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A review of the regulatory framework for environmental protection in BC's mining industry: Lessons learned from the Mount Polley Incident

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Abstract

In 2014, the Mount Polley mine tailings storage facility breached, spilling approximately 25 million cubic metres of water and mine tailings into the surrounding environment and nearby water bodies. Following the incident, an independent review panel and the Chief Inspector of Mines conducted investigations to determine the cause(s) of the failure and to make recommendations. The Auditor General of British Columbia also reviewed the incident during an audit of compliance and enforcement activities in the mining industry. This study was undertaken to determine areas of overlap in the recommendations across the three reports in order to identify regulatory gaps. In the process, this study conducted a review of key pieces of legislation guiding the mining industry in BC, two regulatory bodies, and the three reports. The following four areas of overlap in the recommendations were identified: professional reliance, geotechnical oversight, life-of-mine planning for permitting, and investigation, compliance and enforcement review. These findings suggested that additional controls should be implemented in these areas of overlap in order to prevent another tailings storage facility incident from occurring.

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1.0 Introduction

1.1 Mining in BC

The mining sector is an important part of British Columbia's (BC) economy. In 2018, the total forecasted value of mine production in BC was 10.93 billion dollars (Clarke et al., 2019). This value represented the large reservoir of diverse minerals and deposit types extracted from various mines in the province, which included coal, copper, gold, industrial metals, aggregate, molybdenum, and silver. In 2018, eleven metal mines were in operation with 21 mine development projects at the proposed stage (Clarke et al., 2019). Projects that were in the proposed stage had a resource defined and were prepared to initiate the environmental assessment process. The BC mining industry has continued to grow in order to meet global demands for minerals and metals.

The first step in the mining life cycle is exploration, which involves searching for mineral deposits. In the exploration phase, large areas are evaluated by airborne or ground-based surveys. When a deposit is discovered and the results are positive, the next stage is development, which includes feasibility, design and construction. At the design stage, all aspects of mine construction, operation, closure and reclamation are planned in detail. Construction, followed by operation, begins once all the necessary authorizations are received. Typically, the operation phase lasts 10-30 years before entering into closure. Once the mine is closed, reclamation, environmental monitoring, and water treatment may be required long term.

Depending on the method of mining, the process can generate a number of different pollution sources. In open pit mines, for example, soil and rock overlying the mineral deposit is removed, rock is blasted, and ore is grinded during processing. These processes increase the surface area of rocks exposed to air and water. This can generate acid and metals, otherwise known as acid mine drainage, that can leach into the surrounding environment. The waste rock can also be a source of pollution. When waste rock is stored in piles, it can contain acid generating sulphides, heavy metals, and other contaminants that can leach into the environment.

Ore is the mineralized rock containing a valued metal or mineral substance. After ore is extracted, it is crushed and ground into fine particles the size of sand or silt in order to extract the valued metal or mineral. The fine particles are processed with various reagents to separate the valued metal or mineral components from the uneconomic fraction. The remaining mixture of fine particles and chemicals are called tailings. Mine tailings can be a source of pollution because they may contain elevated levels of metals and/or acid forming minerals. Tailings are often stored in above ground containment areas or tailings storage facilities. A tailings storage facility (TSF) is a structure made up of one or more dams built for the purposes of storing the byproduct of ore processing.

1.2 Mount Polley Tailings Dam Failure

Mount Polley Mine is a copper and gold mine located in the Central Interior of BC, approximately 65 km northeast of Williams Lake (Figure 1). The mine is located in the asserted traditional territory of the Williams Lake Indian Band and Soda Creek Indian Band. The owner and operator of the mine, Mount Polley Mining Corporation (MPMC), is a subsidiary of Imperial Metals Corporation. When the mine was in full operation, approximately 400 people were employed, processing 21,000 tonnes of ore per day. The ore was processed on-site in a mill and generated waste tailings that were stored in a tailings storage facility. The tailings storage facility covered an area of approximately 300 hectares and was enclosed by a dam over four kilometers long.



Figure 1. Mount Polley location map (MEM, 2015).

On August 4th, 2014, the tailings storage facility breached, spilling approximately 25 million cubic metres of water and mine tailings into the surrounding environment and nearby water bodies (Byrne et al., 2018). Initially, the water and tailings spilled into Polley Lake (Figure 2). However, once the lake overflowed, the material entered into Hazeltine Creek before eventually spilling into Quesnel Lake. The incident resulted in environmental (Byrne et al., 2018), social (Shandro et al., 2017), and economic impacts to nearby and downstream communities.



Figure 2. The Mount Polley tailings storage facility breach into Polley Lake, Hazeltine Creek, and Quesnel Lake (MEM, 2015).

