailings facility failure and, in effect, experience a 'disaster'.

The *Sendai Framework* also recognises that disasters are not limited to sudden events, and can involve, for instance, chronic impacts – such as the long-term health effects of tailings dust or water contamination. By contrast, the mining industry's current focus is on tailings facility failures that take the form of sudden and acute events, rather than other types of failures that have slow-moving and chronic impacts. The *Sendai Framework* also recognises that industrial disasters can arise from compound interactions, such as those associated with climate change. For a tailings facility, this includes the compounding effects of extreme weather events, both in contributing to the failure of facilities and in exacerbating the consequences of these failures.

3. FIVE PRINCIPLES OF CONTEMPORARY DISASTER RESEARCH

This section elaborates on five principles that characterise contemporary developments in international disaster research. For each principle, I note the relevance to tailings facilities, and potential implications for the mining industry.

3.1 DISASTER EVENTS AS CONDITIONED BY SOCIAL PROCESSES

According to Oliver-Smith and Hoffman (2002), disasters do not just happen. Rather, they occur through the interaction of two factors: the presence of a human population and a potentially destructive agent. Both of these elements, and the relationship between them, are in turn embedded in broader natural, economic and social processes. Oliver-Smith and Hoffman (2002) approach disasters as processes that reach backwards in time and space, and that are linked to issues that exist beyond the site, and beyond the decisions and actions of those who were implicated in immediate events. They note that the roots of disasters also track forward in time, to impact on future loss of assets and income; political mobilisation (e.g. growth of opposition to large-scale mining); and the time it takes for social and environmental systems to recover from disaster.

From this perspective, tailings dam failures become disasters when people are directly harmed by a failure (e.g. through loss of life or shelter, serious damage to property) and/or there are significant impacts on places to which people have attached value, significance or meaning. These can include places of economic, ecological, cultural and spiritual meaning and value. This perspective positions tailings disasters as imbued in a history and politics, and embedded in a range of issues that exist beyond the time and place that the disaster occurred.

Contemporary scholars argue that, while disasters may be triggered by natural phenomena (e.g. earthquakes, cyclones), the impact of these hazardous events is a function of socially constructed conditions (Santos and Milanez 2017). For example, whether or not people living downstream from a tailings facility have escape routes, access to transport, or dwellings that can withstand an inundation from a flow failure is mainly determined by the societal context, including economic and political processes at different scales. Likewise, these same processes determine where people live and work, their access to information, and their level of protection and preparedness, and therefore who is most vulnerable to or 'at risk' from a tailings facility failure.

Most research about tailings facility failures focuses on the engineered structure and the properties

4. The Sendai Framework follows the Hyogo Framework, which was the global blueprint for disaster risk reduction efforts between 2005 and 2015.

of the materials stored in it, and why the facility failed to contain water and waste. More recently, some research has focused on how organisational factors contributed to failure, with several studies concluding that organisational structure and culture had a significant role to play. However, contemporary disaster research would go further than this and also examine the ways in a broader set of off-site and supra-organisational factors interacted to produce the conditions of disaster. This approach does not deny the significance of the hazard, the engineering or organisational factors of a facility failure, but reminds us that engineered structures and organisations are created by people whose decisions and actions are shaped and constrained by the context in which they operate. This broader context includes processes of governance, law, regulation, policy, enforcement, cultural attitudes towards risk, and a range of micro and macro power structures.

Focusing on the broader context of a disaster highlights that: (i) social and political systems create hazards and the entities that manage them, and (ii) these systems place different people at different levels of risk from the same hazard. The risk status of different groups of people, and their experience of a hazard or a disaster event, is differentiated on the basis of social attributes such as wealth, class, race, ethnicity, language, gender, age, education, health, and immigration or citizen status. Contemporary disaster research demands that developers, states and other 'producers' of hazard examine these factors and understand how they contribute to disaster risk and occurrence.

In short, disasters, should always be seen as a reflection of *existing* social and political processes, rather than as *exceptional* events that sit outside what a society may consider to be 'normal'.

3.2 VULNERABILITY AS A POWERFUL EXPLANATORY VARIABLE

Contemporary disaster research positions the vulnerability of people as a key determinant of whether an event becomes a disaster. The commonplace meaning of vulnerability is the propensity or predisposition of an individual or group of people to suffer damage and loss, including loss of life, livelihood and property or other assets. For the purposes of disaster research, vulnerability refers to those social characteristics and conditions that place people at risk in terms of their ability to anticipate, respond to, and recover from a hazard event (Oliver-Smith *et al.* 2016). As argued above, insofar as vulnerability and people's capability to cope under adverse conditions is socially produced, it is also the case that disaster risk is unevenly distributed across the social spectrum. It is important to recognise, however, that vulnerability to a hazard is not solely defined by poverty and disadvantage. Even though disasters so often affect this demographic, people can be vulnerable to a hazard in many different ways, and for different reasons, not just because they are poor.

In applying the notion of vulnerability to disaster studies, Wisner *et al.* (2003) include a temporal dimension whereby vulnerability is measured in terms of loss and damage to past, present and future livelihoods. Vulnerable individuals and groups are those who would find it hardest to reconstruct their lives and livelihoods, and to recover in the aftermath of a disaster. The same factors in turn make them more vulnerable to the effects of subsequent or compound hazards. The word 'livelihood' is important in this definition, with Wisner *et al.* referring to the command that an individual, family or social group has over their income and the bundles of resources that they can use or exchange to satisfy their needs. These resources may include information, knowledge, social networks, and legal rights, as well as land and other tangible and intangible assets. For these reasons, understanding livelihoods is critical to understanding vulnerability.

Most contemporary disaster research now defines disaster risk in terms of hazard *and* vulnerability. These factors are considered to be interdependent in the sense that exposure to a hazard reflects how social relations of production unfold in territory and geography, including within and across mining landscapes. In short, vulnerability to disaster is characterised by a range of social, economic, political and cultural conditions that increase people's propensity to experience loss and harm. It is increasingly common for people's capabilities to be factored into the equation; that is, their ability to manage a hazard and cope under adverse conditions. This reflects an increasing focus on 'resilience' and represents a distinct point of convergence between human development and disaster research.

3.3 THE PRESSURE AND RELEASE MODEL

The search for deeper explanations as to why disasters unfold has led to the development of models based on analysing people's vulnerability in specific hazardous situations. The Pressure and Release (PAR) Model (Wisner *et al.* 2003) is useful in this regard (Fig. 1). The PAR is not a complete model for

understanding the root causes of disaster, but rather, a model for analysing how people become vulnerable to a hazard. This model helps to bring into frame other root causes of disaster, aside from the precursors and factors driving and mobilising the hazardous event. I introduce the PAR model here not as a replacement for studies of the engineered structure, or studies of organisational factors, but as a complement that might help to build a more complete picture of why a tailings disaster unfolded.

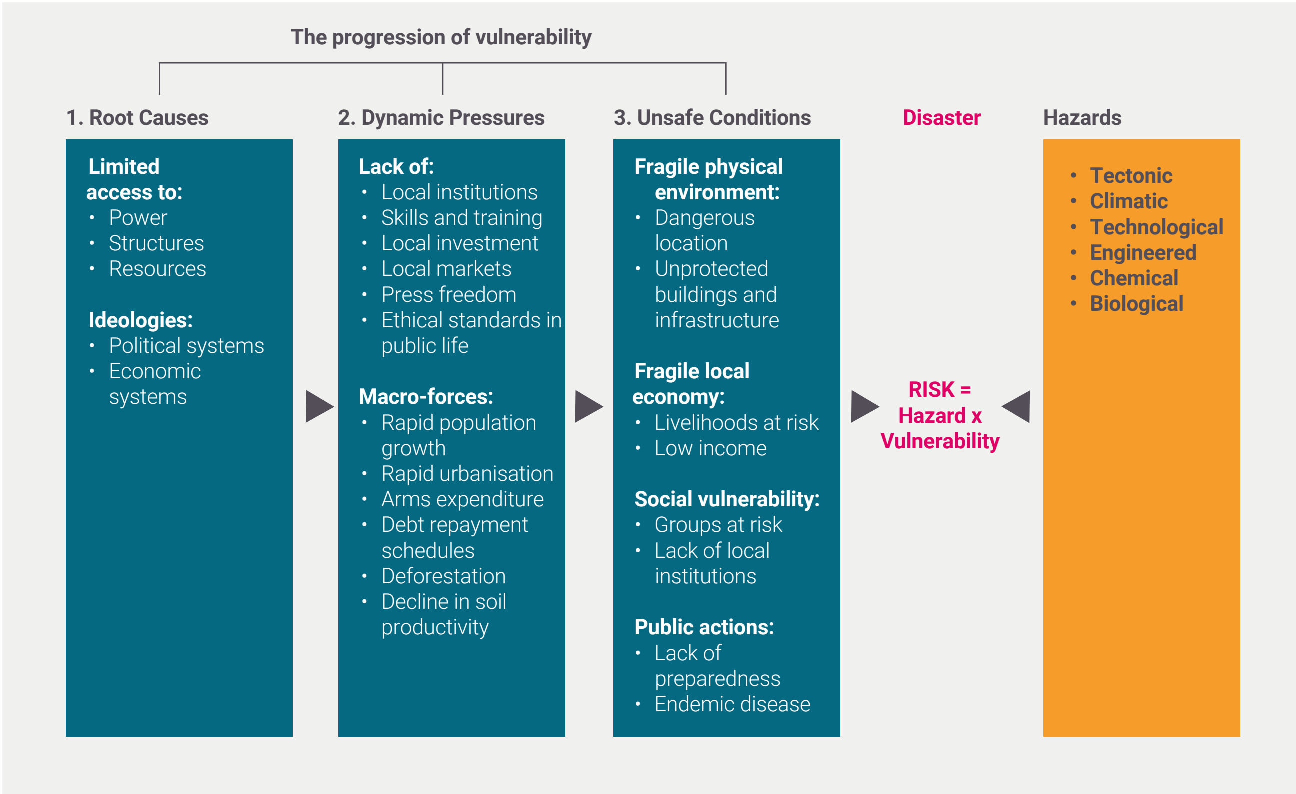

Figure 1. The Pressure and Release (PAR) Model. Adapted from Wisner et al. (2003).

The PAR model represents disaster risk as the interaction of 'hazard' and 'vulnerability', with disaster being the 'crunch point' between these two sides of the equation. The model is weighted to the left, as it is designed to promote an examination of vulnerability at different depths and scales. This model was originally designed to examine vulnerability in the face of natural hazards. Nonetheless, in evaluating the disaster risk of a tailings facility, the model helps to identify the links between the impact of a failure, and those processes that generate conditions of vulnerability.

The PAR model traces the connections that link a disaster with a series of social processes that produce vulnerability. This series starts with deeply structural, generalised and often distant 'root causes'. These causes are 'distant' from the disaster in one or more ways: spatially (arising in a distant centre of economic or political power); temporally (based in the past); or by being so bound up with cultural assumptions, ideology, and established knowledge systems that they have become 'invisible' or 'taken for granted'. These underlying causes are usually connected to the function (or dysfunction) of the state and other economic and political systems that reflect the exercise and distribution of power.

The second link in the chain of causality are 'dynamic pressures', which serve to translate or 'channel' generalised root causes into specific 'unsafe conditions'. These dynamic pressures can include, for example, migration or patterns of production and consumption. Dynamic pressures are not always negative, but in certain circumstances will manifest as 'unsafe conditions'. These conditions may include people having to live or work in hazardous locations, or survive through dangerous or precarious work. The 'crunch point' – the disaster – comes when those conditions combine with a hazardous event in a specific time and place.

3.4 CONTEXT AS POTENTIALLY CAUSAL TO DISASTER

Despite the utility and availability of the PAR and other similar models, the dominant initial response following tailings-related disasters has been to commission studies to identify why the facility failed, rather than inquire why and how people, or things they value, where made vulnerable to the failure. For example, following the 2014 Mount Polley disaster in Canada, the provincial government, with the support of two First Nations, commissioned an independent investigation on the cause of the dam breach. Investigators attributed the cause of the disaster to flaws in the original site characterisation and other technical failures (Morgenstern *et al.* 2015). An investigation by the British Columbia Chief Inspector of Mines (2015) focused on organisational factors that contributed to the dam failure. Neither study considered why First Nation, and sites of importance were at risk, as these broader considerations were not within the scope of either review.

For the more recent 2019 Bruhmidino disaster in Brazil, the operator (Vale SA) commissioned two studies. First, there was a technical review, which concluded that a series of design and engineering flaws created the conditions for failure (Robertson *et al.* 2019). Second, an examination of the organisation concluded that a series of internal factors, such as corporate culture, faulty information sharing, and a skewed compensation structure, had a significant role to play in the failure (Nasdaq 2020). In PAR terms, these studies focussed on the hazard and the hazard-producing entity, rather than also examining why people and significant sites were vulnerable to a large-scale tailings facility failure, how they were affected, what is needed to support recovery, and how this situation might be averted in future. Ideally, a third study would be commissioned, bringing these broader issues into focus.

Brief background descriptions in the academic literature of the Samarco disaster (Demajorovic 2019; Santos and Milanez 2017) provide a sense of the deep historical issues that accompany technical failure. Contributing factors included, for instance: weaknesses in state and voluntary regulation, ritualised licencing processes, structural asymmetries that favoured developers, weak state enforcement capacity, lack of public participation, and limitations of public accountability in the absence of disclosure. In light of these findings, the industry's propensity to focus on the technical hazard is akin to conducting a narrowly scoped 'Bow Tie' analysis of the top event and removing other factors. While it is critical to understand the engineering aspects of a top event, focusing only on this aspect can create blind spots in other areas.

The root causes of vulnerability, and therefore disaster, will always be entangled with underlying problems that are embedded in a society's history, politics, structure, culture, organisation, and the nature of human-environmental relations. These factors will play out in each and every location where a tailings facility is situated. While there may be similarities between cases and contexts, differences must also be understood.

The aim of delving into these aspects is to identify the features of a host context that cultivate and energise the drivers that manifest in patterns of vulnerability. When these patterns are affected by a hazard event, or multiple hazard events, they combine to produce disaster. Identifying the specific features of each situation – at multiple scales of analysis – requires a shift from an exclusive focus on the facility and its failure, to a more inclusive focus that also examines the context in which laws, policies and other frameworks for resource extraction, human rights protection and environmental safeguards are negotiated, developed and governed.

3.5 DEEPER INVESTIGATION AS CRITICAL TO PREVENTION

Understanding different modes of causality is critical for guiding decisions about investing in proactive disaster prevention and risk reduction measures. Around the world, the amount of investment in proactive strategies is eclipsed by the expenditure associated with reacting to disaster through emergency response and recovery efforts after the fact (Kyte 2015). Billions of dollars are committed to assist in emergency response efforts globally, but relatively little investment in research and programmatic interventions to avert future disasters. This is also the case in disasters involving natural and industrial hazards. For instance, the value of BHP and Vale's financial investment in the Renova Foundation, an independent entity designed to support the long-term recovery of affected communities, is likely to eclipse what might have been required to avert the disaster in the first place.

Building the case for addressing the underlying causes of disaster is a complex and multi-layered undertaking. Any call for investment must quantify disaster impacts, their spatial and social distribution, and the potential for loss and damage. The proposition must then address the immediate causes of those losses. This may include, for example, identifying that a loss of housing structures is due to poor building standards, or that loss of agricultural products is due to planting in the flood zone. However, to *prevent* a disaster, strategies must go further than calculating loss and damage and attributing impact to immediate cause. There must be an examination of *why* people were exposed to the hazard, and why conditions of vulnerability existed in the first place. The purpose of identifying deep causal chains and linkages is to identify which issues might be addressed by either long or short-term controls, and thus warrant proactive investment.

Understanding the underlying root cause of vulnerability, particularly multi-generational vulnerability, is not straightforward. Some aspects of the social environment are easily recognised, such as people living in adverse economic situations in hazard-prone zones (e.g. flood plains of rivers, earthquake prone areas). However, there are a myriad of less obvious political and economic factors that contribute to vulnerability to disaster. These factors relate to the manner in which assets, rights, income, and access to resources (such as critical information and data) are disclosed and distributed. People may also experience various forms of discrimination in the allocation of protections and availability of safeguards, including priorities in development, and in disaster relief and recovery efforts.

It is the less obvious factors that link a tailings facility and its associated risks to broader social and political processes. While addressing underlying root causes is unlikely to be the responsibility of a mining company, it is nonetheless a developer's responsibility to support and stimulate the generation of knowledge about the context and conditions in which they have chosen to build and operate a mine and a tailings facility. A commitment to knowledge building is vitally important for developers to know what will be disrupted through their decisions and actions, and to demonstrate how they are preventing or mitigating potential harm.

3.6 DISASTER RESEARCH AS INTER-DISCIPLINARY WORK

Given the complex processes leading to disaster risk and occurrence, it stands to reason that it is beyond the capability of any single group or discipline to analyse the full array of causes and effects that could be associated with a disaster. Disaster research must be a broad-based, collaborative and interdisciplinary undertaking that provides opportunities for a multiplicity of disciplines to engage at depth, while also creating opportunities for work that combines and synthesises different types of knowledge. Oliver-Smith *et al.* (2016) describe this process as broadening the 'circle of knowledge'. They also note that an absence of collaboration between natural, physical and social scientists has been a hindrance to mainstreaming a more integrated approach to disaster research.

Researchers, practitioners and advocates who argue for a deeper examination of vulnerability as a root cause of tailings facility disasters continue to make the point that their approach is not a *replacement* for technical investigations, or a diversion from the important work of engineers and other technical specialists. What they argue is that their approach is complementary and, in fact, essential to supporting the industry's goals of sustainable development and disaster prevention. Demonstrating to industry the value of understanding a diverse set of root causes for these disasters, beyond the engineered structure, needs experts who are willing to work across conventional boundaries. Moving beyond these boundaries also requires engagement with stakeholder groups to create an environment that is conducive to transformative work.

4. BENEFITS OF EXPANDING THE FRAME OF REFERENCE

The five principles discussed above are transforming international disaster research and practice and are helping to prioritise disaster prevention and risk reduction. The emphasis on disaster prevention is mirrored in the stated aims of the GTR and those of the ICMM and many of its members. However, stronger leadership is required to embed this approach in the mining industry, given the dominance of the engineering approach and the inclination to contain the investigative frame, rather than open it up.

According to Andrew Maskrey (2016, p. 5), coordinator of the bi-annual UN Global Assessment Report (GAR) on Disaster Risk Reduction at the UNDRR:

> *Transforming the direction of disaster research in a way that reveals the social construction of risk could contribute to a profound re-definition of disaster risk management. This includes understanding that historical processes operating at different asynchronous spatial and temporal scales configure the specific circumstances in which disaster occurs.*

The way disaster is framed makes a difference to whose interpretations of events are included or excluded in accounts of disasters (Rajan, 2003).

The aim of the UNDRR is to open the frame of reference, and to challenge convention. The ICMM was established to play a similar role; that is, to extend the industry's frame of reference towards sustainable development, and challenge conventional wisdom. From a UNDRR perspective, disasters must no longer be viewed as a single event, but a pivot around which multi-scalar, multi-stakeholder, and multi-disciplinary analysis should be conducted, and preventive and remedial strategies developed. Until we take account of multiple perspectives, and tackle a variety of underlying causes, patterns will re-occur, and the same problems will emerge, again and again.

Casting a broader analytical net is increasingly important given that new risks (and new connections between risks) are emerging in ways that have not been previously anticipated. In the context of climate change, the world is experiencing an ever-growing number of cascading and systemic risks across global and local systems for which predictive models do not yet exist. We have seen the burgeoning use of tailings facilities over the past decade, a trend which is likely to be maintained as demand grows, the mining industry expands, and grades continue to decline. We are also seeing an expansion of mining into remote and often sensitive locations, meaning that tailings facilities will increasingly be situated in complex landscapes that are characterised by a high co-occurrence of risk factors (Owen, *et al.*, 2019).

The UNDRR has challenged the public and private sectors to think in new and creative ways about development and disaster risk. For mining, a shift in perspective would align with existing corporate commitments to international frameworks such as the *UN Guiding Principles on Business and Human Rights*, and the *UN Sustainable Development Goals*. These and other internationally agreed frameworks are interconnected and interdependent in ways that the mining industry has yet to fully acknowledge. There is potential, for instance, for companies to integrate disaster risk reduction into development planning through these instruments. Mining companies could commit to a more coherent implementation of international instruments to which they already subscribe, and consider engaging with other frameworks, such as the *Sendai Framework,* that will help to establish linkages in far more explicit ways.

5. CONCLUSION: LOOKING TO THE FUTURE

If the goal is to prevent catastrophic tailings facility failures, there is little value to be had from confining the industry's attention to a facility focus, in isolation from considering people's vulnerability to that hazard. Yet, in response to recent events, the preference of some in the industry has been to narrow in on the facility, and advocate for other causes of disaster to be excluded from the field of vision. If this approach is maintained, tailings dam disasters are likely to affect human populations and the places they value in ever more profound ways. A broader and deeper analysis is needed – one that seeks to prevent disaster through a comprehensive understanding of the hazard and conditions of vulnerability. This type of analysis would help to ensure that industry efforts to manage risk are appropriate to each and every context in which a tailings facility is located. It would also demonstrate to a concerned public that the mining industry is committed to understanding the full extent of its disaster potential.

Looking to the future, the Standard can play an important role in promoting this shift in thinking. Currently, the Standard does not specify, for instance, that matters of vulnerability should be included in root cause analysis, or that incident investigation should include structural and systemic considerations that reach beyond the immediate proximity of the failure and consider the context in which the facility is situated. Incorporating such requirements into future iterations of the Standard, in line with the shifts that are now well under way in contemporary international disaster policy and practice, would assist the industry to better reconcile its dual potential for human development and disaster. The way in which the mining industry proceeds will be a defining feature of its own future, and that of the communities in which it operates.

KEY MESSAGES

1. Mining companies could improve their 'contextual intelligence' by paying greater attention to the social, environmental and local economic context in which a project is situated, and the project's effects on that context.
2. Including vulnerability as a relevant factor in root cause analysis would support mining companies to account for the structural and systemic aspects of disaster risk.
3. Mining companies could consider utilising other relevant frameworks, such as the *Sendai Framework for Disaster Risk Reduction 2015-2030*.
4. Better enabling of social specialists to contribute to tailings risk management (e.g. through participation in interdisciplinary processes) could help mining companies to avoid harm.
5. Both public and private sector actors should consider broadening the 'circle of knowledge' on disaster prevention, to include the natural, physical and social sciences, and the lived experiences of affected people.

REFERENCES

Blaikie, P., Terry C., Davis, I., and Wisner, B. (1994). *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. London and New York: Routledge.

British Colombia Chief Inspector of Mines (2015). *Mount Polley Mine Tailings Storage Facility Breach: Investigation Report of the Chief Inspector of Mines*. https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/further-information/directives-alerts-incident-information/mount-polley-tailings-breach/mount-polley-investigation.

Demajorovic, J., Lopes, J., Santiago, A. (2019). The Samarco dam disaster: a grave challenge to social license to operate discourse. *Resources Policy*, 61, 273-282.

Kyte, R. (2012). From disaster response to disaster prevention, TEDxSendai (English). https://www.youtube.com/watch?v=cWYcXhMhJF4.

Maskrey, A. (2016). Preface. In *Forensic Investigations of Disasters (FORIN): A Conceptual Framework and Guide to Research, Integrated Research on Disaster Risk*. Oliver-Smith, A., Alcantara-Ayala, I., Burton, I and Lavell, A. (eds). http://www.irdrinternational.org/wp-content/uploads/2016/01/FORIN-2-29022016.pdf

Santos, R.S. and Milanez, B. (2017). The construction of the disaster and the 'privatization' of mining regulation: reflections on the tragedy of the Rio Doce Basil, Brazil. *Vibrant: Virtual Brazilian Anthropology*, *14*(2), 127-149. http://www.ufjf.br/poemas/files/2016/06/Santos-Milanez-2017-The-construction-of-the-disaster-and-the-privatization-of-mining-regulation.pdf

Morgenstern, N., van Zyl, D. and Vick, S. (2015). *Independent Expert Engineering Investigation and Review Panel Mount Polley Tailings Storage Facility Breach*. https://www.mountpolleyreviewpanel.ca/

Nasdaq (2020). 'Brazil's Vale dam disaster report highlights governance shortcomings'. https://www.nasdaq.com/articles/brazils-vale-dam-disaster-report-highlights-governance-shortcomings-2020-02-21

Oliver-Smith, A. and Hoffman, S. (2002). *Culture and Catastrophe: The Anthropology of Disaster* (eds). Oxford: School of American Research Press.

Oliver-Smith, A., Alcantara-Ayala, I., Burton, I and Lavell, A. (2016). *Forensic Investigations of Disasters (FORIN): A Conceptual Framework and Guide to Research, Integrated Research on Disaster Risk.* http://www.irdrinternational.org/wp-content/uploads/2016/01/FORIN-2-29022016.pdf

Owen, J.R., Kemp, D., Lebre, E. Svobodova, K. and Perez Murillo, G. (2019). Catastrophic tailings dam failures and disaster risk disclosure. *International Journal of Disaster Risk Reduction*. https://www.sciencedirect.com/science/article/pii/S2212420919306648

Robertson, P., de Melo, L., Williams, D., and Ward Wilson, G. (2019). *Report of the Expert Panel on the Technical Causes of the Failure of Feijão Dam I.* http://www.b1technicalinvestigation.com/

Sendai Framework for Disaster Risk Reduction 2015 – 2030. (2015). https://www.unisdr.org/we/coordinate/sendai-framework

United Nations Guiding Principles on Business and Human Rights (UNGPs) (2011). https://www.ohchr.org/documents/publications/guidingprinciplesbusinesshr_en.pdf

United Nations Sustainable Development Goals (SDGs) (2011). https://sustainabledevelopment.un.org/

Wisner, B., Blaikie, P. Cannon, T and Davis, I. (2003). *At Risk: Natural Hazards, People's Vulnerability and Disasters*, 2nd ed., London: Routledge.

MANAGEMENT OF TAILINGS: PAST, PRESENT AND FUTURE

CHAPTER V MINE TAILINGS – A SYSTEMS APPROACH

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1. INTRODUCTION

There have been tailings facility failures since the inception of placing tailings on land in facilities versus the practice until about 100 years ago of directly placing all tailings into watercourses. Over the past 100 years, the amount of tailings produced has continued to increase as global ore grades decline and the economics of mining drive towards larger operations. While the number of failures per tonne of tailings produced on an annual basis has declined, the number and nature of facility failures remains wholly unacceptable. The recent failures of tailings facilities have turned the public and technical spotlights on tailings management at mines and the mining industry in general. In the last six years, major failures at Mount Polley, Samarco, Cadia and Brumadinho have led to a loss of confidence in the mining industry to manage the risk of tailings facility failures. Given the communication age upon us, failures that may have happened a few decades ago that only received regional attention, if any, are occurring in front of a global audience.

These failures have resulted in a renewed focus on the impact on lives and on the importance of tailings management relative to a potential failure, as well as the financial and reputational impact to mining companies. Mining is an essential industry to our modern world – it is not an optional industry or one that is likely to reduce in its importance to people in the future. As such, it has become increasingly clear that tailings facilities are important elements of mining operations and their safety must be considered within a larger framework in order to improve overall tailings risk management. The silver lining of the crisis created by the high-profile tailings failures is the enhanced opportunity to improve practices in the area of tailings management so this essential industry can continue with far less impact to the communities where mining takes place.

Progress in tailings management requires taking into consideration that tailings are part of a complex system. There is more complexity to managing tailings than can be handled by simple linear cause-and-effect approaches, and therefore a systemic approach is required. The tailings system needs to balance important components, which can be both interconnected and competing, such as: risk management, societal expectations regarding risk and environmental performance, tighter regulatory requirements, economic expectations from investors, and capital, operational and closure costs. The communities living near a mine, their livelihoods and well-being, are a central consideration necessitating an increased level of systemic risk management at tailings facilities. Further, tailings facilities will exist essentially in perpetuity making them not only complex systems to manage but entities that once developed will exist for generations. Managing the changes that will occur to the facility over those generations is part of the system management challenge.

Significant progress has already been made in addressing these challenges, with corporations and investors increasingly taking longer term views on social, environmental and economic objectives relative to mining, and to tailings management in particular. The drive towards responsible mining needs to incorporate a systems approach to tailings facilities that is designed to prevent significant failures.

According to Garbolino, Chéry and Guarnieri (2019, p.1), the advent of the systemic approach, which considers phenomena and problems as systems, 'heralded a turning point in the history of science and its application to the organisation, and to production'. By recognising that all components of a system are interconnected, the systemic approach highlights emerging behaviour and links knowledge, expertise and data from various elements and disciplines that affect the system. This is precisely what allows significant progress compared to compartmentalised, single-discipline, linear approaches.

This chapter introduces the systems approach to tailings management including the systems that produce tailings, and the systems associated with the design, management and operations of tailings facilities. All of this is seen as part of the broader community and environmental realities at and near mine sites.

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2. SYSTEM CHARACTERISTICS

A socio-technical system includes several groups of people at multiple levels who are involved in performing a technological task to produce an expected result. A socio-technical system has the following features (Durand 2006):

Interaction – elements of a system interact performing actions on other elements while being subject to actions by other elements. The system includes feedback loops.

- Comprehensiveness – a system cannot be reduced to the sum of its parts. There are specific properties to each subset of the system.
- Organisation – refers to both the structure and operation of a system designed to achieve a goal and assures the functions and processes of a system.
- Complexity – systems have complexity that can have several characteristics:
  - new and dynamic system properties can emerge
  - a complex system can change its organisation without external influences
  - sensitivity to conditions and constraints influence subsequent dynamics and adaptability
  - temporal dynamics can produce events that change the system dynamics
  - there is uncertainty in intricately organised systems
  - it is difficult to predict the evolution of a complex system.

According to Garbolino, Chéry and Guarnieri (2019, p.7), unpredictability in a complex system 'can be reduced by taking into account those elements that were originally excluded from the system, but which are subsequently found to have strong causal relationships with those items that were originally included in the system'.

Box 1: Factors in complex socio-technical systems that have the potential to have an adverse impact on safety

1. Performance is an emergent property of a complex socio-technical system. It is impacted by the decisions of all the actors– politicians, managers, safety officers and work planners – not just the front-line workers alone
2. Sub-optimal performance is usually caused by multiple contributing factors, not just a single catastrophic decision or action.
3. Sub-optimal performance can result from a lack of vertical integration (i.e., mismatches) across levels of a complex socio-technical system, not just from deficiencies at any one level.
4. The lack of vertical integration is caused, in part, by a lack of feedback across levels of a complex socio-technical system. Actors at each level cannot see how their decisions interact with those made by actors at other levels, so the threats to safety are far from obvious before an accident.
5. Work practices in a complex socio-technical system are not static. They will migrate over time under the influence of a cost gradient driven by financial pressures in an aggressive competitive environment and under the influence of an effort gradient driven by the psychological pressure to follow the path of least resistance.
6. The migration of work practices can occur at multiple levels of a complex socio-technical system, not just one level alone.
7. Migration of work practices causes the system's defences to degrade and erode gradually over time, not all at once. Sub-optimal performance is released by a combination of this migration in work practices and a triggering event, not just by an unusual action or an entirely new, one-time threat to safety.

Source: Rasmussen (1997) as summarised in Donovan et al. (2017).

Rasmussen (1997) has argued that in complex socio-technical systems, risk management must be done in a cross-disciplinary manner and requires a system-oriented approach, since safety is impacted by decisions, behaviours and actions of actors across all levels of a work system (see Box 1).

3. HOW COMPLEX SYSTEMS FAIL

The terms of reference of recent failure investigation panels were narrowly focused on the immediate technical causes of the failure events. Valuable learnings emerged from these investigations. However, although there are always immediate technical reasons for tailings facilities failures, the overarching technical and governance reasons that allowed the situation to get to the point of failure are, in most cases, the root cause of the failure (see Hopkins, this volume). For example, while it may be true that a flood event caused the overtopping that lead to the facility failure – what was the flaw in the governance process that led to the planner, operator, designer, reviewer and regulator failing to notice the lack of system capacity for either storing this flood event or passing it safely through an adequately designed and constructed spillway? While overtopping may have been the immediate technical cause of the failure event, a series of poor decisions were involved that were most assuredly part of the root cause of that event.

An important consideration for the overall management of tailings is how to characterise and work towards understanding and preventing systems failures, whether these relate to the physical system, the communication system, the management system or any other component of the overall system.

In his book *Drift into Failure*, Sidney Dekker (2011) describes five elements that together may characterise this 'drift to failure', meaning the multiple factors that have been derived from evaluating many systems failures. These elements are listed below; the terminology used by Dekker is inside the parentheses.

1. **Constraints impacting decision-making ('scarcity and competition')** –Three types of constraints have been recognised in complex systems: economic boundary, safety boundary and workload boundary. Economic pressure to reach higher efficiencies will push the system's operations closer to the workload and safety boundaries. If economic pressure wins it may result in borrowing from safety to accomplish the efficiency. Decision-making within these constraints may contribute to failure. There are real constraints on mining companies including: market and political pressures, schedule and budget considerations, development and engagement of a high-quality workforce, and establishment of systems to help maintain the stability of tailings operations.
2. **A series of small decisions can have a large impact ('decrementalism, or small steps')** – Many of the decisions that are made over time in tailings management do not necessarily result in major changes; in most cases they present small incremental changes. However, a series of small, apparently unrelated decisions may in the long-term significantly impact outcomes if their system impacts are misunderstood or neglected.
3. **Misunderstanding of interdependencies ('sensitive dependence on initial conditions')** – An incomplete understanding of system conditions that are interrelated can have significant impacts on outcomes due to a series of decisions that misunderstand and neglect the interdependencies. Anyone who is involved with a tailings facility may be unaware of the interdependencies of some decisions as they may have an incomplete understanding of how they are related to the specific tailings system at that site.
4. **Models may not be reliable ('unruly technology')** – Parameter uncertainties can be included in evaluations before a decision is made. However, the models may not always be reliable. Despite our best attempts, there can be unknowns that are not effectively evaluated due to incomplete information or other factors. Models may not capture everything that could go wrong and there is a danger that the 'calibrations' may not be correct.
5. **Failure to benefit from available governance and other systems ('contribution of protective structure')** – There are many regulations, management procedures, governance measures, institutional knowledge, etc. in place that can provide support in maintaining systems integrity. These measures and procedures must be identified and applied in the day-to-day approach to the management of complex systems.

These concepts indicate the difficulty of analysing systems failures using a linear cause-and-effect Newton/Descartes approach (Box 2). While it is a challenge to find the 'immediate technical cause of a failure', it is much more difficult to find the cause of failure of the entire complex system.

Box 2: Investigating Failures in Complex Systems

We can all work on letting a post-Newtonian ethic of failure emerge if we embrace systems thinking more seriously than we have before. In a post-Newtonian ethic, there is no longer an obvious relationship between the behavior of parts in the system (or their malfunctioning, for example 'human errors') and system-level outcomes. Instead, system level behaviors emerge from the multitude of relationships, interdependencies and interconnections inside the system, but cannot be reduced to those relationships or interconnections. In a post-Newtonian ethic, we resist looking for the 'causes' of failure or success. System-level outcomes have no clearly traceable causes as their relationships to effects are neither simple nor linear.

Source: Dekker 2011, p. 201

A critical governance concept that must be addressed in the safe design, construction, operations and closure of tailings facilities is normalisation of deviance (Dekker 2011; Pinto 2014; Vick 2017). In summary 'normalisation of deviance suggests that the unexpected becomes the expected, which becomes the accepted' (Pinto 2014, p.377). Vick (2017) describes three tailings facility and conventional water dam projects where this concept was demonstrated. In these cases, the failure modes were recognised but not adequately acted upon due to a normalisation of deviance: repeated deviations from intended performance became accepted as normal, deviations were rationalised, and warning signs were ignored. The accepted deviances allowed the failure triggers to go unrecognised. Another related human-issue concern are the hierarchical models that are prevalent in companies/society that limit communication that can prevent root causes of failures (e.g., where concerns are not raised out of fear of retribution), or simply structures that allow the strongest personalities to dominate the decision-making process.

In reviewing possible ways of preventing failure of complex systems, Dekker (2011) suggests that the inclusion of diversity can reduce the overall chances for drifting into failure. Diversity impacts the five elements identified above and results in a much more resilient outcome. Safety-critical organisations are complex adaptive systems. These organisations must pay attention to diversity that brings a larger number of perspectives resulting in a wider range of possible outcomes.

4. TAILINGS PRODUCTION, OPERATIONS AND MANAGEMENT

The production and management of tailings can be thought of as part of a larger system consisting of several interconnected systems. Although much can be said about this larger system, this chapter focuses on the systems and the aspects of these systems that most directly affect tailings. This encompasses:

- Mine-related factors – the location and nature of resources, and the landscape in which they occur. These variables determine the location and type of mine, and ultimately the amount and character of the tailings. These characteristics are inflexible, and they constrain the system.
- Processing plant characteristics – these affect the physical and chemical nature of the tailings produced.
- Tailings facility planning, design and operation.
- Tailings facility governance and oversight (inclusive of independent review and the regulatory system).
- Mine operation, governance and social performance.
- Local and regional social and environmental system.

Combining all these layers and contextual factors effectively defines the overall tailings system, which both affects and is affected by these broader systems and cannot be adequately conceived or managed without taking account of this context.

The community and its social, cultural and economic framework are critical elements of the overall system. The environmental system upstream and downstream of the tailings facility is also a critical component. A defined ore deposit – the prospective mine – will be located within a broad landscape, where people may live and pursue a variety of activities. Further, mines can exist over many decades and even more than a century so what may start as a remote site for a mine can evolve into a mine with many interfaces with people and their economic and/or recreational pursuits. Traditionally, a new or established mine interfaces with the social, cultural and economic landscape through national and regional government regulators on one hand, and communities and civil society on the other hand. Many aspects of a proposed mine will come under scrutiny – access, energy and water use, potential effects on local livelihoods and traditional culture and heritage, biodiversity and the environment. Among these, the siting of the tailings facility and the associated risks – real and perceived – are critically important and perhaps an important decision in terms of the relationship between the value from the mine for society and the potential impacts that value entails. Once in production, concerns and opposition among local people may decrease or increase depending on performance and the relationship between the mine and the communities.

An understanding of this broader system is required from the start of a project and effective interactions with the broader system need to be maintained for the long term. This is the overarching system that needs to be continuously recognised, respected and improved upon.

The remainder of this chapter focuses on the more local, mine specific tailings systems and how they can be improved to minimise the risk of failures of tailings facilities. The local systems, which interact as an operation-wide system, include both tailings as part of the mine and processing plant system, and the tailings facility as a system in itself.

5. TAILINGS AS PART OF THE MINE AND PROCESSING PLANT SYSTEM

The production and processing of tailings relates to the orebody, the ore processing and extraction technology, and the overall mine infrastructure.

Many of the major metals used by society occur in specific types of ore deposits defined by geological, geometric and mineralogical characteristics. Each deposit type has a range of distinct chemical and physical properties. The nature of the ore deposits largely determines how they are mined (e.g., at surface or underground), how the ore is processed, and the scale of the mining operation (e.g. tonnes of ore treated by the plant per day). These factors also determine the amount of waste rock and tailings that will be produced by the mine, and the mineralogical, chemical and physical nature of the tailings.

Major ore deposits contain metals in concentrations that range from a few parts per million (ppm) to more than 65 per cent, with the remainder of the mined rock following removal of metal-bearing minerals constituting waste rock and/or tailings. In some cases, metal can be recovered by direct leaching of broken or fragmented rock piles, a process known as 'heap leaching'. This is restricted to near-surface ore deposits where surficial weathering has changed the mineralogy allowing leach solutions to capture the metals of interest, most commonly copper, nickel and gold. No tailings are produced in the leaching process, but the leached rock represents volumes of waste rock, some of which may contain significant concentrations of deleterious elements both inherent to the waste and added during processing.

The metal concentration and mineralogy of the ore constrain the processes used to extract the mineral or metal of interest. Detailed assessment of the defined ore body generates extensive data on the mineralogy, concentrations of all elements (including those that may be deleterious to humans or the environment), and the physical properties of the rocks. These data are used to design the mine and processing facilities and assess detailed economic feasibility. In addition, these data are used to evaluate the tailings that will be produced, and to assess how the tailings volumes and character may change over time due to variability of the ore body and the related adjustments to the processing plant.

While the volume and character of tailings are strongly influenced by the type of ore deposit, including its metal concentration and mineralogy, mining and processing options also influence tailings (see also Williams, this volume). For example, new ore sorting technologies deployed on shovels or conveyer belts at the mine may remove rock with low metal concentrations prior to crushing or grinding, hence decreasing the material that is fully processed and the resulting amount – and, in some cases, properties – of tailings that are produced. Processing technologies that can have a significant impact on tailings properties include the degree of ore grinding, the flotation process, the use of thickeners or centrifuges to decrease the water content of tailings, and the use of additives such as flocculants and coagulants.

Traditionally, ore processing technology tended to be exclusively focused on maximising recovery and minimising costs, however currently there is an increasing trend of taking into consideration the resulting tailings properties. There are examples of secondary processing that both enhance recovery and optimise tailings properties. Governance decisions are evolving into a bigger picture business analysis of the system that considers optimising not only recovery but also tailings management operations, facility construction and closure, and environmental management.

6. TAILINGS FACILITY DEVELOPMENT AND MANAGEMENT AS A SYSTEM

After the processing plant, tailings may be further

processed and then are conveyed to a tailings storage facility, which in itself is part of a complex system. The tailings facility system, as other parts of the mine operations system, includes both a technical and a governance system, which are intimately connected. This is the system that is most directly related to – and has the most influence on – reducing the risk of failure of the tailings facility. This section describes the tailings facility system, starting from its most local components and expanding into the broader systems.

6.1 THE TAILINGS FACILITY PLANNING, DESIGN AND OPERATION (THE INNER CIRCLE)

Tailings facilities are distinct from infrastructure projects where a design is done according to pre-established planning parameters, followed by construction to implement the design, supported by a quality assurance / quality control process (QA/QC) until the project is complete. Tailings facility projects, by contrast, require continual involvement of the planning, design, construction, QA/QC, and operations functions, all linked to the overall mining development, and undertaken in a dynamic environment with changes due to ore variability, processing plant issues and market pressures. In other words, a tailings facility is a highly integrated dynamic system with a high degree of complexity.

The diagram in Figure 1 provides an idealised depiction of common elements of the local system ('inner circle') that represents the fundamental circle of activities for the development and operation of a tailings facility: tailings facility planning, design and operations, and the relationships between these activities. For simplicity, inputs and outputs of this system are not illustrated.

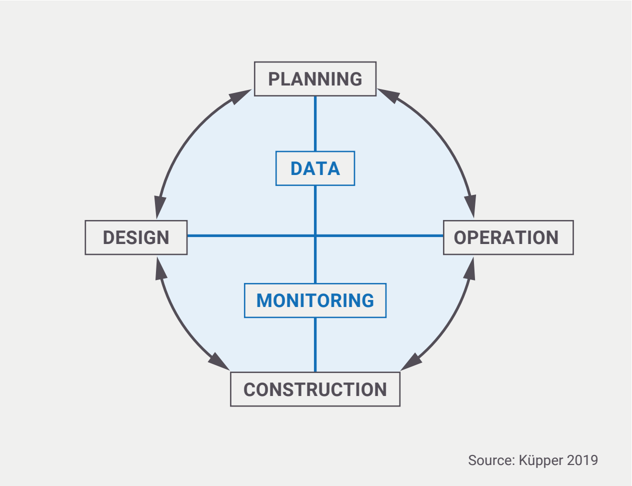

Figure 1. Simplified diagram of the 'inner circle' of the tailings facility system

This inner circle includes the typical day-to-day activities that involve the planning, design, construction and operations functions and the important interactions between these groups. The inner circle can be more complex in larger operations and involve more 'boxes', but the key issues remain similar. The main sub-systems that form the inner circle system are described below.

Planning

The Planning work for a tailings facility involves several aspects. One of the main activities involves determining the volume of tailings and water that requires deposition and containment with time and consequently the required rate of rise of the tailings facility. It also involves defining the construction process to meet the storage requirements according to the design. For example, some of the important considerations are the availability of construction materials (borrow material, tailings, overburden, waste rock or other mine waste), access from the material source to the construction area, location of tailings and water lines, as well as recycle water facilities. For larger operations, the Planning function may include several teams such as mine planning and tailings planning, or short-term planning and long-term planning. Material quality, quantity and availability schedule have a profound impact on design and construction and, in some cases, safety of a tailings facility. For this reason, planners need to work in effective collaboration with geologists, mineral processing engineers and geotechnical engineers (both the designers and the monitoring team) to support the safe construction and operation of a tailings facility. Involvement of the designers at an earlier stage allows cost savings: for example, by developing a design that seeks to optimise the use of available materials and the site development schedule, and by piggy-backing on geology drilling programmes for geotechnical characterisation of overburden materials and tailings facility foundation. Finally, planning that does not take closure considerations into account will almost never lead to an integrated tailings facility concept. All tailings facilities will spend more of its lifecycle in the closed configuration than in operation, so commensurate attention to this condition during the planning stage is paramount to the safety of the tailings facility throughout its lifecycle.

Design

The Engineer of Record (EOR) is responsible for the design of the tailings facility, which is a critical element of the safety of the facility. Fundamental elements supporting a 'solid blue' robust design are shown in the diagram of Figure 2: get the geology 'right', get the soil mechanics 'right', get the hydrology 'right', and get the implementation 'right'. To accomplish this, the EOR team needs to have both competency and experience commensurate with the specific requirements of the project. Further, it is necessary to have an appropriate level of competent and credible review that is independent of the EOR and the facility owner – this review is further described in the 'outer circle' following in this chapter. Effective collaboration with Planning, Operations and Monitoring is critical for the EOR to: (1) produce a design that is calibrated to the site conditions and performance; (2) adjust this design as the site conditions evolve; and (3) bring to the system a depth of understanding of the design assumptions, design intent, uncertainties and an appreciation of the risks of each structure and how they are managed in the design. An effective and balanced collaboration among the Design, Planning, Operations and Monitoring functions can reduce costs and manage risks to the integrity of the tailings facility.

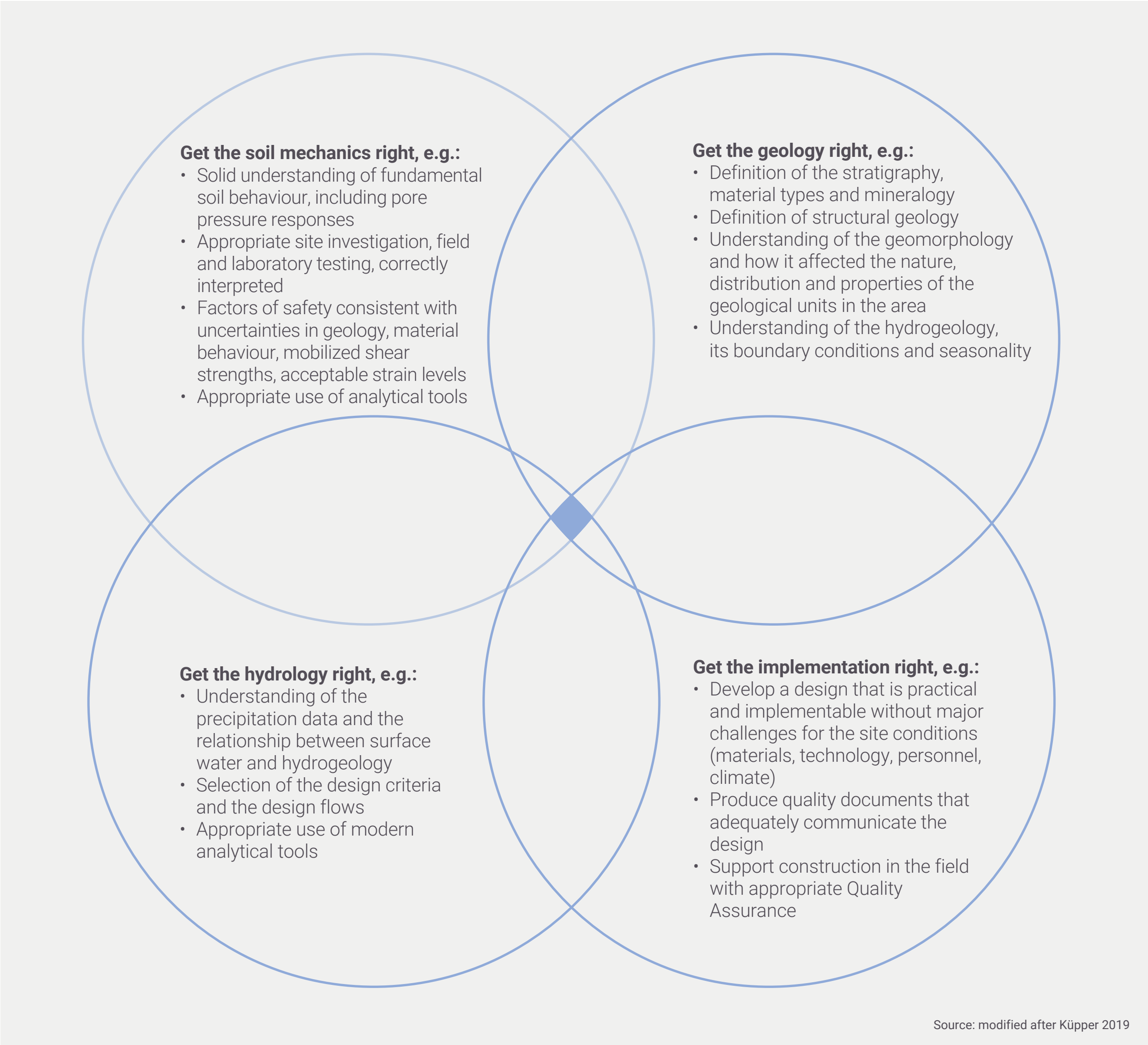

Figure 2. Simplified diagram of elements of the design of a tailings facility

Construction and Operation

In some cases, construction of the starter dyke, if there is one, is carried out by a contractor. However, when construction of the starter dyke is complete, Construction and Operations often become the same as these activities are taken care of by the mine operations. This merger of functions increases the complexity of the system and the interaction between its parts. Operations is affected by Planning, for example, as material availability may affect the rate of construction. Operations can also influence Planning; for example, by providing feedback and contributing to make future plans more realistic and better suited to tailings facility operation and safety. An important interaction between Design and Operations occurs through QA. Beyond checking the QC programme, QA should have sufficient understanding of the design to assess whether construction meets the design intent and to identify whether there is a need to adjust the design to the observed site conditions, including materials. Operations interacts with the other sub-systems of the inner circle, but also with the physical environment; for example, having to manage high precipitation events by adjustments to the normal operations.

At the centre of the inner circle is the data system required for all the sub-systems to work adequately. The quality of the work product is only as good as the quality of the data that the work is based on. The data system includes the geological data and model, geotechnical data (e.g., borehole logs, sampling, test results, instrumentation readings, etc.), planning data, construction QA/QC and as-built data, monitoring data, operational data, and social and environmental data. It is essential to have complete, detailed and accurate data that are easily accessible to all parties involved and that are geo-referenced where appropriate. Data integrity is critical.

Another essential element of the tailings planning process is the use of risk assessments. These are employed throughout the design process and necessarily inform all aspects of the planning and operating phases for the facility.

All the people involved in the inner circle of work need to understand the purpose, importance and potential consequences of their work. This is regardless of whether they are in planning, design, construction, operation, or are involved in obtaining the data (for example, instrumentation monitors, surveyors, drillers and geo-professionals on site investigation or in the laboratory). Moreover, their practical knowledge and observations need to be considered in planning and designing the tailings facility. This is important for improving the quality of the work and the safety of the facility.

6.2 THE TAILINGS FACILITY GOVERNANCE AND OVERSIGHT SYSTEM (THE OUTER CIRCLE)

Tailings facilities are also part of a management system that relates to the various layers of governance and oversight. This system includes company personnel, consultants, regulators, and local and non-local communities. The diagram in Figure 3 (below) provides an idealised representation of common elements of a tailings facility management system and the relationships between these elements. Again, for simplicity, the fundamental drivers – input and output – of this system are not illustrated. This 'outer circle' provides support and oversight to enable participants in the inner circle to get their best work done. This circle also provides important 'end goals' for the inner circle and links to the broader systems. The outer circle is formed by senior management, independent reviewers, regulators and communities that provide oversight of the tailings facility. The blue shading in the diagram in Figure 3 emphasises that the entire system must be supported by high quality, accessible data. Like the inner circle, each rectangular box of the outer circle is a system in itself; however, in the case of the outer circle, these systems involve more complexity.

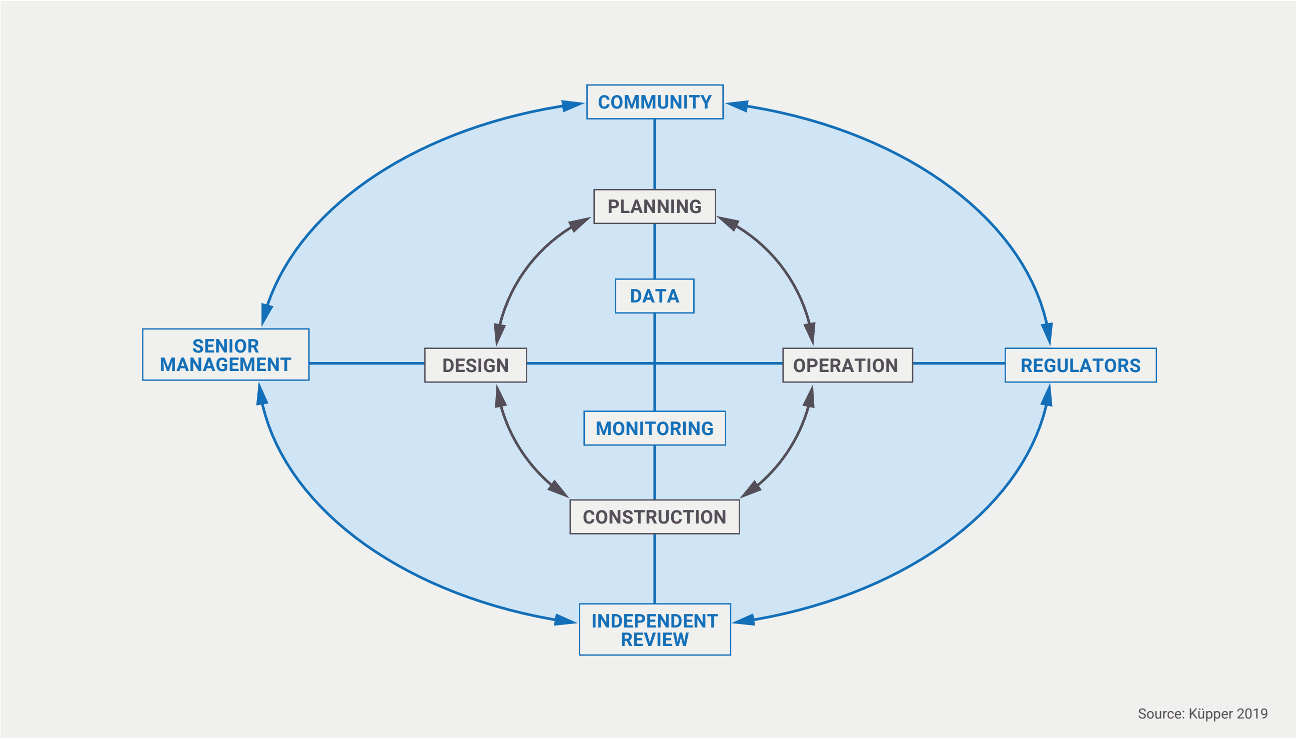

Figure 3. Simplified diagram of the 'inner circle' and 'outer circle' of the tailings facility system

The oversight provided by the outer circle includes the governance of the mining company, local and general, as well as through its board of directors. The governance system includes risk management and technical and operational reviews provided by independent reviewers and auditors. The other important elements are the regulatory system and the community, which provide oversight of the tailings facility. The main sub-systems that form the outer circle are described below.

Senior Management
Senior managers are responsible for development and continuous improvement of tailings stewardship and governance throughout the company's operations, including the implementation of audits, conformance reviews and independent technical reviews. Senior managers can support building a quality and safety culture. They interact with other senior managers, communicate with the executive and board on tailings matters, and are typically actively involved in national and international tailings activities. It is essential that senior management be receptive to input from the team at all levels when concerns are raised. Past examples of retribution to individuals approaching senior management and/or fear of such reprisals have left senior management uninformed and ill-equipped for decision making. A healthy organisation is one where the senior management understand that their role in governance is to facilitate and encourage a flow of information in all directions that will meet the needs of the safety culture required for the tailings facility management.

Independent Review
Independent technical review of the design, construction, operation and closure of tailings facilities is an important element of risk management. The independent review also helps identifying opportunities for improvement. The expertise of the reviewers relates to the specific technical aspects of the tailings facility site, material and design characteristics. The quality of reviews is directly affected by the information presented to the reviewers, the core competency of the reviewers relative to the nature of the facility being reviewed, and by the nature of the communications.

Regulators
This term encompasses all relevant public sector agencies. At the highest level, regulators are responsible for legislation, regulations and guidelines that ideally support the entire system without stifling creativity and technical development by being too prescriptive. Regulators have a unique position of independent oversight of the construction,

operation, maintenance, and closure of tailings facilities. Discharging this role effectively, requires a comprehensive understanding of the planning and engineering necessary to build, operate, maintain, and ultimately close tailings facilities. Ideally, regulators should also be in a position to set up a professional inspection and enforcement programme capable of identifying problems and making sure those problems are corrected promptly before they increase the risk of catastrophic failures.

Community involvement
Communities also have an important role to play in participating as stakeholders who bring diversity of input and accountability to the system. The community brings a diversity of perspectives, providing a broader context of the local environment and areas of most concern to them. These contributions should be incorporated into the system. See Box 3 for a community-society perspective.

Box 3: A community-society role

Communities are also proxies for society in general and therefore can play an important role in tailings management. Mining has historically been driven towards a 'Net Present Valuation' for commodity development which is a logical approach for the orebody evaluation. However, for the perpetual legacy of tailings facilities this is a false premise as there is no discounting of future risks by present risk transference or vice versa. Consequently, tailings management requires a much broader view, which takes account of how the true cost of a commodity includes the cost of tailings management. Society, as driven by its communities, sets values for raw materials through consumptive patterns and if those patterns were to insist on more life-cycle investment in mine tailings as part of the cost of a mined commodity, one of the significant barriers existing in many parts of the world to improved tailings management could be overcome.

Source: Michael P. Davies, personal communication

The outer circle, again similarly to the inner circle, needs competent people in all functions (see Evans and Davies, this volume) who understand the importance of their work for the overall system and who can work collaboratively with others in the system. Their work also needs to be based on high quality, accessible, data, and information sharing.

6.3 THE COMPLETE TAILINGS FACILITY LOCAL SYSTEM

For the tailings facility system to work well and for risks to be adequately managed, not only it is necessary to have competent and experienced personnel leading all the functions represented by the 'boxes' in the diagram in Figure 3 but the interaction between the boxes needs to be cooperative and effective.

Integration and communication across the overall tailings system are fundamental. Risk assessments support the overall work of the tailings system by helping communicate and provide clarity on the requirements and the uncertainties, and by allowing risk mitigation across all elements of the system. Risk assessments form part of the basis for risk-informed decision making for follow-up action to manage risk. In addition to be an element of the risk management framework, risk assessments are a powerful tool to help individuals in all functions of the tailings system recognise the risk elements, the inter-dependencies, and the potential impact of their decisions on the tailings facility, while supporting vertical and horizontal integration across the system.

Leadership throughout the entire tailings system is required to create, implement and maintain a culture of quality, safety and transparency. Continuity of personnel is another key element of tailings storage facilities stewardship. It is invaluable to have institutional memory and people in the system who are well calibrated to site conditions, local materials and practices, and who will mentor others as part of a well laid out succession plan. The cult of personality, where decisions are owned by the loudest voices or the most senior opinion, is to be avoided and challenged by the healthy organisation – one that sees all individuals and all information as part of the overall management of a safe facility.

The safety of tailings facilities can only be improved by each person in the system, no matter which role they play. This entails being technically competent, understanding what needs to be achieved and why, having a view of the causes and consequences, and producing detailed and accurate data to support each other's work, within a culture where effective, collaborative relationships promote quality work.

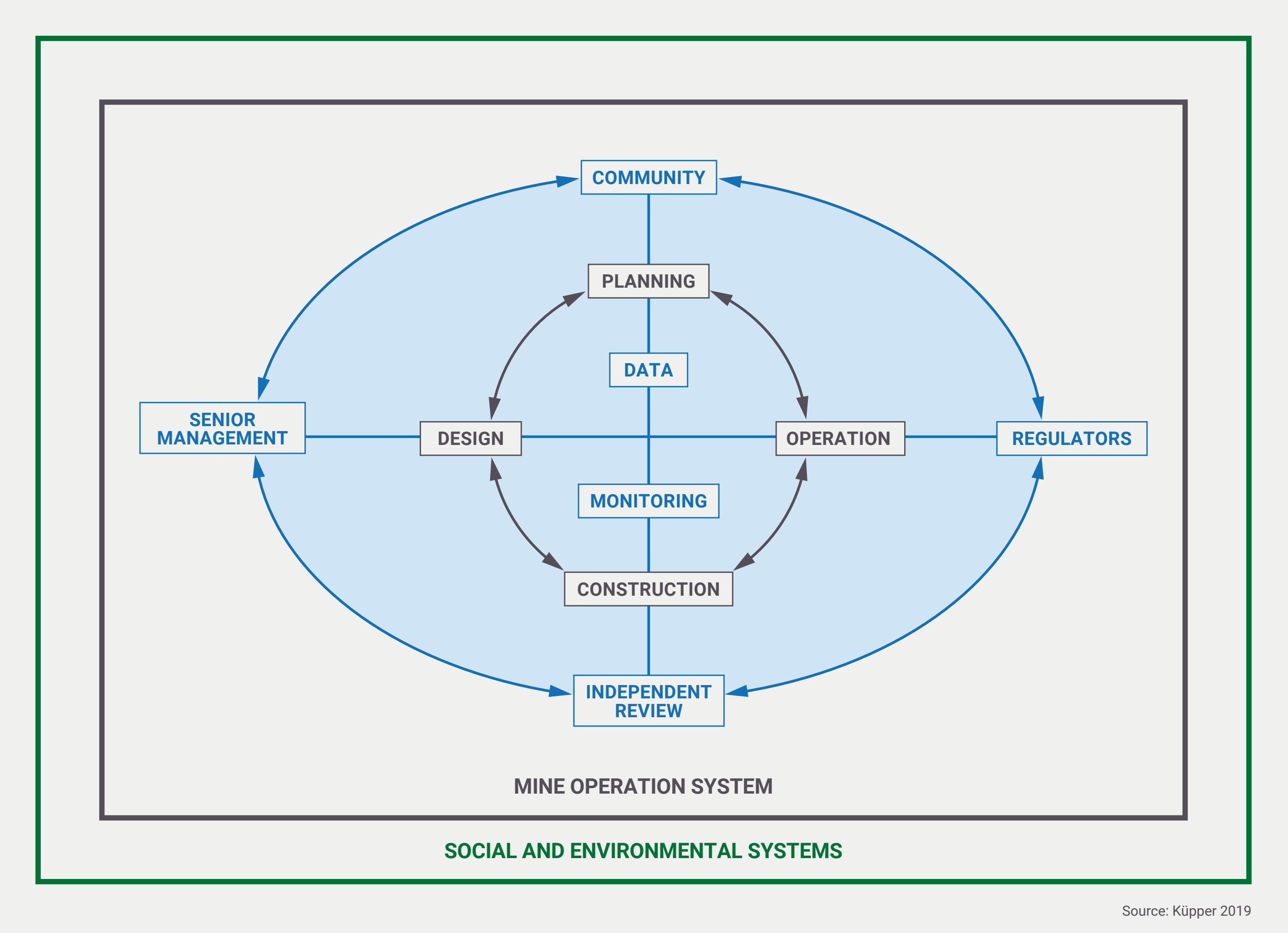

Figure 4. Simplified diagram of the elements of the tailings storage facility system

Note: Each rectangular box in this diagram represents a system in itself.

6.4 THE MINING OPERATIONS SYSTEM

The tailings facility system is an integral part of the mine operations system (Figure 4). It is affected by the mine and the processing plant (as discussed above) while at the same time enabling the functioning of these operations. It is also a critical component of the overall mine infrastructure, personnel and governance system.

6.5 THE SOCIAL AND ENVIRONMENTAL SYSTEM

As Figure 4 also shows, the tailings facility and the mine operations system are in turn embedded into larger social and environmental systems. This overall system is complex, intricate, and governance happens at many levels with several groups of people involved.

The selection of the tailings facility site is an activity where the interaction with the broader social and environmental system is particularly critical. The site selection process must consider and optimise a variety of aspects related to: the physical and social environment within which the facility is located; parameters from the ore body; the processing plant; the conveyance system; the design, construction and operation of the facility; and its closure and final land use. Some of these items have competing requirements and the optimisation process is not simple. Techniques, such as risk assessments, multiple account analyses and others, can be used to support the process. However, most importantly, it is necessary that specialists from all these areas work in collaboration, sharing the same goals, to achieve a solution that appropriately considers all the relevant elements.

Ideally, the selected site:

- minimises impact to people, their culture and livelihood
- minimises impact to the environment, including fauna, flora, hydrological resources, air and water quality
- has adequate foundation conditions for a stable structure, along with sufficient storage capacity for tailings
- is located at a relatively short distance from the processing plant, and
- is feasible for closure in a manner consistent with future land use by the local communities.

The interaction with the social and environmental system during construction, operations and closure of a tailings facility includes many important aspects, such as: environmental monitoring and management (with modification of plans and designs, and implementation of remedial measures as required); open lines of communication with communities; assessment and management of social impacts; management and communication of risks; and regulatory compliance and regulatory oversight.

7. RECOGNISING AND MANAGING TAILINGS FACILITIES AS A SYSTEM

The tailings facility system is complex and typically involves many people in different groups with different objectives and different responsibilities. The importance of treating it as a system comes from the need to align the objectives and responsibilities from all areas of the system, such that sound stewardship is achieved.

Several organisations within the mining industry have recognised that tailings must be managed as a system. The Mining Association of Canada (MAC) has been one of the pioneers in the governance of tailings facilities as a system. Its publications in this area (MAC 2019 and 2018, for example) have been helpful in promoting awareness and the implementation of a systemic approach to governance of tailings facilities. The Global Tailings Review further reinforces and broadens this perspective.

Some mining companies have also recognised the need for a systemic approach for the technical and operational aspects of tailings facilities and have established tailings stewardship programmes aimed at a more effective risk management of their facilities.

An example of an area where the mining industry has used the systemic approach with significant success is the management of occupational health and safety. By approaching occupational risk management as a system, the industry has involved engineering, process technology, information technology, ergonomics, sociology and psychology to build a positive cultural change in the workplace supported by tools that lead to a decrease in occupational accidents. Key features of the systemic approach are demonstrated in the modern management of occupational health and safety that are familiar in the mining industry (see Box 4).

Box 4: Systemic approach features in the modern management of occupational health and safety

- Vertical integration – there is support to safety from all levels within the organisation.
- Horizontal integration – all groups within the organisation participate in safety programmes and safety training.
- Knowledge from individuals in all levels within the organisation is respected and integrated into improved procedures, policies, etc. 'Safety shares' are common and frequent.
- Information is gathered, valued, and compiled to improve the organisation through continued education, awareness, and knowledge sharing; this includes access to knowledgeable specialists inside and outside the organisation and use of a wide variety of monitoring technologies.
- There is a clear understanding of the role of everyone at all levels within the organisation in improving safety by taking personal responsibility for individual actions as well as the actions of others, and by implementing correct procedures, use of adequate equipment, developing positive attitudes, and seeking continuous improvement.
- Governance support is provided, including through the continuous updating of regulations.

Most mining companies have developed a solid safety culture; thus, the systemic approach and its implementation would be familiar. The same type of processes, level of effort and emphasis can be applied successfully to tailings facilities risk management.

8. THE PATH FORWARD

A path forward to the improvement of the safety of tailings facilities would involve a deeper understanding and a broader implementation of a systemic approach, along with an improvement of the technical knowledge related to tailings facilities across the entire system.

There is a varied level of awareness within the mining industry in regard to a tailings facility being a system and the requirement to be managed as such. Moreover, there have been varied levels of success in managing tailings facilities using a systemic approach. However, anywhere within this spectrum, improvements could be made for continuing improvement to the management of these facilities.

A systemic approach to tailings facilities should include understanding the system for a specific site and managing this system by considering the intricacies of complex systems. The approach should involve identifying all elements that directly or indirectly affect the system and addressing all these elements and their interaction in a governance system (structure and operation) that promotes collaboration towards the common goal of tailings facility safety. Management of tailings facilities benefits from applying a multi-disciplinary perspective. It can also benefit from recognising that complex systems are dynamic, so adaptability needs to be promoted along with a robust approach to handling of uncertainty.

The specifics of implementing a systemic approach will vary in each case, however some common elements include:

- Vertical integration from the worker level to the board of directors, where there is support for and understanding of the measures, activities and attitudes required for safe tailings management.
- Horizontal integration, with all groups within the operation supporting tailings facility safety as one of their key objectives.
- Knowledge integration from all levels within the operation – from workers to the C-suite. Knowledge is gathered, respected and integrated into improved plans, designs, operational procedures and policies.
- Information gathered and compiled to improve the organisation and support continued education, awareness, knowledge sharing, including access to knowledgeable specialists, inside and outside the organisation.
- Development and implementation of a robust data management system where all data relative to geology, hydrology, materials, volumes, schedule, designs, specifications, surveys, photographs, as-builts, reports, instrumentation, monitoring data, etc., are easily accessible and available in an efficient, timely and practical manner to the entire organisation. Data accuracy and data integrity are a must.
- Consistent use and application of risk assessments and risk management principles with program priorities being informed by these assessments.
- Clear understanding of the role of everyone at all levels within the organisation in improving safety of the tailings facility by adopting correct procedures, adequate equipment, positive attitudes, and continuous improvement approaches.
- Transparency in internal and external communications and a supportive culture such that problems can be aired and addressed in a constructive manner.
- Establishment of tailings as a career path in the organisation and within the mining industry with well-defined objectives, technical knowledge and experience expectations, and with growth opportunities.
- Clear succession plans, with candidates identified, for all key roles in the organisation related to tailings management.
- A strong governance framework that supports and reinforces all the above.

With the concepts mentioned above in mind, a management framework can be developed such that tailings management is supported by effective communication, underpinned by an accessible and robust data management, flow of information and adequate levels of knowledge and experience. A management structure that includes embedded monetary and non-monetary incentives to support the alignment of the objectives and promotes vertical and horizontal integration is more likely to minimise the risk of catastrophic failures of tailings facilities, improve efficiency and reduce unnecessary costs. Leadership and personality traits from individuals at all levels within complex socio-technical systems can also affect the outcome. These factors need to be managed to promote the best culture and the best outcome for the work system.

9. CONCLUSION

It has become increasingly clear that tailings facilities are important elements of mining, an essential industry, and that the safety of tailings facilities must be managed within a larger framework in order to improve overall risk management and to renew confidence in tailings facility management. Tailings facilities are a highly integrated dynamic system with a high degree of complexity. Therefore, risk must be managed using a system-oriented approach in a cross-disciplinary manner, since safety is impacted by decisions, behaviours and actions of actors across all levels of the system. This chapter has provided an overview of the elements needed to incorporate a systemic approach to effective tailings management.

KEY MESSAGES

1. Tailings facilities are complex entities that operate as a system within the broader context of mining operations, their external societal and environmental settings, and their potential to last in perpetuity.

2. Tailings facilities are complex systems that need to be managed with a systemic approach for effective risk management

3. Although there are always immediate technical reasons for tailings facilities failures, the overarching technical and governance factors that allowed the facilities to approach a critical state are, in most cases, the root cause of the failure.

4. The systematic management approach for tailings facilities involves vertical and horizontal integration of all functions (planning, design, construction, operation, management, oversight) that operate and collaborate within a broader framework.

5. The resulting management framework must be supported by effective communication, transparent and robust data management, and information flows that builds knowledge and experience. Success also requires leadership, appropriate incentives and a culture of performance.

6. Ultimately, the framework and resulting systems management has to be based on leadership that drives a culture of system-level performance.

REFERENCES

Dekker, S. (2011). *Drift into Failure: From Hunting Broken Components to Understanding Complex Systems.* Burlington Vt: Ashgate.

Durand, D. (2006). *La systémique.* France: Presses Universitaires de France.

Donovan, S-L., Salmon, P., Lenné, M., Horberry, T. (2017). Safety leadership and systems thinking: application and evaluation of a Risk Management Framework in the mining industry. *Ergonomics*, 60:10, 1336-1350.

Garbolino, E., Chéry, J.-P., Guarnieri, F. (2019). The systemic approach: concepts, method and tools. In *Safety Dynamics: Evaluating Risk in Complex Industrial Systems*, Guarnieri, F. and Garbolino, E. (eds). Switzerland: Springer.

