Ministry of Energy and Mines
British Columbia

Synthesis and Analysis of Submissions to the Chief Inspector's Orders

For

Project Management, Engagement and Geotechnical Review of Dam Safety Inspections in BC

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Report on

Synthesis and Analysis of Submissions to the Chief Inspector's Orders

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Executive Summary

In light of the recent tailings dam failure at Mount Polley mine on August 4, 2014, the British Columbia Chief Inspector of Mines issued Orders to the owners, agents or managers responsible for tailings dams to review the safety of tailings impoundment structures at mines in the Province, and to establish where improvements may be required.

The Orders expedited the normal annual Dam Safety Inspections (DSI) schedule from March 30, 2015 to December 1, 2014. Furthermore, the Orders required mine managers to have the DSI reviewed by an independent qualified professional engineer, update and test the Emergency Preparedness and Response Plan (EPRP), complete a Dam Break Inundation Study, and summarize in an attending letter commitments for completing the recommended work along with a schedule for implementing the work. All the required documents were to be submitted to the Chief Inspector by December 1, 2014.

The intent of the Orders was to provide an overall picture of dam safety in the Province of BC, recognizing that the Orders, and associated document submissions, provide information on a component of a much larger dam safety framework.

There are 60 permitted mines registered in the Province. Four mines had no defined tailings dams and were therefore not required to respond to the Order. Four mines were granted an extension as they were unable to retain a qualified engineer to visit their site before winter conditions set in. Mount Polley mine has been exempted from the Chief Inspector orders as the tailings storage facility is the subject of three separate investigations and is currently not in use. Thus, 51 of the 60 mines have submitted documents as per the Orders.

The Ministry of Energy and Mines (MEM) commissioned Hatch to assist with a high-level review of all of the submissions to ensure consistency and compliance with the Order, and to share this information with the public.

The general findings of the review are as follows:

- Good response from mines to fulfill the Chief Inspector's Orders by the specified time
- The majority of reports were deemed to satisfy the Orders, some with additional information required;
- The dam safety inspections and third party reviews did not identify immediate safety concerns at any of the tailings storage facilities in the province;
- Mine Managers have provided commitments to complete any necessary maintenance or repairs;

- Mines with a High to Extreme consequence classification were required to conduct a Dam Break Inundation Study, and to update and test their EPRP. Through these exercises, the mine managers and responding agencies have a better understanding of their emergency management procedures and requirements, and mining companies are able to identify gaps and incorporate lessons learned into the EPRPs; and,
- All outstanding requirements have been documented in the Chief Inspector's response letters to the mine managers and will be followed-up for compliance.

1. Introduction

The Ministry of Energy and Mines (MEM) retained Hatch Ltd. (Hatch) to assist with the oversight of the review process for dam safety inspection reports and independent reviews of all permitted tailings storage facilities in the province of British Columbia.

The Chief Inspector of Mines ordered all mining companies to conduct a Dam Safety Inspection (DSI) for every tailings storage facility at permitted mines by December 1, 2014 (MEM, 2014). Under the Chief Inspector's Order, DSI reports required a review by an independent qualified third-party professional engineer from a firm not associated with the tailings facility. The Order also included a requirement for a third-party review of the dam consequence classifications. In addition, mines with tailings dams classified as High, Very High or Extreme consequence were required to have an updated and tested Emergency Preparedness and Response Plan as well as a Dam Break Inundation Study.

All information obtained under this Order has been made available to First Nations and to the general public on a Government website.

There are 60 permitted mines in British Columbia. Seventeen of these mines are active (operating or under construction) with the remaining 43 mines being either permanently closed or under care and maintenance. Each mine may have multiple tailings storage facilities and there may be a number of dams associated with each facility.

Hatch's scope of work included assisting MEM with the high-level review of all of the submissions to ensure consistency and compliance with the Order, and information sharing with the public. The primary deliverable for the project is this Synthesis Review report, which includes:

- Description of the methodology adopted for the high-level screening of submitted documents for consistency and compliance to the Order;
- Background information, a glossary of terms, a summary of compliance; and
- Analysis of the compiled data to identify overall trends and common themes observed from the submissions.

2. Background

2.1 Tailings Storage

- In mining and mineral processing plants, mechanical and chemical processes are used to extract the valuable minerals from the ore. The remaining material after extraction of the value minerals is commonly referred to as tailings. Tailings are comprised of unrecoverable and uneconomic crushed and milled rock particles and process water, which are by-products of the mineral processing plant.
- The tailings are discharged, commonly in slurry form, to a final surface storage impoundment. The impoundment is generally referred to as a Tailings Storage Facility (TSF), however may also be referred to as Tailings Management Facility (TMF), Tailings Management Area (TMA) or Tailings Impoundment Area (TIA). Tailings may alternatively be stored in the form of dry stockpiles if adequately dewatered or stored underground in mined out cavities using technology commonly referred to as paste backfill.
- The TSF impoundment is formed by constructing an engineered retaining structure (dam) and where suitable topography allows, relying on natural valley containment. Tailings dams are the most common type of dams associated with mining operations and typically contain large quantities of entrained process water and milled particles. The tailings may cause environmental damage if released suddenly and in an uncontrolled manner.