1.3 Post-event Investigations and Reports

In the years after the breach, the following two main investigations took place in order to determine the cause(s) of the event and make recommendations: Independent Expert Engineering Investigation and Review Panel and Investigation Report of the Chief Inspector of Mines. The incident was also reviewed in an audit of compliance and enforcement activities in the mining industry conducted by the Auditor General of BC.

The purpose of the Panel investigation, consisting of government officials, indigenous members, and stakeholders, was to determine the cause of the failure of the tailings storage facility and to make recommendations to prevent a similar failure at other mine sites in BC. The investigation concluded that “[t]he dominant contribution to the failure resides in the design. The design did not take into account the complexity of

the sub-glacial and pre-glacial geological environment associated with the Perimeter Embankment foundation. As a result, foundation investigations and associated site characterization failed to identify a continuous glaciolacustrine unit layer in the vicinity of the breach and to recognize that it was susceptible to undrained failure when subject to the stresses associated with the embankment. The specifics of the failure were triggered by the construction of the downstream rock fill zone at a steep slope of 1.3 horizontal to 1.0 vertical” (IEEIRP, 2015, p. iv). The investigation resulted in the following seven recommendations:

1. To implement Best Available Technology using a phased approach
2. To improve corporate governance
3. To expand corporate design commitments
4. To enhance validation of safety and regulation of all phases of a TSF
5. To strengthen current regulatory operations
6. To improve professional practice
7. To improve dam safety guidelines

The purpose of the Chief Inspector of Mines investigation was to determine the root and contributory cause(s) of the event and prepare findings to address the accountability of the industry, the Regulator, engineering practices, and any other contributors to the event. There were three key findings from the investigation:

1. The dam failure mechanism was geotechnical: sliding failure on a weak clay layer 10 m below the surface
2. The dam breach mechanism was hydrologic: insufficient beaches to protect the embankment from the surplus of water in the tailings pond once the embankment failed
3. The root causes of the event were organizational: mistaken belief that adequate foundation studies were completed – misplaced faith in the Factor of Safety that resulted – overconfidence in the reliance on professional judgement – narrow planning perspective in mine management – failure to adequately understand and act on risk

As a result, a total of 19 recommendations were made for the mining operator, the mining industry, professional organizations, and the Regulator.

The purpose of the Auditor General’s audit was to determine whether the regulatory compliance and enforcement activities of the Ministry of Energy, Mines and Petroleum Resources (EMPR) and the Ministry of Environment and Climate Change Strategy (ENV), pertaining to mining, were protecting the province from significant environmental risks. Although the audit mainly examined the regulatory framework of

the two ministries, the Auditor General also conducted a review of the Mount Polley incident. The audit was conducted based on the following seven key elements of a comprehensive compliance and enforcement program: planning, permitting, compliance promotion, compliance verification, enforcement, evaluation and adjustment, reporting. Deficiencies were identified in the seven areas, resulting in recommendations for the two ministries.

While the investigative reports were able to determine similar causes of the event, the investigations were limited by their mandates, which generated different recommendations for their target audiences. The main purpose of this report is to review these recommendations for areas of overlap, identify regulatory gaps that may have contributed to the failure, and to make recommendations to reduce the risk of such an event from occurring again.

2.0 Objectives

The objectives of this study are to:

- Review and assess the investigations of the failure,
- Assess B.C. mining regulations and determine possible deficiencies related to the failure,
- Evaluate the regulatory framework in B.C., and
- Make recommendations for policy changes to strengthen environmental protections and the mining industry in B.C.

3.0 Methods

This review focused on two main aspects of the investigative reports: recommendations for professional reliance and recommendations for the regulator. Since each of these investigations had already investigated the root cause of the failure, reviewed available documentation, and audited the regulatory bodies, the focus of this review was to determine overlaps in the reports rather than investigate the main cause(s) of the failure.

The three reports within the scope of this review are:

- Independent Expert Engineering Investigation and Review Panel
- Investigation Report of the Chief Inspector of Mines
- An Audit of Compliance and Enforcement in the Mining Sector

The following three key pieces of legislation were also reviewed to determine its application in this incident: *Mines Act*, *Environmental Management Act*, and *Environmental Assessment Act*. In the process, the two main regulatory bodies that were reviewed included the Ministry of Energy, Mines and Petroleum Resources (EMPR) and the Ministry of Environment and Climate Change Strategy (ENV). A literature review provided background information regarding the environmental and social impacts of the incident.

This review relied on a number of different assumptions. Firstly, it was assumed that despite the differences in mandates for each of the reports, the overlaps in recommendations suggested that these were important reoccurring themes that contributed to the cause of the failure. It was assumed that these recommendations would highlight regulatory gaps that created the conditions which allowed the failure to occur. Secondly, although the incident represented a complex instance with multiple causes, it was assumed that the lessons and recommendations from the Mount Polley incident would be applicable to other mines in the province. Lastly, this review did not take into account the changes to legislation that has occurred over the years leading up to the incident, which may have influenced the safety of the mine.