Küpper, A.G. (2019). 'Tailings Dams', 2019 Distinguished Lecture Program, Geological Engineering: University of British Columbia, Canada.

MAC (2019). *A Guide to the Management of Tailings Facilities, Version 3.1*. February 2019. Ottawa: Mining Association of Canada. https://mining.ca/documents/a-guide-to-the-management-of-tailings-facilities-version-3-1-2019/

MAC (2018). *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities*. November 2018. Ottawa: Mining Association of Canada. https://mining.ca/documents/oms-guide-second-edition-2019/

Pinto, J.K. (2014). Project management, governance and the normalization of deviance. *International Journal of Project Management*. 32, 376-387.

Rasmussen, J. (1997). Risk Management in a Dynamic Society: A Modelling Problem. *Safety Science*, 27 (2-3), 183-213.

Vick, S.G. (2017). Dam safety risk – from deviance to diligence. *Proc. GeoRisk* 2017, American Society of Civil Engineers. 19-30, GSP282.

CHAPTER VI THE ROLE OF TECHNOLOGY AND INNOVATION IN IMPROVING TAILINGS MANAGEMENT

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1. INTRODUCTION

While there is no 'silver bullet' to cover all tailings in all climatic, topographic and seismic settings, much can be learnt from recent high-profile and well-documented tailings facility failures which, while rare, continue to occur at an unacceptably high frequency in terms of both industry and societal expectations. A rethink is also required about the way in which many view tailings management in terms of economics, relying on a net present value (NPV) approach with a high discount factor, rather than a whole-of-life economics approach. There is scope for the further development and implementation of new tailings management technologies and innovations, and for the use of different economic models. Change is most readily achieved in new mining projects and hence change in tailings management for the mining industry as a whole will be generational.

For context, this chapter first describes conventional tailings management, arguing that applying NPV accounting to tailings management supports the transportation of tailings as a slurry to a facility, with insufficient consideration being given to the potential risks and long-term costs of this method of storage. While this conventional management approach can be the optimal NPV and life-cycle choice for a given operation, there is often a divergence when a whole-of-life approach is fully considered. The constraints under which a conventional surface tailings facility must operate are also described. The chapter then outlines the key causes of the unacceptable consequences of tailings facility failures and the threats posed to industry, regulators and society by such failures. Alternative approaches to tailings management are described in the main body of the chapter. Issues relating to the closure and rehabilitation of tailings facilities are also discussed.

The chapter draws on the author's own research, the work of other researchers active in this area, and a large and growing body of guidance documents on best or leading tailings management practice. An Appendix to the chapter lists the more significant of these documents.

2. CONVENTIONAL TAILINGS MANAGEMENT

The conventional approach to tailings storage is to thicken the tailings just to the extent that they can be pumped using robust centrifugal pumps by pipeline to a surface tailings facility, where the tailings are deposited sub-aerially (that is, above water and on the surface) forming a beach.

The forms of tailings containment and method of construction and facility raising varies from region to region. Upstream construction, using tailings where possible, is widely employed in southern Africa, Australia and the south-west of the USA, which have in common a dry climate. Centerline and downstream construction, by contrast, is usually employed in wet and/or high seismic regions. While the necessity for centreline or downstream construction is understandable in wet climates, the choice between upstream construction and other geometries is not so obvious. It seems that this is more a function of past experience and established regional practices, which vary and are difficult to change. Sand facilities, cycloned and/or compacted, are widely employed in South America and Canada, now usually raised by the centreline or downstream methods. Rockfill and/or roller compacted concrete facilities are finding favour for high tailings facilities in the deep valleys of the Andes in South America.

2.1 NET PRESENT VALUE ACCOUNTING APPLIED TO TAILINGS MANAGEMENT

There is a commonly held perception that transporting tailings as a slurry to a facility is the most economic approach. However, to a large extent this is because the costs of closing and rehabilitating the resulting tailings facility are discounted by the NPV accounting approach and are not considered to be significant. Instead, the NPV approach prioritises the minimisation of short-term capital costs (Williams 2014). While the best practices in the industry have moved beyond the NPV approach, with a growing number of owners and jurisdictions now embracing true full-life economics, there remains a substantive portion of global tailings practice that still uses the NPV approach.

This way of thinking leads to tailings being stored as a slurry in surface facilities that are often initially too small, leading to high rates of rise, and creating wet and soft tailings deposits that store excessive amounts of water. Operating costs tend to blow out, and the risk of tailings run-out on loss of containment increases. The wet and soft tailings can also be difficult and expensive to rehabilitate, due to the challenge of capping a 'slurry like' tailings. This is contrary to good practice, which aims to optimise tailings management by improving tailings dewatering, density and shear strength, and maintaining a safe, stable and non-polluting tailings storage (see Box 1).

Box 1: Limitations of the NPV Approach

The use of NPV and an artificially high Discount Factor result in apparent cost savings in tailings management in the short-term, but at the price of increasing operational and capital costs, and unintended cumulative detrimental impacts over time, and ever-increasing closure and rehabilitation risks and costs in the long-term. This is particularly the case in flat terrain, such as much of Australia, where there is limited free storage in valleys, resulting in containment walls extending around an increasing proportion of the tailings storage perimeter as they are raised, making high facilities too costly. As a result, facility heights are limited, and tailings storage footprints grow ever larger.

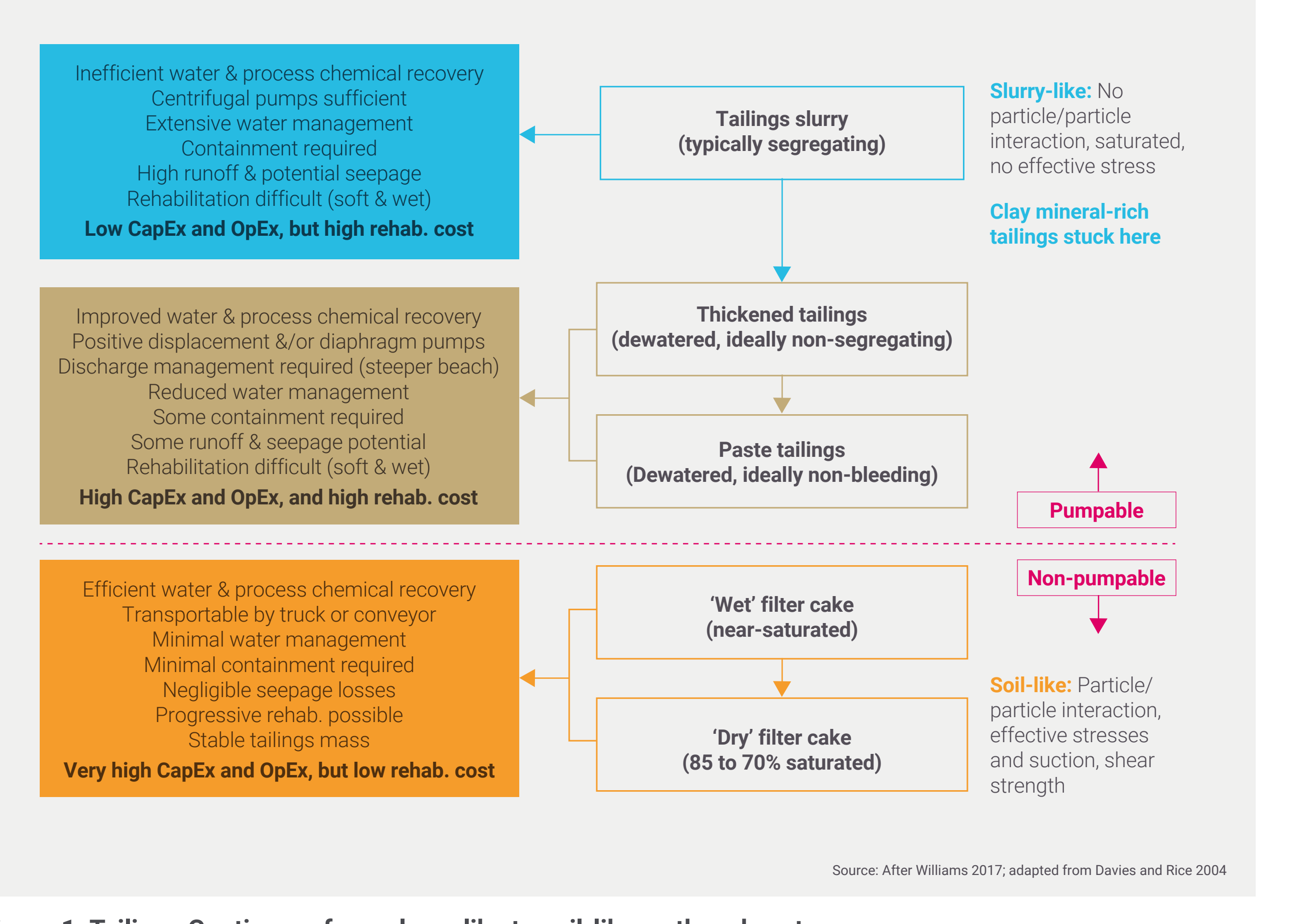


Figure 1. Tailings Continuum from slurry-like to soil-like as they dewater

Figure 1 shows five different tailings treatment options, the advantages and disadvantages of each option, and the relative levels of capital (CapEx), operational (OpEx) and rehabilitation expenditure required for each option. It can be seen that the NPV approach, which prioritises the minimisation of CapEx and OpEx over the minimisation of rehabilitation costs, favours what is often the least desirable option from a long-term management perspective.

Most tailings can be thickened mechanically, some to a paste or filter cake consistency. However, clay mineral-rich tailings, such as coal tailings, mineral sands tailings, tailings from some oxide ores, and residue from the processing of bauxite, nickel laterite and oil sands, are difficult to dewater mechanically, particularly where the unstable, moisture-reactive sodium smectite clay mineral is present, even in small proportions. As a consequence, dewatering tailings to a paste or by filtration has conventionally been seen as too capital intensive and too expensive to operate, and as being difficult to scale-up for large production rates. The long-term benefits of reduced storage volume occupied by tailings paste or filter cake, and the relative ease of capping 'soil-like' tailings have been discounted, as have the potential for a higher level future land use and/or improved ecological function.

3. CONSTRAINTS UNDER WHICH A CONVENTIONAL TAILINGS STORAGE MUST OPERATE

Conventional tailings storage remains the optimal solution for a wide-range of existing and proposed facilities. However, conventional tailings storage is not ideal for every site. For those locations where conventional facilities are both false economics and poor technical choices, there is a series of constraints that counter their use. The constraints under which a conventional surface slurried tailings storage must operate include the following (Williams 2014):

- the climatic, topographic, seismic and geological settings
- the nature of the tailings, and potential contaminants, including sulphides, salinity, radioactivity, cyanide, etc., and how these may change during the mine life
- the tailings production rate and solids concentration which must be accommodated, and how these change during the mine life
- the need to manage, store, and recycle, when possible, supernatant tailings water
- the need to minimise the risk of the release of tailings and tailings water through overtopping, tailings storage embankment instability, or excessive seepage
- the need to meet discharge water quality licence conditions
- the need to maximise the tailings settled dry density, and hence minimise wall raising and the required tailings storage volume
- the need to facilitate upstream wall raising, where appropriate
- the need to rehabilitate the tailings storage on closure to a safe, stable and non-polluting structure in perpetuity, and to achieve some post-closure land use or ecological function.

3.1 SETTING OF THE MINE SITE

Tailings management is typically easier, at least physically, in dry climates, where advantage can be taken of desiccation (that is, drying by exposure to the wind and sun) to naturally dewater, increase the density of the tailings and strengthen the tailings. However, on desiccation in a dry climate, sulphidic and otherwise potentially contaminating tailings can oxidise, potentially leading to acidic and otherwise contaminated seepage and runoff. On the other hand, the limited rainfall in a dry climate will reduce the transport of any contaminants that are generated. Unrelated to water transport, fugitive dust generation from tailings in arid climates is a significant contributor to off-site impacts in many regions.

High topographic relief provides 'free storage' in valleys, requiring a facility of limited width, but also results in a high embankment to create the storage for the facility, leading to initially high rates of rise and the need to divert steam flows. High seismicity can also dictate design, such as in Chile, which experiences about 40 per cent of global seismicity.

Different combinations of these aspects may dominate in particular geographical areas. For example, in much of Australia, apart from the humid and cold West Coast of Tasmania and the seasonally wet tropics, the climate is dry, the topography generally flat (which limits the height of tailings facilities but not their extent) and the seismicity generally low. The same is generally the case for southern Africa and the South-West of the United States of America (USA).

In Chile, by contrast, the climate is dry, but the topography and seismicity are extreme. Prior to 1965, the majority of Chilean mining companies, (which at the time, mainly operated in Central Chile, above Santiago) employed cycloning to form a sand facility that was constructed upstream. However, a magnitude 7.4 earthquake in 1965 caused a liquefaction failure of the cycloned, upstream tailings facility at El Cobre Mine, resulting in more than 200 fatalities. This failure occurred in a decade when world copper production, particularly in Chile, increased significantly.

The failure resulted in almost immediate industry-initiated changes to tailings facility construction in Chile. These included:

- using dozers to flatten the downstream slope to about half (from an angle of repose of wet sand of about 2.5 horizontal to 1 vertical to about 4 to 1), also inducing compaction
- moving from upstream to downstream and centreline construction
- the installation of centralised cyclone stations
- in some instances, the installation of a 'temporary' upstream liner to limit seepage from the slimes into the sand facility, and
- limiting the percentage of fines in the sand facility to a maximum of about 20 per cent.

The Chilean regulators followed the industry some years later with Decrees in 1970 and 2016 (see Box 2).

Box 2: Tailings facility performance in Chile

Since 1965, Chilean tailings facilities have increased in height to 200 metres or higher. There are currently about 740 tailings facilities in Chile, of which about 100, mostly downstream sand facilities with a dozed downstream slope, are active; about 470, mostly former upstream sand facilities, are inactive; and about 170, mostly former upstream sand facilities, are abandoned. The active Chilean downstream sand tailings facilities have performed well since 1965, due to improved construction methods. The large number of inactive or abandoned Chilean sand tailings facilities have also performed well since 1965, as they have drained down in the dry Chilean climate.

In western portions of British Columbia, the climate is wet, the topography extreme and earthquake loading can be high, if infrequent. In continental Canada, the climate is dry but seasonal, the topography low relief, and the seismicity low. Brazil has an extreme wet season and high topographic relief, but low seismicity. The 2015 Fundão and 2019 Brumadinho tailings facility failures in Brazil were influenced by the wet season rainfall and the high topographic relief.

3.2 NATURE OF TAILINGS

Tailings are typically mainly silt-sized (0.002 to 0.06 millimetres in size) but may also contain sand-sized particles (0.06 to 2 millimetres in size) and clay-sized particles or clay minerals (finer than 0.002 mm). Tailings particles can also have a range of specific gravities, ranging from as low as 1.8 for coal-rich tailings to 4.5 for iron-rich tailings. This compares with a specific gravity of about 2.65 for normal mineral matter. The variable particle size and specific gravity of tailings particles result in hydraulic sorting down the tailings beach on conventional sub-aerial deposition.

The presence of clay minerals in tailings, even in small proportions, can limit sedimentation and consolidation, and water recovery. Tailings can be hypersaline due to the chemistry of the ore and/or the process water; acidic due to the presence of sulphides and/or acidic process water; or alkaline as a consequence of caustic processing, such as for bauxite, nickel laterite and oil sands.

3.3 CONVENTIONAL SUB-AERIAL TAILINGS SLURRY DISPOSAL AND STORAGE

The conventional approach to tailings disposal and storage, supported by the NPV approach, is to thicken the tailings just to the extent that they can be pumped using inexpensive and robust centrifugal pumps by pipeline to a surface tailings storage, where the tailings are deposited sub-aerially forming a beach.

Conventional sub-aerial tailings slurry disposal to a surface tailings storage involves the processes of beaching, hydraulic sorting of particles down the beach according to their particle size and specific gravity, settling of particles, consolidation, desiccation if exposed to the sun and wind, and loading by an upstream raise or cover placed for rehabilitation purposes. Beaching and hydraulic sorting are best assessed on the beach. Settling involves very large deformation and little strength gain, consolidation involves large deformation and significant strength gain, and desiccation involves some deformation and substantial strength gain. Loading the tailings beach could cause 'bow-wave' failure of tailings with a desiccated surface crust, requiring that loading be progressive on a broad front, which will result in strength gain in the tailings as they drain over time.

3.4 KEY CAUSES OF TAILINGS FACILITY FAILURES

Tailings facilities continue to fail at an unacceptably high rate of about two per year (Rico *et al.* 2008). Recent high profile failures in Brazil in 2015 and 2019 resulted in significant fatalities and involved major mining companies.

Most tailings facilities that fail have marginal stability, and most tailings facility failures involve 'water', making drainage, clay cores and water management key. Many tailings are potentially liquefiable, either under earthquake or static loading, although not all fail since the facility usually has adequate stability. Further, tailings in the embankment shell of centerline and downstream facilities that have been placed with compaction and drainage (as in Chile and Canada), have been shown not to be susceptible to liquefaction. Another cause of tailings facility failure can be a weak foundation layer (often unidentified, possibly moving from over- to normally-consolidated on progressive raising).

Many tailings facilities that fail have been constructed upstream. Equally, there are many traditional tailings facilities that have used the upstream method of construction that are fully resistant to all external loads and will provide excellent operating and closure stability. Nonetheless, use of upstream construction takes a higher level of design, independent review and operating discipline than some facilities are afforded and unless all of the key elements of strong design, review and operating practices can be assured, upstream facilities do present a higher risk than centreline or downstream facilities.

In relation to the design of tailings facilities, reliance has traditionally been placed on stability analyses carried out using the deterministic Limit Equilibrium method, typically with a single set of design parameters (see Box 3). The key parameters include the annual rainfall, which typically varies from 50 to 200 per cent of the average annual rainfall. The site seismicity has a variability of perhaps ±20 per cent for operations to perhaps ±50 per cent for closure

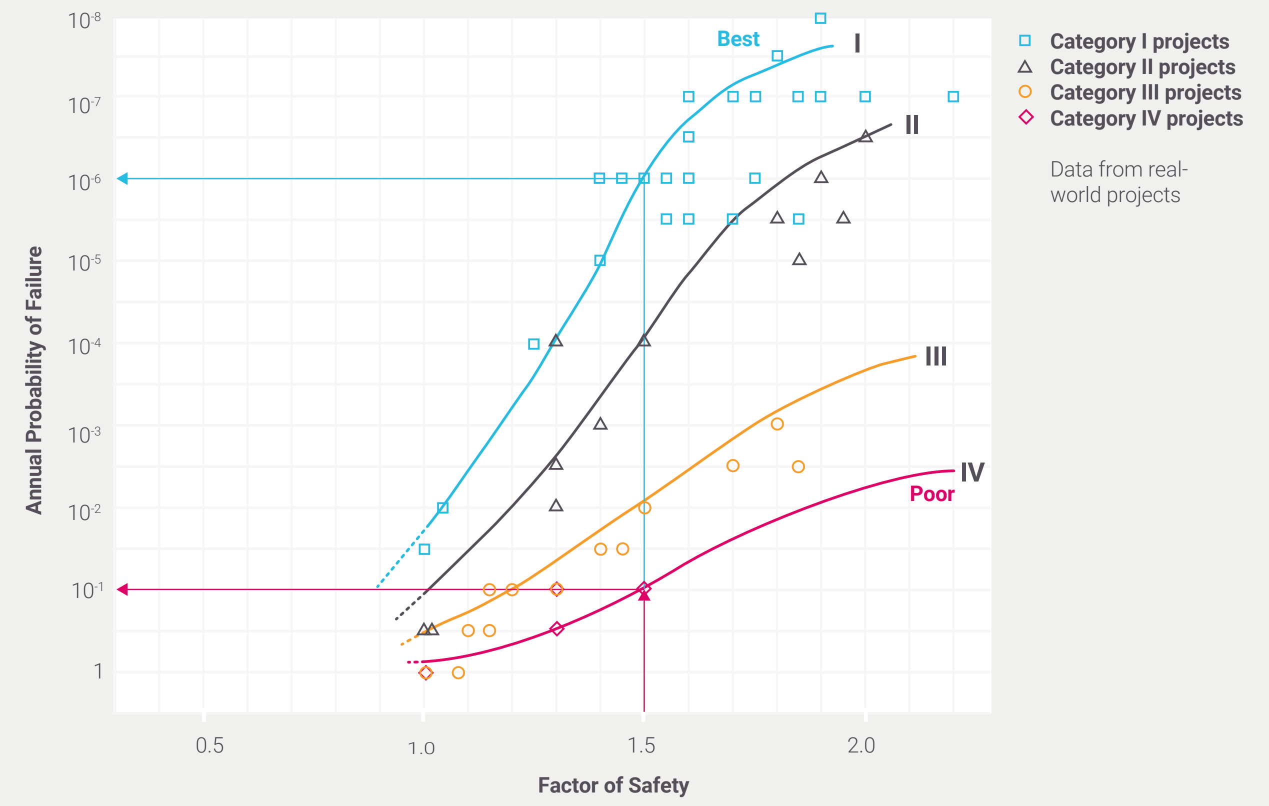
Box 3: Constraints of the Limit Equilibrium method

The calculated factor of safety does not warrant a precision of more than one decimal place. The Limit Equilibrium method also assumes that all points along the critical failure surface are at the same state (of failure), notwithstanding that brittle, cemented or bonded tailings resulting from desiccation and oxidation may be at different failure states.

(the higher variability for closure reflects the fact that closure is in perpetuity, nominally 10,000 years, requiring gross projections from available earthquake data in most cases). The undrained shear strength estimate for tailings may be ±50 per cent, while the estimated drained friction angle for tailings may be ±3 degrees. There is clearly a need to use conservative values in design and to carry out sensitivity analyses, but this has not always been the case in practice.

The relationship between the calculated factor of 'safety' and the corresponding probability of 'failure' must also be understood, particularly as it relates to the standard of design and construction. This is illustrated in Figure 2 (adapted from Silva *et al.* 2008). The figure shows that poor design and construction to a factor of safety of 1.5 corresponds to a very high and unacceptable probability of failure of 10^{-1}. By contrast, best design and construction, also to a factor of safety of 1.5, corresponds to a very low probability of failure of 10^{-6}, at the level of acceptability generally adopted for aircraft travel.

While attractive to many, the use of limit-equilibrium factors of safety are, at best, a guide and should not be the sole discriminator for the security of a tailings facility. Alternative approaches, for example deformation evaluations, may be far more appropriate for many facilities. Further, depending upon the parameters used, a factor of safety of 1.1 can be associated with a facility presenting zero risk of harm to society, whereas one with a much higher computed value (above 1.5) may present a high risk of harm. How a facility will strain under load (brittle versus ductile), along with the nature of the input parameters, are but two key reasons why the factor of safety is not as useful a tool as many consider it to be.



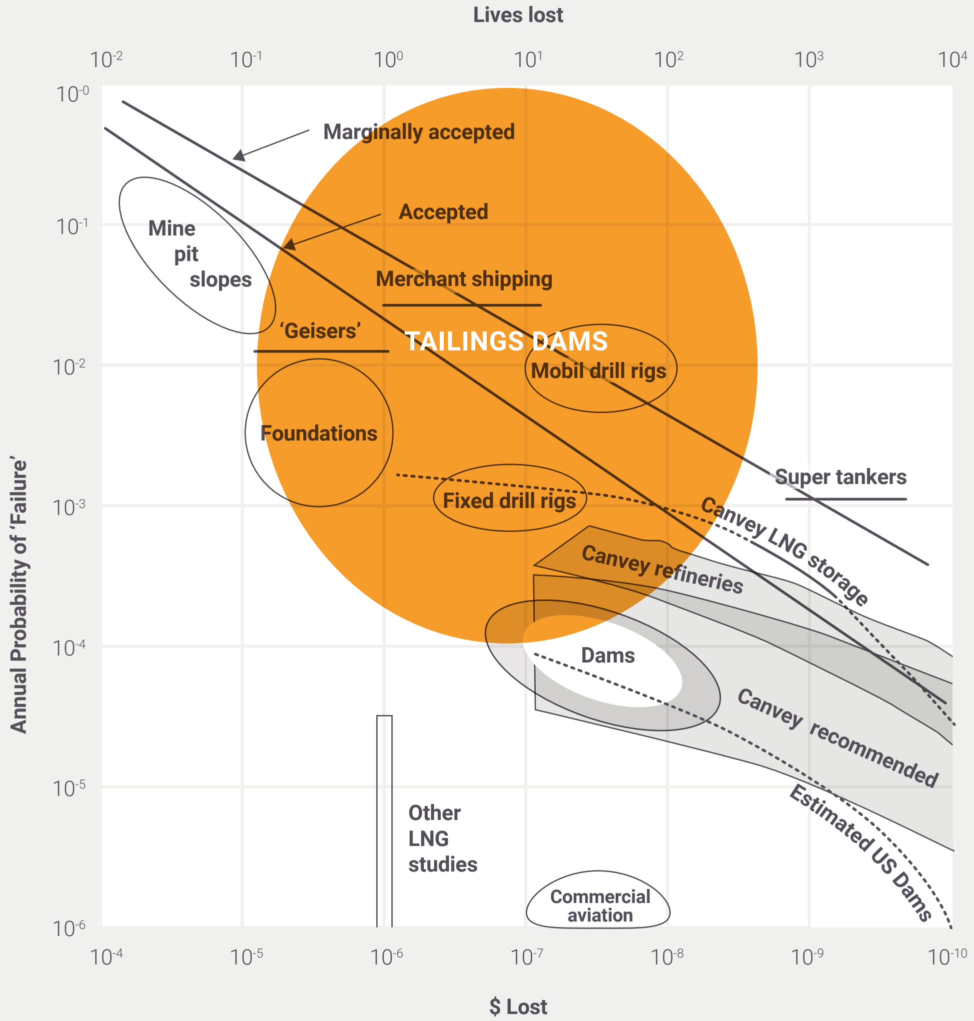
Source: Adapted from Silva et al. 2008

Figure 2. Relationship between calculated factor of safety and corresponding probability of failure, as it relates to standard of design and construction

While considerable work has been devoted to risk assessment, there is relatively little guidance on the acceptability of risk. Whitman (1984) attempted to plot the annual probability of failure against lives lost and dollars lost (in 1984 $). Key findings from this analysis are reproduced in Figure 3. Whitman assigned bubbles to represent different activities and types of infrastructure such as civil aviation (assigned an 'acceptable' annual probability of failure of about 10^{-6}), water facilities (at about 10^{-4}), buildings (at between 10^{-5} and 10^{-4}), foundations (at between 10^{-3} and 10^{-2}), mine pit slopes (at about 10^{-1}), and shipping (at between 10^{-3} and 10^{-2}). Whitman also added possibly upper bounds for 'acceptable' and 'marginally acceptable'. To Whitman's plot has been added the wide range for tailings facilities (from 10^{-4} to 1), based on the high tailings facility failure rates and consequences. Implications for tailings facility design are given in Box 4.

Box 4: Implications for Tailings Facility design

Clearly, tailings facilities can be built to a similar margin of safety as water facilities, at a probability of failure of about 10-4. If this were done, it would prevent many tailings facility failures, and the associated loss of life, damage to infrastructure, and environmental harm.



Source: Adapted from Silva et al. 2008

Figure 3. Acceptability of failure

3.5 CONSEQUENCES FOR INDUSTRY

As a result of the unacceptably high rate and severe consequences of ongoing tailings facility failures, there has been a loss of trust and confidence in the industry's ability to safely manage tailings. While the vast majority of tailings facilities do not fail, the failure rate is still beyond that deemed acceptable to both the industry and society. Further, the very clear lessons from failures indicate that there is an ability to reduce the rate of failures considerably towards a goal of zero catastrophic incidents. The track record to date, however, has created threats to the mining industry's financial and social licences to operate, coming from:

- an instantly 'social media-connected', although not necessarily well-informed, community
- major investors, such as the Church of England, BlackRock and the United Nations-supported Principles for Responsible Investment international network (PRI)
- insurers, who are making cover more difficult to obtain and more expensive, leading to self-insurance by major mining companies and creating difficulties if not near impossibility for mid-tier mining companies in securing cover
- regulators, who are imposing stricter requirements (for example, outlawing upstream construction

in Chile following an earthquake-induced tailings facility failure in 1965 that killed more than 200 people, and in Brazil following the Brumadinho tailings facility failure in 2019 that killed 270).

3.6 ALTERNATIVE APPROACHES TO TAILINGS MANAGEMENT

'Leading' or 'best' current practice in tailings management has been documented in numerous guidance documents, guidelines and handbooks (see the Appendix to this chapter). Conventional storage methods can be a 'best practice' for the right site conditions, but for many sites, alternative technologies would be a better option. Alternatives to current tailings management practices are described in several of these documents.

The following sections consider a range of alternative tailings management options, most of which use currently available technology (Williams 2015). The innovative aspects of these technologies lies mainly in their application to tailings management. Sound management practices are also essential for conventional tailings deposition.

3.7 ACHIEVING PHYSICAL STABILITY AND WATER RECOVERY VIA DEWATERING TAILINGS

Achieving physical stability of tailings via dewatering (how dry is possible, and how dry is dry enough) must be balanced against the need to ensure their geochemical stability. The latter requires maintaining the tailings near-saturated and preferably permanently under water, requiring a permanent impoundment and water supply.

The recovery of water in-plant is the most effective means of maximising water return for recycling and the retention of any residual process chemicals. Tailings are conventionally thickened prior to disposal to a surface tailings storage. The slurry concentration achievable by conventional thickeners varies with the type of tailings, typically ranging from 25 per cent solids by mass for coal tailings and alumina residue (red mud), and up to 40 to 50 per cent solids for metalliferous tailings. Smaller diameter high rate and high compression thickeners raise the solids concentration further, but with less torque than conventional thickeners.

Water recovery from the tailings storage itself is generally limited to the recovery of supernatant water[1] (the water that pools at the end of the tailings beach), although seepage through the wall may also be collectable. Other tailings water is lost to entrainment within the tailings, evaporation from the decant pond[2] and wet tailings, and seepage into the foundation and through the embankment.

In order to maximise the recovery of supernatant water from the tailings storage, good design, construction and management of the water return system is required. This should include the planning and implementation of tailings disposal to direct supernatant water to the decant pond, minimising the size of the decant pond and the rapid return of supernatant water to minimise evaporation losses, and maintaining the decant pumps and water return pipelines.

The overall tailings water recovered as a proportion of the total water used in processing is typically 50 to 60 per cent for tailings disposal as a slurry. This increases to 60 to 70 per cent for tailings disposal as a high-density slurry.

3.8 ON-OFF TAILINGS CELLS

As an alternative to in-plant dewatering, desiccation and harvesting of black coal tailings in 'on-off' tailings cells has been employed at a number of mines, including at Charbon Coal Mine in New South Wales since 1990 (see Figure 4). This method can be effective provided that the tailings are deposited in thin sub-layers, preferably no more than 600 milimetres thick, since desiccation by solar and wind action drops off exponentially with depth. Sufficient time (of the order of several weeks) must also be allowed for desiccation of each sub-layer before further sub-layers are added, to a maximum depth of about 3 metres, and before the full depth of dried tailings is harvested. This necessitates a large number of cells covering a large footprint -although probably no larger a footprint than would ultimately be needed for a conventional surface slurried tailings facility. The harvested dried tailings can be co-deposited with coarse wastes, so that ultimately there is no dedicated tailings storage facility.

1. Supernatant water is the water that pools at the end of the tailings beach.
2. The decant pond is the body of supernatant (process) water that has separated from the tailings solids, plus any rainfall runoff collected on the tailings facility. (Department of Industry 2016, p.110).

Source: Author

Insufficient desiccation | Full-depth drying | Dumping

Figure 4. On-off coal tailings cells, employing solar and wind drying, harvesting and disposal with coarse reject

3.9 THICKENING – IS THERE A PRACTICAL LIMIT?

If conventional thickening and slurry disposal fails to achieve adequate settling and consolidation and supernatant water recovery, secondary (inline) flocculation[3] can be applied just prior to tailings discharge to re-flocculate conventionally thickened tailings that have been shear-thinned by pumping.

The practical limit to thickening is considered to be a consistency that is just pumpable by inexpensive and robust centrifugal pumps. However, this consistency will vary with the particle size distribution of the tailings and, particularly, with the clay mineral type and proportion.

3.10 'FARMING' OF TAILINGS

Some forms of wet and soft tailings, particularly clay-rich tailings or process residue, may benefit from 'farming' by the use of equipment such as an amphirol or scroller, and/or later by a D6 Swamp Dozer. Farming is widely applied to red mud in Australia, and has been trialled on other tailings, including on coal tailings and fly ash in Australia, and oil sands tailings in Canada.

An amphirol (shown in Figure 5, Williams 2014) has a very low bearing pressure of 3 to 5 kilopascals and is used first. The principles of tailings or residue farming by amphirol are as follows:

- The tailings or residue can be poured to a thickness of 700 to 900 mm, up to three times the thickness if surface desiccation only was allowed.
- Some drying and strengthening of the tailings or residue surface is required to allow safe and efficient amphirol operation.
- Too heavy a bearing pressure from the amphirol and/or too soft a tailings or residue surface leads to bogging of the amphirol. An amphirol will only achieve minimal consolidation or compaction of the tailings or residue since its bearing pressure is low.
- An amphirol should:
  - essentially 'float' over the tailings or residue surface
  - create trenches down the tailings or residue beach to facilitate the drainage of surface water
  - maximise the tailings or residue surface area exposed to evaporation and strengthening, and
  - expose undesiccated tailings or residue on further farming.
- An amphirol should not over-shear the tailings or residue by excessive or repeated farming; about four amphirol passes is optimal.

A D6 Swamp Dozer has a bearing pressure of about 35 kilopascals and can be used once the tailings or residue has gained sufficient shear strength and bearing capacity to safely support it (see Figure 6). A dozer could be used after amphirolling or simply after the tailings or residue has desiccated naturally on exposure. Dozing improves the already desiccated tailings by compaction, leading to a further increase in dry density and shear strength.

3. Flocculation is a process widely used in mineral processing whereby small particles in suspension are aggregated to make larger clusters (flocs) that are more easily separated than the original particles.

Red mud has a specific gravity of about 3.0 and is difficult to densify due to it forming a loose 'card-house' structure of low permeability. Without farming, the dry density achieved is typically limited to about 0.7 tonnes per cubic metre, and desiccation is limited to a depth of about 300 mm. Amphirolling or scrolling can increase the dry density to about 0.9 tonnes per cubic metre, and dozing can increase it further to 1.3 to 1.4 tonnes per cubic metre.

Figure 5. Amphirol or scroller on red mud

Source: Author

Figure 6. D6 Swamp Dozer on red mud

3.11 PASTE TAILINGS

Paste thickeners raise the percentage of solids to between 45 per cent (for red mud) and 75 per cent for metalliferous tailings. The relative consistencies of high-density thickened slurry and high and low slump paste metalliferous tailings are illustrated in Figure 7.

Pumping paste tailings to a surface tailings storage requires piston pumps, which are about an order of magnitude more expensive than centrifugal pumps, cost more to operate, and are more sensitive to variable input feeds. Also, piston pumps discharge a 'toothpaste-like' consistency, which requires that the discharge point be constantly moved. However, paste tailings can be delivered under gravity as underground backfill (usually with cement added) or into a pit if the dewatering facility is located close to the discharge point, possibly on a mobile skid that can be moved. Underground tailings paste backfill will generally reach its intended destination under gravity, provided that the angle between the discharge and final points is steeper than 45 degrees.

The overall tailings water recovery as a percentage of the total water used in processing increases to about 80 per cent for tailings disposal as a high slump paste, and to 85 to 90 per cent for tailings disposal as a low slump paste. However, to date the practical applications of paste tailings have typically been limited to gravity deposition in-pit or as a cemented underground backfill.

Source: Author

High density slurry | High slump paste | Low slump paste

Figure 7. Consistency of thickened and paste tailings

3.12 FILTRATION AND DRY STACKING

If a consistency greater than is readily pumpable by centrifugal pumps is desirable, filtration may be preferable to producing paste tailings. Centrifuges or belt press filters can produce a 'wet' filter cake, while plate and frame or screw filtration can produce a 'dry' filter cake. The filter cake can then be transported by truck or conveyor. Centrifuged filter cake may still flow, while dry filter cake can be compacted.

Filtration of tailings can be achieved by vacuum, belt press, plate and frame, or screw (although screw filters have not been taken up for tailings) methods. While centrifuging and filtration can produce a cake of similar moisture content or the percentage of solids, the greater pressures imposed by filtration will create a 'structure' that makes the filtration cake more 'permanent', more readily transportable by conveyor or truck without inducing flow, and more manageable (see Figure 8).

Centrifuged (wet cake)

Filtered (dry cake)

Figure 8. Consistency of centrifuged and filtered tailings

Dry tailings filter cake better lends itself to dry stacking, although even then compaction may be required to form a stable stack, and to limit oxygen ingress and rainfall infiltration into potentially contaminating tailings in order to minimise contaminated seepage. Dry stacking, sometimes involving compaction, has found most favour in dry climates such as northern Chile. Dry tailings filter cake can also be co-disposed with coarse-grained wastes, as shown in Figure 9 for coal tailings. It is essential to avoid confusion around the nomenclature adopted for these filtered tailings: although termed 'dry', they do retain moisture after processing and when placed. The more correct term would be 'unsaturated' stacked tailings, but the existing terminology is well-established and should be understood by most in the industry.

Belt press filter

Conveying

Co-disposal in spoil piles

Figure 9. Belt press filtering of coal tailings, transportation of filter cake and coarse reject by conveyor, and end-dumping in spoil piles

3.13 BRIQUETTING

Briquetting has been shown in trials to be very effective in dewatering ultra-fine black product coal (Williams 2012). This technology can also potentially be applied to tailings. In the trials, ultra-fine product coal that was initially at 40 to 45 per cent total moisture content was dewatered to about 15 per cent total moisture content (85 per cent solids) by squeezing the slurry between two rollers under very high stress (of the order of 50 megapascals). The very high stresses imposed over very limited duration resulted in further dewatering of the briquettes formed, in a dry atmosphere, to about 2 to 5 per cent total moisture content (95 per cent solids). The air-dried briquettes can re-wet in a humid atmosphere, but only to about 15 per cent of total moisture content, and they retain their 'briquette' lumpy structure. This sequence of drying and re-wetting is illustrated in Figure 10. However, the high initial CapEx and high OpEx of briquetting have discouraged its application to either ultra-fine black product coal or tailings.

3.14 CO-PLACEMENT OF TAILINGS AND COARSE-GRAINED WASTE

Co-placement of fine coal (tailings) rejects and coarse rejects into a material that is transportable by truck has been practiced in British Columbia. This results in a compactable material that can be used to develop stable stacks that more resemble a conventional mine waste dump than a tailings facility.

The pumped co-placement of combined coal tailings and coarse coal rejects has been practiced at a numerous coal mines in Australia and Indonesia, since this method was first introduced at Jeebropilly Coal Mine in the Ipswich Coalfields of South-East Queensland in about 1990.

Pumped co-disposal in-pit at Jeebropilly Coal Mine is shown in Figure 11 (Morris and Williams 1997; 1999). Unfortunately, in order to avoid pipeline blockages, the combined washery wastes are pumped at a low 25 to 30 per cent solids and at high velocity (up to 4 m/s). This results in the unintended segregation of most of the fines and the generation of an undesirable flat (at about a 1 in 100 slope) fines beach (mostly tailings) beyond the desirable steep upper coarse-grained beach (at about a 1 in 10 slope). In addition, the inclusion of the coarse rejects results in high pump and pipeline wear.

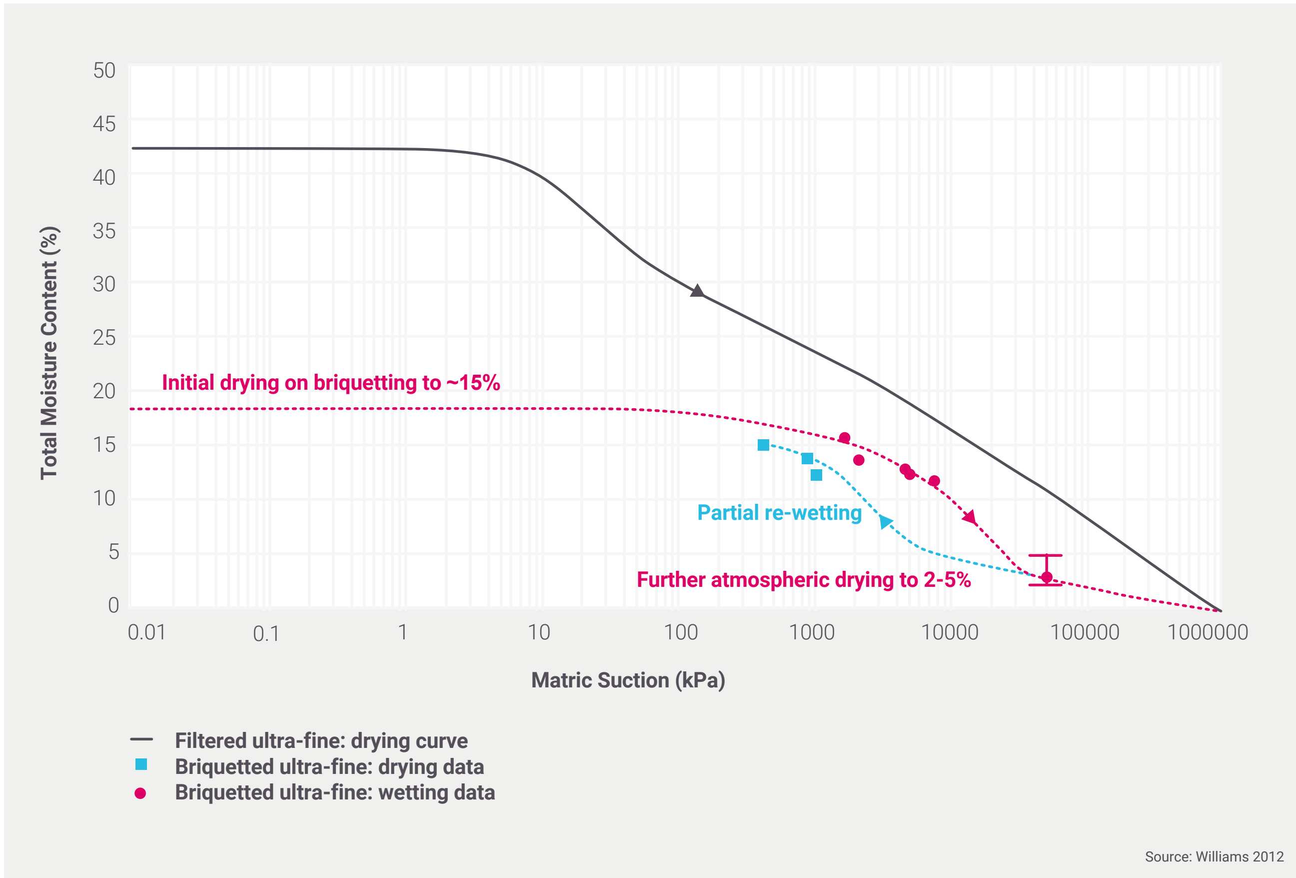


Figure 10. Briquetting trial on ultra-fine black product coal

Figure 11. Pumped co-disposal of combined coal tailings and coarse coal rejects

3.15 PIT TAILINGS STORAGE

Storing tailings in completed pits is gaining favour, particularly as permitting of new surface tailings storages meets with increasing community opposition. This option can be attractive when pit backfilling does not sterilise potential future ore reserves. It can be very attractive financially as it eliminates the need for the construction of a containment structure and does not require further thickening of the tailings. It also fills the void, albeit with wet and soft tailings that are very difficult to rehabilitate.

A challenge with implementing this option is that the rate of rise will be high in-pit due to its small footprint, particularly in the early stages. It is also difficult to manage the supernatant water due to the steep pit slopes limiting access to pumps, and the reduced evaporation of water by sun and wind (by up to 2-fold compared with surface ponds). This will severely limit dewatering, consolidation and strengthening of the tailings through desiccation. Consolidation of the tailings will be high and ongoing, causing the tailings surface to 'dish', reflecting the shape of the pit. A further disadvantage could be the potential for the contamination of any groundwater resources surrounding the pit, if contaminated pit water rises above the surrounding groundwater level. In addition, the stability of underground mining operations in the vicinity may be jeopardised. A further consideration is that, in a dry climate, a final pit lake over tailings will inevitably contain water of increasingly poor quality due to the concentration of salts and contaminants through net evaporation.

3.16 WASTE LANDFORMS

Integrated waste landforms are being employed in Australia, particularly at coal and iron ore projects, including new projects. This involves either the construction of a robust containment for thickened tailings using waste rock, or the co-disposal of mixtures of filtered tailings, and waste rock or coarse-grained processing wastes, delivered by combined pumping (such as for coal washery wastes), or by haul truck or conveyor. This method has also been employed in the wet tropics to encapsulate potentially acid forming tailings and waste rock behind a robust containment of more benign waste rock constructed in compacted layers.

3.17 'PASTE ROCK' AND 'ECOTAILS/GEOWASTE'

Another approach has been to combine filtered tailings with waste rock. Examples include:

- 'Paste Rock', patented by Golder Associates, which has been trialled in Canada for mine waste covers (Wilson *et al.* 2008)
- 'EcoTails/GeoWaste', patented by Goldcorp, which incorporates filtered tailings and screened or crushed waste rock (Burden *et al.* 2018).

The practical and economic challenges that must be overcome to promote the combination of filtered tailings and waste rock include:

- Minimising the extent to which the tailings must be dewatered, in order to save costs, while not compromising the stability of the tailings/waste rock mixture.
- Minimising the crushing or screening of the waste rock to allow mixing with the filtered tailings and transportation. The top-size of the waste rock for conveying is about 200 to 300 mm, while coarser-grained waste rock can be trucked.
- Achieving adequate mixing of the filtered tailings and waste rock. This is unlikely to occur on a conveyor or on dumping from a haul truck, but may be achieved by a number of drop points into hoppers along a conveyor line.
- Compaction of the mixture may be required to produce a stable deposit, although this could be restricted to the perimeter of the emplacement.

The benefits of combining filtered tailings and waste rock can include improved geotechnical parameters, including increased shear strength, reduced compressibility and a permeability that is lower than that of waste rock alone, but higher than that of tailings alone.

3.18 REDUCED TAILINGS PRODUCTION

While it is not the major focus of this chapter, it should be noted that more attention is now being paid to finding ways of reducing tailings production. This is in response to the ever-increasing production of tailings, due to decreasing ore grades and increasing demand for minerals. Another driver has been the rising cost of energy and other mining and processing inputs. The primary focus of innovation has been on coarse particle or dry processing. New technologies that are being applied to facilitate these alternatives include ore sorting using magnetic resonance technology, and 'precision mining'.

4. CLOSURE CONSIDERATIONS

Surface tailings storage closure should be developed with community input and address the agreed post-mining land use. Irrespective of the use(s) agreed upon, considerations for all facilities entering their closure phase will include:

- facility geotechnical instability – Tailings are expected to drain down on cessation of deposition, but may be recharged by high rainfall (in the absence of a spillway)
- facility erosional instability, particularly in a dry climate if the slope is flattened and topsoiled
- differential tailings settlement, affecting slope profile and drainage
- poor water quality (saline, and/or acidic, or alkaline), after a lag:
  - ponded water, and in any spill ponding below the tailings facility
  - emerging at low points around toe, and/or
  - infiltrating to any groundwater resource.

Box 5 summarises the challenges involved in closing facilities containing wet and soft tailings deposits.

The rehabilitation of tailings can range from direct revegetation of benign tailings, to soil covers, and also water covers, depending on the climatic setting. The Global Acid Rock Drainage [GARD] Guide (INAP 2009) recommends that the choice between cover types based on climatic conditions should be guided by the following considerations (Figure 12):

Box 5: Challenges of closing conventional tailings facilities

Post-closure, surface tailings facilities are required to remain physically and chemically stable in perpetuity, which can be mutually exclusive objectives. Some conventional wet tailings facilities have soft tailings deposits that are difficult and expensive to physically cover and rehabilitate, particularly at the end of the mine life when it is no longer producing revenue and construction equipment is being demobilised. Further, the presence of wet and soft tailings at some locations will limit the future land use potential of the tailings storage. On the other hand, their high degree of saturation will limit the oxidation of any sulphides present in the tailings.

- water covers are appropriate for wet climates as effective oxygen barriers
- water-shedding soil covers are appropriate in moist climates to promote rainfall runoff and limit net percolation of rainfall
- store and release soil covers, which store wet season rainfall, releasing it through evapotranspiration during the dry season to sustain revegetation, are appropriate for dry or seasonally dry climates to sustain vegetation and limit net percolation of rainfall.

In seasonally dry climates, store and release covers are more robust than rainfall-shedding covers since they better sustain vegetation and limit erosion. Store and release covers require a base sealing layer to limit the breakthrough of rainfall infiltration, and may take advantage of the natural tailings beach slope to direct clean excess rainfall infiltration towards a collection point, avoiding breakthrough into the underling tailings.

Any soil cover over tailings is necessarily relatively thin, and hence is prone to breakthrough. Also, all soil covers have some 'store and release' function. Historically, soil covers were limited in thickness and were placed primarily to support revegetation. Over time, an increase in cover thickness was seen as an 'improvement'. Rainfall-shedding covers followed the approach taken to cover landfills, but are prone to failure in dry or seasonally dry climates due to erosion. Too thin a cover lacks the capacity to store rainfall infiltration, can dry out during prolonged dry periods, and can be punctured by erosion. Store and release

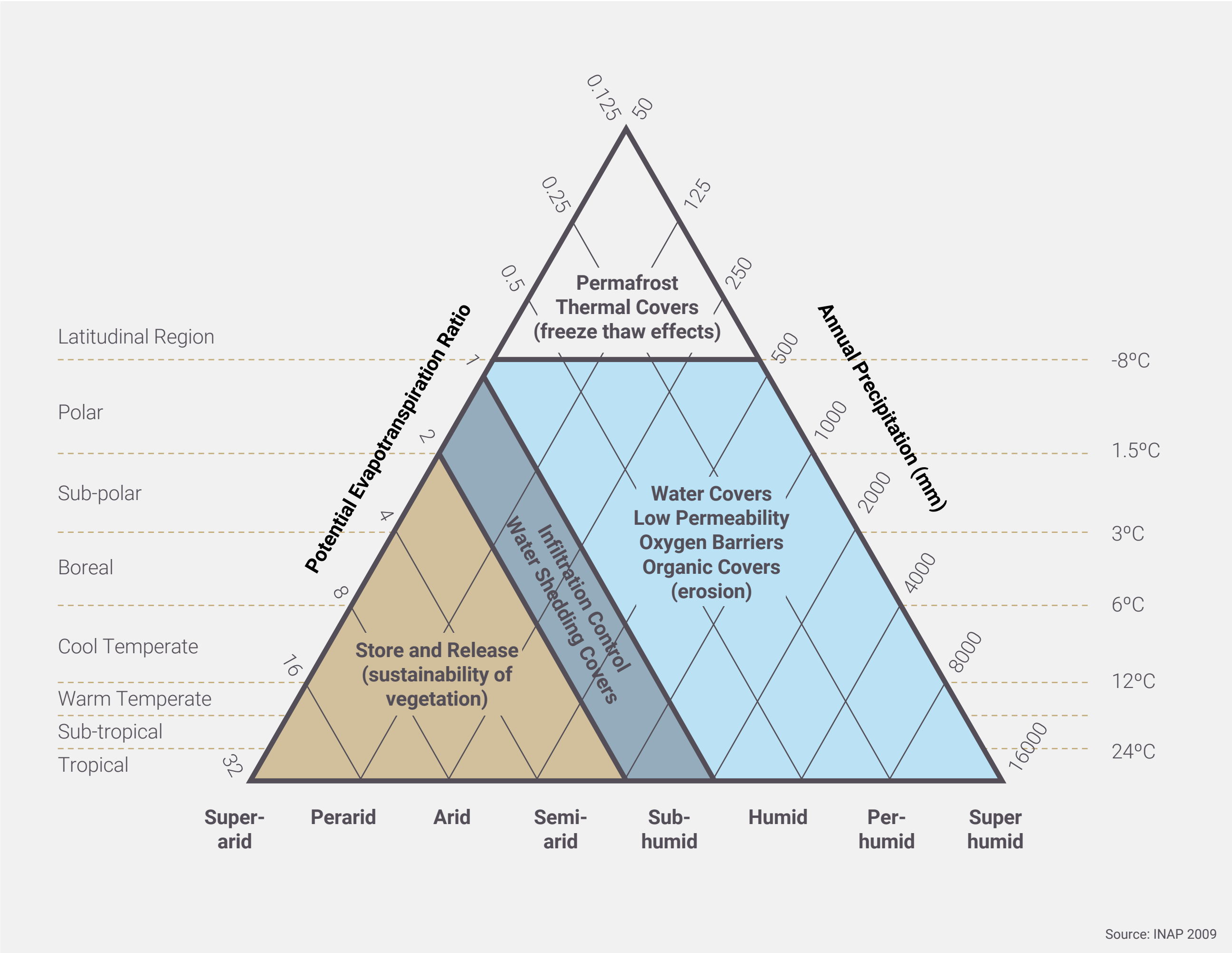


Figure 12. Choice of cover related to climate

covers gained popularity for dry climates but have not always been well designed and constructed. A composite cover is seen by regulators to be 'better', but by operators to be more costly.

Tree death (when tree roots reach contaminated tailings) and/or blow-down of shallow-rooted trees, due to roots spreading laterally across a compacted layer or contaminating tailings, can threaten the integrity of a cover over tailings. However, excluding tree growth is unsustainable. To address these issues, use may be made of shallow-rooted plants or plants that can survive on toxic tailings and/or take-up contaminants.

Store and release covers are designed to have sustainable tree, shrub and grass cover to transpire moisture. There is an optimal store and release growth medium thickness, of the order of 1.5 to 2 m. Too thin a layer does not store sufficient rainfall infiltration delivered by the climate, while too thick a layer makes it difficult for roots to extract deep drainage, leading to a wetting-up of the cover and increased risk of breakthrough.

Exposure to the atmosphere of potentially acid generating or otherwise potentially contaminating tailings may require that they be maintained under water, preferably from disposal onwards. The downside is that this will leave slurry tailings soft and wet. In wet climates and valley topographies, it may be possible to maintain the tailings underwater in perpetuity, provided that the stability of the facility's containment embankment can be assured. In dry climates and in flat terrain, the focus will need to be on minimising rainfall runoff over exposed contaminating tailings and the net percolation of rainfall that would transport contaminants. Alternatively, potentially contaminating tailings could be placed in a completed pit or underground mine and maintained underwater, or contaminants could be removed by additional processing, such as desulphurisation.

Without proper management, differential consolidation settlement of tailings can disrupt any constructed surface drainage features on a tailings cover, particularly as they are gently sloping (typically less than one per cent). This will also result in surface ponding of rainfall runoff on the tailings, recharging and exacerbating seepage. However, the hydraulic conductivity (permeability) is generally low due to the fine-grained particle size of most tailings, and particularly those that contain clay minerals or sulphides that hardpan. Consequently, consolidation can be slow and difficult to predict, and clay mineral-rich tailings may remain under-consolidated.

The treatment of the side slopes of a tailings facility is often given only limited attention. While slope flattening will increase geotechnical slope stability, it may not be required for this purpose. A downside of slope flattening is that it will likely increase the potential for erosion due to the increased slope catchment and runoff, particularly if erodible topsoil is placed on the slope to facilitate revegetation. Further, contour and downslope drains on tailings facility embankment slopes concentrate rainfall runoff and are prone to failure due to overtopping and piping failure.

The reality is that in many regions in the world, few surface tailings storages have been successfully rehabilitated, due to the associated costs, with reprocessing and in-pit storage being increasingly considered as alternatives. As argued above, the conventional cost-based approach to surface tailings storage rehabilitation is often at odds with the potential for value-added rehabilitation, as described in Table 1 (Williams 2019). A focus on the costs of tailings storage rehabilitation by operators and regulators discourages rehabilitation activities post-closure, which in turn is likely to lead to increased impacts over time, exacerbating the situation. By contrast, identifying and realising potential opportunities for value-added rehabilitation and post-closure land uses sets the rehabilitation budget and is a potential win for all stakeholders.

Table 1. Conventional cost-based rehabilitation versus value-added rehabilitation

Conventional Cost-Based Rehabilitation	Value-Added Rehabilitation
Production rules	Post-closure 'value' is identified upfront
Rehabilitation is seen by operator and regulator as a 'cost'	Examples of post-closure value include: • Re-processing of tailings to extract metals of value, depositing the residual tailings in-pit and reducing the rehabilitation liability • Industrial land use • Renewable energy– solar, wind and pumped storage, delivered to the grid via mine transmission lines • Agriculture and/or fishery impoundment • Tourism and heritage (older the better)
Operator discounts cost over time, discouraging rehabilitation	
Infrastructure such as power lines and buildings are stripped for little financial gain	
Rehabilitation is limited to 'smoothing' and 'greening' (where sustainable)	
Post-closure land use and function are limited	'Value' sets rehabilitation budget
Operator is threatened with loss of financial and social licences to operate	Potential wins for operator, future land user and Government

4.1 BARRIERS TO IMPLEMENTATION OF INNOVATIVE TAILINGS MANAGEMENT

Conventional slurried tailings deposition remains a best practice option for many sites. However, the industry currently has a range of options beyond this conventional approach and for those where conventional deposition and storage is not the best option. This begs the question of what is stopping adoption of alternative tailings management. Barriers to the implementation of innovative tailings management include the following:

- The continued reliance on NPV accounting and the use of a high discount factor (typically 6 to 10 per cent, which is three to five times the consumer price index). This approach favours tailings management options that are cheap in the short-term (particularly for CapEx), and delays necessary expenditure on rehabilitation. These factors together are likely to exacerbate impacts and blow-out rehabilitation costs.

- Alternative tailings management options, such as mechanical dewatering and co-disposal, are seen as too costly. This view is reinforced by NPV accounting.
- There are perceived and real technical difficulties associated with mechanical dewatering and co-storage (for example, high clay mineral content, and handling coarse-grained wastes).
- Uncertainty – and perceived higher risk – of new approaches also serve to discourage innovation.

Underlying all of this is an inherent resistance to change, which is often disguised as unsubstantiated claims about perceived high costs, perceived technical obstacles, and perceived uncertainty.

CONCLUSIONS

Tailings management must take into account the nature of the tailings and, importantly, the climatic, topographic and seismic settings of the mine. The ongoing rate of tailings facility failures is unacceptable to both industry and society, and there is a need to restore trust and confidence in the industry's ability to safely manage tailings. A rethink is required about the way in which tailings management is costed. Too many jurisdictions continue to rely largely on a net present value (NPV) approach with a high discount factor, rather than a whole-of-life cost approach. There is scope for the further development and implementation of new tailings management technologies and innovations, and for the use of different cost models, but this must overcome the natural resistance to doing things differently to the way they are usually done in those jurisdictions.

Tailings facilities can be built to a similar margin of safety to that of water dams, at a probability of failure of about 10^{-4}. This would prevent many tailings facility failures, and the associated loss of life, damage to infrastructure, and environmental harm. It would also restore the industry's financial and social licences to operate. The implementation of existing and new technologies to tailings management could help to eliminate the risks posed by a subset of conventional tailings facilities, possibly removing them altogether. Such technologies include:

- optimising in-plant dewatering of tailings, particularly by thickening or filtration
- 'farming' deposited tailings that consolidate poorly
- dry stacking of filtered tailings
- co-disposal of tailings and coarse-grained waste
- in-pit tailings disposal, particularly if final pit lakes containing water of diminishing quality can be avoided by complete back-filling
- integrated waste landforms that re-combine tailings and coarse-grained wastes
- reduced tailings production through coarse or dry processing
- value-added tailings rehabilitation post-closure.

As discussed, there are several barriers to the implementation of innovative tailings management where they are indicated by site-specific conditions, particularly where existing facilities are concerned. Change will be more readily achieved in new mining projects and hence change in tailings management for the mining industry as a whole will necessarily be generational.

KEY MESSAGES

1. If tailings facilities were built to a similar margin of safety to water dams, this would prevent many tailings facility failures.
2. There is a commonly held perception in the mining industry that transporting tailings as a slurry to a facility is the most economic approach, but this fails to factor in the true cost of closing and rehabilitating the resulting tailings facility.
3. A rethink is required about the way in which tailings management is costed. A substantial portion of global tailings practice still uses the Net Present Value (NPV) approach with a high discount factor. What is needed is a whole-of-life cost approach.
4. In practice, not enough tailings facilities have been successfully rehabilitated, due to the difficulty of capping a 'slurry-like' (wet and soft) tailings deposit and the excessive cost involved, particularly at a time when the mine is no longer producing revenue.
5. The implementation of existing and new technologies to tailings management could help to eliminate the risks posed by the nature of conventional tailings facilities that have been responsible for the failures that have occurred, possibly removing them altogether.
6. A fundamental barrier to the implementation of innovative tailings management at those sites that would benefit from these technologies is people's resistance to change, which is often disguised as unsubstantiated claims about perceived high costs, technical obstacles and uncertainty.
7. Change is more likely to be achieved in new mining projects than existing operations. Hence, change in tailings management for the industry as a whole will necessarily be generational.

REFERENCES

ANCOLD (2012). *Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure*. Canberra: Australian National Committee on Large Dams.

Burden, R., Wilson, G.W, Williams, D.J. and Jacobs, M. (2018). The shear strength of filtered tailings and waste rock blends. *Proceedings of Tailings and Mine Waste 2018,* 29 September to 1 October 2018. Keystone, Colorado. 347-355.

CDA (2013). *Dam Safety Guidelines*. Toronto: Canadian Dam Association.

CDA (2020). *Application of Dam Safety Guidelines to Mining Dams*. Toronto: Canadian Dam Association.

Davies, M.P. and Rice, S. (2004). An alternative to conventional tailing management – 'dry stack' filtered tailings. *Proceedings of Tailings and Mine Waste 2004.* 10-13 October 2004. Vail, Colorado. 411-422.

International Network for Acid Prevention [INAP] (2009). *Global Acid Rock Drainage Guide*. www.gardguide.com.

Department of Industry (2016) *Tailings Management*. Leading Practice Sustainable Development Program for the Mining Industry. Australian Government: Canberra. www.industry.gov.au/data-and-publications/leading-practice-handbook-tailings-management.

MAC (2019). *Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities, Version 3.1.* Ottawa: Mining Association of Canada.

USEPA (1994). *Technical Report – Design and Evaluation of Tailings Dams*. Washington DC: United States Environmental Protection Agency.

ICMM (2016). *Position Statement – Tailings Management.* London: International Council on Mining & Metals. https://www.icmm.com/position-statements/tailings-governance

ICOLD (from 1982). *Various bulletins on tailings storage*. Paris: International Committee on Large Dams.

Morris, P.H. and Williams, D.J. (1997). Co-disposal of washery wastes at Jeebropilly Colliery, Queensland, Australia, *Transactions IMM, A: Mining Industry*. 106:A25-A29.

Rico, M., Benito, G., Salgueiro, A.R., Díez-Herrero, A. and Pereira, H.G. (2008). Reported tailings dam failures. *Journal of Hazardous Materials*, 152(2): 846-852.

Shokouhi, A. and Williams, D.J. (2015). Settling and consolidation behaviour of coal tailings slurry under continuous loading. *Proceedings of Tailings and Mine Waste 2015.* 26-28 October 2015. Vancouver, BC, Canada. 1-11.

Silva, F., Lambe, T.W. and Marr, W.A. (2008). Probability and risk of slope failure. *Journal of Geotechnical and Geoenvironmental Engineering, ASCE*, 134(12): 1691-1699.

SANS 10286 (1998). *Code of Practice for Mine Residue Deposits*. South African Bureau of Standards.

United Nations (2014). *Safety guidelines and good practices for tailings management facilities*. United Nations Economic Commission for Europe.

Whitman, R.V. (1984). Evaluating calculated risk in geotechnical engineering. *ASCE Journal of Geotechnical Engineering*, 110(2): 143-188.

Williams, D.J. (2012). Some mining applications of unsaturated soil mechanics. *Geotechnical Engineering*, 43(1), 83-98.

Williams, D.J. (2014). An alternative whole-of-life approach to tailings management. *Proceedings of Life-of-Mine 2014,* 16-18 July 2014, Brisbane, Australia. 285-298.

Williams, D.J. (2015). Towards the elimination of conventional surface slurried tailings storage facilities. *Proceedings of Tailings and Mine Waste Management for the 21st Century,* Sydney, Australia, 27-28 July 2015, 11-23.

Williams, D.J. (2017). Future Tailings Management. *Proceedings of Tailings 2017,* Santiago, Chile, 12-14 July 2017, 8 p.

Williams, D.J. (2019). Obstacles to effective mine closure, rehabilitation and relinquishment. *Proceedings of Tailings and Mine Waste 2019,* 17-20 November 2019. Vancouver, Canada. 1271-1286.

Wilson, G.W., Wickland, B. and Miskolczi, J. (2008). Design and Performance of Paste Rock Systems for Improved Mine Waste Management. *Proceedings of Fifth International Seminar on the Management of Rock Dumps, Stockpiles and Heap Leach Pads.*5-6 March 2008. Perth, Australia. 107-116.

APPENDIX – GUIDANCE ON BEST OR LEADING TAILINGS MANAGEMENT

Global references to best or leading tailings management include (but are not limited to):

- ICOLD bulletins:
  - 44: Bibliography: Mine and Industrial Tailings Dams and Dumps (1982)
  - 44a: Bibliography: Mine and Industrial Tailings Dams and Dumps (1989)
  - 45: Manual on Tailings Dams and Dumps (1982)
  - 74: Tailings Dam Safety – Guidelines (1989)
  - 97: Tailings Dams – Design of Drainage (1994)
  - 98: Tailings Dams and Seismicity – Review and Recommendations. (1995)
  - 99: Dam Failures Statistical Analysis (1995)
  - 101: Tailings Dams – Transport, Placement and Decantation (1995)
  - 103: Tailings Dams and the Environment – Review and recommendations. (1996),
  - 104: Monitoring of Tailings Dams – Review and recommendations (1996)
  - 106: A Guide to Tailings Dams and Impoundments – Design, construction, use and rehabilitation (1996)
  - 121: Tailings Dams: Risk of dangerous occurrences – Lessons learnt from practical experience (2001)
  - 139: Improving Tailings Dam Safety – Critical Aspects of Management, Design, Operation and Closure (2006)
- EPA (1994). Technical Report – Design and Evaluation of Tailings Dams
- SANS 10286 (1998). Code of Practice for Mine Residue Deposits
- GARD Guide (2009)
- ANCOLD (2012) Guidelines on Tailings Dams
- Leading Practice Handbook: Tailings Management (2016)
- CDA (2013). Dam Safety Guidelines
- CDA (2020) Application of Dam Safety Guidelines to Mining Dams. Canadian Dam Association
- Mining Association of Canada [MAC] (2019). Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities
- UN (2014). Safety guidelines and good practices for tailings management facilities.
- ICMM (2016). Tailings Management.
- ICMM (2019). Global Tailings Review.

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CHAPTER VII
LESSONS FROM TAILINGS FACILITY DATA DISCLOSURES

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1. INTRODUCTION AND SUMMARY OF FINDINGS

In this chapter we report on lessons derived from an analysis of the most comprehensive global survey of tailings facilities ever undertaken. The data are derived from information disclosures by publicly listed companies, following a request by the Church of England Pensions Board and the Council on Ethics of the Swedish National Pension Funds. The request was made on behalf of the Investor Mining and Tailings Safety Initiative, a group of 112 investors that represent US$14 trillion in assets under management. The information disclosures reveal new data on 1743 unique tailings facilities, containing 44.54 billion m^3 of waste material.[1]

The chapter analyses this unique dataset for the first time, presenting findings across a range of topics, including facility construction method, consequence of failure, the number of facilities that have reported at least one past stability issue, volume of tailings under storage, and the rate of uptake of alternative technologies to dewater tailings and reduce geotechnical risk. While the findings presented here are only the beginning of the potential insights that can be generated from the current dataset, they represent a significant advancement of the science on tailings facilities.

Although the dataset does not capture all tailings facilities (see Box 1), it does represent 30 per cent of contemporary global commodity production, with 83 per cent of the market capitalisation of publicly listed companies in the industry responding to the disclosure request. This significant representation of active facilities makes it possible to scale trends within the data to generate global estimates for some parameters.

Our analysis finds that the number of tailings facilities has significantly increased over time. The number of facilities doubled between 1955 and 1969 (14 years), doubled again between 1969 and 1989 (20 years) and again between 1989 and 2020 (31 years). We project the total number of active tailings facilities worldwide to be around 3,250 and the total number of active, inactive and closed facilities around 8,500. This estimate is calculated by scaling the number of facilities reported in the dataset to global mineral production as reported by the United States Geological Survey mineral commodity summaries.

1. For a sense of scale, if this volume were spread evenly across an area the size of Manhattan island, it would be higher than all the skyscrapers.

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> **Box 1: Data limitations**
>
> There may be incentives for companies to under-report on parameters such as the existence of past stability issues, and to that extent the analysis and data presented herein should be considered conservative. The failure of tailings facilities also has the effect of contributing to under-reporting by the very fact that in some cases those facilities no longer exist and thus their characteristics are not disclosed.
>
> The method used to request information disclosure on tailings facilities from publicly-listed contemporary companies has produced a dataset that is likely more representative of active tailings facilities, omitting some closed facilities and the large number of abandoned facilities for which there is no longer an owner responsible. There is also a possibility that the survey under-samples less diligent companies, with lower governance standards, who failed to respond to the disclosure request.
>
> The dataset does not include information from companies that are not publicly listed, such as state-owned entities, privately-owned companies, and many mid-sized and junior companies, contributing to an under-representation of facilities in countries such as China and Chile, and potentially an over-representation of larger facilities.

Planned generation of tailings over the coming five years is 2.5 billion m^3 per year for the reporting companies, with the total planned tailings under storage expected to be 56.2 billion m^3, which represents a 26 per cent increase in tailings under storage over this five-year period. When scaled to global mineral production we estimate 11.1 billion m^3 of additional tailings is expected to require storage in tailings facilities per year over the coming five-year period (14.4 billion *t*). Baker *et al.* (this volume) used mineral production and ore grades for a wide range of commodities to estimate an annual output of 8.85 billion *t* of tailings for 2016.

Of the reported tailings facilities, the upstream construction method is the most common, followed by downstream construction. Centreline, hybrid,[2] and single raise construction methods are the next most common. In-pit/natural landform and dry-stacked are the least common construction methods. While upstream facilities currently make up 37 per cent of total reported number of facilities, they have declined from a peak of 85 per cent of facilities constructed in 1920-1929 to 19 per cent of new facilities in 2010-2019. However, there is variation across commodities.

Analysis of the incidence of past stability issues reveals strong trends across tailings facility raise types and other parameters.[3] Upstream and hybrid facilities are the most likely to have reported a past stability issue when normalised against the frequency of each raise type, with 18 per cent of active upstream facilities reporting 'notable stability concerns' or failure to be 'confirmed or certified as stable' at some point in their history. The normalised prevalence of past stability issues reported by active upstream facilities is twice that of downstream facilities and six times as many as dry-stack facilities. No active in-pit/natural landform facilities reported a past stability issue. These observations are consistent with analyses of tailings facility failures, which show a greater prevalence of failure for upstream facilities than for other raise types (ICOLD and UNEP 2001).[4]

Taller and larger facilities (by volume) are also more likely to have reported a past stability issue, although facilities over 100m in height show fewer issues, perhaps due to higher standards of construction. The relationship with seismic hazard is complex. As seismic hazard increases, facilities are initially less likely to have reported a stability issue, which may be explained by the lower proportion of upstream and hybrid facilities in this fraction or the possibility that facilities are built to higher standards of construction in earthquake prone regions. However, at locations of high and very high seismic hazard, the likelihood of a facility reporting a past stability issue increases.

Hybrid, upstream, downstream and centreline tailings facilities were found to be associated with a significantly higher consequence of facility failure than those for dry-stack, single raise and in-pit/natural landform facilities, as determined by company-

2. The term 'hybrid' facility is used here to refer to facilities where multiple raise methods are utilised in the same facility over time.

3. We refer to stability issues throughout the chapter as synonymous with *geotechnical* stability, acknowledging that the *geochemical* stability of tailings is a critically important issue, but not one addressed by the disclosures.

4. In their analysis of tailings facility failures ICOLD and UNEP (2001:20) find a greater prevalence of failures for upstream facilities, though they qualify this by stating: 'The [*stability*] incidents must be reviewed in terms of the number of particular dam types in operation. The upstream method is the oldest and most commonly used method of tailings dam construction.' Elsewhere, ICOLD and UNEP (2001:24) argue that 'In general, dams built by the downstream or centreline method are much safer than those built by the upstream method, particularly when subject to earthquake shaking.'

commissioned modelling during facility design and construction.[5] Given that upstream facilities have been considered by ICOLD and UNEP (2001) as less safe than downstream and centreline facilities, it could be expected that the construction of these facilities is avoided in locations where the potential consequence of failure is high, however, this does not appear to be the case.