Tailings dams are usually earthen structures constructed from:

- Natural borrowed soil materials;
- Blasted or crushed inert waste rock generated from underground, open pit mining or quarry excavation;
- Tailings particles either with or without additional processing; and/or,
- Incorporating geosynthetic materials.

2.2 Regulations for BC Mining Dams

- The management and safe operation of dams constructed for impoundments on a mine site is the responsibility of the owner of the mine. Authorization to construct and operate an impoundment and associated dam(s) on mine sites in British Columbia is provided in a Mines Act permit issued by the MEM prior to construction of the dam. The permit includes conditions under which the impoundment and dam(s) is to be operated, managed and monitored.

- The design, construction and operation of dams on mine sites in British Columbia is covered by regulations and requirements under the *Mines Act* and the Health, Safety and Reclamation Code for Mines in British Columbia (MEMPR, 2008). The Code requires major impoundments, water management facilities and dams be designed in accordance with the criteria provided in the Canadian Dam Association (CDA) Dam Safety Guidelines (CDA, 2013). Specific sections of the Code require that the long-term stability of exposed slopes of major impoundments meet the criteria provided in the CDA guidelines and that all permanent spillways be designed by a qualified professional engineer in accordance with the CDA guidelines. Spillways must be installed prior to final closure of the impoundment.
- The Code also requires Annual Dam Safety Inspections to be carried out for all dams on a mine site in accordance with MEM guidelines for DSI (MEM, 2013). Reports are required to be submitted by a qualified professional engineer registered with the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). The professional engineer is deemed to be the Engineer of Record (EOR) for the facility unless another engineer is identified within the Dam Safety Inspection report as having this responsibility.
- Mines are also required to complete a separate Dam Safety Review (DSR) at intervals based on the dam consequence classification as outlined in the CDA Guidelines. The DSR is a comprehensive, formal review carried to determine whether an existing dam is safe, and where deficiencies are identified, to determine what improvements are required. Dam Safety Reviews in BC must be conducted in accordance with APEGBC's Professional Practice Guidelines titled "Legislated Dam Safety Reviews in BC" (APEGBC, 2013). The CDA Mining Dams Committee recently released a technical bulletin on mining dams in October 2014 (subsequent to the issuance of the Order). This technical bulletin complements the CDA 2007 guidelines by providing additional information with respect to how the concepts described in the CDA Guidelines apply to mining dams (CDA, 2014). Tailings dam owners will be required to adhere to the design and safety standards provided in the bulletin in their future submissions to MEM.
- Mining dams fall under the responsibility of MEM and are regulated under the *Mines Act* and the Health, Safety and Reclamation Code for Mines in BC (Code). Non-mining dams, and clean water dams on mine sites that require a water license, are regulated by the Ministry of Forests, Lands and Natural Resources (MFLNRO) under the *Water Act* (RSBC 1996, Chapter 483). For these types of dams, the BC Dam Safety Regulation defines the responsibilities of the dam owner for the safe operation of a dam and prescribes documentation requirements.

- For mining dams that require a water license (no TSFs fall under this category), regulatory responsibility is shared by MEM and FLNRO. Water discharge from all facilities is regulated by the BC Ministry of Environment (MOE). A Memorandum of Understanding (MOU) between MEM, MFLNRO and MOE was updated in 2014 and outlines the responsibilities for the shared regulation of impoundments and diversions on a mine site. Accordingly, MEM, under the *Mines Act* and the Code, is responsible for approving the siting, design, construction, modification, operation, maintenance, abandonment and reclamation of Tailing Storage Facilities (TSF), Flooded Impoundments (FI), sedimentation control and sludge storage ponds.
- See Section 9 for other useful information with respect to tailings dam safety.

2.3 Dam Consequence Classification

- CDA's dam consequence classification scheme is based on the potential impact to human life, environmental and cultural values, infrastructure, and economics should the dam fail, and is set out according to the CDA guidelines (CDA, 2013). According to the CDA guidelines, the consequence of a dam failure can be ranked as Low, Significant, High, Very High, or Extreme. The CDA classification scheme also provides guidance on the standard of care expected of dam owners and designers. A simplified version of the CDA's dam classification scheme is shown in Table 2-1 of this report.

According to the CDA guidelines, dams with higher consequence classifications must be designed for stronger earthquakes and larger flood events and are subject to more frequent dam safety reviews.

Table 2-1: Dam Consequence Classification

Dam Class	Population at risk	Incremental losses		
		Loss of life	Environmental and cultural values	Infrastructure and economics
Low	None	0	*Minimal short-term*	*Low* losses Limited infrastructure/ services
Significant	Temporary only	Unspecified	*No significant* loss Restoration *highly possible*	*Losses* Seasonal/ infrequently used
High	Permanent	<=10	*Significant* loss Restoration *highly possible*	*High* losses Infrastructure/public transportation
Very High		<=100	*Significant* loss Restoration *possible but impractical*	*Very high* losses Important infrastructure/ services
Extreme		>100	*Major* loss of *critical* habitat Restoration *impossible*	*Extreme* losses Critical infrastructure/ services

Notes (CDA, 2007):

1. Economic Losses: The estimate of economic losses should include direct damage to third-party property, facilities, other utilities, and infrastructure
2. Environmental Losses: The significance of environmental losses should be assessed in terms of whether restoration of the environment is feasible and how long it would take
3. Incremental and Total Consequences: These guidelines are based on the traditional assumption that due diligence and the standard of care expected of a dam owner relate to the potential damage above and beyond that caused by a natural event when the dam does not fail.
4. Population at risk = None: There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.
5. Population at risk = Temporary: People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).
6. Population at risk = Permanent: The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).
7. Loss of life = Unspecified: The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions.