4.0 Background

4.1 Regulatory Regime

At Mount Polley, a Memorandum of Understanding is in place between the Ministry of Energy, Mines and Petroleum Resources (EMPR), the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) and the Ministry of Environment and Climate Change Strategy (ENV). The Memorandum of Understanding is a formal document which describes the responsibilities of the ministries. While EMPR is responsible for the engineering aspects of the Mount Polley tailings storage facility, including seepage collection ponds and diversions, ENV is responsible for the water quality of any discharges from the mine. MFLNRO is responsible for the issuing of water licenses or approvals regulating the diversion, use and storage of surface water in or from a natural watercourse on a mine site. The government's role is to ensure that the activities of the mine operator are protecting the environment.

Generally, the responsibilities of EMPR are within the mine site. The ministry has two primary responsibilities: (1) grant permits under the *Mines Act* to ensure mines are designed, built, operated and reclaimed to an acceptable standard and (2) collect security deposits from mining companies to help ensure that reclamation obligations are kept. The Chief Inspector of Mines, appointed by the Minister of Energy, Mines and Petroleum Resources, administers the *Mines Act* and the Health and Safety

Reclamation Code for Mines in BC to ensure regulatory oversight of BC's mineral exploration and mining industry.

ENV's responsibilities are mostly beyond the borders of the mine site. Through the *Environmental Management Act*, ENV grants permits that ensure the quantity and quality of any waste discharges from metal and coal mines meet provincial guidelines.

The following sections provide a brief description of three key pieces of legislation that ensure the activities of mining companies are protecting the environment.

4.1.1 Mines Act

EMPR has two regulatory tools: The *Mines Act* and the Health and Safety Reclamation Code (Code) for Mines in British Columbia. While the Mines Act governs all activities that occur on mine sites, the Code regulates all mining activities.

The purpose of the *Mines Act* and the Code is to:

- Protect the health and safety of workers and public from mining activities
- Protect and reclaim the land and watercourses affected by mining
- Support and monitor the efficient development of the Crown's mineral and coal resources, while managing environmental impacts
- Facilitate successful reclamation and closure of mine operations
- Regulate environmental and reclamation liabilities at mines through permitting and bonding to ensure that public funds will not be required to pay the costs of mine clean up

4.1.2 Environmental Management Act

The purpose of the *Environmental Management Act* is to regulate industrial and municipal waste discharge, pollution, hazardous waste and contaminated site remediation. This act enables the use of permits, regulations and codes of practice to authorize discharges to the environment and enforcement options, such as administrative penalties, orders, and fines to encourage compliance. Permits that are granted from the *Environmental Management Act* provide the authority to mines to introduce wastes into the environment while meeting provincial guidelines. The guidelines and objectives for water quality are developed under the *Environmental Management Act*.

4.1.3 Environmental Assessment Act

In Canada, any mining development project that may have adverse effects to the environment must undergo an Environmental Assessment (EA). The purpose of an EA

is to minimize or avoid adverse environmental effects before they occur and to incorporate environmental factors into decision-making. Provincial and federal departments, depending on the jurisdiction and scale of the project, carry out these assessments. At the federal level, the *Canadian Environmental Assessment Act*, 2012 (CEAA, 2012) and its regulations establish the legislative basis for the practice of EA in Canada. While at the provincial level, EA occurs within a legal framework that includes three main sources: the *Environmental Assessment Act*, regulations under the *Environmental Assessment Act*, and Common law regarding First Nation consultation. Since the *Environmental Assessment Act* came into force in 1995, the legislative framework has undergone many different revisions over the years (Powell, 2014).

Before the introduction of the *Environmental Assessment Act* in 1995, proponents applied for project certifications under the *Mines Act*. When the *Environmental Assessment Act* came into force in 1995, Mine Development Certificates continued in force as EA certificates. For instance, while the Mount Polley mine received project certification in 1992 under the *Mines Act*, this certificate continued in force as an EA certificate in 1995, although no formal environmental assessment took place under the *Environmental Assessment Act*. While both are key pieces of legislation that govern and regulate mining and mineral exploration activities in the province, they serve different roles in mitigating adverse impacts from mining developments and activities.

5.0 Results

5.1 Post-Event Investigations

The following sections provide a summary of the areas of overlap in recommendations among the three reports. These areas of overlap were initially identified in the Chief of Mines investigation (MEM, 2015, p. 171). However, the summary table did not include recommendations from the Auditor General's report, which was released shortly afterward. The recommendations from the audit have also been included in this analysis. These areas of overlap are described in Table 1, Table 2, Table 3, and Table 4. The four areas of overlap across the three reports include:

- Professional Reliance Standards
- Geotechnical Oversight
- Life-Of-Mine Planning for Permitting
- Investigation, Compliance and Enforcement Review

5.1.1 Recommendations for Professional Reliance

Table 1. Summary of recommendations for professional reliance.

