Review of Risk Management and Regulatory Framework of Mine Waste Facilities in Zambia

Fatal and life threatening incidences related to mine waste facilities occurring in the mining sector worldwide are a source of concern to the industry. Despite the implementation of management strategies and enforcement of relevant pieces of legislations, fatalities associated with the operations of mine waste facilities have continued to befall the mining sector.

In view of continued occurrence of fatal incidences at mine waste facilities, there is particular concern regarding the need to adopt adequate risk management strategies and regulatory frameworks for management of mine waste facilities. Evidence shows that generally mine waste facility management has not been given the necessary attention it deserves. This is attributed to Mine Waste being at the last part, or rather the "tail-end" of mining and mineral processes. In addition, the regulatory framework on the management of mine waste facilities is seemingly inadequate when it comes to implementation. There is also no country or country-customised standards setting out risk and general management requirements for the mine waste facilities.

It is therefore critical that adequate Best Available Technologies and Practises of risk management are documented and effectively implemented to prevent fatal incidences and injuries associated with mine waste facilities. In addition, the regulatory framework should adequately deter mine owners from neglecting responsible management of their mine waste facilities.

Key Words: Mine Waste facility, Risk Management, Regulatory framework, Management Standards, Responsible Management

Authors;

*Mr Patrick Tembo (**Lead Author**)*
Environmental Practitioner
Knight Piesold Zambia Consulting
ptembo@knightpiesold.com

Mr Gibson Mupeyo
Senior Civil Engineer
Knight Piesold Zambia Consulting
gmupeyo@knightpiesold.com

Mr Chalwe Bulaya
Principal Civil Engineer
Knight Piesold Zambia Consulting
cbulaya@knightpiesold.com

Mr Boston Katongo
Principal Environmental scientist
Knight Piesold Zambia Consulting
bkatongo@knightpiesold.com

Introduction

Mine waste facilities have the high potential to pose environmental and geotechnical risks that must be managed throughout the life of the facilities from the design stage, construction, operation and through to the closure of the mine waste facility and beyond. In Zambia the sight of mine waste dumps is visually evident as one traverse through the mining towns on the Copperbelt. Some of the older dumps are now being reclaimed for further processing due to improvements in mineral processing technologies. Other dumps sites remain classified as active with waste dumping taking place on some of them.

Despite having regulations which in the past mainly emphasised on safety and integrity of mining operation, mine waste facilities have affected the environment in which they are located such as dam failure or dam wall breach, damage to properties, loss of life and environmental degradation (Banda, 1993). It has also become apparent that management of mine waste facilities has not been given the necessary attention it requires. This lack of necessary attentions is attributed to mine waste facilities being at the last part, the "tail-end" of mining and mineral processes. As more mining operations open and reclamation operation of old mine waste dumps increases in Zambia it is vital more than ever that adequate regulations, risk management practices and modern technology are established and employed to reduce the damage and negative effects that can arise from mine waste-related sources.

This paper will give a snap review of the mine waste facilities and risk management practices in Zambia and the regulatory framework governing the operations of mine wastes facilities. It will also attempt to highlight benefits of current risk-based international practises and guidelines. Although a bias is put on tailings storage facilities, generalities to other waste dumps will be made where necessary.

General Overview of Mine Waste Facilities and Associated Risks in Zambia

Mining and mineral processing on the Copperbelt has been characterised by both open cast and underground mining with very large open pits and deep shafts. These mining operations have generated large volumes of waste material for disposal which has led to the creation of numerous mine waste facilities. There are at least 21 waste rock dumps covering more than 388 hectares, 9 slag dumps covering 279 hectares and more than 45 tailing dams covering an area of around 9125 hectares. In total, more than 10 000 hectares on the Copperbelt is covered with mineral waste (Lindahl, 2014). The following is the brief description on the types mine waste facilities from mining and mineral processes in Zambia

Overburden Dumps these are dumps made up of soil, gravel, and other loose materials that cover the surface above ore bearing rock. It is often used as a construction material during mine development or may be stored in large piles and used after mining is complete to restore the environment.

Waste *Rock Dumps* Consists of solid material removed from both open pit and underground mining that does not contain enough minerals to be considered ore for processing. It is stored on site and may be used to construct mine facilities – such as roads and tailings storage areas.