The removal of water from tailings to generate thickened, paste or filtered tailings is an important innovation in tailings practice that has been identified by a significant number of authors as having the potential to improve geotechnical and geochemical stability (Nguyen and Boger 1998; Boger 2009; Boger *et al.* 2006; Jewell and Fourie 2006; Davies *et al.* 2011; Franks *et al.* 2011; Edraki *et al.* 2014). Tailings dewatering has been identified as a priority by individual mining companies and peak industry bodies (see for example, ICMM 2019). Analysis of the disclosures shows that the uptake of filtered and in-situ dewatering of tailings has not significantly increased over recent decades.

The findings reported here complement those from analyses of individual tailings facility failures, such as those reported by Morgenstern *et al.* (2015; 2016) and Robertson *et al.* (2019), and the analysis of datasets of multiple tailings facility failures, such as those reported by ICOLD and UNEP (2001), Azam and Li (2010), and Bowker and Chambers (2017).

2. BACKGROUND AND METHODS

On April 5, 2019, the Church of England (CoE) Pensions Board and the Council on Ethics of the Swedish National Pension Funds, on behalf of 112 investors, representing US$14 trillion in assets under management, wrote to Board Chairs and Chief Executive Officers of listed extractive companies and requested specific disclosure on tailings facilities (CoE and Swedish Council on Ethics, 2019a). The disclosure questions were developed in consultation with independent technical advisors, the ICMM Secretariat and four mining companies. Barrie *et al.* (this volume) provide a full list of the disclosure questions. The letter requested that the responses be uploaded to the company website, signed by the CEO or Board Chair. A follow-up letter was sent on April 17, setting an extended deadline of June 7, 2019 for the disclosure (CoE and Swedish Council on Ethics, 2019b). Correspondence was sent to a total of 727 companies, representing publicly listed mining, as well as oil and gas companies. The later were included due to the potential exposure to tailings from oil sands operations and joint ventures.

A specialist Environmental, Social and Governance (ESG) financial services provider was commissioned to compile the list of companies and distribute the letter requesting disclosure. The list of companies was generated using the Global Industry Classification Standard.[6] An additional 88 small and mid-market companies not listed in the above codes were added by investor participants in the initiative.

The request specified that companies should report all tailings facilities where the company has any interest, through subsidiaries, partnerships, joint ventures both incorporated and unincorporated, and any other enterprises of whatever legal form. All joint venture partners were requested to report on jointly owned facilities, even if the reporting company was not the operating partner.

Of the 727 companies contacted:

- 339 responded (representing 47 per cent of the companies contacted)
- 187 of these companies confirmed they did not have tailings facilities (representing 55 per cent of those responding and 26 per cent of all companies)
- 152 confirmed they did have tailings facilities.

As of March 2020, 45 of the companies that confirmed exposure to tailings facilities had not published their disclosure on a website or asked for extra time to complete their disclosure.

For the mining sector specifically:

- 45 out of the 50 largest mining companies by market capitalisation in the world responded
- 83 per cent of the industry by market capitalisation responded
- 60 per cent of the industry by market capitalisation publicly disclosed
- All 23 out of 23 publicly listed members of the International Council on Mining and Metals (ICMM) publicly disclosed.

The proportion of market capitalisation of the respondents was calculated on 4 November 2019 using the Thomson Reuters Eikon financial data platform.

In December of 2019 and January of 2020, a compilation of the disclosed data was sent to each reporting company for verification. The majority of disclosing companies responded to this extra request, resulting in 86 per cent of the entries of the dataset being subject to this additional layer of verification. A full list of the companies that were contacted and the status of their disclosure is publicly available and published on the Investor Mining and Tailings Safety Initiative website (CoE and Swedish Council on Ethics, 2019c). The version of the dataset analysed in this chapter was current as at February 26, 2020.

Due to duplicate reporting by multiple owners, the disclosures were corrected for analysis to represent only unique tailings facilities. Where there were discrepancies in the reported data by multiple owners of the same facility, we prioritised data for analysis which were disclosed by the operating companies. Where the ownership of the facility was a separate joint-venture company, we prioritised the data reported by the owner with the highest ownership share. In the case of 50/50 joint ventures, we prioritised the data of the owner by alphabetical order.

Each ‘tailings facility’ in the dataset represents a unique tailings structure. In some cases, tailings facilities may consist of multiple structures. This generated a second type of duplicate in the raw data that is relevant for calculations of volume. Companies that reported facilities with multiple structures sometimes reported the same total volume and planned volume for multiple data entries. In our calculations of volume, duplicate data have been corrected by evenly distributing the reported volume against the number of structures that make up the facility. It is also worth noting that ‘tailings facilities’ in the dataset include tailings production at mines, but also tailings, slimes, ash and other wastes produced at mineral processing and smelting facilities.

With funding support from the United Nations Environment Program (UNEP) and the Investor Mining and Tailings Safety Initiative, GRID-Arendal compiled the data into a database for analysis. The individual company disclosures were compiled independently by two additional research teams from The University of Queensland and The University of the Witwatersrand, and shared with the GRID-Arendal team for cross-checking, comparison and data-cleaning. A searchable online database of the disclosures was published by GRID-Arendal on the 24th of January 2020, as the Global Tailings Portal (http://tailing.grida.no).

The S&P Global Metals and Mining Industry database was used to assign individual mine site mineral production to the active tailings facility entries. The most recent S&P Global production figures (2018) were used.[7] All tailings production was assigned to the primary commodity of the operation. Global mineral production figures from the United States Geological Survey (USGS), *Mineral Commodity Summaries* (2019, reporting 2018 data) were used to calculate the representativeness of the dataset as a function of global production and to project a global estimate of tailings production and number of facilities.[8] The tailings facility dataset represents an average of 30.2 per cent of global commodity production. The relatively high sample rate provides confidence in the global representativeness of the dataset for active tailings facilities.

The tailings production (as stored in tailings facilities) for each mine was calculated by using the annual average of the planned tailings storage in five-years, which was reported by the companies. Production data is available in the S&P database for a range of commodities (bauxite, coal, cobalt, copper, diamonds, gold, iron ore, lanthanides, lead, lithium, molybdenum, nickel, niobium, palladium, phosphate, platinum, potash, silver, tin, uranium, zinc). For commodities where production data is not available from the S&P Global database or cannot be matched with USGS production data (alumina, aluminium, borates, chromite, ferrochrome, ferromanganese, ferrovanadium, ilmenite, manganese, rutile, tantalum, titanium, vanadium, oil sands, refineries, smelters, power plants), which represents 16 per cent of the reported active facilities, the average coverage of the other commodities (30.2%) was used to project the global estimate. The number of tailings facilities was estimated by projecting the proportion of global production represented by the mines in the tailings

5. A tailings dam breach analysis is conducted by a dam safety professional to identify and characterise threats to public safety and the environment. The results are typically presented as inundation and deposition maps and used to classify the consequence of a potential failure of a facility, as well as to assist in emergency planning, dam safety management, failure mitigation planning, and mine closure and dam decommissioning planning (Martin et al. 2019).

6. Companies in the following sub-industry codes were contacted: oil and gas drilling, oil and gas exploration and production, integrated oil and gas, coal and consumable fuels, fertilizers and agricultural chemicals, aluminium, diversified metals and mining, copper, gold, precious metals and minerals, silver, steel, and construction materials.

7. Except bauxite, where the most recent production data available in the S&P Global database was 2016.

8. USGS commodity summaries do not include artisanal and small-scale mining production, for which extraction is commonly of placer deposits with consequent low production of tails.

facility dataset for active mines. If a constant sample rate is assumed between active, inactive and closed facilities then an estimate can also be calculated for the total number of facilities.

Data on seismic hazard were derived from the Global Seismic Hazard Assessment Program (Zhang *et al.* 1999) which provides a global dataset of seismic risk based on Peak Ground Acceleration risk estimates. Data on wind was sourced from Global Wind Atlas (2017), and data on precipitation sourced from Fick and Hijmans (2017).

3. FINDINGS

3.1 TAILINGS PRODUCTION

A total of 44.54 billion m^3 of tailings is currently under storage by the facilities disclosed in the dataset. Expected generation of tailings over the coming five years is 2.52 billion m^3 per year for the reporting companies (2019-2023), with a 26 per cent increase in tailings under storage over this five-year period to 56.2 billion m^3 at January 2024. When these numbers are scaled to represent global mineral production we estimate 11.1 billion m^3 (14.4 billion *t*)[9] of additional tailings will require storage per year over the coming five-year period.[10] This annual estimate of worldwide increase in tailings requiring storage (see Figure 1) is higher than the global tailings production estimates reported by Baker *et al.* (this volume), who used mineral production and ore grades to estimate 8.85 billion *t* of tailings produced per year in 2016 for a range of commodities.

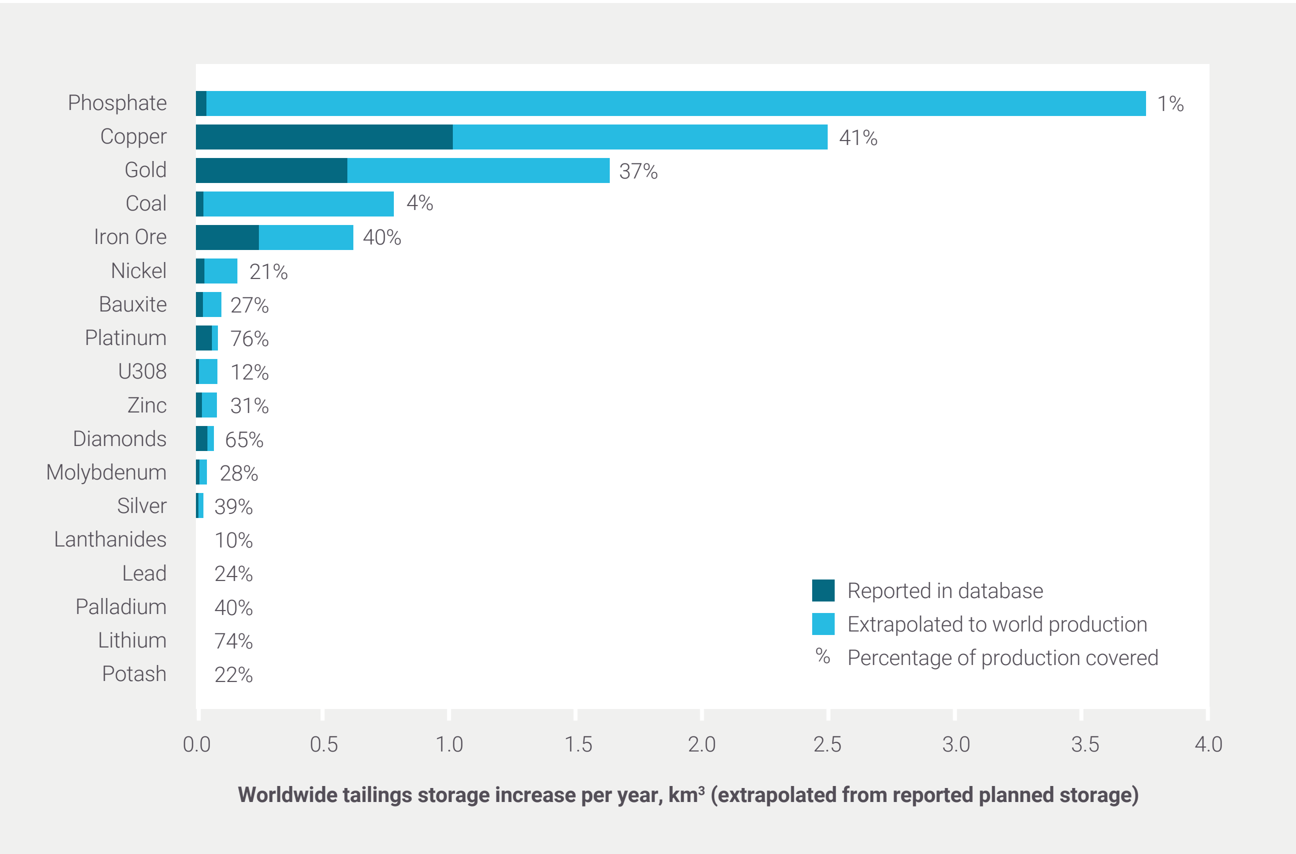

Figure 1. Tailings storage increase per year for a range of commodities as reported in the dataset and extrapolated to world production

9. Tailings production by weight calculated assuming the modal average of tailings bulk density reported by 20 companies as part of the disclosures (1.3 t/m^3). The reprocessing and reclamation of tailings (a type of negative production of tailings) was not considered in the calculation of expected future tailings production.

10. This estimate does not include tailings that are not stored in a tailings facility (e.g. tailings backfill and heap leach pads).

3.2 NUMBER OF FACILITIES AND THEIR MANAGEMENT

A total of 1743 unique facilities are reported in the dataset (725 of which are currently active). This number has significantly increased over time as illustrated by Figure 2, which shows the number of tailings facilities by decade of construction.

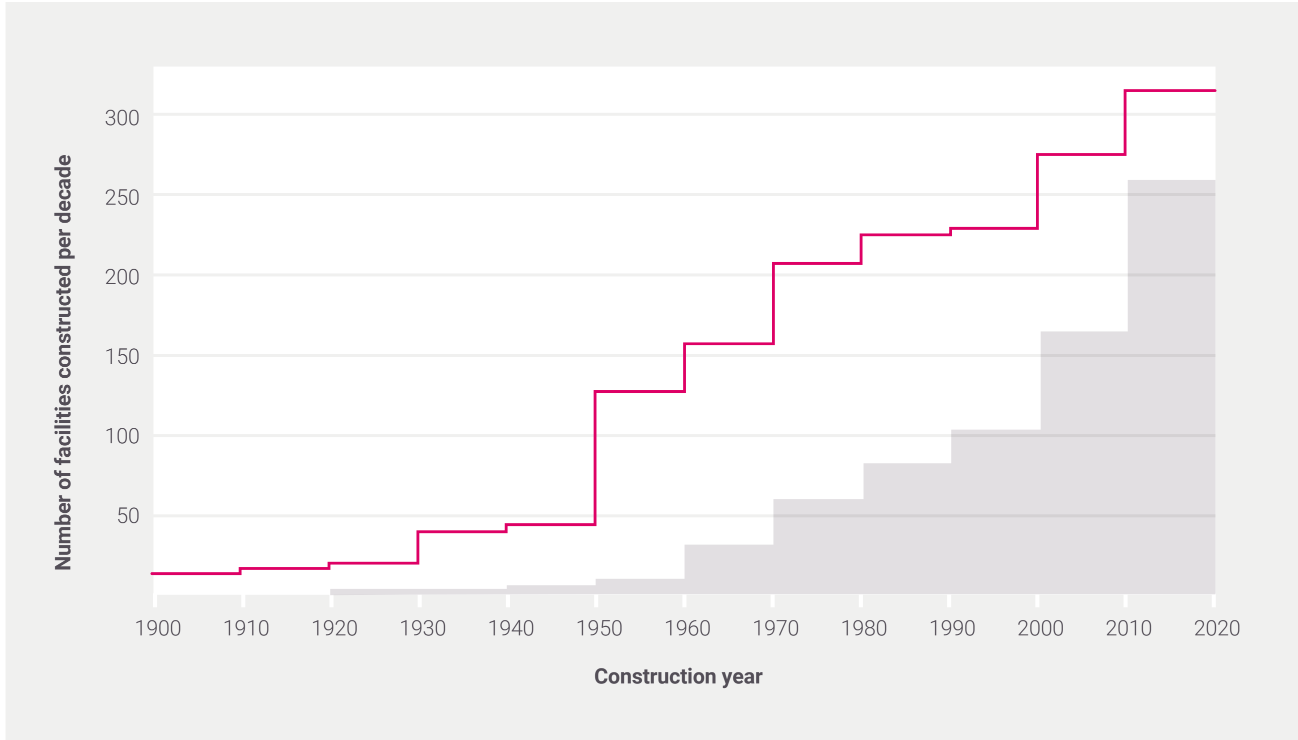

Figure 2. Tailings facilities by decade of construction

Note: shading indicates active facilities

The number of tailings facilities doubled between 1955 and 1969 (14 years), doubled again between 1969 and 1989 (20 years) and again between 1989 and 2020 (31 years). The largest reported facility by tailings under storage is 1.56 billion m^3. The largest active tailings storage facility by volume of tailings under storage is 1.19 billion m^3. The mean facility volume for all facilities is 26.3 million m^3 and for active-facilities-only is 43.7 million m^3, which may indicate an increase in individual facility volume over time.

We estimate that the total number of active tailings facilities worldwide is around 3,250 and the total number of active, inactive and closed facilities is 8,500. This estimate was calculated using the reported number of facilities projected to global commodity production using USGS mineral commodity production estimates. Due to the data considerations outlined in Box 1 it is important to note that this is a conservative estimate that does not include abandoned facilities. Davies and Martin (2000) cite a global estimate of 3,500 tailings facilities, while Yin *et al.* (2011) cite 12,000 facilities just in China. Other researchers have estimated as many as 18,000 facilities (Brown and Elliott 2019). However, the methods for determining the aforementioned estimates are unknown, and it is not clear whether they refer to active, inactive, closed, or abandoned facilities.

Companies reported that most facilities keep full and complete engineering records (85 per cent), have an accompanying closure plan (93 per cent), and include long-term monitoring in their closure plans (87 per cent). Oversight of the management of the facilities is predominantly undertaken jointly by both external engineering specialists and in-house professionals (72 per cent), followed by external-only (20 per cent) and internal-only oversight (6 per cent). For around two per cent of the facilities (46 in total) it was not clear whether they were under any kind of engineering oversight. Three of these facilities reported a past stability issue.

3.3 CONSTRUCTION METHODS

Figure 3 shows the total number of tailings facilities in the database, categorised by raise type. The upstream construction method is historically the most common, followed by downstream construction. Centreline, hybrid, and single raise construction methods are the next most common. In-pit/natural landform and dry-stacked are the least common facility types.[11]

While upstream facilities make up 37 per cent of total reported facilities, they have declined from a peak of 85 per cent of new facilities in 1920-1929 to 19 per cent of new facilities in 2010-2019 (see Figure 4). Upstream facilities make-up 43 per cent of facilities that are inactive, closed or reclaimed. In the past twenty years the number of new downstream and in-pit/natural landform facilities have risen sharply, while the number of new upstream facilities has declined.

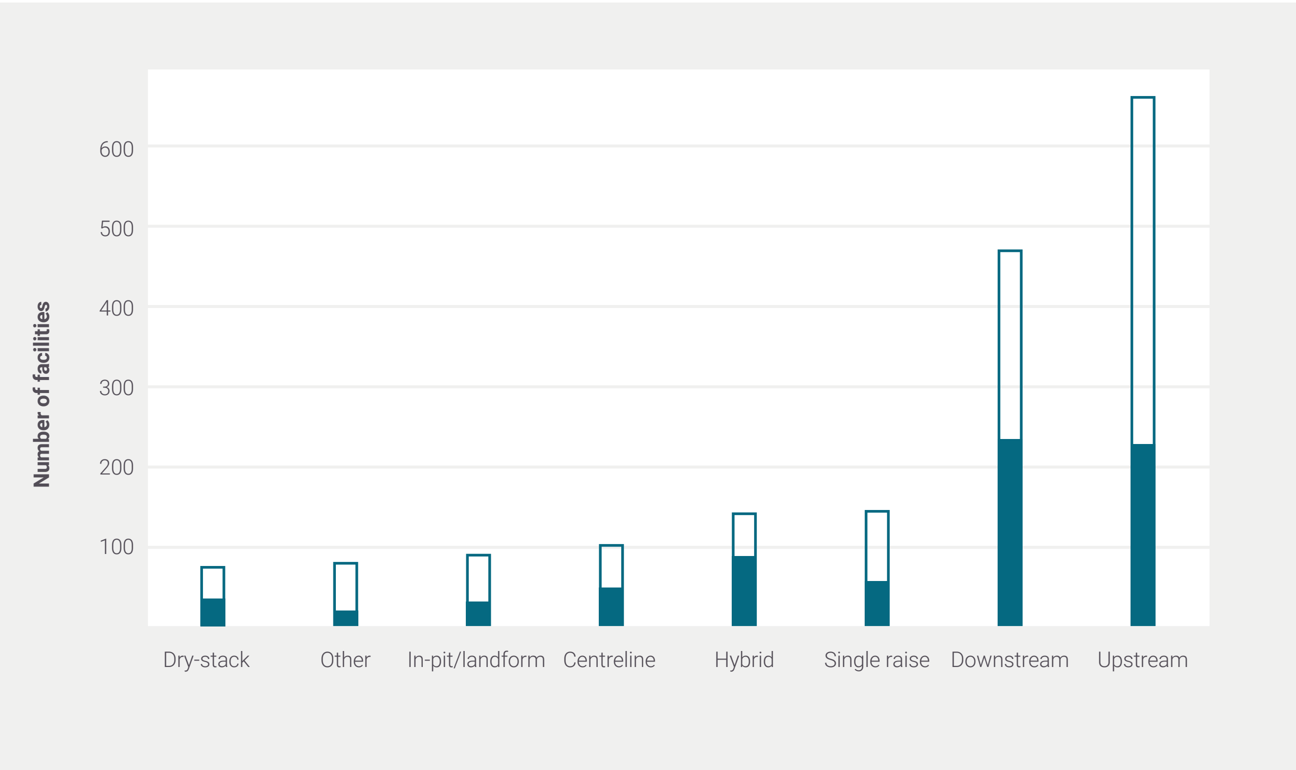

Figure 3. Tailings facilities by raise type

Note: shading indicates active facilities

The relative frequency of facility construction methods varies by continent, which is due to a range of factors, including commodity, ore type, climate, seismic hazard, topography, and governance (see Figure 5). Upstream facilities now represent a relatively low number of active facilities in North and South America when compared to Africa and Oceania. This may partly reflect different regulatory approaches; for example, upstream facilities were banned in Chile following the La Ligua earthquake in 1965 and the collapse of the El Cobre tailings facilities, which resulted in the deaths of more than 200 people.

11. For data analysis purposes Modified Centreline facilities were categorized together with Centreline facilities. Operations that produce paste or thickened tailings were classified by companies by the facility raise type, rather than whether the tailings themselves have been dewatered. A small number of Central Thickened Discharge facilities were reported in the dataset, but not enough to undertake meaningful analysis.

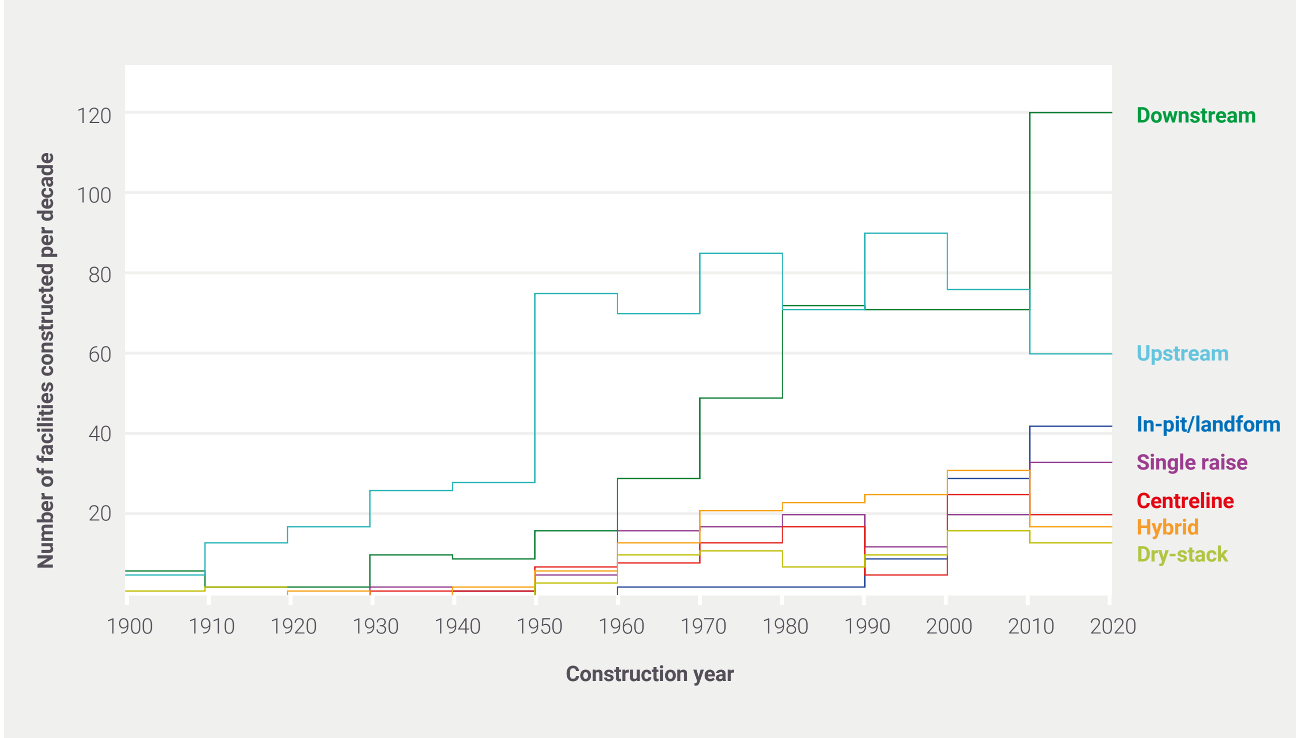

Figure 4. Number of facilities constructed per decade by raise type

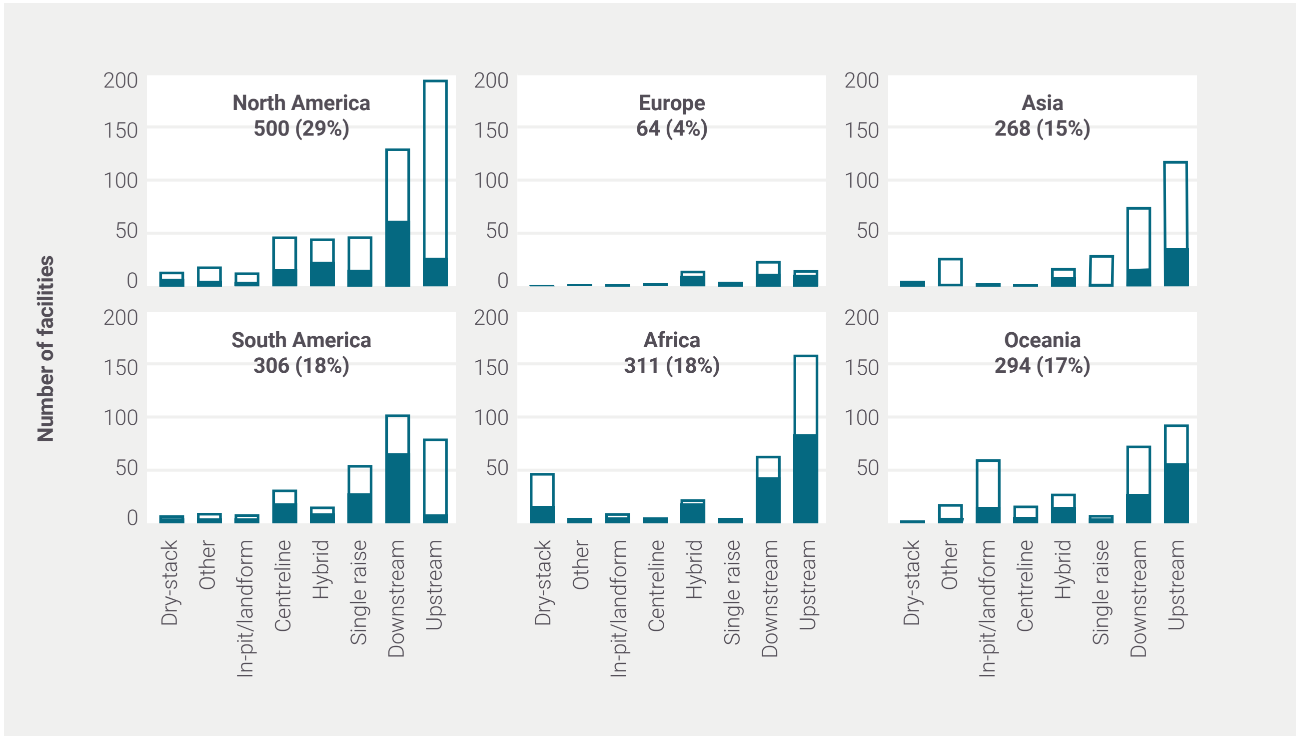

Figure 5. Distribution of tailings facility raise type by continent[12]

Note: shading indicates active facilities

12. Countries are assigned to continents according to https://www.geonames.org/countries/.

The volume of tailings under storage also varies with facility construction methods. Upstream facilities contain the highest total volume of tailings under storage, followed by downstream, hybrid and centreline, single raise, in-pit/natural landform, dry-stack and other facilities (see Figure 6). The highest median volume of tailings stored per facility are hybrid facilities (18.3 million m³), followed by centreline (7.3 million m³) and upstream (5.9 million m³).

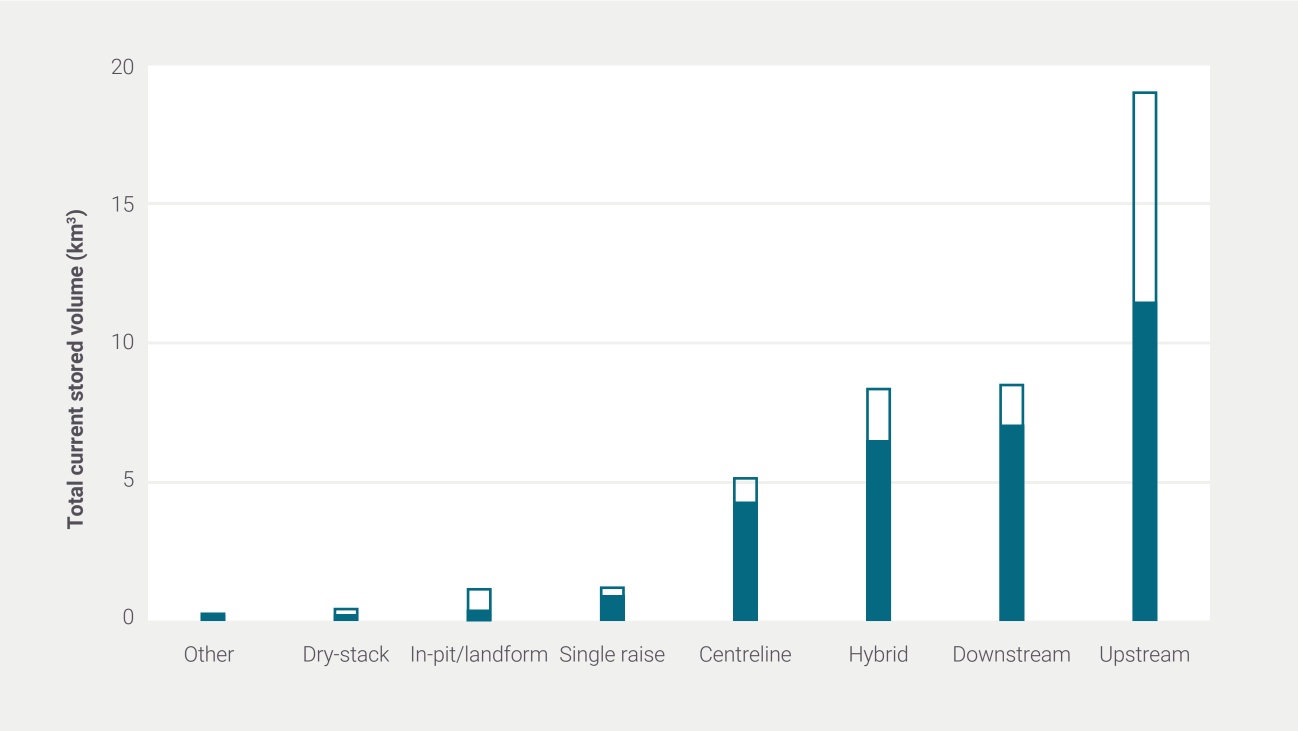

Figure 6. Current volume of tailings under storage (in cubic kilometres) by raise type of active, inactive and closed facilities

Note: shading indicates active facilities

3.4 INCIDENCE OF PAST STABILITY ISSUES

Companies were requested to disclose any situation where a facility, 'at any point in its history, failed to be confirmed or certified as stable, or experienced notable stability concerns, as identified by an independent engineer (even if later certified as stable by the same or a different firm).' The reported issues ranged in seriousness from relatively minor to major issues. In total 10 per cent of facilities reported having experienced a past stability issue. The data exhibits distinct trends according to construction method, governance, age, height, volume and seismic hazard.

Upstream and hybrid facilities were the most likely to report a past stability issue, when normalised against the frequency of each raise type. They were followed by centreline, downstream and single raise facilities (see Figure 7). The likelihood of a past stability issue having been reported by active upstream facilities is twice that of active downstream facilities and six times as many as active dry-stack facilities. No active in-pit/natural landform facilities reported a past stability issue. From a geotechnical perspective the rate of past stability issues is significant (> 1 per cent) for most construction methods, highlighting the universal importance of careful facility management and governance.[13]

One limitation of the dataset is that the occurrence of multiple instances of past stability issues at the same facility is not recorded. This may have the effect of undercounting the prevalence of stability issues for facilities prone to experiencing them. Due to this limitation, the findings are not a calculation of the rate of instability over a normalised period of time; however, they do enable the comparison of general stability trends between facility types.

13. Construction practices that have been reported to improve geotechnical performance of conventional tailings facilities include: comprehensive characterisation of both the tailings and underlying soils, keeping the size of the decant pool as small as possible, allowing the development of long beaches to promote the desiccation and densification of tailings, and continuous monitoring of the disposal facilities (Williams, this volume; Santamarina et al. 2019).

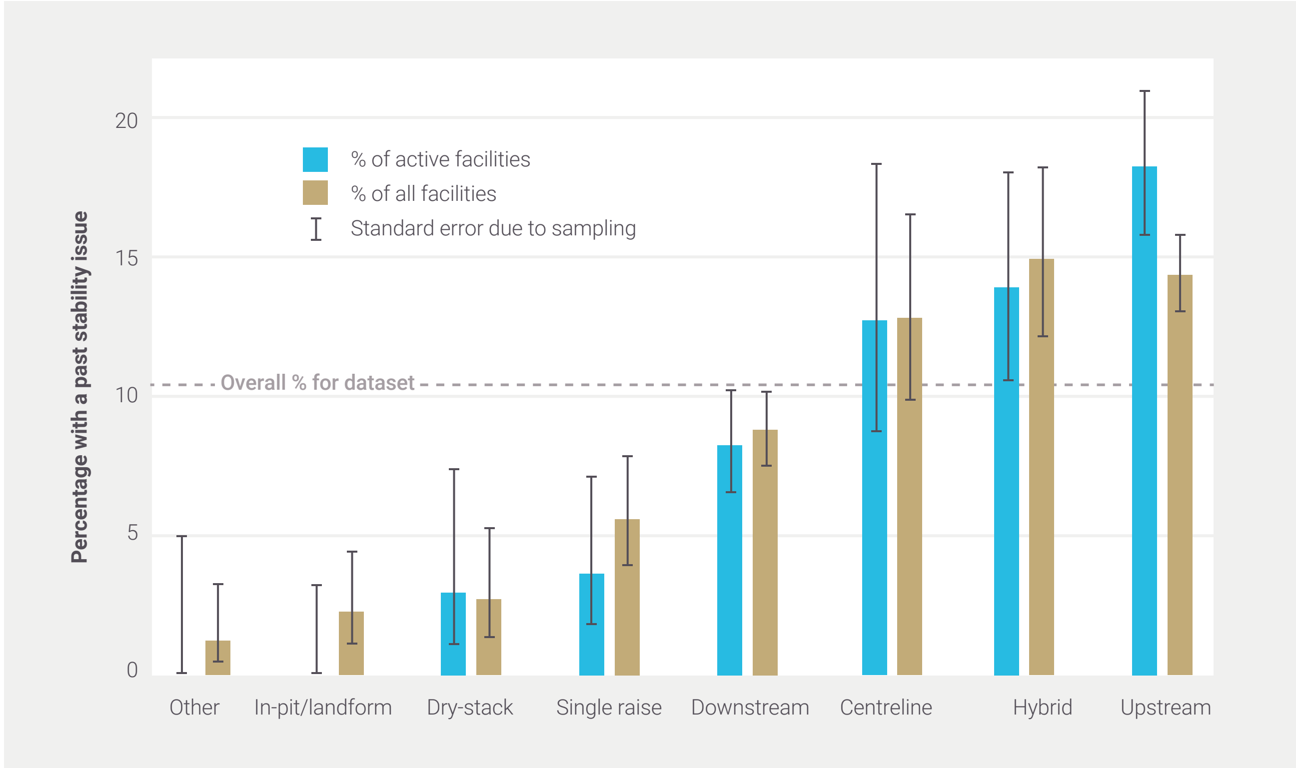

Figure 7. Proportion of facilities with a past stability issue by raise type[14]

It is possible that the incidence of past stability issues for any one particular construction method is not a function of the unique characteristics of these facilities, but rather, an artefact of the distribution of that facility type across other common characteristics known to influence geotechnical stability. For example, a particular construction method might have a greater proportion of facilities that are older, higher, larger, located in lower governance settings, in regions with a greater seismic hazard, or where rainfall is higher. These differentially distributed attributes might lead to these facilities demonstrating a higher or lower incidence of past stability issues, for reasons unrelated to the construction method. In the remainder of this section we will explore the influence of these factors on the past stability of the tailings facilities. At the conclusion of this section we return to the question of whether the higher prevalence of past stability issues reported by upstream facilities is an artefact of the distribution of these facilities or a feature of the construction method itself.

Tailings facilities located in OECD-countries, as well as those operated by ICMM-member companies generally reported a lower normalised incidence of past stability issue across those raise types that were elevated (see Table 1). This finding lends some weight to the view that tailings governance plays some role in ensuring geotechnical stability. However, the proportion of facilities reporting past stability issues for facilities located in OECD-countries and those operated by ICMM-member companies, remains high in absolute terms across a number of raise types (most notably upstream, hybrid and centreline).

14. Error bar lengths here, and in subsequent figures, are binomial confidence intervals for the subsample represented by each bar, showing +/-1 standard error (approximately 68%).

Table 1. Occurrence of a past stability issue by raise type and governance context

Raise Type	All facilities	Active-only facilities	OECD countries (active-only)	Non-OECD countries (active-only)	ICMM member (active-only)	Non-ICMM member (active-only)
Upstream	94 of 653 (14.4%)	41 of 224 (18.3%)	12 of 87 (13.8%)	29 of 137 (21.2%)	24 of 142 (16.9%)	17 of 82 (20.7%)
Downstream	41 of 464 (8.8%)	19 of 230 (8.3%)	7 of 106 (6.6%)	12 of 124 (9.7%)	8 of 128 (6.2%)	11 of 102 (10.8%)
Hybrid	21 of 140 (15.0%)	12 of 86 (14.0%)	7 of 46 (15.2%)	5 of 40 (12.5%)	4 of 34 (11.8%)	8 of 52 (15.4%)
Centreline	13 of 101 (12.9%)	6 of 47 (12.8%)	2 of 25 (8.0%)	4 of 22 (18.2%)	3 of 31 (9.7%)	3 of 16 (18.8%)
Single raise	8 of 143 (5.6%)	2 of 55 (3.6%)	2 of 22 (9.1%)	0 of 33 (0.0%)	0 of 40 (0.0%)	2 of 15 (13.3%)
In-pit/ landform	2 of 89 (2.2%)	0 of 30 (0.0%)	0 of 20 (0.0%)	0 of 10 (0.0%)	0 of 17 (0.0%)	0 of 13 (0.0%)
Dry-stack	2 of 74 (2.7%)	1 of 34 (2.9%)	0 of 10 (0.0%)	1 of 24 (4.2%)	1 of 25 (4.0%)	0 of 9 (0.0%)
Other	1 of 79 (1.3%)	0 of 19 (0.0%)	0 of 12 (0.0%)	0 of 7 (0.0%)	0 of 12 (0.0%)	0 of 7 (0.0%)

All other things being equal, we would expect older structures to be more likely to have reported a stability issue than younger structures. This is because older facilities have had a longer opportunity for a stability issue to manifest. To control for this, we mapped the number of facilities that had reported a past stability issue against the age of the facility in years. This was done for all active facilities, and for all active upstream, downstream and dry-stack facilities specifically. The results are presented in Figure 8, which shows the number of facilities reporting a past stability issue, by facility age and the proportion of facilities of different ages that had reported a stability issue.

As to be expected, a higher proportion of long-active conventional tailings facilities reported a past stability issue. Upstream facilities demonstrate a relatively higher prevalence of stability issues just ten to twenty years after construction. The very small number of active dry-stack facilities reporting a past stability issue (1) produces an artefact of apparently high proportion of stability concerns at facilities aged 40-50 years old, due to this being the age of the single active dry-stack facility with a past stability issue.

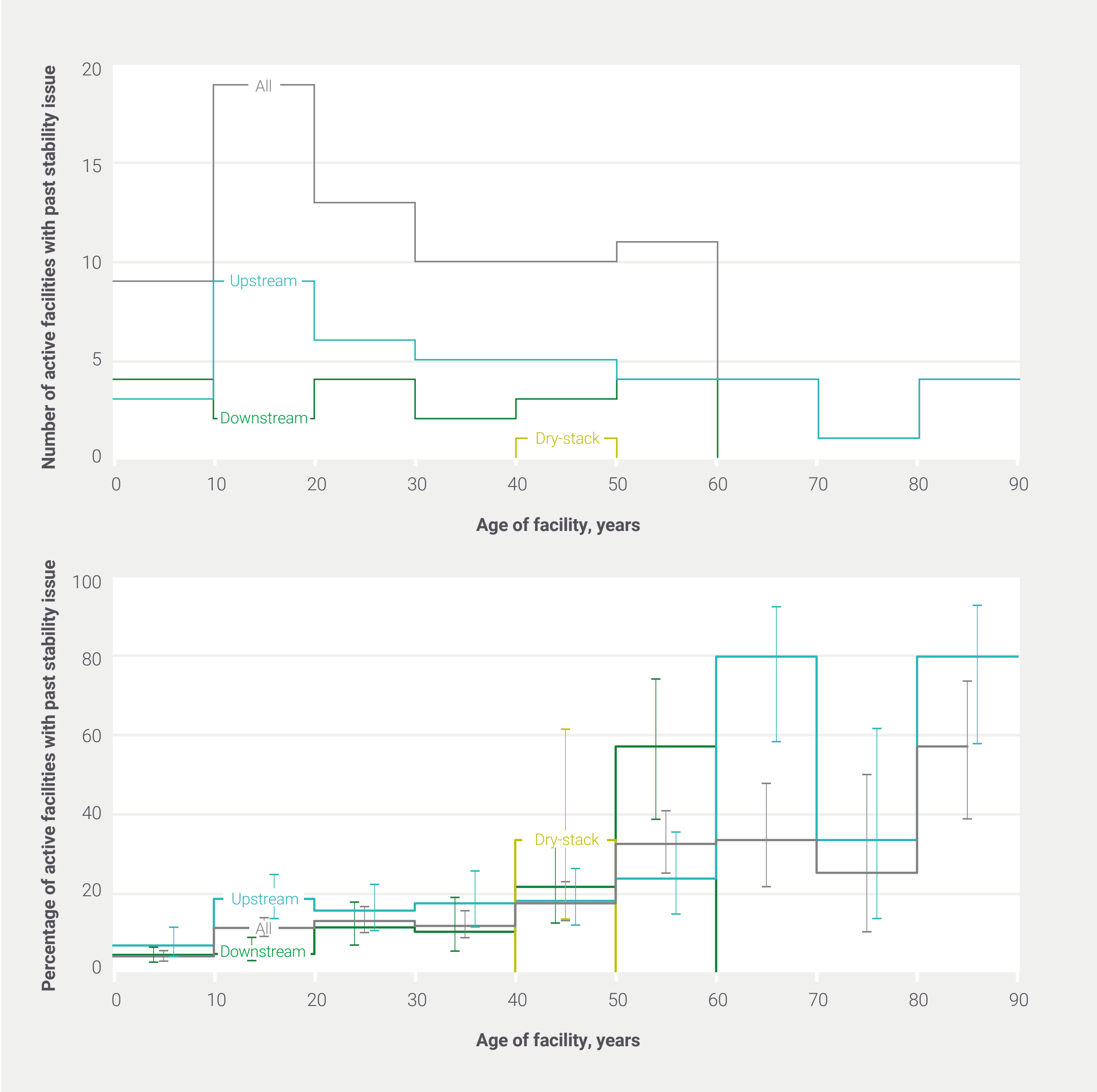

Figure 8. Relationship between facility age, facility raise type and past stability issue

Note: Top graphic shows number of active facilities reporting a past stability issue; bottom graphic shows proportion of active facilities in each age category reporting a past stability issue

The dataset also points to a relationship between facility embankment height and whether a facility had reported a past stability issue, but this relationship is not straightforward (see Figure 9). The likelihood of a past stability issue being reported for a facility with an embankment between 80-100m is notably 5 times higher than for facilities with embankments between 0-20m. But in the relatively small number of cases where an embankment height exceeds 100m, there is a decline in the proportion of facilities that reported a past stability issue. A possible explanation for this, may be that higher standards of construction have been applied for facilities with very high embankments (although we have no direct measure of this).

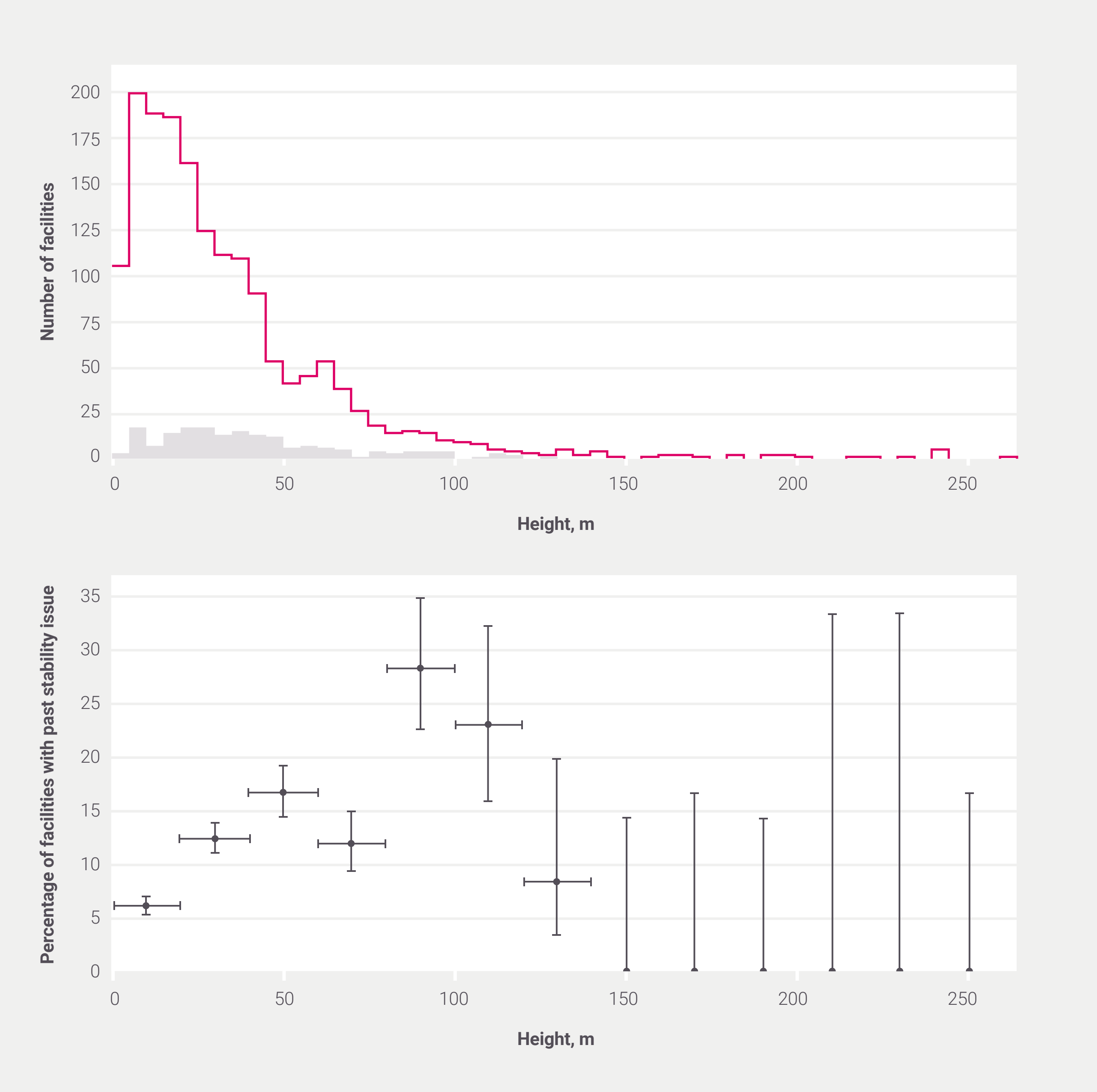

Figure 9. Relationship between facility embankment height and reported occurrence of past stability issues, all facilities[15]

Note 1: Top graphic shows distribution of tailings facilities by embankment height; shading indicates number of facilities reporting a past stability issue.
Note 2: Bottom graphic shows proportion of facilities reporting a past stability issue by embankment height.

We also found that the larger the facility, the more likely it is to have reported a past stability issue (see Figure 10). Due to the very large range of reported volumes, from just 10m^3 to over 1 billion m^3, a logarithmic scale is used to display the distribution. The broad trend in stability issues this reveals should be interpreted accordingly: similar *proportional* increases in volume (e.g. 10 times greater) seem to

15. There are no instances of stability issues in heights above 140m. Vertical error bars for these categories show the range of fractions for which the probability of finding zero in a sample of that size is greater than 74% (the same confidence interval as shown for the other points).

be associated with similar *absolute* increases in the fraction with issues (e.g. 5% higher). This analysis cannot distinguish between the possibility that the increased incidence is due to the greater surface area of the material, the greater stress from the increased mass, or the potential for these or other factors (such as age) to act in combination.

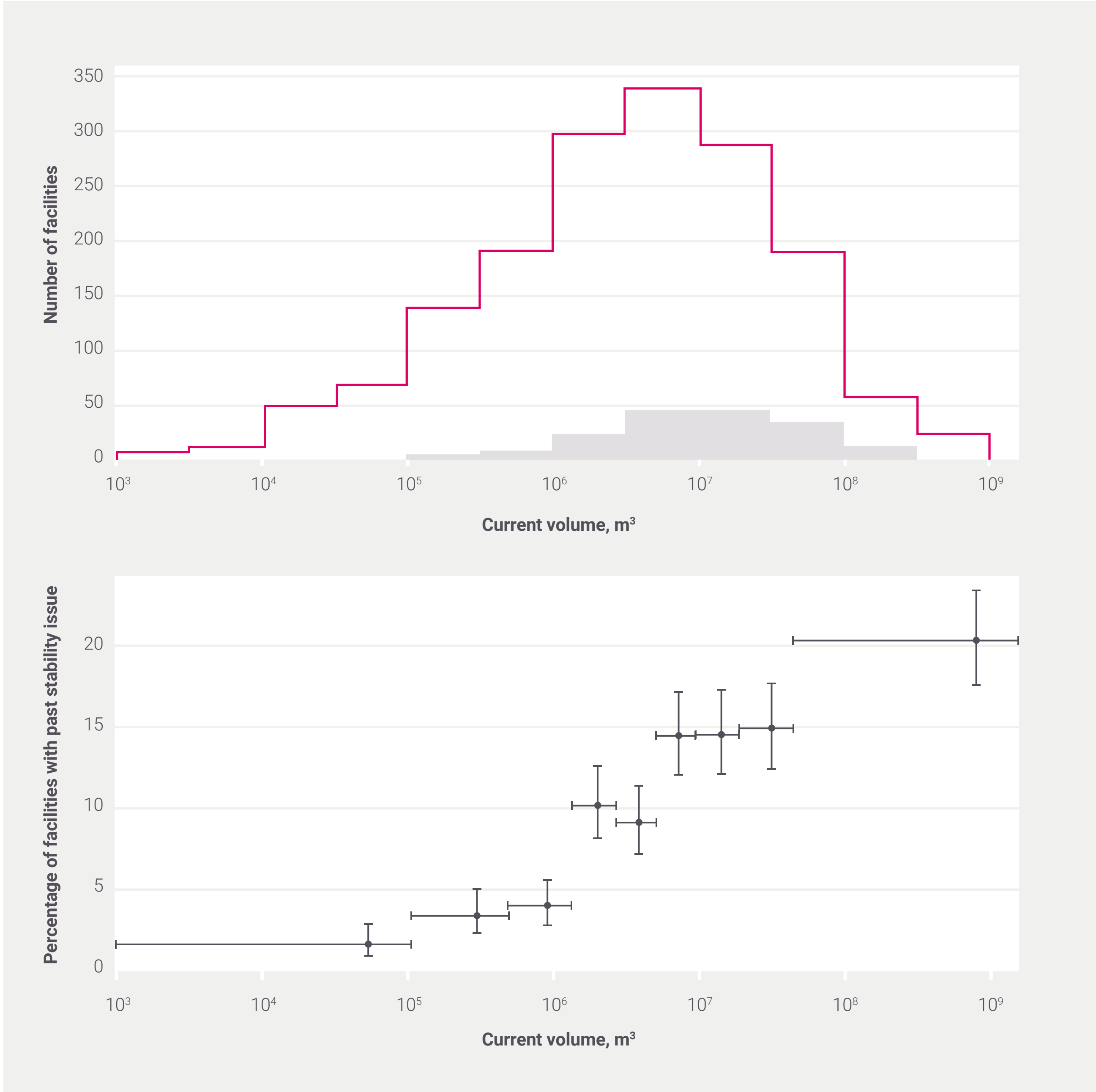

Figure 10. Relationship between facility volume and history of past stability issue, all facilities

Note 1: Shading in top graphic indicates number of facilities reporting a past stability issue
Note 2: Top graphic shows distribution of tailings facilities by volume; bottom graphic shows proportion of facilities reporting a past stability issue by facility volume.

Seismicity is another factor that may affect the stability of a facility. Facilities built in seismically active regions might be expected to show a higher incidence of past stability issues. Figure 11 shows the distribution of tailings facilities by seismic hazard and the proportion of tailings facilities with a past stability issue by seismic hazard.

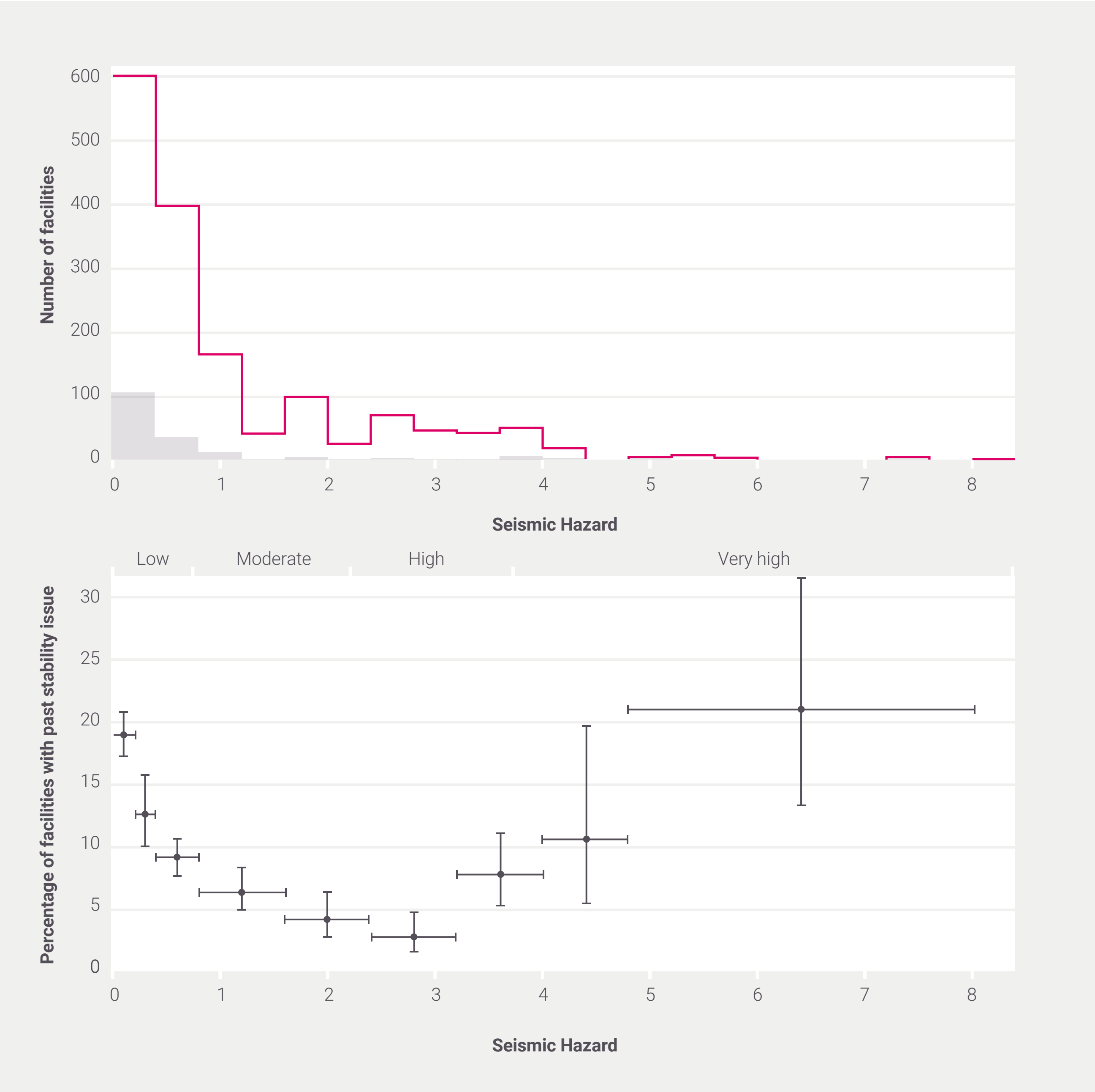

Figure 11. Relationship between seismic hazard and history of past stability issue, all facilities

Note 1: Top graphic shows distribution of tailings facilities by seismic hazard; shading indicates number of facilities reporting a past stability issue.
Note 2: Bottom graphic shows proportion of past stability issue by seismic hazard as defined by the Global Seismic Hazard Assessment programme

Most facilities are built in locations with a seismic hazard below 1. As seismic hazard increases, the likelihood of a facility having reported a stability issue initially decreases. However, above a seismic hazard of three, the proportion of facilities reporting a past stability issue then increases. This relationship is not attributable to other factors that may be changing coincidentally with seismic hazard. In particular, facility height and storage volume do not change significantly for any given range in seismic hazard.

It is worth noting that the proportion of upstream facilities is lower in seismically active regions, with a corresponding increase in downstream facilities

(see Figure 12). This may be due to concerns by governments and companies about the relative stability of the upstream raise type and may be a factor in the lower likelihood of reported stability issue with increasing seismic hazard (between 0-3). Another possible interpretation for the described trend (though one for which we do not have direct data), is that facilities in locations with elevated seismic hazard may be built to higher standards of construction than facilities in locations with very low seismic hazard, thus leading to an initial improvement in geotechnical stability with increasing seismic hazard. However, above a certain point of seismic hazard (3+), facility stability may be reduced even for those facilities built to higher construction standards.

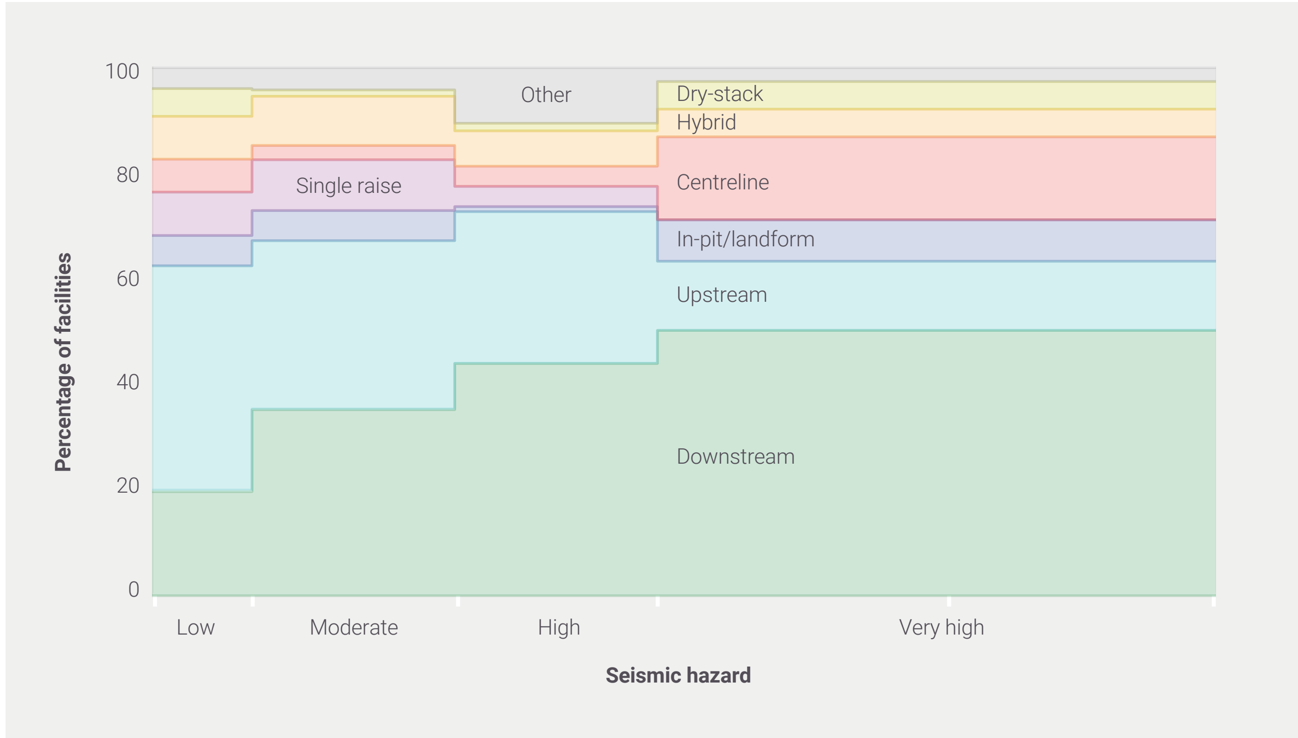

Figure 12. Proportion of facility raise type by seismic hazard

We now return to the question of how to account for the higher proportion of upstream facilities that report a past stability issue. Could this be just an artefact of the other properties that these facilities happen to have (age, dimensions, seismic hazard etc.), and not a feature of the construction method itself?

The result in Figure 7 showed that the relative frequency of stability issues in the upstream subsample is a few standard errors above that for the dataset as a whole. If these subsamples of different raise types were no different in any other respect (i.e. unbiased), this would be a high-confidence result, but they are not. For example, the distribution in facility age for the subsamples is not the same. As this section has now shown, the distribution of stability issues also varies by facility size, height and location. This raises the possibility that these could be the real underlying reasons for the difference in the past stability issues seen in Figure 7. This is a hypothesis that can be tested. If it were true, and we took any two subsamples from the dataset which had almost identical distributions in these variables, we would expect to find almost the same stability fraction in both subsamples; even if one sample is comprised entirely of facilities with a given raise type, and the other contains none.

To carry out this test, we generated two such subsamples. The first contains all the upstream facilities that have known values for all parameters (559 facilities). To generate the second, we take all facilities with other raise types that have known parameter values (864), and select a test subsample that matches the size and distribution of the upstream subsample. To make the test robust, 100 different versions of the test subsample were generated by randomly selecting within constraints to match the distributions. The distributions of these, and of the upstream sample, are shown in Figure 13.

In the upstream subsample, 82 (14.7%) of facilities have had past stability issues. In the test samples, the average number was under 59 (10.5%), slightly higher than the overall non-upstream stability fraction (8.8%). If the two samples had the same underlying likelihood of stability issues, as in our hypothesis, the probability of them differing by this much (23 or more) would be very low – about 3 per cent. This margin is sufficient that any further corrections for the remaining differences in the parameter distributions would be unlikely to reverse the result of the test. The result provides a high confidence confirmation (greater than 95%) that the observed higher likelihood of stability issues in upstream facilities is not an artefact of these other properties.

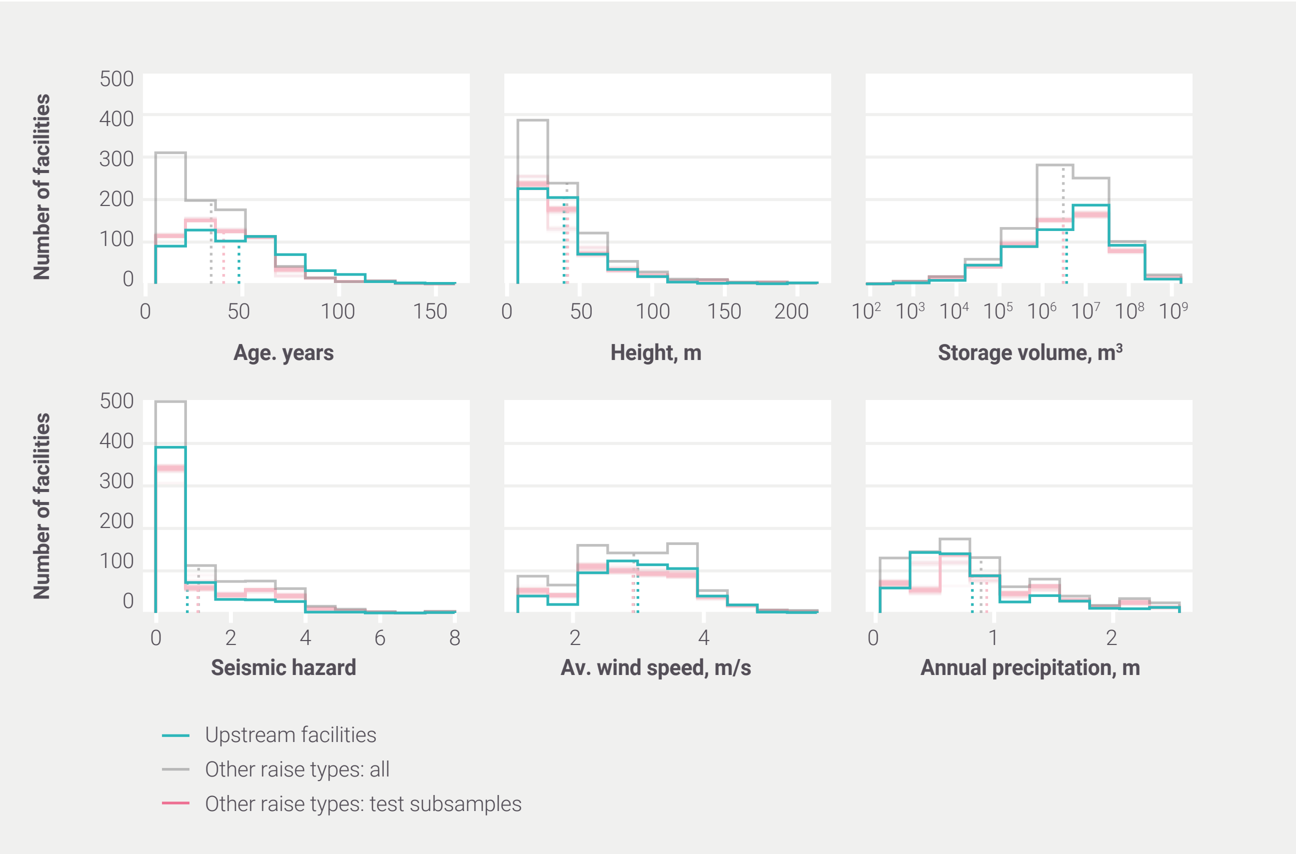

Figure 13. Distribution of the two subsamples of facilities across six quantitative variables that may be related to stability issues

Note 1: The vertical dotted lines show the mean of each subsample. (In the case of the test subsamples, this shows the mean of all 100 versions.)
Note 2: The underlying distribution of the variables in the other raise types is also shown for comparison.

3.5 CONSEQUENCES OF FAILURE

The consequence category for each tailings facility was reported by the companies. Consequence ratings are typically classified as part of modelling undertaken in the facility design and construction phase. The categories correspond to various country-level, industry and corporate classification systems, using different metrics of consequence. Tailings facilities were classified against a total of 62 different classification schemes. The five most common schemes reported in the dataset are listed in Table 2. Collectively these schemes cover 68 per cent of all facilities and 76 per cent of currently active facilities.

Table 2. Five most common consequence classification schemes reported against in the dataset[16]

Name	Number (all facilities)	Number (active facilities)
Canadian Dam Association (CDA)	577 (33.1%)	225 (31.0%)
Australian National Committee on Large Dams (ANCOLD)	243 (13.9%)	128 (17.7%)
South African National Standards (SANS)	158 (9.1%)	87 (12.0%)
Brazilian Ordinance 70.389/17 (BRA)	114 (6.5%)	63 (8.7%)
Anglo American Technical Standard (AA)	98 (5.6%)	47 (6.5%)
Total	1190 of 1743 (68.3%)	550 of 725 (75.9%)

Figure 14 shows the frequency of the distribution of active facilities by consequence category for each of the five most common schemes[17]. For the AA, SANS and BRA schemes, a trend is apparent where a greater number of facilities are classified by progressively higher consequence of failure ratings.

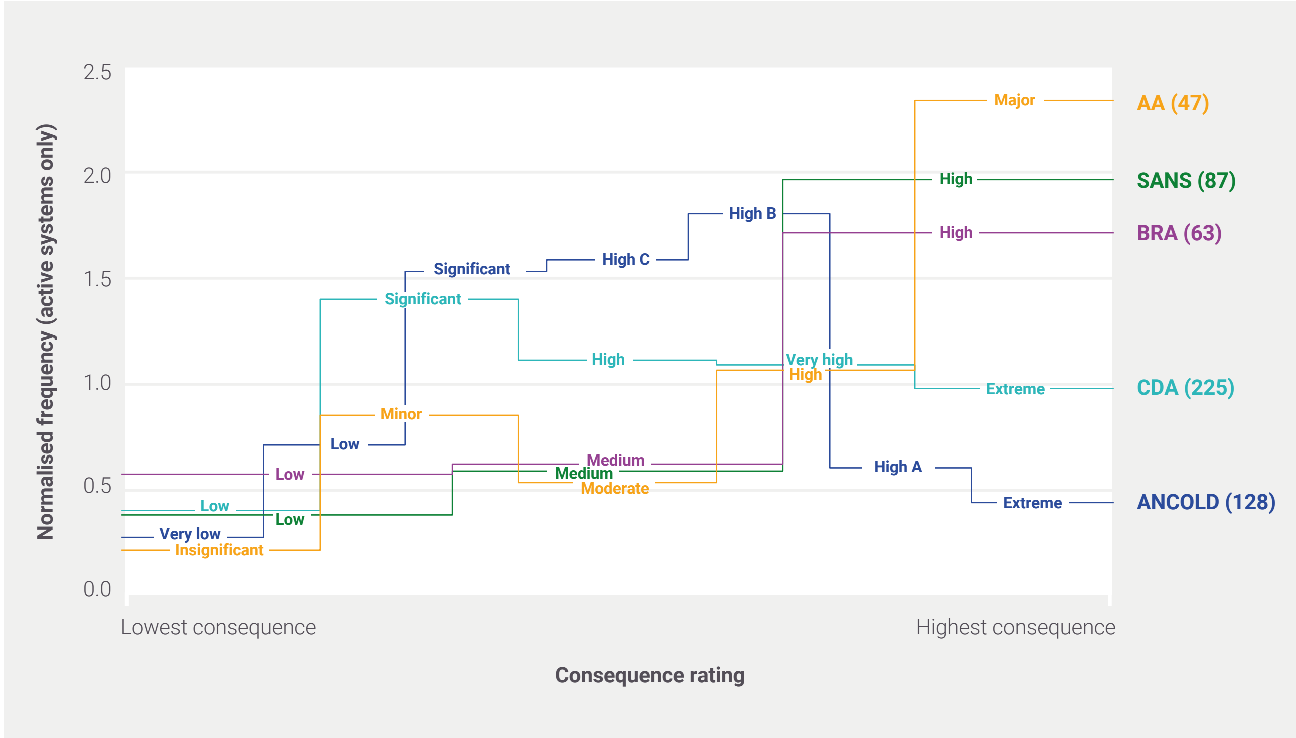

Figure 14. Distribution of active facilities by consequence rating for each of the five most common consequence classification schemes

Figure 15 reports consequence of failure by facility raise type for active facilities across the five most common schemes. A trend is apparent where hybrid, upstream, downstream and centreline facilities are more likely to be associated with higher consequence ratings than are dry-stack, single raise and in-pit/natural landform facilities. This general trend holds across each of the individual consequence schemes.