2.4 Chief Inspector's Orders

- On August 4, 2014 a tailings dam failure occurred at the Mount Polley Mine in south central British Columbia. In light of this incident, and in order to review the safety of other tailings management facilities in the province, the Chief Inspector of Mines issued a set of Orders pursuant to Section 18 of the Mines Act (MEM, 2014).
- As per the Orders from the Chief Inspector of Mines, the owners, agents or managers responsible for tailings dams were required to perform the following activities:

1. Conduct a Dam Safety Inspection (DSI) by December 1, 2014. The DSI must cover all dam structures for all tailings storage facilities at the mine site. The DSI must be conducted by a qualified professional engineer consistent with MEM Guidelines for Dam Safety Inspections.
2. The DSI must be reviewed by an independent qualified third party professional engineer (TPR) from a firm that has not been associated with the tailings dam. This review must also include a review of the dam consequence classification.
3. Both the DSI and the TPR must be sealed by the qualified licensed professional engineers who performed the work.
4. Any recommendations made in the DSI or the TPR must be summarized in an enclosed letter from the Mine Manager to the Chief Inspector outlining the commitments for completing the recommended work along with a schedule for implementing the recommended work.
5. The DSI, TPR, and Mine Manager's Letter to the Chief Inspector must be submitted by December 1, 2014.
6. All tailings dams with a consequence classification of High, Very High or Extreme (and taking into account any change in dam classification resulting from Orders 1 through 5), must have an Emergency Preparedness and Response Plan (EPRP) and a Dam Break Inundation study.
7. The EPRP and Dam Break Inundation study must be completed and tested consistent with the CDA Guidelines. If the tailings facility already has an existing EPRP, it must be reviewed and updated for consistency with the CDA Guidelines and with current standards of engineering practice.

8. The Dam Break Inundation study must be prepared by a qualified licensed professional engineer. The EPRP must be informed by the Dam Break Inundation study, with input from the qualified licensed professional engineer.

9. The Dam Break Inundation study, EPRP, and a summary of the EPRP Test including any identified gaps and lessons learned from the EPRP Test, must be submitted to the Chief Inspector by December 1, 2014.

- MEM has relied on the seal of the qualified professionals undertaking the above work. All reports and reviews that were submitted to satisfy these Orders have been subjected to additional high-level review by Hatch. As well, in the interest of transparency, all submitted documents related to the Orders have been made available to the public via website.

- In response to the Orders, the mines executed the work and submitted six common report types as follows:

1. Dam Safety Inspection (DSI) Report;
2. Third Party Review (TPR) Report;
3. Mine Manager Letter (MML);
4. Emergency Preparedness and Response Plan (EPRP);
5. EPRP Test; and,
6. Dam Break Inundation (DBI) Study.

These report types are further described in the following sections.

2.4.1 Dam Safety Inspection (DSI) Report

A Dam Safety Inspection (DSI) typically involves review of existing documents, a site visit by the qualified engineer to the mine, interviews with the facility inspector and operators, a visual inspection of the facility, and a review of available instrumentation and monitoring data. The annual DSI report is to review the operation, maintenance and surveillance of the tailings and water management facilities and associated dams with a focus on safety and environmental impact.

DSIs must be conducted annually in accordance with the Code and MEM's Guidelines for Annual Dam Safety Inspections.

2.4.2 Third Party Review (TPR) Report

As part of the response to the tailings storage facility breach at the Mount Polley Mine, the Chief Inspector of Mines added a requirement that each DSI be reviewed by an independent qualified third-party professional engineer from a firm that has not previously been associated with the tailings storage facility. The Order also included a requirement for a third-party review of the dam consequence classifications. The TPR report includes the reviewer's comments on the overall condition and consequence classification for each dam, as well as the reviewer's recommendations to improve the overall safety of the tailings storage facility.

2.4.3 Mine Manager Letter (MML)

As part of the Chief Inspector's Order, all permitted mines were required to submit a letter referred to as the Mine Manager Letter (MML). The MML was required to outline the commitments for completing the recommended work proposed in the DSI and TPR reports, along with a schedule for implementing the recommended work. The MML was required to acknowledge the content of these reports and their findings even if the reports provided no recommendations.

2.4.4 Emergency Preparedness and Response Plan (EPRP)

- Effective emergency management relies on the establishment of a clear emergency response structure consisting of four components:
- An internal Emergency Response Plan (ERP);
- An Emergency Preparedness Plan (EPP) for external use;
- Municipal / regional emergency plans developed by responding agencies; and
- A testing and training program to ensure that these processes are effectively integrated and kept up to date (CDA, 2013).
- The dam owner is required to establish a formal internal ERP documenting the procedures that operations staff should follow in the event of an emergency at the tailings impoundment or dam. The ERP outlines the key emergency response roles and responsibilities, in order of priority, as well as the required notifications and contact information.