Waste rock backfill of open pits is the new technology which should be encouraged and is being used at some of the new open pits mines in the North-western Province. For the mine operator, pit backfill could mean shortened and potentially less costly haulage routes, and a potential way to dispose of reactive (e.g., acid-generating) waste rock. For regulators, pit backfill, if placed to optimised elevations, results in a long-term passive hydraulic sink (i.e., no discharge of impacted water to groundwater), and minimal surficial pit waste dumps exposed to humans or wildlife habitats. (Jonhson and Carroll, 2007).

Slag Dumps Waste material produced from the smelting process of metal concentrates in furnaces and is generally delivered for disposal in a molten or granulated state. In Zambia large quantities of old copper slag dumps (containing cobalt and other high grade minerals) exist. Due to improvements in the mineral processing techniques which never existed when the molten slag were being dumped, the dumps are now being reclaimed for further processing for cobalt and copper extraction. These old slag dumps have now stimulated interest for large and small scale mining activates of reclamation and reprocessing. (Mututubanya, 2000).

Tailings Storage Facilities Ore or mineral milling or concentration can be performed by a number of methods, such as gravity concentration, magnetic separation, electrostatic separation, flotation, and leaching. The objective, in each case, is to separate the metal from the less valuable matrix of rock, or tailings. The valuable metal-bearing material produced during milling is called concentrate, while the undesirable waste material is called tailings. Since ores are usually crushed and ground before milling, both concentrate and tailings consist of finely ground particles. Mill tailings are then discharged to impoundments called the tailings storage facilities. The most tailings storage facilities in Zambia have been developed through cycloning and the tailings material itself being used to build the confining embankments. Tailings are turned into a mixture of water and solids called slurry in the thickener before being pumped to the tailings storage facility. Frequently, tailings are cyclone-classified before deposition. Coarse sands are used to build-up the confining outer embankments, while the finer fraction also called slimes are deposited inside the facility. The slimes, composed of finer solids and water mixture, provide some degree of sealing, which slows the rate of seepage from the pond.

The Zambia mining sector has one of the largest mine waste facilities in the world particularly the tailings dams. Negative impacts of mine waste include pollution to surface water through increased sediments and chemical contamination and underground water contamination through Acid Mine Drainage and other toxic leachate, air pollution through dust generation, slurry spills, land degradation and disturbance of the ecosystem. Tailings Dam pose the greatest risk to the environment among other types of mine waste (David M Chambers, 2011). Unlike water dams which have a definite life span, tailings dams are supposed to be perpetual facilities. It is also known that tailings dams have statistically a higher rate of failure than water dams. Thus mine waste risk to the environment and human life should be managed responsibly for sustainable development.

The following table summarizes some common issues of mine waste, affected aspects and impacts of mine waste facilities:

Risk	Affected aspect	Impacts
Overtopping of tailing dam. Collapse of tailing dam by poor construction. Collapse of tailings by seismic event. Delivery Pipe leakage. Ground of tailing pond not leak lined & decant or spillway failures Waste rock stockpiles exposed to rainwater. Dust from waste rock and Overburden Dumps No dump –rehabilitation after cases of mining operation Poor reclamation method of slag dumps.	Groundwater surface water, soil, Air Land –use ,long-term contaminated land And Dump or landslides Surface water	Water pollution Air Pollution Loss of biodiversity Soil contamination Rivers and stream siltation's Loss life and damage to properties

Risk management of Mine Waste Facilities

Recent disasters such as Mount Polley (Canada) tailings dam failure on August 4, 2014 with heavy environmental damage, Samarco Tailings Failure on November 5, 2015 in Brazil with 17 fatalities and environmental damage and the 21 November 2015, Myanmar waste heap failure which killed 113 people, should inform the mining industry about the risk exposure due to mine waste. The United Nations Environment Programme (UNEP) urges countries and the industry to "end deadly and damaging mining waste spills by enforcing a zero-failure objective" (United Nations Environment Programme, 2017).

The main aim of this section is to create a thirst for responsible management of mine waste among engineers, mine owners and regulators anchored on risk-based approaches.. The authors advocate that risk based approaches should be applied throughout the life cycle of the waste facilities, starting from conceptual planning stage, planning, design, construction, operation, and closure and post closure stages to optimize benefits leading to sustainable waste management

Risk-based approaches are strategies of management that draw heavily from the Risk Management displine of study for which standard procedures are described in risk management literature. Common features of risk management include the following steps.