16 A small number of facilities reported against more than one scheme.
17. To allow fair comparison of the distributions, the frequency of the Y-axis is normalised so that the area under each consequence classification curve is the same.

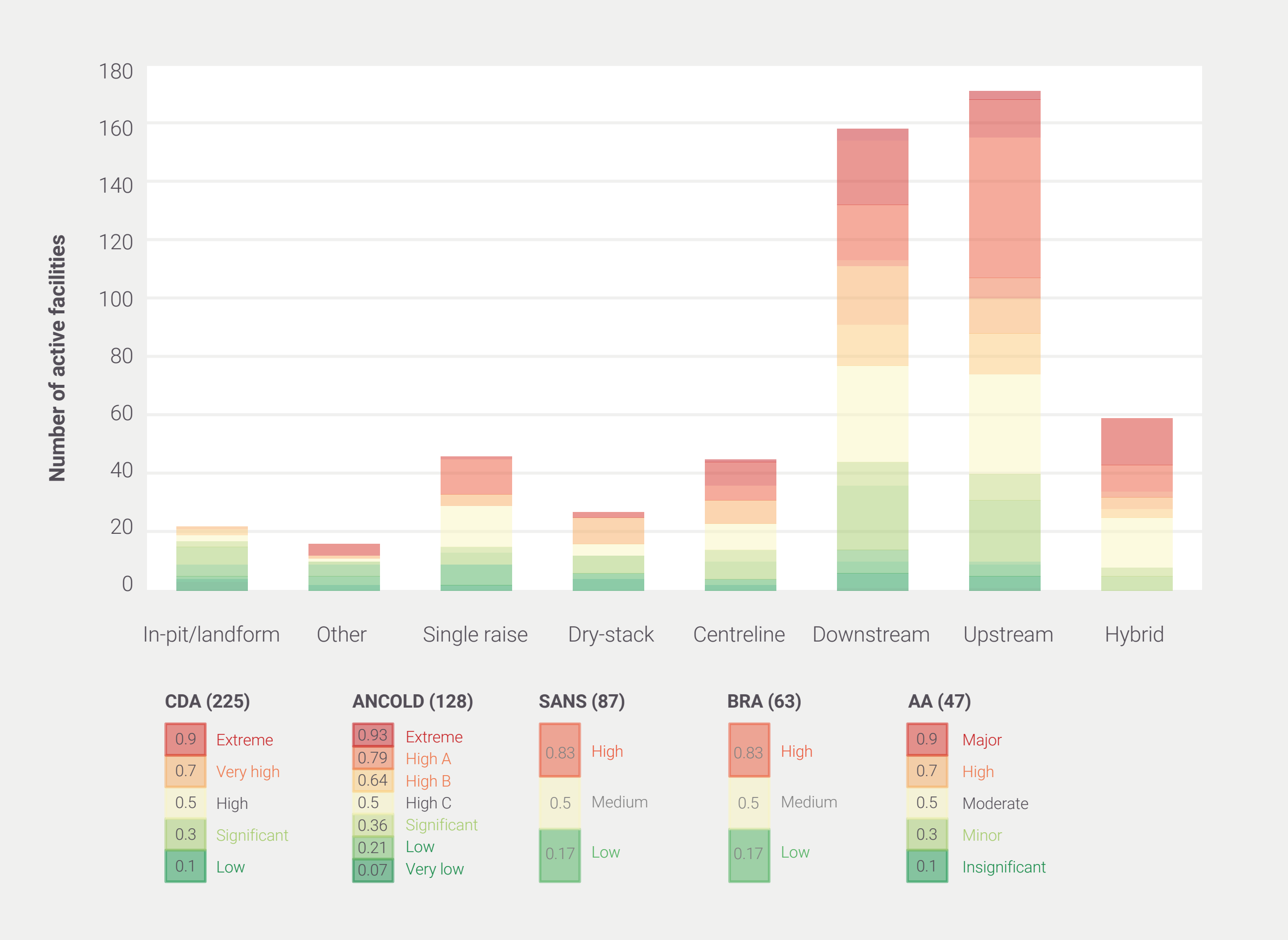

Figure 15. Consequence of failure by facility raise type (active facilities) for five most common consequence classification schemes

The associations in Figure 15 are influenced by at least two factors: (1) the nature of tailings flow (for example, hydraulically deposited tailings deposited in conventional facilities have a greater propensity to flow than filtered tailings that are deposited in dry-stack facilities); and (2) the decision on the selection of the construction method for different geographic circumstances (for example, a larger number of a particular type of facility may have been constructed in locations where the consequence of failure is higher). Given that upstream facilities have been considered by ICOLD and UNEP (2001) to be less safe than downstream and centreline facilities, it could be expected that the construction of these facilities would be avoided in locations where the potential consequence of failure is high. However, based on the data presented here, this does not appear to be the case.[18]

Figure 16 illustrates the likelihood of a past stability issue being reported within each consequence category for the five most common schemes. A trend is apparent across most schemes (with the exception of ANCOLD) where facilities that have been assigned a higher consequence rating are more likely to have reported a past stability issue. This finding is somewhat counter-intuitive as higher consequence facilities are expected to be built to higher construction standards, though it may in part be explained by the lower proportion of dry-stack and in-pit/natural landform facilities that are classified in higher consequence categories, which are also associated with a lower likelihood of past stability issues.

18. It should be noted that some jurisdictions (such as Chile, Peru and Brazil) have restricted upstream facilities due to a view that they hold a greater 'likelihood' of failure in their local operating conditions.

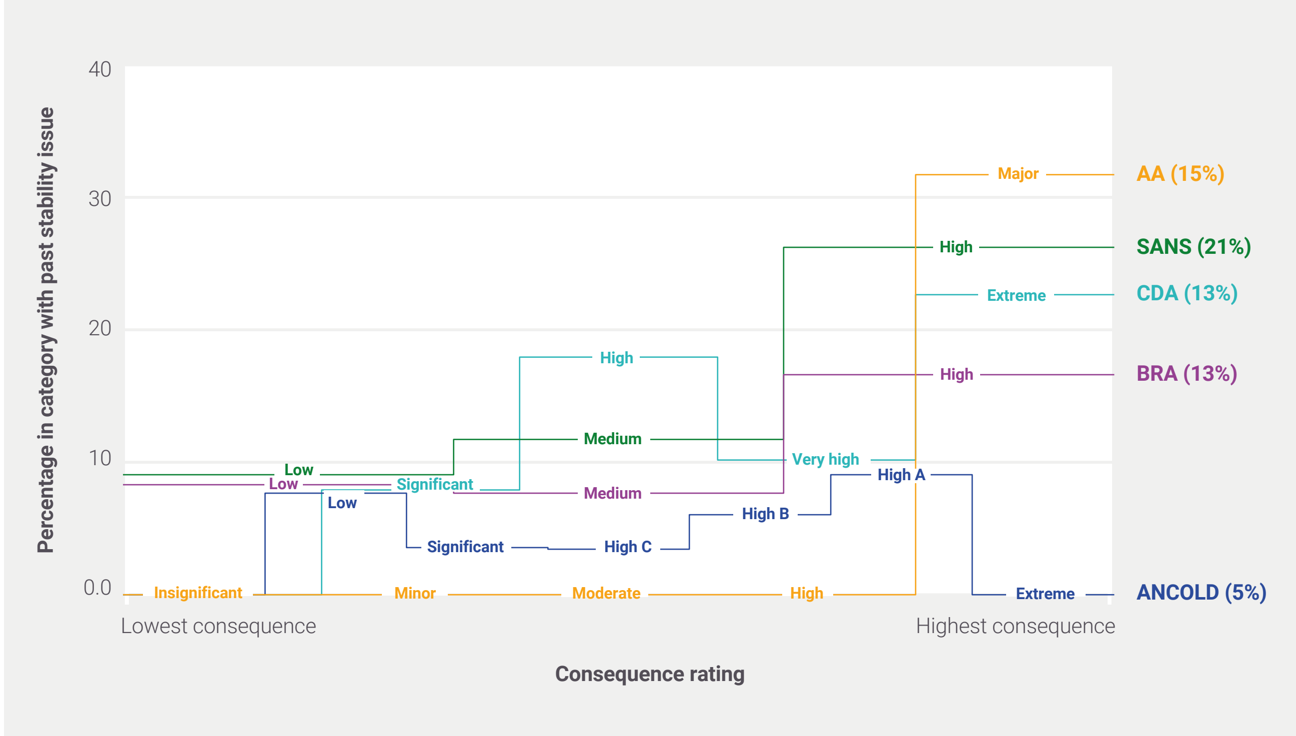

Figure 16. Proportion of sites reporting a past stability issue by consequence of failure five most common consequence classification schemes

Note: the overall percentage for each scheme is given in brackets.

3.6 UPTAKE OF DEWATERING TECHNOLOGIES

The removal of water from tailings is an important innovation that has been identified by a significant number of authors as having the potential to improve geotechnical and geochemical stability (Nguyen and Boger 1998; Boger 2009; Boger *et al.* 2006; Jewell and Fourie 2006; Davies *et al.* 2011; Franks *et al.* 2011; Edraki *et al.* 2014). Dewatering technologies have experienced a wave of different advances over the past few decades: cycloning in the late 1960s, tailings thickening in the mid-1970s, filtered tailings in the 1980s and paste facilities from the 1990s (Davies *et al.* 2011). When analysing the disclosures, it was not possible to differentiate paste and thickened tailings from wet tailings due to the fact that the former are also stored within conventional tailings facilities. Similarly, the dataset does not include details on the uptake of paste backfill because this type of waste is not stored in a 'facility' per se. Dry-stack facilities are identifiable in the dataset, however, it is worth noting that this categorisation includes both in-situ dewatering of tailings (sometimes referred to as mud-farming) and the filtering of tailings prior to deposition (beginning in the 1980s).

Dewatered tailings are commonly assumed to have increased in popularity over recent years, and have also been identified as a priority by individual mining companies and peak industry bodies. The data indicate that no more than 13 dry stack facilities were constructed in the last decade. Furthermore, since 1980, the percentage of new tailings facilities that are dry-stack has fluctuated between 4 and 6% (see Figure 17), indicating that the uptake of tailings filtration and in-situ dewatering has not significantly increased in recent decades.[19]

19. It is possible that uptake may have been slowed by the long lead times for new projects and the time taken for regulators to approve 'new' disposal methods. However, it seems very unlikely that these factors alone can account for what is effectively a flat line over the last two decades.

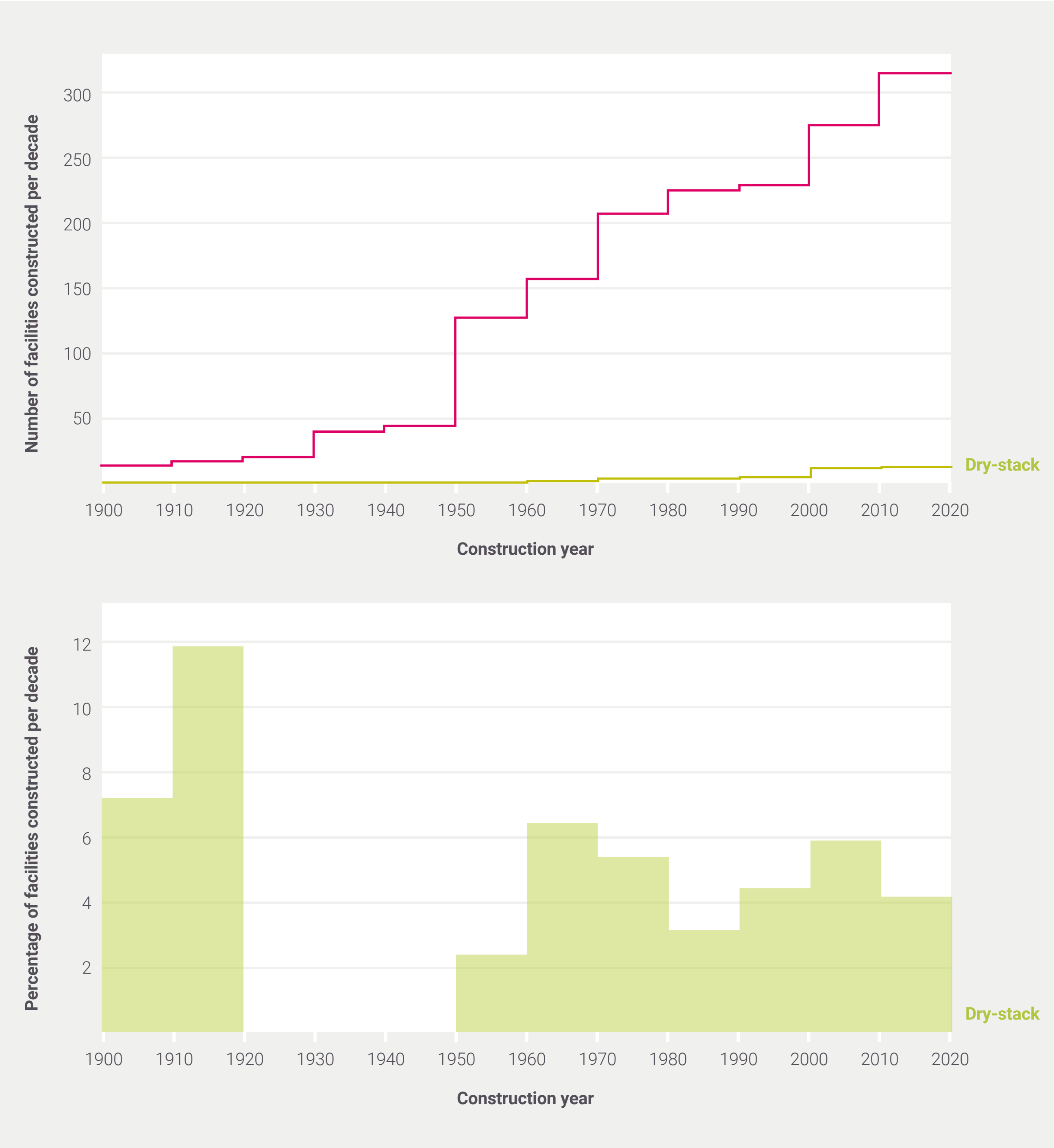

Figure 17. Dry-stack facilities by decade of construction

Note: Top graphic shows number of facilities; bottom graphic shows proportion of facilities.

This finding is further confirmed by the fact that just one international mining company operates, or is the majority shareholder in, 72 per cent of all dry-stack facilities. This raises a question about whether the economic and policy incentives to transition to these new technologies are sufficient, noting that performance factors also influence rate of uptake (e.g. production throughput, climatic considerations, dust generation) as does the regulatory context (permitting and approval processes).

4. CONCLUSION AND FUTURE DIRECTIONS

In this chapter we have undertaken an analysis of the features of global tailings facilities, utilising company provided data. The analysis demonstrates that the characteristics of tailings facilities are highly variable by construction type, geography and size. The findings point to the value of information disclosure by companies for understanding tailings facilities and their management.

The sheer scale of global tailings production, the expansion of tailings facilities over time, and the high impact of tailings facility failures highlights the need for more to be done on developing and implementing new tailings disposal and management approaches at scale and also on reducing the volume of tailings generated (see the review of alternative approaches to tailings management by David Williams, this volume).

More work is also required to understand and overcome barriers to innovation.

The findings presented here demonstrate some of the potential insights that can be generated from the current dataset, with further analysis of parameters such as climate and topography most obvious. Future disclosure requests can be refined with questions about the type of past stability issue, better breakdown of tailings production over time, indication of the type of operation (open-cut, underground etc.), date of closure of facilities, date of any past stability issue, better differentiation of tailings type (slurry, co-disposal, cycloned, thickened, paste and filtered), the presence of liners, seepage and seepage treatment, and reporting on the presence of paste backfill and other tailings management options that go beyond the definition of a 'facility.'

KEY MESSAGES

1. The Investor Mining and Tailings Safety Initiative, as described in Chapter XVII, conducted the most comprehensive global survey of tailings facilities ever undertaken. The trends identified from this dataset highlight the value of information disclosure by companies.
2. Analysis of company-disclosed data collected through the Initiative indicate that upstream facilities still make up the largest proportion of total reported facilities (37 per cent), although construction rates for upstream facilities have declined in recent years.
3. The rate of reported past stability issues for facilities in the data base exceeded one per cent for most construction methods, highlighting the universal importance of careful facility management and governance.
4. Over 10% of facilities in the database reported a stability issue, and the percentages for upstream, hybrid and centreline facilities were even higher. Statistical analysis provides a high level of confidence that the higher rate of reported stability issues for upstream facilities is not attributable to 'confounding' factors such as differences in facility age, the volume of material stored, or the level of seismic hazard.
5. Based on company commissioned modelling, hybrid, upstream, downstream and centreline facilities are more likely than other types of facilities to be associated with a higher consequence of facility failure.
6. Facilities with higher consequence of failure ratings were also more likely to report a stability issue.
7. Based on the data provided by companies, the uptake of filtered and in-situ dewatering of tailings across the wider industry has not significantly increased over recent decades. This is notwithstanding that dry-stack (and in-pit/natural landform facilities) report fewer past stability issues and are typically associated with lower consequence of failure ratings.

REFERENCES

Azam, S. and Li, Q. (2010) Tailings Dam Failures A Review of the Last One Hundred Years. *Geotechnical News*, 28, 50-54.

Boger, D.V. (2009). Rheology and the resource industries. *Chemical Engineering Science*, 64 (22):4525-4536.

Boger, D.V., Scales, P.J. and Sofra, F. (2006). Rheological Concepts. In R.J. Jewell, A.B. Fourie (Eds.). *Paste and Thickened Tailings: a Guide*. Australian Centre for Geomechanics (third edition), pp. 21-46. Chapter 3.

Bowker, LN and Chambers, D.M. (2017). The Risk, Public Liability and Economics of Tailings Storage Facility Failures. Online resource: https://earthworks.org/cms/assets/uploads/2018/12/44-Bowker-Chambers.-2015.-Risk-Public-Liability-Economics-of-Tailings-Storage-Facility-Failures.pdf Accessed: 10 March, 2020.

Brown, M. and Elliott, D. (2019). AP Explains: What are the dangers of mining waste in Brazil. Online resource: https://apnews.com/98cf6d47bf8547b88d12c9b151ee19ed Accessed: 10 March, 2020.

Church of England Pensions Board (CoE) and Council on Ethics of the Swedish National Pension Funds. (2019a). Council on Ethics of the Swedish National Pension Funds. Letter to Board Chairs and Chief Executive Officers of listed extractive companies. April 5, 2019. Online resource: https://bit.ly/3aJH9Sq Accessed: 10 March 2020.

CoE and Council on Ethics of the Swedish National Pension Funds. (2019b). Council on Ethics of the Swedish National Pension Funds. Letter to Board Chairs and Chief Executive Officers of listed extractive companies. April 17, 2019. Online resource: https://bit.ly/2Ivmd5T Accessed: 10 March 2020.

CoE and Council on Ethics of the Swedish National Pension Funds. (2019c). Information on which companies have disclosed. February 26, 2019. Online resource: https://bit.ly/3cDRl0G. Accessed: 10 March 2020.

Davies, M., Lupo, J., Martin, T., McRoberts, E., Musse, M., Ritchie, D. (2011). *Dewatered Tailings Practice – Trends and Observations, Proceedings of the 14th International Conference on Tailings and Mine Waste.* Vail, Colorado, 17-20 October, 2010. CRC Press.

Davies, M. and Martin, T.E. (2000). Upstream Constructed Tailings Dams – A Review of the Basics. In *Proceedings of Tailings and Mine Waste '00*, Fort Collins, January, Balkema Publishers, pp. 3-15.

Edraki, M., Baumgartl, T., Manlapig, E., Bradshaw, D., Franks, D.M. and Moran, C.J. (2014). Designing mine tailings for better environmental, social and economic outcomes: a review of alternative approaches. *Journal of Cleaner Production* 84(1): 411-420.

Fick, S.E. and Hijmans, R. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology* 37(12): 4302-4315.

Franks, Daniel M., Boger, David V., Côte, Claire M. and Mulligan, David R. (2011). Sustainable development principles for the disposal of mining and mineral processing wastes. *Resources Policy 36*(2):114-122.

Global Wind Atlas (2017). World – Wind Speed And Wind Power Potential Maps, World Bank.

ICOLD and United Nations Environment Programme (UNEP) (2001). *Tailings dams risk of dangerous occurrences—Lessons learnt from practical experiences*. Bulletin 121. Paris: International Commission on Large Dams.

ICMM (2019). *Tailings Management.* Online resource. London: International Council on Mining and Metals. https://www.icmm.com/en-gb/environment/tailings Accessed: 10 March 2020.

Jewell, R.J., Fourie, A.B. (eds.) (2006). *Paste and Thickened Tailings – A Guide*. Perth: Australian Centre for Geomechanics (third edition).

Martin, V. Al-Mamun, M., Small, A. (2019). CDA Technical bulletin on tailings dam break analyses. *Sustainable and Safe Dams Around the World*. Tournier, J.P., Bennett, P. and. Bibeau, J. (eds.) Proceedings of the ICOLD 2019 Symposium, June 9-14, 2019. Ottawa: Canada.

Morgenstern, N.R., Vick, S. G., Viotti, C.B., Watts, B.D. (2016). *Report on the immediate causes of the failure of the Fundão dam.* Commissioned by BHP Billiton Brasil Ltda., Vale S.A., and 20 Samarco Mineração S.A.

Morgenstern, N.R., Vick, S.G., and Van Zyl, D. (2015*). Report on Mount Polley Tailings Storage Facility Breach. Independent Expert Engineering Investigation and Review Panel*. January 30. Government of British Columbia.

Nguyen, Q.D. and Boger, D.V. (1998). Application of rheology to solving tailings disposal problems. *International Journal of Mineral Processing*, 54 (3–4):217-233.

Robertson, P.K., de Melo, L., Williams, D., Wilson, W. (2019). *Report of the Expert Panel on the Technical Causes of the Failure of Feijão Dam* I. December 12.

Roche, C., Thygesen, K., Baker, E. (eds.) (2017). *Mine Tailings Storage: Safety Is No Accident. A UNEP Rapid Response Assessment*. United Nations Environment Programme and GRID-Arendal, Nairobi and Arendal.

Santamarina, J.C., Torres-Cruz, L.A. and Bachus, R.C. (2019). Why coal ash and tailings dam disasters occur. *Science*, 364 (6440):526-528.

USGS (2019). Mineral commodity summaries 2020: United States Geological Survey: Washington,. Online resource: https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs2019_all.pdf. Accessed: 10 March 2020.

Yin, G, Li, G., Wei, Z., Wan, L. Shui, G. and Jing, X. (2011). Stability analysis of a copper tailings dam via laboratory model tests: A Chinese case study. *Minerals Engineering*, 24 (2):122-130.

Zhang, P., Shedlock,K. M., Grünthal,G., & Giardini, D. (1999). The GSHAP Global Seismic Hazard Map. *Annals of Geophysics*, 42(6).

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CHAPTER VIII
CLOSURE AND RECLAMATION

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1. INTRODUCTION

Tailings landforms are an enduring legacy of many mining landscapes – the design and construction of these facilities to perform well for the next millennium is just as great a challenge and effort as is maintaining operational dam safety. This chapter provides an overview of leading practices for design, construction, deposition, stabilisation, decommissioning, capping, reclamation, and aftercare for tailings facilities. It builds on the work detailed in *Sustainable design and post-closure performance of tailings dams* (ICOLD 2013).

An important advance in mine closure design is the framework of landform design — a new concept that is breaking out internationally under different names by various groups and practitioners. Landform design entails a paradigm shift away from the practice of separating construction and operations from closure and reclamation. Instead, it calls for a fully integrated approach that provides design, support, and stewardship throughout the life of the mine and beyond.

A new Landform Design Institute (LDI 2020) was recently formed, which provides 'how-to' advice on designing, constructing, and reclaiming mining landforms and landscapes that are easy to reliably reclaim. The Institute helps mines meet their commitment to be temporary users of the land. Effective reclamation of tailings facilities requires sound design and planning before construction of the mining landform even begins. Globally, there are tens of thousands of mining landforms that are partially constructed and in need of improved reclamation practices. Sections 5 and 6 of this chapter provides a more complete discussion of the landform design approach to overall mine (and specifically tailings) closure for both existing and new mining landforms.

2. OVERVIEW OF CURRENT PRACTICE

Worldwide, many mines have one or more active or inactive tailings facilities. Each tailings facility is a mining landform that is already part of the permanent landscape, and which will require reclamation as part of mining's commitment to be a temporary use of the land and to enable individual mines to leave a positive mining legacy. Each of these tailings landforms must be sited, designed, constructed/filled, decommissioned, stabilised, reclaimed, and deregulated as dams, relinquished and then maintained over the long-term by landowners or regulatory agencies. Where the relinquishment cannot be accomplished, ongoing maintenance will be responsibility of the mine owner.

Tailings facilities typically occupy 10 to 40 per cent of the area of a reclaimed mining landscape, with pits and waste rock dumps responsible for most of the rest. Typically, regulators require reclaimed facilities to meet agreed-upon land uses and performance standards that sustain landscapes for the benefits of local communities (e.g. Brazilian Mining Association [IBRAM] 2014). After mining, the sites are commonly used as natural areas or wildlife habitat (especially for remote mines). Near cities, they may be used for agricultural, recreational, or industrial activities (Pearman 2009).

Most tailings facilities are difficult to stabilise and reclaim to the point where they meet societal expectations of only an extremely low risk of catastrophic failure, acceptable residual impacts on the environment, and access for agreed-upon land uses. Many dams cannot be deregulated (i.e. where they are no longer regulated as a dam but as a mine waste storage facility). In particular, it is very unlikely that a dam will be deregulated if it contains ponded water or potentially mobile materials, due to concerns

*Member of the GTR Expert Panel

regarding catastrophic dam failure even after closure. In practice, most tailings landforms need regular monitoring and maintenance, perhaps in perpetuity.

Historically, tailings dam design has focussed on safely containing hydraulically placed tailings during mine operations. More recently, designing these tailings landforms to be safe, stable, and useful after filling and reclamation has become a parallel but not necessarily integrated focus (ICOLD 2013). But improvements are needed. Most tailings facilities owners and users still face one or more significant geotechnical, safety, geo-environmental, or financial risks related to operational reclamation activities and long-term landscape performance (McKenna 2002).

Reclamation practices vary widely according to climate, commodity, and regulatory environment. Most mines employ conventional reclamation techniques, including regrading of slopes, placement of cover materials (usually a growth medium), and planting with site-appropriate, ideally native, vegetation. Reclamation is often conducted progressively, whereby mine areas, especially mine waste landforms such as tailings facilities and waste rock dumps, are reclaimed soon after bulk material placement is completed. At some mines, each lower bench of dams and dumps is reclaimed as the next bench above is placed. This approach cannot be used for most downstream and centerline constructed facilities which can generally only be reclaimed once all lifts have been added.

Though it is an increasingly rare practice, some mines still carry out little in the way of reclamation until after mining and milling cease. Small mines often have just one tailings facility, one pit, and one or two waste rock dumps, and at these sites the opportunities for progressive reclamation are limited. On the other hand, many active underground and open-pit mines have about 10 to 30 per cent of their area reclaimed. These mines benefit from a 'learn-as-you-go' approach to mine reclamation, allowing operators, regulators, and local communities to see first-hand how the landscape performance of reclaimed land is faring. Operators are also able to reduce liability for future reclamation. In some jurisdictions, mines vie for reclamation awards given by the regulator for exemplary achievements in progressive reclamation. It should be noted though that, progressive reclamation of tailings dams is not always practical. This is most notably the case for dams constructed by the downstream method, which receive regular depositions. For some dams with active pouring above reclaimed areas, line spills and deposition of windblown sand from beaches or benches, can damage the reclamation below.

Currently, most mines have a 'conceptual closure plan' that details what needs to be done for the mine site (landscape scale) and for each mining landform (such as waste rock dumps, tailings facilities, open pits, and plant sites). The plan applies to decommissioning, regrading / stabilisation, mine reclamation, and water management and water treatment. Excellent guidance for development of modern closure plans is provided by IBRAM (2014), Government of Western Australia (2015), Asia Pacific Economic Cooperation (APEC, 2018) and ICMM (2019). However, at most mines, the design and operation of tailings facilities is conducted separately from closure and reclamation.

Mines are required to post financial assurances to cover the costs of reclamation and long-term care in most jurisdictions, but depending on the regulatory framework, the assurances can end up being a small fraction of the eventual requirements. In some jurisdictions the land may be abandoned while only partially reclaimed, and must be managed by the state, with little or no funding available for the remaining work.

3. TAILINGS CLOSURE: WHAT IS GOOD PRACTICE?

Good practice tailings closure development and design starts during the initial stages of the mine development programme, when decisions are made about site selection and tailings management. The initial closure plan forms the basis for ongoing plan refinement and confirmation as the operations proceed. Pilot studies can be used to refine cover design and placement, vegetation plans, surface drainage plans, etc. The closure plan is never stagnant.

Similarly, there should be ongoing engagement of communities to get their perspectives and advice on the closure of the site. The communities are to be the long-term neighbours of the site and will often become the owner of the closure facility. It is therefore important that they not only understand the closure concepts and approaches but also contribute to and accept the designs and resulting landforms.

A good-practice approach to closure therefore includes the following aspects.

3.1 DEVELOP CLOSURE CRITERIA

Site specific closure criteria are ideally developed at the outset of the project by drawing on:

- regulatory requirements
- mining company corporate closure criteria
- commitments made by the company to regulatory agencies and communities during the mine life cycle
- leading international practices for projects in similar climates, with similar physical and chemical conditions and environmental settings, and in similar socio-economic settings.

These criteria are captured and addressed in the design basis memorandum (DBM) as described below, and then reviewed periodically. For existing tailings facilities that have no or too simplistic closure criteria, a DBM should be developed as a high priority.

3.2 IDENTIFY ALTERNATIVE TECHNOLOGIES

The next step is to identify the alternative tailings and closure technologies and practices that will satisfy the closure criteria. An options analysis is undertaken using mine plans that incorporate each of the leading tailings technologies. (See Consortium of Tailings Management Consultants [CTMC] 2012, for a list of nearly 100 tailings technologies). This requires considering the climatic and topographical location of the tailings facility and the feasibility (technical and economical) and constructability of different options.[1]

Technology developments during the facility mine life may also generate new technologies that can then be considered for adoption during regular closure updates, as part of the mine lifecycle refinements of the closure plan.

3.3 COMMUNITY ENGAGEMENT

Meaningful community engagement is undertaken as an ongoing process throughout the mine lifecycle, with the aim of ensuring that the concerns of local communities are heard and addressed. True collaboration, rather than just consultation, is key to closure reclamation success. (See Joyce and Kemp, this volume.)

4. SPECIFIC TAILINGS CLOSURE AND LANDSCAPE PERFORMANCE ISSUES

Tailings facilities typically have several components, with some attributes easier to reclaim than others. Dams constructed of clean rockfill or borrow are often straightforward to reclaim and perform well, as do tailings sand beaches. However, tailings facilities typically present several challenges for closure and reclamation:

Sand dams, comprised of fine sand and silt tailings, are highly erodible. Even when capped and revegetated, gullies can penetrate the cover, leading to erosion of mine waste, fan deposition, and elevated suspended sediments in downstream watercourses, necessitating ongoing maintenance.

Tailings and the tailings pore-water (the water that fills the porosity between the grains of tailings) may contain elevated levels of metals and may be prone to acid rock drainage. Both can affect groundwater and surface water, creating unacceptable water quality and toxicity to plants, animals, and aquatic life.

- Tailings dam internal drainage systems (underdrains, gravel drains within the dam, and socked-slotted drainage pipe) can be prone to clogging, fouling, or collapse, affecting the long-term groundwater table and the geotechnical and erosional stability of dams.
- Potentially mobile materials (soft tailings, liquefiable tailings, or water) stored behind dams may pose elevated risks of sudden catastrophic dam failures and outflows that threaten lives, the environment, and property downstream.
- Soft tailings are difficult to drive equipment on, expensive to stabilise, cap, and reclaim, and may be prone to many metres of post-reclamation settlement over decades or centuries. At most tailings landforms, just a small percentage of the beach / plateau area is underlain by soft tailings); in some cases (including most oil sands tailings facilities), the majority of the beach area (the tailings plateau) is comprised of soft tailings.
- The outlet spillway structure for tailings dams, if not anchored in bedrock, is a fragile element for closure, especially when retrofitted to a sand dam.
- Few tailings facilities have a DBM that addresses long-term reclamation performance. Lack of clear agreement on design objectives and future performance creates a gap between what is planned by the mine and what is expected by regulators and local stakeholders.
- 'Conceptual closure plans' for many or most tailings facilities are not detailed enough for informed decision-making, and many have undetected fatal flaws.

1. In practice, most of the decisions regarding closure and reclamation of tailings are made before tailings deposition even begins – especially the tailings technology and the location and form of the tailings landform.

In many cases, mine operators have expected to be able to 'walk away' from reclaimed landscapes, including the associated tailings facilities once reclamation has been completed. This strategy implies that the dams can all be deregulated, and that no human inputs are needed to continue to meet the agreed-upon uses, goals, and objectives. The new owner (usually the state) presumably cares for the landscape and protects the past miners' liability. However, experience has shown that only the smallest and most basic mines can realistically implement walk-away solutions; almost all mines need to have some level of effective, permanent aftercare to continue to meet their commitments, especially those with large tailings facilities (Bocking and Fitzgerald 2012). The level of care and maintenance must be factored into the design basis and should be considered when determining the financial assurance posted.

These and other risks, and associated costs, can be reduced by recognising them early in the mine lifecycle and by using a more systematic life-cycle approach to tailings technology selection, production, containment, deposition, stabilisation, capping and reclamation. The growing acknowledgment of the shortcomings in closure and reclamation performance has attracted considerable attention and given rise to several new guidelines from governments and other organisations. Some solutions to these issues are highlighted below.

5. LANDFORM DESIGN

Landform design is the multidisciplinary process that builds mining landforms, landscapes, and regions to meet agreed-upon land use goals and objectives. This section considers four useful terms related to scale: the region, the landscape (mine site), the landform, and the element scale (see Figure 1 and Table 1).

Table 1. Landform design scales

Design scale		Representative dimension, m	Description and examples
Regional		100,000	A grouping of mines in a valley or region Regional plan, cumulative effects assessment
Lease/landscape		10,000	A single mine lease/property. More generally: everywhere you can see from a point on the land (the Renaissance definition) Life-of-mine-plan, mine closure plan, landscape ecology
Landform		1,000	A single mine facility: dump, mined out pit, stockpile, tailings facility Dump design, dam design, landform design
Landform elements	Macro-topography	100	A single designed feature on a landform: toe berm, bench, shoreline, wetland Landform design (as above)
	Meso-topography	10	Fine tuning of topography: swales and ridges Field fit
	Micro-topography	1	Roughening: mounds and pits, individual boulders Field fit

Source: Adapted from Pollard and McKenna 2018

Source: Illustration by Derill Shuttleworth, dshuttleworth.com

Figure 1. Four scales of landform design

The *region* typically hosts several mine sites. Designers and regulators consider the cumulative effects of neighbouring mines and other extractive industries (McGreevy *et al.* 2013). There is also an opportunity for sharing resources and know-how between the mines in a region.

Each mine site can be considered a landscape. Renaissance artists considered the landscape as comprising everywhere that can be seen from a point. Today we think of a mine site as at the landscape scale. Life-of-mine plans are done at this scale. The site-wide surface water drainage and groundwater management are a major focus of working at this landscape scale. The discipline of landscape ecology also comes to bear as the design for wildlife habitat land uses consider the needs of wildlife to move through and use the reclaimed land.

It is useful to divide the mine site into distinct *landforms*, which are distinct topographic features created by natural or artificial processes (McKenna *et al.* 2013). Taken together, natural and artificial landforms make up the surface of the earth. Mining landforms include tailings facilities, waste rock dumps, pits and pit lakes, landfills, borrow sites, and similar facilities (Pollard and McKenna 2018). It can also be useful to consider site-wide drainage, the plant site, and perhaps the access roads and infrastructure as individual mining landforms for management and design purposes. Using this landform terminology allows mines to tap into hundreds of years of geomorphic and ecological experience and literature for use in design and assessment, as well as to learn from the performance of natural and other mining landforms in the region.

Most mine sites have 10 to 20 mining landforms planned, in construction, or reclaimed. Recent literature suggests that tailings facilities should be turned into landforms 'at closure.' The alternative view, as argued in this chapter, is that the tailings facilities are each their own landform even during the planning phase, and certainly with the initial construction of the starter dam. One can argue that at any point in time, every square metre of the earth's surface belongs to a landform. As mentioned above, this framework allows the design to focus on the long-term issues.

The smallest scale of interest, the *element* scale, refers to features on a landform such as mounds, trails, or wetlands). These elements are chosen and built to satisfy the requirements in the DBM.

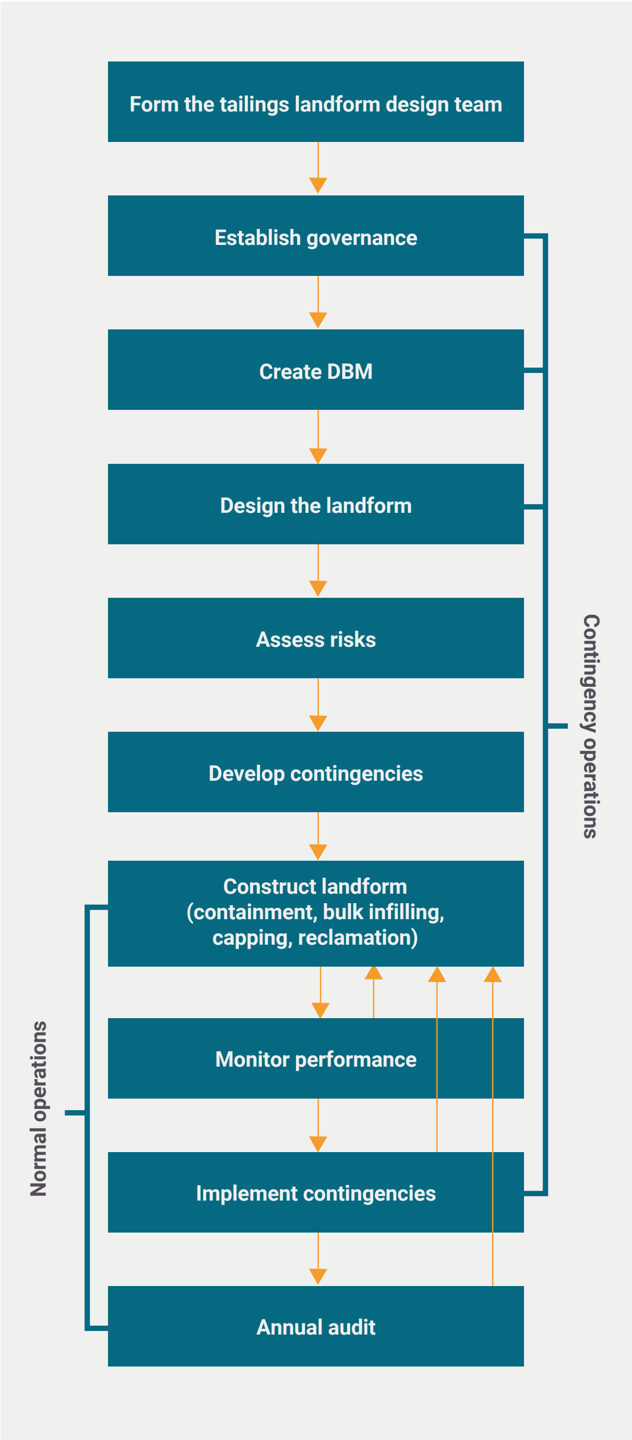


Figure 2. Steps in landform design for tailings facilities

6. LANDFORM DESIGN FOR TAILINGS FACILITIES

This section provides a step-by-step basis for landform design of tailings facilities. The major steps are shown in Figure 2 and described in the subsections below.

At most tailings facilities, the level of uncertainty in the foundation geology, dam construction, and tailings deposition usually precludes a fully deterministic landform design. Instead, design teams can follow Peck's (1969) geotechnical observational method which involves designing for the most likely conditions, developing a full suite of contingencies that can be enacted if field conditions are worse than expected, and a monitoring programme that allows timely adoption of contingency measures where needed. This method is used widely in dam design and is suited to landform design, mainly because it embraces the full development of contingencies. In the same way that a pre-designed toe berm may be a contingency for dam safety on dams with poor foundation conditions, shallow wetlands may be a contingency for reclamation for pockets of beaches that have undergone differential settlement.

The first two steps involve defining the landform boundary and forming the tailings landform design team. The team works at the various scales (region, landscape, landform, element) with a focus on the specific tailings landform. At successful mines, the landform design team works around a single plan – the life-of-mine-plan – rather than with separate mine, tailings, closure, and reclamation plans. The team works to support the life-of-mine plan by providing landform designs at each scale: the landscape scale for the life-of-mine plan, the landform design for an individual tailings landform (which embraces and influences the dam design), and design of various elements as needed.

The team provides various levels of design, ensuring that each design has enough detail to allow for sound financial, operational, regulatory, and stakeholder decisions. The notion of 'conceptual designs' is no longer entertained as these have been consistently shown to be insufficient for good decision-making and often contain fatal flaws. Instead, designs are completed to a pre-feasibility, feasibility, detailed, and issued-for-construction level. As built / construction and annual performance reports are also produced as a matter of routine.

6.1 DEFINING THE LANDFORM BOUNDARIES

Defining the tailings landform boundary is essential to successful reclamation. This is often done at the landscape scale. Usually the entire tailings facility is selected as a single landform. This includes the dam, the pond/plateau/beach depositional area, and the disturbed area around the periphery of the tailings facility (including roads, pipelines, powerlines, and other related infrastructure). In the past, some operators have chosen to treat the dam and its beaches/ pond contents as different landforms. While sometimes practical, this separation often leads to a lack of cross-disciplinary coordination, whereby the operational geotechnical stability of the dam can become the sole focus, with the contents simple considered 'dense fluids,' which overlooks the need to integrate the two elements of the deposit. Mines are diligent with dam safety but then are surprised by the cost of soft tailings stabilisation (see below).

6.2 FORMING THE TAILINGS LANDFORM DESIGN TEAM

The landform design team usually includes mine and tailings planners, a geotechnical engineer, a surface water hydrologist, a groundwater hydrologist, a geochemist, and specialists in covers/soils, vegetation, and reclamation, along with other specialists as required (McKenna 2002). One member of the team, sometimes the geotechnical Engineer of Record, takes overall responsibility for the design.

Teams typically comprise a 40/40/20 mix of engineers, biologists, and other specialists. Large mines often have all the engineers and specialists on staff, while smaller mines often use consultants. All members are part of all phases of design, construction, in-filling, stabilisation, capping, reclamation, and aftercare, though their level of activity varies over the decades. These teams often take a few years to learn to work as a highly functioning team, one in which each member understands the different approaches and priorities of their colleagues.

6.3 ESTABLISHING GOVERNANCE

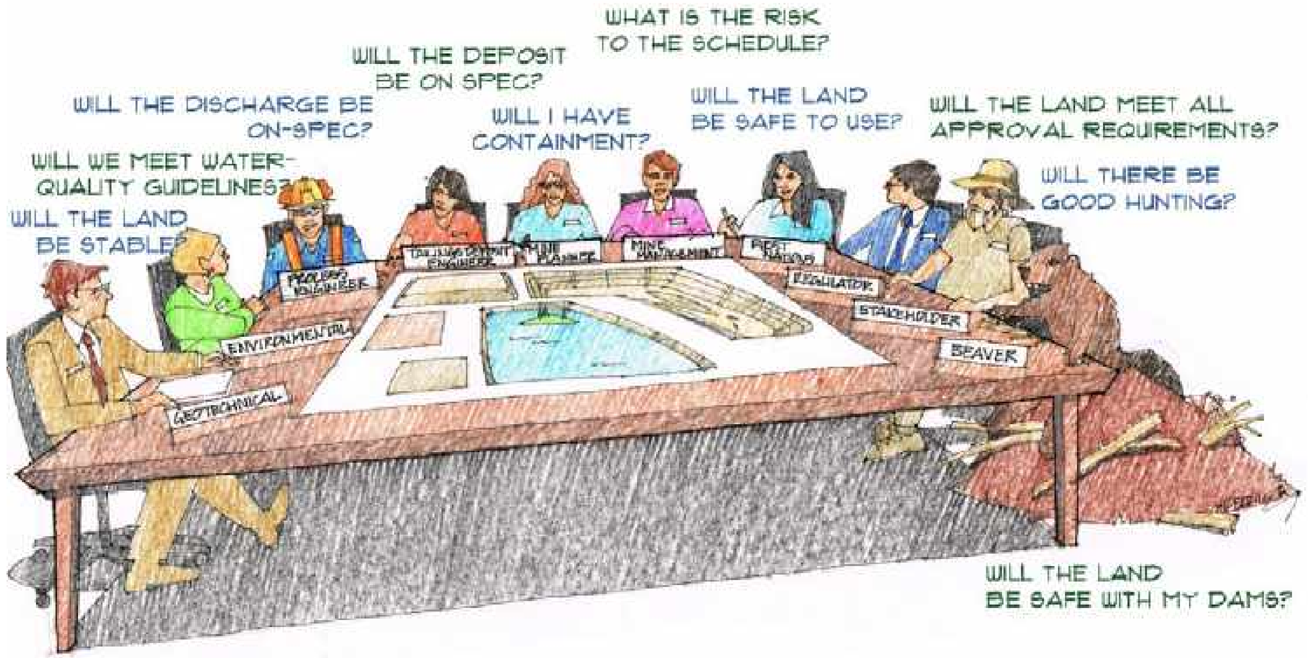
Just as there can be an accountable executive for tailings management and/or dam safety there should be an accountable executive for closure landform integrity including design and construction of the tailings landform – the two activities are one and the same. Often the costs of closure and reclamation of a tailings facility are similar to the cost of tailings containment and deposition, which is one more reason for close management. The accountable executive defines the project, provides adequate resourcing, delegates the activities to qualified personnel, and ensures the landform is designed and constructed to meet the agreed-upon goals and objectives in the design basis.

6.4 CREATING THE DESIGN BASIS MEMORANDUM

The landform design team creates a 10-20 page design basis memorandum (DBM) at the landscape level (to support the life-of-mine plan) and a separate, slightly more detailed, DBM for each mining landform (Ansah-Sam *et al.* 2016). Producing a DBM is a critical step often missing in the current state of practice. This oversight can lead to higher risks, costly rework, and ultimately to non-acceptance of the completed landform by regulators and local communities, even if the project is otherwise well constructed and reclaimed.

The vision is set out by working with regulators and local communities to determine target post-mining land uses. The report requires a lengthy table that describes the goals, supporting design objectives, and design criteria. The design objectives are measurable, and criteria may include items such as geotechnical factors of safety, allowable settlement, the service life, and magnitude and return periods for design events such as precipitation and seismic events. Each of the disciplines on the design team will contribute design objectives and criteria.

Ideally, a DBM is written jointly by the mine operator, its regulators and local stakeholders (Figure 4). In practice, the DBM is usually advanced in consultation (or sometimes even collaboration) with these groups. Periodic reviews of the DBM and the design and performance of the tailings landform, in conjunction with all affected groups, is key.



Source: Illustration by Derrill Shuttleworth , dshuttleworth.com

Figure 3. Different perspectives on tailings landform design

6.5 DESIGNING THE LANDFORM

The landform team designs the tailings landform to meet the requirements of the DBM and to align with the overall mining landscape during and after operations. The designs are supported by site investigations, which entail not just an examination of the pre-existing conditions prior to dam construction and infilling, but also of the dam construction and annual investigations of the pond and infilling. A large investigation is required just before capping and reclamation and is usually dominated by cone penetration testing, along with sampling of tailings materials and installation of piezometers and settlement monuments.

One of the major components of landform design is the selection of tailings technology, as described above. This decision, which is typically based on results of laboratory analysis of samples from a pilot milling process, has a profound effect on all remaining decisions for a tailings facility. There is a trend toward the use of 'dry-stack' tailings to minimise many of the concerns about dam safety and long-term stability. However, such tailings facilities still need landform design, and care must still be exercised to ensure that dry-stack tailings present an extremely low risk of post-closure static or dynamic liquefaction.

6.6 ASSESSING RISKS

The design is assessed using engineering risk assessment tools. A fatal-flaw analysis may be used to uncover any design aspects that are technically impossible or economically unfeasible. A failure modes assessment (FERC 2019) has proven useful for screening long lists of failure modes, with the highlighted failure modes then subjected to a more detailed failure modes and effects analysis (FMEA) (see MEND 2012). A list of residual risks is used to develop the contingencies and monitoring programme. Risk assessment is an ongoing activity throughout design and construction of tailings landforms. It is done formally every three to five years, or when there is a significant design change.

6.7 DEVELOPING CONTINGENCIES

Contingency measures for the residual risks are developed in some detail. They are part of the design. The monitoring programme aims to identify when performance deviates from what is expected and when these pre-planned contingencies are enacted. Where there are deficiencies, construction practices can be changed, or design contingencies implemented. In some cases, the DBM will need to be revisited.

6.8 CONSTRUCTING THE LANDFORM

Tailings dam construction is a mature technology, as is tailings deposition methods. The other components, which include stabilisation of the tailings plateau (especially in the case of soft tailings), capping, placement of reclamation material, and revegetation may or may not be common at commercial scales in the region where the tailings landform is located. Ideally, tailings would be easy to stabilise, cap, and reclaim. To this end, production of fluid tailings and soft tailings should be minimised (McKenna *et al.*, 2016).

6.9 MONITORING AND AUDITING PERFORMANCE

Throughout all phases of construction, performance is monitored and compared against design assumptions, by applying first-class construction practices and the observational method. This is routine for geotechnical dam construction and can be applied to tailings management and reclamation. An annual third-party independent audit can help to improve the effectiveness of the observational method. This should ensure that all aspects of the tailings landform are designed, constructed and monitored according to the design basis and the operating and maintenance manual.

Source: Illustration by Derrill Shuttleworth , dshuttleworth.com

Figure 4. Good practices for design of tailings landforms

7. PRACTICAL ADVICE FOR DESIGNING FOR DEREGULATING AND CLOSURE

This section contains useful advice for the landform design team. It provides some hard-won lessons and outlines techniques to improve the design and construction of tailings dams and tailings facilities. Much of the advice is unique to certain climates, which is the main filter of landform design. The objective is for facilities to be easily decommissioned, easily reclaimed, and easily deregulated. In time, these sites transition to agreed-upon post-mining land uses with acceptable performance, cost, and risk. Figure 4 highlights some of the elements important to building a sustainable tailings landform.

7.1 LANDFORM LONGEVITY

The service life of a tailings landform is the subject of considerable debate, and declaration of a service life is a key aspect of the DBM. In the absence of an agreed-upon service life, some will assume that this life is 'forever' or 'until the glaciers return,' while others give it little thought. Service life is important for long-term geomorphic and ecologic processes (Holden *et al.* 2019) and will affect predictions and designs for dozens of evolutional mechanisms, such as: dam slope erosion, failure of internal drainage elements and liners, geochemical evolution and geochemical weathering, impacts on water balance and flows due to climate change, and ecological and land use changes. There may be a convergence of consideration of service life of 1000 years for tailings facilities (ICOLD 2013; Slingerland 2019). Some components, such as some internal drains, may require ongoing monitoring and maintenance over the service life unless they can be demonstrated to be robust or unimportant to future performance.

Designing for climate change is part of the state of practice for design and construction of tailings landforms. Changes in vegetation in response to climate change can have a significant effort on landscape performance. Design methods for including climate change are evolving rapidly (e.g. Slingerland 2019).

7.2 FREEBOARD, BEACH LENGTHS, AND GEOTECHNICAL CRITICAL AND BUFFER ZONES

In the effort to arrive at successful reclamation of tailings facilities, one of the main considerations is the potential for ponded water to gather behind a tailings dam. It is often difficult to decide upon an acceptable area, volume, or location of water in the final landform. Clearly, there needs to be a generous stable outlet, suitable freeboard, and a required offset from the ponded water to the inside dam crest. If a wet cover is employed (typically to mitigate acid rock drainage), the water pond will be large and managed, and will have a freeboard and minimum beach lengths similar to those of the active pond.

Even for tailings facilities with very small ponds, the freeboard requirement for closure is typically greater than that of an actively managed pond, especially if inspections are infrequent or have been discontinued. For large, active, oil sands ring-dam tailings facilities in northern Canada, a typical operating freeboard is 3 m, with long sand beaches to control seepage and wave runup. For closure, when no human intervention is anticipated, 6 m of freeboard or more may be required in order to manage up to 1 m of long-term dam settlement, a 3 m high beaver dam at the outlet, a probable maximum precipitation event of 0.6 to 1.0 m, wave setup and runup, while allowing some residual freeboard.

Ponded water near the dam crest may trigger overtopping, slope instability, piping (internal erosion), or loss of crest due to wind-wave or current erosion. But how far should any ponded water be kept away?

A useful design requirement is to allow no water to pond in the geotechnical critical zone. This area is built-up and sloped upstream to avoid the potential for any ponded water. Upstream is a geotechnical buffer zone that allows water to pond only during extreme events, such as in a 1-in 500-year precipitation event, for a period of weeks or months. This area is also sloped toward the pond with enough gradient to ensure the static water level does not encroach. Designs are complicated by slow consolidation settlement of soft tailings and by the desire, in some jurisdictions, for wetlands and other aquatic habitat in tailings areas. Where long-term management is assured, the numerical values of these criteria will be less than in cases where no, or infrequent, monitoring or maintenance is planned. Poor communication of these criteria during operations means that many (or even most) tailings ponds are 'overfilled' with tailings by the time of closure.

7.3 OUTLET DESIGN AND MAINTENANCE

For the reclaimed tailings facility, the final outlet location and elevation (to the nearest 0.1 m) is one of the main design considerations. The design of the topography of the tailings plateau is governed by this requirement, and all the plateau water (and the upstream watershed) must flow to this point. The outlet location should be determined before the

tailings facility is constructed. Many tailings facilities, especially ring dams, have no outlet during operations, with the result that the outlet location is often overlooked until closure.

Ideally, the outlet and spillway are sized to pass the design flood, which for closure is typically the probable maximum flood. Loss of a spillway can lead to a loss of the dam or a major erosion event for the landform. Ideally, the outlet and spillway are founded in competent *in situ* bedrock. Where this is impractical, the spillway should be located on compacted, stable dam fill with low permeability and low erodibility. Retrofitting sand dams that contain soft tailings near an outlet is especially expensive and challenging and highlights the need for up-front design. Often what would otherwise be an ideal location for an outlet requires earthworks on soft tailings (that usually accumulate at the low point in the beach next to the dyke). This is clearly a less than optimal outcome.

Spillways in non-bedrock locations are typically armoured with durable, angular riprap. Smaller spillways with low risk may be armoured with vegetation. Almost all spillways will require periodic monitoring and maintenance. Limiting the gradient of the spillway improves its robustness.

7.4 SOFT TAILINGS

Soft tailings are those that are difficult to traffic with normal mining equipment, due to extremely low shear strengths (Jakubick *et al.* 2003). The strengths of soft tailings are often compared to various foods such as porridge, yogurt, pie filling, and even chocolate milk (McKenna *et al.* 2017).

Soft tailings are typically generated by the partial segregation of fines from the coarse tailings stream; the sand drops out on the beach, and the fines are carried with the water to the distal toe of the deposit (the fines content increases down the beach). In some cases, it is the rock-flour-like gradation that causes the tailings to settle slowly and form loose liquefiable deposits with fluid-like strengths (peak undrained strengths < 2 kPa). Often 5 to 10 per cent of the deposit will exhibit peak undrained strengths that are very soft (< 12 kPa), requiring amphibious equipment for access.

Tailings that have naturally occurring clay minerals can cause the majority of the tailings plateau to be soft or even fluid. These are common in oil sands, some kimberlite operations, some coal mines (Williams 2017), and a few metal mines (Montana DEQ and BLM 2008). The cost to stabilise and reclaim soft tailings can be ten times the cost of normal dump or dam reclamation, approaching the combined cost of dyke construction and tailings operations.

Common techniques for stabilising soft tailings include: allowing time for consolidation, re-handling, and reprocessing; crust management techniques; use of wick drains to speed consolidation; reprocessing; or deep soil mixing with cement-like amendments. Five common techniques for capping soft tailings are: water capping, floating covers, raining-in of sand, beaching with sand, and soft ground techniques (Figure 5). McKenna and Cullen (2010) provide an overview of the design process for capping and reclaiming soft tailings for existing deposits.

Source: Illustration by Derrill Shuttleworth, dshuttleworth.com

Figure 5. Common methods for capping soft tailings (McKenna et al 2018)

7.5 SAND DAM EROSION

Tailings sand, which is typically angular, cohesionless fine sand or coarse silt, has a high friction strength when compacted, but is vulnerable to erosion by wind and water. Many tailings dams are constructed from hydraulically placed and compacted tailings sand (sand dams) without regard to long-term erosional stability of the downstream face. Erosion is typically controlled by regrading the downstream face of dams to avoid concentrating or ponding of runoff water, and by using a soil cover and vegetation to limit erosion. In some cases, a rock erosion cover is employed. The slopes are maintained in the operational phase and are likely to require some maintenance during after-care.

Several methods can be employed to predict erosion of reclaimed slopes (Slingerland *et al.* 2019). Various empirical agricultural erosion models, such as RUSLE have been adapted to predict erosion rates on mining landforms but provide little design guidance. Complex numerical models such as SIBERIA and CEASAR are rapidly evolving models that are becoming more useful for the design of tailings dam slopes, especially with respect to cover systems and surface water drainage schemes. Such models, and hard-won experience, indicate the need for consideration of erosion control measures as part of the initial tailings landform (dam) design.

7.6 CONTROL OF TAILINGS SEEPAGE WATER

Tailings pore waters contain process-affected water, which is often elevated in salts and metals, especially where there are elevated sulphide contents which can lead to acid rock drainage. Control of dyke seepage is key to limiting the need for expensive, long-term, water collection and treatment. Several methods can be applied to limit these impacts. These include: the selection of tailings technologies that do not produce acid rock drainage (e.g., desulphurising tailings); avoiding (or sealing against) aquifers in the tailings foundation; lining the facility with a low-permeability liner (although the longevity of such liners may be less than the service life); installing seepage cut-off facilities downstream of the facility; and using low-net-infiltration covers on the tailings plateau and downstream facilities. Control of groundwater entering the facility may also be required. (See MEND 2012; INAP 2017; INAP 2018 for useful guidance). It is often practical to control tailings geochemistry by limiting the oxygen and water ingress into the tailings by constructing an engineered cover system after tailings deposition is complete.

7.7 DECOMMISSIONING

Decommissioning involves the removal of unneeded infrastructure (pipelines and pumphouses, powerlines, roads, instruments, derelict equipment, etc.) and trash from the tailings landform footprint. Ideally, housekeeping has been exemplary so that there is little trash and debris, and the rest of the equipment – once no longer needed – has already been removed.

7.8 DEREGULATING AND RECLAMATION SIGNOFF

Many mines are intent on eliminating the need to monitor and maintain reclaimed tailings facilities as dams. Under this scenario, there would be no requirement for daily inspections of the pond and beaches, no annual dam safety inspections, and no dam safety reports.[2]

To achieve this objective, the mine operator must convince corporate management and the regulator that the reclaimed tailings facility no longer meets the criteria of a dam, and that it no longer needs to be regulated as a dam (although it would still be regulated as a mine waste structure like a waste rock dump, until final completion / signoff). This requires the operator to demonstrate that the failure modes important to dam safety no longer apply or are extremely unlikely to occur. The main failure modes are overtopping, downstream slope failure, upstream slope failure, piping failure / internal erosion, failure of the outlet or spillway, settlement leading to ponding behind the dam, liquefaction, and excessive slope erosion.

Regulatory agencies that do not wish to inherit responsibility for dams may require the deregulation of tailings facilities prior to signoff. Prospects for signoff are improved if the mine, the regulator, and local communities have been involved with crafting and updating the DBM and have jointly monitored performance of the landform throughout its life.

7.9 AFTERCARE

Most jurisdictions, and most operators, recognise the need for managing long-term liability for the majority of reclaimed tailings facilities, as part of the reclaimed mining landscapes. This management will require ongoing operation, monitoring and maintenance. Large international mining companies each have up to several dozen closed sites and have institutionalised such activities. Common activities include maintaining access and access controls, periodic visual monitoring, monitoring of geotechnical and groundwater instrumentation, repairing gullies, collecting and treating contaminated water, maintaining the surface water drainage system, and annual reporting. Ideally, the facilities will have been designed and constructed to minimise or streamline these activities. Financial assurance for long-term maintenance can be costly, especially if active water treatment is required. The intensity of aftercare is best managed through the DBM and landform design process before landform construction begins.

2. The Oil Sands Tailings Dam Committee for the Oil Sands Research and Information Network (OSTDC 2014) provides a model for deregulating oil sands tailings dams. More general guidance is available from The Canadian Dam Association (CDA 2019).

8. CASE STUDY: SUNCOR POND 1 / WAPISIW LOOKOUT LANDFORM DESIGN

Suncor Energy's Pond 1 is a case history that demonstrates the application of landform design to the stabilisation and reclamation of a 2.2 square kilometer tailings plateau (see Anderson and Wells 2010; Russel *et al.* 2010). Figure 6 below shows the progression from end of operations, through design, capping, and revegetation.

Pond 1 and Tar Island Dyke represent the first tailings facility in the oil sands region. Construction of Tar Island Dyke's initial sand dam began in 1967 and reached its final height of 92 m in 1985. Afterward, settling pond operation and tailings infilling continued at a slower rate, with sand infilling of the pond to create an internal underwater buttress beginning in 2003.

Suncor, working with the regulator and local communities, decided in 2007 that this oil sands tailings pond surface would be stabilised and reclaimed by the end of 2010. The goals listed in the design basis were to create a trafficable landscape that could be rapidly reclaimed to boreal forest wildlife habitat, and to direct all surface water away from the dam crest and toward a future pit lake that would be developed from the existing tailings pond (visible in the upper left corner of each photo in Figure 6). A key aspect of the design involved using topography and 8.9 km of vegetated swales to manage seepage and surface water.

Capping soft tailings in this way was new in the oil sands and, following the observational method, contingency measures were put in place. A monitoring programme was used to track performance during construction. This was done by mostly visual, means, supplemented by standpipes and vibrating wire piezometers and frequent bathymetric soundings

Figure 6. Suncor Pond 1 tailings landform case history

An initial design basis and whiteboard-level design was crafted in early 2008. Sand capping and displacement of the soft tailings using cycloned tailings sand was implemented immediately. Site investigations, detailed design, and stabilisation and reclamation operations continued in parallel over the next three years. The displaced fluid tailings were reprocessed and deposited in a nearby tailings facility, the water was recycled to the extraction plant, the newly formed tailings sand beach was landform-graded into a ridge-and-swale topography, a small wetland was constructed, and the site was revegetated, first with native grasses, then with 600,000 native shrub and tree seedlings. Various wildlife habitat enhancements were added as part of this reclamation.

Construction and reclamation were completed successfully. Landscape performance monitoring continues as the vegetated cover matures. through a reclamation observation, monitoring and maintenance plan (see Crossley et al. 2011). This plan is referenced for closure and reclamation work in Suncor's Operations, Maintenance, and Surveillance Manual, which is employed for the overall facility and dam. As expected, the main challenge during construction was excavation of the deep channels in the saturated tailings sand cap. To deal with this, construction practices and designs were adjusted to accommodate changes in local conditions on a daily basis. A celebration with management, staff, contractors and consultants, regulators and politicians and the local First Nations communities capped the 50 years of landform construction. During the celebration, the landform's name was changed from Pond 1 to Wapisiw Lookout, with the local First Nation intending to use the area again for community gatherings as they had been doing traditionally for thousands of years.

9. CONCLUSION

Designing and constructing tailings landforms so that they can be safely and efficiently decommissioned and reclaimed requires as much attention as operational dam safety. To be successful, both activities need to commence well before mining begins, and be factored into planning and design of the mine and associated infrastructure. Planning and design for closing tailings facilities reduces costs, reduces risks, and allows mines to meet the agreed upon goals and objectives. Landform design, done well – and underpinned by good governance and collaboration between the mine, the regulator, and local communities – will result in a positive mining legacy for generations to come.

KEY MESSAGES

1. Current practice at most mining operations largely divorces the long-term closure and reclamation of tailings facilities from the operational dam construction, tailings deposition, and geotechnical dam safety considerations. This artificial division leads to higher life-cycle costs, reduced performance and increased risk.

2. Closing and reclaiming tailings facilities presents numerous challenges, especially if these challenges are overlooked during the initial design and construction of these mining landforms.

3. Landform design provides a framework for inclusion of all aspects of the life cycle of a tailings facility. This is a multidisciplinary process for building mining landforms, landscapes, and regions to meet agreed-upon land use goals and objectives. The process ideally begins with the initial designs of tailings landforms (or in the case of most existing sites, are adopted midstream) and continues long after operations have ceased.

4. Tailings landforms are important features in the mine's closure landscape that will last for millennia and will serve as a major component of a mine's enduring legacy. Mines, by working with their regulators and local communities, can help establish a positive mining legacy by returning lands for use by local communities in a timely manner.

REFERENCES

Anderson, H.B., Wells, P.S., and Cox, L. (2010). Pond 1: Closure of the first oil sands tailings pond. *Mine Closure 2010*, Vina del Mar: Chile.

Ansah-Sam M., Hachey L., McKenna, G. and Mooder, B. (2016). The DBM approach for setting engineering design criteria for an oil sands mine closure plan. *Fifth International Oil Sands Tailings Conference*, December 4-7. Lake Louise.

APEC (2018). *Mine closure checklist for governments*. Asia-Pacific Economic Cooperation. APEC Mining Task Force. Singapore. February 2018.

Bocking, K.A. and Fitzgerald P. (2012). Management and financing of post-closure liabilities. *Mine Closure 2012*. 49-56.

CDA (2019). *Technical bulletin: application of dam safety guidelines to mining dams*. Toronto: Canadian Dam Association.

Crossley C., Russell, B., Van Zyl, D. and McKenna, G. (2011). Developing an operation, maintenance, and surveillance manual for the post-closure management of tailings facilities. *Mine Closure 2011 Conference*. September 121. Lake Louise.

CTMC (2012). *Oil Sands Tailings Technology Deployment Roadmap: Project Report – Volume 2, Component 1 Results*. June 22, 2012. Consortium of Tailings Management Consultants.

FERC (2018). *Engineering Guidelines for the Evaluation of Hydropower Projects*: Chapter 14: Dam safety performance monitoring program. Washington DC: US Federal Energy Regulatory Commission.

Government of Western Australia (2015). *Guidelines for preparing mine closure plans*. May 2015. Perth: Department of Mines and Petroleum.

Holden, A., Provost H., Pollard, J., McKenna, G. and Wells, P.S. (2019). Evolution of landforms in reclaimed landscapes in the surface mineable Athabasca oil sands. *Tailings and Mine Waste Conference.* Nov 17-20. Vancouver.

IBRAM (2014). *Guide for Mine Closure Planning*. Instituto Brasileiro de Mineracao. Brasilia: Brazilian Mining Association.

ICMM (2019). *Integrated Mine Closure: Good Practice Guide*. 2nd ed. London: International Council on Mining and Metals.

ICOLD (2013). Sustainable design and post-closure performance of tailings dams. *Bulletin 153*. Paris: International Commission on Large Dams.

INAP (2017). *Global Cover System Design: Technical Guidance Document*. November 2017. Saskatoon, SK: International Network for Acid Prevention.

INAP (2018). *Global Acid Rock Drainage Guide*. International Network for Acid Prevention. http://www.gardguide.com. Accessed 29 March 2020.

Jakubick, A.T., McKenna, G.T. and Robertson, A.M. (2003). Stabilization of tailings deposits: international experience. Sudbury 2003. Sudbury: Mining and the Environment.

LDI (2020). Landform Design Institute. http://www.landformdesign.com. Accessed 29 March 2020.

MAC (2019). *A guide to the management of tailings facilities*. Version 3.1. February 2019. Ottawa: Mining Association of Canada.

McGreevy, J., McKenna, G., An R. and Scordo, E. (2013). Regional mine closure plans – the next improvement in closure planning. *Tailings and Mine Waste 2013 Conference*. Banff. Nov 3-6. 627-636.

McKenna G., Mann V., Fisseha, B., Beier, N.,and Olmedo, N. (2016). The geotechnical vane strength of soft tailings compared to soft foods. *International Oil Sands Tailings Conference*, Lake Louise.

McKenna, G., Mooder, B., Burton, B., & Jamieson, A. (2016). Shear strength and density of oil sands fine tailings for reclamation to a boreal forest landscape. *International Oil Sands Tailings Conference*. Lake Louise. Dec 4 to 7.

McKenna G., Scordo, E., Shuttleworth, D., Straker. J, Purdy, B., & Buchko, J. (2011). Aesthetics for mine closure. *Mine Closure 2011 Conference*. Lake Louise. 1:603-612.

McKenna, G. and Cullen, V. (2008). Landscape design for soft tailings deposit. *Tailings and Mine Waste 08 Conference*. Vail, CO.

McKenna, G., An R., Scordo, E. and McGreevy, J. (2013). Toward effective closure planning: From progressive reclamation to sustainable mining. *Tailings and Mine Waste Conference.* Banff. 615-625.

McKenna, G. (2002). 'Landscape engineering and sustainable mine reclamation.' PhD Thesis, Department of Civil and Environmental Engineering, University of Alberta.

MEND (2012). *Cold Regions Cover System Design Technical Guidance Document*. Report 1.61.5c. Mine Environment Neutral Drainage Program. July 2012.

Montana DEQ and BLM (2008). *Final environment Impact Statement FES 031 for the proposed M-Pit Mine Expansion at the Montana Tunnels Mine*. July 2008. Butte, ID: State of Montana Department of Environmental Quality and United States Department of the Interior Bureau of Land Management.

OSTDC (2014). *De-licensing of oil sands tailings dams: Technical guidance document*. March 2014. Oil Sands Tailings Dam Committee for the Oil Sands Research and Information Network. University of Alberta.

Pearman, G. (2009). *101 Things to do with a Hole in the Ground*. Cornwall UK : Post-Mining Alliance.

Peck, R.B. (1969). *Advantages and limitations of the observational method in applied soil mechanics, Milestones in Soil Mechanics -- The First Ten Rankine Lectures*. 263-279. Edinburgh: Institution of Civil Engineers.

Pollard, J. and McKenna, G. (2018). Design of landform elements for mine reclamation. *British Columbia Mine Reclamation Symposium*. Williams Lake, BC.

Russell, B., McKenna, G., Leblanc, M., Wells, P.S., and Anderson, H.B. (2010). Design and construction of the reclamation surface for the first oil sands tailings pond. *Mine Closure 2010*, Vina del Mar, Chile.

Slingerland, N.M. (2019). 'Geomorphic landform design and long-term assessment of tailings storage facilities in the Athabasca oil sands.' PhD Thesis, Department of Civil and Environmental Engineering, University of Alberta.

Williams, D.J. (2017). Rehabilitation options for potentially contaminating coal tailings stored in pits. *Acid and Metalliferous Drainage Workshop*. November 20-23. Burnie. Tasmania: Sustainable Minerals Institute.

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MANAGEMENT OF TAILINGS: PAST, PRESENT AND FUTURE

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.

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.

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.

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.

REFERENCES

Ashton, P.J. and Evans, L.H. (2005). Community development through mine site rehabilitation projects'. In *Proceedings, People Place Prosperity SD05 Sustainable Development Conference*. Canberra: Minerals Council of Australia.

Bellenfant, G., Guezennec, A.G., Bodenan, F., D'Hugues, P. and Cassard, D. (2013). Reprocessing of mining waste: combining environmental management and metal recovery? *Mine Closure 2013*. Tibbet, M., Fourie, A.B. and Digby, C. (eds). Perth: Australian Centre for Geomechanics.

Bennett, K. (2016). Abandoned mines – environmental, social and economic challenges. *Mine Closure 2016.* – Fourie, A.B. and Tibbett, M. (eds). Perth: Australian Centre for Geomechanics.

Brundtland, G. (1987). *Report of the World Commission on Environment and Development: Our Common Future.* United Nations General Assembly document A/42/427.

Carvalho F.P. (2017). Mining Industry and Sustainable Development: time for change. *Food and Energy Security* 6(2), 61-77.

Castrilli, J.F. (2010). Wanted: A Legal regime to clean up orphaned / abandoned mines in Canada. *McGill International Journal of Sustainable Development Law and Policy* 6 (2), 109-141.

Cowan, W.R., Mackasey, W.O., and Robertson J.G.A. (2010). *The Policy Framework in Canada for Mine Closure and Management of Long-Term Liabilities: A Guidance Document*. Sudbury: Cowan Minerals. https://docplayer.net/16118806-The-policy-framework-in-canada-for-mine-closure-and-management-of-long-term-liabilities-a-guidance-document.html

Cronje, F., Reyneke, S. and van Wyk, D. (2013). Local communities and health disaster management in the mining sector. *Jamba: Journal of Disaster Risk Studies* 5(2), 1-12.