- In cases where a hypothetical dam failure or passage of a major flood could result in loss of life or environmental damage, the dam owner must prepare and maintain an external EPP. The EPP should be clear, simple and contain information needed by the external responders. The EPP contains essential information, such as inundation maps and flood arrival details, so that local authorities can develop their own response plans.
- The dam owner is responsible for updating the EPP and ERP annually or as deemed practical or necessary. EPRP should be prepared in accordance with CDA guidelines and current standards of engineering practice.

2.4.5 EPRP Test

As recommended by the CDA guidelines, the EPRP should be tested regularly to ensure its effectiveness. This test allows for the identification of any gaps, and a determination of length of time it takes to communicate through the chain of command. Tests can range from limited table-top exercises to full-scale simulations of an emergency and can include multiple failure scenarios.

2.4.6 Dam Break Inundation (DBI) Study

A dam break inundation map is an effective means of showing the timing and extent of expected flooding from a hypothetical dam failure. Dam break inundation maps should be developed in coordination with the appropriate provincial and local emergency management agencies.

The outcomes of the Dam Break Inundation (DBI) study are inundation maps and tailings run-out configurations, which show the area downstream of a dam that could be impacted in the event of a breach. These studies assist in determining the consequence classification of a tailings facility as well as in emergency response planning. The DBI should be completed in accordance with the CDA guidelines and current standards of engineering practice.

3. Methodology

3.1 Screening of Submissions

A high-level screening of all submitted documents for each tailings facility was carried out by Hatch to check for completeness, compliance with the Order, and best engineering practices. The screening exercise was conducted by Hatch's team of professional geotechnical and hydrotechnical engineers licensed in the Province of British Columbia.

Checklists were developed and used to maintain consistency and to provide a systematic process for the evaluation of the submitted documents in accordance with the relevant regulations or guidelines.

The screening of the report submissions against the developed checklists was carried out in two-steps involving two Hatch team members, namely, an Auditor and a Checker. The objective of this approach was to increase the consistency and quality of the screening process. The Auditor carried out the first step of the screening. The objective of the Audit step was to verify the contents of the submitted documents against items listed on corresponding checklists, comment on gaps, and list analysis methods adopted in various reports. The Checker reviewed the Auditor's completed checklist, assessed areas of the documents, which had been highlighted by the Auditor as requiring further examination, and addressed outstanding comments from the Auditor.

One of two compliance levels was assigned for the mine's overall submission based on whether the mine did or did not submit all documents as required as follows:

- Satisfactory; and,
- Incomplete.

This above determination was based on completeness of the overall submission.

The screening exercise carried out by the Auditor and Checker evaluated each document against the developed checklists and made a determination on the level of acceptance based on any deficiencies identified. Depending on the level of deficiencies identified, mines were required to either update and resubmit the document, or incorporate the required items into the next revision.

The compliance assignment for each document was based on consistency with guidelines, the spirit of the Order (to improve safety) and good engineering practice. A list of principal deficiencies and a timeline to address these non-conformances was outlined in a letter issued by the Chief Inspector of Mines.

3.2 Synthesis Review

The synthesis review involved two parts: summary of information submitted in response to the Order, and a comparison of data in the form of tables and charts to determine the nature and trends of recommendations made in the report submissions. The graphic presentation selected was based on consideration of the objective of the synthesis review, which is to assist the public in understanding the information provided, significant factors relevant to the Order and the industry response. The results of this synthesis process are discussed in the following section.

4. Synthesis Results

4.1 Submission Status

Table 4-1Table 4-1 summarizes the response received from mine owners to the Orders. A total of 9 mines were excluded from this review, as they were either granted extensions (May Mac , Mosquito Creek, Taurus Gold and Shasta), or their tailings storage facility (TSF) was not classified as a dam (Cassiar-McDame, Eskay Creek, Lumby Project/Quinto and Moberly Silica), or they were exempt from the Order (Mount Polley).

Of the 51 mine submissions reviewed, 46 mines submitted all the required reports and five submitted a portion of the required reports, as described in Table 4-1, and shown in Figure 1[1].

Table 4-1: Summary of Submission Status

Submission Status	Number of Mines
Submissions	51
Granted Extension	4
Tailings Storage Facilities without dams	4
Exempt from Order	1
Total	60

MEM has contacted all mines and has directed those with outstanding submission requirements to submit these items.

4.2 Operation Status

The phases in the life of tailings dams are: design, construction, operation, under care and maintenance, and closed.

According to the information provided by MEM, 17 mines have a TSF that is under-construction or operating. Definitions for various phases of dam life are included in the Glossary. The majority of TSFs are either under care and maintenance, or closed (Table 4-2 and Figure 2). The data shows that more than half (31) of the permitted mines have a closed TSF, which are considered to be in a steady-state condition, where sufficient experience and monitoring has demonstrated that no immediate intervention is required to ensure the safety of the dams, but where continual inspection, monitoring and maintenance may be required.

[1] All figures are presented in Appendix A.

Table 4-2: Summary of Operational Status

Operational Status	Number of Mines
Construction	1
Operating	16
Under Care & Maintenance	12
Closed	31
Total	60

4.3 Dam Consequence Classification

As part of the DSI Order, all mines were requested to confirm the consequence classification of their TSF dams in accordance with the 2007 CDA guidelines. The Order also requested all mines to revaluate and confirm the consequence classification of the TSF dams by carrying out a Third Party Review (TPR). Some mines have more than one tailings facility therefore the highest dam classification at the mine site is shown in Table 4-3.