What is the meaning of risk and risk management?

Several experts agree in general terms what risk and risk management is in connection with projects. Here no attempt is made to give details of the formal practical process of risk management but merely to lay a common ground for what risk management entails. The International Standard Organization (ISO), (2009) defines risk as *effect of uncertainty on objectives*. A Guide to the Project Management Body of Knowledge (The Association for Project Management, 2012), renders risk as "an uncertain event or set of uncertain circumstances that, should it occur, will have an effect on achievement of objectives." For example a slag dump may give-in during the process of reclamation and cause fatality and suspension of mining operations. This event is uncertain that/when it can occur but presents a possibility of occurring with impacts that may affect the project and therefore it is a risk. The Institute of Civil Engineers (2014) render risk as "a possible occurrence which could affect (positively or negatively) the achievement of the objectives for the investment". Hillson (2009) made his point by simply stating that "risk is uncertainty that matter". So in risk management we are not dealing with issues prevailing on a waste facility but potential events. Secondly, not every risk matters. It is those risks that could affect the objectives of a project that should be given priority in controlling. It is stressed here that a risk is a <u>potential event</u> which could occur and impact either positively or negatively on the set goals or objectives. As can be appreciated, risk plays on objectives and so the very first key steps to risk identification and management of risks is to identify the objectives of the facility, activity or project. The answer to the question 'What uncertain thing or set of circumstances could occur and affect the planned facility, activity or project?' is a risk.

Risk management is a deliberate proactive, rigorous and documented process of identifying uncertainties in a project which might have significant impact on outcomes of the project, then analyzing them so that a proactive action is taken to control the effects of the risks before it actually occurs. Risk management goes beyond the mental ideas or actions thought about in response to risk but are a documented process. Control of negative risks include: risk avoidance, risk reduction, risk acceptance and risk transfer. Control of positive risk may include: risk exploitation, risk enhancement, risk acceptance and risk transfer.

Step 1: Risk identification

This step call for identification of all possible risk such as environmental pollution and those due to the chemical, physical/mechanical properties and behaviour of the stored solid material (slurry transport and/or liquefaction phenomena) in the event of an accident. The hazards identified will decide the level of ambition needed in the further assessment. It can also include identification positive risks such as possibility of new technologies to use mine waste e.g. mine backfill.

Step 1.1: Accident scenarios.

This Step describes scenarios of possible failure modes and identifies all potential causes. The scenarios need to consider: (a) the impact of possible natural phenomena at the Tailing Storage Facility location (e.g., excessive rain, snowfall or snowmelt, earthquakes, landslides, avalanches); (b) failures of already built structures (e.g., other dams) situated upstream, whose failure could cause domino effects; and (c) causes related to the design, management and control of the Facility, including human error. In the scenario description, records of accidents and near-misses at similar facilities should be considered. No plausible scenario should be excluded.

Step 1.2: Identification of potential receptors

In this step the there is need to identify who and what can be affected assuming possible scenarios (failures). Aspects for consideration relate to the environment (water, soil, and biota), human health and living conditions, economic losses (damage to infrastructure or property). Special attention should be directed to scenarios that can cause damage in a transboundary context.

Step 1.3: Safety measures

It requires describing safety measures aimed primarily at the prevention of potential scenarios (causes of failures) as identified in step 2. Secondly, measures aimed at limiting the consequences/impact, should a failure still happen, should be described. The latter will include measures for preparedness (warning, alert and alarm systems) and emergency response plans. Cooperation between TMF operators, competent authorities and local authorities (the community) is recommended for emergency planning.

Step 6: Risk assessment and evaluation

Finally, it involves also assess the probability of principal scenarios (potential failures) as described in step 2, taking into account the proposed safety measures and their reliability. In doing so, site-specific or generic data should be considered and if no such data are available expert judgement should be applied. In some cases it will be possible to quantify the probability of the scenario, e.g., return periods for flood events; in other cases, it will only be possible to discuss low and high probabilities in general terms. The resulting risks are a combination of the probability that a certain scenario will take place and the potential impact if it does. The different scenarios (failure modes) studied can be presented in a matrix with probability on one axis and impact on the other. In this step, the operator of the facility should also make a judgement if the risks related to the different scenarios are to be considered acceptable. Such acceptability assessments will distinguish risks potentially ranging from low probability and low impact to high probability and high impact. It is useful to make a division into three classes of risk: green — acceptable; yellow — conditionally acceptable; and red — unacceptable.