Report	Recommendations
Independent Expert Engineering Investigation and Review Panel	<p>Improve professional practice:</p> <ul style="list-style-type: none"> • Encourage the APEGBC to develop guidelines that would lead to improved site characterization for tailings dams with respect to the geological, geomorphological, hydrogeological and possibly seismotectonic characteristics
Investigation Report of the Chief Inspector of Mines	<p>Professional Reliance Standards:</p> <ul style="list-style-type: none"> • Reliance on professional practice requires that the organizations overseeing the professionals or developing guidelines and standards for the professional community incorporate best available practices into their oversight. Organizations supporting such standards include: <p>Association of Professional Engineers and Geoscientists of BC (APEGBC).</p> <ul style="list-style-type: none"> • Responsibilities include professional practice guidelines. APEGBC should develop specific practice guidelines for site investigation, roles and responsibilities of the Engineer of Record (EoR), standards of practice for transfer of EoR, especially when the transfer involves changing engineering companies, and standards for engineering presence on site during construction. <p>Mining Association of Canada (MAC).</p> <ul style="list-style-type: none"> • Responsibilities include participatory guidelines applicable to tailings and water management, including applicable safety, operations, design, construction, surveillance, and planning; and corporate governance

	<p>standards of practice. MAC should review existing guidelines to define the roles and responsibilities of the mine dam safety manager, and should develop guidance on what is required to document the tailings management system such that it can be audited by a qualified third party such as the International Standards Organization (ISO).</p> <p>Canadian Dam Association (CDA).</p> <ul style="list-style-type: none"> Responsibilities include the ongoing development of design guidelines for water and mining dams. CDA should update safety guidelines to reduce ambiguity, and develop specific guidelines for mining embankments which recognize the continued changes and raises during the life of the TSF and the consequence classification associated with a tailings dam failure.
An Audit of Compliance and Enforcement of the Mining Sector	<p>Qualified Professionals</p> <p>Recommend that government establish policies and procedures for the use and oversight of qualified professionals (QP) across the natural resources sector. These policies and procedures should have the following:</p> <ul style="list-style-type: none"> Guidance for staff that outlines the specific nature and amount of oversight expected of a QP's work Guidance for staff as to expected timeframe for review and response to QP reports Updated guidance for staff for recognizing and responding to misconduct by a QP Controls in place to ensure that there is no undue influence on the QP's by the industry Controls in place to ensure that recommendations by QP's are adhered to

5.1.2 Recommendations for Geotechnical Oversight

Table 2. Summary of recommendations for geotechnical oversight.

Report	Recommendations
Independent Expert Engineering Investigation and Review Panel	<p>Strengthen current regulatory operations</p> <p>Utilize the recent inspections of TSFs in the province to ascertain whether they may be at risk due to the following potential failure modes and take appropriate actions</p> <ol style="list-style-type: none"> 1. Undrained shear failure of silt and clay foundations 2. Water balance adequacy 3. Filter adequacy <p>Utilize the concept of Quantitative Performance Objectives to improve Regulator evaluation of ongoing facilities</p>
Investigation Report of the Chief Inspector of Mines	<p>Geotechnical Oversight</p> <ul style="list-style-type: none"> • The Regulator has a responsibility to oversee the decisions of the EoR. The Regulator must maintain sufficient technical capacity to conduct appropriate oversight of the professional opinions on which it relies. A Regulatory Dam Safety Manager dedicated to the coordinated regulatory oversight of tailings dams in the Province could be responsible for ongoing policy development, technical review, and inspection capacity as it relates to tailings impoundments. Effective oversight of professional reliance in the design, maintenance, and operation of tailings impoundments will increase compliance with engineering and operational standards, reducing risk in tailings storage facilities across mines in the Province.

An Audit of Compliance and Enforcement of the Mining Sector	Strategic Planning <ul style="list-style-type: none"> Recommend that government develop a strategic plan that would detail the activities of an integrated and coordinated regulatory approach, and the necessary capacity, tools, training and expertise required to achieve its goals and objectives.
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5.1.3 Recommendations for Life-of-Mine Planning for Permitting

Table 3. Summary of recommendations for life-of-mine planning for permitting.