Edraki, M., Baumgartl, T., Manlapig, E., Bradshaw, D., Franks, D.M. and Moran, C. (2014). Designing mine tailings for better environmental, social and economic outcomes: A review of alternative approaches. *Journal of Cleaner Production* 84: 411-420.

Ericsson M. and Lof, O. (2019). Mining's contribution to national economies between 1996 and 2016. *Mineral Economics* 32, 223-250.

European Union (EU) (2006) Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC – Statement by the European Parliament, the Council and the Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32006L0021

ICMM (2016) *Making a Positive Contribution: How mining companies can contribute to the Sustainable Development Goals.* London: International Council on Mining and Metals. http://www.icmm.com/sdgs

ICMM (2019) *Integrated Mine Closure: Good Practice Guide.* London: International Council on Mining and Metals. https://www.icmm.com/en-gb/environment/mine-closure/integrated-mining-closure

IIED (2002). *Breaking New Ground: the report of the Mining, Minerals and Sustainable Development (MMSD) Project May 2002.* International Institute for Environment and Development. London: Earthscan.

IIED (2012). *MMSD+10. Reflecting on a decade of mining and sustainable development.* London: International Institute for Environment and Development.

International Union for Conservation and Nature (IUCN) and ICMM (2006). *Dialogue discussion report* (in Unger 2017).

IUCN, ICMM and Post Mining Alliance (2008). *Roundtable on restoration of legacy sites: Roundtable Report*. https://www.iucn.org/sites/dev/files/import/downloads/iucn_icmm_post_mining_alliance_2008_legacy_roundtable_report.pdf

Lottermoser, B.G. (2010). *Mine Wastes: Characterisation, Treatment and Environmental Impacts*. Berlin: Springer-Verlag.

McClellan, B., Corder, G., Guiro D. and Green, S. (2009). Incorporating sustainable development in the design of mineral processing operations – a review and analysis of current approaches. *Journal of Cleaner Production* 17, 1414-1425.

McCullough, C.D. (2016). Key mine closure lessons still to be learned. In *Mine Closure 2016*.Fourie, A.B. and Tibbett, M. (eds). Perth: Australian Centre for Geomechanics.

OECD (2019) *Circular Economy and Sustainable Materials Management: Waste and Materials* . November 2019. Organisation for Economic Cooperation and Development. https://www.oecd.org/environment/environment-at-a-glance/Circular-Economy-Waste-Materials-Archive-February-2020.pdf

Pearman, G. (2009). *101 Things to do with a Hole in the Ground*. Cornwall UK: Post-Mining Alliance.

Poswa, T.T. and Davies, T.C. (2017). The Nature and Articulation of Ethical Codes on Tailings Management in South Africa. *Geosciences* 7, 101-139.

Reuters (2019) China seeks to tackle environmental damage caused by mining. www.reuters.com/article/us-china-environment/ china seeks to tackle environmental damage caused by mining-idUSKBN1YS0WP (accessed December 29, 2019).

Tutu, H., Cukrowska, E.M., McCarthy T.S., Mphephu, N.F. and Hart, R. (2003). Determination and modelling of geochemical speciation of uranium in gold mine polluted land in South Africa. *Proceedings: 8th International Congress on Mine Water and the Environment*. Johannesburg: South Africa: 137-155.

UNDP (2011). *Managing Natural Resources for Human Development in Low-Income Countries*, Working Paper 2011-002 – December. United Nations Development Programme. http://www.undp.org/content/dam/rba/docs/Working%20Papers/Natural%20Resources%20Low-Income%20Countries.pdf

UNEP (2001). *Abandoned Mines – Problems, Issues and Policy Challenges for Decision-Makes: Summary Report*. United Nations Environment Programme. http://wedocs.unep.org/handle/20.500.11822/8116

UNEP (2017). *Towards a Pollution-Free Planet*. Nairobi Kenya: United Nations Environment Programme. https://www.unenvironment.org/ietc/resources/publication/towards-pollution-free-planet

UNEP (2019). *A Roadmap for Improved Mine Waste Management: Summary Report of the Workshop on Mine Waste*. United Nations Environment Programme, Canadian International Resources and Development Institute, and GRID Arendal. https://www.grida.no/publications/442

UNEA (2019). *Resolution adopted by the United Nations Environment Assembly on 15 March 2019. 4/19. Mineral resource governance. UNEP/EA.4/Res.19.* United Nations Environment Assembly.

Unger, C. (2017). Legacy Issues and Abandoned Mines. *Mining in the Asia-Pacific. The Political Economy of the Asia Pacific*. O'Callaghan, T. and Graetz, G. (eds). Springer International Publishing.

Unger, C.J., Lechner, A.M., Kenway, J., Glenn, V. and Walton, A. (2015). A jurisdictional maturity model for risk management, accountability and continual improvement of abandoned mine remediation programs. *Resources Policy* 43, 1-10.

Unger, C.J., Lechner, A.M., Glenn, V., Edraki, M. and Mulligan, D.R. (2017). Key elements of global leading practice in abandoned mine programs and their application to Australia. In *From Start to Finish a Life-of-Mine Perspective*. AusIMM Spectrum Series Publication. Melbourne: Australian Institute of Mining and Metallurgy.

Van Zyl, D. and Joyce, S. (2016). Waste not want not – rethinking the tailings and mine waste issue. *AusIMM Bulletin* December. Melbourne: Australian Institute of Mining and Metallurgy.

Van Zyl D., Sassoon M., Digby C., Fleury A-M., Kyeyune S. (eds) (2002): *Mining for the Future: Main Report,* London: International Institute for Environment and Development.

Worrall, R., Neil D., Brereton, D. and Mulligan, D. (2009). Towards a sustainability criteria and indicators framework for legacy mine land. *Journal of Cleaner Production 17*, 1426-1434.

BUILDING ORGANISATIONAL CAPACITY

CHAPTER X ADDRESSING THE ORGANISATIONAL WEAKNESSES THAT CONTRIBUTE TO DISASTER

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1. INTRODUCTION

Major accidents occurring in hazardous industries such as petroleum, mining, and aviation are invariably rooted in organisational weaknesses. A case in point is the recent disastrous loss of two Boeing 737-800 MAXs. This has been widely attributed to a company reorganization in 2001, when Boeing replaced its engineering-focussed top management with managers whose primary concern was profit maximisation (Useem 2019). The significance of organisational factors is often recognised by the companies concerned, following a disaster. For example, in 2010 the petroleum company BP experienced a blowout in the Gulf of Mexico that killed 15 people and did massive environmental damage. Subsequently, the company entirely reorganised itself to give safety a much higher priority (Hopkins 2012).

Tailings facility (TSF) failures are likewise rooted in organisational weaknesses. The report of the Chief Inspector of Mines on the Mount Polley tailings facility failure in British Columbia in 2014 provides an illuminating example (British Columbia, Chief Inspector of Mines [BC, CIM] 2015). The Inspector conducted a root cause analysis of the accident, using an accident analysis method developed by the US National Aeronautical and Space Administration. The method postulates that root causes are organisational in nature and the analysis continues until these are identified. Among the root causes identified in the Mount Polley inquiry were: production priorities prevailing over other considerations, logistics limitations, demand for increased TSF capacity, no long-run planning, no qualified person in charge of the facility, no site integration, insufficient management oversight, and lack of any mechanism by which employees could escalate concerns (BC CIM 2015, pp.130,137,138, 141). Of these, the report found that the most fundamental was the tendency for production to over-ride all other considerations.

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This tendency has been identified in numerous reports on major accidents in many industries. It follows that organisational changes must be designed to counteract these pressures (Hopkins 2019). This chapter present a series of organisational strategies aimed at achieving this outcome.

At several points the chapter refers to requirements in the new Global Industry Standard on Tailings Management ('the Standard'). However, the purpose of the Chapter is not to explain those requirements, but to make recommendations that go beyond them and which might be considered in future revisions of the Standard.

2. BOARD ACCOUNTABILITY

It is commonly asserted that the board has ultimate accountability for the management of major accident risk, including tailings facility failures. But what this means is seldom clear. Accountability only has meaning if the following three questions are answered.

- Accountable *to* whom?
- Accountable *for* what?
- How is the accountable person or entity *held to account*?

Holding a person or entity to account means requiring them they give an account; that is, an explanation. It also must include the possibility of imposing consequences, where the account is found to be unsatisfactory (Keay & Loughrey 2015).

In relation to the first question, in many jurisdictions boards are accountable *to* the courts, *for* compliance with various regulations, but rarely are they *held to account*, meaning that this is seldom an effective form of accountability. Boards are also accountable *to* shareholders *for* generating acceptable shareholder returns and are *held to account*, sometimes, at shareholder meetings. If boards are held to account by their shareholders only after a major accident that affects shareholder returns, this will be a relatively ineffective form of accountability, since such accidents are rare within any one company. On the other hand, if shareholders hold their boards to account for managing major accident risks on a more regular basis, this can be a very effective form of accountability. Shareholders are increasingly looking for ways to hold boards accountable for the on-going management of major accident risks, especially in relation to tailings facilities.

A third form of accountability that is relevant in the present context is *to* project-affected-people, *for* project impact. However, it is difficult to see how project-affected-people could directly *hold* a board *to account*, unless they are highly politically organised. There are, however, indirect means, such as provided for in the Standard. Companies are required to 'meaningfully engage' with project-affected-people. This term is carefully defined in the Standard's glossary and is quite eye-opening for people unfamiliar with the issue. Failure to meaningfully engage could have consequences for the company, in terms of the auditing process, and it is this that renders a company and its board potentially accountable to project-affected-people.

Finally, employees can hold a board to account when they are represented on the board, as is the case in some countries. There may also be indirect means, such as when regulatory regimes are designed to give employee representatives a voice.

One way that boards can respond to the possibility of being held to account is to appoint at least one board member who has expertise in the relevant major accident risks. In the petrochemical industry, stakeholders in the United Kingdom (UK) have signed up to a set of 'process safety principles'. (Process safety is the term used in this industry to refer to major accident risks, such as the risk of gas explosions.) One of these principles reads as follows:

At least one board member should be fully conversant in process safety management in order to advise the board of the status of process safety risk management within the organisation and of the process safety implications of board decisions. (UK Health and Safety Executive [HSE] n.d.)[1].

1. See also http://www.hse.gov.uk/comah/guidance/major-hazard-leadership-intervention-tool.pdf

The mining industry, too, faces catastrophic risks, such as tailings facility failures, high-wall collapses in open cut pits, and explosions in underground coal mines. These are the equivalent of process safety risks in the oil and gas industries. The developments referred to above are therefore of direct relevance to the mining industry. A board which includes one or more experts in major accident risks in the mining sector is in a good position to reach down into the organisation and ask intelligent and probing questions about how risks are being managed. In turn, such a board is better able to provide an account of how the company is managing such risks, if called upon to do so.

Furthermore, there is a widespread view that the more serious the possible consequences of a risk decision, the higher in the corporation that decision should be made. Where the potential consequences are catastrophic, threatening the survival of the corporation in its existing form, it should be the board which makes the final decision. Of course, boards will be advised by the company specialists who might otherwise be making these decisions. But boards may take a broader view than these experts. In particular., they may give greater weight to the reputational damage that a catastrophic failure could cause, even though the likelihood of such a failure might be extremely remote. A board member with specialist knowledge about the major accident risks faced by the corporation can greatly assist this process. As one investor said during the consultation process for the Standard:

We want to know that oversight and decision making for these high consequence, material risks resides at the highest level of the company, where our Board nominees can have influence / at very least be aware of status, and where decisions are less susceptible to the internal corporate influences that executives can be exposed to.

The idea that boards might be involved in such decision-making is sometimes opposed on the grounds that this inappropriately blurs the line between boards and executive managers. A board's role, according to this argument, should be to ensure that there are systems in place to manage risk and that these systems are properly audited, but to inquire too deeply into how these risks are being managed, or get involved in particular decisions, infringes the role of senior management. However, this is too rigid a view. Where risks can have material consequences, that is, can significantly affect the share value, it is ultimately the responsibility of the board to decide whether, or on what basis, to accept the risk. This principle is well understood in the case of purely financial decisions, such as mergers and acquisitions. It should also be the case in relation to major accident risks, which can materially affect the business. There is not and cannot be a rigid line between the board and the executive in regard to this matter.

To sum up, the idea of board accountability is an important one, but boards will only be accountable for major accident risk if there are persons or entities able to hold them to account. This can most easily be done by shareholders.

3. AN ACCOUNTABLE EXECUTIVE

The Standard requires the appointment of one or more Accountable Executive(s). The use of this term is not restricted to the mining industry and its meaning varies with the context. Some of the matters that depend on that context are: who may be appointed an accountable executive, to whom the appointee is accountable, for what they are accountable, and by what mechanism they might be held to account. The Standard clarifies some but not all of these matters. For this reason, the discussion here proceeds independently of the Standard and defines from first principles an ideal role for an Accountable Executive in the mining industry.

Recall that the most fundamental of the root causes of the Mount Polley failure was the priority given to production over all other considerations. The role of the Accountable Executive must therefore be to correct this imbalance by ensuring the proper management of major of accidents risks, in particular, tailings facility risks.

There is an inevitable tension between production, on one hand, and safety, or risk control, on the other. It is important that this tension be manifested at the highest level of the corporation, with these two goals championed to varying degrees by different people. In situations where Chief Operating Officers and business unit leaders may tend to give greater emphasis to production or profit, an Accountable Executive must be able to argue unequivocally for safety. Where there are significant differences of opinion, it will be the CEO who makes the decision, but with the benefit of hearing the arguments on both sides. For this arrangement to be effective, the Accountable Executive must have the same status as those on the other side of the debate, which means that if they report directly to the CEO, so must the Accountable Executive. Without an Accountable Executive operating in this way, the tension between production and safety is buried and resolved at lower levels of the organisation, too often in favour of production.

Furthermore, given earlier observations about boards, directors need to be able to see the tensions in the organisation and satisfy themselves that management is dealing properly with the trade-offs between these somewhat competing objectives (International Commission on Large Dams [ICOLD] 2017, pp. 55,77). This requires a direct line of communication between the Accountable Executive and the board. The Accountable Executive must be able to raise issues in a timely manner, not restricted to scheduled quarterly or annual reporting. This Executive therefore has dual reporting lines, to both the CEO and the board. Finally, to maximise the autonomy of the position, the appointment should be made or confirmed by the board[2].

It is clear from this discussion that the Accountable Executive cannot be anyone who has production responsibilities or targets. This should be no barrier to finding an appropriate person, as companies often have a Chief Sustainability Officer, or a Chief Risk Officer, or an Executive Manager for Health and Safety, or for Safety and Major Accident Risk. As long as such people report to the CEO, they can fulfil the role of Accountable Executive described above.

Next there is the question of what the Accountable Executive is accountable for. The easiest way to answer this question in the present context is to say that the incumbent should accountable for the implementation of the Standard. More generally, because the Accountable Executive's role will be broader than tailings management, it can be specified as ensuring that proper attention is paid to risk management and compliance throughout the corporation. Given the breadth of this role, there will need to be a structure of positions subordinate to the Accountable Executive to which the responsibilities of the role are delegated.

Finally, since the Accountable Executive is at least confirmed by the board, this confirmation can be withdrawn, which provides one mechanism for holding this Executive accountable.

2. The Mining Association of Canada's *Guide to the Management of Tailings Facilities* (MAC 2019) envisages that the Accountable Executive will be 'designated' by the board.

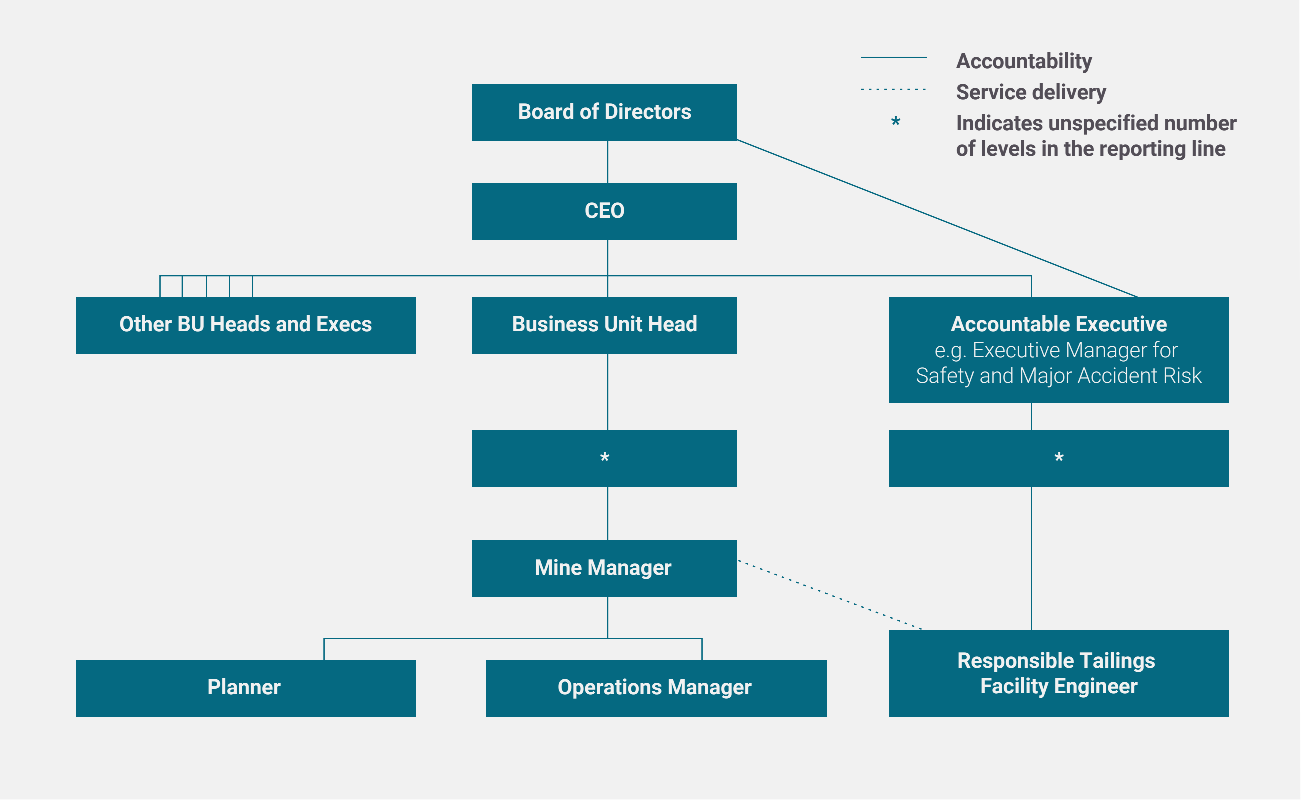

Figure 1. Skeletal Organisational Chart Showing Relationships Referred to in the Text
Updated on 12 August 2020

4. AN INDEPENDENT LINE OF ACCOUNTABILITY

The Standard requires the appointment of a responsible tailings facility engineer (RTFE) to oversee the construction of the tailings facility in a manner that complies with the requirements of the Standard. In many cases the position will also have responsibilities for managing people and budgets. In the normal course of events, therefore, the tension between production and safety is internalised in this individual. This section proposes a set of reporting arrangements to deal with this problem, drawing on insights from other industries (Hopkins 2019). Again, the proposal here goes beyond the Standard.

Specifically, it is proposed that the RTFE should have dual reporting lines: a primary line that culminates with the Accountable Executive and a secondary reporting line to the local site manager. Provided the company maintains this primary/secondary distinction this will ensure that safety and facility integrity take precedence over production. In terms of organisational charts, this can be represented as a solid reporting line that culminates with the Accountable Executive and a dotted reporting line to the site manager (see Figure 1 below). Note that this is the reverse of the more common situation where the primary reporting line is within the business unit, with a dotted line to an external technical specialist at corporate level. The arrangement described here protects the RTFE from undue commercial pressures from mine management which might otherwise result in decisions that are undesirable from a safety point of view. Of course, there will need to be coordination between the immediate supervisor in the business unit and the supervisor in the line to the Accountable Executive, but these matters are not difficult to resolve.

The critical feature of this organisational design is that the RTFE has a performance agreement with a supervisor in the line reporting to the Accountable Executive. This agreement will naturally give priority to safety. The annual performance assessment of the RTFE will be based on this performance agreement.

There are many examples of companies in hazardous industries operating with a dual reporting structure of the type described here. An outstanding example is BP, as it was re-organised after the Gulf of Mexico blowout in 2010. BP's engineers report primarily up an engineering line that culminates several steps above site level in a global head (although not one answering directly to the CEO). Moreover, BP has a Safety and Operational Risk function with a head answering to the CEO and with staff embedded in local business units, both providing risk management services and ensuring compliance. This approach seems less common in the mining industry, but arguably disasters such as the Brumadinho tailings dam failure in Brazil in 2019 will drive the industry in this direction. The company responsible for the Brumadinho failure, Vale, has already implemented some of these ideas. (Nasdaq 2020)

The co-convenors of the Standard raised the following questions:

- How can company tailings experts be more 'empowered through internal governance structures…'?
- What changes should be considered to enable significant risks relating to tailings storage facilities to be elevated to senior management, e.g. Executive Committee level?

The structure proposed here responds directly to those questions.

5. APPROPRIATE FINANCIAL INCENTIVES

Many commercial organisations pay their staff bonuses (incentive payments). These bonuses are largely determined by the organisation's overall commercial success, as a well as the individual's contribution to that success. This is problematic from a risk management point of view, but in different ways for different types of employee. Two types of employee are singled out here: first, employees whose primary task is risk control, particularly in relation to major accident risks; and second, employees whose major activity is production, albeit, safe production. The section concludes with some remarks about the performance bonuses paid to top executives.

Given the tension between short term profit maximisation and longer-term risk control, any system that incentivises commercial success is inappropriate for people whose primary task is risk control. This issue has been highlighted in the finance sector. Many banks now have a Chief Risk Officer (CRO) who is part of the executive team, answerable directly to the CEO. Reports into recent banking scandals demonstrate that the CRO in these cases had not carried out the responsibilities of the role effectively, because the incentive payments available to this Officer prioritised annual profit, rather than risk control. Here is a passage from a report into one Australian bank:

[T]he CRO's …. remuneration mix is not materially different to that of the business unit Group Executives. Industry practice for CRO remuneration arrangements varies, with CROs at some other banks having a quite different … remuneration mix than their executive colleagues, typically with a higher weighting on fixed remuneration aimed at safeguarding the independence of this critical function. (Australian Prudential Regulation Authority [APRA] 2018a, p.78).[3]

This principle extends to anyone engaged primarily in risk control. A much-quoted guidance document for the finance sector in the UK gives the following advice:

Staff engaged in financial and risk control should be compensated in a manner that is independent of the business areas they oversee and commensurate with their key role in the firm. (UK Financial Stability Forum 2009, p.7)

These ideas are equally applicable to the management of major accident risk in the mining sector. Following the Brumadinho disaster, an independent report found that bonuses of employees in the geo-technical area overseeing dam safety were linked almost exclusively to financial targets with safety goals representing a small portion of compensation metrics. Vale subsequently changed its compensation practices to give greater weight to safety, implicitly acknowledging the role incentive payments had played in the disaster (Nasdaq 2020).

The direct implication here is that neither the Accountable Executive nor the staff in that function should be incentivised in relation to production, profit or cost reduction. The simplest way to achieve this outcome is to pay them a fixed salary, augmented, if necessary, to compensate for the fact that they are not eligible for bonuses. Alternatively, if it is important to pay them bonuses, they can be incentivised on the basis of how well they perform in relation to their job specification or performance agreement. This can be based on judgements made by a supervisor at the time of a performance review. These conclusions apply also to the RTFE, whose primary reporting line culminates in the Accountable Executive.

For employees whose primary role is to contribute to production or cost reduction, albeit safely, the implications are different. Presumably, the major component of their bonuses will be based on

3. See also APRA 2018b, p.18.

production and cost reduction, but there should also be a component based on safety or integrity. However, it is a mistake to base this component on quantitative metrics such as injury rates. This leads almost inevitably to attempts to manage the metric, rather than the risk. For example, the primary effect of using injury rates as a basis for safety bonuses is to suppress reporting. This problem can be overcome if bonuses are based on qualitative judgements about the employee's contribution to safety and operational integrity. It will be up to the employee to make this case during performance reviews. This will provide a strong incentive for employees to take these matters into account.

One of the most effective ways that production-oriented employees can also contribute to safety is by reporting problems that they become aware of in their normal duties. Companies should incentivise such reporting. They need not reward people each and every time they speak up, as this runs the risk of generating a large number of trivial reports. Rather, they should offer periodic rewards or awards for the best or most helpful reports at each site. That will encourage the reporting of whatever it is that the site management finds most helpful. Award winners should be publicly recognised, preferably with a material reward, and with a clear explanation of how their contribution resulted in safer facility management. (For a more extensive discussion of how this works, see Hopkins 2019, pp. 127-135.)

Most discussions of the effect of bonuses on safety ignore the issue of long-term bonuses. The top office holders of large public companies – for example, the CEO and the Chief Financial Officer – are often paid very large long-term bonuses. These are awarded provisionally and are actually paid (vest) some years later (typically three years), depending on company profit in the intervening period. They do not depend in any way on the safety performance of the company during this period (except in the unlikely event that the safety performance is so bad that it affects the share price). They therefore operate as an incentive for top office holders to focus single-mindedly on shareholder returns.

This problem is well understood in the banking industry. Nowadays it is commonplace in the UK banking sector for long term bonuses to include consideration of non-financial performance (APRA 2019, p.32). In Australia, the regulator is proposing to limit to 50 per cent the contribution of financial metrics to such bonuses (APRA 2019, p31). The remaining 50 per cent would be made up of considerations such as: effectiveness and operation of control and compliance; customer outcomes; market integrity objectives; and reputation.

In the mining industry, the relevant non-financial considerations would include how well the company was managing catastrophic risk. It is recommended that long term bonuses in this industry be modified to take account of major accident risk. This is not a simple matter and companies will need to be innovative to implement this recommendation. It will be important that they are transparent about how they do this.

The scoping document for the development of the Standard invited the Expert Panel to address the question: 'What are the cultural, behavioural and *incentive* barriers within companies that block better management of TSFs?' (emphasis added). The preceding discussion is in part an answer to that question.

6. CONCLUDING OBSERVATIONS

The root causes of major accidents, in particular tailings facility failures, are to be found at the level of governance and management. Best practice requires that boards be held effectively accountable to their shareholders in these matters. This requires a company to set up an organisational structure for the management of risk that is as independent as possible from the company's business units. This risk management structure should be headed by an executive who reports to the CEO but who is also accountable to the board. Care must be taken to ensure that, where bonuses are paid, they do not undermine these arrangements.

The ideas proposed here are in principle accepted in the banking industry and increasingly in other industries. The Standard is a step in this direction, but it does not go as far as the recommendations made here. Fortunately, there is nothing to stop mining companies implementing these governance arrangements now. Some are already ahead of the Standard in this respect. Conceivably, some of these ideas will be adopted in future revisions the Standard.

KEY MESSAGES

1. Accident analysis should always seek to identify the organisational causes of the accident.
2. Shareholders should hold boards accountable for the on-going management of major accident risks.
3. Boards should ensure that at least one of their members has expertise in the relevant major accident risks and is able to advise the board on the status of major accident risk management within the organisation and of the implications of board decisions for major accident risk.
4. Mining companies should have an executive responsible for major accident risk (an Accountable Executive) answering directly to the CEO. This executive should also have a direct reporting line to the board and should be held to account by the board.
5. Where a major part of an employee's role is to ensure compliance with standards and procedures, as is the case for the responsible tailings facility engineer, the employee should have dual reporting lines: a primary line that culminates with the Accountable Executive and a secondary line to the local site manager. Any performance review should be carried out by a supervisor in the line reporting to the Accountable Executive.
6. Neither the Accountable Executive, nor staff in lines reporting to that position should be incentivised in relation to production, profit or cost reduction. This applies, in particular, to the Responsible Tailings Facility Engineer (RTFE).
7. For employees whose primary role is to contribute to production, albeit safely, any bonuses paid should have a component for safety or facility integrity. This should not be based on quantitative metrics but on qualitative judgements about the employee's contribution to safety and operational integrity. It will be up to employees to make this case during performance reviews.
8. Companies should incentivise the reporting of issues relating to major accident risk.
9. Long term bonuses that vest after a period of years should be modified to take account of how well major accident risk is managed.

REFERENCES

APRA (2018a). *Prudential Inquiry into the Commonwealth Bank of Australia (CBA) Final Report*. Sydney: Australian Prudential Regulation Authority. https://www.apra.gov.au/sites/default/files/CBA-Prudential-Inquiry_Final-Report_30042018.pdf

APRA (2018b). *Remuneration Practices at Large Financial Institutions.* Sydney: Australian Prudential Regulatory Authority. https://www.apra.gov.au/sites/default/files/180328-Information-Paper-Remuneration-Practices.pdf

APRA (2019). *Discussion Paper: Strengthening Prudential Requirements for Remuneration.* Sydney: Australian Prudential Regulatory Authority. https://www.apra.gov.au/sites/default/files/discussion_paper_strengthening_prudential_requirements_for_remuneration_july_2019_v1.pdf

British Columbia Chief Inspector of Mines (2015). *Mount Polley Mine Tailings Storage Facility Breach, August 2014.* Ministry of Mines and Energy. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/mineral-exploration-mining/documents/directives-alerts-incidents/chief-inspector-s-report-page/m-200_mount_polley_2015-11-30_ci_investigation_report.pdf

Hopkins, A. (2012). *Disastrous Decisions: The Human and Organizational Causes of the Gulf of Mexico Blowout*. Sydney: CCH.

Hopkins, A., (2019). *Organising for Safety: How Structure Creates Culture*. Sydney: CCH.

ICOLD (2017). *Dam Safety Management: Operational Phase of the Dam Life Cycle, Bulletin* #154. Paris: International Commission on Large Dams. http://www.ussdams.org/wp-content/uploads/2016/04/B154.pdf

Keay, AR. and Loughrey, J. (2015). The framework for board accountability in corporate governance. *Legal Studies*, 35 (2), 252-279.

Nasdaq (2020). 'Brazil's Vale dam disaster report highlights governance shortcomings'. https://www.nasdaq.com/articles/brazils-vale-dam-disaster-report-highlights-governance-shortcomings-2020-02-21

MAC (2019). *A Guide to the Management of Tailings Facilities Version 3*, Ottawa: Mining Association of Canada. https://mining.ca/documents/a-guide-to-the-management-of-tailings-facilities-version-3-1-2019/

UK Financial Stability Forum (2009). *FSF Principles for Sound Compensation Practice.* https://www.fsb.org/wp-content/uploads/r_0904b.pdf

UK Health and Safety Executive (n.d.) *PSLG Principles of Process Safety Leadership,* UK HSE. https://www.hse.gov.uk/comah/buncefield/pslgprinciples.pdf

Useem, J., (2019). 'The long-forgotten flight that sent Boeing off course: A company once driven by engineers became driven by finance.' *The Atlantic*, November 20. https://www.theatlantic.com/ideas/archive/2019/11/how-boeing-lost-its-bearings/602188/

CHAPTER XI
CREATING AND RETAINING KNOWLEDGE AND EXPERTISE

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1. INTRODUCTION

Recent investigations into significant failures of tailings facilities have not revealed previously unknown failure modes or required new and detailed technical research to be undertaken to understand why the failures occurred. Instead, commonly known and well understood mechanisms have been identified as the main physical triggers for failure. In seeking to explain why these triggers were activated, investigations have highlighted an overall governance challenge which has included deficiencies in management systems, poor decision-making processes, breakdowns in communication, and the lack of effective review and monitoring processes. These shortcomings have involved and impacted on the industry and its stakeholders, including local communities, owners/operators and regulators.

Such findings strongly suggest that the main challenge facing the mining industry in this area is not a lack of technical knowledge about the behaviour of tailings facilities: this information is already available if people know how to access and apply it. Rather, the main challenge is one of ensuring that all those involved in the design, construction, management, monitoring, review and regulation of individual facilities possess the requisite knowledge and expertise to make informed decisions across the full operations lifecycle from design to decommissioning.

Our assessment is that there is currently a relatively small group of specialists working in industry, consultancies, regulatory teams and as independent reviewers who possess deep technical capability in this area. Thereafter, there is a rapid fall-off of knowledge and expertise amongst operational management and other key actors such as regulators. Access to suitable education and training programmes and expertise is unevenly distributed around the globe and there is only limited capability in the area of tailings governance (defined broadly to encompass both internal organisational governance and regulation and oversight by the state).

If we accept the proposition that there are indeed significant shortcomings in knowledge management around tailings, then several questions emerge:

1. What depth of knowledge is required by different actors who have key roles to play in the governance processes relating to tailings facilities – including owners/operators, and government and community organisations?
2. How well do current education and training programmes prepare graduates and technical staff to work in roles related to the design and management of tailings facilities?
3. What are the best educational approaches for ensuring that all stakeholders, including those from outside companies, are able to develop their knowledge of tailings facilities to the level they require?
4. What resources will be required – and how long will it take – to build and sustain the necessary capacity across all relevant actors, including in critical functional areas in owners/operators and consultancies/reviewers?

Our aim in this chapter is to briefly explore these questions, and to identify priority focus areas. While we will use examples to illustrate existing approaches and initiatives, the chapter does not pretend to present a comprehensive inventory of all current education initiatives addressing tailings management.

We note that the primary focus of the Global Tailings Review (GTR), the Global Industry Standard on Tailings Management ('the Standard) and other recent initiatives such as the International Council on Mining and Metals (ICMM) forthcoming International Guide to Tailings Management is the prevention of catastrophic failures of tailings facilities. However, there are other important aspects of tailings management which should also be addressed in the design and management of tailings facilities. These include avoiding or minimising social dislocation and adverse environmental impacts (e.g. dust, groundwater contamination), and these aspects should likewise be a focus of education and knowledge management initiatives.

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2. TAILINGS KNOWLEDGE – WHO, WHAT, AND WHEN?

Consideration of matters related to tailings commences at the point when a mining project is conceptualised and continues through to post-closure. During this time, a range of key actors (see below) will engage with information and decisions relating to the tailings facility, its risks and impacts. These actors will come from a variety of disciplinary backgrounds, and will invariably have different levels of knowledge of – and experience in – the design and management of tailings facilities.

2.1 INTERNAL COMPANY PROJECT TEAMS

These teams are formed to carry a mining project through the development and construction phases. It will be relatively rare for company personnel involved at the front-end of projects to continue through to operational roles at the mine.

Once a mineral resource has been confirmed, owners will usually conduct multiple studies, starting with an order-of-magnitude assessment of project viability, and then progressing through to a full 'bankable' feasibility study. Options for tailings treatment and storage will be considered from an early stage, and there will – or should – be communications with regulators and the community throughout this process. Internal knowledge will usually be supplemented by external expertise, with specialist consultants either embedded in teams or conducting options studies as independent operators.

The physical engineering aspects of different options and locations will figure prominently in these analyses, with input being provided from professionals with geology, mining and mineral processing expertise. Other critical, non-technical, considerations will also influence the final design decision, such as whether an option will necessitate displacement of communities from the proposed site for the dam and/or immediate downstream locations, or otherwise have a significant impact on local livelihoods. Environmental impacts will also be a key determining factor in design choices, particularly with respect to hydrological impacts.

2.2 CORPORATE TAILINGS SPECIALISTS

In recent years, the increased focus on tailings management and the broader challenges of mine closure have prompted several larger mining companies that control multiple sites to form internal teams of tailings specialists. Such teams mostly consist of just a few individuals, typically with a civil, geological/geotechnical or mining engineering background, although in some cases other science/engineering-based professionals may also occupy these roles. These individuals will usually have had direct experience of managing tailings facilities at different stages of the project lifecycle, and often in different global contexts.

2.3 SPECIALIST ENGINEERING CONSULTANTS

Some geotechnical and/or hydrotechnical consultancies, as well as some individual consultants, have developed a specific capability in tailings management. Several of these consultancies operate on a global basis. Specialist consultants will usually be involved in the design stages, including options studies and final design, and will often participate in reviews of design changes, expansions and closures as well. In many cases these specialists will also undertake quality assurance roles during facility construction, both at the startup stage and when significant changes are made to the facility, such as progressive raises of the tailings dam wall.

Often consultancies will provide owner/operators with the services of the 'Engineer of Record', who is the designated individual responsible for signing off on all designs. The Mining Association of Canada's Guide for Tailings Management (2019) is a widely used document defining the attributes for this role in relation to tailings facilities.

The dominant discipline amongst specialists in this area is geological engineering/civil engineering, with some individuals also likely to have specialised in geotechnical engineering

2.4 OWNER/OPERATOR MANAGEMENTS TEAMS

During the operational phase of a mine, responsibility for the management of a tailings facility will often fall to the Processing Plant Manager, who is usually under the direct supervision of the mine's General Manager. The Plant Manager is typically a professional with a mineral processing or chemical engineering background. Other functional roles, such as environmental and community relations personnel, are also likely to have responsibilities in regard to monitoring the performance of the facility and engaging with local stakeholders and/or regulators.

2.5 GOVERNMENT AUTHORITIES AND AGENCIES

Final mine designs, including plans for tailings facilities, must be approved by the relevant regulatory bodies. Depending on the jurisdiction, this could involve officials from local, regional and national authorities. Regulators also play a critical role in the ongoing governance of tailings facilities, undertaking a variety of inspection and auditing activities according to local regulations.

In many jurisdictions, mining engineering is the most common disciplinary background for mines inspectors. Particularly in emerging mining economies, personnel in regulatory oversight roles can find themselves working well outside their areas of core expertise. In Indonesia for example, the duties of mines encompass all safety, environmental and community-related issues, including the performance of tailings facilities.

It is generally rare to find a high level of expertise in tailings design and management within regulatory bodies, and it is common for them to rely on external advice when conducting design reviews. A particular challenge for regulatory agencies globally is attracting and retaining highly qualified experts in the face of better opportunities within the resources industry.

2.6 LOCAL COMMUNITIES AND AUTHORITIES

The knowledge held by local communities and authorities regarding tailings will vary greatly, depending on the prior extent of mining in the region, as well as the experience of specific community members. Where community members are part of the construction or mining workforce, they may also acquire some knowledge and information about the tailings facility, through both formal and informal processes.

The design and location of a tailings facility will often be one of the most significant decisions in a mining project from the perspective of local communities, given the nature and scale of such facilities, and the possible consequences of failure. Reducing the potential asymmetry of knowledge between communities and project proponents should therefore be a priority in early engagement with local stakeholders, for both owner/operators and regulators.

2.7 OWNER/OPERATOR BOARDS, INSURERS AND SHAREHOLDERS

These groups of actors can range across the spectrum from being very knowledgeable to completely unaware of tailings issues. Knowledge is mostly acquired from experience, rather than from specific educational programmes or training courses. Owner/operator boards often include senior mining professionals who are very familiar with the issues. Where the owner/operator employs a designated tailings specialist, all board members will more than likely get at least annual updates from the specialist. Increasingly, insurers are also engaging knowledgeable sources in industry for advice on tailings risks.

3. THE CURRENT TAILINGS EDUCATION LANDSCAPE

This section provides an overview of existing tailings education options and addresses opportunities and challenges. Currently, the main options available in this area are: a limited number of dedicated tertiary programmes; coverage of tailings as part of broader degrees; competency-based skills training focussed on supervisory and monitoring roles; and a range of professional development options offered outside the formal education system. At the same time, the global landscape for education is changing at a rapid pace, with several new initiatives offering alternatives which allow for greater flexibility and easier access to material.

3.1 TAILINGS-SPECIFIC TERTIARY QUALIFICATIONS

Formal qualifications that cover the topic of the design and management of tailings facilities in sufficient depth provide some assurance that individuals in key tailings-related roles in industry, professional services and government have the requisite knowledge to perform these roles.

Currently there are only a limited number of tertiary institutions around the world that offer courses in mine waste management directly related to tailings, and taught by qualified instructors who have practical experience in this field. Less than ten educational institutes offer post-graduate training and instruction by staff with salient experience, and these institutes are concentrated in just a few geographical regions.

A recent survey completed by 33 Universities, undertaken as part of the consultation process for a Global Tailings Consortium, identified only two programmes that were explicitly focussed on tailings management: one delivered by the University of British Columbia and the other by the University of Chile (Box 1). Another six thematic programmes included substantive content related to tailings. It should be noted, however, that, several institutions are currently at various stages of implementing additional postgraduate programmes in this area, so the situation may improve over the next few years.

Box 1: Example of a specialist tertiary qualification relating to tailings

The University of Chile currently offers a Diploma in Tailings Engineering, a three-month programme designed for engineers and geologists working in the sector to improve knowledge regarding the design, construction, operation, and closure of tailings facilities. The Diploma covers eight topics:

1. Introduction to Tailings Engineering
2. Earthquake and Geological risks
3. Geotechnical Elements of Design, Construction, and Operation
4. Environmental and Social Impact
5. Geotechnical and Chemical Instrumentation and Monitoring
6. Water Recovery, Management, and Disposal of Tailings
7. Management and Governance
8. Group Project

Source: https://portaluchile.uchile.cl/cursos/155096/diplomado-ingenieria-de-relaves

3.2 COVERAGE OF TAILINGS IN RELEVANT ENGINEERING DEGREES

The most common disciplinary background for specialists working in the field of tailings design is a Civil Engineering or Geological Engineering degree. These fields of study will normally include the fundamentals of soil mechanics, liquefaction, hydrology and fluid mechanics. While the mining context and specifics of tailings dams may not be addressed in depth, the principles of earthworks and generic dam construction and operation are usually covered.

Mining engineering and mineral processing degrees generally provide some coverage of issues associated with tailings, but this is usually done at a relatively broad level. For example, mining engineering students would normally study the principles of soil mechanics but would not be expected to analyse a tailings dam construction in detail. There are a small number of mining programmes globally that include a specific course on Mine Waste Management, for example one taught at the University of British Columbia.

The pragmatic managerial and technical challenges facing actual facilities – challenges that have been cited over and over as the leading causes for the catastrophic failures that have occurred – rarely receive much coverage in the university environment. While a basic theoretical understanding of the design and management of tailings facilities is clearly essential, it is also very important that university training programmes related to mine tailings incorporate a strong practical component and draw on experience and learnings from case studies of failures.

The challenge for educators is to find ways of raising the profile of tailings management within existing degrees without crowding out other important topics from the curriculum or attempting to turn civil or geotechnical engineers into mining engineers, and vice versa. One possible approach is to incorporate a tailings focus into established subjects that deal with cross-cutting topics such as mine planning, mine management and project evaluation. An example is a common final year Mine Feasibility Project subject delivered by several Australian universities, which includes the requirement for students to plan, design and cost a tailings facility as part of an overall feasibility study of a hypothetical mine project.

3.3 DAM AND TAILINGS-RELATED OPERATIONAL QUALIFICATIONS

At the Vocational Educational and Training (VET) level, there are isolated examples of specific qualifications designed to address the need to build competency in supervision and monitoring of tailings dams, and of dam structures more generally. For example, in Australia a specific competency unit was developed as part of the formal Mining Industry Skills Framework and is now included in the current Diploma of Process Plant Technology qualification (see Box 2).

Box 2: Example of a VET-level unit on tailings management

PMAOPS560 Plan and design tailings management facilities

'This unit of competency applies to health, safety and environment (HSE) managers/officers, frontline managers, site managers/officers or those in similar roles who are required to develop risk identification and management strategies (business and environmental) and scope and design tailings disposal management systems and facilities.'

Source: https://training.gov.au/Training/Details/PMAOPS560

Overall, however, qualifications which focus on the operational governance aspects of tailings facilities do not appear to be widely available, or to enjoy high levels of support.

3.4 PROFESSIONAL DEVELOPMENT IN TAILINGS MANAGEMENT

Currently, short courses offered as professional development activities by universities, consultancies and individual experts are the most visible mechanism in the mining sector for transferring knowledge about different aspects of tailings management (for an example, see Box 3.) These courses, which vary in scope and target audience, typically run for 3-5 days and are usually delivered in a face-to-face workshop format. Such courses are not normally accredited, but they probably have the best global coverage and the highest participation rates of any of the education and training initiatives discussed here.

Box 3: Example of an online short course on tailings management

Edumine online training course on Tailings Facility Design, Operation, and Closure

The online provider Edumine is based in Canada, but with a global reach. The total duration is of this course is 19 hours. According to the course description:

'The course covers tailings as part of the mining process, tailings types and characteristics, tailings facility types and components, and tailings facility design, performance, construction, operation and closure... illustrated by case histories.

This course is for anyone involved in the different aspects of tailings listed above, including engineers, environmentalists, geologists, operators and regulators.'

Source: https://learn.edumine.com/store/690638-tailings-facility-design-operation-and-closure

3.5 CROSS-CUTTING THEMES IN TAILINGS EDUCATION

Several cross-cutting themes have emerged in recent discussions on tailings education and engineering curricula more broadly. These themes are often closely linked. Together, they highlight the need to ensure that a broad disciplinary paradigm is applied when designing tailings facilities. Here we focus on three thematic areas in particular: risk management, economic valuation, and socio-economic impact analysis.

Risk management is the key framework applied in the mining industry (by both owners/operators and regulators) to understand and assess the likelihood and consequences of failures, and to minimise both from the design stage onwards. The new Global Industry Standard on Tailings Management is firmly embedded in this approach. Risk management is also the basis of safety legislation in many jurisdictions around the world.

Training in risk assessment is commonplace at all levels in the mining industry and is also introduced early in the curricula of most engineering programmes. However, confusion persists amongst both internal and external actors about how the concept of risk should be applied and interpreted, including in relation to tailings facilities. This is a strong reason for ensuring that risk management concepts and risk analysis techniques are explicitly addressed in all education initiatives in this area.

A less prominent but equally important cross-cutting theme is economic valuation, particularly with respect to decision-making regarding tailings facilities and technology options. The dominant approach to economic analysis in the industry – and in most engineering education programmes – remains Discounted Cash Flow or Net Present Value (NPV) financial analysis. It is now well-documented that this approach is not well-suited to dealing with issues of long-term liability, or with low risk but significant consequence events. This is because the high discount rates often adopted for mining projects result in a focus on short term outcomes at the expense of longer-term considerations.

As discussed earlier, understanding the potential socio-environmental impacts of tailings dams through the lifecycle is also critical, as is consideration of the direct social consequences of dam failure. Knowledge of the local social context is likewise crucial when it comes to emergency preparedness. All of those involved in tailings management need to understand these aspects at a basic level (at least) and be prepared to ask relevant questions of specialists engaged to work in these areas.

Most modern engineering curricula currently identify a set of graduate attributes that include such elements as systems thinking capability, the ability to communicate horizontally and vertically within organisations, and the ability to work in multi-disciplinary teams. These are increasingly being designed into assessment activities for courses. Developing these attributes should also better equip graduates to engage with the significant governance challenges associated with tailings management, particularly when combined with other initiatives discussed here.

3.6 NEW CHANNELS FOR EDUCATION

In recent years there have been several significant changes in the education landscape. One change of particular relevance to this chapter has been the emergence of new online platforms providing free – or low cost – globally-accessible content. Various universities around the world have formed international consortia to establish and support these platforms and are also developing suites of new 'micro-credential' offerings in many disciplines. These offerings typically take the form of individual modules which can be taken on a stand-alone basis, combined with other modules to form a subject, or aggregated into certificates or even diplomas. In contrast to conventional qualifications, micro-credentials are designed for flexibility and mobility, providing recipients with highly transferrable pathways to future studies, upskilling, recognition of prior learning and/or continued professional learning. Many observers have noted the trend towards alternative credentials, and several countries have introduced enabling policies for micro-credentials linked to national Qualifications Frameworks.

Until recently, mining education providers at the tertiary level have not shown a strong interest in online delivery of content at scale, or the development of micro-credentials. However, there are indications that this situation is rapidly changing, in response to shifting market conditions and the high costs associated with traditional teaching methods. By developing flexible and globally available material, education providers can significantly increase their reach while potentially lowering the cost of delivery. One of the benefits of this new model is that it could help to overcome the uneven geographic distribution of expertise and the knowledge asymmetries that we have previously referred to.

3.7 TEACHING CAPACITY

As noted above, practical knowledge of tailings design and management is a critical – but often missing – element of current curricula. However, finding capable and experienced people to teach this material is becoming increasingly difficult. In many jurisdictions, universities now rely heavily on indicators of research excellence and associated outputs (such as publications and grants) as key criteria for the selection and promotion of academic staff. This is sometimes at the expense of valuing practical experience, which in turn can hinder the recruitment of teaching personnel with predominantly industry backgrounds. At the relatively small number of universities that currently offer tailings-specific programmes or courses, several prominent faculty staff are nearing the end of their teaching careers without clear succession plans being in place. This is a critical issue for universities to address.

4. INDUSTRY NETWORKS, RESOURCES AND COMMUNITIES OF PRACTICE

Industry and professional networks, and communities of practice, play a valuable role in sharing knowledge amongst practitioners and keeping them informed about new developments. These less formal and often voluntary processes are particularly important in the field of tailings practice, given the relatively small number of specialists in the area. We discuss some examples below.

4.1 INTERNAL COMPANY KNOWLEDGE SHARING

As mentioned earlier, larger companies which operate multiple sites will often invest resources in creating an internal 'community of practice' led by experienced tailings specialists. Such individuals are playing an increasingly critical role in internal knowledge management relating to the organisation's portfolio of tailings facilities, including by providing internal training and leading the development and implementation of corporate policy and guidance documents. Increasingly, specialists from different companies are sharing knowledge amongst each other and/or offering their experience and knowledge to support global efforts, including by contributing to guidance documents and conferences.

4.2 NATIONAL AND INTERNATIONAL INDUSTRY ASSOCIATIONS AND GUIDANCE RESOURCES

At the collective level, national industry associations have played a key role in mobilising industry expertise and producing guidance documents. Examples include: The Mining Association of Canada's (MAC) *Guide to Tailings Management* (see Box 4), the Australian National Committee on Large Dams (ANCOLD) *Guidelines* and the South African National Standard (SANS) 10286:1998 *Code of Practice*. These and related guidance documents have often formed the basis of short courses. They generally have a strong focus on governance, in recognition that tailings facilities are complex engineered facilities that must be managed appropriately over long periods of time, often in perpetuity. (See Golder Associates [2016] for a helpful review of the various guidance documents in this area.).

Box 4: An industry-wide knowledge-sharing initiative from Canada

The initial version of MAC's *Guide to Tailings Management* was published in 1998 and the *Operation, Maintenance* and *Surveillance Manual for Tailings and Water Management Facilities (the OMS Guide)* in 2003. Both documents have been regularly updated since and are widely utilised in the global mining industry. The 2018/19 updates are available in several languages. The OMS Guide is particularly relevant to the practical operational governance aspects highlighted in this chapter.

4.3 INDUSTRY CONFERENCES AND EVENTS

There are several national and international conference events that bring together industry and government representatives to share the latest knowledge on tailings. Box 5 provides an example.

Box 5: Annual Tailings and Mine Waste Conference

Tailings & Mine Waste is an international annual conference started in the late 1970s through the Colorado State University (CSU) (Fort Collins), which has evolved to be a rotating event organised by CSU, the University of Alberta and UBC and offered at Canadian and United States venues. In 2019, the conference was held in Vancouver and saw a record of more than 800 delegates attend over four days of podium, poster presentations and other activities. Several short courses were also held as part of the overall programme.

These types of events are usually convened by professional associations working closely with industry groups and sponsors. They typically feature short courses and side events that encourage knowledge sharing and network development.

4.4 INTERNATIONAL CAPACITY BUILDING INITIATIVES

Over the last 30 plus years, various initiatives have been undertaken to improve the governance of mining activities in emerging resource economies. This work has been funded and co-ordinated by what can be broadly termed the 'international development' sector, comprising a mix of multilateral bodies (e.g. The World Bank) overseas aid programmes of

national governments (e.g. The German Corporation for International Cooperation [GIZ], and the Canadian International Development Agency) and donor bodies (e.g. the Open Society Foundation). Capacity building activities undertaken by these bodies have included providing technical assistance to governments, developing guidance materials, convening conferences and workshops, and delivering or sponsoring training programmes. The main target groups for these initiatives have typically been government officials and, in some circumstances, civil society organisations and local educational institutions.

With good reason, the primary focus to date of these capacity building initiatives has been on legal frameworks and economic and fiscal issues, rather than on the more technical aspects of mining operations. However, there are a few examples of initiatives that have specifically focused on tailings management (see Box 6). Some organisations have also convened activities in related areas such as Mine Closure.

Box 6: A capacity building initiative for government personnel

The International Mining for Development Centre (IM4DC) was an initiative of the Australian Government which operated between 2011 and 2015. During these four years the Centre delivered five courses on the Management of Large Volume Waste, with a major focus on tailings. These courses were developed following ongoing requests from partner governments, and were led by experienced researchers from The University of Western Australia and The University of Queensland. The final two-week program was held in Baguio City in the Philippines. It was attended by 36 staff – predominantly Mines Inspectors – from the Mines and Geoscience Bureau and included site inspections at two nearby operations. Previous workshops had been held at partner Universities in Ghana and Zambia, targeted at government and academic participants.

Given the level of international concern about the safety of tailings facilities, the aid sector should be encouraged to undertake or support more initiatives to build regulatory and oversight capacity in this area. Entities that could potentially play a lead role here include the World Bank's Extractives Program, the Intergovernmental Forum on Mining Minerals, Metals and Sustainable Development (IGF) and the United Nations Environment Program (UNEP), as well as the national aid programmes of some countries. There are also opportunities for these various entities to exploit synergies in objectives, including by cross-promoting courses, running joint programmes and sharing course materials.

5. FUTURE DIRECTIONS AND PRIORITIES

We have argued in this chapter that knowledge and expertise regarding tailings management are limited and unevenly distributed, both geographically and between different actors (e.g. project proponents, consultants, regulators, local communities). The question of what should be included in the scope of tailings education also needs careful consideration. To address these and other issues, we suggest a focus on the following areas, all of them inter-related.

5.1 BROADENING THE FOCUS OF TAILINGS EDUCATION

A recurring theme in both this chapter and the GTR process has been the need to adopt a multi-disciplinary approach to the challenges of tailings management. In addition to dealing with the technical aspects of tailings, education and training programmes should be covering topics such as the socio-economic and environmental impacts of tailings facilities, and the application of appropriate economic and risk management frameworks in decision-making. Programmes should also aim to provide a balance between conventional tailings dam expertise and the application of alternative/emerging technologies.

5.2 DEVELOPING FORMAL QUALIFICATIONS IN TAILINGS DESIGN AND MANAGEMENT

Setting up dedicated postgraduate programmes that address tailings design and management will provide an incentive for individuals to specialise in this area, rather than tailings-related work just being seen as a 'tour of duty' within a more general career trajectory. An equally important aspect is therefore for the industry to establish career path options for those specialising in this area, and to support such programmes by ensuring that a critical mass of enrolments can be sustained.

Consideration should also be given to establishing appropriate certification processes for professionals in supervisory roles. One of the requirements for certification could be completion of a diploma or similar level course that focuses on operational and monitoring activities.

Wherever possible, courses designed for people already in the workforce should be taught in flexible and accessible modes to broaden their reach: for example, allowing the course to be taken on-line and/or on a part-time basis.

5.3 INCREASING EMPHASIS AND CONTENT IN RELEVANT DEGREES

Many industry personnel who occupy senior operational management roles with responsibility for tailings facilities are likely to have had only limited exposure to key principles of tailings management in their university courses. Looking to the future, universities have a responsibility to ensure that this critical aspect of mining operations is adequately addressed in the undergraduate curricula for mining engineering and processing degrees, and that teaching content includes relevant and recent case studies.

The linkages between design and operational decisions taken across the mine lifecycle and the performance of tailings facilities should also be emphasised. It is noteworthy that the survey of experts conducted by Morrison et al (2017) identified verification of tailings characteristics over the life of the facility as their number one concern – an issue closely linked to mining and processing operational management practice.

5.4 LEARNING FROM EXPERIENCE

Tragedies such as the recent tailings dam failures in Brazil offer important lessons which should be shared. Storytelling is a valuable form of knowledge transfer, both within organisations and more broadly in the public domain. Sharing information about failures, as well as successes, also helps to promote a learning (as opposed to blaming) culture within and between organisations.

There are several examples of powerful fact-based case histories that have been used in educational settings. One such case is a video describing the fatal air-blast incident at the Northparkes block caving operation in Australia (Minerals Industry Safety and Health Centre and Rio Tinto 2005). This was funded by the then mine owner Rio Tinto and was made publicly available in order to disseminate the lessons learned across the industry.

5.5 STRENGTHENING KNOWLEDGE NETWORKS

As discussed in the previous section, existing professional and industry networks play an important role in disseminating knowledge about industry developments, new technologies and innovations in tailings management. In our view, creation of a more formal alliance of key stakeholders would provide an additional mechanism for disseminating knowledge and promoting good practice. This alliance could include mining companies, universities, regulators and other stakeholders. A key focus of such an alliance should be on developing and disseminating public domain educational resources, designed to suit a range of different stakeholder groups according to need. This would also assist in reducing geographical disparities in the distribution of knowledge and expertise and asymmetries between different actors. A model for such a network is described elsewhere in this report (Franks, Littleboy and Williams, this volume).

5.6 HUMAN CAPITAL

An immediate challenge in progressing several of the initiatives proposed in this chapter is the shortage of educators with appropriate levels of competence and background experience. As flagged earlier, only a small number of educational institutions offer specialist expertise in tailings, and there are significant gaps in global coverage. One way to grow the pool of qualified educators in this area would be for the University sector and industry to work together to improve exchange of knowledge and experience through short term secondments or placements.

Enrolments in mining-related programmes are declining in most parts of the world. When coupled with a generally negative view of the sector in the wider society, this is reducing the potential pool of future tailings specialists. Support must be provided to encourage bright young people to become the tailings stewards of the future, taking up the design, operational, regulatory or civil society roles that will all be critical to meeting the target of zero failures.

6. CONCLUSION

In this chapter we have reviewed the existing landscape of education and knowledge management activities that relate to the design and management of tailings facilities. We have argued that there are geographical and organisational disparities in the current distribution of expertise in this area, and have identified gaps in coverage of important topics, particularly in the area of governance. Good design and management of tailings facilities requires access to capable professionals from diverse disciplines who are able to work together. However, at present there is a shortage of professionals who have the requisite expertise and knowledge required to undertake these roles effectively. Current industry knowledge sharing activities are designed to promote good practice in this area, but tend to be inward-looking and are not necessarily increasing the broader distribution of expertise.

Going forward, a collaborative approach will be essential for addressing the issues raised in this chapter, as no single stakeholder group can achieve the changes required on their own. It is beyond our scope to suggest specific implementation pathways. However, it is clear that improving the way in which we manage and apply existing knowledge, including through the integration of knowledge from different disciplinary domains, will be key to preventing further catastrophic tailings dam failures.

KEY MESSAGES

1. Technical expertise in the design and management of tailings facilities is unevenly distributed across the globe, as is access to relevant education programmes.
2. There is a need to go beyond a narrow engineering design focus and embed a multi-disciplinary approach within tailings-related education.
3. The ability to understand and apply Risk Management frameworks is a critical capability for tailings governance and needs to be explicitly addressed in education initiatives.
4. It is essential that all education and training programmes related to mine tailings, including university courses, have a strong practical as well as theoretical focus, and draw on experience and learning from case studies of failures.
5. At a time of increased concern regarding the management of tailings facilities, our ability to educate specialists and those charged with managing such facilities is limited by a shortage of qualified and experienced educators.
6. Globally, there are very few programmes that address the operational governance aspects of tailings facilities. The international development sector should be encouraged to support the development and deployment of such programmes in countries that cannot easily access this expertise.

REFERENCES

Golder Associates (2016). *Review of Tailings Management Guidelines and Recommendations for Improvement.* https://www.icmm.com/tailings-report

MAC (2019). *A Guide to the Management of Tailings Facilities Version 3.1.* Ottawa: Mining Association of Canada. https://mining.ca/our-focus/tailings-management/tailings-guide/

Minerals Industry Safety and Health Centre and Rio Tinto (2005). *Managing major hazards in the mining industry*. video presentation. Available at: https://www.youtube.com/watch?v=Qni0NhxWS3Y

Morrison K. et al. (2017). *What does it mean to be the Engineer of Record (EoR) for a Tailings Storage Facility (TSF).* http://knightpiesold.com/en/news/publications/what-does-it-mean-to-be-the-engineer-of-record-eor-for-a-tailings-storage-facility-tsf/

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THE GOVERNANCE DIMENSION

CHAPTER XII
THE ROLE OF THE STATE

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1. INTRODUCTION

This chapter focuses on the crucial role of the State[1] in ensuring the safe design, construction, operation and closure of tailings facilities. The roll-out of the Global Industry Standard on Tailings Management ('the Standard') is expected to make a significant contribution to improving the management of tailings facilities in the sector. However, the best standards in the world, whether mandated by local law or adopted voluntarily, as with the Standard, will not prevent catastrophic tailings facility failures unless those standards are scrupulously followed and unless noncompliance results in significant consequences for the violator. Monitoring compliance and carrying out enforcement is primarily the domain of the State, as it alone has the authority to set and enforce sector-wide minimum standards and to ensure that corrective action is taken where Operators (as defined in the Standard) fall short. States must therefore be prepared and equipped to embrace this responsibility fully.

The chapter focuses on four related questions:

1. What responsibilities does the State have in relation to tailings facilities and what does good regulatory practice in these areas entail?
2. How can States manage the interface between their own regulatory processes and the requirements of the Standard to avoid unnecessary duplication and overlap and achieve better regulatory outcomes?
3. What factors currently limit the ability of States to provide effective regulation and oversight of tailings facilities, and how can these capacity constraints be overcome?
4. What roles can other actors (investors, insurers, local communities and civil society) play in ensuring the long-term success of tailings facility management?

1. The Standard includes the 'State' within the broad category of public sector agencies. The Standard defines that term to include '[a]ll governmental agencies at the State, regional, and/or local level with some responsibility or authority for regulating mining activities that occur within or impact their jurisdictions.'

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Box 1: How the Standard can contribute to better regulatory practices

The Standard focuses specifically on the obligations of Operators and does not address the roles and responsibilities of the State, except where a state entity is itself the Operator of a facility. But the Standard also does not seek to circumvent or override the State, as the preamble to the Standard makes clear.

Conformance with the Standard does not displace the requirements of any specific national, state or local governmental statutes, laws, regulations, ordinances, or other government directives.

Although the Standard does not – and cannot – impose any obligations on States, it should serve as a valuable source of guidance to regulators about what constitutes good practice in tailings management and what can reasonably be required of Operators. Also, if the Standard succeeds in improving management systems and controls in the mining industry, this will ease the burden on States and facilitate more effective State regulation, leading to a reduced risk of future catastrophic failures and better outcomes for affected people and the environment.

2. REGULATORY FUNCTIONS OF THE STATE

States generally have legislative and regulatory authority over tailings facilities and exercise that authority to varying degrees through statutes, regulations, and inspection and enforcement protocols. States are also uniquely situated to provide independent oversight of the permitting, construction, operation, maintenance, monitoring and closure of tailings facilities. They are likewise the most appropriate entities to hold performance bonds or similar financial assurance instruments and to implement independent inspection and enforcement programmes capable of identifying and remedying problems early.

This section addresses three particular areas where the State can and should play a prominent role: (1) the permitting (or licensing) of facilities; (2) financial assurance and insurance requirements; and (3) inspections and enforcement of regulated facilities. Each of these aspects is addressed in more detail below.

2.1 THE PERMIT APPLICATION PROCESS

The State bears the initial responsibility for obtaining information about any proposed or existing mining operation that is sufficiently comprehensive to allow the State to oversee and regulate the mine effectively. The Standard recognises this and requires the production of most or all of the information that the State will normally require of an Operator of a tailings facility.

Permitting of a tailings facility will likely happen in conjunction with permitting for the mine that is served by the tailings facility. Whatever the scope of the permit or licensing process, it should begin with a written application containing relevant information about the applicant, including details about its corporate relationships and mining history. Applications should also provide the State with basic information such as:

- details on mining methods, engineering techniques, and the equipment used or proposed
- the anticipated starting and termination dates of each phase of mining operation and number of acres of land to be affected
- a map describing the particular lands that will be affected by mining and when and how they will be affected.

States should also inquire about the compliance history of the owner or Operator of the mine in other jurisdictions and should deny permits to Operators who fail to demonstrate timely correction of significant violations at other mine sites. Ideally, States should establish a global data base for sharing compliance information so that the compliance history of individual companies and their affiliates can be readily ascertained. This data base should be designed and maintained by whatever entity is tasked with certifying/verifying compliance with the Standard and made accessible to State regulator and the public. In this way, violations by an Operator at another mine site can help inform the State about potential problems that might be encountered at the new site. The State might also insist that these violations be corrected before further processing of the application proceeds.

The Standard lays out much of what would be required for a good permit application. For example, the Standard anticipates that Operators will prepare a multi-criteria alternatives analysis and environmental and social impacts assessment for new facilities and a range of other plans and reports including Closure and Post-Closure Plans, Design Basis Reports, Dam Safety Reviews, Emergency Preparedness and Response Plans, Emergency Response Plans, Environmental and Social Management Systems, Operations, Maintenance and Surveillance Manuals, Trigger Response Action Plans, and Tailings Management Systems.

States must employ a knowledgeable, professional staff capable of reviewing the detailed design, construction, operation and monitoring plans submitted by the applicant. State officials may appropriately assist applicants in understanding the information that they require, but the actual review of the permit application should not commence until the State regulators are satisfied that the application is complete and ready for comprehensive review.

The State's permit review process must include a thorough and independent review of all reports and documents submitted by the applicant. This must be done by technical experts who can fairly assess the sufficiency of the reports provided. States will most likely request some changes to these documents during the review process, and the applicant may want to pursue modifications either in response to issues raised by the State or because of changes in the applicant's plans. Provided that these changes are not substantial and do not interfere with the meaningful engagement of interested parties, they should not cause a significant delay in processing the permit application.

The Standard requires Operators to undertake meaningful engagement with project- affected people on key decisions that affect them. The State is in a strong position to facilitate, and where appropriate, to supplement such engagement as necessary to give affected parties a real voice in decisions. For example, the State can help ensure that affected parties receive sufficient notice of proposed actions and that they have an adequate opportunity to make their views known. The State can also establish informal and formal processes, including site visits, as necessary, to educate affected parties and to ensure that engagement opportunities are truly meaningful.

Because aspects of the tailings facility site and its management will likely change in some significant ways over time, States should limit permits to a relatively short term of years – no more than every ten years – to allow for a periodic, holistic review of the facilities. States should use the renewal process to identify and demand appropriate changes to the operation or maintenance of the facility to reflect the information that the Operator and the State have learned during the course of facility operations. While changes, even significant ones, may be needed to the operation and maintenance of the facility, Operators should have the right to renew their permits so long as they have complied with the original permit terms and are prepared to make the required changes.

2.2 PERFORMANCE OBLIGATIONS : MANAGING THE INTERFACE BETWEEN REGULATORY PROCESSES AND THE STANDARD

The Standard lays out specific performance obligations and establishes monitoring protocols to ensure that these obligations are met. These provisions provide a blueprint for more general application by States.

States should work with the Operator and affected parties to agree on a set of performance obligations and clarify how compliance with these requirements will be achieved. So, for example, the State may require the Operator to perform progressive reclamation of a facility contemporaneous with mining to the fullest extent possible.[2] The State should also work with the Operator to ensure that monitoring data are accurate, transmitted to State officials in a timely manner, and made available promptly to the interested public.

In order to provide effective oversight, States should insist on monitoring metrics that are specific, measurable, attainable, relevant and time-bound (SMART). Properly designed, such metrics can afford the State a relatively easy way to ascertain whether a tailings facility is being well-managed and meets regulatory requirements for safety and integrity. Following the example of progressive reclamation described above, the State might impose specific, measurable, time-bound requirements on completing certain phases of reclamation such that regulators can readily ascertain whether the Operator is achieving these requirements.

Of course, problems can arise even at the best managed facilities, including those that have been certified under the Standard. The Standard provides guidance on various mechanisms that can alert the State to potential problems at a facility. Most importantly, the Standard requires Operators to prepare, report, and act on monitoring data on a regular basis. States, for their part, should establish their own programmes to ensure that: (a) monitoring processes are current and handled with integrity; and (b) appropriate enforcement action is taken to ensure that problems identified during monitoring are corrected in a timely fashion.

The Standard also requires Operators to establish mechanisms that encourage employees, contractors and third parties to report potential problems at site. Under the Standard, such parties can generally remain anonymous and receive whistle-blower protection. States should require all Operators to protect whistleblowers as a matter of State law and also adopt their own requirements to protect government whistleblowers.

2.3 FINANCIAL ASSURANCES

Performance Bonds

All tailings facilities are at risk of abandonment before they are safely closed and reclaimed. Abandonment can occur when a mining company goes bankrupt, where a facility is transferred to a third party without significant assets who goes bankrupt, or simply because the permittee or their successor chooses to walk away. All other things being equal, abandoned facilities pose a much higher risk of failure because they are not being monitored or managed. Such facilities impose a significant and unfair burden on States because it is the State that must ultimately bear responsibility for protecting its citizens from the adverse consequences of facility failures. Where failures do occur, the cost to States, in terms of responding to community impacts, stabilising the site, and restoring the local environment to the extent possible, can run into the billions of dollars. Even where abandoned facilities have not yet failed, the threat of failure imposes a high burden on the States and communities, given the need to maintain a constant vigil over these sites to identify changes to facilities that signal an increase in the risk (see also Nash, this volume).

2. Requirement 5.6 of the Standard specifies that '[t]he design should include, progressive closure and reclamation during operations'.

In light of this potentially enormous burden, States must do everything possible to minimise the possibility that future facilities will be abandoned. Specifically, States must require Operators to provide financial assurances, such as performance bonds, that are sufficient to guarantee that a tailings facility is properly reclaimed and closed even if the Operator, for whatever reason, walks away.

Financial assurances provide resources that can be used to avoid or remedy both the short- and long-term adverse consequences that could result from abandonment. As a practical matter, assurances also make abandonment far less likely, since abandonment of a facility would lead to forfeiture of the bond. States must be vigilant in ensuring that performance bonds or other financial assurances are adequate to fully reclaim and close a facility in the event that the State is forced to hire a contractor to perform the work. This must include regular review of the bond to ensure it keeps pace with the ever-changing cost of reclamation and closure at an active site. Even if the bond or other financial assurances are not adequate to cover full cost of reclamation and proper closure of a tailings facility, the money will go a long way toward safely stabilising the site and mitigating adverse impacts to the fullest extent possible.

States must also take all appropriate steps to ensure that bonds are only available to be used for reclamation and closure of a site in the event of forfeiture. Operators who are required to post bonds should insist on such a requirement so that they do not risk any further liability after a facility has failed. It is also critically important that States deny the transfer of permits to other parties who lack the capacity to post adequate financial assurances to cover the cost of reclamation and closure. This may pose a particular risk where mineral production is in decline, or where commodity prices make it difficult to justify further mine operations, since Operators may be tempted to sell off such assets to other Operators who are undercapitalised.

The Standard requires Operators to maintain adequate financial capacity to cover the cost of closure and reclamation and requires annual public disclosure of the Operator's financial capacity. It also requires Operators to use 'best efforts' to ensure that a change in ownership does not undermine the financial capacity to cover proper closure and reclamation. Whether or not this requirement is adequate will likely depend on whether it is scrupulously implemented and enforced. But this is an important matter where the State can play an essential role. If a State is satisfied that an Operator has sufficient tangible assets to effectively guarantee the cost of reclamation and safe closure of tailings facilities it may want to allow the Operator to 'self-bond'. The State can ensure the integrity of self-bonding by requiring an annual financial assessment by the Accountable Executive with an opportunity for public review and comment on the assessment. Given the volatility of commodity prices and the long-term financial risks that many mining companies face, States should design procedures to review and approve financial assurance demonstrations generally, and self-bonds in particular. Third-party bonds should be required where the Operator's financial assets are found to be inadequate.

States should also develop procedures for bond release (a topic not addressed in the Standard). Because financial assurances can tie-up significant assets, Operators will understandably want to be released from their bonding obligations as soon as possible. Bond release, however, should track progress on reclamation and safe closure. Since the bond amount is tied to the cost of final reclamation and closure, all work carried out by the Operator toward this goal should reduce the amount of the financial instrument. In addition to ensuring that the amount of the bond tracks the cost of reclamation and closure, this should act as an incentive for Operators to undertake progressive reclamation of tailings facilities.

Lastly, States should establish a public process that allows for meaningful public engagement in the partial and final bond release process. At-risk local communities have a particularly important stake in the reclamation and safe closure of tailings facilities, and in knowing that adequate money has been set aside to ensure proper reclamation and closure. They therefore should be afforded a fair opportunity to participate in any process that leads to the partial or full release of financial assurances.