Table 4-3: Dam Consequence Classification Details (based on 2014 DSIs)

No	Permit #	Mine Name	Company	Region	Latitude	Longitude	Classification*	
							Before Order	After Order
101	M-206	Kemess South	AuRico Gold Inc.	Central - Northeast (Prince George)	57.06200	126.70000	Very High	
102	M-190	Snip	Barrick Gold Inc	Northwest (Smithers)	56.6667	131-08333	Significant	
103	M-197	Eskay Creek	Barrick Gold Inc	Northwest (Smithers)	56.64650	130.44370	TSF with no Dams	
104	M-64	Giant Nickel/Pride of Emory	Barrick Gold Inc.	Southwest	49.48500	121.46056	Low	Very High
105	M-173	Nickel Plate	Barrick Gold Inc.	South Central (Kamloops)	49.3667	120.03333	Very High	
106	M-207	Bralorne	Bralorne Gold Mines Ltd.	South Central (Kamloops)	50.78020	122.80850	High	
107	M-29	Copper Mountain (Similco)	Copper Mountain Mine (BC) Ltd.	South Central (Kamloops)	49.33111	120.53417	Very High	
108	M-226	Max Molybdenum	FortyTwo Metals Inc.	Kootenay (Cranbrook/Fernie)	50.63758	117.58544	High	
109	M-40	Gibraltar	Gibraltar Mines Ltd.	South Central (Kamloops)	52.52750	122.32138	Extreme	
110	M-6	Granisle	Glencore Canada Corporation	Northwest (Smithers)	54.56400	126.09300	Low	
111	M-12	Brenda	Glencore Canada Corporation	South Central (Kamloops)	49.87944	120.00639	Extreme	
112	M-35	Bell	Glencore Canada Corporation	Northwest (Smithers)	55.00300	126.23100	Low	
113	M-101	Boss Mountain	Glencore Canada Corporation	South Central (Kamloops)	52.09667	120.90750	Significant	
114	M-114	Equity Silver	Goldcorp	Northwest (Smithers)	54.18944	126.26333	Very High	
115	M-203	Huckleberry	Huckleberry Mines Ltd.	Northwest (Smithers)	53.68278	127.17389	Very High	
116	M-112	Afton/Ajax/Abacus	KGHM International	South Central (Kamloops)	50.64917	120.50000	Very High	Extreme
117	M-200	Mount Polley	Mount Polley Mine Corporation	South Central (Kamloops)	52.54881	121.64068	Exempt	
118	M-229	New Afton	New Gold	South Central (Kamloops)	50.65146	120.50876	Very High	
119	M-26	Myra Falls	Nyrstar	Southwest	49.55388	125.56055	High	
120	C-172	Quinsam	Quinsam Coal Corporation	Southwest	49.94950	125.35320	Very High	
121	M-240	Red Chris	Red Chris Development	Northwest (Smithers)	57.7049	129.79142	Not Classified	Very High
122	M-5	Pinchi Lake	Teck	Central - Northeast (Prince George)	56.00449	125.55880	Significant	
123	M-71	Beaverdell	Teck	Kootenay (Cranbrook/Fernie)	49.43222	119.06111	Significant	
124	M-74	Sullivan	Teck	Kootenay (Cranbrook/Fernie)	49.70750	116.00528	High	Very High
125	M-11	Highland Valley Copper	Teck	South Central (Kamloops)	50.43670	120.90450	Extreme	
126	C-156	Quintette	Teck Coal	Central - Northeast (Prince George)	54.94200	120.96200	High	
127	C-158	Bullmoose	Teck Coal	Central - Northeast (Prince George)	55.15000	121.55000	High	
128	C-2	Elkview Operations	Teck Coal	Kootenay (Cranbrook/Fernie)	49.74500	114.83000	Very High	
129	C-3	Fording River Operations	Teck Coal	Kootenay (Cranbrook/Fernie)	50.16200	114.91100	High	
130	C-137	Greenhills Operations	Teck Coal	Kootenay (Cranbrook/Fernie)	50.20028	115.00830	High	