Report	Recommendations
Independent Expert Engineering Investigation and Review Panel	Implement Best Available Technology (BAT) using a phased approach: <ul style="list-style-type: none"> For existing tailings impoundments. Rely on best practices for the remaining active life. For new tailings facilities. BAT should be actively encouraged for new tailings facilities at existing and proposed mines. For closure. BAT principles should be applied to closure of active impoundments so that they are progressively removed from the inventory by attrition.
Investigation Report of the Chief Inspector of Mines	Life-of-Mine Planning for Permitting <ul style="list-style-type: none"> Short-term, incremental <i>Mines Act</i> permit amendment applications can obscure life-of-mine conditions and long-term risks. The Regulator should ensure a perspective that spans the life of the mine be considered for <i>Mines Act</i> permit applications, while acknowledging that the nature of mining frequently requires changes to the life-of-mine plan.

	<ul style="list-style-type: none"> Requiring life-of-mine planning in TSF design and the permitting process will enhance the robustness of the overall design of proposed structures.
An Audit of Compliance and Enforcement of the Mining Sector	<p>Mine design</p> <ul style="list-style-type: none"> Recommend that government adopt appropriate standards, review mine designs to ensure that they meet these standards, and ensure that mines, as constructed, reflect the approved design and standards.

5.1.4 Recommendations for Investigation, Compliance and Enforcement Review

Table 4. Summary of recommendations for investigation, compliance and enforcement review.

Report	Recommendation
Independent Expert Engineering Investigation and Review Panel	<p>Strengthen current regulatory operations</p> <p>Utilize the recent inspections of TSFs in the province to ascertain whether they may be at risk due to the following potential failure modes and take appropriate actions</p> <ol style="list-style-type: none"> 1. Undrained shear failure of silt and clay foundations 2. Water balance adequacy 3. Filter adequacy <p>Utilize the concept of Quantitative Performance Objectives to improve Regulator evaluation of ongoing facilities</p>
Investigation Report of the Chief Inspector of Mines	<p>Investigation, Compliance and Enforcement Review</p> <ul style="list-style-type: none"> The Regulator must enhance its investigative capacity, as well as its ability to exercise its existing compliance and enforcement authority under the <i>Mines Act</i> and Code. A supported director-equivalent position specific to investigation, compliance and enforcement should be established to

	<p>evaluate and oversee these roles. This oversight should extend to applying recommended standards to the Regulator's compliance and enforcement function. A full range of regulatory tools, such as incentives, administrative penalties, outside agency collaboration and other best practices should be considered.</p> <ul style="list-style-type: none"> Improved investigative and enforcement capacity will enhance the ability of the Chief Inspector to increase compliance and achieve greater safety at mines, improve industry practices, and lead investigations in the future.
An Audit of Compliance and Enforcement of the Mining Sector	<p>Reclamation Guidance</p> <ul style="list-style-type: none"> Recommend that government develop clear and comprehensive reclamation guidance for industry. <p>Incentives</p> <ul style="list-style-type: none"> Recommend that government create effective incentives to promote environmentally responsible behavior by industry. <p>Risk-based Approach</p> <ul style="list-style-type: none"> Recommend that government develop a risk-based approach to compliance verification activities, where frequency of inspections are based on risks, such as industry's non-compliance record, industry's financial state, and industry's activities (e.g. expansion), as well as risks related to seasonal variations. <p>Security – Adequate Coverage</p> <ul style="list-style-type: none"> Recommend that government safeguard taxpayers by ensuring the reclamation liability estimate is accurate and that the security held by government is sufficient to cover potential costs. <p>Systematic Compliance Verification</p> <ul style="list-style-type: none"> Recommend that government systematically monitor and record compliance with high-risk mine permit requirements. <p>Policies, Procedures and Tools</p> <ul style="list-style-type: none"> Recommend that government develop policies, procedures and enforcement tools for responding to non compliances when industry does not meet government's specified timeline.

5.2 Response to Recommendations

Table 5. Summary of response to recommendations from professional associations and the regulator in the areas of overlap.

Recommendation	Implementation
Professional Reliance	<ul style="list-style-type: none"> Engineers and Geoscientists BC updated professional practice guidelines for dam site characterization assessments <p>Changes made to the tailings portion of the Code:</p> <ul style="list-style-type: none"> The Code outlines requirements for the designation and reporting responsibility for the mine to designate an Engineer of Record who is a professional engineer The Engineer of Record has a duty to report any unresolved safety issue that compromises the integrity of the TSF Additionally, the Code sets out requirements for professionals or designated responsibilities for the creation of water management and water balance plans All existing mines in British Columbia with TSFs must establish an Independent Tailings Review Board The Terms of Reference and the proposed membership of the Independent Tailings Review Boards must be approved by the Chief Inspector of Mines
Geotechnical Oversight	<ul style="list-style-type: none"> The position of Dam Safety Manager within EMPR has been created and filled