Step 6: Risk Control and action plan

Risk Control strategies include: reduction or mitigation, avoidance, acceptance, transference of risks to ensure that residual risk is acceptable. In the case of positive risks, control measures could include: acceptance, enhancement, and increasing chances of the risk. For example that a tailings dam may provide a source of water for industrial use is positive risk and should be enhanced. Risk management will be useless unless there is an action that follows the plan.

Risks should be updated at every change of facility elements (change management), such as extension of capacity, suspension or resumption of operation of the tailings facility. (United Nation Economic For Europe, 2014).

It is the conviction of the authors that neglect of proper risk management of mine waste will continue to be the omen of disasters which could otherwise be prevented.

Example of risks identification and control

Two examples of risks and control are given in this paragraph. The first example is that a tailings dam may lead to pollution of air quality in the down-winds areas and the residents may have health issues. This risk should be managed from the conceptual planning stage. It might mean that all residents in the downstream areas within the reach of dust should be relocated. It may also include well planned control measures of revegetating the slopes and ensuring that the beach is regularly wetted. Another example can be that the nature of the ore bearing rock may have high levels of unstable pyrite which when exposed to air and water may lead to acid generation in the tailings body which in turn could lead to dissolution of heavy metals and underground water contamination. Control measures for this risk may include total lining of the base of the tailings dam. But even the solution to line should be accepted after a further risk assessment of future possible failures in the lining. Copeland, a veteran consultant based in South Africa, (Copeland, 2018) advised that even such a solution should be chosen after thorough risk-based analysis.

Risk-Based Mine Waste Management in Zambia

A scan through the Zambian mining sector reveals that at best, the historical risk management practices have been predominantly emphasizing on safety and mine operation integrity (Banda, 1993). The mines had been content that they have continued to operate smoothly without major accidents. This legacy may have lingered to the present day. Perpetual long term environmental risks related to the mine waste facilities are not in general well managed, at least not in the total sense of modern risk management. Risk associated with mine dumps includes geotechnical risks, geochemical risks (Acid Mine Drainage), chemical, water and air pollution and general environmental Mine waste risks may also include financial, economic, regulatory and societal risks. All these risks do affect the objectives of a mine firm and other stake-holders. The authors would like to suggest that the concept of risk management should be well understood by scientists, engineers, mine firms and regulators if mine waste management has to yield optimum benefits to overall sustainability of mining environment in Zambia.

The million dollar question that remains unanswered is how many mine firms in Zambia practice rigorous risk management and keep a risk register for the waste dumps and tailings dams? The hypothesis that the authors propose is that there is only a handful of firms that have documented registers of risks in waste management in all the stages of life cycle. Statistics are required in order to exonerate the mines from the guilty cloud hanging over them concerning risk management of mine waste. Unfortunately risks cannot be dumped and sooner or later when conditions are sufficient they will occur and cause negative impacts.

The fact that Zambia has not witnessed several disasters arising from mine waste since the Mufulira disaster in 1970, does not mean that management of mine waste risk has necessarily improved. It may just mean that the conditions for risk occurrence have not just matured. As a matter of recent fact, Zambia witnessed a mine waste related disaster (the black mountain disaster) on June 20, 2018 in which 11 people lost their lives when a slag dump slumped down during reclamation. The risk could have been prevented from occurring had proper risk management been effected at the right time.