Liability Insurance

Over many years tailings facility failures have imposed massive off-site costs on communities and ecosystems, including loss of life and serious injuries, water contamination, and other serious environmental harms. Most Operators maintain liability insurance that covers limited off-site injuries, but few insure against catastrophic failures. Part of the reason for this is that insurance companies are reluctant to cover failures that can lead to billions of dollars in liability. Moreover, even where such insurance might be available, the few insurance companies willing to issue policies may believe it necessary to charge

inflated premiums for policies that cover incidents which have a very low probability of occurring but which create enormous liability if they do. This problem is made all the more difficult by the fact that insurers may lack sufficient capacity to oversee tailings facilities to the extent necessary to ensure that such risks are minimised.

Liability insurance is nonetheless important for two reasons. First, it aligns with a fundamental principle of environmental law that holds that the polluter should pay for any third parties injuries that result from their activities. Moreover, an independent insurance company has a strong incentive to learn enough about the activity it is insuring to demand that the Operator comply with the very best practices.

Insurance can also help to mitigate environmental and natural resource damages. Natural resource damage assessments, with concomitant liability, are fairly common in the context of events like oil spills. Insurance can safeguard against the public having to bear the cost for those damages.

As with financial assurances, the Standard requires liability insurance but only 'to the extent commercially reasonable'. States would be wise to go beyond the Standard and demand liability insurance sufficient to address a catastrophic failure of a tailings facility. As with financial assurances for closure and reclamation, the State may wish to afford Operators the opportunity to 'self-insure' subject to similar limitations that apply to self-bonding. This option may be necessary where full liability insurance policies are not available or prohibitively expensive. The State would still, however, have to assure itself that the Operator has sufficient tangible assets to cover any potential liability from a catastrophic failure. Over time, it is hoped that the insurance industry will gain enough experience with the mining industry to better understand the risks and thus, to be in a better position to provide Operators with affordable policies where Operators cannot meet the financial conditions for self-insurance or where Operators prefer to rely on the private marketplace. (See Becker, this volume, for a more detailed discussion of issues relating to the insurance of tailings facilities.)

While Operators likely have a legal and ethical responsibility to indemnify parties who suffer losses as a result of a catastrophic tailings facility failure, if they lack sufficient assets those harmed as a result of a catastrophic failure may never be fully and fairly compensated. Thus, States should approach the 'self-insurance' option with caution because the enormous potential liability from a single catastrophic failure that causes a significant loss of human life and the destruction of ecological resources will be difficult for any Operator to bear.[3] Moreover, self-insurance raises far more serious questions of uncertainty than self-bonding, because the scope of losses from a catastrophic failure is far harder to estimate than the cost of reclamation and closure of a facility.

All of this suggests the critical need for States to adopt their own requirement for Operators to obtain liability insurance for losses that may result from catastrophic failures at a tailings facility. This would allow States to develop expertise on the cost of catastrophic failures and provide powerful incentives to put in place appropriate protections to avoid such failures. Moreover, while the State might not be directly liable for damages to people and the environment from catastrophic failures, such events nonetheless impose a heavy cost on States in the form of having to provide affected people with essential public services and other forms of public assistance, as well as burdening States with irreparable harm to their natural resources.

2.4 INSPECTION AND ENFORCEMENT

Inspections

A well-resourced inspection programme, staffed by qualified personnel, is essential for ensuring compliance with legal requirements, including permit or licence conditions. Ideally, this programme should include regular, random, unannounced inspections of every single facility, and immediate additional inspections whenever the State receives credible information about a serious problem or violation of the law.

The Standard requires regular inspections of tailings facilities by qualified personnel. Where an Operator

3. For example, Vale's estimate of the losses it will suffer from the Brumadinho failure are $4.8 billion. See https://www.nytimes.com/2019/07/10/world/americas/brazil-vale-dam.html. This is in addition to the billions of dollars in liability for the losses at the Samarco Mine that the company jointly operated with BHP. See https://www.leadersleague.com/en/news/bhp-and-vale-reach-settlement-with-brazilian-authorities-over-samarco-dam-disaster.

has been certified under the Standard, the appropriate role of the State would be to oversee the Operator's inspection process and to carry out independent inspections as appropriate to ensure the safety and sound management of facilities.

Identifying and hiring qualified inspectors will likely pose a significant challenge to States, because of the small pool of competent professionals in this area and competition from the private sector. Some strategies for addressing this are discussed in the next section and also in the chapter in this volume by Evans and Davies ('Creating and Retaining Knowledge and Expertise').

Enforcement
The Standard applies to Operators and is strictly voluntary. While it is anticipated that an agency will be established to oversee the Standard and certify compliance, the Standard itself is not enforceable other than perhaps by withdrawing certification for a facility that does not meet its requirements.

Enforcement of laws and regulations is the exclusive prerogative of the State. Those States that are serious about avoiding tailings facility failures should be prepared to take enforcement action against Operators that violate a State's laws and regulations, including the terms and conditions of State-issued licences or permits. To perform this function effectively, States must make clear to Operators that they are serious about full compliance with their legal standards.

One way for States to send this message and promote full compliance is to adopt a policy of mandatory enforcement. This policy requires an inspector to cite an Operator for any violation observed. Taking discretion out of the hands of the inspector is important because it minimises pressure on the inspector to look the other way when violations are found. If State law requires the inspector to cite every violation that is detected, the Operator will have no cause to complain about overly aggressive enforcement. The State may retain discretion to decide whether penalties or other sanctions should be imposed, and it may determine that no sanctions are necessary for relatively minor violations that are promptly corrected. However, mandatory enforcement ensures transparency and a comprehensive record of an Operator's compliance history. This information could be particularly valuable when the Operator applies for a permit renewal or for a permit at another site.

Citations generally take two forms. A 'notice of violation' or some similar device can be used for routine noncompliance that does not pose a serious threat to people or the environment. A 'cessation order' or 'compliance order' should also be available to afford the inspector with the authority to order that activities at a tailings facility cease, or to require that immediate corrective action be taken where the inspector determines that this is necessary to address a significant and imminent threat to people or the environment.

States should also adopt laws and policies that allow for civil or even criminal penalties to be imposed for intentional or reckless violations of State standards. In egregious cases, where an Operator knowingly takes an action that threatens the lives of people or significant environmental harm, criminal penalties may include imprisonment. In addition, or alternatively, State laws should also authorise civil penalties to be assessed directly against corporate directors, officers, or agents who commit knowing or wilful violations of the law. Fines paid out of corporate coffers might simply be seen as the cost of doing business, whereas fines assessed directly against officers or agents of the Operator will be felt personally and can send a strong message about the importance of full compliance with the law.

3. CAPACITY ISSUES

3.1 STAFFING

Clearly, not all States currently have the capacity to carry out the regulatory functions proposed in this Chapter. Effective State oversight requires a comprehensive understanding of the planning and engineering necessary to build, operate, maintain, and ultimately close tailings facilities. It also requires inspectors with the experience, integrity, credibility and authority to issue citations and to mandate appropriate corrective actions. This must include the capacity to recognise and evaluate problems on the ground and to identify the most appropriate solutions to these problems.

States that aspire to develop and implement an effective regulatory programme for tailings facilities must also employ a highly qualified and well-trained professional staff with sufficient resources to oversee all aspects of these facilities throughout their lifecycle. Moreover, the programme should be designed to allow the inspection and enforcement unit to operate independently from other elements of the regulatory

agency to minimise the risk of agency capture.[4] Salaries and employment conditions for these professional staff must be competitive with what the private sector offers so that experienced professionals see government employment as a realistic career choice. Developing a reliable, professional staff where one does not currently exist will require time and significant resources (see Evans and Davies, this volume) but for States this offers what is perhaps the long-term best insurance against future catastrophic failures.

3.2 FINANCING THE REGULATORY PROGRAMME

All States struggle to resource regulatory functions adequately. One option for addressing this problem would be to require a substantial permitting or licencing fee sufficient to cover the cost of issuing and reviewing permits, coupled with an annual fee that is sufficient to maintain a strong oversight and enforcement programme. Because this could disadvantage small to medium sized Operators, States might also consider imposing a severance tax[5] or requiring an enhanced royalty payment that would be dedicated to funding the State regulatory programme.[6] With adequate funding, States will be in a much stronger position to hire qualified personnel as well as to cover the costs of processing and approving permit applications, and undertaking inspection and enforcement activities.

3.3 THE ROLE OF THE STATE IN STRENGTHENING INTERNATIONAL ADHERENCE TO HIGH STANDARDS

When States step up to their responsibility to oversee the proper management of tailings facilities throughout the project lifecycle, they model behaviour for other countries and provide a framework for them to emulate. Of course, even well-run programmes will make mistakes, but these mistakes can, in themselves, offer important lessons for how to avoid future problems. Over time, the best ideas gained from the best run regulatory programmes will offer a clear framework that all States can use to design and operate their own programmes.

International organisations, such as the co-convenors of the Standard, and other entities such as the World Bank and the International Finance Corporation (IFC), have an important role to play here, as they are well-placed to identify innovative regulatory programmes and examples of leading practice, and to promote their adoption internationally. A clearinghouse and database that identifies and tracks the best ideas for addressing the particular problems posed by tailings facilities could prove enormously useful to countries around the world as they struggle to design their own programmes. Knowledge transfer could also be facilitated through technical assistance and mentoring programmes whereby a country with a successful programme offers support to another country that is trying to develop own programme. As discussed by Evans and Davies (this volume), international organisations could help to facilitate such arrangements.[7] The long-term aim should be to level the playing field so that the regulation of mining is similar regardless of where the mining takes place.

4. This issue was highlighted in a 2016 report of the Auditor General of British Columbia, who recommended that the Provincial Government '... create an integrated and independent compliance and enforcement unit for mining activities ... [g]iven that the Ministry of Energy and Mines (MEM) is at risk of regulatory capture, primarily because MEM's mandate includes a responsibility to both promote and regulate mining' (2016, p. 11).

5. A severance tax is a tax levied on the extraction of natural resources in a State. It is typically assessed as a percentage of the value of the extracted resource. This form of tax is popular in the United States, which unlike most countries allows private ownership of minerals: a severance tax allows the State to generate revue for mineral extractions even when it does not own the resource. In most States, mineral ownership is the norm, and thus an enahnced royalty payment might offer an easier way to generate additional revenues without stressing the balance sheet of smaller companies. A number of American States operate 'severance tax' programmes, and these taxes tend to be much higher than the tax imposed under the Surface Mining Control and Reclamation Act (SMCRA). For example, Montana imposes a coal severance tax of 15 per cent on the contract sale price of surface mined coal with a BTU greater than 7,000. See https://mtrevenue.gov/taxes/natural-resource-taxes/coal-severance-tax/. States might, however, want to consider flat rate severance taxes as opposed to one based on a percentage of the resource's value. Revenues can be more easily estimated with a flat fee and thus the State can more easily generate what it needs to operate the regulatory programme thereby avoiding both under and over taxing mineral production.

6. The U.S. SMCRA, 30 U.S.C. §1201, et seq., which applies exclusively to the regulation of coal mining in the United States, uses two different models for generating significant revenue. The first, requires payment of a fee 'that may be less than but that shall not exceed the actual or anticipated cost of reviewing, administering, and enforcing the permit.' 30 U.S.C. §1257(a). The regulatory agency can develop procedures so that this fee is paid over the term of the permit, so that payments are more closely aligned with revenue streams. A second programme imposes what is essentially a tax on all coal produced. Companies typically pay \$0.28/ton for surface mined coal and \$0.12/ton for underground mined coal. U.S.C. §1232(a). Well over \$11 billion has been raised through this tax since its inception in 1977. SMCRA targets this money for cleaning up abandoned mines, and that is certainly a worthy cause. Still, it has proved an effective way to generate significant revenue that could be used for other purposes. It also has the advantage of generating revenue alongside production, such that benefits to the government and the Operator are aligned

7. The International Mining for Development Centre (IM4DC) was a programme funded by the Australian government in the years 2012-2015 which was designed for exactly this purpose. The University of British Columbia likewise operates a programme entitled the Canadian International Resources and Development Institute (CIRDI) that works with countries to improve governance on a wide range of natural resource development issues (see: https://cirdi.ca/.) Perhaps countries like Canada, Australia and the United States with significant experience regulating mining activities should come together to establish a similar entity to work with developing countries, local communities, and community organisations interested in improving compliance with sound regulatory standards.

4. THE ROLE OF OTHER STAKEHOLDERS

While an effective State regulatory and enforcement regime is an essential element for the long-term success of tailings facility management, other stakeholders such as investors, insurers, affected communities and NGOs also have important roles to play. States would be wise to recognise the value that these parties contribute to good outcomes by encouraging their constructive involvement to the fullest extent possible.

Investors can condition their financial support on compliance with strict standards for tailings facility management such as the Standard proposed here. Investors can further demonstrate their commitment to strict standards by insisting on regular reporting, public disclosure of relevant documents, and third-party audits that ensure compliance (see Barrie *et al*., this volume).

As previously discussed, insurance companies that indemnify Operators against damages to people and the environment from tailings facility failures can also play an important role in overseeing the safe operation of tailings facilities and in insisting that Operators minimise the risk of failure to the fullest extent possible. This would limit their exposure to significant claims which, as noted, can easily exceed billions of dollars. Private insurance also offers a distinct advantage over self-insurance because it incentivises insurance companies to closely monitor tailings facilities and demand immediate correction of problems as they are identified.

Local communities and civil society organisations have a strong interest in ensuring that tailings facilities are managed so as to protect public safety and the environment. These stakeholders can best perform this function if they are given a meaningful role in key decisions that affect them (as proposed in the Standard). They are also in a strong position to demand transparency from Operators regarding tailings facility plans, management plans, and other data and information relating to the tailings facility. By insisting on strict compliance with the Standard, States can also help build positive relationships and foster trust between the mining companies and the communities where they operate. As noted above, developed countries could play a useful role in supporting these efforts.[8]

8. See footnote 6 and the accompanying text.

5. CONCLUSION

The Global Industry Standard on Tailings Management, if fully implemented, will go a long way towards assuring the public that Operators are committed to the safe construction, operation, and closure of tailings facilities. However, the Standard is voluntary and not all Operators will commit to compliance with it at all of their tailing facilities. It is also the case that full compliance with the Standard may not be possible at some existing facilities.

States are in a position to fill the gap left by the Standard and demand adherence to the highest and best practices that are feasible, even at tailings facilities where Operators are not willing or able to adopt the Standard. Moreover, States do not need to 'reinvent the wheel'. They can look to the Standard for guidance as to the most appropriate requirements for assuring tailings facility safety and they can incorporate those requirements into their laws and regulations.

As discussed in this chapter, States are also uniquely positioned to undertake the important task of monitoring and enforcing safety requirements at tailings facilities, whether those requirements are the result of a voluntary commitment by the Operator or a mandatory obligation imposed by the State. Establishing and maintaining a credible and well-trained professional staff that is capable of effectively carrying out this task will not be easy, but the health and safety of people and the environment depend on doing so. It is hoped that States will embrace the opportunity that they alone possess to fulfil this responsibility that they owe to their public.

REFERENCE

Auditor General of British Columbia (2016). *An Audit of Compliance and Enforcement of the Mining Sector*. Victoria, May 2016. https://www.bcauditor.com/sites/default/files/publications/reports/OAGBC%20Mining%20Report%20FINAL.pdf

KEY MESSAGES

1. States play a critical role in the success or failure of tailings facilities
2. The Standard offers a roadmap for States for how to establish an effective regulatory programme for tailings facilities.
3. States have understandable concerns about their capacity to fund and implement a regulatory programme. Operators should therefore be expected to bear the cost of the programme, including the cost of training competent personnel.
4. States bear a substantial part of the burden when people and the environment suffer from tailings facility failures. States should therefore embrace requirements for adequate performance bonds to assure full reclamation and safe closure, and for insurance to cover liability for injuries to third parties.
5. States are uniquely positioned to monitor the performance of Operators and to take appropriate enforcement action where violations of tailings facility requirements occur.
6. States that lack the capacity to adopt and implement a sound regulatory programme with well-trained staff should work with other countries and the international community to build that capacity.

BUILDING ORGANISATIONAL CAPACITY

CHAPTER XIII
COMPARATIVE ANALYSIS OF TAILINGS-RELATED LEGISLATION IN KEY MINING JURISDICTIONS

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1. INTRODUCTION AND METHODOLOGY

This chapter analyses tailings-related legislation in a selection of key mining jurisdictions: Australia (federal/Queensland), Brazil (federal/Minas Gerais), Canada (federal/Ontario), Chile, China, Ghana, Kazakhstan, Russia and South Africa ('Key Jurisdictions').[1] The results are based on a survey of issue-specific legislation in the Key Jurisdictions, carried out with the assistance of local counsel,[2] to compare the extent to which each of the fifteen principles in the proposed Global Industry Standard on Tailings Management (the 'Principles' and the 'Standard', respectively)[3] are addressed in each country's legislative framework.

The outcome of the analysis considers the scope of the Standard and its ambitions for technical and regulatory protocols to heighten requirements for tailings dam management, safety and accountability. A score, ranging from 1 to 5, was applied to rank the completeness and quality of legislation in the Key Jurisdictions relative to the treatment of issues raised in the Standard for each Principle. A description of the scoring criteria is provided in Table 1 below. Appendix 1 provides a breakdown of scores against the Principles for each Key Jurisdiction.

Table 1. Scoring Criteria

Score	Scope of Legislation in Key Jurisdictions Compared with the Standard
1	'Not Addressed' (i.e. there is no applicable legislation addressing the Principle)
2	'Minimally Addressed' (i.e. the elements of the Principle are marginally or peripherally addressed in regulation)
3	'Partially Addressed' (i.e. most but not all elements of the Principle are addressed in the legislation, or all elements of the Principle are addressed but to a lesser standard)
4	'Comprehensively Addressed' (i.e. the elements of the Principle are addressed in legislation to about the same standard as the Standard)
5	'Higher Standard' (i.e. all elements of the Principle are addressed more comprehensively and/or more strictly in the legislation than the Standard)

1. The Key Jurisdictions were chosen to reflect a global cross-section of countries where mining is a significant sector of the economy and is predominantly regulated by State and/or Provincial governments.
2. See Acknowledgements.
3. In addition to the 15 Principles, the Standard also recommends 74 Requirements, which represent specific guidance on the operation and management of tailings facilities.

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2. OVERVIEW OF FINDINGS

Figure 1 and Figure 2 represent the average score of each of the nine Key Jurisdictions for each of the fifteen Principles of the Standard. To have a clear representation of the averages and scores the countries have been split by southern and northern hemisphere – five Key Jurisdictions are included in Figure 1 (Australia, Chile, South Africa, Ghana and Brazil) and four Key Jurisdictions are included in Figure 2 (Russia, China, Kazakhstan, Canada). The fifteen Principles of the Standard are listed in Table 2.

Table 2. The fifteen Principles of the Standard

Mine Tailings Standard Principles	
Principle 1	Respect the rights of project-affected people and meaningfully engage them at all phases of the tailings facility lifecycle, including closure.
Principle 2	Develop and maintain an interdisciplinary knowledge base to support safe tailings management throughout the tailings facility lifecycle, including closure.
Principle 3	Use all elements of the knowledge base – social, environmental, local economic and technical – to inform decisions throughout the tailings facility lifecycle, including closure.
Principle 4	Develop plans and design criteria for the tailings facility to minimise risk for all phases of its lifecycle, including closure and post-closure.
Principle 5	Develop a robust design that integrates the knowledge base and minimises the risk of failure to people and the environment for all phases of the tailings facility lifecycle, including closure and post-closure.
Principle 6	Plan, build and operate the tailings facility to manage risk at all phases of the tailings facility lifecycle, including closure and post-closure
Principle 7	Design, implement and operate monitoring systems to manage risk at all phases of the facility lifecycle, including closure
Principle 8	Establish policies, systems and accountabilities to support the safety and integrity of the tailings facility
Principle 9	Appoint and empower an Engineer of Record
Principle 10	Establish and implement levels of review as part of a strong quality and risk management system for all phases of the tailings facility lifecycle, including closure
Principle 11	Develop an organisational culture that promotes learning, communication and early problem recognition
Principle 12	Establish a process for reporting and addressing concerns and implement whistleblower protections
Principle 13	Prepare for emergency response to tailings facility failures
Principle 14	Prepare for long term recovery in the event of catastrophic failure
Principle 15	Publicly disclose and provide access to information about the tailings facility to support public accountability

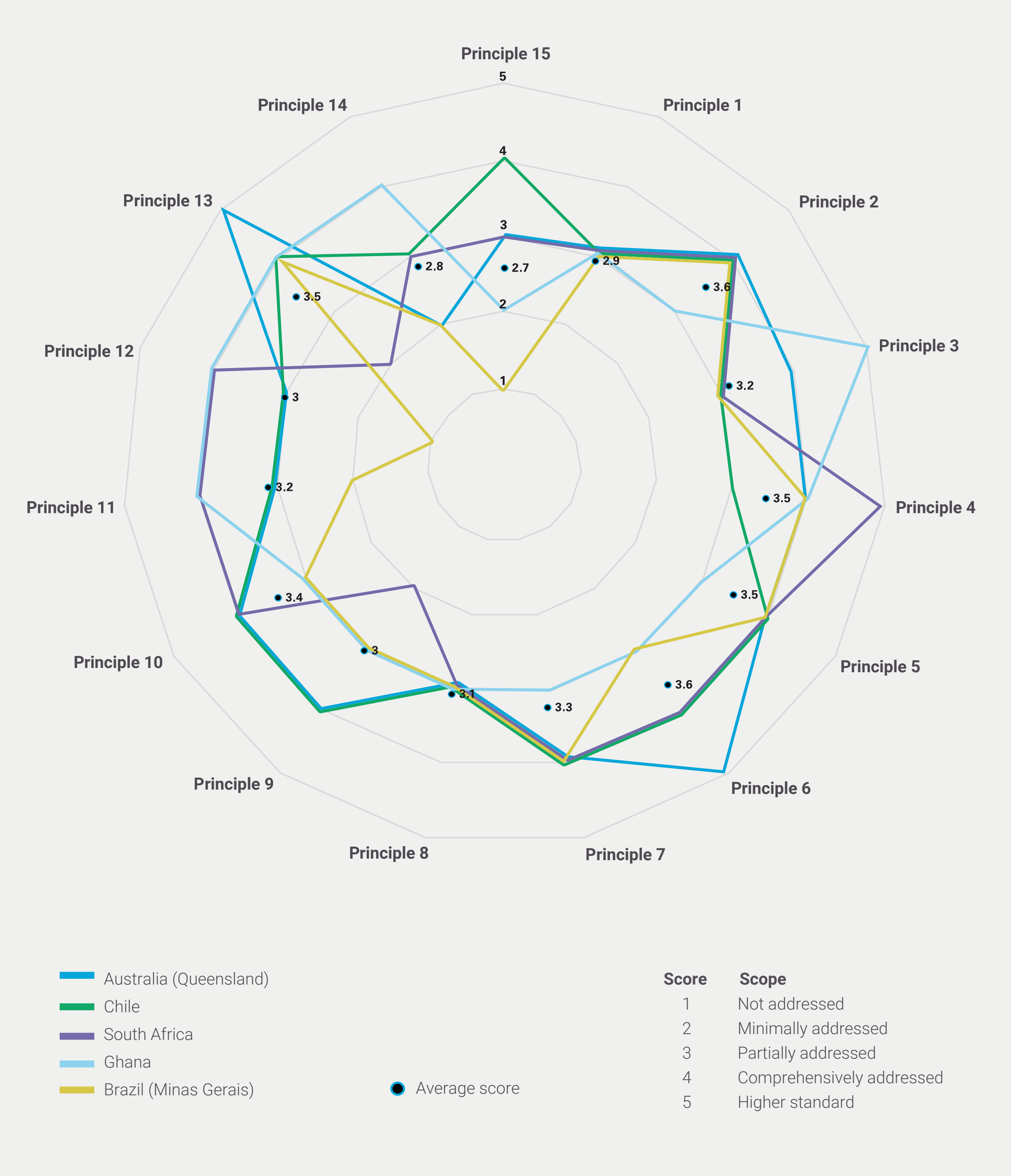

Figure 1. Scores against the Standard by Principle: Australia, Brazil, Chile, Ghana and South Africa

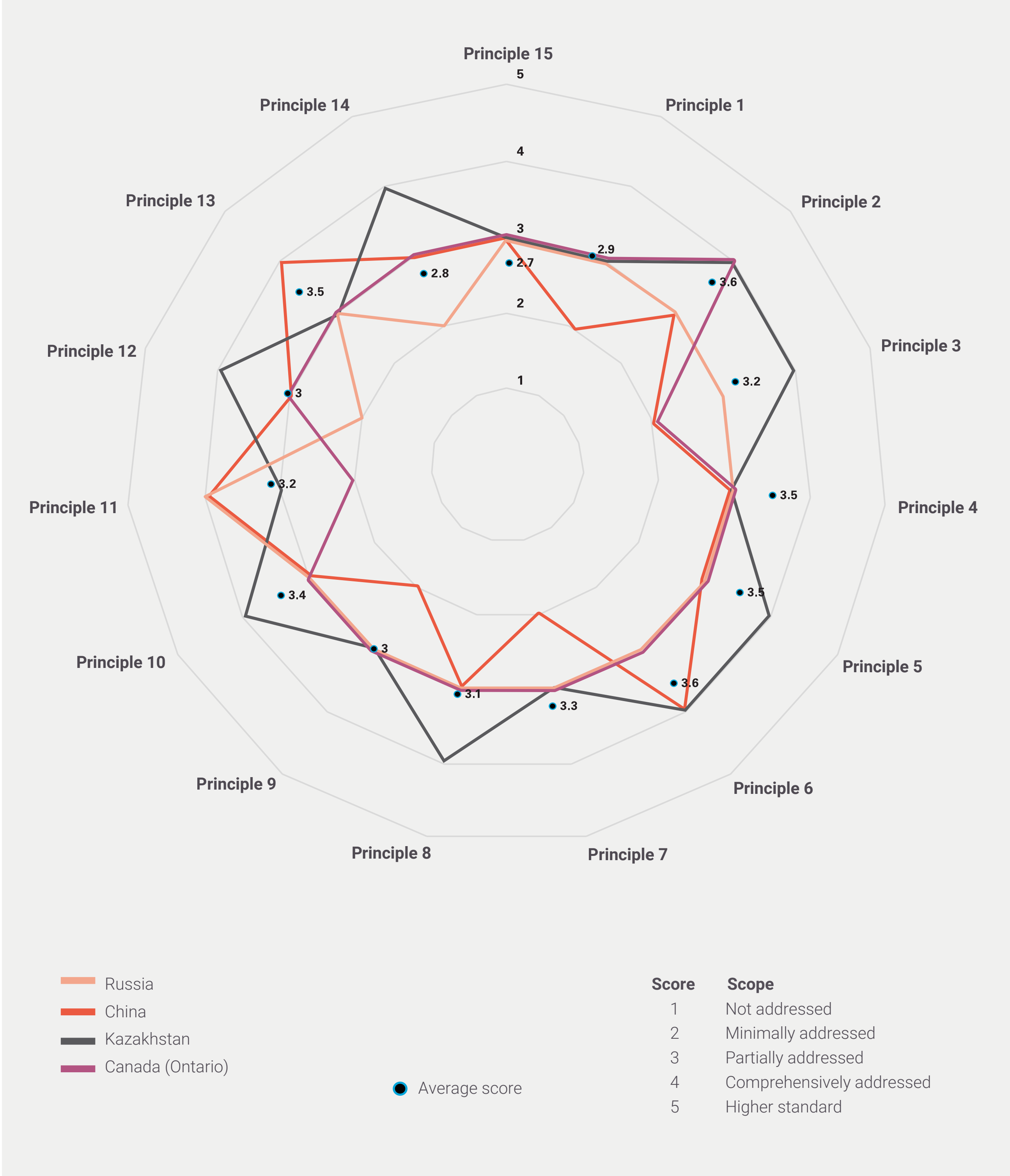

Figure 2. Scores against the Standard by Principle: Russia, China, Kazakhstan and Canada

3. FINDINGS BY PRINCIPLE

Topic I: Affected Communities

PRINCIPLE 1:

Respect the rights of project-affected people and meaningfully engage them at all phases of the tailings facility lifecycle, including closure.

Principle 1 of the Standard recommends the inclusion of human rights principles in accordance with the United Nations Guiding Principles on Business and Human Rights (UNGPs). Some Key Jurisdictions have developed levels of community engagement for project-affected people in the context of mining or environmental permitting processes, and the majority of Key Jurisdictions mandate engagement of potentially affected people. The concept of stakeholder engagement has complexities that are particular to each jurisdiction. For example, in Queensland, Australia (score 3), there is no formal requirement for free, prior and informed consent (FPIC), but there are requirements to consult or engage with potentially affected people and local communities, including at the exploration stage or where there may be an impact on cultural heritage. Although this includes grievance mechanisms and public disclosure of information, there is no legislation in place in Queensland, for example, that requires consultation in the closure phase. In Chile (score 3), Canada (score 3) and South Africa (score 3), there is no legislation applying the UNGPs; however, a process of consultation is carried out to address the impacts of a project on indigenous people or affected parties. In most of the Key Jurisdictions, it is unclear whether communities are engaged in all stages of the tailings facility lifecycle. Some aspects, such as resettlement, are not addressed in the context of tailings related legislation. The Requirements under the Standard establish a broader scope for engagement with communities and potentially affected people, and provide stringent guidelines for engaging communities that may be impacted by the operation or failure of tailings facilities.

Topic II: Knowledge Base

PRINCIPLE 2:

Develop and maintain an interdisciplinary knowledge base to support safe tailings management throughout the tailings facility lifecycle, including closure.

As part of the requirements of Principle 2, operators must develop and document knowledge throughout all stages of a tailings facility, from construction, operation and closure to post-closure. In a majority of the Key Jurisdictions (Canada, Chile, South Africa, Kazakhstan, Ghana and Brazil), tailings-related legislation comprehensively addresses the development of a robust knowledge base. In Chile (score 4), operators are required to submit detailed information of different technical aspects of tailings facility operations to the Mining Authority (*Regulation on the Approval, Design, Construction, Operation and Closure of Tailings Dams, Supreme Decree No. 248, Mining Ministry* 2007). Similarly, in Canada (score 4) operators are required to develop a closure plan that includes technical details of mineral and tailings management, from construction to post closure (*Ontario Regulation 240/00 Mine Development and Closure under Part VII of the Mining Act* 2019, Schedule 11). In Australia (score 4), although the socio-economic and environmental aspects of tailings facility are typically addressed as part of the overall mine project impact assessment (*Environmental Protection Act* 1994*; the State Development and Public Works Organisation Act* 1971*)*, there is no requirement to have a standalone document that just addresses the tailings facility. Other Key Jurisdictions, such as Russia (score 3) and China (score 3) have partially addressed elements of Principle 1 (*Federal Law No. 89-FZ on the Industrial and Consumption Wastes* 1998 and *Management Rules on Safety Supervision of Mine Tailings Dams* 2009, respectively), however, they do not have explicit documentation requirements. This may have a knock-on effect for impact management and performance improvement. Overall, the model proposed in the Standard provides for a broader stock of knowledge as compared to existing regulations in Key Jurisdictions, especially in its requirement to develop and document lifecycle information for tailings facilities.

PRINCIPLE 3:

Use all elements of the knowledge base – social, environmental, local economic and technical – to inform decisions throughout the tailings facility lifecycle, including closure.

Principle 3 focuses on how operators review and update impact assessments to reflect significant changes to the social and environmental context, and assessing best available technologies to update any new information relevant to the operation and maintenance of the tailings facility.[4] It is noteworthy that regulatory requirements in Ghana (score 5) set a higher standard than described in this Principle. The Environmental Assessment Regulations include assessment and consideration of climate change issues in the context of site selection and the development of impact mitigation plans for the environmental impact assessment ('EIA') (*Environmental Assessment Regulations* 1999, Regulation 12 and Regulation 22). Most of the remaining Key Jurisdictions only partially address the requirements of Principle 2. In Chile (score 3), China (score 3) and Brazil (score 3) there are requirements for minimising risk of tailings facility failures, but climate change considerations are not included in the evaluation of environmental impacts. However, for Brazil there is a National Policy on Climate Change, which foresees as one of its general guidelines 'adaptation measures to reduce the adverse effects of climate change and the vulnerability of environmental, social and economic systems' (*Federal Law No. 12,187/2009* 2009). In South Africa (score 3), the courts have determined that notwithstanding the lack of an express legal obligation to conduct a focused climate change impact assessment, climate change remains a relevant element to consider when granting an environmental authorisation. In this way, through the addition of technology-based factors, the Standard is setting a higher benchmark than in most of the Key Jurisdictions.

Topic III: Design, Construction, Operation and Monitoring of the Tailings Facility

PRINCIPLE 4:

Develop plans and design criteria for the tailings facility to minimise risk for all phases of its lifecycle, including closure and post-closure.

Legislation in all of the Key Jurisdictions address risk mitigation in the construction and management of tailings facilities. Ghana (score 4) and Brazil (score 4) comprehensively address the elements of Principle 4, similar to the Standard. However, South Africa (score 5) is noteworthy in its application of more extensive measures and therefore a higher standard than the one proposed. Applicable legislation in South Africa requires an assessment of the nature of the mine residue stockpiles to consider whether these could pose a potentially significant health and safety or environmental risk (*Mineral and Petroleum Resources Development Act* 2002). As there is no requirement under the Standard to consider the physical or chemical characteristic of mine residue, the legislation in South Africa sets a bar higher than the Standard. The other Key Jurisdictions do not achieve the aspirations of the Standard in this regard. For example, Russia (score 3) does not appear to consider design criteria as an element of risk management. However, there are no requirements for a review by an Independent Tailings Review Board ('ITRB') or requirements for a risk or consequence matrix for tailing facilities, even where there are multiple requirements for the safe design of tailings facilities. Therefore, the caliber of technical requirements under this Principle, for the most part, adds another dimension to the quality of construction and risk minimization that is higher than current regulatory requirements in the Key Jurisdictions.

4. Global Industry Standard on Tailings Management, Requirement 2.4 [Commentary].

PRINCIPLE 5:

Develop a robust design that integrates the knowledge base and minimises the risk of failure to people and the environment for all phases of the tailings facility lifecycle, including closure and post-closure.

According to the Standard, integration of a knowledge base to minimise risks of failure during the lifecycle of a tailings facility is fundamental for monitoring risk and maintaining the integrity of the facility. Australia (score 4), Chile (score 4) and Brazil (score 4) have comprehensively addressed measures to design and minimize the risk of tailings facilities failures. Australian legislation also addresses water management, along with Kazakhstan (score 4) and Ghana (score 3). This is an important aspect of tailings management.[5] In China (score 3), many elements of Principle 5 are addressed but they appear to be addressed to a lesser degree or scope than the Standard. In Canada (score 3), there is no specific requirement to develop, implement and maintain water balance and water management plans for tailings facilities, but the legislation does reference technical documents, design, construction and decommissioning requirements that proponents must meet. The Standard sets a high threshold for factors such as facility failure as part of lifecycle risk assessment, including the impact of water management. However, based on information from most of the Key Jurisdictions, the Requirements of this Principle go beyond what is currently identified in their various legislation.

PRINCIPLE 6:

Plan, build and operate the tailings facility to manage risk at all phases of the tailings facility lifecycle, including closure and post-closure.

Principle 6 reflects the fact that a tailings facility is most likely situated within a complex and dynamic local and global environment.[6] To handle such complexity, many Key Jurisdictions have developed sophisticated monitoring mechanisms and requirements to manage risk at all stages of the facility lifecycle, such as certification of design plans and drawings, periodic reports to the authorities, engagement with independent experts, among others. Legislation in Australia (score 5), is developed to a high standard for managing risks in all stages of planning, building and operating the tailings facility. Legislation in Chile (score 4), South Africa (score 4), China (score 4) and Kazakhstan (score 4) comprehensively addresses the requirements of Principle 6. Other Key Jurisdictions only meet certain aspects of Principle 6, such as Ghana (score 2), where the requirement for an operator to update quality control plans and verification of the design criteria only applies before commencing construction and not during construction of the tailings facilities. The Standard appears to be aligned with good industry practice in most of the Key Jurisdictions, but some of the Requirements set out additional measures, such as monitoring at all stages of the facility lifecycle.

PRINCIPLE 7:

Design, implement and operate monitoring systems to manage risk at all phases of the facility lifecycle, including closure.

The intention behind Principle 7 is to encourage the establishment of a system of internal assurance, by regularly reviewing the performance of the tailings facility.[7] All of the Key Jurisdictions have developed basic regulations to monitor and control tailings facilities. However, only Australia (score 4), Chile (score 4), South Africa (score 4) and Brazil (score 4) comprehensively address the elements set out by the Standard. For example, in South Africa, an audit report must be provided to assess the level of compliance with the conditions of the environmental authorisation. The report must also be published online by the holder of the environmental authorisation (*Environmental Impact Assessment Regulations* 2014, Regulation 35(6)). Neither Australia, China, Kazakhstan, Ghana nor Canada, establish any obligation to publish results of the monitoring programme on a regular basis, as set out in the Requirements of this Principle. The requirement for regular publication of the results of the monitoring programmes is an enhanced condition included in the Standard compared with the Key Jurisdictions. Considering the importance of transparency and inclusion in understanding and addressing risks of tailings facility failures, including for stakeholder engagement, this is an essential element for improvement.

5. Requirement 5.3: 'Develop, implement and maintain a water balance and water management plans for the *tailings facility*, taking into account the knowledge base including climate change, upstream and downstream hydrological basins, the overall mine site, mine planning and operations and the integrity of the tailings facility for all stages of its lifecycle. The water management program must be designed to protect against unintentional releases.'

6. Requirement 6.1: 'Build, operate, monitor and close the tailings facility according to the design intent at all stages of the *tailings facility lifecycle*, using qualified personnel and appropriate methodology, equipment, procedures, data acquisition methods, the TMS and the overall *environmental and social management system* (ESMS) for the mine and associated infrastructure.'

7. Requirement 7.1 Commentary: 'The intention of this requirement is to set up performance monitoring of the key management systems (TMS and ESMS) as an additional level of internal assurance. In order to reduce the potential for information not being shared and not informing decisions across both systems, the requirement is for an integrated monitoring programme for those aspects of the ESMS that are related to safety of the tailings facility.'

Topic IV: Management and Governance

PRINCIPLE 8:

Establish policies, systems and accountabilities to support the safety and integrity of the tailings facility.

Most tailings-related legislation does not comprehensively address the management roles, functions, accountability and remuneration systems of a tailings facility. In general, these elements are addressed under other areas of law. Most Key Jurisdictions cover the liability of directors in cases of damages to the tailings facility, rather than addressing roles and functions. Chile (score 3) and Kazakhstan (score 4) are the only two countries where legislative requirements are included in mine tailings legislation. In Chile, the legislation is aligned with Principle 8 as it requires operators to develop internal regulations to ensure the integrity of workers, facilities, equipment and the environment (*Mining Safety Regulation*, *Supreme Decree No. 132* 2004). In Kazakhstan, there are requirements to appoint roles and functions at each facility for conducting industrial environmental control and for interaction with regulatory authorities (*Environmental Code* 2007). Legislation in Kazakhstan also sets out provisions for environmental crimes and for failure of directors to comply with environmental requirements (*Administrative Violations Code* and *Penal Code of Kazakhstan*). Many of the other Key Jurisdictions do address accountability and liability but this is in the context of other legislation, such as company law or to a lesser degree. For example, in Australia (score 3) regulations exist establishing roles, functions and remuneration systems to support the integrity of the tailings facility, but the *Environmental Protection Act* 1994 governs compliance with the conditions set out by the environmental authority and non-compliance can lead to criminal liability of directors. The Requirements of Principle 8 develop a variety of specific elements related to accountability and for the most part none of the Key Jurisdictions has comprehensively addressed the Principle. Therefore, the Standard establishes a new standalone mechanism for accountability for tailings facility management and compliance.

PRINCIPLE 9:

Appoint and empower an Engineer of Record.

Regulations in the majority of the Key Jurisdictions, including South Africa (score 2), Russia (score 3), China (score 2), Kazakhstan (score 3), Ghana (score 3), Brazil (score 3) and Canada (score 3), do not have a specific requirement to appoint and empower an Engineer of Record, as set out in Principle 9 of the Standard. Instead, these countries require for project designers and workers to have necessary professional and technical qualifications. Only Australia (score 4) requires that, on completion of construction, the engineer of record who supervises the construction of the regulated tailings facility must provide certification to the administering authority in the form required by the Assessment Manual. Chile (score 4) comprehensively addresses this Principle by setting out requirements for the engagement of an independent engineer. Therefore, the Standard adds a requirement designed to address the integrity of tailings facilities, as well as independent review and accountability for tailings facility design, development, construction, management and compliance.

PRINCIPLE 10:

Establish and implement levels of review as part of a strong quality and risk management system for all phases of the tailings facility lifecycle, including closure.

The majority of Key Jurisdictions – Australia (score 4), Chile (score 4), South Africa (score 4), China (score 3), Kazakhstan (score 4), Ghana (score 3) and Canada (score 3) require some level of adequate financial capacity to cover the reclamation, closure and post-closure costs included in Principle 10. In Australia, mining activities, including tailings dams, must be rehabilitated in accordance with an approved Progressive Rehabilitation and Closure Plan, including the requirement for payment or a surety to cover for the rehabilitation (reviewed annually).[8] The size of the surety can be increased if the risk rating or cost estimate goes up, or reduced if the risk rating or cost estimate reduces. Risk management systems for all stages of the tailings facility lifecycle have also been developed by Chile and these allow for a wide variety of instruments to be used to meet adequate financial capacity obligations,

8. Requirement 15.1.B.10 requires 'Annual confirmation that the Operator has adequate financial capacity (including insurance to the extent commercially reasonable) to cover estimated costs of planned closure, early closure, reclamation, and post-closure of the tailings facility and its appurtenant structures (Requirement 10.7).'

including cash, letters of credit, bond, trusts and insurance policies. The Requirements of Principle 10 are addressed to some degree in all of the Key Jurisdictions, although none of them exceeds the Standard.

PRINCIPLE 11:

Develop an organisational culture that promotes learning, communication and early problem recognition.

South Africa (score 4), China (score 4) and Ghana (score 4) have developed regulations that comprehensively address elements of Principle 11 similarly to the Standard. They have not only established mechanisms to promote learning into the planning, design and operations of the tailings facility lifecycle, but regulations in these countries have also focused on protecting employees and contractors who speak out about issues in relation to the facility management.[9] For instance, in South Africa whistle-blowers are protected from civil and criminal liability and from being dismissed for having provided information related to an environmental risk (*Code of Practice for Mine Residue* 1998). Whistle-blowers also have some level of protection under Canadian law, but it is limited to violations of certain statutes. The Requirements of this Principle to provide education and training of relevant personnel in safety operation and risk prevention exist in most of the Key Jurisdictions, but for the most part to a lesser extent than the Standard.

PRINCIPLE 12:

Establish a process for reporting and addressing concerns and implement whistle-blower protections.

Principle 12 encourages the establishment of an internal, confidential process to investigate and address concerns in relation to the tailings facility, such as violations of permit conditions. Kazakhstan (score 4) sets an example of a Key Jurisdiction which has established an internal mechanism to encourage parties to raise concerns about possible permit violations. Its legislation sets out the requirement for an employee to respond immediately to violations of environmental requirements, or in the case of any danger to human life and health (*Environmental Code* 2007). Ghanaian legislation[10] (score 4) also provides measures for whistle-blower protection (*Minerals and Mining (Health, Safety and Technical) Regulations* 2012). Although most of the Key Jurisdictions require authorities to conduct investigations about possible failures relating to tailings facilities, there is room for improvement in developing and implementing internal mechanisms to investigate.

Topic V: Emergency Response and Long-Term Recovery

PRINCIPLE 13:

Prepare for emergency response to tailings facility failures.

Emergency response plans have been developed by most Key Jurisdictions, and in many cases they are required as part of the environmental and social impact assessment and/or permitting process. However, most of the Key Jurisdictions do not include in tailings-related legislation a specific reference or guidance for best practice. Australia (score 5) stands apart from other Key Jurisdictions as there is multiple legislation and guidance to address responses to tailings facility failures. This goes beyond the current recommendations of the Standard. On the other hand, in South Africa (score 2), there is no specific requirement to prepare emergency responses in cases of tailings dam failures. In Russia (score 3), an owner or operator must develop and submit for the state approval various documents relating to safety of the operated facilities. Having a tailings-specific requirement for emergency response and preparedness is a requirement of the Standard that is not currently consistently applied in the Key Jurisdictions.

PRINCIPLE 14:

Prepare for long term recovery in the event of catastrophic failure.

The Standard proposes a new metric for long-term recovery in the event of catastrophic failure. Ghana (score 4) and Kazakhstan (score 4) set out comprehensive rules and procedures on remediation, reclamation and post-failure response. In Chile (score 3) notwithstanding there are no specific requirements to develop high-level principles describing how the parties will approach compensation, remediation and recovery in case of a catastrophic failure, there are several mechanisms by which the public agencies may engage in the control, investigation and sanction of mining emergencies or catastrophes, as well as measures to be adopted by the operators. However, some Key Jurisdictions such as Australia (score 2) and Brazil (score 2) have no specific guidelines in relation to post-failure response. Most Key Jurisdictions have not established statutory or regulatory rules on the mechanisms to engage or compensate affected people, post-failure of tailings facilities. Overall, the Standard proposes a more robust regime for recovery in the context of catastrophic failure.

Topic VI: Public Disclosure and Access to Information

PRINCIPLE 15:

Publicly disclose and provide access to information about the tailings facility to support public accountability.

Some Key Jurisdictions, including Chile (score 4), Canada (score 3) and South Africa (score 3), have specific statues that govern access to public information. For example, in Ontario, the *Freedom of Information and Protection of Privacy Act 2000* gives individuals the right to request access to government-held information. A similar provision can be found in the *Chilean 'Transparency Act'* (*Law No. 20,285 on Access to Public Information*). However, these regulations do not provide for an automatic public access to information on tailings facility decisions, as contemplated by Principle 15. In this way, the Standard shifts focus on to the need for access to information by local authorities, individuals and communities that may be affected by tailings facilities, emphasising the need for transparency. At the same time, the Standard accommodates the protection of confidential information, balancing the needs of all parties.

4. SUMMARY OF FINDINGS

As a general observation, it is clear that although many of the Principles are well-reflected in the laws and regulations of some of the Key Jurisdictions, the ambitions of the Standard, when compared to domestic law, set a higher threshold for achieving the degree of integrity, safety and community protection necessary for the development and management of tailings facilities. This research has identified certain areas where the Standards sets a higher bar than legislation in Key Jurisdictions, which could provide the impetus for regulators to consider where changes could be made to address tailings facility safety and management.

The overall results of the analysis of tailings safety legislation in the Key Jurisdictions, expressed as average scores (see Appendix 1) e, show how the Standard can be a catalyst for improvement in regulation of tailings facilities. The analysis brings to the fore both the scope and need for a consistent approach to tailings facility management, safety and operation.

The gap between the most and least aligned Key Jurisdictions draws out the need for more emphasis on catastrophic failure, accountability and engagement of communities as the starting point of tailings dams regulation. Working backward from a worst case scenario informs the approach to permitting, approvals and enforcement from the beginning, which in turn sets the tone for iteration and improvement.

A final observation is that, while legislation is an essential tool for regulating tailings facility safety and management throughout the lifecycle, other forms of best practice exist and jurisprudence are also developing, both of which may also be effective in helping to achieve the goals of the Standard.

9. This is set out in Requirement 11.5: 'Establish mechanisms that recognize, reward and protect from retaliation, employees and contractors who speak up about problems or identify opportunities for improving facility management. Respond in a timely manner and communicate actions taken and their outcomes.'

10. Grievance mechanisms are covered in the *Whistleblower Act 2006* and the *Health, Safety and Technical Regulations 2012*.

APPENDIX 1 – SUMMARY OF SCORES AGAINST THE STANDARD BY KEY JURISDICTION

Principle	Australia (Queensland)	Chile	South Africa	Russia	China	Kazakhstan	Ghana	Brazil (Minas Gerais)	Canada (Ontario)	Average Score
Principle 1: Respect the rights of project-affected people and meaningfully engage them at all phases of the tailings facility lifecycle, including closure.	3	3	3	3	2	3	3	3	3	**2.9**
Principle 2: Develop and maintain an interdisciplinary knowledge base to support safe tailings management throughout the tailings facility lifecycle, including closure.	4	4	4	3	3	4	3	4	4	**3.7**
Principle 3: Use all elements of the knowledge base – social, environmental, local economic and technical – to inform decisions throughout the tailings facility lifecycle, including closure.	4	3	3	3	3	4	5	3	2	**3.3**
Principle 4: Develop plans and design criteria for the tailings facility to minimise risk for all phases of its lifecycle, including closure and post-closure.	4	3	5	3	3	3	4	4	3	**3.5**
Principle 5: Develop a robust design that integrates the knowledge base and minimises the risk of failure to people and the environment for all phases of the tailings facility lifecycle, including closure and post-closure.	4	4	4	3	3	4	3	4	3	**3.5**
Principle 6: Plan, build and operate the tailings facility to manage risk at all phases of the tailings facility lifecycle, including closure and post-closure.	5	4	4	3	4	4	3	3	3	**3.7**
Principle 7: Design, implement and operate monitoring systems to manage risk at all phases of the facility lifecycle, including closure.	4	4	4	3	2	3	3	4	3	**3.3**
Principle 8: Establish policies, systems and accountabilities to support the safety and integrity of the tailings facility.	3	3	3	3	3	4	3	3	3	**3.1**
Principle 9: Appoint and empower an Engineer of Record.	4	4	2	3	2	3	3	3	3	**3**
Principle 10: Establish and implement levels of review as part of a strong quality and risk management system for all phases of the tailings facility lifecycle, including closure.	4	4	4	3	3	4	3	3	3	**3.4**
Principle 11: Develop an organisational culture that promotes learning, communication and early problem recognition.	3	3	4	4	4	3	4	2	2	**3.2**
Principle 12: Establish a process for reporting and addressing concerns and implement whistleblower protections.	3	3	4	2	3	4	4	1	3	**3**
Principle 13: Prepare for emergency response to tailings facility failures.	5	4	2	3	4	3	4	4	3	**3.5**
Principle 14: Prepare for long term recovery in the event of catastrophic failure.	2	3	3	2	3	4	4	2	3	**2.9**
Principle 15: Publicly disclose and provide access to information about the tailings facility to support public accountability.	3	4	3	3	3	3	2	1	3	**2.8**
Total Score for Each KMJ	55	53	52	44	45	53	51	44	44	**49***

*Average total score for KMJ

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SOURCES

Australia (federal/Queensland)
Aboriginal Cultural Heritage Act 1988
Aboriginal Land Rights Act
Australian National Committee on Large Dams, Guidelines on Tailings Dams 2019 (ANCOLD Guidelines)
Code of Environmental Compliance for Environmental Authorities for High Hazard Dams Containing Hazardous Waste – EM1698 (High Hazard Dam Code)
Coal Mining Safety and Health Act 1999 (CMSH Act)
Coal Mining Safety and Health Regulation 2017
Environmental Protection Act 1994
Environmental Protection Regulations 2019
Guideline ESR/2016/1934 on 'Structures which are Dams or Levees Constructed as part of Environmentally Relevant Activities' (ERA Guideline)
Guidance Note QGN 29 on 'Surface Tailing Storage Facility Management' 2018 (QGN29)
Manual ESR/2016/1933 for 'Assessing Consequence Categories and Hydraulic Performance of Structures' (Assessment Manual)
Mineral and Energy Resources (Financial Provisioning) Act 2018 (Queensland)
Mining and Quarry Safety and Health Act 1999
Mining and Quarry Safety and Health Regulation 2017
Mineral Resources Act 1989 (Queensland)
Planning Act 2016
Professional Engineers Act 2002
State Development and Public Works Organisation Act 1971 (Queensland)
Water (Safety and Reliability) Act 2008

Brazil (federal/Minas Gerais)
Competent Council Joint Resolution No. 2.372/2016
Council for Environmental Policy (COPAM) Deliberation no. 87/2005
Council for Environmental Policy (COPAM) Normative Deliberations Nos. 62/2002, 87/2005, 124/2008.
National Department of Mineral Production (DNPM) Ordinance No. 70,389/2017
National Policy on Dam Safety (Federal Law No. 12,334/2010)
National Policy on Climate Change (Federal Law No. 12,187/2009)
Resolution No. 01/1986 of the National Council for the Environment
State Decree No. 46,993/2016
State Law No. 23,291/2019
State Law No. 21.291/2019
State Law No. 6.496 of 7 December 1977
State Law No. 12,187 of 29 December 2009
State Secretariat of Environmental Development (SEMAD) and State Environment Foundation (FEAM) Joint Resolution No. 2.372/2016
The National Council of the Environment (CONAMA) Resolution No. 09/1987
The National Council of the Environment (CONAMA Resolution No. 237/1997

Canada (Federal/Ontario)
Endangered Species Act 2007
Environmental Assessment Act 2012
Environmental Bill of Rights 1993
Environmental Protection Act 1999
Freedom of Information and Protection of Privacy Act 2000
Mineral and Petroleum Resources Development Regulations 2004
Mining Act 1990 (Ontario)
Occupational Health and Safety Act 1990
Ontario Regulation 240/00, Mine Development and Closure of the Mining Act 2019
Ontario Water Resources Act 1990

Chile
Law No. 20,555 the Mining Sites and Facilities Closure Act and its regulation (the 'MCA')
Law No. 19,300, the General Environmental Act and its regulation (the 'GEA')
Mining Safety Regulation, Supreme Decree No. 132/2004 2004
Regulation on the Approval, Design, Construction, Operation and Closure of Tailings Dams, Supreme Decree No. 248/2007 2007
Supreme Decree No. 132 of the Mining Ministry 2004, Mining Safety Regulation (the 'MSR')
Transparency Act Law No. 20,285 on Access to Public Information 2009

China
Code for Design of Tailings Facilities (or '尾矿设施设计规范') (GB 50863-2013), issued jointly by Ministry of Housing and Urban-Rural Development (or '中华人民共和国住房和城乡建设部') and General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China on 8 June 2013
Law of the People's Republic of China on Environmental Impact Assessment (or '中华人民共和国环境影响评价法'), last revised by the Standing Committee of the National People's Congress on 29 December 2018
Law of the People's Republic of China on Preventing Environmental Pollution by Solid Waste (or '中华人民共和国固体废物污染环境防治法'), issued by the Standing Committee of National People's Congress on 7 November 2016
Management Rules on Preventing Environmental Pollution by Mine Tailings (or '防治尾矿污染环境管理规定'), last revised by Ministry of Ecology and Environment on 22 December 2010
Management Rules on Safety Supervision of Mine Tailings Dam (or '尾矿库安全监督管理规定'), issued by Ministry of Emergency Management (or '应急管理部') on 20 December 2019
Mine Safety Law of the People's Republic of China (or '中华人民共和国矿山安全法'), last revised by the Standing Committee of the National People's Congress on 27 August 2009
Provisional Guidance on Emergency Management of Mine Tailings Dam Environment (or '尾矿库环境应急管理工作指南(试行)'), issued by Ministry of Ecology and Environment (or '生态环境部') (formerly Ministry of Environmental Protection) on 30 September 2010
Provisional Rules on the Supervision and Management of Mine Tailings Dam by Gansu Province (or '甘肃省尾矿库监督管理试行办法'), issued by the Provincial Government of Gansu on 1 January 2018

Regulations for the Implementation of the Mine Safety Law of the People's Republic of China (or '中华人民共和国矿山安全法实施条例'), issued by Ministry of Labour & Social Security (now dissolved) on 30 October 1996
Safety Regulations for Tailings Pond (Draft Subject to Public Comments) (or '尾矿库安全规程(征求意见稿) '), issued jointly by General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (or '中华人民共和国国家质量监督检查检疫总局') and the Standardization Administration (or '中国国家标准化管理委员会') on 2 September 2019

Ghana
Commission on Human Rights and Administrative Justice Act 1993
Environmental Assessment Regulations 1999
Environmental Protection Agency (EPA) Grievance Redress Mechanism Operational Manual 2016

Local Government Act 1993 (Act 462)
Minerals and Mining (Compensation and Resettlement) Regulations 2012
Minerals and Mining (Health, Safety and Technical) Regulations 2012
National Building Regulations 1996 (LI 1630)
The Companies Act 2019
Whistleblower Act 2006 (Act 720)

Kazakhstan
Administrative Infra
ctions Code of the Republic of Kazakhstan dated 5 July 2014 No. 235-V, as amended
Environmental Code of the Republic of Kazakhstan dated 9 January 2007 No.212, as amended
Law No.401-V of the Republic of Kazakhstan 'On Access to Information' dated 16 November 2015, as amended
Law No. 242 of the Republic of Kazakhstan 'On Architectural, Town-planning and Construction Activity in the Republic of Kazakhstan' dated 16
July 2001, as amended
Penal Code of the Republic of Kazakhstan dated 3 July 2014 No. 226-V, as amended
Public Hearings Rules, approved by the Order of the Ministry of Environmental Protection dated 7 May 2007 No.135-п, as amended
Rules of Formation of Reclamation Funds for Landfills, approved by the Order No. 125 of the Minister of Energy of the Republic of Kazakhstan dated 13 November 2014, as amended
The Rules on Industrial Safety for Tailings and Tailings Management Facilities on Hazardous Production Sites, approved by the Order No. 349 of the Minister for Investment and Development dated 30 December 2014, as amended

Russia
Decree of the Federal Mining and Industrial Supervision Authority of Russia No. 6 'On the Approval of the Rules of Safety of Hydrotechnical Constructions Storing Liquid Industrial Wastes' dated 28 January 2002
Decree of the Government of the Russian Federation No. 20 'On the Engineering Survey for the Preparation of Design Documentation, Construction, Reconstruction of Capital Construction Facilities' dated 19 January 2006, as amended
Decree of the Government of the Russian Federation No. 145 'On the Procedure for Organization and Holding of the State Expert Review of Design Documentation and Results of Engineering Surveys' dated 05 March 200, as amended
Federal Law No. 89-FZ 'On the Industrial and Consumption Wastes' dated 24 June 1998, as amended
Federal Law No. 117-FZ 'On the Safety of Hydrotechnical Constructions' dated 21 July 1997, as amended
The Town-Planning Code of the Russian Federation (Federal Law No. 190-FZ) dated 29 December 2004, as amended

South Africa
Code of Practice for Mine Residue 1998 ('SABS Code 0286)
Constitution of the Republic of South Africa 1996
Department of Mineral Resources and Energy (DMRE), 'Guidelines Document for the Evaluation of the Quantum of Closure-related Financial Provision Provided by a Mine' 2005
Environmental Impact Assessment Regulations 2014
Guidelines on Water Management for Mine Residue Deposits prepared by the Department of Water and Forestry
Income Tax Act No. 58 1962
Mineral and Petroleum Resources Development Act 2002
Minister of Environmental Affairs, 'Financial Provision Regulations' 2015
National Environmental Management Act 1998
National Environmental Management Waste Act 2008
National Water Act 1998

CHAPTER XIV SUMMARY OF EXISTING PERFORMANCE STANDARDS FOR TAILINGS MANAGEMENT

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1. INTRODUCTION

When the development of the Global Industry Standard on Tailings Management (the Standard) was initiated, standards and guidance were already in place that describe various aspects of best practices related to tailings management. The scope of the Standard is broad, with requirements falling into three general categories:

- tailings management governance
- community engagement and public disclosure
- technical design considerations.

There are three existing standards that address the first two of these categories (tailings management governance, and community engagement and public disclosure). These are the:

1. International Council on Mining and Metals (ICMM) Performance Expectations
2. Mining Association of Canada (MAC) *Towards Sustainable Mining*® (*TSM*®)
3. Initiative for Responsible Mining Assurance (IRMA).

This chapter provides an overview of each of these standards, including:

- background information on the organisations and standards
- scope of application
- how the standards address performance related to:
- tailings management governance
- community engagement and public disclosure
- water management, which is also relevant to tailings management
- performance measurement and verification
- external Inputs to the development and implementation of the standard
- implementation of the standard
- disclosure of performance against the standard.

There are no existing standards for technical design considerations, although guidance is provided by several organisations such as the International Commission on Large Dams (ICOLD) and national/regional organisations such as the Australian National Committee on Large Dams (ANCOLD) and the Canadian Dam Association (CDA). The guidance from these organisations is focused on tailings dams and containment structures and not on tailings management and tailings facilities more broadly.

It is important to emphasise that while these organisations do not prescribe performance expectations, many regulatory authorities incorporate this guidance into various legal requirements (e.g. site-specific permits for tailings dams).

This chapter does not provide summaries of existing technical guidance. Readers should refer to the websites of the above-listed organisations for information.

2. ICMM PERFORMANCE EXPECTATIONS

2.1 BACKGROUND ON THE ICMM AND THE PERFORMANCE EXPECTATIONS

The ICMM is an international organisation dedicated to a safe, fair and sustainable mining and metals industry. ICMM consists of 27 mining and metals companies and 38 regional and commodities associations.

* Member of the GTR Multi-stakeholder Advisory Group

In February 2020, ICMM introduced its updated Mining Principles. All company members are expected to implement these Principles as a condition of membership. Performance Expectations were introduced for each Principle, defining the good practice environmental, social and governance requirements, with the goal of maximising benefits to host communities and minimising negative impacts to effectively manage societal challenges.

The Mining Principles are an update to ICMM's 10 Principles for Sustainable Development, first established in 2003. The Performance Expectations build upon these Principles and upon the work that ICMM has done since they were introduced to develop position statements and guidance to improve company member performance.

There are 10 Mining Principles:

1. **Ethical Business**. Apply ethical business practices and sound systems of corporate governance and transparency to support sustainable development.
2. **Decision-Making**: Integrate sustainable development in corporate strategy and decision-making processes.
3. **Human Rights**. Respect human rights and the interests, cultures, customs and values of employees and communities affected by our activities.
4. **Risk Management**. Implement effective risk-management strategies and systems based on sound science, and which account for stakeholder perceptions of risk.
5. **Health and Safety**. Pursue continual improvement in the health and safety performance with the ultimate goal of zero harm.
6. **Environmental Performance**. Pursue continual improvement in environmental performance issues, such as water stewardship, energy use and climate change.
7. **Conservation of Biodiversity**. Contribute to the conservation of biodiversity and integrated approaches to land-use planning.
8. **Responsible Production**. Facilitate and support the knowledge-base and systems for responsible design, use, re-use, recycling and disposal of products containing metals and minerals.
9. **Social Performance**. Pursue continual improvement in social performance and contribute to the social, economic and institutional development of host countries and communities.
10. **Stakeholder Engagement**. Proactively engage key stakeholders on sustainable development challenges and opportunities in an open and transparent manner, effectively report and independently verify progress and performance.

ICMM documents, including position statements and guidance, are available free of change on the ICMM website.

2.2 ASPECTS OF THE ICMM PERFORMANCE EXPECTATIONS RELEVANT TO THE SCOPE OF THE STANDARD

ICMM Performance Expectations relevant to the scope of the Standard are described primarily in the ICMM Position Statement on Tailings Management. Requirements of the Standard related to community engagement are not directly addressed in this Position Statement but are explicitly addressed in other aspects of the ICMM Performance Expectations (see below). In addition, ICMM Performance Expectations related to water stewardship, summarised in below, are also relevant to tailings management.

The ICMM Performance Expectations do not address technical design aspects related to tailings management. Instead, company members are expected to refer to technical guidance from the ICOLD, ANCOLD CDA, or to guidance from similar organisations relevant to the mine location.

Tailings Management Governance

The ICMM Position Statement on Tailings Management sets out expectations for company members. The Position Statement, which was released in 2016, commits company members to implement practices consistent with a Tailings Governance Framework (the Framework) so that the risk of catastrophic failure of tailings storage facilities is minimised.

ICMM company members were expected to implement the commitments in this Position Statement by November 2018.

The Position Statement pre-dates the updated Mining Principles and the introduction of the ICMM Performance Expectations. It addresses Principles 1, 2, 4, 5, 6, 7 and 10. The Performance Expectations further commit company members to design, construct, operate, monitor and decommission tailings facilities using comprehensive, risk-based management and governance practices in line with internationally recognised good practice. Company members are expected to commit to implementing practices consistent with the Framework, in addition to meeting the Performance Expectations.

The Framework focuses on six elements of tailings management and governance, summarised as follows:

1. **Accountability, responsibility and competency**. Accountabilities, responsibilities and associated competencies are defined to support appropriate identification and management of tailings facility risks.
2. **Planning and resourcing**. The financial and human resources needed to support continued tailings management and governance are maintained throughout a facility's life cycle.
3. **Risk management**. Risk management associated with tailings facilities includes risk identification, an appropriate control regime and the verification of control performance.
4. **Change management**. Risks associated with potential changes are assessed, controlled and communicated to avoid inadvertently compromising tailings facility integrity.
5. **Emergency preparedness and response**. Processes are in place to recognise and respond to impending failure of tailings facilities and mitigate the potential impacts arising from a potentially catastrophic failure.
6. **Review & assurance**. Internal and external review and assurance processes are in place so that controls for tailings facility risks can be comprehensively assessed and continually improved.

Community Engagement and Public Disclosure

Several ICMM Performance Expectations address aspects of community engagement, particularly:

1. Ethical Business

2. Decision-Making

3. Human Rights

4. Risk Management

6. Environmental Performance

9. Social Performance

10. Stakeholder Engagement

In addition, there are two position statements that company members are expected to implement.

Position Statement: Indigenous Peoples
This position statement was put in place in 2013, replacing ICMM's 2008 Mining and Indigenous Peoples Position Statement. The Position Statement sets out ICMM members' approach to engaging with Indigenous Peoples and to Free, Prior and Informed Consent (FPIC).

The commitments may be summarised as requiring members to:

- Engage indigenous peoples to ensure that their rights and interest are respected and that they obtain sustainable benefits through the development of mining projects.
- Understand and respect their rights and interests regarding a project and its potential impacts.
- Agree and document appropriate engagement and consultation processes with potentially impacted indigenous peoples and relevant government authorities.
- Work to obtain the consent of indigenous communities for new projects (and changes to existing projects) that are located on lands traditionally owned by or under customary use of indigenous peoples and are likely to have significant adverse impacts on indigenous peoples.
- Collaborate with the responsible authorities to achieve outcomes consistent with the position statement where government is responsible for managing indigenous peoples' interests.
- Address the likelihood that differences of opinion will arise and agree on avenues of recourse.

Position Statement: Partnerships for Development
This position statement was put in place in 2010. It commits ICMM company members to actively support or help develop partnerships with other stakeholder groups with the aim of enhancing the social and economic contribution of mining through development partnerships. In practical terms this means:

1. Either individually or collectively through ICMM publicly express their willingness to work in partnership with development agencies, host governments, civil society organisations, and local communities to enhance mining and metals' contribution to social and economic development.
2. For major investments in regions where socio-economic outcomes are highly uncertain or where there are significant opportunities to enhance such outcomes: (i) develop an understanding of the social and economic contribution of the project, including an analysis of the barriers that might weaken this contribution; and (ii) actively support or help develop partnerships or collaborations with other stakeholder groups with the aim of ensuring the project's potential socio-economic contribution is realised.
3. Review the relative success of their development partnerships and collaborations at suitable intervals and adapt these over time to ensure they continue to contribute to the overall goal of enhancing the social and economic contribution of mining.
4. Provide an overview of their work on such partnerships, as appropriate, in their annual external reporting and communications.

ICMM Guidance Documents
ICMM has also developed a number of guidance documents related to community engagement.

- Community Development Toolkit (2012) – an update to the original toolkit released in 2005
- Stakeholder Research Toolkit (2015)
- Understanding Company-Community Relations Toolkit (2015)
- Integrating Human Rights Due Diligence into Corporate Risk Management Processes (2012)
- Good Practice Guide to Indigenous Peoples and Mining (2015)
- Land acquisition and resettlement: Lessons learned
- Handling and Resolving Local-Level Concerns and Grievances: Human Rights in the Mining and Metals Sector (2009, updated in 2019)

In addition, ICMM, in partnership with International Finance Corporation, the International Committee of the Red Cross, and the global oil and gas industry association for environmental and social issues, has produced Voluntary Principles on Security and Human Rights: Implementation Guidance Tools.

Water Management

Several of the ICMM's Performance Expectations address aspects of water management, particularly:

1. Human Rights
2. Risk Management
3. Environmental Performance
4. Conservation of Biodiversity
5. Stakeholder Engagement

ICMM company members are also expected to implement the Water Stewardship Position Statement, which was put in place in 2017. Water stewardship is the use of water in ways that are socially equitable, environmentally sustainable, and economically beneficial. The Position Statement describes three member commitments. These are aligned with the expectation that effective stewardship requires collaboration and concerted action from all parties, including government, civil society, business and local communities through inclusive stakeholder engagement.

This position statement commits company members to:

- Apply strong and transparent corporate water governance
- Manage water at operations effectively
- Collaborate to achieve responsible and sustainable water use

ICMM has also developed A Practical Guide to Catchment Based Water Management.

2.3 PERFORMANCE MEASUREMENT AND VERIFICATION

Measurement of performance against the Performance Expectations is conducted on a site or asset-specific basis.[1] This includes assessing performance against the Performance Expectations and applicable ICMM Position Statements. In the case of tailings facilities, this would include implementation of the Framework.

Performance measurement and verification includes:

- Self-assessment of all assets to confirm the existence and integrity of systems and/or practices relating to implementation of applicable Performance Expectations and Position Statements.
- Prioritisation of assets for third-party validation following criteria chosen by the company and including transparent disclosure of the selection process.
- Third-party validation of the reasonableness and authenticity of assertions made in self-assessments.[2]

1. Assets are operations involved in the production or refining of minerals and metals for sale or further processing. An asset may comprise several sites in different locations (e.g. a port, a pipeline desalination facility), under the same management control which 'support the production and sale' of minerals.
2. Third-party validations must be conducted by qualified validation service providers (VSPs). VSPs are professional service providers and must meet ICMM requirements for independence, experience, expertise and lack of conflicts of interest. ICMM will keep a register of VSPs that members use.

These performance measurement activities are designed to evaluate the implementation of the Performance Expectations individually, and relevant Position Statements. There is no overall outcome or score for a given asset. The possible outcomes for each Performance Expectation are: 'meets', 'partially meets', and 'does not meet'. In some situations, the outcome may be 'not applicable'.

2.4 EXTERNAL INPUT TO DEVELOPMENT AND IMPLEMENTATION OF THE ICMM PERFORMANCE EXPECTATIONS

To obtain external input to the updated Mining Principles and development of the Performance Expectations, ICMM launched a global public consultation in 2018. The objective of the consultation process was to obtain views from individuals and organisations to help improve the environmental and social performance of the mining and metals industry.

An online survey in English, French, Portuguese, Spanish and Japanese was used to obtain input on the 10 Principles and 38 proposed Performance Expectations. The consultation was conducted over a period of about seven weeks. In total, 263 respondents from 30 countries completed the survey, with the number of people commenting on each proposed Performance Expectation ranging from 205 to 263.

A report summarising the consultation is available on the ICMM website.

2.5 IMPLEMENTATION OF THE ICMM PERFORMANCE EXPECTATIONS

ICMM's Mining Principles apply to roughly 650 assets in over 50 countries. Details of the tailings storage facilities that ICMM members own or operate are available at https://www.icmm.com/member-tsfs.

2.6 DISCLOSURE OF PERFORMANCE AGAINST THE ICMM PERFORMANCE EXPECTATIONS

Members are required to publicly disclose their performance measurement activities on an annual basis. The disclosure can be made on a member's website or in a sustainability or corporate report. The asset-by-asset disclosures that apply to self-assessments and third-party validations from 2022 onwards will provide information to interested parties of the status of implementation of the Performance Expectations.

3. MINING ASSOCIATION OF CANADA – *TOWARDS SUSTAINABLE MINING*® (*TSM*®)

3.1 BACKGROUND ON MAC AND *TSM*

The Mining Association of Canada (MAC) is an industry association that represents the interests of the mining sector in Canada. MAC has 42 members, including Canadian and foreign-based companies, involved in the mining of metals, oil sands, metallurgical coal and diamonds.

In 2004, MAC launched *Towards Sustainable Mining* (*TSM*) to improve environmental and social performance. *TSM* provides eight performance measurement protocols (standards) to measure *TSM* performance at the facility level. These protocols are in three focus areas:

Environmental Stewardship

- tailings management
- biodiversity conservation management
- water stewardship.

Communities and People

- Indigenous and community relationships
- safety and health management
- crisis management and communications planning (measured at the facility and corporate level)
- preventing child and forced labour.

Energy Efficiency

- energy use and greenhouse gas emissions management.

All *TSM* protocols and associated documents can be accessed free of charge on the MAC website, and are available in English, French, and Spanish:

https://mining.ca/towards-sustainable-mining/

https://mining.ca/fr/vers-le-developpement-minier-durable/

https://mining.ca/towards-sustainable-mining/hacia-una-mineria-sostenible/

3.2 SCOPE OF APPLICATION

TSM protocols are designed primarily to be applied to mines and related facilities (e.g., smelters and refineries) in the operating phase of the life cycle. *TSM* has been applied voluntarily to closed facilities and many elements can also be applied to facilities at pre-operational phases of the life cycle. Guidance documents developed under the tailings management component of *TSM* are designed to be applicable throughout the life cycle of tailings facilities.