No	Permit #	Mine Name	Company	Region	Latitude	Longitude	Classification*	
							Before Order	After Order
131	M-4	Endako	Thompson Creek Metals	Northwest (Smithers)	54.03959	125.13473	High	
132	M-236	Mount Milligan	Thompson Creek Metals	Central - Northeast (Prince George)	55.17000	123.88400	Not Classified	Very High
133	C-223	Wolverine Coal	Walter Energy	Central - Northeast (Prince George)	55.08751	121.24977	High	
134	M-95	Dankoe	439813 B.C Ltd.	South Central (Kamloops)	49.05694	119.69000	Not Classified	Low
135	M-133	Mosquito Creek	Barkerville Gold Mines	South Central (Kamloops)	53.11056	121.59361	Granted Extension	
136	M-198	QR	Barkerville Gold Mines	South Central (Kamloops)	52.66667	121.78333	Significant	
137	M-147	Goldstream	Bethlehem Resources (1996) Corporation	Kootenay (Cranbrook/Fernie)	51.63034	118.42823	High	
138	M-179	Premier Gold Project	Boliden	Northwest (Smithers)	56.11667	130.01667	Very High	
139	M-33	Gallowai/Bul River	Bul River Mineral Corporation	Kootenay (Cranbrook/Fernie)	49.50470	115.36667	Not Classified	Low
140	M-127	Table Mountain/Cusac	China Minerals/Cassiar Gold Inc	Northwest (Smithers)	59.18370	129.69240	Low	
141	M-149	Taurus Gold	China Minerals/Cassiar Gold Inc	Northwest (Smithers)	59.27444	129.68944	Granted Extension	
142	M-18	Cassiar-McDame	Cassiar Jade Contracting Inc.	Northwest (Smithers)	59.33996	129.83967	TSF with no Dams	
143	M-174	Lawyers/Cheni	Ministry of Energy and Mines	Northwest (Smithers)	57.33333	127.16667	Not Classified	
144	C-217	Basin Coal/Tulameen	Coalmont Energy Corporation	South Central (Kamloops)	49.50889	120.76694	Low	
145	M-184	Samatosum	FQM (Akubra) Inc.	South Central (Kamloops)	51.81858	119.81858	Significant	Low
146	M-209	May Mac	Golden Dawn	Kootenay (Cranbrook/Fernie)	49.01190	118.70400	Granted Extension	
147	M-181	Moberly Silica	HCA Mountain Minerals	Kootenay (Cranbrook/Fernie)	51.36668	116.96510	TSF with no Dams	
148	M-233	Greenwood (Zip)	Huakan International Mining Inc.	Kootenay (Cranbrook/Fernie)	49.08639	118.56806	High	Significant
149	M-68	Craigmont	Huldra Properties Inc.	South Central (Kamloops)	50.18452	120.87912	Low	
150	M-65	Silvana/Klondike	Klondike Gold Corp.	Kootenay (Cranbrook/Fernie)	49.96667	117.25000	High	
151	M-8	Jumbo/Red Mountain	Ministry of Energy and Mines	Kootenay (Cranbrook/Fernie)	50.40000	116.46667	Low	
152	M-50	Alwin	Ministry of Energy and Mines	South Central (Kamloops)	50.47742	121.10114	Low	
153	M-138	Carolin/Ladner Creek	New Carolin Gold Corp.	Southwest	49.49583	121.28750	Significant	
154	M-187	Golden Bear	North American Metals Corporation	Northwest (Smithers)	58.51667	132.28333	Low	
155	M-215	Lumby Project/ Quinto	Quinto Technology Inc.	South Central (Kamloops)	50.26558	118.94027	TSF with no Dams	
156	M-218	HB Tailings landfill	Regional District of Central Kootenay	Kootenay (Cranbrook/Fernie)	49.13790	117.24216	Very High	
157	M-189	Shasta & Baker Mill	Sable Resources Ltd.	Central - Northeast (Prince George)	57.27400	127.03100	Granted Extension	
158	M-178	Johnny Mountain	Skyline Gold	Northwest (Smithers)	56.63333	131.08333	Low	
159	M-171	Blackdome	Sona Resources Corp.	South Central (Kamloops)	51.31583	122.49916	Low	Significant
160	M-235	Yellowjacket	Yellow Jacket Resources Ltd.	Northwest (Smithers)	59.59461	133.54892	Low	

* Note: Classification refers to the highest consequence classification for TSF dams at a given site

Table 4-4 and Figure 3 shows the distribution dam consequence classifications for all TSFs as noted on the 2014 DSIs. Of the total 60 mines, 9 were exempted or granted extension, 21 of the mines have a TSF with consequence classification of Low to Significant, and 29 mines have a TSF with consequence classification of High to Extreme (dam classification for one mine is still under review).

Table 4-4: Distribution of Highest Dam Consequence Classification Categories

Highest Dam Consequence Classification (2014 DSIs)	Number of Mines		
	Construction / Operating	Care & Maintenance / Closed	Total Mines
Low	-	13	13
Significant	1	7	8
High	6	5	11
Very High	7	7	14
Extreme	2	2	4
Not Classified	-	1	1
Exempted (Mount Polley)	1	-	1
Exempted (TSF with no dams)	-	4	4
Granted Extensions	-	4	4
Total	17	43	60

One of the objectives of the Order was to reduce the number of dams in the province that had classifications that were dated or under review. As a result of this exercise, there is now only one dam that is under review. A summary of dam consequence classifications as indicated by the 2014 DSI reports is shown in Table 4-5. There are still four mines, which have been granted an extension and are required to confirm their TSF classifications in spring of 2015.

Table 4-5: TSF Dam Consequence Classification

Highest Dam Consequence Classification	Number of Mines
Low	13
Significant	8
High	11
Very High	14
Extreme	4
Not Classified	1
Exempted/ Granted Extensions	9
Total	60

4.4 Compliance Status

The number and type of submissions required for each mine was dependent on the highest consequence classification assigned to the TSF dams on that mine site. All mines were requested to submit a minimum of three documents: the Dams Safety Inspection (DSI) Report, the Third Party Review (TPR) report, and the Mine Manager Letter (MML). For the 29 mines with a TSF dam of High to Extreme classification, an updated Emergency Preparedness and Response Plan (EPRP), a Dam Break Inundation (DBI) Study was also required, along with a letter summarizing the gaps and lessons learned from a recent EPRP test.