It is not beneficial to try to manage consequences of risks. The best success in mine waste risk management can be achieved when the process is started long before a risk can occur. Risk tends to persist unless treated and has risk residue at the end of its management. There can therefore be risk left-over even after risk control has been done. This residual risk also needs to be managed using the similar process as the original risk until the remaining risk becomes acceptable. It can then be appreciated that if risk is managed at every stage of the project, there could be low risk level occurring to impact on the objectives of the firm. Outcomes of a risk management process should be documented in a Risk Management Plan and would include a risk register, wherein risk and its management are recorded. Risk should be prioritized and major risks managed in the order of their size (Probability multiplied by the impacts). This does not mean risks of lesser level should not be managed. Without control, risk can grow bigger until the condition of occurrence is reached. At this stage, it may be almost too late to manage
It is common knowledge that mine waste management is risky. Mine waste have potential to pollute surface water, air quality and general environment and the requirements of financing institutions concerning project risks have awaken top management to the realities of risks inherent to mine waste. The sad scenario is that in the past there has been less attention paid to the waste side of mining projects by developers. The names given to the mine waste facilities such as *waste yards, dumps, tailings*, etc. have a connotation of something that does not matter anymore and so not really worthy of careful management. Of late there has been an increase in awareness of the benefits of risk management in managing mine waste facilities. Benefits have included: good risk management is responsible management which yields cost effective benefits in the long run; leads to compliance to country environmental legislation; it improves mine firms' chances of receiving financing from international agencies that are environmental pressure groups (Banda, 1993).

Regulatory Framework of Mine Waste Facilities in Zambia

In Zambia the regulatory framework governing the management of mine waste facilities is mainly anchored on the Environmental Management Act No.12 of 2011 and its subsidiary legislations, the Environmental Impact Assessment Regulations, Statutory Instrument No. 28 of 1997, and the Environmental Management (Licensing) Regulations, Statutory Instrument N0. 112 of 2013. The Mines and Minerals Development Act No. 11 of 2015 and its subsidiary legislation including the Mines and Minerals (Environmental) Regulations, 1997 and the Mines and Minerals (Environmental Protection Fund) Regulations, Statutory Instrument No. 1998 are also part of the regulatory framework governing the management of mine waste facilities.

The Third Part (Part III) of the Environmental Management (Licensing) Regulations, 2013 prescribes the waste management regulations to be complied with by project developers who intend to "reclaim, re-use, recover, recycle, transport, dispose of, transit, trade in, export waste or collect and dispose waste from industrial, commercial, domestic or community activities or own or construct or operate a waste disposal site or facility for the permanent disposal or storage of waste" (GRZ, 2013). For any person to undertake the activities outlined above there is need for a waste management licence to be obtained. The license highlights specific conditions as regards management of waste by a person intending to engage in such activities prescribed by the regulations.

In addition, the regulation requires that any person intending to engage in waste management related activities shall demonstrate technical capabilities to undertake such activities. The person shall also put in place measures and facilities to ensure safe reclamation, re-use, recovery or recycling of waste, among other provisions.

Part III of the Mines and Minerals (Environmental) Regulations, 1997 provides for procedures to be followed before dumping, rules for dumping, procedures for dumping on decommissioned dump and prohibition of dumping. In addition, the regulations require owners and operators of mine waste dumps to ensure that the dump walls are stable, drainage of the dam is good, among other requirements. The Zambia Environmental Management Agency (ZEMA) under the Ministry of Lands, Natural Resources and Environmental Protection and the Mine Safety Department under the Ministry of Mines, Energy and Water Development enforce the provisions of the Environmental Management Act, 2011 and the Mines and Minerals Development Act, 2015 respectively to ensure that the provision of the Acts and their respectively subsidiary legislation are complied with by owners and operators of mine waste facilities. There are also other government agencies and line ministries that enforce environmental-related legislations (Lindahl, 2014; MTENR, 2009). However, it has been recognised that the Environmental Management Act is the principal legislation among all the environmental legislation in Zambia.

Although the legal framework, as seen in the creation of Acts and agencies, exists in Zambia to regulate environmental management, implementation of these regulations on the ground has not yet yielded the expected results. The Environmental Management Act No. 12 of 2011 established the Zambia Environmental Management Agency (ZEMA). ZEMA is responsible for controlling risks to the environment by granting permits to developers after approval of Environmental Impact Statements. The Environmental Impact Assessment (EIA) Regulations, Statutory Instrument No. 28 of 1997 provides the framework for compiling and implementation of the Environmental Social Impacts Management Plans to redress the identified impacts. The regulations also provides for regular audits to check effectiveness of the implemented plans for control of impacts. However, as Lindahl (2014) suggested, ZEMA does not have adequate capacity to implement their mandate of ensuring environmental protection compliance among project developers. There are other Acts such as the Mines and Minerals Development Act of 2015, which mandates the Mine Safety Department (MSD) to deal with risks arising from mining activities. Lindahl (2014) has suggested that part of the reason why implementation of environmental regulations has not yielded expected results is the lack of coordination among the regulating institutions.