Life of Mine Planning for Permitting	<p>Changes made to the tailings portion of the code:</p> <ul style="list-style-type: none">• A mine plan must be included in the Mines Act permitting application that includes an inventory of areas disturbed to date, and projected over the next 5 years and over the projected life of the mine• Mine, environmental protection, reclamation and closure plans shall be prepared in consideration of the HSRC Guidance Document, by qualified professionals or persons who in the opinion of the chief inspector are qualified to perform the work
Investigation, Compliance and Enforcement Review	<ul style="list-style-type: none">• Deputy Chief Inspector of Mines position in place• The legislation increased penalties available for court prosecutions under the act from \$100,000 and/or up to one year imprisonment to \$1 million and/or up to three years imprisonment• Regulation for administrative penalties now in effect to enable penalties for non-compliance• Deputy Minister Compliance and Enforcement board created to establish compliance and enforcement oversight• Budget lift for MEM for mines permitting and oversight

6.0 Discussion

6.1 Professional Reliance

Professional reliance is an important regulatory model that is used in the natural resource sector. In one definition, professional reliance is the “...regulatory model in which government sets the natural resource management objectives or results to be achieved, professionals hired by proponents decide how those objectives or results will be met, and government checks to ensure objectives have been achieved through compliance and enforcement” (Haddock, 2018, p. 6). For example, in mining, regulators rely heavily on the professionalism and expertise of engineers for decisions and advice on the design, construction, operation and closure of mines and mine facilities. In turn, the government also relies on the professional and ethical codes the professional is required to follow and the oversight provided by professional associations.

In the Mount Polley incident, the key players in the regulatory model for professional reliance included the regulators (the Ministry of Energy, Mines and Petroleum Resources and the Ministry of Environment), the proponent (Mount Polley Mining Corporation), and the professionals hired by proponent. While EMPR was responsible for monitoring, compliance, and enforcement of permits on the mine site, ENV was responsible for regulatory activities outside of the mine site. The proponent and hired professionals were responsible for the design, construction, and operation of the mine and tailings storage facility.

The incident demonstrated that although professional reliance is an important model that is used across all industries, it is not well defined (Table 1). Both the Expert Panel and the Chief Inspector of Mines investigation recognized limitations in the relationship between the Regulator and the Engineer of Record (EoR), otherwise known as the designer. For instance, the Expert Panel emphasized that “[t]he Regulator is not the designer, and this limits the degree of inquiry that is manageable” (IEEIRP, 2015). As the designer, the EoR interpreted the site conditions, designed the dam, and monitored the overall performance of the tailings dam structure. In comparison, the Regulator had the capacity to regulate the construction, but did not have the capacity to modify the design. As a result, the investigations recommended that there should be an independent group reviewing the work of the designer. In addition, the implementation of professional reliance should be adequately structured and formalized in policy.

The Auditor General’s report not only recognized this limitation, but also concluded that there was an overreliance on qualified professionals. Specifically, the Auditor General concluded that this was one of the reasons why the Regulator did not enforce the design of the tailings storage facility. Other reasons provided included

inadequate standards to guide both inspectors and industry, inspections that did not meet policy, and a lack of enforcement culture (Bellringer, 2016). However, the government rejected this finding and argued that the main cause of the tailings dam failure was due to the lack of appropriate subsurface site characterization when the dam was designed and built.

The three reports similarly concluded that professional organizations were lacking standard of practice guidelines and professional reliance guidelines. Firstly, when the tailings storage facility was constructed, there were no formal standard of practice guidelines for site investigations in BC (MEM, 2015). This resulted in the inaccurate characterization of the tailings dam foundation. Secondly, there were no standards guiding the definition and practice standards of an Engineer of Record, or around the change of an EoR (MEM, 2015). Throughout the life of the facility, three external engineering consultants, Knight Piesold, AMEC Foster Wheeler, and BGC Engineering, acted as the EoR. The Chief Inspector of Mines investigation determined that it was unclear how much information was transferred during each transition. Lastly, there was no requirement for a qualified professional to design and manage water balance and no guidelines to require water management at the time of the incident (MEM, 2015). As a result of these findings, professional associations have developed new professional reliance standards and practice guidelines.

6.2 Geotechnical Oversight

Although the Regulator is not responsible for the design of the dam, the Regulator has responsibility to oversee the decisions of the EoR. In order for effective oversight to occur, the Regulator must have the sufficient technical capacity and resources to review the professional opinions of the qualified professional. The Chief Inspector of Mines investigation recommended that there should be a Regulator Dam Safety Manager responsible for ongoing policy development, technical review, and inspection capacity (Table 2).

6.3 Life-of-Mine Planning for Permitting

A long-term perspective throughout the life of the mine is an important component of mine management for the owner and for the regulator. There are multiple phases that require careful planning to prevent and mitigate adverse impacts from mining on the environment. For example, during the operating phase of a tailings storage facility, there are complex interactions among variables such as the tailings waste generated, the height of the dam, and availability of tailings waste available for dam construction. These interactions are further complicated by seasonal constraints, which limit the time available for construction. As well, prior to any changes, permits

must be approved by regulating bodies. Without a long-term perspective to guide mine development, minor issues can quickly develop into long-term risks.