The submitted documents for each mine site were checked for consistency and compliance with the Order as well as best engineering practice (see Section 2.4). Through this screening exercise, each document was assigned one of the two compliance levels, as stated in Section 3.1.

Table 4-7 and Figure 4 summarize the compliance status assigned based on the high-level review of the submissions. The data shows that the majority of the submissions were of good quality and have followed MEM and CDA guidelines. Follow-up letters have been issued by the Chief Inspector of Mines to all permitted mines under this Order with a list of any deficiencies and the timeline to address them. Table 4-7 shows a summary of the compliance status for different submissions.

Table 4-6: Overall Compliance Status

Compliance Status	Number of Mines
Satisfactory	45
Incomplete	6
Exempted/ Granted Extensions	9
Total	60

Table 4-7: Summary of Compliance Status for Various Types of Reports

Compliance Status		Number of Mines					
		DSI	TPR	MML	EPRP	EPRP test	DBI
Satisfactory	Minor follow-up in next document revision	50	49	40	13	24	22
	Require update and resubmission	1	-	10	15	1	4
Incomplete		-	2	1	1	4	3
Exempted (Mount Polley)		1			1		
Exempted (TSF with no dams)		4			-		
Granted Extensions		4			-		
Total		60			30		

4.5 Submission Deficiencies

For cases where the submission of additional information was required, the following typical observations were noted:

Dam Safety Inspection Reports

- Factual data was stated or summarized in the report; however, the author did not provide review comments on the following topics as per the Order and MEM's Guidelines for Dam Safety Inspections
  - Climate data
  - Water balance
  - Freeboard and storage availability
  - Quantity and quality of seepage water and discharge flows
  - A single high dam consequence classification was assigned and presented for the entire TSF, even though there are multiple dams. Each dam should have been presented with its own specific classification assignment.
  - Dam consequence classification was assigned under the old CDA classification system (prior to 2007) using the 4 tier classification system and should be updated to the new 5 tier system, to adhere to the current 2007 CDA Guidelines.

- Mining Bulletin applicable to the mining dams was published in October 2014 after the issuance of the Order. Thus, all submissions did not strictly adhere to the consequence classification as defined in the Mining Bulletin.
- Absence of professional engineer's stamp as per the Order, engineer signature was provided on the majority of submissions
- OMS, EPP and DBI were not available at the time of the DSI to confirm suitability of the assigned dam consequence classification.

EPRP / EPRP Test Reports

- Absence of a fully developed internal Emergency Response Plan (ERP).
- EPRP not linked to the Dam Break Inundation Study.
- Missing or inadequate inundation maps.
- No confirmation that coordination has been made with the government agency contacts.

Dam Break and Inundation Study Reports

- Missing sensitivity analysis on inundation maps.
- In addition to overtopping and piping failures, no other credible modes of failure were assessed in the inundation studies.
- Missing or inadequate tailings run-out analysis.

Third Party Review Letters

- TPR had stated the dam classification, but had not explicitly confirmed whether they agree with the dam classification provided in the DSI.

Mine Manager's Response Letters

- Select recommendations provided in the DSI or TPR studies were excluded from the commitment list by the mine managers.
- Missing schedules and priorities for addressing the recommendations.

The relevance or significance of the aforementioned deficiencies varies on a case-by-case basis. Where deficiencies are minor in nature, the mine is required to address these issues in the next report submission. Where deficiencies are more significant, the mine is required to rectify the deficiencies and resubmit the report within a specified timeframe.

4.6 Nature of Recommendations

The recommendations provided in the DSI and TPR reports were generally related to the need for improved maintenance or better management practices and do not reflect immediate stability and safety concerns of the tailings dams. The 2014 recommendations made in the DSI and TRP have been categorized into five groups:

- Operation;
- Document Update and Training;
- Inspection and Instrumentation;
- Repair and maintenance; or,
- New analyses required.

The distribution of recommendations are shown in Table 4-8 and Figure 5.

Table 4-8: Summary of Recommendation Types in DSI and TPR reports

Recommendation Type	Distribution (%)	
	Construction / Operating	Care & Maintenance / Closed
Revise operational procedures	8	7
Carry out new analyses (DSR, stability, spillway capacity)	24	22
Update documentation (OMS, EPRP) or training	12	15
Instrumentation or Inspection	32	30
Repair and maintenance	24	25
Total	100	

5. Mine Compliance and Follow-up

Two phases have been developed to ensure mine compliance with all submission requirements:

- Phase 1 – This phase is complete and involved the review of all submissions as outlined in this document to evaluate completion and compliance with respect to the Orders.
- Phase 2 – This phase will follow-up with the mine managers to determine the status of completion for those recommendations provided in all report submissions (and as outlined in their commitment letters). Overall submission deficiencies related to the Order will be followed-up as outlined in the Chief Inspector's response letters.

6. Concluding Remarks

The general findings of the review are as follows:

- Good response from the mines to fulfill the Chief Inspector's Orders by the specified time;
- Majority of overall submissions were deemed to be satisfactory;
- The Dam Safety Inspection and Third Party Review reports submitted were of high quality;
- Dam Break Inundation studies, updating EPRPs and testing provided valuable information to mine staff and emergency response agencies in efforts to improve dam safety management at mine sites in BC.
- All outstanding requirements have been documented in the Chief Inspector's response letters to the mine managers and will be followed-up for compliance.