The other reason for concern in Zambian mine waste management is that there is no coordinated code of practice that guides and controls risk management of mine waste. This code is necessary to translate environmental regulations into implementable guidelines. As it is presently, each mine develops its own waste management system based on what each miner owner perceives as best practice around the world. While there are benefits of using world best-practice in the industry for management of mine waste, global best practice can overshadow development of the country specific practices that can impart sustainable development to the environment and human health.

International Best Practice and Guidelines of Mine Waste Facilities

This section of the paper looks at various current practices taking place in the different mining regions where an appreciable amount of development has taken place in terms of a risk based approach to the design, operation and closure of mine waste facilities. Mining companies do recognise the significant role that mine waste facilities play in the overall risk profile of their mining operations. More important, Financiers and Government Regulatory Bodies recognise this significant risk and are eager to see an improved safe and sustainable approach to mine waste facilities. These practices or guidelines have been developed by specific organisations and member firms in the mining sector are expected to follow these guidelines in their operations, of course, subject to prevailing legislations in the various jurisdictions they operate in. Recent disasters or failures associated with mine waste dumps have already been discussed and articulated. Some of these disasters have brought about litigation that is costing mine owners, developers and designers millions of dollars in clean-up cost, compensatory payments and closure of operations. Although not specifically developed as risk management guidelines the minimum requirements that have been developed for the design, construction, operation, decommissioning and closure are currently comprehensive to ensure risks are identified, managed and mitigated through the life cycle of the facility.

There are several national and international available guidelines for the design, construction, operation and closure of tailings dams. Some of the most comprehensive include International Commission on Large Dams (ICOLD), Mining Association of Canada (MAC), Australian Commission on Large Dams (ANCOLD), Canadian Dams Association (CDA), SANS Code of Practice, United States Army Corps of Engineers (USACE). These guidelines have some variations to one another but all look into the safe and sustainable management of tailings facilities and waste facilites.

The practices developed by the Mining Association of Canada have been given a closer review under current relevant practices. This is based on the premise that some of the major mining companies in Zambia are adopting MAC's approach and code of practice in their mine waste management practices. Audits recently done on some of the mine waste facilities are based on the MAC guidelines. In addition most mining companies that are members of the International Council of Mining and Metals (ICMM) and have operations in Canada adopt MAC & CDA guidelines which they have subsequently also adopted at mine site they operate outside of Canada. In a review done by ICMM in 2016 and in regard to the Canadian guidelines state the following *"The Canadian guidelines (MAC and CDA) when taken together represent the most comprehensive of the national frameworks. Member companies that adopt the Canadian guidelines guidance would be rated as adequately complying with good practice."*

A Position Statement was subsequently developed by ICMM on preventing catastrophic failure of tailings storage facilities. The Position Statement commits ICMM members to minimise the risk of catastrophic failures of tailings dams by adopting six key elements of management and governance namely Accountability, Responsibility, and Competency, Planning and Resourcing, Risk Management, Change Management Emergency Preparedness and Response, Review and Assurance.

The Mining Association of Canada (MAC) guides as follows in connection with Tailings management. *Managing tailings facilities in a manner commensurate with the physical and chemical risks they may pose.., includes: regular, rigorous risk assessment; application of most appropriate technology to manage* and control *risks on a site-specific basis* taking into account present circumstances*; application of industry best practices to manage risk and achieve performance objective.* (Mining Association of Canada, 2017).

Risk management framework and approach proposed by MAC ensures tailings are managed in a manner consistent with responsible management i.e. "responsible management is defined by *comprehensive assessments* of the risks associated with a tailings facility, both physical and chemical, that evaluate the potential health, safety, environmental, societal, business, economic and regulatory impacts, and the implementation of appropriate controls to effectively manage those risks." (Mining Association of Canada, 2017).