Both the Panel and the Chief Inspector of Mines investigation concluded that a lack of long-term planning was a contributing factor to the failure (Table 3). The Panel described variables that needed to be considered for the long term, including impoundment water-level projections, production and transport of mine waste for raising, and seasonal constraints on construction. However, rather than considering these variables for the long-term, these interactions were projected a year at a time, resulting in responses to the events as they occurred (IEEIRP, 2015). Similarly, the Chief Inspector of Mines investigation concluded that a lack of long-term planning was one of the conditions that contributed to a proximate cause of the failure (MEM, 2015). Other conditions were also identified: no qualified person, no site integration, uncontrolled water balance, and poor water management. In addition, the time delay in completing the permit process was identified as a contributing factor to the proximate cause of the dam failure.

The Auditor General's audit determined that EMPR did not meet the policy of having a geotechnical inspection performed minimally once a year. In particular, no geotechnical inspections were conducted during 2009, 2010, and 2011. The audit suggested that although the inspections would not have identified the weakened layer, regulatory staff could have reviewed documents and determined that the dam was being raised without long-term planning.

6.4 Investigation, Compliance and Enforcement Review

The role of the government as a regulator is to ensure that the activities undertaken by the mine operators will not cause adverse impacts to the environment. As discussed previously, the two primary permitting agencies with environmental protection mandates under provincial legislation are the Ministry of Energy, Mines and Petroleum Resources (EMPR) and the Ministry of Environment and Climate Change Strategy (ENV). These two ministries rely on compliance and enforcement activities to ensure that mining operators are protecting the province from significant environmental risks.

Although the main focus of the Panel investigation was technical, they concluded that the performance of the Regulator was as expected. The following list is a summary of their findings concerning the regulator:

- The Panel found that inspections of the TSF would not have prevented failure and that the regulatory staff are well qualified to perform their responsibilities
- From 2009-2011, no inspections were conducted. However, the Panel concludes that because there were no precursors to be detected, no amount of inspections could have detected a hidden flaw

- MEM correctly queried the designer about the softer conditions in the glaciolacustrine soils encountered in a groundwater well that were similar to those at the breach
- The roles and responsibilities of MEM to regulate impoundments and diversions at mines are well defined and agreed upon with other ministries
- Within MEM, the roles and responsibilities of the geotechnical engineering group responsible for regulating the design, construction and operational aspects of the TSFs are also clearly defined

The Chief Inspector of Mines investigation recommended that the Regulator should increase its investigative capacity and its compliance and enforcement authority under the *Mines Act* and Code (Table 4). For instance, in the regulatory review, the Chief Inspector of Mines described how “[t]he Regulator has full authority to question, and request clarification of engineering specifications and design elements; however, it does not have the capacity to full use of this authority in many cases” (MEM, 2015, p. 151). In fact, the investigation not only determined that the ministry was lacking the capacity to oversee the EoR, but also found that the regulator’s role did not support effective controls. Controls are an active mechanism (e.g. audit, inspection, or investigation) used to detect the initiation of an event and/or hazard and enable an active device (hardware, software, or human) to prevent or reduce the potential that the hazard will produce an undesired outcome. For example, an active mechanism such as an audit may have revealed that there were missing requirements to ensure information transfers between EoRs, possibly preventing information loss.

The Auditor General’s audit focused on the following seven key areas of a compliance and enforcement program: planning, permitting, compliance promotion, compliance verification, enforcement, evaluation and adjustment, and reporting. The audit determined that there were deficiencies in both ministries within the seven areas. In particular, the audit found that both ministries lack “...the resources, training, and tools necessary for compliance and enforcement” (Bellringer, 2016, p. 41). The follow list is a summary of key findings from the report regarding the Mount Polley incident:

- MEM accepted over-steepened downstream embankment slopes
- MEM did not enforce the development of an adequate tailings beach
- MEM did not enforce the establishment of buttressing, as designed, along the Main Embankment

The audit concluded that the Ministry of Energy and Mines did not enforce the design due to an overreliance on qualified professionals, inadequate standards to guide both inspectors and industry, inspections that did not meet policy, and a lack of enforcement culture (Bellringer, 2016)

6.5 Limitations and Uncertainties

Each report was constrained by their mandate and was biased to investigate the incident from a certain perspective. This may have reduced the overlap in recommendations across the reports. For example, the Independent Expert Engineering and Review Panel did not conduct their investigation according to formal legal procedures. In doing so, the Panel did not conduct an assessment of roles and responsibilities, specifically between the designers and the owner. In comparison, formal legislation provided the Chief Inspector of Mines with the statutory authority to investigate the roles and responsibilities of the Regulator and the mine operator. In the process, the Chief Inspector of Mines was specifically authorized to determine any contraventions of the Mines Act and Code. However, since the authority of the Chief Inspector of Mines was limited to the mine, any area beyond the mine was beyond the scope of the investigation. Lastly, the purpose of the Auditor General's report was to audit compliance and enforcement in the mining sector. The Mount Polley incident was not the main focus of the audit.