TSM protocols are designed to be applicable to any mine, located anywhere in the world.

3.3 ASPECTS OF TSM RELEVANT TO THE SCOPE OF THE STANDARD

Requirements of the Standard related to tailings management governance are addressed in the *TSM Tailings Management Protocol*. Within the tailings management component of *TSM* there are some requirements specific to community engagement, particularly in the context of emergency preparedness. Community engagement is addressed more broadly in the *Indigenous and Community Relationships Protocol*, summarised below. The *Water Stewardship Protocol*, summarised below, is also relevant to tailings management and the scope of the Standard.

TSM does not address technical design aspects related to tailings management. Company members are expected to refer to technical guidance from the ICOLD, ANCOLD, CDA, or guidance from similar organisations relevant to the mine location.

Tailings Management Governance

The *Tailings Management Protocol* describes five performance indicators:

1. Having a corporate tailings management policy or commitment

Intent: confirm that companies have established and effectively communicated a policy or commitments that express intention, commitments and principles in relation to tailings management.

2. Developing and implementing site-specific tailings management systems, and emergency preparedness

Intent: confirm that companies have:

- developed and implemented a tailings management system
- developed and tested emergency response plans and emergency preparedness plans.

3. Assigning accountability and responsibility for tailings management

Intent: confirm that accountability for tailings management is assigned to an Accountable Executive Officer, and that an appropriate management structure and resources are in place to provide assurance to the company that tailings are managed responsibly.

4. Conducting annual tailings management reviews

Intent: confirm that there is an annual review of tailings management that is reported to the Accountable Executive Officer to ensure corporate governance over tailings management and to ensure that the company is satisfied that the tailings management organisational structures and systems are effective and continue to meet the needs of the organisation.

5. Developing and implementing site-specific Operational, Maintenance and Surveillance (OMS) manuals

Intent: confirm that the company has developed and implemented a tailings facility-specific OMS manual to facilitate implementation of the tailings management system.

The *Tailings Management Protocol* refers to two guidance documents:

1. A Guide to the Management of Tailings Facilities ('the Tailings Guide')

2. Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities ('the OMS Guide').

Elements described in the performance indicators must be implemented in conformance with these Guides. A comprehensive Table of Conformance has been developed to aid in measuring performance again the indicators in the Protocol.

The Tailings Guide, first released in 1998, is modelled on the ISO 14001 *Environment Management Systems* but is tailored to tailings management. It provides guidance on:

- development and implementation of site-specific tailings management systems
- emergency preparedness
- assurance, including independent review

The OMS Guide, introduced in 2003, provides guidance on the development, implementation, and review and updating of site-specific OMS manuals that describe all operation, maintenance, and surveillance activities related to the management of a tailings facility.

In 2015, MAC launched independent and internal reviews of the tailings management component of *TSM*. As an outcome of these reviews, the Protocol and Guides were revised in two-step process:

2017:

- third edition of the Tailings Guide
- revised *Tailings Management Protocol*
- introduced the Table of Conformance

2019:

- second edition of the OMS Guide
- version 3.1 of the Tailings Guide
- revised *Tailings Management Protocol*
- revised Table of Conformance

Community Engagement and Public Disclosure

The *TSM Indigenous and Community Relationships Protocol* was developed to measure performance related to community engagement. This protocol was introduced in 2019 and replaces the *Aboriginal and Community Outreach Protocol*, introduced with the launch of *TSM* in 2004.

The *Indigenous and Community Relationships Protocol* has five performance indicators:

1. Community of Interest (COI) identification

Intent: confirm that processes are in place to identify COI, including Indigenous communities and organisations, affected or perceived to be affected by the company's operations and activities or who have a genuine interest in the performance and activities of a company and/or operation.

2. Effective COI engagement and dialogue

Intent: confirm that processes have been established to support development and maintenance of meaningful relationships with COI, including Indigenous communities and organisations, to gain mutual understanding of viewpoints, to build effective relationships, and to create shared value and mutual benefits.

3. Effective Indigenous engagement and dialogue

Intent: confirm that mining facilities are actively building meaningful relationships and implementing engagement and decision-making processes with Indigenous communities. This includes aiming to achieve FPIC for impacts on rights of directly affected Indigenous peoples before proceeding with development and maintaining it throughout the life of the project. This indicator also confirms that efforts are made to ensure that Indigenous peoples have equitable access to opportunities with the company. Furthermore, this indicator seeks to ensure that management and designated employees are educated on the history of Indigenous peoples and receive skills-based training in intercultural competency, conflict resolution, human rights, and anti-racism.

4. Community impact and benefit management

Intent: confirm that processes have been established to ensure that adverse community impacts, including human rights impacts, are identified, avoided and mitigated and that processes are in place to encourage and optimise social benefits generated from the facility. Additionally, this indicator seeks to confirm that facilities identify and engage with COI on potential adverse environmental impacts that may directly affect communities, including those associated with tailings management (as applicable), and potential adverse impacts related to community safety and health.

5. COI response mechanism

Intent: confirm that there are processes in place to receive, track and respond to incidents, concerns and feedback from COI, including Indigenous communities and organisations, leading towards stronger relationships and building trust.

Water Management

The *TSM Water Stewardship Protocol* was introduced in 2019 and is based on the ICMM Water Stewardship Position Statement. The *Water Stewardship Protocol* has four performance indicators:

1. Water governance

Intent: confirm that commitment and accountabilities are in place and communicated to relevant COI to support water stewardship.

2. Operational water management

Intent: confirm that water-related plans and management systems are implemented at the facility level. This indicator includes both water quality and water quantity.

3. Watershed-scale planning

Intent: confirm that the facility supports engagement with other water users and COI in the watershed and participates in watershed-scale planning and governance fora, where they exist. This indicator focuses on watershed planning beyond the operational footprint of the facility.

4. Water performance and reporting

Intent: confirm that water related objectives or targets have been established to measure performance and that reporting is in place to inform decision-making and to communicate performance publicly.

3.4 PERFORMANCE MEASUREMENT AND VERIFICATION

Each *TSM* protocol provides several performance indicators with performance measurement criteria for each indicator. Performance is measured on a scale from Level C to Level AAA.[3]

- Level C: No systems in place; activities tend to be reactive; procedures may exist, but they are not integrated into policies and management systems.
- Level B: Procedures exist but are not fully consistent or documented; systems/processes planned and being developed.
- Level A: Systems/processes are developed and implemented.
- Level AA: Integration into management decisions and business functions.
- Level AAA: Excellence and leadership.

TSM uses four layers of performance measurement and verification:

1. *Self-assessment:* Every year, each facility conducts a detailed and thorough self-assessment against each protocol. It is important to note however, that under the *Tailings Management Protocol*, an internal audit is required for a Level A and an external audit is required for a Level AA. There is no self-assessment for this protocol.
2. *External verification*: Every three years, a Verification Service Provider (VSP) reviews a company's self-assessments to determine if there is adequate evidence to support the performance ratings the facility has reported, and to adjust ratings as appropriate. VSPs are experienced auditors who are independent of the company being verified.
3. *CEO letter of assurance*: In the year of external verification, the company's CEO or most senior executive in Canada submits a letter to MAC that confirms an external verification has been conducted. CEO Letters of Assurance are available on the MAC website.
4. *Post-verification review*: Each year, MAC's Community of Interest Advisory Panel selects a sample of companies to appear before the Panel to present and discuss their *TSM* results. Through these discussions, the Panel tests to see whether and how facility systems are leading to performance improvement.

3. There are two exceptions to this: crisis management and communications planning and preventing child and forced labour. For these two protocols, performance is measured on a yes/no basis.

3.5 EXTERNAL INPUT TO DEVELOPMENT AND IMPLEMENTATION OF *TSM*

When *TSM* was being developed, MAC established a Community of Interest Advisory Panel (COI Panel) to provide advice and oversight on the development and implementation of the programme. The COI Panel played an important role in the original design of *TSM* and continues to inform its implementation and evolution. The Panel serves as a platform for communities of interest and MAC members to discuss and collaborate on issues of mutual concern.

The Panel is an independent, multi-stakeholder group comprised of about 12 to 15 individuals from Indigenous groups, communities where the industry is active, environmental and social non-government organisations, and labour and financial organisations. A small number of members of the MAC Board of Directors also sit on the Panel to provide a mining industry perspective to discussions. The Panel:

- provides support and advice for the *TSM* programme.
- conducts a yearly review of a sample of companies' verified *TSM* results to analyse company systems and practices.
- provides critical perspectives by raising emerging issues of concern beyond those currently covered under *TSM*.

3.6 IMPLEMENTATION OF *TSM*

Participation in *TSM* is mandatory for all MAC members for their operating mines in Canada. Some MAC members also voluntarily apply and report on *TSM* at their operations in other countries. In addition, within Canada, *TSM* has been adopted by the Association minière du Québec (AQM), the provincial industry association in the province of Québec.

In 2018, MAC and AQM members applied the tailings management component of *TSM* at approximately 55 tailings facilities[4] in Canada (including five closed facilities), and six operating facilities in Finland, Surinam, Burkina Faso, Mexico, Peru, and the United States.

In addition to the international application of *TSM* by MAC members, *TSM* has been adopted by industry associations in Finland (2015), Argentina (2016), Botswana (2017), the Philippines (2017), Spain (2018), Brazil (2019), and Norway (2020). Adoption is being seriously considered in several other countries.

At this time, MAC does not have an estimate of the number of tailings facilities to which *TSM* is being applied through *TSM* programmes of industry associations in other countries. In addition, because of the phase-in period following adoption, facilities in those countries are at different stages of implementation of *TSM*.

3.7 DISCLOSURE OF PERFORMANCE AGAINST TSM

For MAC members, all *TSM* results must be reported and publicly disclosed on an annual basis. An annual *TSM Progress Report* is available on the MAC website. For other industry associations adopting *TSM*, public disclosure is a condition of adoption.

4. Note that a small number of mine sites have multiple tailings facilities. In such case, TSM scores for the individual tailings facilities are aggregated to give a since score. Thus, the total number of tailings facilities included is actually higher.

4. INITIATIVE FOR RESPONSIBLE MINING ASSURANCE (IRMA)

4.1 BACKGROUND ON IRMA

IRMA was founded in 2006 by a coalition of nongovernment organisations, businesses purchasing minerals and metals for resale in other products, affected communities, mining companies, and labour unions. IRMA's mission is to establish a multi-stakeholder and independently verified responsible mining assurance system that improves social and environmental performance and creates value for leading mine sites. Through IRMA:

industrial-scale mines can document their leadership and receive value for proven responsible performance

purchasers of metals and minerals can source from mines that meet or are working toward meeting a full array of leading practices in social and environmental responsibility

communities, workers, and civil society organisations can convey social licence with assurance that the mine operates to leading levels of socially and environmentally responsible performance.

The IRMA Standard for Responsible Mining (the IRMA Standard) specifies performance requirements for environmentally and socially responsible practice and is designed to support the achievement of four overarching principles:

Principle 1—Business Integrity

Intent: Operating companies conduct their business in a transparent manner that complies with applicable host country and international laws, regulations and best practice, respects human rights, and builds trust and credibility with workers, communities and stakeholders.

Principle 2— Planning and Managing for Positive Legacies

Intent: Operating companies engage with stakeholders from the early planning stages and throughout the mine lifecycle to ensure that mining projects are planned and managed to deliver positive economic, social and environmental legacies for companies, workers and communities.

Principle 3— Social Responsibility

Intent: Operating companies engage with workers, stakeholders and rights holders to maintain or enhance the health, safety, cultural values, quality of life and livelihoods of workers and communities.

Principle 4—Environmental Responsibility

Intent: Operating companies engage with stakeholders to ensure that mining is planned and carried out in a manner that maintains or enhances environmental values and avoids or minimises impacts to the environment and communities.

4.2 SCOPE OF APPLICATION

The IRMA Standard is intended to be applicable to:

- all types of industrial – or large-scale – mining (including surface, sub-surface and solution mining), and all mined materials (e.g., minerals, metals) with the exception of energy fuels
- mining and associated activities, such as construction of infrastructure or preliminary ore processing, that occur on the mine site, and includes requirements that pertain to different phases of the mine life cycle.

4.3 ASPECTS OF THE IRMA STANDARD RELEVANT TO THE SCOPE OF THE STANDARD

Requirements of the Standard related to tailings management governance are addressed in a chapter in the IRMA Standard entitled 'Waste and Materials Management'. This chapter includes a small number of requirements specific to community engagement, particularly in the context of emergency preparedness. Community engagement is addressed more broadly in chapters under Principle 2— Planning and Managing for Positive Legacies, and Principle 3— Social Responsibility, summarised below. The chapter on Water Management, summarised below, is also relevant to tailings management and the scope of the Standard.

Like ICMM and *TSM*, the IRMA Standard does not address technical design aspects related to tailings management. It does, however, include requirements related to conducting alternatives assessment and application of best available technologies (BAT) and best available/applicable practices (BAP). These requirements are based on the MAC Tailings Guide but are not reflected in the *Tailings Management Protocol,* as *TSM* participation is not required during the planning and design phases of the life cycle.

Tailings Management Governance

The scope of the requirements in the IRMA Standard for waste and materials management includes tailings as well as spent heap leach materials, waste rock, overburden, low grade ore and other wastes and materials. The requirements are relevant for all mines. However, IRMA states that 'at the present time [June 2018 when version 1 of the Standard was released] mine sites using riverine, submarine and lake disposal of mine waste materials will not be certified by IRMA.'

The objective of the relevant chapter in the IRMA Standard is to ensure that wastes and materials are managed in a manner that minimises their short- and long-term physical and chemical risks and protects the health and safety of communities and future land and water uses. This chapter aims to align with requirements in the 2017 versions of MAC's *Tailings Management Protocol* and Tailings Guide. The IRMA Standard, however, also applies the MAC protocol and guidance to mine waste facilities other than tailings facilities.

The relevant requirements of the IRMA Standard are listed below. Note that IRMA does not provide summary descriptions for each of the following categories of requirements. Rather than develop such summaries, the requirements of the IRMA Standard have been summarised below, omitting sub-bullets which contain additional details.

Policy and governance:

The operating company shall:

- develop a policy for managing waste materials and mine waste facilities in a manner that eliminates, if practicable, and otherwise minimises risks to human health, safety, the environment and communities
- demonstrate its commitment to the effective implementation of the policy.

Safe management of materials other than mine wastes

- Not relevant to tailings management governance since this applies to materials, substances and wastes other than mine wastes (e.g. used oils and solvents from vehicle maintenance).

Mine waste source characterisation and impact prediction:

The operating company shall:

- identify all existing and/or proposed mine waste facilities that have the potential to be associated with waste discharges or incidents, including catastrophic failures, that could lead to impacts on human health, safety, the environment or communities
- perform a characterisation for each mine waste facility that has chemical risks
- identify physical risks related to all mine waste facilities where the potential exists for catastrophic failure resulting in impacts on human health, safety, the environment or communities.

Waste facility assessment:

The operating company shall:

- implement a risk-based approach to mine waste assessment and management
- carry out an alternatives assessment to inform mine
- waste facility siting and selection of waste management practices.

Mitigation of risks and management of mine waste management facilities:

The operating company shall:

- design mine waste facilities and mitigate risks in a manner consistent with best available technologies (BAT) and best available/applicable practices (BAP)
- develop and implement risk management strategies
- develop a critical controls framework (e.g. as per MAC's Tailings Guide)
- develop an OMS manual (or equivalent)
- evaluate the performance of mine waste facilities on a regular basis
- update the OMS manual and implement new or revised risk and critical control strategies if information reveals that mine waste facilities are not being effectively operated or maintained
- implement an annual management review to facilitate continual improvement.

Independent Review of Mine Waste Management Facilities

- Siting and design or re-design of mine waste facilities, and the selection and modification of risk management strategies shall be informed by independent reviews.
- Reviews shall be carried out by independent review bodies, which may be composed of a single reviewer or several individuals who are objective, third-party, competent professionals.
- Independent review bodies shall report to the operation's general manager and an Accountable Executive Officer of the operating company or its corporate owner.
- The operating company shall develop and implement an action plan in response to commentary, advice or recommendations from an independent review, document a rationale for any advice or recommendations that will not be implemented, and track progress of the plan's implementation. All of this information shall be made available to IRMA auditors.

Stakeholder Engagement in Mine Waste Management

- Stakeholders shall be consulted when assessing alternatives for mine waste facility siting and management and prior to the finalisation of the design.
- Emergency preparedness and response plans shall be discussed and prepared in consultation with potentially affected communities and workers and/or workers' representatives, and in collaboration with first responders and relevant government agencies.
- Emergency and evacuation drills (desktop and live) related to catastrophic failure of mine waste facilities shall be held on a regular basis.
- If requested by stakeholders, the operating company shall report to stakeholders on mine waste facility management actions, monitoring and surveillance results, independent reviews and the effectiveness of management strategies.

Community Engagement and Public Disclosure

Requirements related to community engagement and public disclosure are described in several different chapters under Principles 1, 2 and 3 of the IRMA Standard. The relevant chapters within each of these principles are:

Principle 1. Business Integrity

Chapter 1.2—Community and Stakeholder Engagement
Intent: Support mining company decision-making and enable communities and stakeholders to participate in mining-related decisions that affect their health, well-being, safety, livelihoods, futures and the environment.

Chapter 1.3—Human Rights Due Diligence
Intent: Respect human rights, and identify, prevent, mitigate and remedy infringements of human rights.

Chapter 1.4—Complaints and Grievance Mechanism and Access to Remedy
Intent: Provide accessible and effective means for affected communities and individuals to raise and resolve mine-related complaints and grievances at the mine operational level, while not limiting their ability to seek remedy through other mechanisms.

Principle 2. Planning and Managing for Positive Legacies

Chapter 2.1—Environmental and Social Impact Assessment and Management
Intent: Proactively anticipate and assess environmental and social impacts, manage them and monitor and adapt environmental and social management systems in a manner that protects affected communities, workers and the environment.

Chapter 2.2—Free, Prior and Informed Consent
Intent: Demonstrate respect for the rights, dignity, aspirations, culture, and livelihoods of Indigenous peoples, participate in ongoing dialogue and engagement and collaborate to minimise impacts and create benefits for indigenous peoples.

Chapter 2.3—Obtaining Community Support and Delivering Benefits
Intent: Obtain and maintain credible broad support from affected communities and produce tangible and equitable benefits.

Chapter 2.4—Resettlement
Intent: Avoid involuntary resettlement, and when that is not possible, equitably compensate affected persons and improve the livelihoods and living standards of displaced persons.

Chapter 2.5—Emergency Preparedness and Response
Intent: Plan for and be prepared to respond effectively to emergency situations that may affect offsite resources or communities.

Chapter 2.6—Planning and Financing Reclamation and Closure
Intent: Protect long-term environmental and social values and ensure that the costs of site reclamation and closure are not borne by affected communities or the wider public.

Principle 3. Social Responsibility

Chapter 3.3—Community Health and Safety
Intent: protect and improve the health and safety of individuals, families, and communities affected by mining projects.

Chapter 3.4—Mining and Conflict-Affected or High-Risk Areas
Intent: prevent contribution to conflict or the perpetration of serious human rights abuses in conflict-affected or high-risk areas.

Chapter 3.7—Cultural Heritage
Intent: protect and respect the cultural heritage of communities and indigenous peoples.

Water Management

The objective of this chapter of the IRMA Standard is to ensure that water resources are managed in a manner that strives to protect current and future uses of water. The scope includes both water quality and quantity. Requirements in this chapter address the following topic areas:

- water management context and collaboration at the local and regional level
- site characterisation and prediction of potential impacts
- prevention and mitigation of impacts to water
- monitoring and adaptive management
- data sharing, communications and reporting on water management performance.

4.4 PERFORMANCE MEASUREMENT AND VERIFICATION

IRMA will provide certification on a site-specific basis for mine sites that have met all relevant requirements of the IRMA Standard. Operating companies must apply to seek IRMA certification, and certification is carried out by independent certification bodies.

There are intermediate steps that an operating company can take in the certification process.

IRMA provides a self-assessment tool for operating companies potentially interesting in seeking certification. Operating companies can also seek verification of individual chapters of the IRMA Standard (called IRMA Transparency), and there are IRMA 50, IRMA 75 and IRMA 100 Certified levels. These are illustrated in Figure 1 below.

Source: https://responsiblemining.net/what-we-do/certification/

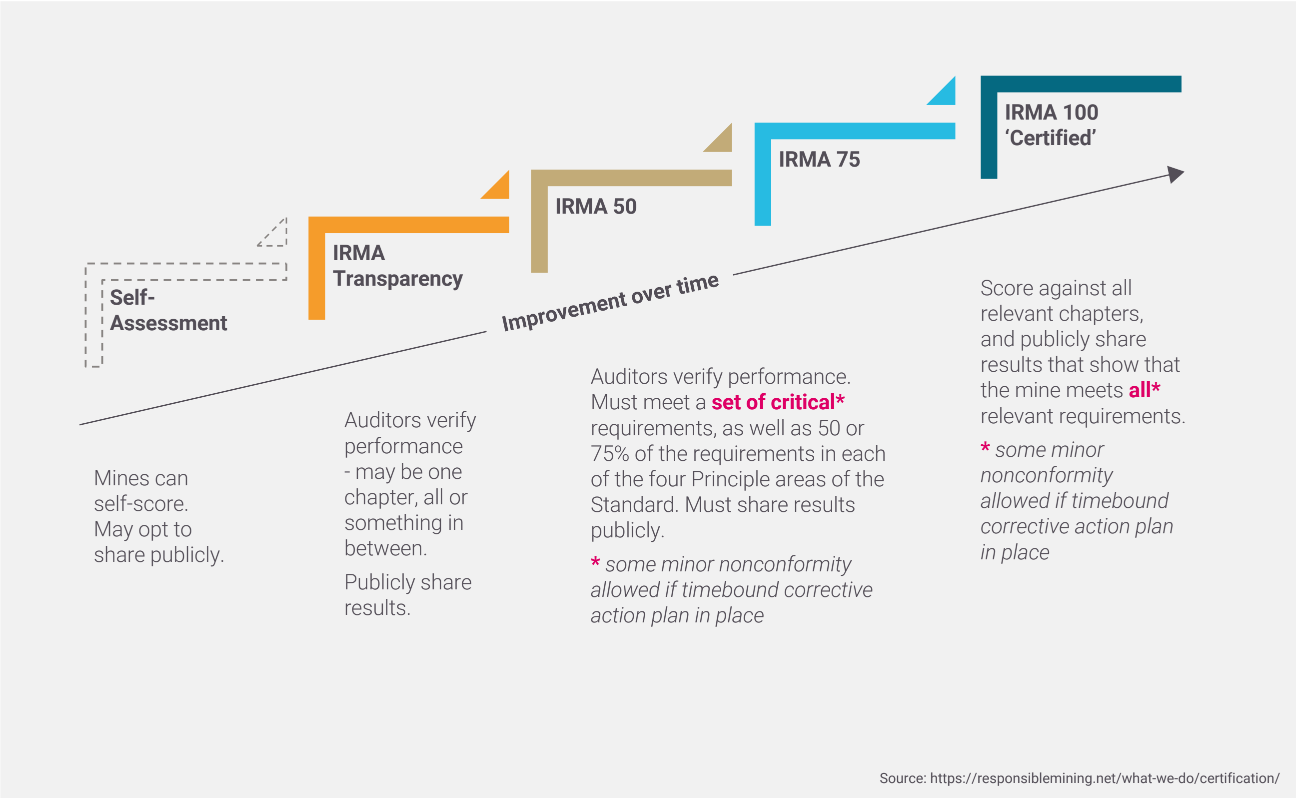

Figure 1. IRMA Achievement Levels

IRMA has prepared IRMA Certification Body Requirements which set out the activities that all certification bodies shall undertake when assessing mining projects that wish to become certified to the IRMA Standard, obtain a verified level of achievement, or undergo surveillance or recertification. The document is intended to:

- enable all certification bodies to operate in a consistent and controlled manner
- enable oversight of certification bodies by IRMA in a consistent and controlled manner
- provide the transparency that is required of an international certification scheme for it to have credibility with stakeholders
- provide documentation for continuity and consistency of the delivery or IRMA certification.

To support performance measurement, IRMA has developed a guidance document. For each requirement of the IRMA Standard this document describes the means of verification and provides examples of evidence and explanatory notes.

4.5 EXTERNAL INPUT TO THE DEVELOPMENT AND IMPLEMENTATION OF THE IRMA STANDARD

The IRMA Standard was created by the multi-stakeholder IRMA Steering Committee (now Board of Directors) and Secretariat through an intensive multi-year consultation process. Representatives of IRMA's five core sectors, as well as representatives from government agencies, financial institutions, academic organisations, related certification programmes, and others, participated in the process to define the content of the Standard.

IRMA conducted two rounds of public consultation (in 2014 and 2016) and two field tests (one in Zimbabwe and one in the United States) in order to collect input on the requirements of the Standard. IRMA also convened multi-stakeholder working groups and consulted independent experts to further articulate requirements that reflect responsible mining.

During the two public consultation periods, more than 120 individuals and organisations provided over 2,100 comments and recommendations that informed the content presented in the IRMA Standard.

4.6 IMPLEMENTATION OF THE IRMA STANDARD

At present, according to the IRMA website, there are two mines that are under assessment by a certification body: one in Mexico and one in Zimbabwe. In addition, a self-assessment has been completed at one mine in South Africa.

4.7 DISCLOSURE OF PERFORMANCE AGAINST THE IRMA STANDARD

Results of assessments by certification bodies will be available on the IRMA website as they become available. Operating companies that conduct self-assessments may opt to make the results of those assessments public.

5. COMPARISON OF THE STANDARD AND OTHER EXISTING STANDARDS

5.1 TAILINGS MANAGEMENT GOVERNANCE

As defined by ICMM, tailings management governance refers to the organisational structures and processes that a company puts in place to ensure the effective management, oversight and accountability for tailings. Tailings management governance consists of several elements:

- assigning accountability and responsibility for tailings management
- implementation of a management systems approach (i.e. tailings management system) to integrate all the Operator's systems, practices and processes related to tailings management (e.g. risk management, managing change) into one comprehensive framework
- assessing and managing risk
- developing and implementing OMS activities to operationalise the tailings management system, risk management plans and related components on a day-to-day basis
- emergency preparedness
- assurance, including Independent Review.

Table 1, below, summarises how each of these elements is addressed in the Standard, the ICMM Performance Expectations, MAC's *TSM* programme and the IRMA Standard.

Table 1. Comparison of governance provisions across standards

The Standard	ICMM Performance Expectation	MAC TSM	IRMA Standard
Accountability and responsibility			
• Requires assignment of executive level accountability, site and/or corporate level responsibility and having an Engineer of Record.	• Addressed, in general terms, but specific aspects not addressed, such as executive level accountability, site-level responsibility and engineer of record. • No additional guidance at present on how to implement, although guidance is under development.	• Requires assignment of executive level accountability, site and/or corporate level responsibility and having an engineer of record. • Tailings Guide provides description of roles and responsibilities of each, which become requirements by way to table of conformance.	• Not explicitly addressed. • Two requirements refer to an accountable executive office. • No requirements pertaining to site and/or corporate level responsibility. • No requirements pertaining to an engineer of record or similar.
Tailings management system			
• Requires development, implementation and review of a tailings management system. • System is less comprehensive than under MAC TSM, with some requirements disconnected from the requirement related to a tailings management system.	• Not addressed. • ICMM guidance currently under development will address tailings management systems, based on the MAC Tailings Guide.	• Requires development, implementation and review of a tailings management system. • Tailings Guide provides a detailed description of a tailings management system, most of which becomes required by way to table of conformance.	• Not addressed.
Assessing and managing risk			
• Includes requirements to assess risk and development and implement risk management plans • Focus is on physical risks of failure • Addresses critical controls management	• Addressed, but at a high level • No additional guidance at present on how to implement, although guidance is under development	• Includes requirements to assess risk and development and implement risk management plans, as part of requirements for a tailings management system. • Focus is on both physical and chemical risk. • Tailings Guide provides details, some of which becomes required by way to table of conformance. • Addresses critical controls management • Further guidance in an appendix	• Includes requirements to assess risk and development and implement risk management plans • Focus is on both physical and chemical risks • Addresses critical controls management, with reference to MAC Tailings Guide • Most detailed of the standards with respect to chemical risks
Operations, maintenance and surveillance activities			
• Requires development and implementation of an OMS manual • Less comprehensive than under MAC TSM, with some requirements disconnected from the requirements related to an OMS manual	• Not addressed. • ICMM guidance under development will address OMS manuals, based on the MAC OMS Guide.	• Requires development, implementation and review of an OMS manual. • OMS Guide provides details, many of which are required by way to table of conformance.	• Requires development, implementation and review of an OMS manual
Emergency preparedness			
• Includes requirements to develop emergency response plans, and to work with potentially impacted communities in the development and testing of plans. • Requires development of inundation studies.	• High level requirements to develop and test plans. • No additional guidance at present on how to develop and test plans, although guidance is under development.	• Includes requirements to develop emergency response plans, and to work with potentially impacted communities in the development and testing of plans. • Requires development of inundation studies for some tailings facilities. • Tailings Guide provides details which becomes required by way to table of conformance	• Includes requirements to develop emergency response plans, and to work with potentially impacted communities in the development and testing of plans. • No requirement to develop inundation studies.
Assurance including independent review			
• Requires development and implementation of independent review mechanisms. • Level of effort scaled based on consequence classification. • Also addresses other assurance mechanisms.	• Addresses at a high level • Independent review not explicitly addressed	• Requires development and implementation of independent review mechanisms. • Level of effort scaled based on risk profile but less prescriptive than the Standard. • Measurement of performance against the Tailings Management Protocol requires internal audit for level A and external audit for level AA. Audits are a form of assurance.	• Requires development and implementation of independent review mechanisms. • Level of effort scaled based on risk, but less prescriptive than the Standard. • IRMA certification would require assessment by a certification body which is a form of assurance.

5.2 COMMUNITY ENGAGEMENT AND PUBLIC DISCLOSURE

The Standard can also be compared with the existing standards with respect to community engagement and public disclosure. However, this comparison is necessarily less detailed that the comparison above for tailings management governance, due to:

- the more diverse ways in which community engagement and public disclosure are addressed in the various standards
- the fact that the Standard is entirely focused on tailings management and requirements related to community engagement and public disclosure are presented in that context, whereas most requirements in the other standards are in the context of site-wide activities related to community engagement.

Based on the structure of the Standard, the table below compares across three areas:

1. engagement with affected communities
2. community engagement in emergency preparedness
3. public disclosure.

Table 2. Comparison of community engagement and public disclosure provisions across standards

Global Industry Standard on Tailings Management	ICMM Performance Expectation	MAC *TSM*	IRMA Standard
Engagement with affected communities			
• Specific requirements for community engagement, respect for human rights, FPIC, social impact assessment.	• Mining Principle 3 – Human Rights, provides eight Performance Expectations. • Mining Principle 9 – Social Performance, provides four Performance Expectations. • Mining Principle 10 – Stakeholder Engagement, provides four Performance Expectations. • FPIC and relationships with Indigenous communities are addressed in Mining Principle 3 and in the *Position Statement: Indigenous Peoples.* • Social impact assessment not explicitly addressed.	• *Indigenous and Community Relationship Protocol* has specific requirements for community engagement and FPIC. • Social impact assessment not explicitly addressed.	• Detailed requirements in • Chapter 1.2—Community and Stakeholder Engagement • Chapter 1.3—Human Rights Due Diligence • Chapter 1.4—Complaints and Grievance Mechanism and Access to Remedy • Chapter 2.1—Environmental and Social Impact Assessment and Management • Chapter 2.2—Free, Prior and Informed Consent • Chapter 2.3—Obtaining Community Support and Delivering Benefits • Chapter 2.4—Resettlement • Chapter 2.6—Planning and Financing Reclamation and Closure.

Global Industry Standard on Tailings Management	ICMM Performance Expectation	MAC *TSM*	IRMA Standard
Community engagement in emergency preparedness			
• Specific requirements to engage with local communities, first responders and others in the development and testing of emergency plans related to tailings management.	• Not specifically addressed in the Position Statement on Tailings Management.	• Specific requirements to engage with local communities, first responders and others in the development and testing of emergency plans related to tailings management.	• Specific requirements to engage with local communities, first responders and others in the development and testing of emergency plans related to tailings management.
Public disclosure			
• Detailed requirements for disclosure of information specific to tailings management.	• Mining Principle 10 – Stakeholder Engagement, includes a Performance Expectation that addresses disclosure. • Since this Performance Expectation is not intended to be specific to tailings management, it does not prescribe specific disclosure or reporting requirements related to tailings.	• *Indigenous and Community Relationship Protocol* has requirements for public reporting. • Since this Protocol is not intended to be specific to tailings management, these requirements do not prescribe specific disclosure or reporting requirements related to tailings.	• The following chapter in the IRMA Standard all have requirements related to disclosure: • Chapter 2.1—Environmental and Social Impact Assessment and Management • Chapter 2.2—Free, Prior and Informed Consent • Chapter 2.4—Resettlement • Chapter 2.6—Planning and Financing Reclamation and Closure. • Since none of these chapters are intended to be specific to tailings management, these requirements do not prescribe specific disclosure requirements related to tailings.

5.3 STATUS OF IMPLEMENTATION OF THE STANDARD

The status of implementation of a standard gives an indication of its maturity. While a more mature standard it not necessarily more effective in achieving its objectives, lessons learned and incorporated over the long period of implementation can help to improve a standard an improve effectiveness of implementation (e.g. performance indicators and criteria refined base on experience to ensure measurability of performance).

MAC *TSM*

This is the oldest and most mature of the standards. The MAC Tailings Guide was first introduced in 1998 and the OMS Guide was introduced based on implementation experience with the Tailings Guide. The *Tailings Management Protocol* was introduced in 2004 and there has been public reporting of performance against the Protocol since 2006, so there is now about 15 years of experience with implementation of the Protocol.

The Protocol, Tailings Guide and OMS Guide were extensively revised and modernised between 2015 and 2019 and a Table of Conformance was introduced to help measure performance against indicators in the Protocol.

TSM is being implemented in more than 60 facilities around the world as part of the MAC *TSM* programme and has been adopted by industry associations around the world. The global adoption and implementation of *TSM* continues to grow.

ICMM Performance Expectations

While the ICMM Performance Expectations were only introduced in February 2020, they are based on the development and implementation of the ICMM Principles of Sustainable Development that date to 2003, and several different Position Statements relevant to the scope of the Standard. Position statements and guidance related to community engagement are the most mature of these.

The Position Statement on Tailings Management is newer and there is less experience with its implementation, particularly at the site-specific level. ICMM does not yet have guidance related to tailings management but a comprehensive guidance document is under development.

As a condition of membership, since 2018 ICMM company members have been required to implement the Position Statement on Tailings Management.

The mechanisms to implement and measure performance against the Performance Expectations are new and as yet un-tested.

IRMA Standard

Version 1 of the IRMA Standard was released in 2018 and version 2 has not yet been released. IRMA development has considered lessons from similar initiatives, including close alignment with MAC *TSM* on tailings management, rather than starting from scratch. In addition, two tests of an early draft of the IRMA Standard were conducted. There has been careful consideration of implementation mechanisms in advance of roll-out of the Standard.

However, the IRMA Standard is both very broad in scope and very detailed. No assessment yes been completed and, to date, no facility has received IRMA certification. Thus, it is certainly less mature than MAC's *TSM*. It is more difficult to compare the IRMA Standard with the ICMM Performance Expectations, since Performance Expectations are, in effect, a new mechanism that brings together a range of pre-existing Position Statements.

Global Industry Standard on Tailings Management

This is a completely new standard. It has been developed in a relatively short period of time (less than one year), resulting in less opportunity to consider and learn from existing standards. This was offset in some respects by the experience of the members of the Expert Panel. However, as an un-tested standard, questions remain, for example, about the measurability of performance against some of the requirements.

More significantly, the implementation mechanism for the Standard is yet to be determined and will be critical to its effectiveness.

KEY MESSAGES

1. When development of the Standard was initiated, several other standards related to tailings management were already in place. Like the Standard, these standards address tailings management, governance, and community engagement and public disclosure.

2. International Council on Mining and Metals (ICMM) Performance Expectations were introduced in 2020 and are being implemented by ICMM's 27 members. Commitments relevant to the Standard are described in:
   - Position Statement: Tailings Management (2016)
   - Position Statement: Indigenous Peoples (2013)
   - Position Statement: Partnerships in Development (2010)
   - Position Statement: Water Stewardship (2017)

3. The Mining Association of Canada (MAC) *Towards Sustainable Mining®* (*TSM®*), was introduced in 2004 and its being implemented at over 60 facilities. TSM has also been adopted by industry associations in several other countries. Requirements relevant to the Standard are described in:
   - *Tailings Management Protocol* (2004, revised 2017 & 2019).
   - *Indigenous and Community Relationships Protocol* (2004, revised 2019).
   - *Water Stewardship Protocol* (2019).

4. The Initiative for Responsible Mining Assurance (IRMA) *Standard for Responsible Mining* was launched in 2018 and is currently being implemented at two mines. Requirements relevant to the Standard are described in:
   - Environmental Responsibility Requirements
     - Chapter 4.1: Waste and Materials Management
     - Chapter 4.2: Water Management
   - Business Integrity Requirements (3 relevant chapters).
   - Planning for Positive Legacies Requirements (6 relevant chapters).
   - Social Responsibility Requirements (3 relevant chapters).

5. There are no existing standards for technical design which is a topic addressed in the Standard. However, guidance from organisations such as the International Commission on Large Dams (ICOLD) is frequently incorporated into legal requirements (e.g. site-specific permits for tailings dams).

CHAPTER XV
INSURABILITY OF TAILINGS RELATED RISK

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1. INTRODUCTION

Mining is and has always been a perilous business, and tailings facilities are integral to mining operations. The tragic consequences of the failures of tailings facilities in Brazil and elsewhere in recent years cost many lives and severely impacted on the livelihoods of large numbers of people. These events also triggered major financial losses for the mining companies that operated these facilities and prompted regulators, civil society organisations, rating agencies and investors around the world to turn their attention to tailings dam safety (Johnson 2019). An industry-wide safety review of tailings dams in Brazil has led to the closure of numerous large mines in the country, while a group of almost a hundred large investors have called on over 700 mining companies to disclose information on their tailings facilities (see Barrie *et al.*, this volume).

Clearly, there needs to be a strong focus on minimising the possibility of such tragic events occurring again. Much can be done to advance this goal, as the necessary technologies, skills and protocols have been around for some time. However, while hoping for the best, we must always be prepared for the worst. Despite the best laid plans, and even if the Global Industry Standard on Tailings Management ('the Standard') is enthusiastically embraced by all involved parties, the fact remains that one will never have full control over forces of nature such as extreme weather events or earthquakes. Insurers are also aware that the majority of incidents giving rise to an insurance claim are attributable to human error, rather than to extraneous factors such as so-called 'acts of God'.

Insurers can help improve industry risk management and at least financially support their clients after tragic events, but this can only be done if there is transparency in the assessment of risks, and if covers are based on risk-adequate prices and conditions. For both the mining industry and insurers, the principles of safety and responsibility must be adhered to, not only in workplaces but also regarding possible consequences for the general public. Adequate insurance has to be part of any effective solution to mitigate the effects of a sudden and accidental catastrophic event. Insurers can also play an important role in preventing future failures by creating incentives for companies to improve their management practices, for example by making access to insurance dependent on companies committing to comply with certain standards.

Unfortunately, the reality at present is that both the prevention and mitigation of tailings facility failure events come at a price that many mining operations cannot currently afford. Insurance solutions need to be accessible and affordable to mining companies and other interested parties wherever possible. An effective solution will also require the energetic and active engagement of global bodies such as the United Nations (UN), the World Bank as well as the governments of individual countries (as discussed later in this chapter). In this context, the development of the Standard provides a unique opportunity to address insurance availability concerns and drive improved tailings facility management practices in the mining sector (Battello 2019).

The remainder of this chapter is organised as follows. Sections 2 and 3 provide an overview of the 'state-of-play' regarding the insurance of tailings facilities and highlight limitations of existing approaches. Section 4 deals with how the management of tailings-related risks currently works and how this can be improved – a key concern of insurers. Section 5 explores the potential to expand insurance solution options, focusing particularly on the use of insurance 'pools' to spread financial risk. Section 6 briefly addresses the broader question of how to maximise the impact of the new Standard. A short glossary is also provided at the end of the chapter for readers unfamiliar with insurance industry terms.

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2. THE RELATIONSHIP BETWEEN MINING AND INSURANCE

The attractiveness of a mining venture to a mining company is often determined by whether or not the company can transfer risk to the insurance industry. It is extremely difficult to raise capital or a loan for an uninsured mine. Investors and banks want to know that their respective activities are protected: no insurance generally means no loan and no capital. Mine operators therefore have to do whatever they can to make a risk quantifiable because the insurance industry, understandably, is only willing to assume risk that is assessable. This task will be made easier if a mine can show that it adheres to certain standards and is fulfilling its obligation to do whatever is necessary to avoid an incident from occurring. Mines need to help the insurance industry help them.

The insurance industry has to set the bar high, even where standards exist. This is especially so in the case of tailings facilities, given that the risks involved are sizable and extremely challenging to assess. Many tailings dams are thirty or more years old, making it almost impossible to accurately establish their current condition, much less how they will continue to perform over time. This is a major reason why tailings dams are generally not insured.

The possible effects of climate change on tailings facilities are adding to the challenges faced by the industry and creating an additional level of uncertainty for insurers. Unlike water retention dams, tailings dams are continuously constructed by 'raises' during the life of a mine (Dugdale and Isleib 2019). Given the potential for the frequency and intensity of rainfall to increase in certain regions, this can increase the aggregate risk of dam failure – as tailings may liquify or break down over time when exposed to heavier rainfall if not managed appropriately.

Even where standards are in place, they are far from providing an absolute guarantee. As insurance expert Manuela Battello explains:

There was no shortage of best available practices and best available technology before the catastrophic events in Brazil. Yet, tailings facility failures occurred there and elsewhere anyway, even on mines managed by the largest and reputedly most sophisticated of mining companies. It is little wonder that insurers are reluctant to underwrite tailings facility exposures. Few mining companies, on the other hand, can afford to bear the full cost of a catastrophic tailings facility event (Battello 2019).

Despite the obvious demand from the mining sector for insurance coverage, given that a 'no insurance' scenario is not viable, the trend in the insurance sector is to move away from covering mining risk. This is creating an imperative for mining companies to find an effective mechanism to provide additional risk-transfer capability in order to safeguard their business.

3. WHERE THE MINING INDUSTRY FINDS ITSELF TODAY

3.1 SIZE AND SCOPE OF THE CHALLENGE

Tailings facilities are integral to any mining operation, irrespective of mining method or mined material. There now exist more than 10,000 dams around the world – the exact number is yet to be determined – of widely varying age, construction type and quality. Size, shape or form can vary considerably, depending on location and/or the commodity being mined. This variability means that there can be no 'one size fits all' solution to insuring these facilities.

Property and business interruption insurance – which is not well-suited to dealing with the perils and exposures that characterise mining operations – has been the home of coverage for tailings facility risks until now. If insured at all, tailings facilities are typically covered as part and parcel of a wider mining operation – i.e. there is no specific 'tailings storage facility insurance' product as such. Instead, insurance cover for facilities can be found in areas such as property insurance, construction insurance, liability insurance, environmental liability insurance, or directors' and officers' insurance. Not one of these products offers anything approaching a comprehensive tailings facility insurance solution.

In light of the recent tailings facilities failures in Brazil and elsewhere, the insurance industry has been revisiting its approach and has been waiting on the release of the Standard for further guidance. The ideal outcome for the Standard is that it becomes truly globally adopted and applied in a way that builds sufficient confidence in the insurance industry for insurers to properly address tailings facilities (Battello 2019).

3.2 LUMP-SUM AGREEMENTS AND HIGHER LIMITS

The shortcomings of property insurance principles become apparent when it comes to business interruption following an insured property damage loss. Loss of revenue due to business interruption is only covered if triggered by an insured property-damage loss. However, tailings of mining operations – the waste from the beneficiation process – are typically a product of little or no value, and thus are not generally covered under generic property policies.

Insurance for tailings facilities was not readily available until about 15 years ago, when the risk of exposure to failing facilities became increasingly apparent outside of the immediate mining world. Insurers responded by providing a lump-sum indemnity for property and business interruption combined, without forensic assessment of each individual tailings dam. Lump-sum coverage effectively treats tailings dam failure as an event (e.g. earthquake) and all subsequent damages downstream of the dam are included in the tailings dam limit. Again though, this cover is limited to property damage and business interruption.

An increasingly competitive insurance environment over the last decade has made it possible for mining companies to conclude such lump-sum agreements, the monetary value of which has increased year after year. However, the wisdom of this approach has been questioned in light of the latest tailings facility incidents. For the moment, the market seems to agree that lump-sum cover is the way to approach tailings dam insurance going forward, with cover limits depending on the quality of the information available and the situation of the actual dam, such as whether it is located above a plant, or at the end of a valley. However, even though lump-sum insurance for property damage and business interruption is better than nothing, it is still only a partial solution.

4. THE WAY FORWARD

The recent tailings facility incidents – and the resultant fatalities, environmental damages and impact on civil society – clearly show that insurance for tailings facilities has to go far beyond the requirements of a property and casualty insurer (although these might be regarded as guiding principles in the initial stages). A different approach is required to provide more effective cover going forward.

4.1 INDIVIDUAL RISK ASSESSMENT: WHY IT IS NEEDED

Much will rest on the ability of the insurance industry at large to correctly assess risks so that they can be insured commensurately. In order to build this capability, insurance professionals who are also experts in the field of mining will need to work closely with mining companies. Structured research should form the basis of the risk assessments for each tailings facility, given that every facility has unique characteristics. This research would provide a basis for calculating critical risk scenarios based on the scope of cover and enable limits of indemnity to be determined. Relevant factors for consideration would need to include the age of a facility, construction type (upstream, centreline or downstream), building materials, probable service life and expected output of operations. Exclusion criteria would also have to be defined. For example, a facility might be excluded if the level of sludge in the retention basin is just below the top of the dam, as this could pose a substantial risk of the dam overflowing during the next heavy rain event.

Assuming that a tailings facility is not excluded from being insured at this initial stage, the next step would be for the insurance underwriters to individually determine the stability of the tailings dams, based on geotechnical reports. This is necessary because, as noted, each tailings facility is different due to varying geological conditions. Important factors to consider in making this assessment would include the material the dams are made from, the method used to raise walls, properties of the soil on which the dam is built, regional weather patterns and seismic activity in the area.

According to Property and Mining consultant Arnold Pulle (2019):

Underwriters will always request reputable third-party engineering reports to give credence to the information provided to them. In relation to tailings dams this means a growing demand for external audit reports and dam break analysis. Markets are placing greater emphasis on the conclusions of these reports and require insureds to follow up on any resultant risk recommendations. The key is to be able to evidence proper controls are in place with regular maintenance… We have recently seen underwriters refuse to cover tailings dams where the required information was not forthcoming and impose restrictions where they were not comfortable with the standard of engineering.

In addition to addressing risks specific to the tailings facility, consideration also needs to be given to the more general risks that affect all infrastructure projects. These include political dangers and construction, operating, maintenance, legal, contractual, financial and revenue risks, as well as 'acts of God'. How can this diversity of risk be managed? The short answer is to take on individual risks from those who are demonstrably best able to control and minimise them. To do this, the parties involved have to clarify who is assigned which risks.

The challenge for participating insurers is to understand the intricacies of tailings facility risks as a whole, and to assess them in a risk-appropriate manner. Ultimately, what is required is a holistic dam-safety management system that covers all phases of tailings dam projects from planning to closure, including the management of the facilities. Widely used and understood consequence-based principles should be extended to cover the entire life span of tailings dams, including the dam safety management system (Herza *et al*. 2019). The latter is essentially what the Standard proposes, with the aim of preventing another Brumadhino-type disaster.

4.2 BEST PRACTICES FOR EVALUATING TAILINGS-RELATED RISK

Debate surrounds what constitutes best practice in the management of tailings-related risk. Country regulations will differ, but insurers should establish that agreed minimum criteria are being addressed in order to be satisfied that tailings dams are meeting applicable internationally recognised standards. Adherence to local country regulations alone would not be acceptable.

The following list is not comprehensive but can be taken as guidance on current best practice. The list will surely evolve further once the Standard is published and experts in all related fields explore all the necessary practical measures that should be taken.

Those developing, managing and maintaining tailings facilities should ensure that:

- Appropriate quality assurance and control procedures are in place to ensure safe construction of dams and subsequent lifts.
- An operation, maintenance, and surveillance (OMS) manual has been developed and is in use.
- Operating parameters are continuously monitored, e.g. phreatic surface, freeboard, beach width, etc. Insurance coverage is only available if such minimum conditions are being maintained.
- The rate of rise of dam walls is limited below certain maximum thresholds.
- Levels of responsibility are clearly defined, and oversight arrangements are in place. For example, senior managers are on site, an Engineer of Record has been appointed, third-party audits are undertaken, and an Independent Tailings Review Board has been established.
- Audit and inspection recommendations are implemented as soon as practicable.

Significant deviations from these best practices may limit or invalidate available insurance cover.

There are certain types of tailings facilities that may not be insurable under any circumstances due to their high-risk nature. An example would be upstream-constructed dams located in seismically active regions where the potential for liquefaction is increased.

Once it has been established that a given tailings facility is insurable, then the parameters of such cover should be clearly defined. If there is a lack of clarity about what cover is being provided, then significant delays could be incurred in determining indemnity and additional costs. It is important to note that tailings and other waste material are always excluded from cover, and this may further limit the amount insurers may be liable for in the event of a loss. Other considerations that would need to be addressed include the extent to which downstream exposures are covered as a consequence of being damaged by the release of tailings from their containment and what, if any, delays in production may be indemnifiable. Insurers must also be confident that the values being declared for tailings dam cover are adequate and have been calculated in accordance with the basis of settlement in the policy wording. This can prove contentious, particularly for dam structures that have been in existence for a prolonged period of time.

Alternative tailings disposal methods and storage options may prove more resilient to failure, for example: dry-stack tailings, co-disposal facilities, in-pit storage, riverine-disposal, and deep-sea disposal. However, all of these alternatives will have specific hazards and failure mechanisms of their own, which mine operators will need to manage appropriately, and insurers will need to assess for risk.

Ultimately, the question to be asked of mine operators is: 'Can you do more to make these structures and disposable methods safer, in line with the best practices outlined above?' The answer should dictate the relative insurability of such infrastructure.

5. EXPANDING POTENTIAL INSURANCE SOLUTION OPTIONS

As discussed above, it may not always be possible for mining companies to obtain cover for existing or new tailings facilities due to the uncertain history of a storage facility, limited resources, poor upstream construction, hazardous location, or some other factor beyond the control of the mining company that renders them unable to qualify for insurance. However, the very real need for insurance still remains in these instances. In fact, the needs of mining companies that are unable to qualify for, or pay for, insurance are likely to be greater than for those companies that are able to meet the requirements for insurance.

So how can we put these companies in a position where they can protect both themselves and the environment they operate in? One possible answer may lie in the formation of national and global funding pools. For example, a 'Global Tailings Facility Pool' could be subsidised by individual mining companies, governments, or by international organisations such as the UN and the World Bank. This option is explored in more detail below.

5.1 THE BENEFITS OF POOLS

A challenge involved in the insurance of tailings facilities is that neither insurers nor individual markets, may have the capacity to cover the risk on their own, especially where these risks are large and there is high accumulation loss potential. Creating pool solutions is a means of keeping these risks manageable for the industry and making them in principle insurable.

Reitsma (2019, p.715) identifies the following reasons for why pools are commonly formed:

- the number of risks to be insured is relatively small
- the risk (amount) to be insured is largely unknown
- the risks to be insured require a capacity which could not be provided within the means of individual members
- the nature of the risk in question makes coverage by conventional methods difficult if not impossible.

These criteria, with the exception of the first, largely align with the insurance needs of a great many tailings facilities, especially older facilities, for which the insurance pool concept would make a great deal of sense. An international pooling mechanism would also result in economies of cost, the benefits of which could be shared by participants in the pool. Demonstrating full compliance with tailings facility safety standards, as set out in the Standard, would be a prerequisite for participating in the pool.

5.2 SETTING UP A GLOBAL POOL

A means of creating a global fund would be to form a global company, or other stand-alone entity, to:

- manage contributions and invest them appropriately
- sponsor research to identify the best practices for mining companies and tailings facility management
- select and appoint engineering firms to check compliance and provide tailings facility certification
- offer loans to mining companies for immediate clean-up costs
- provide reinsurance capacity to insurers.

Such a fund would be subsidised by mining companies, governments (e.g. using a percentage share of earned royalty income) and insurers – who could, for example, pay a premium for access to the capital, such as a percentage share of their committed capacity (Birchall 2020).

6. MAXIMISING THE IMPACT OF THE NEW GLOBAL INDUSTRY STANDARD ON TAILINGS MANAGEMENT

The new Standard will only be effective in preventing future catastrophes to the extent that it is implemented by the mining industry, encouraged by governments and, not least, actively promoted by the UN. Investors will also have an important role to perform, as discussed by Barrie *et al.* (this volume).

6.1 GOVERNMENT INVOLVEMENT

In addition to any role governments might play in setting up national or global pools, each national government should have a political, financial and safety interest in encouraging adequate tailings facility insurance, supporting the principles of the Standard, and monitoring compliance by mining companies and the uptake of this form of insurance. In certain instances, it may even be in a government's interest to build the recommendations of the Standard into a

regulatory framework. Governments could also play a role in selecting and appointing local engineering companies (to be certified by the International Council on Mining and Metals [ICMM] or some other body) who would manage compliance with Standard requirements.

6.2 UNITED NATIONS INVOLVEMENT

Efforts to tighten safety standards and requirements for tailings facilities risk being undermined through bribery and corruption. The UN can help curb these unfortunately widespread practices by working with national governments and other bodies to promote independent compliance checks and strengthen regulatory mechanisms. The open, active and energetic support of the UN will be key to the successful implementation of the Standard and to the development of more effective tailings facility insurance mechanisms. At a broader level, the UN can play a valuable role by continuing to promote good practices in the private sector, through its support for initiatives such as the Principles for Responsible Investment (PRI) and the Principles for Sustainable Insurance (PSI).[5]

A FINAL WORD

Whether the Standard leads to safer tailings facilities and fewer catastrophic events will depend heavily on key stakeholders fulfilling their responsibilities. These stakeholders include not only mine operators, their shareholders, partners, employees and technical consultants, but also insurers. Assuming an ideal world, the insurance sector would very much like to see the Standard adopted as a prerequisite for considering the transfer of tailings facility risks. The benefits of reduced hazards and the transference of risks could then be measured and appreciated in commensurate prices for insurance. However, given the complex situation in the real world, insurers remain sensitive to the fact that it is not possible to solve all challenges at the push of a button.

From the insurers' point of view, the Standard is undoubtedly an important first step towards providing responsible mining companies access to more comprehensive and improved insurance cover and making it more attractive for insurance companies to provide tailings facility cover. Both of these aspects can play a key role in preventing future catastrophic events that cause serious negative consequences for both the environment and society. In the unfortunate but possible circumstance of a loss event, both aspects will also contribute to mitigating the financial impact. This is the economic and societal role of insurers, and they are committed to delivering on that role.

5. Information on these two initiatives can be accessed at https://www.unpri.org/ and https://www.unepfi.org/psi/

KEY MESSAGES

1. Tailings facilities are integral to almost any mining activity. While the facilities themselves represent minor economic value compared to the remainder of the operation, their leakage or rupture can have considerable consequences for people, ecosystems and property.
2. Even if the highest available standards for the safe construction, maintenance and operation of tailings facilities are strictly adhered to, it will never be possible to have full control over forces of nature such as extreme weather events or earthquakes; nor can human error be ruled out.
3. The insurance industry stands ready to meet its role in alleviating the potentially catastrophic effects of a tailings facility failure on innocent third parties and the mining operators themselves. An indispensable prerequisite, however, is that the insured party undertakes whatever is humanly possible to prevent such an incident from occurring.
4. What these precautions should include, in terms of technical to organisational measures, has been defined in the Standard. Adherence to the Standard must be seen as a premise for any insurance cover.
5. Consideration should be given to organising insurance cover in the form of a pool, with a view to creating sufficient capacity to cover the risks of tailings facility failures.
6. As the mining sector is a global industry, the Standard should likewise be applied globally. National governments, regulatory bodies, insurance associations and the like should actively promote the acceptance of the Standard within their respective spheres of influence.
7. This support can be further enhanced by supranational organisations such as the UN and the World Bank, along with global initiatives such as the Principles for Responsible Investment (PRI) and the Principles for Sustainable Insurance (PSI).

GLOSSARY

Business Interruption Insurance	Insurers indemnify the insured for Loss of Revenue for the time its business was interrupted by an insured property damage incident.
Claim	Request by a policyholder or third party from an insurance company for compensation of losses covered by insurance.
Deductible	Specific amount the policyholder must pay out-of-pocket before the insurer pays a claim.
Exclusion	Items or conditions that are not covered by the general insurance contract.
Insurance	A contract in which an insurer financially indemnifies the insured against losses from specific contingencies and/or perils. This is provided by insurance companies, which are for-profit organisations.
Insurable	Fundamentally anything can be insurable, for a cost. The relative insurability of tailings storage facilities has waxed and waned as the insurance market has moved through its various cycles and in consequence of loss experience.
Named Perils	Perils specifically covered on insured property.
Obligatory duty	Obligation of the Insured to do whatever is necessary to avoid an incident giving rise to a claim.
Policy Limit	The maximum amount an insurer will pay under a policy for a covered loss.
Premium	A policy's premium is its price, typically expressed as a monthly cost. The premium is determined by the insurer based on the risk profile of an individual or business.
Products	The insurance industry offers a wide array of products designed around the needs of a specific industry or situation. Of particular relevance in the tailings facility context are liability insurance, property insurance, directors' and officers' liability, and building and construction insurance.
Property	Anything that has value. Traditionally, tailings are defined as having no value and are thus uninsurable.
Reinsurance	In effect, insurance that an insurance company buys for its own protection. The risk of loss is spread, so a disproportionately large loss under a single policy does not fall on one company.
Risk Management	Management of the pure risks to which a company might be subject. Risk management means risk transfer from one party to another, where the party that assumes the risk is paid a premium to do so.
Sub-limit	A sub-limit caps the cover of a specified risk at an amount below the full coverage limit under an overall policy. For example, the insurance coverage falling under property policies for losses associated with tailings facilities is usually sub-limited, meaning it is capped to an amount below the full coverage limit under the property policy.

REFERENCES

Battello, M (2019). Leveraging Risk Transfer Needs in the Mining Sector to Support Adoption of the Global Tailings Standard. Marsh Canada Limited.

Becker G. (2017). Risk-prone dams, 12 January. https://www.munichre.com/topics-online/en/infrastructure/risk-prone-dams.html. Accessed 17 March 2020.

Birchall, B. (2020). Personal Communication.

Dugdale D. and Isleib F. (2019) Dam failure: addressing risk management challenges in the global mining sector. April 25. https://www.manulifeam.com/Research-and-Insights/Market-Views-And-Insights/Dam-failure-addressing-risk-management-challenges-in-the-global-mining-sector/. Accessed 17 March 2020.

Herza, J., Ashley, M. , Thorp J. and Small, A. (2019). 'A Consequence-Based Tailings Dam Safety Framework,' in *Proceedings of the 87th Annual Meeting of International Commission on Large Dams (ICOLD),* 9-14 June 2019. Ottawa, ON: Canadian Dam Association. Available at: https://www.researchgate.net/publication/333845055_A_consequence-based_tailings_dam_safety_framework

Johnson M. (2019). Tailings dam exposure is an unsustainable risk for insurers. June 21. *Insurance Day* https://insuranceday.maritimeintelligence.informa.com/ID1127795/Focus-Tailings-dam-exposure-is-an-unsustainable-risk-for-insurers?vid=Maritime&processId=b5b31ada-ff28-4ab4-b778-9f404dafe99e. Accessed 17 March 2020

Pulle A. (2019) Tailings dams come under growing scrutiny. Miller Insurance Property and Casualty Bulletin. Available at: https://www.miller-insurance.com/news-and-insights/latest-bulletins/property-and-casualty-bulletin---2019/tailings-dams-come-under-growing-scrutiny. Accessed 17 March 2020.

Reitsma S. (n.d.) Nuclear Insurance Pools: World-wide Practice and Prospective. Available at: https://inis.iaea.org/collection/NCLCollectionStore/_Public/31/051/31051428.pdf.

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RELATED INITIATIVES

RELATED INITIATIVES

CHAPTER XVI
INVESTOR MINING AND TAILINGS SAFETY INITIATIVE

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1. INTRODUCTION

The Investor Mining and Tailings Safety Initiative ('the Initiative') was established following the Brumadinho tailings dam disaster that occurred at a Vale owned iron ore mine in Brazil on 25th January 2019. The Initiative, chaired by the Church of England Pensions Board and the Council on Ethics of the Swedish National Pension Funds, is supported by 112 international investors with over USD $14 trillion in assets under management. The Initiative aims to improve understanding and transparency related to the social and financial risk associated with tailings dams and to act to ensure that best practice and standards in the management of mine tailings are implemented. It has been successful, especially within the investor community, in raising awareness of the potentially catastrophic damage that tailings dam failure can have on communities and the environment.

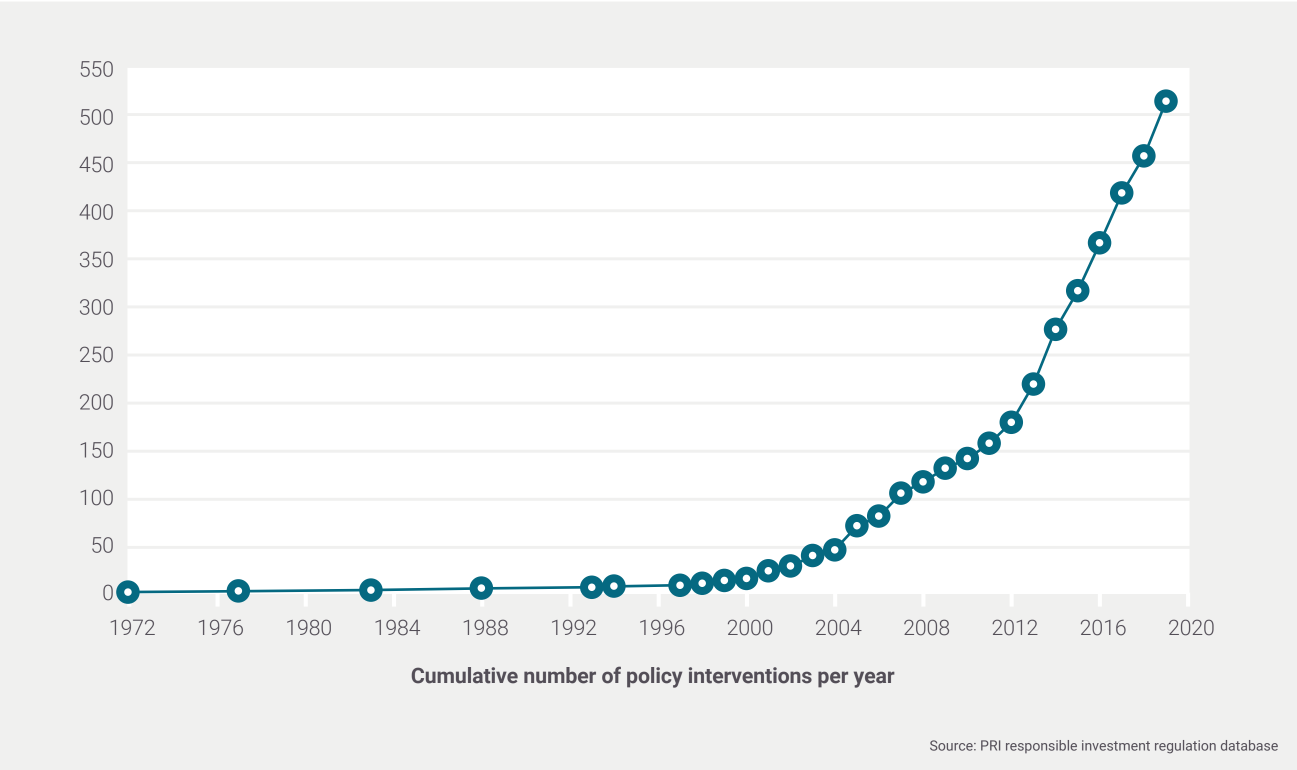

Figure 1: Global cumulative number of 'hard and soft law' policy interventions per year promoting consideration of ESG factors

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It has also invited and gathered extensive new disclosures on tailings storage facilities, and it continues to work on ways to encourage and assess safe tailings practice. This chapter provides some context in relation to the responsible investment approaches of investors more broadly, and outlines the interventions made by the Initiative in 2019 and early 2020.

2. ROLE OF THE ETHICAL/RESPONSIBLE INVESTMENT IN TAILINGS REFORM

A significant and growing proportion of investors take the view that thinking about and acting on environmental, social, and governance (ESG) considerations represents an important part of what it is to be a good long term investor. For many financial institutions, attending to these aspects of the companies they own helps them to control for risk and create competitive advantage. Academic research appears to support the view that there is a positive relationship between ESG factors and corporate financial performance (Busch *et al.* 2018), and globally there is increasing regulatory guidance indicating that ESG considerations ought to be integrated into decision making (Figure. 1)

For some investors, uncovering troubling policies, practices, or events results in disinvestment and exclusions, where an investor excludes a particular company from their portfolio. Standard exclusions cover companies involved in the manufacture of controversial weapons (e.g. cluster bombs, chemical and nuclear weapons) and the most carbon intensive companies (e.g. thermal coal and tar sands producers). Exclusions may also include so called 'sin stocks' such as companies that derive revenue from tobacco, gambling, and pornography. Where concerns are raised about a company that does not fall under these headings, standard practice is for investors to engage with the board of the company over a period of time, to try to seek improvements.

Some investors, including the Church of England's investing bodies, the Swedish AP Funds and Germany's Union Investments, have excluded investment in Vale (Financial Times 2019). However, the approach of the Investor Mining and Safety Initiative is one of positive engagement with the industry, recognising that good practice exists in the sector and seeking to bring influence to bear in order to improve safety practices[1].

1. Investors have long engaged with mining companies on other safety matters, for example in relation to welfare, operational health and safety, and fatalities.

Responsible investors seek improvements in the underlying companies in their portfolios, and they do this using a number of tools. These include: letters engaging directly with the Board (e.g. the Chairman, CEO and lead independent Director); face to face meetings between shareholders and Board members; proxy voting; and the filing of shareholder resolutions (where shareholders vote or raise issues to be voted on at the Annual General Meeting). Investors also seek to influence companies indirectly, such as through the development of formal shareholder expectations or assessment tools, where investors publish and support particular standards they expect to be met; and through regulatory influence, where investors seek to improve the regulatory environment.

It is relatively unusual for investors to attempt to engage with an entire sector. However, there are some examples where systemic challenges are evident, such as in relation to climate change. At some of the early investor roundtables, the Investor Mining and Tailings Safety Initiative ('the Initiative') began to develop the shared view that tailings represent a systemic challenge for the sector and for other sectors linked to mining through the supply chain. This confirmed and developed views previously expressed by GRID Arendal (Roche, Thygesen, and Baker eds. 2017) and the Church of England (Church of England Ethical Investment Advisory Group 2017), among others.

3. INTERVENTIONS

On 31st January 2019, after the official mourning period for the victims of the Brumadinho disaster ended, members of the Initiative first made a public call for new global tailings standards to be developed, based upon the consequences of failure. Investors called for the standards to be developed independently from industry and with an emphasis on public accessibility (Church of England Media Briefing 2019a). This was one of the key drivers for establishing the Global Tailings Review (GTR). It led to the Principles for Responsible Investment (PRI) becoming a co-convenor of the GTR, in conjunction with the Church of England Pensions Board and Swedish Council on Ethics as the PRI's investor representatives. During the consultation phase of the GTR, the PRI investor representatives consulted with the wider Investor Mining and Tailings Safety Initiative members to develop the PRI's input into the GTR process.

The prospect of a standard is particularly significant for investors because it presents an opportunity to drive safety and operational standards in tailings management globally, in a way that is (or should be) applicable to the whole industry. First and foremost, this may save lives, but in investment terms, will also control for environmental and social risks, while improving governance around an aspect of mining that has often lacked transparency. A high degree of exposure to tailings risk may be a factor in investment decisions. For 'universal owners' (investors so large and diversified they effectively own a portion of the entire market, and are therefore exposed to systemic risks), long term investors, and those with stewardship responsibilities exposed to the mining sector through e.g. passive investment or in the supply chains of other holdings, opportunities to understand, assess and mitigate risk will be welcome.

Recognising the systemic challenge posed by tailings, investors interrogated the state of corporate reporting and investor analysis on the risks and exposure to tailings in their portfolios. Consensus among investors was that while tailings may be mentioned in the risk reporting companies undertake, this fell short of the level of detail investors required. The second intervention by the Initiative was therefore to make a disclosure request of publicly listed extractive companies – 727 in total – requiring them to disclose answers to 20 questions on each tailings facility at operations they directly controlled, or where they were a joint venture partner.

The 20 disclosure questions (see Table 2 below), were developed in consultation with independent technical advisors, the Secretariat of the International Council on Mining and Metals (ICMM) and four mining companies. These questions were primarily designed to elicit basic engineering and governance information, and also to assess the state of risk assessment for each facility (for example, question 19 asks whether engineering assumptions have been adjusted to take climate change into account).

4. TIMELINE

Table 1 below shows the timeline for various milestones of the Investor Mining and Tailings Safety Initiative. These include the interventions outlined in this chapter, and the various meetings that took place that enabled investors to improve their understanding of the issues, engage with industry, and coordinate the interventions. Meetings were hosted in London with some participants dialling-in remotely, each event gathering between 60 and 120 participants from a variety of disciplines under the Chatham House Rule. Attendees included investors, bankers, insurers, representatives of mining companies, engineering and geological experts, community representatives, regulators, government officials, and data experts. A financial/reporting working group was established in June 2019 with participants forming five investor institutions, which presented findings to the October 2019 Summit. This is an ongoing work-stream of the Initiative

Table 1. Milestones for the Initiative

Timeline	Date
Call for new global tailings standard	31 January 2019
1st investor round table	4 March 2019
2nd investor round table	1 April 2019
Company disclosure request	5 and 17 April 2019
3rd investor round table	7 May 2019
Initial company response deadline	7 June 2019
4th investor round table	10 June 2019
Establishment of Financial/Reporting Working Group	10 June 2019
Mine and Tailings Safety Summit	31 October 2019
Global Tailings Summit	25 January 2020
Joint shareholder delegations to Minas Gerais	To be determined

5. THE DISCLOSURE REQUEST

The disclosure request letter, originally sent on 5 April 2019, is available online (Matthews and Howchin 2019). The detailed disclosure questions and accompanying notes are provided below in Table 2. It is notable that the letter asked companies to post answers on their website as a matter of urgency within 45 days, and to have them authorised by the Chief Executive Office, and/or the Chair of the board. The letter also attempted to close what might be called disclosure loop-holes by also requiring disclosure of tailings dams operated by subsidiaries, partnerships and joint ventures, even if the disclosing company was not the 'operating partner' in the joint venture.

In all, 727 companies were approached for disclosure, and the net was cast relatively wide in relation to companies' potential involvement in tailings[2]. For example, we approached companies in the oil and gas sector, due to their potential involvement through tar sands operations.

Table 2. Information sought in disclosure request

Information requested	Instructions
1.'Tailings Facility' Name/identifier	Please identify every tailings storage facility and identify if there are multiple dams (saddle or secondary dams) within that facility. Please provide details of these within question 20.
2. Location	Please provide Long/Lat coordinates
3. Ownership	Please specify: Owned and Operated, Subsidiary, JV, NOJV, as of March 2019
4. Status	Please specify: Active, Inactive/Care and Maintenance, Closed etc. We take closed to mean: a closure plan was developed and approved by the relevant local government agency, and key stakeholders were involved in its development; closed facility means the noted approved closure plan was fully implemented or the closure plan is in the process of being implemented. A facility that is inactive or under Care and Maintenance is not considered closed until such time as a closure plan has been implemented.
5. Date of initial operation	(date)
6. Is the Dam currently operated or closed as per currently approved design?	Yes/No. If 'No', more information can be provided in the answer to Q20
7. Raising method	Note: Upstream, Centreline, Modified Centreline, Downstream, Landform, Other.
8. Current Maximum Height	Note: Please disclose in metres
9. Current Tailings Storage Impoundment Volume	Note: (m^3 as of March 2019).
10. Planned Tailings Storage Impoundment Volume in 5-years-time.	(m^3 as planned for January 2024.)

2. We approached companies with the following GICS sub-industry categories: Oil and Gas Drilling, Oil and Gas Exploration and Production, Integrated Oil and Gas, Coal and Consumable Fuels, Fertilizers and Agricultural Chemicals, Aluminium, Diversified Metals and Mining, Copper, Gold, Precious Metals and Minerals, Silver, Steel, and Construction Materials. We also incorporated some additional companies at the request of investor participants in the Initiative.