A specific look at the recent developments that MAC and CDA has developed in regards to tailings storage facilities has been the incorporation of the following key principles in the Third Edition of the "Guide to the Management of Tailings Facilities" (Mike Davies, Charles Dumaresq., 2018)**.**

1. **Risk-Based Approach.**
   Managing tailings facilities in a manner commensurate with the physical and chemical risks they may pose.
2. **Best Available Technology and Best Available Practice for Tailings Management.**
   The identification and implementation of appropriate tailings management technologies, including the application of site-specific BAT and BAP are key to achieving performance objectives and managing risks.
3. **Independent Reviews**
   Independent evaluation of all aspects of the planning, design, construction, operation, maintenance of a tailings facility by competent, objective, Third-Party reviewer on behalf of the Owner
4. **Designing and Operating for Closure**
   This is considered the best practice for mitigating long-term risks and reducing liability. This gives way to better design and operational practices that will entail reduced long term impacts and risks. The tailings facilities, designed for closure, is intended to remain physically and chemically stable for the long-term.
5. **Engineer-of-Record**
   The Engineer of Record provides technical direction on behalf of the Owner and verifies whether the tailings facility has been designed in accordance with performance objectives and indicators, applicable guidelines, standards and regulatory requirements. The Engineer of Record will be responsible to ensure the construction and operation through the facilities' life cycle is in accordance to design, performance objectives, applicable guidelines, regulatory requirements and standards.

Conclusion

The authors do recognize efforts by mines and regulators to manage risk in the area of Safety Health and Environment in general terms. However, most efforts in risk management in Zambia have remained directly developer-driven. It is concurred with United Nation Environment Programme that the Owner driven risk assessment of dumps lacks impartiality.

Lack of coordination among the regulating agencies has been cited as source of concern in mine waste management. In addition, the regulatory framework should be adequately implemented to enhance responsible management of the mine waste facilities.

The standards codes for planning, project and infrastructures design and Risk Assessment procedures need to be identified and implemented is required for the Zambian mining sector if all operations have to be done through responsible risk management and promote sustainability of natural resources the country is endowed with.

It is critical that adequate and practical risk management practice/process by mine firms are documented and effectively implemented to enhance sustainability of resources and to create a better environment in Zambia.

Research is required to evaluate the nature and adequacy of mine waste risk management practices practiced by different mines in Zambia.

References

Copeland, A., 2018. *Lined tailings facilities Consequential risks require better understanding,* South Africa: Mining Review Africa.
David M Chambers, B. H., 2011. *Long Term Risks of Tailings Dam Failures* , s.l.: s.n.
Hillson, 2009. *Managing Risk in Projects,* Farnham: Gower.
Institution of Civil Engineers, 2014. *Risk Analysis and Management for Projects,* London: ICE Publishing.
International Standard Organisation, 2009. *Risk Management -Principles and Guidelines,* Switzerland: ISO.
Lindahl, J., 2014. *Environmental Impacts of Mining in Zambia,* Uppsala: Sveriges Geologiska Undersokning.
Mining Association of Canada, 2017. *A Guide to the Management of Tailings Facilities* , Canada: Mining Association of Canada.
Paul Banda, P. B., 1993. *Waste Management for Solid Waste,* Zambia: International Mine Water Association.
Peter Zhou, L. H. L. F. G. d. F., 2015. *Scoping study for a non-renewable resources, climate change and environmental programme in Southern Africa,* London: CROWN COPYRIGHT.
The Association for Project Management, 2012. *Project Risk Analysis and Management,* Buckinghamshire: APM.
United Nations Environment Programme, 2017. *UNEP Tailings Dams report and residual risk assessment* , Geneva: UNEP.

United Nation Economic For Europe 2014 Safety guidelines and good practices for tailings management facilities new York and Geneva.
Jonhson .B and Carroll K 2007 .*Waste Rock Backfill of Open Pits: Design, Optimisation, and Modelling Considerations* Mine Closure 2007, Conference Proceedings paper, Santiago, Chile.
Mututubanya, 2000 *Cobalt recovery from old Nkana Copper Slag via solid state carbothermic reduction and sulphation:* University of Zambia.

Copeland, A., Lyell K., 2002. *Risk Management on Tailings Dams - World Wide Perspective*
Golder Associates., 2016.*Review of Tailings Management Guidelines and Recommendations for Improvemen*t
Mike Davies, Charles Dumaresq., 2018 *Mining Association of Canada's Guidance onTailings Management.*