While many lessons were learned from the Mount Polley incident, the case study represented a complex instance with multiple causes that may not be applicable to other tailings storage facilities. Specifically, the Chief Inspector of Mines investigation determined five main proximate causes for the breach of the tailings dam. Behind each of these causes, the investigation identified a number of defeated or absent barriers/controls. If these barriers/controls were in place, the undesired outcome of the breach of the dam may have been avoided. Therefore, the Mount Polley incident is an example of the complexity of mine failures and the difficulty in quantifying risk when multiple variables are at play.

A major focus of the three reports was the *Mines Act* and Code; however, over the years, the legislation surrounding mining developments have been amended to further consider environmental impacts before mine development occurs. Mount Polley received project certification in the form of a Mine Development Certificate in 1992, prior to the existence of the *Environmental Assessment Act* in 1995. This certificate continued in force as an Environmental Assessment certificate in 1995, although no formal environmental assessment took place under the *Environmental Assessment Act*. While both are key pieces of legislation that govern and regulate mining and mineral exploration activities in the province, they serve different roles in mitigating adverse impacts from mining developments and activities. It is unclear how the introduction of the environmental assessment process has affected the safety of Mount Polley mine and other mines built before 1995.

7.0 Conclusion

Through this analysis, the four key areas of overlap were determined across the three investigative reports: professional reliance, geotechnical oversight, life-of-mine planning for permitting, and investigation, compliance and enforcement. These recommendations were the result of investigations that focused on technical aspects of the failure, regulatory gaps, and compliance and enforcement activities of responsible ministries. While the purpose of the investigations varied, the overlaps in recommendations suggested that these were reoccurring themes that created the conditions possible for a failure to occur (Table 6). Therefore, in order to prevent another incident from occurring again, additional controls should be implemented in these areas.

Table 6. Summary of key findings.

Area of Overlap	Findings
Professional Reliance	<ul style="list-style-type: none"> • The Regulator has the capacity to regulate construction, but does not have the capacity to change the design • There are inadequate standards to guide inspectors and industry • Professional organizations are lacking practice standard guidelines and professional reliance guidelines • New guidelines are required for water balance management
Geotechnical Oversight	<ul style="list-style-type: none"> • The Regulator must have sufficient technical capacity to oversee the decisions of the qualified professional
Life-of-Mine Planning for Permitting	<ul style="list-style-type: none"> • A lack of long-term planning from MPMC contributed to the failure • The Ministry of Mines should have a long-term perspective spanning the life of the mine • The Regulator did not meet policy for annual inspections
Investigation, Compliance and Enforcement	<ul style="list-style-type: none"> • The Regulator should increase its investigative capacity • The ministries have deficiencies in all seven areas of a compliance and enforcement program

7.2 Recommendations

The analysis focused on the recommendations within the reports for two main audiences: professional organizations and the Regulator. This section provides a summary of the recommendations for professional associations and the Regulator.

Recommendations for Professional Associations:

- Encourage professional associations to continue updating guidelines for site investigations for tailings storage facilities
- Encourage professional associations to continue updating guidelines for Engineers of Record
- Encourage professional associations to continue updating water management guidelines for qualified professionals

The incident revealed the limitations in the relationship between the Regulator and the Engineer of Record, particularly concerning the design of the overall structure of the tailings storage facility. Independent review boards should be reviewed to ensure their effectiveness in overseeing the decisions of the EoR.

Professional Associations should focus on the continual development of guidelines for site investigations, Engineers of Record, and water management at mining sites with tailings storage facilities.

Recommendations for the Regulator:

- Encourage the development of professional reliance guidelines in three areas: competency, clarity of expectations, and accountability
- Ensure that the Regulator has the capacity to oversee the decisions of the Engineer of Record
- Ensure that the Regulator has a long-term perspective of the mine during permitting
- Ensure that the Regulator has the resources and capacity to engage in investigation, compliance and enforcement activities

Professional reliance is an important part of the mining sector. The Regulator should focus on developing professional reliance standards for the inspector. In addition, the government should ensure that the Regulator has the capacity to oversee the decisions of the Engineer of Record.

The government should ensure that the Regulator has the resources and capacity to engage in investigation, compliance and enforcement activities while maintaining a long-term perspective throughout the life of the mine.

9.0 References

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