Information requested	Instructions
11. Most recent Independent Expert Review	(Date). For this question we take 'Independent' to mean a suitably qualified individual or team, external to the Operation, that does not direct the design or construction work for that facility.
12. Do you have full and complete relevant engineering records including design, construction, operation, maintenance, and/or closure?	(Yes or No). We take the word 'relevant' here to mean that you have all necessary documents to make an informed and substantiated decision on the safety of the dam, be it an old facility, or an acquisition, or legacy site. More information can be provided in your answer to Q.20.
13. What is your hazard categorisation of this facility, based on the consequence of failure?	
14. What guideline do you follow for the classification system	
15. Has this facility, at any point in its history, failed to be confirmed or certified as stable, or experienced notable stability concerns, as identified by an independent engineer (even if later certified as stable by the same or a different firm).	(Yes or No). We note that this will depend on factors including local legislation that are not necessarily tied to best practice. As such, and because remedial action may have been taken, a 'Yes' answer may not indicate heightened risk. Stability concerns might include toe seepage, dam movement, overtopping, spillway failure, piping etc. If yes, have appropriately designed and reviewed mitigation actions been implemented? We also note that this question does not bear upon the appropriateness of the criteria, but rather the stewardship levels of the facility or the dam. Additional comments/information may be supplied in your answer to Q20.
16. Do you have internal/in house engineering specialist oversight of this facility? Or do you have external engineering support for this purpose?	Note: Answers may be 'Both'.
17. Has a formal analysis of the downstream impact on communities, ecosystems and critical infrastructure in the event of catastrophic failure been undertaken and to reflect final conditions? If so, when did this assessment take place?	Note: Please answer 'yes' or 'no', and if 'yes', provide a date.
18. Is there: a) a closure plan in place for this dam, and b) does it include long term monitoring?	Please answer both parts of this question (e.g. Yes and Yes).
19. Have you, or do you plan to assess your tailings facilities against the impact of more regular extreme weather events as a result of climate change, e.g. over the next two years?	(Yes or No).
20. Any other relevant information and supporting documentation.	Note: this may include links to annual report disclosures, further information in the public domain, guidelines or reports etc.

6. RESULTS OF THE DISCLOSURE REQUEST

As of March 2020, just under half of the companies approached had responded, with 152 companies confirming that they have tailings storage facilities (this includes both operator and joint venture interests). The 152 companies represent approximately 83% of the publicly listed mining industry by market capitalisation, and include 45 of the 50 largest companies.

The Church of England Pensions Board has maintained a public record of the companies contacted, and of those that have – and have not – responded.[3] Robeco, a Dutch asset management firm, have coordinated an engagement programme among investors to encourage disclosure from laggards.

7. THE PORTAL

These disclosures led to the third intervention, which was the creation of a public and free to use global tailings data portal. The Initiative formed a partnership with the Norwegian Foundation, GRID Arendal, the University of Sydney and UNEP to ensure that the new disclosures are gathered, standardised and presented in an accessible format.

The database was launched as the Global Tailings Portal,[4] in January 2020, on the eve of the first anniversary of the Brumadinho disaster. It contains detailed information on more than 1,700 tailings storage facilities around the world. Previously, very little information about these facilities was publicly available, and the data that were available were disclosed inconsistently across company annual reports, websites, and regulatory filings. See Franks *et al.* (this volume) for some initial findings from these disclosures.

Investors plan on using the portal for ESG due diligence, to complement the assessment of current and prospective investments. We expect the Portal and the Global Industry Standard on Tailings Management ('the Standard') to be mutually supportive, and that the portal could serve as a repository of relevant disclosure information required by the Standard. The portal could also provide a tool to monitor the progress of adoption of the Standard.

The next steps in the development of the Global Tailings Portal involve the establishment of a board and governance structure to help further define the role and mission of the portal. At present there are plans to include information on closed and legacy sites to support monitoring and remediation, a system to identify dangerous dams, and links to an alert system.

8. LOOKING FORWARD

The Initiative continues to meet and engage with the sector. Most recently a Global Tailings Summit was convened by the Initiative on the anniversary of the Brumadinho disaster. At the Summit, a delegation of members was announced that will visit mine sites and communities in Brazil. The voice of community members from affected areas in Brazil has been a regular feature of the Initiative's meetings, and this delegation is a positive response to their invitation for investors to 'come and see'.

The Initiative's co-chairs continue to support the GTR as co-convenors on behalf of PRI, because the Standard is a centrally important project that will drive good practice and good governance. There can be no single solution to the kind of challenges that tailings facilities raise. There are human, engineering, environmental, economic and regulatory factors at work. This is all the more reason for all involved to continue to work towards safer tailings.

At recent meetings, the Initiative has also considered 'Investor Expectations' on tailings management, and has called for a global independent monitoring station to be established with the capacity to provide a 24/7 alert system along the lines of those established for the shipping and aviation sectors. Investors are considering how they can support improved reporting and the provision of insurance for tailings facilities. The Initiative has also suggested the need for a systematic identification and removal of the most dangerous tailings facilities.

All of these various activities are in the fascinating space where long term commercial and investor initiatives overlap with the public good – the common good. It is in society's interest to have more transparent and timely information on large structures that can pose risks to people and the environment. It is tragic that it takes such a catastrophe to focus minds and create the urgency that we hope can begin to make tailings facilities safer.

3. See https://www.churchofengland.org/investor-mining-tailings-safety-initiative
4. See http://tailing.grida.no/

KEY MESSAGES

1. A coalition of 112 international investors with over USD $14 trillion in assets under management was established in 2019 to improve understanding and transparency related to the social and financial risk associated with tailings dams.

2. Investors are increasingly scrutinising company performance on environmental, social, and governance (ESG) criteria. Tailings storage facilities have implications for all three 'ESG' pillars.

3. Investors have taken the view that tailings represent a systemic challenge for the mining sector and for other sectors linked to mining through the supply chain

4. The Investor Mining and Tailings Safety Initiative has made a number of interventions, including calling for a Global Tailing Standard, asking for improved disclosure from 727 extractive companies, and collating and organising those disclosures in an accessible database: The Global Tailings Portal.

5. The response to the disclosure request has been positive. As of March 2020, 152 companies have confirmed that they have tailings storage facilities (this includes both operator and joint venture interests). The 152 companies represent approximately 83% of the publicly listed mining industry by market capitalisation, and includes 45 of the 50 largest companies.

6. The Initiative continues to work for safer, and more well understood tailings facilities. It is pursuing projects on insurance and disclosure, tailings monitoring, and the removal of the most dangerous dams.

REFERENCES

Busch, T., Friede, G., Lewis, M. and Bassen, A. (2018). *Digging Deeper into the ESG-Corporate Financial Performance-Relationship* DWS Investment. https://download.dws.com/download?elib-assetguid=714aed4c2e83471787d1ca0f1b559006&wt_eid=2156623951900953270&wt_t=1566240624353

Church of England Ethical Investment Advisory Group (2017). *Extractive Industries Ethical Investment Policy.* Available at: https://www.churchofengland.org/sites/default/files/2018-03/Extractive%20Industries%20Policy%20and%20Advice.pdf

Church of England Media Briefing (2019). *Call for new independent mine safety system to address tailings dam failures.* https://www.churchofengland.org/more/media-centre/news/call-new-independent-mine-safety-system-address-tailings-dam-failures

Financial Times 2019. V*ale under pressure over safety as Union Investment sells stake.* https://www.ft.com/content/308c0a20-579a-11e9-91f9-b6515a54c5b1

Roche, C., Thygesen, K., Baker, E. (eds.) (2017). *Mine Tailings Storage: Safety Is No Accident.* Nairobi and Arendal: United Nations Environment Programme and GRID-Arendal.

Matthews, A. and Howchin, J. (2019). Urgent request for information concerning tailings dam management. https://www.churchofengland.org/sites/default/files/2019-04/Disclosure%20Letter%20to%20the%20Extractive%20Industry%20.pdf

United Nations Principles for Responsible Investment [UNPRI] (2019). *Responsible Investment Regulation Map.* September. https://www.unpri.org/sustainable-markets/regulation-map

RELATED INITIATIVES

CHAPTER XVII UNITED NATIONS ENVIRONMENT ASSEMBLY RESOLUTION ON MINERAL RESOURCE GOVERNANCE

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1. INTRODUCTION

Minerals underpin global development and are critical to the achievement of the United Nations (UN) Sustainable Development Goals (SDGs), even while the production of mineral commodities continues to be characterised by significant environmental, social and economic challenges. The UN has a long history of involvement in the governance of mineral resources for sustainable development and has played a key role in a range of initiatives (see Text Box 1).

In 2017, UNEP and GRID-Arendal initiated a work programme on tailings aimed at suggesting policy actions which may accelerate the change required to ensure the safety of tailings dams. This was in response to the call for action from several Non-Governmental Organisations (NGOs) to the Executive Director of the United Nations Environment Programme (UNEP) first in 2015, and again in 2016, following the Mt Polley and Fundão tailings dam disasters. The work programme subsequently contributed to the foundations of the Global Tailings Review (GTR) which UNEP co-convened in close cooperation with the mining and investor community. Simultaneously the International Resource Panel (IRP), an initiative of UNEP, commenced a study on mineral resource governance, while UNEP and GRID-Geneva conducted research on sand governance.

These interlocking activities culminated in the adoption of the Resolution on Mineral Resource Governance ('the Resolution') at the fourth session of the United Nations Environment Assembly (UNEA) in 2019. The Resolution and its implementation are a point of focus for greater coordination of mineral governance initiatives. In this chapter we summarise the background and content of the Resolution, detail the findings of recent reports on mineral governance that have contributed to its adoption, and outline future directions for its implementation.

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2. CONTENTS OF THE UNEA-4 RESOLUTION

UNEA is the principal global decision-making body on the environment. Membership of the assembly includes all 193 UN Member States.

The fourth session of the UNEA, held in Nairobi, Kenya, from 11-15 March 2019 adopted the UNEA Resolution UNEP/EA.4/Res. 19 on Mineral Resource Governance (UNEA 2009). The Resolution recognises the important contribution of mining towards the achievement of the SDGs, the dependence of low-carbon clean technologies on metals and minerals, and the critical role that governance plays in ensuring positive outcomes from mineral development. The operative text of the Resolution is reproduced below.

Operative text from the UNEA-4 Resolution on Mineral Resource Governance[1]

1. *Recognises* the findings of the International Resource Panel related to the sustainable management of metal and mineral resources and the need for further action, as well as the findings of the United Nations Environment Programme on mine tailings storage and those of the United Nations Environment Programme and its Global Resource Information Database (GRID)-Geneva on sustainable sand management;
2. *Also recognises* that sustainable management of metal and mineral resources contributes significantly to the achievement of the Sustainable Development Goals;
3. *Underlines* 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;
4. *Requests* the Executive Director of the United Nations Environment Programme, on the basis of reports such as those prepared by the International Resource Panel and United Nations Environment Programme-GRID, to collect information on sustainable practices, identify knowledge gaps and options for implementation strategies, and undertake an overview of existing assessments of different governance initiatives and approaches relating to sustainable management of metal and mineral resources, and report thereon to the United Nations Environment Assembly at its fifth session;
5. *Encourages* governments, businesses, non-governmental organisations, academia and international institutions, within their different areas of competence, to promote:
   a. Awareness of how the extractive industries can contribute to the sustainable development of countries and the well-being of their populations, as well as of the possible negative impacts on human health and the environment when these activities are not properly managed;
   b. Due diligence best practice along the supply chain, addressing broad-based environmental, human-rights-, labour- and conflict-related risks in mining, including the continuing increase in transparency and the fight against corruption, with the support of the Extractive Industries Transparency Initiative, implementation and monitoring of existing environmental standards, and accountability;
   c. Capacity-building mechanisms for the sustainable management of metal and mineral resources, including the management of major hazards, as well as to address mine closure requirements and the remediation of contaminated sites, including abandoned mines;
   d. Public-private partnerships to promote sustainable management of metal and mineral resources;
   e. Research, development and technological innovations to sustainably manage metal and mineral resources;
   f. Sustainable mining and sourcing of raw materials in order to move towards decoupling economic growth from environmental degradation through approaches including but not limited to resource efficiency and the circular economy;
   g. A reduction of the impacts associated with the materials needed for the transition to an innovative and environmentally friendly economy.

1. The full Resolution including the preamble paragraphs can be found here: https://bit.ly/3apGrcX

Box 1: UN involvement in the governance of mineral resources for sustainable development

(a) The UN Global Compact (2000)
(b) The Kimberley Process Certification Scheme (2001)
(c) The International Cyanide Management Code (2002)
(d) The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (2002)
(e) The Yaoundé Declaration on Artisanal and Small-scale Mining in Africa (2002)
(f) The IFC Performance Standards on Environmental and Social Sustainability (2006)
(g) The Africa Mining Vision (2009),
(h) The UN Guiding Principles on Business and Human Rights (2011)
(i) The Minamata Convention on Mercury (2013)
(j) The Mosi-oa-Tunya Declaration on Artisanal and Small-scale Mining, Quarrying and Development (2018)
(k) The Global Tailings Review (GTR) (2019-20)

3. BACKGROUND TO THE UNEA-4 RESOLUTION

The UNEA-4 Resolution on Mineral Resource Governance is the culmination of a series of interlocking initiatives.

3.1 TAILINGS

Following the disasters at Mt Polley and Fundão, UNEP established a work programme on tailings management. The disasters demonstrated that tailings management remained unfinished business, despite being core to the Mining, Minerals and Sustainable Development Project's call to action nearly 20 years ago (International Institute of Environment and Development [IIED] 2002; Franks *et al.* 2011).

In 2017, UNEP and GRID-Arendal published a rapid assessment report *Mine tailings storage: Safety is no accident* (Roche *et al.* 2017), which was launched at the third session of UNEA in December 2017. The report examines the human and environmental costs of continued tailings dam disasters, assesses why tailings dam failures occur, and suggests policy actions aimed at catalysing the change needed to ensure tailings dam safety.

The report proposes the establishment of a stakeholder forum to facilitate international strengthening of tailings dam regulation and recommends three priority actions:

Action 1. Facilitate international cooperation on mining regulation and the safe storage of mine tailings through a knowledge hub.

a. Create and fund an accessible public-interest, global database of mine sites, tailings storage facilities and research.

b. Fund research into mine tailings storage failures and management of active, inactive and abandoned mine sites.

c. Compile and review existing regulations and best practice guidance.

Action 2. Failure prevention.

d. Expand mining regulations, including tailings storage, independent monitoring and the enforcement of financial and criminal sanctions for non-compliance.

e. Regularly publish disaster management plans that relate to local and regional circumstances and planning.

f. Increase gender diversity on company boards and include local representatives and skill sets focusing on community engagement, ethics, and social and environmental impact.

g. Establish independent waste-review boards to conduct and publish independent technical reviews prior to, during construction or modification and throughout tailings storage-facility lifespan.

h. Avoid dam construction methods known to be high risk.

i. Ensure any project assessment or expansion publishes all externalised costs, with an independent life-of-mine sustainability cost-benefit analysis.

j. Require detailed and ongoing evaluations of potential failure modes, residual risks and perpetual management costs of tailings storage facilities.

k. Enforce mandatory financial securities for life of the mine (includes post-closure).

l. Ban or commit to not use riverine tailings disposal. Adopt a presumption against the use of submarine tailings disposal, water covers on tailings dams and the use of upstream and cascading tailings dams unless justified by independent review.

Action 3. Crisis response.

m. Establish a global financial assurance system for mine sites to ensure rehabilitation, tailings management and monitoring.

n. Fund a global insurance pool to address any unmet liabilities from major tailings dam failures on local communities.

In December 2018, UNEP and GRID-Arendal held a stakeholder workshop to catalyse actions on tailings. Proceedings of the meeting were published as *A roadmap for improved mine waste management* (UNEP 2019a). The roadmap identifies three priorities for action on the mine tailings agenda:

1. enlarging the stakeholder forum and reinforcing communication and awareness raising
2. developing a global standard for mine waste management, beginning by reviewing existing standards, conventions and multi-stakeholder initiatives relevant to responsible mine waste management
3. developing a global data base of mine sites, tailings dams and mine waste volumes and characteristics.

3.2 SAND

Urbanisation and infrastructure are creating substantial demand to supply aggregate (sand, gravel and crushed stone) for the construction sectors. This is driving environmental change, particularly where sand and gravel are sourced from natural waterways. Tailings are one potential source of alternate construction material to replace the mining of aggregate.

In 2019 UNEP and GRID Geneva published *Sand and Sustainability: Finding New Solutions for Environmental Governance of Global Sand Resources*. The report builds on earlier work by Peduzzi (2014) and finds that the scale of the sand and gravel extraction makes it one of the major sustainability challenges of the 21st century. These materials are one of the largest resources extracted and traded by volume, with as much as 50 billion tonnes of aggregate produced from quarries, rivers, lakes and the ocean each year (Bendixon *et al*. 2019; Franks 2020).

The report recommends the following:

- Utilise existing solutions to prevent or reduce damage to river, beach and marine ecosystems and social risks to workers and communities in sand extraction sites:
  - avoiding consumption through reducing over-building and over-design
  - using recycled and alternative materials to sand in the construction sector
  - reducing impacts through implementing existing standards and best practices.
- Customise existing standards and best practices to national circumstances and extend where necessary to curb irresponsible and illegal extraction.
- Reconcile globally-relevant policies and standards with the local realities of domestic sand resource availability, local development imperatives and standards and enforcement realities.
- Invest in sand production and consumption measurement, monitoring and planning.
- Establish dialogue between key players and stakeholders in the sand value chain based on transparency and accountability.
- Build consensus through improved coordination and public awareness-raising at the global, regional and national levels on how much our current development trajectory is dependent on sand supply and the sustainability challenges this poses.

3.3 MINERAL RESOURCE GOVERNANCE

In February of 2020 the IRP and UNEP published the report *Mineral Resource Governance in the 21st Century: Gearing Extractive Industries Towards Sustainable Development* (Ayuk *et al.* 2020). The report proposes a new governance framework for the extractive sector, based on the concept of a Sustainable Development Licence to Operate. It follows an earlier summary report for policy makers published in 2019 that was presented at UNEA-4 and discussed in the context of the UNEA-4 Resolution. The report was initially requested by the IRP Steering Committee at its 18th Meeting (Cape Town, 6-9 June 2016) and responds to a Recommendation adopted at the 21st Meeting of the Convention on Biological Diversity Subsidiary Body on Scientific, Technical and Technological Advice (Montreal, 11-14 December 2017).

The report concludes that, despite moves to decouple economies from resource use and promote greater recycling, extractive resources will continue to play a central role in driving the global economy. Emerging economies, expanding populations, global middle-class growth and increased urbanization, as well as the global transition to clean energy production, are some of the drivers highlighted in the report as contributing to an increase in demands for minerals and metals.

The report observes that there is now a plethora of domestic, regional and international legal and regulatory frameworks, as well as voluntary formal and informal initiatives and instruments, aimed at improving governance of the extractive industry in order to increase economic prosperity and strengthen environmental protection. However, collectively, these legal frameworks and initiatives have failed to bring about a transition away from the 'extractivist' and anthropocentric model that is prevalent in the developing world. In most resource-rich developing countries, the extractive sector has remained an enclave with inadequate linkages to the wider local economy, and the wealth generated from mineral resources has not translated into broader economic, human and social development. Furthermore, mining in these contexts continues to prioritise human needs and wants over the integrity of ecosystems.

The report calls for concerted global efforts to consolidate existing rules and regulations in the mining sector and to agree on international standards. This new global governance architecture needs to support ongoing economic development, structural transformation and economic diversification in resource-rich countries. It should address not only resource security, but also resource efficiency, the decoupling of resource use, and the environmental impacts from economic growth. In particular the report recommends:

- greater harmonisation and alignment across existing instruments and standards

- international dialogue to consider options for new agreements to strengthen transnational governance of mining
- creating, empowering and building capacity in national, sub-national and local institutions
- creation of an International Minerals Agency, or the signing of an international agreement, to, *inter alia*, coordinate and share data on economic geology, mineral demand needs, and promote transparency on impacts and benefits
- relevant international communities of experts to consider options for forming a 'High-level Panel on Sustainable Development of Mining', to develop recommendations for the design of transnational instruments to strengthen mining governance (Ayuk *et al*. 2020).

4. IMPLEMENTATION OF THE UNEA-4 RESOLUTION AND FUTURE DIRECTIONS

The above reports provide an important knowledge base for advancements in minerals resource governance. Their findings will be complemented with additional work carried out by UN agencies on this agenda, including work focusing on artisanal and small-scale miners, which led to the *Mosi-oa-Tunya Declaration on Artisanal and Small-scale Mining, Quarrying and Development* (Franks *et al.* 2020) as well as work focussing on so-called 'Development Minerals', that is, minerals and materials that are mined, processed, manufactured and used domestically (Franks 2020).

In order to move forward in the discussion on mineral resource governance, greater public engagement is needed. Regional stakeholder consultations will be convened as part of the implementation of the Resolution. The consultation process is supported by a discussion paper and will use three different strategies to maximise participation and reach:

1. expert workshops held either as stand-alone events or back-to-back with existing conferences and intergovernmental meetings
2. briefing sessions within existing conferences and intergovernmental meetings; and
3. virtual engagement through webinars, combined with a process to receive written submissions.

The consultations will obtain feedback on the governance of extractive industries, with the aim of understanding the political landscape as well as regional needs. More specifically, and as requested by the UNEA-4 Resolution, the consultations will also help identify best practices and knowledge gaps and assess governance options.

The overall objective of regional consultations is to progress the request to the UNEP Executive Director included in the operative text of the Resolution and feed the outcomes into UNEA-5. Actions required to achieve this are to:

- assess what works and what does not work in the various overlapping initiatives and national policies aimed at improving the sustainable management of minerals and metals
- report back on current governance frameworks of key issues, such as mine tailings, sand extraction, conflict minerals and critical metals
- identify the knowledge gaps on good governance observed in different parts of key mineral value chains
- explore how these gaps can be addressed given the knowledge, implementation capacity and awareness differentials in different mining geographies
- explore the kind of institutional and governance frameworks best suited to support sustainable development with regard to the sustainable management of minerals and metals across the whole life-cycle.

Findings from the regional consultations will feed into the report on the implementation of the Resolution. The report will be presented to the fifth session of UNEA in February 2021, for consideration on any next steps.

5. CONCLUSION

In this chapter, we have provided an overview of the background and content of UNEA Resolution 4/19 on Mineral Resource Governance. Section1.3 of this Chapter has detailed the findings of recent reports on mineral governance that contributed to the adoption of the Resolution, and section 4 has outlined future directions for the implementation of the Resolution.

Amongst other things, the recent reports emphasise that minerals and metals contribute to the development of national economies and provide raw materials to several industries including almost every sector of the global economy. Moreover, a diverse range of stakeholders are part of the value chain of minerals and metals management – from informal artisanal miners to large-scale mining operations. These reports also highlight that, despite the urgent call in the 2030 Agenda for Sustainable Development to decouple resource extraction from economic development, the demand for minerals and metals is likely to continue growing. This will be driven by emerging economies with expanding populations, global middle-class consumption, the global transition towards low-carbon energy production technologies, urbanisation and infrastructure needs.

Ensuring that the management of minerals and metals contributes to the 2030 Agenda, including the 17 SDGs and 169 associated targets, requires governance reform of the sector. Such reform will need to assess the numerous existing governance frameworks and initiatives which address different dimensions of sustainable development. This includes frameworks and initiatives that contribute to the sound management of mine tailing facilities, but which currently do not operate in a sufficiently coordinated or integrated manner.

The UNEA-4 Resolution on Mineral Resource Governance provides an opportunity for any governance reforms related to tailings to be connected to wider initiatives across the spectrum of sustainability issues. The process for consultation on the UNEA-4 Resolution on Mineral Resource Governance has been designed so that all stakeholders in the extractive sector can contribute towards improved mineral resource governance at all scales. Following the consultation period, the findings and recommendations of the discussions will be presented for consideration by the UNEA at its fifth session in February 2021.

REFERENCES

Ayuk, E.T., Pedro, A.M., Ekins, P., Gatune, J., Milligan, B., Oberle, B., Christmann, P., Ali, S., Kumar, S.V., Bringezu, S., Acquatella, J., Bernaudat, L., Bodouroglou, C., Brooks, S., Burgii Bonanomi, E., Clement, J., Collins, N., Davis, K., Davy, A., Dawkins, K., Dom, A., Eslamishoar, F., Franks, D.M., Hamor, T., Jensen, D., Lahiri-Dutt, K., Petersen, I., Sanders, A.R.D., Nuss, P. and Mancini, L. (2020). *Mineral Resource Governance in the 21st Century: Gearing Extractive Industries towards Sustainable Development.* International Resources Panel. United Nations Environment Program. https://bit.ly/32tN1fS;

Bendixen, M, Best, J, Hackney, C, and Lønsmann Iversen, L. (2019). Time is running out for sand. *Nature* 571, 29-31.

Franks, D.M. (2020). Reclaiming the neglected minerals of development. *The Extractive Industries and Society*. In Press. https://doi.org/10.1016/j.exis.2020.02.002.

Franks, D.M., Ngonze, C., Pakoun, L. and Hailu, D. (2020). Voices of artisanal and small-scale mining, visions of the future: report from the International Conference on Artisanal and Small-scale Mining and Quarrying. *The Extractive Industries and Society*. In Press. https://doi.org/10.1016/j.exis.2020.01.011

Franks, D.M., Boger, David V., Côte, C. M. and Mulligan, D. R. (2011). Sustainable development principles for the disposal of mining and mineral processing wastes. *Resources Policy* 36(2),114-122.

IIED (2002). *Breaking New Ground; Mining Minerals and Sustainable Development. The Report of the MMSD Project*. International Institute of Environment and Development, London: Earthscan. http://pubs.iied.org/9084IIED

Peduzzi, P. (2014). Sand, rarer than one thinks. *P. Environ. Dev.* 11, 208–218.

Roche, C., Thygesen, K., Baker, E. (eds), (2017). *Mine Tailings Storage: Safety Is No Accident. A UNEP Rapid Response Assessment.* Nairobi and Arendal: United Nations Environment Programme and GRID-Arendal.

UNEA (2019). *Resolution adopted by the United Nations Environment Assembly on 15 March 2019. 4/19. Mineral resource governance. UNEP/EA.4/Res.19.* United Nations Environment Assembly.

UNEP (2019a). *A Roadmap for Improved Mine Waste Management: Summary Report of the Workshop on Mine Waste*. United Nations Environment Programme, Canadian International Resources and Development Institute, and GRID Arendal.

UNEP (2019b). *Sand and Sustainability: Finding New Solutions for Environmental Governance of Global Sand Resources*. Geneva: GRID-Geneva, United Nations Environment Programme. https://bit.ly/2uxyu6g

RELATED INITIATIVES

CHAPTER XVIII
GLOBAL RESEARCH CONSORTIUM ON TAILINGS

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1. INTRODUCTION

Industry and public sector investment in research have expanded the approaches available to address tailings management challenges, but much of this learning remains underutilised. The University of Queensland (UQ) in partnership with a wide range of research and education institutions convened a global series of consultation workshops in 2019 to explore how the research community could best support improved tailings management, and to specifically consider the potential value of a global research and education consortium focused on the topic of tailings. The vision of the consortium is a multi-party collaborative initiative of the world's leading thinkers and practitioners in tailings and mine waste management: researchers, industry professionals, consultants, regulators, civil society and community representatives to develop transdisciplinary knowledge-solutions (science, technology and practices) to address the technical, social, environmental and economic risks of tailings. In this Chapter we report back on the outcomes of the consultations to date and outline future directions.

2. BACKGROUND

In late February 2019, the Sustainable Minerals Institute (SMI) at UQ prepared a concept note for discussion 'Towards a Global Research Consortium on Tailings.' The concept note was released widely and proposed the formation of a global consortium of research and education institutions to:

- extract value from existing knowledge
- prioritise action in areas that require collective effort
- support evidence-based policy-making
- contribute to increased education of, and communication between, all stakeholders
- support the implementation of existing and new initiatives.

The concept note proposed that activities of the consortium could include:

- facilitating dialogue between researchers, practitioners and those impacted by tailings
- collating the state of the art of global research and practice
- defining an agreed program of applied research with consortium members addressing the critical knowledge gaps
- creating a forum for knowledge exchange and research translation with industry, government and civil society
- incubating innovations and ideas, seed research and undertake feasibility studies to implement innovations
- growing a portfolio of research solutions.

In June 2019, Professor Neville Plint, Director of the SMI, wrote to global institutions involved in tailings research and education, and invited them to express interest in the consortium and participate in a series of consultation workshops to establish the initiative. The invitation remains open to all institutions with tailings expertise and experience to get involved. Thirty-two institutions from five continents, including Africa and South America, and thirteen countries have expressed interest to date (see Figure 1).

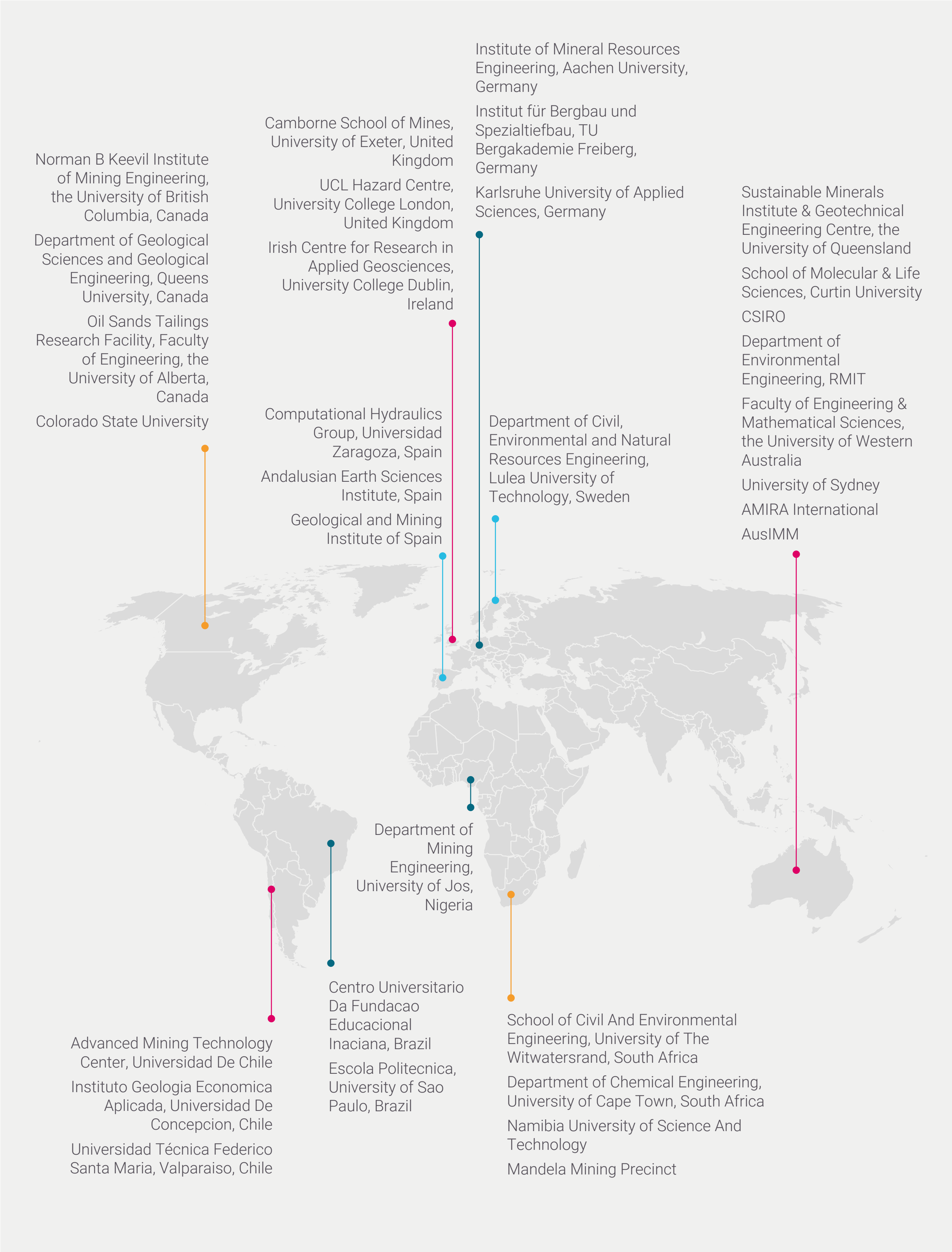

Figure 1. Institutions that have expressed interest in the Consortium.

Five consultation workshops and two presentations were held in 2019, involving more than 300 participants in total. The workshops were held in: Santiago, Chile (prior to the 6th International Seminar on Tailings Management and in partnership with the SMI-International Centre of Excellence in Chile); Cape Town, South Africa (in partnership with the Geotechnical Division of the South African Institute of Civil Engineering, The University of the Witwatersrand and The University of Cape Town); Melbourne, Australia (in partnership with The Minerals Council of Australia and The Australasian Institute of Mining and Metallurgy); Vancouver, Canada (prior to the Tailings and Mine Waste 2019 Conference); and Brussels, Belgium (as part of EU Raw Materials Week; see Figure 2). In addition, presentations on the concept were made at the Mining and Tailings Safety Summit in London, and the ICMM Tailings Working Group meeting in Vancouver.

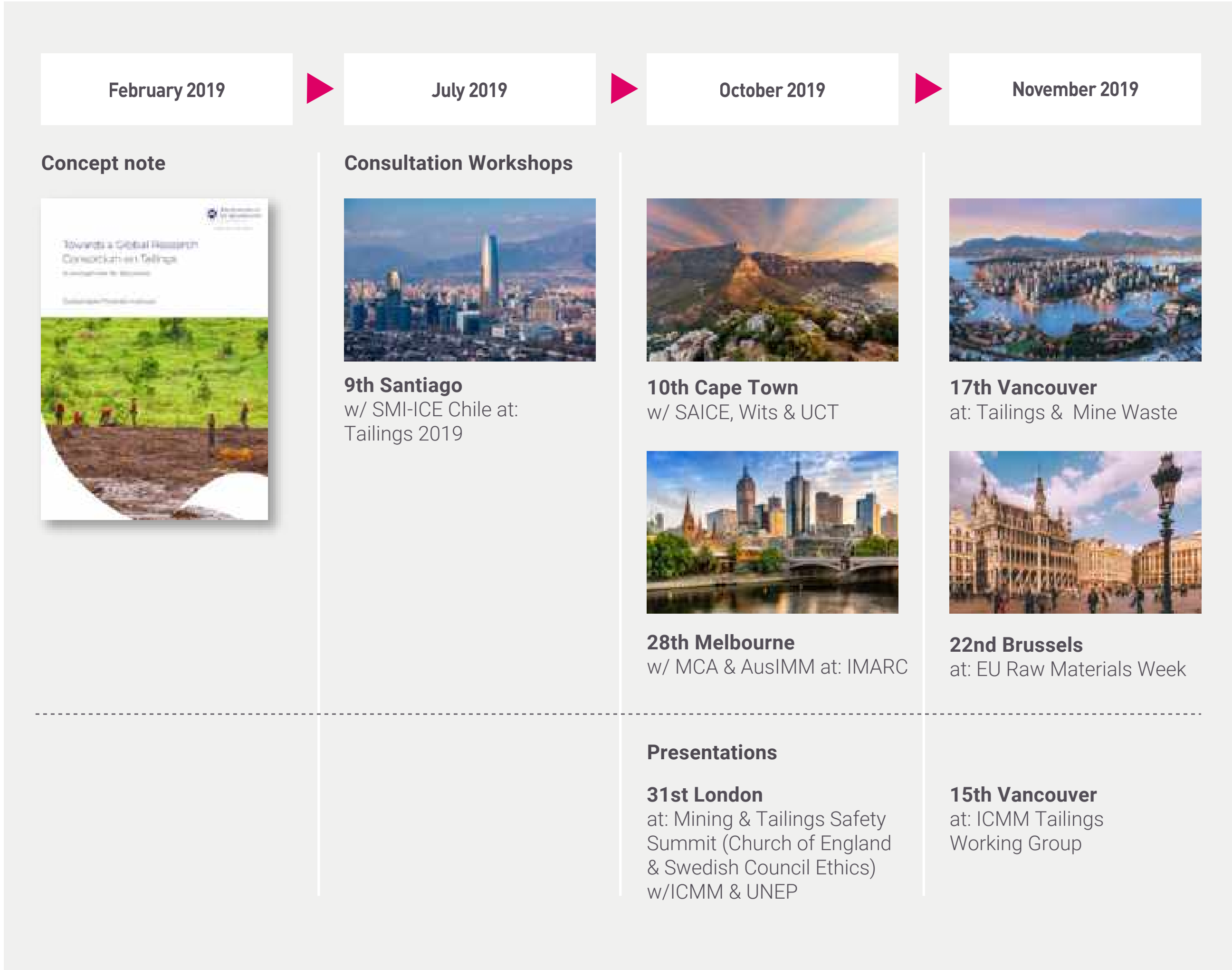

Figure 2. Timeline of the consultation workshops

3. FEEDBACK FROM THE CONSULTATION WORKSHOPS

The feedback from the consultation phase was overwhelmingly positive, with enthusiasm and support for the consortium and its potential. Participants in the consultations made recommendations under the following headings.

Focus

- Be positive and ambitious where 'failure is not an option' and 'nothing is impossible.'
- Produce public good, non-competitive, outputs that are publicly shared.
- Synthesize existing knowledge, and not repeat or duplicate existing work, unless this is needed as part of experimental design.
- Avoid the creation of additional silos or barriers to the uptake of innovative research, education and practice.
- Address the geotechnical and geochemical stability of tailings; tailings production, storage, re-use, re-processing and rehabilitation; the environmental, social and economic risks and consequences from catastrophic and chronic events; and the technical, science, policy, practice, and community aspects.
- Ensure a strong role for capacity building and education.
- Prioritise applied and action-focused research.
- Promote partnership and not duplicate or compete with the work of individual research groups.
- Involve non-traditional actors in research and practice e.g. environmental and engineering consultancies, technology and equipment providers, at-risk communities, regulators, civil society and unions.
- Avoid the promotion of one research group over another.
- Prioritise areas that require collective effort.
- Support the implementation of existing initiatives (e.g. Global Tailings Review & standard; Global Mineral Professionals Alliance).
- Support evidence-based policy-making and practice.

Governance and structure

- Be genuinely multi-stakeholder: a necessity to rebuild public trust.
- Be global but regionally decentralised.
- Have a staged approach to establishment.
- Be managed by an independent internationally experienced minerals research management organization that is not involved in project delivery.
- Involve sponsors actively: industry, government and multi-lateral.
- Be facilitated by a Consortium Manager or Coordinator.
- Allow the possibility for sponsors to be selective in assigning projects to preferred research and education providers.

4. CONCLUSION AND FUTURE DIRECTIONS

Discussions are currently underway with Amira Global, an independent minerals research management organisation with a long-track record in the sector, to develop the initiative.

It is expected that the governance of the consortium would include:

- a global multi-stakeholder governing council
- regional nodes
- a secretariat and dedicated coordinator with tailings expertise.

It is anticipated that the consortium will focus on three pillars of tailings research and education (see Figure 3).

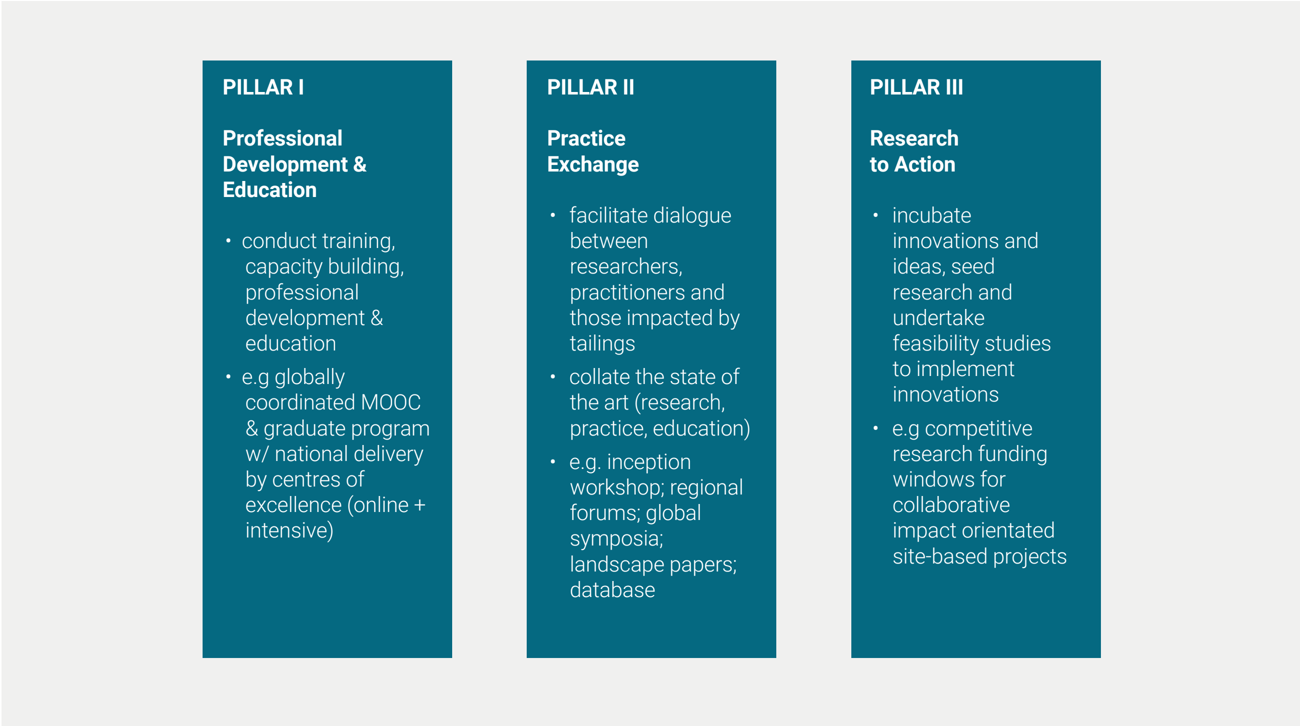

Figure 3. Proposed pillars of the Consortium

Research, education and training projects within each pillar could be proposed by collaborations of investigators across the consortium and selected by project sponsors with the input of the global multi-stakeholder governing council. Priority for the initial phase is likely to be on capacity building, professional development, and the exchange of existing knowledge. The development of education and research roadmaps would allow for later phases of the consortium to expand in these areas should there be interest.

A global research consortium on tailings could tackle a bold and globally significant agenda with the potential for meaningful impact. Members of the consortium would benefit from robust, transdisciplinary, game-changing research with partners that have deep knowledge of the sector.

KEY MESSAGES

1. Industry and public sector investment in research have expanded the approaches available to deal with tailings management challenges, but much of this learning remains underutilised.
2. The University of Queensland, in partnership with a wide range of research and education institutions, is exploring the potential to establish a global research and education consortium to support improved tailings management.
3. The overarching aim of the consortium would be to develop transdisciplinary knowledge-solutions (science, technology and practices) that address the technical, social, environmental and economic risks of tailings.
4. The vision of the consortium is a multi-party collaborative initiative of the world's leading thinkers and practitioners in tailings and mine waste management: researchers, industry professionals, consultants, regulators, civil society and community representatives.
5. A global research consortium on tailings could tackle a bold and globally significant agenda with the potential for meaningful impact.
6. Members of the consortium would benefit from robust, transdisciplinary, game-changing research with partners that have deep knowledge of the sector.
7. Discussions are currently underway with Amira Global, an independent minerals research management organisation with a long-track record in the sector, to develop the initiative.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the partners, speakers and participants who attended the consultation workshops. Financial support to hold the consultation workshops was provided by the Transforming the Mine Lifecycle Programme at UQ, SMI-International Centre of Excellence in Chile, and The University of Cape Town. Special thanks are expressed to Professor Ward Wilson at the University of Alberta, Professor Dirk Van Zyl at the University of British Columbia, Dr Michael Davies of Teck, Dr Luis A. Torres Cruz at the University of the Witwatersrand, Professor Sue Harrison and Associate Professor Jenny Broadhurst at the University of Cape Town, and Hernan Cifuentes of UQ for assistance and support.

PATHWAYS TO IMPLEMENTATION

CHAPTER XIX ESTABLISHING AN INDEPENDENT ENTITY

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1. INTRODUCTION

The completion of the Global Tailings Review (GTR) represents the commencement of another phase of the process. The GTR has produced a Global Industry Standard on Tailings Management ('the Standard'); a Consultation Report, providing an overview of the public consultation process and a summary of the feedback received; and finally, a set of GTR Papers, canvassing a broad set of considerations about the public safety and integrity of tailings facilities.

The next challenge will be to build on the work of the GTR and ensure that the Standard delivers on its promise. The ultimate measure of success will be evidence that the Standard has contributed to a significant and sustained reduction in the number and severity of catastrophic tailings facility failures. For this goal to be achieved, the Standard needs to be widely adopted within the mining industry, and used to drive improved tailings management practices at the operational level. Given the level of public concern about the will and the capacity of the mining industry to ensure the safety of tailings facilities, another important goal must be to ensure that the Standard has credibility in the eyes of governments, affected communities, and wider society.

This Paper has been prepared to inform the three co-conveners – the United Nations Environment Programme (UNEP), the International Council of Mining and Metals (ICMM), and the Principles for Responsible Investment (PRI) – about possible options for implementing the Standard and to put forward one preferred option for consideration.[1]

It draws on the direct experience of the authors in implementing other voluntary schemes and in conducting research about their uptake and effectiveness.

2. OPTIONS

There are at least five different pathways that can support the roll-out the Standard and promote its uptake.

1. **Global guidance:** The Standard is released and promoted as a normative set of expectations to be implemented by interested companies, and for use by any stakeholder group that wishes to hold companies to account against a global Standard. A standardised assessment and/or reporting process is not available; rather, it is left to individual organisations to determine how they wish to use the Standard. An example of this approach would be the UNEP's well-established Awareness and Preparedness for Emergencies at Local Level (APELL) programme.
2. **Industry self-regulation:** Industry organisations such as the ICMM agree to formally adopt the Standard and make it a requirement that member companies agree to follow the Standard. Companies commit to test conformance either via self-assessment, or by hiring external auditors/assessors of their choice. This process is internal and controlled and managed by the company or an industry body. Assessment reports may or may not be released publicly, depending on what the industry body requires. An example of this approach would be the Mining Association of Canada's Towards Sustainable Mining scheme.
3. **State-based regulation:** States undertake to require or promote implementation through legislation, regulations, guidelines or other

1. This was flagged as a topic of interest by the co-conveners at the time the GTR was launched. According to the 'Scope of Work' summary on the GTR website: '[T]he Chair is empowered to independently propose recommendations both on best practices in the management of tailings and on a proposal for establishing an independent body to manage implementation of the Standard' (https://globaltailingsreview.org/about/scope/).

* Member of the Expert Panel

regulatory mechanisms (approval or permitting conditions) and hold enforcement power. Each jurisdiction determines which requirements in the Standard will apply and how they will be monitored. An example of this would be the development of National Action Plans by states as an instrument to implement the UN Guiding Principles on Business and Human Rights.[2]

4. **Third-party regulation:** Other economic actors such as banks, insurers and investment funds make compliance with the Standard a condition for investing in a company, approving loans for projects, providing insurance for tailings facilities, and so on. The basis on which the third-party makes this assessment, and whether this is publicly disclosed, is a matter for the third- party. An example of this approach would be the way in which the finance sector uses the International Finance Corporation's Environmental and Social Performance Standards in the application of the Equator Principles.
5. **Independent entity:** An independent entity is established to host the Standard, test conformance, and report assessment outcomes in the public domain. A certificate of conformance is issued through a process governed by an independent entity, which is not controlled or managed by any single stakeholder group. An example of such an entity is the International Cyanide Management Institute, which manages the International Cyanide Management Code.

Clearly, these pathways are not mutually exclusive. It is possible, for example, to conceive of hybrid models that incorporate elements of two or more approaches (e.g. an industry organisation makes it a condition of membership that a company commits to having its operations certified and reported on by an independent entity). Looking further ahead, it is also possible to envisage a multi-layered system of governance in which several approaches - perhaps even all - are utilised to some extent (e.g. some companies opt to self-assess, some participate in industry-managed processes, and others submit to an external certification process, all within a framework where both governments and third parties impose their own requirements).

Although there are multiple possibilities, our assessment is that Option 5 – the establishment of an independent entity – should be a point of focus for the co-conveners. This would entail establishing a 'home' for the Standard in an organisation with a multi-stakeholder governing body that considers the priorities of relevant constituencies. The key functions of this entity would be to design, manage and promote a credible certification process. This could include:

a. developing and quality assuring an audit protocol
b. approving or accrediting assessors
c. developing guidance materials for operators seeking certification
d. testing and tracking conformance over time
e. regular public reporting on the work of the entity against agreed indicators
f. updating the Standard where required (e.g. as technology or best practices evolve, or as implementation shows deficiencies in the Standard)
g. engaging with third parties, including governments, communities, insurers and investors, to promote understanding of, and build confidence in, the Standard.

In our view, the independent entity has several advantages over other models.

First, creating a standing body will provide a mechanism for institutionalising the Standard and will maintain the momentum for change. By contrast, simply releasing the Standard and leaving it to other parties to decide when and how to take it forward (Option 1) presents a risk of dilution and uneven take-up.

Second, such an entity would provide the Standard with a certain autonomy from industry, reduce the risk (real or perceived) of industry capture and build trust and credibility with external stakeholders. It would certainly score higher on transparency criteria. This is a significant advantage over an industry-operated scheme (Option 2) or one that leaves it to individual companies to self-assess against the Standard (Option 1).

Third, such a body could provide a neutral space in which industry and third parties could share views about the operation and effectiveness of the Standard, and focus on the common goal of preventing future catastrophic tailings facility failures.

Incorporating the Standard into a state-based regulatory framework (Option 3) would be a good long-term outcome and should be encouraged, but this is unlikely to happen quickly, or in a uniform way.

2. See https://www.ohchr.org/Documents/Issues/Business/UNWG_NAPGuidance.pdf

Arguably, states will be more likely to pick up the Standard once its credibility has been established via an independent entity. This will also be the case for third party actors such as banks and insurers, who are looking for certification processes that they can have confidence in (Option 4). These other actors have a valuable role to play in promoting industry uptake of the Standard, but they are unlikely to be able to lead the implementation process.

The following sections of this Paper outline a potential pathway towards establishing the independent entity. It also discusses implementation challenges that will need to be addressed, including how the entity would be resourced, how to secure industry participation in such a scheme, and the relationship between – and interface with – other voluntary schemes.

3. THE INDEPENDENT ENTITY OPTION

3.1 ROLES AND FUNCTIONS

Core function

The primary purpose of an independent entity would be to manage an assurance framework for facilities to be audited against the Standard, with certification conducted by qualified, independent third-party assessors (see the section on 'certification' below). This purpose would need to be reflected in an organisational charter, along with other aspects of the organisation's remit.

Other activities

There are a range of other activities that an independent entity could perform, although in general, the more the organisation expands outside its core function, the less focussed it is likely to be. Some of the roles listed below could be considered after a reasonable level of financial stability and participation had been achieved. Initially, however, the focus should be on the core mission of setting up and ensuring a credible and sustainable certification process.

Certification – the provision by an independent body of written assurance (a certificate) that the product, service or system in question meets specific requirements.

Source: International Organisation for Standards (ISO): https://www.iso.org/certification.html

One activity that should be regarded as core is to provide or arrange training to promote awareness of and understanding of the Standard. It will be essential that the entity itself hosts this training to ensure that there is consistency in messaging the Standard's expectations and interpretation of its audit protocols and guidance documents. Training should be open not just to the industry but also to other stakeholders, such as states and other interested parties. The independent entity could also, for instance, facilitate a programme of public education about mine tailings and storage facilities.

Other activities which could be considered include:

- advocacy on issues pertaining to management of tailing facilities
- hosting roundtables of experts and key stakeholders on issues of concern
- participation in (or driving) global initiatives
- encouraging innovation
- sharing best practice technologies and approaches for tailings facilities
- presenting at international forums (e.g. the Intergovernmental Forum)
- engaging investors/financers and governments to encourage uptake.

In the longer term, the independent entity may also be in a position to identify and recommend research in priority topic areas. If the financial model provides for a surplus, the entity could itself commission research that the industry or individual companies may not be in a position to support, and that the independent entity or its Board or advisers agree is a priority.

3.2 ORGANISATIONAL GOVERNANCE AND STRUCTURE

Organisational capability

The independent entity would need the internal capability to support its core activities with room for growth. Expertise in different functional areas would be necessary for the entity to fully support core activities. These would likely include the following domains.

- **Technical:** Technical expertise will be essential, comprised of professionals with deep knowledge of tailings management and dam design, and other disciplines as well. This technical expertise whether internal or contracted will support the development of the assurance procedures, protocols and criteria for implementation. As participating companies move to certify facilities, technical expertise may also be needed to provide guidance and interpretation of Standard on matters as they arise.

- **Communications:** The communications arm would focus on establishing the brand, publicising the organisation and the scheme, promoting the benefits of certification, and profiling facilities that achieve certification. This function could either be outsourced, in whole or in part, or established as an in-house, dedicated resource.
- **Administrative:** Programme administration would likely include managerial, administrative and accounting functions. Additionally, this arm of the organisation would monitor and report to other parts of the organisation on interest in the scheme and uptake of certification.
- **Executive:** This arm would include a President (or Chairperson), a governing Board of Trustees or Directors, and a Chief Executive Officer who is answerable to the Board (see below).

Governance arrangements

As with other organisations, it would be the role of the executive arm to provide strategic direction. It is envisaged that the board would comprise representatives from across the stakeholder spectrum to provide different constituencies with a voice in decision making, but with a 'super majority' having a working knowledge of mining and tailings facilities. The board may wish to appoint advisory groups to provide advice on specialist matters as they arise.

This proposed configuration bears some similarity to the arrangements for managing the International Cyanide Management Code; where it differs is that it also includes a multi-stakeholder Board of Directors. The Mining Association of Canada has appointed a multi-stakeholder Advisory Group to provide advice on community-related issues but does not include non-industry representation on its Board. What is envisaged here is the inclusion of non-industry, multi-stakeholder perspectives within the core governance structure. The benefit of this approach is that it builds relationships of trust amongst different stakeholder groups, and addresses stakeholder concerns about the potential of the independent entity to be 'captured' by industry interests.

Start-up cost estimates over two years (USD 3.3 million):

- Working group support (travel, secretariat) – 175,000
- Legal services (document review, trademark, anti-trust compliance, bylaws, dispute resolution, registration and incorporation of entity) – 300,000
- Technical consultants (drafting audit protocols, guidance documents, internal procedure and process documents, field testing) – 420,000
- Outreach and communications (website, promotional materials, webinars, meetings/ conferences) – 315,000
- Training seminars (travel, facilities, materials) – 220,000
- Translation services (10 documents in six languages) – 280,000
- Staffing (including benefits for one-year) – 1,080,000
- Rental , furnishings, utilities (one-year) – 200,000
- Director and officers liability insurance (one-year) – 65,000
- Audit by external accounting firm (one-year) –15,000
- Board support (travel and accommodations for one-year) – 230,000

3.3 RESOURCING AND FUNDING MODEL

Experience has shown that the development of assurance schemes can be both lengthy and resource intensive. Nonetheless, the establishment of an independent managing entity could occur within a 6-12 month period. It will be important to the ultimate success of the scheme that commitment and support by the co-conveners and stakeholders be maintained in the establishment phase, and then throughout the development of the entire scheme and, which may take up to two years.

Seed capital will be needed to establish the independent entity and fund its initial work in

preparation of administering the standard and certification process. Preliminary calculations indicate that the initial work of scoping, designing, and standing up an independent body, with appropriate governance arrangements, can be accomplished for a modest sum. The larger expenses will be the staffing, engagement of consultants, establishment of administrative procedures and systems, and the development of the necessary programme documents, including but not limited to, audit protocols, guidance documents for auditors and participants, and a dispute mechanism. Additional work would involve the development of a website, outreach materials, field trials of assessment documents, and the recruitment and vetting of assessors to perform the envisioned certification work. The work described above, we believe, can be accomplished within a two-year period for approximately USD 3.3 million.[3]

There are several funding models available to support a new independent entity. One option would be to approach a Foundation, or similar body, for a large, multi-year grant to provide the seed capital necessary to establish and sustain the organisation in the early stages. Such grants, however, are difficult to secure, particularly where funders may see this as something that the mining industry should bear responsibility for. Alternatively, one or two of the co-conveners could consider providing the funding for the first year(s) of operation.

Another option is for industry to bear a significant proportion of the costs of establishing and maintaining the new entity. One way of doing this would be through a membership model, where companies pay an annual fee to belong to the entity and support its activities. Other sectors that are likely to utilise the Standard (for example insurers and investment funds) could also be invited to become members.

Given the controversy around tailings facility management practices, an industry-only membership model would be likely to raise concerns amongst stakeholders about the independence of the entity. It may be possible to overcome this, but it would require extensive thought and consideration to be given to governance processes. For example, the independence of the governing board would have to be guaranteed, the board would need to include several non-industry members, and the appointment of CEO would need to be endorsed by both non-industry and industry members.

A further possibility is for the entity to rely primarily (or partly) on income earned through the charging of fees for participating companies, based on a formula that considers the number of facilities to be included in the programme. In this model, companies are effectively customers, rather than members. The entity would still need to be attuned to the interests and concerns of companies, given that their participation is voluntary, but the entity would not be subject to their control.

3.4 THE ASSESSMENT FUNCTION

Selection of assessors

To fulfil its core purpose, the entity would need to accredit a cadre of qualified and experienced assessors to assess facilities against the Standard. Our assumption is that these assessors would be self-employed consultants or employed by a professional services firm, rather than being employees of the independent entity. Companies applying for certification would contract accredited individuals or firms to assess conformance against the Standard.

Criteria for assessors will need to be established. Rather than the new entity accrediting assessors, it may rely on professional accreditation by other bodies. The entity could set minimum qualifications and note that accreditation by certain bodies would be acceptable.

The issue of auditor or certification liability will require consideration. It will also be imperative to have a process for managing conflicts of interest, particularly given that there are likely to be only a limited number of available professionals who could competently assess conformance with the Standard. In time, market forces may help to expand the pool, though this may depend on the criteria developed for accrediting assessors and the level of participation by companies.

Given the broad scope of the Standard's requirements, audits will likely need to be conducted by teams of assessors from different disciplinary backgrounds. Having non-engineers review, evaluate, and pass judgement on the sufficiency of engineering design criteria or construction documents, or management practices, will not be acceptable. Likewise, an

3. In estimating costs we assume that initial staffing will be small, with support from contractors, and augmented through secondees. After the first year, staffing increase as work commences and revenue becomes apparent. Over time, costs will be gradually covered through revenue and earnings.

assessment that only involved engineers, and focused solely on the facility, would be contrary to the scope and intent of the Standard. It may not be necessary, however, to include community specialists in all instances, for example, where a facility has no proximate population or downstream community. Assessment teams could be calibrated to match the profile of a facility. In all cases a lead assessor will need to be appointed, and qualifications for that role would have to be defined.

Assessment process

Once the question of the composition and qualifications of assessment teams is resolved, it is likely that the mechanics of the certification would be much the same as with other voluntary schemes.

The process would commence with assessors examining documentation, conducting interviews with corporate and site-based personnel and local stakeholders, and visiting the facility and nearby and downstream communities as appropriate. Having considered the evidence, assessors would submit a report to the independent entity indicating whether certification is warranted, and, if not, the corrective actions needed to achieve certification.

The role of the independent entity would be to determine whether the assessors made clear findings to warrant certification and specify whether conditions are to be applied before certification is granted (such as a corrective action plan). Any follow-up process, including specified actions and deadlines for implementation, would involve assessors in agreeing to the corrective action plan. This entire process would need to be outlined in a series of audit procedures and protocols.

3.5 THE CERTIFICATION FUNCTION

Unit of certification

Certification schemes vary in terms of their 'unit' of certification. The Standard was written with the intent of certifying individual facilities – not operations or companies. While the wording of the Standard was drafted this way, it is the case that some operations will have multiple storage facilities, while others will be located some distance from a mine.

The new entity would need to establish greater precision as to the unit of certification in a wide variety of operational circumstances. It may be prudent, for instance, to certify two adjacent facilities in the one assessment, particularly if they are governed by a common operator, management framework, or set of systems.

Likewise, the entity would need to define the process for follow-on certification where the unit of certification was a new facility (i.e. a facility in the pre-construction phase), given that many elements of the Standard would have been assessed in the initial assessment (e.g. alternatives analysis, consequence classification, and design criteria). The draft Standard has provided an indication of which requirements would apply to new and existing facilities, but this will need further refinement from a 'unit of certification' perspective.

Mechanics of certification

The purpose of an independent entity would be to provide assurance that the unit of certification (i.e. the facility) conforms to the requirements of the Standard. A simple model of assurance would conclude that a facility was either 'compliant' or 'non-compliant' with the Standard and would answer the question in a 'yes' or 'no' format. It is rare, however, that industry certification schemes that are geared towards performance improvement proceed on this basis. Instead, most industry certification schemes have a graduated model to encourage initial uptake, and to encourage continual improvement over time.

To balance the need for a high bar and to encourage uptake, some schemes nominate a 'core' set of criteria judged by compliance/non-compliance and a threshold of performance with room for improvement for all other requirements. Some schemes have, in addition to this, a graduated level of achievement, such as the Mining Association of Canada's Towards Sustainable Mining scheme that allows for recognition at upper and lower ends of the performance curve. A graduated process is envisaged for the Global Industry Standard on Tailings Management, with a period for operators to address non-core gaps either before certification is granted or as part of a conditional certification.

In terms of encouraging certification, the entity could consider establishing an online platform for private self-assessment, as a 'confidence-builder' for operators interested in certification. The Mining Association of Canada's Towards Sustainable Mining scheme and the Aluminium Stewardship Initiative offer self-assessment tools for companies interested in testing their level of conformance before commencing the formal certification process.

Communicating the outcome

Communicating the outcome of certification would need to be formalised under the schemes' audit procedures and protocols. It is envisaged that an operator would be notified of the outcome first, with agreed protocols for the public communication of a successful outcome, alongside an announcement by the independent entity.

The level of public disclosure and transparency across all elements of the programme would need to be carefully considered by the organisation's executive and governing board. If the focus is safety, in particular public safety, then not disclosing failed assessments and informing potentially affected people of the failures and the reason for the failure seems contrary to the purpose of the programme. Similarly, whether pre- or post-certification conditions or opportunities for improvement over and above the minimum requirement would be disclosed is another matter to be clarified. Given the Standard's emphasis on transparency and public disclosure, it is envisaged that any conditions for certification would be publicly disclosed. If an operator is not comfortable with this level of disclosure, they would have to close out any gaps prior to certification.

The International Cyanide Management Code posts on its website summary audit reports for each certified operation in its programme. This allows stakeholders to read for themselves what the auditors found during their inspection. This high level of transparency sets the programme apart from other certification schemes. Furthermore, the auditors' credentials are posted along with summary audit reports so that the public can see who audited the operation, and their experience and qualifications.

Finally, assessment and audit reports are an important source of data for understanding the overall impact and effectiveness of a scheme, and where industry practice sits across assessed facilities. The entity would therefore need to monitor, evaluate and report on the uptake and impact of certification on a regular basis. The entity would also serve as a repository of data from the assessments, providing a source of evidence about industry changes in global tailings management, over time. The International Cyanide Management Institute also reports annually on findings, assessment trends and so forth. The disclosure of information would contribute to the stock of publicly available knowledge about tailings facilities globally.

Period of certification

At this stage, it is envisaged that certification would stand for a defined period, after which a follow-up assessment would be required. A shorter certification period for facilities that hold the potential for loss of life might be considered appropriate, with a longer period for facilities that have no potential for loss of life. This would reflect the goal of zero tolerance for human fatality and avoid low consequence facilities having to be subject to burdensome certification renewal processes. Likewise, the period of certification should also consider changes in a facility. For example, a tailings facility that has had multiple lifts or a facility that is approaching capacity may warrant a shorter recertification period. Change in ownership might also be a consideration, as these may substantially change resources and management focus.

A possible way forward is to require re-certification every f three years for higher consequence facilities (i.e. 'Extreme', 'Very High' or 'High'), and at five year intervals for lower consequence facilities (i.e. 'Significant' and 'Low'), but this would need further discussion.. Given a shortage of experienced professionals available to assess against the Standard, differentiated time periods for certification could be a practical approach. Likewise, it may be prudent to calibrate a renewal process based on risk.

3.6 NON-COMPLIANCE AND CORRECTIVE ACTION

Addressing issues of non-conformance while under certification would be important for upholding the credibility of the scheme, while at the same time encouraging industry uptake. Most existing schemes are able to withdraw certification to sanction an identified or reported non-conformance. The Responsible Jewellery Council, for instance, applies a 'suspension' procedure and a five-stage re-certification process. Other schemes can trigger a corrective action procedure that does not involve suspension, but rather, provides a defined period for the operator to correct the non-conformance before moving to suspension.

Most certification schemes have a complaints mechanism for stakeholders to lodge complaints or issues. The Responsible Jewellery Council, for example, has a formal mechanism that aims to resolve complaints related to non-conformance with certification and accreditation of members.

The process of lodging a complaint is clearly articulated, and available to the public. Likewise, the Cyanide Code has a multi-tiered dispute resolution process that allows stakeholders to challenge audit findings. Any new independent entity should consider similar processes, particularly given the Standard's requirements that relate to the reporting of concerns and complaints.

3.7 FAILURE EVENTS

The Standard includes requirements for emergency planning and local-level preparedness, and pre-emptive engagement about long-term recovery in the event of a failure. However, in the immediate aftermath of an incident, certification could be 'suspended' while facts are established. If necessary, it is envisaged that certification could be revoked. A corollary would be that the entity would want to review the most recent audit report to determine if the assessors missed anything or if the Standard or any of the protocol or guidance documents were deficient.

To uphold a commitment to suspend certification after a major failure event, the certifying organisation would have to define a threshold for 'catastrophe'. It is possible, for instance, that a facility experienced a failure, but that control measures prevented catastrophic outcomes. Such an incident may result in a suspension and corrective action, rather than a revocation. The procedures and protocols for dealing with both catastrophic and non-catastrophic failure events would need to be carefully and thoughtfully developed.

3.8 INITIAL PROGRAMME OF WORK

Once established, a first task of an independent entity would be to prepare audit procedures and protocols for the purposes of implementing the certification scheme. Amongst other things, this would include defining:

a. indicators for each requirement
b. rankings or weightings of certain requirements
c. minimum standards of evidence
d. criteria for accrediting assessors
e. how often, and under what circumstances, certifications need to be renewed
f. consequences for non-conformance
g. data collection, reporting and archiving.

There are many voluntary schemes and standards, and the new entity would need to ensure that its scheme takes priority place for tailings management in the evolving landscape of voluntary schemes available to the global mining industry.

In order to encourage certification, the independent entity would need to publicise the scheme, and communicate information about the certification process, including the 'value proposition' for why companies should submit to this process. It would also be beneficial for the entity to engage with other organisations that may utilise the results of audits: such as insurance companies, banks, investment funds and regulatory agencies. If these organisations see the certification process as credible and are willing to use the outcomes to inform decisions (e.g. about whether to invest in or insure a company, or approve a licence application), this will be a significant incentive for companies to participate in the scheme.

4. OTHER MATTERS TO RESOLVE

4.1 RELATIONSHIP TO OTHER SCHEMES AND THE ISSUE OF 'EQUIVALENCY'

Once the entity is established and develops implementation protocols, there will need to be consideration of 'equivalency' with existing voluntary schemes and standards – where operators seeking certification are relieved of having to demonstrate conformance if this has been demonstrated under a cognate scheme.

Industry concerns about adding to the audit and assessment burden were a prominent theme during the public consultation and would need to be addressed. The degree to which existing standards cover the specific requirements associated with the safe management of tailings facilities – and can therefore be considered equivalent – will need to be forensically analysed and carefully calibrated.

It is logical to first construct a standard that covered all necessary requirements – both general and specific – and then for the independent entity to consider equivalency as a high priority matter. It is only after finalising the Standard that this question can be fully interrogated.

4.2 PRIORITISING FACILITIES FOR CERTIFICATION

The scope of the GTR was focused on large facilities and does not discern on the basis of whether those facilities are owned or operated by a company with one, or many facilities. The Standard does not, therefore, address the question of how a company with hundreds of facilities should proceed with certification.

It is, of course, up to individual companies to sequence the certification of their facilities in the manner that they deem appropriate – the Standard is not prescriptive in this regard. Nonetheless, companies should be encouraged to reflect on the risk-based orientation of the Standard, and to seek certification of the highest risk facilities as a matter of priority. These are the facilities that most concern the market, external stakeholders and project-affected communities.

4.3 LOCATION OF THE NEW ENTITY

The issue of which jurisdiction the entity should be located in would also need to be considered as part of a full design proposal.

5. SUGGESTED NEXT STEPS FOR THE CO-CONVENERS

In this Paper we have provided an initial sketch of matters to be considered in designing and establishing an independent entity to drive the work of the GTR forward. How best to implement the Standard is an issue of critical importance, but this was not within the brief of the Independent Chair or the Expert Panel and, in any event, it is not a task that these parties are equipped to undertake.

Rather, we see this as a matter that falls within the purview of the three co-conveners. This group proactively initiated the GTR to develop the Standard, and it is also the group that can drive the next phase. Without an effective implementation strategy, the time, effort and resources invested in building the Standard could dissipate and the problems which gave rise to the GTR persist. Involving all three co-conveners will also help to ensure that the Standard continues to be viewed as a multi-stakeholder initiative that represents a broad range of interests.

Below are five recommended actions which we believe will maintain the momentum for change and ensure that the return on the work and effort that has been put into developing the Standard is maximised.

1. *Once the Standard has been formally endorsed by the co-conveners, the parties should actively promote the Standard to their respective constituencies, and other interested parties.*

The ICMM is ideally placed to promote the Standard to mining companies and industry bodies; the UNEP has an opportunity to engage with State actors as part of the implementation of the UNEA4 resolution on Mineral Resource Governance; and the PRI can provide a valuable conduit into the investment community. The co-conveners are also encouraged to present on the Standard at professional forums, such as researcher and practitioner conferences, and to groups of other interested stakeholders.

2. *The co-conveners should formally launch the Standard and announce that: (a) a small working group will be formed to develop a design proposal for the establishment of an independent entity; and (b) the intention is for the new entity to be established within a 6-12 month time frame.*

The design proposal should address the matters that have been raised in the preceding discussion, including: the role and scope of the new entity, governance arrangements, location, resourcing requirements, and how the entity will be funded in the start-up phase, and over the longer term. The working group should comprise people with experience in designing and administering voluntary certification schemes, or who have extensive knowledge about the operation of such schemes. The proposal should map out a plan of work for the first 6-12 months, and define key performance indicators.

3. *Other bodies that have developed standards and/or are engaged in certification processes relevant to tailings should be encouraged to begin exploring equivalency issues between these schemes and the Standard.*

This will be key to maximising uptake of the Standard and minimising duplication. Relevant initiatives include Mining Association of Canada's Towards Sustainable Mining Tailings Management Protocol, the Initiative for Responsible Mining Assurance, and the World Gold Council's Responsible Gold Mining Principles.

4. *Establish a multi-stakeholder reference group to provide input and feedback to the co-conveners and the Working Group on the design of the new entity.*

The reference group could include representatives of key stakeholder groups, including the mining industry, insurers and investors, civil society, and government representatives. This would reflect the multi-stakeholder architecture of the first phase of the GTR work and provide confidence to all stakeholders as the next phase of work moves forward.

5. *Co-conveners should explore the potential for tracking the immediate and organic uptake of the Standard, in all its forms, prior to the establishment of the independent entity.*

In the 6-12 months before the entity is formally established, the Standard will take on a life of its own. Already, elements of the Standard are being referred to in public presentations, policies and standards; referenced in academic papers; discussed at industry forums; incorporated into policies and standards; and considered for incorporation into law or regulatory guidance in several jurisdictions globally. A university research centre, or similar entity, could be supported to track uptake in this intervening period, which would help to validate the utility of the Standard, and build confidence that the work is relevant and important. Once established, the independent entity would formalise a monitoring and evaluation programme as part of its core programme of work.

6. CONCLUSION

This Paper has elaborated a potential pathway for establishing an independent entity to house the Standard, and to support its evolution. Reflecting the urgency of the challenge, the Standard and accompanying GTR Papers were completed through a rapid and concerted effort. To maintain momentum, we encourage the co-conveners to initiate the next phase of work and to continue the process with the same sense of urgency. This way, the Standard can be deployed globally, to full effect, as soon as possible.

Co-convened by the International Council on Mining and Metals (ICMM), United Nations Environment Programme (UNEP) and Principles for Responsible Investment (PRI), the Global Tailings Review has established a robust, fit-for-purpose international standard for the safer management of tailings storage facilities.

GlobalTailings
Review.org