No immediate safety concerns were identified for the 51 mine submissions received. Areas of concerns have been identified by the mines' engineering consultants, and recommendations to rectify them have been provided to the mine owners. The mine manager's letter provides the mine's commitment and timeline to address these recommendations.

The Chief Inspector of Mines has provided a letter to each mine outlining the status of their submissions and his expectations for compliance.

7. Report Closure

We trust that this document meets your requirements. Please contact the undersigned if you require further information regarding this review.

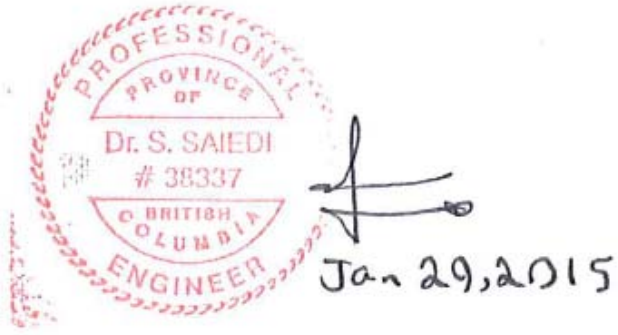
Yours faithfully,
Hatch Ltd

Siavash Farhangi, PhD, PEng

Senior Geotechnical Engineer / Tailings Consultant

Derek Li, MASc, PEng

Senior Geotechnical Engineer / Tailings Director - Canada



Saied Saiedi, PhD, PEng

Senior Hydrotechnical Engineer / Hydrotechnical Discipline Lead

8. References

APEGBC, 2013. Professional Practice Guidelines – Legislated Dam Safety Reviews in BC, Association of Professional Engineers and Geoscientist of BC.

CDA, 2007. Dam Safety Guidelines, Canadian Dam Association.

CDA, 2013. Dam Safety Guidelines, Canadian Dam Association, Original 2007, Revised 2013.

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MEM, 2014. Notification of Chief Inspector's Orders – Tailings Dams – Independent Review of Dam Safety and Consequence Classification, British Columbia Ministry of Energy and Mines Health, Safety and Permitting Branch, August 14, 2014.

MEMPR, 2008. Health, Safety and Reclamation Code for Mines in British Columbia, British Columbia Ministry of Energy, Mines and Petroleum Resources, Mining and Minerals Division, Victoria, British Columbia.

Vick, S.G., 1990. Planning, Design, and Analysis of Tailings Dams, Vancouver, BiTech, ISBN: 0921095120, 2nd Edition.

9. Useful Information

Below is a list of links to web-pages with relevant information with respect to tailings dam safety:

- Association of Professional Engineers and Geoscientists of British Columbia (APEGBC)
- BC Dam Safety Regulation
- Canadian Dam Association (CDA)
- International Commission on Large Dams (ICOLD)
- Memorandum of Understanding
- Mines Act - BC Laws
- Mining Association of Canada (MAC)
- Mining Association of BC (MABC)
- Ministry of Energy and Mines (MEM) - Geotechnical Information
- Ministry of Forests, Lands and Natural Resource Operations (MFNLR) - Dam Safety Program
- Tailings Info

10. Glossary

Below is a brief description of some of the common terminology and acronyms generally used in the design, safety inspection and review of tailings dams, which may be found in this report or the reports posted to the website forming the Chief Inspector's Order submissions. For further details, refer to CDA guidelines (CDA, 2013).

Abutment	That part of the valley side or other supporting structure against which the dam is constructed
Annual Exceedance Probability (AEP)	The probability that an event of specified magnitude will be equaled or exceeded in any year
Care and Maintenance	Operating status of a mine (TSF) applying to mines that have been closed temporarily or have a water treatment facility.
Centerline Construction	One of the three main TSF construction methods, in which tailings are discharged from the embankment crest to form a beach behind the dam wall. When subsequent raising is required, material is placed on both the tailings and the existing embankment
Classification	A system of assigning dams to categories, usually on the basis of the consequences of failure, so that appropriate dam safety standards can be applied
Closed	Final operating status of a mine (TSF) where all mining activities have ceased. The mine owner is still responsible for compliance with the Mines Act, Code, and permit conditions (i.e. ongoing responsibilities with respect to inspection, monitoring and maintenance).
Consequences of failure	Impacts on the downstream or upstream area of a dam as a result of failure of the dam or its appurtenances
Dam	A barrier constructed for the retention of water, water containing any other substance, fluid waste, or tailings, provided the barrier is capable of impounding at least 30,000 m^3 of liquid and is at least 2.5 m high
Dam Break Inundation (DBI) Study	The study involves determining the ultimate discharge from a hypothetical breach of the dam
Dam Consequence Classification (DCC)	The consequence classification of the dam in case of a hypothetical failure, according to guidelines
Dam Safety Inspection (DSI)	An annual safety inspection, involving review of existing documentation, site visit, review of monitoring data and interview with site staff.

Dam Safety Review (DSR)	A comprehensive, review carried out at scheduled intervals to determine whether an existing dam is safe, and if it is not safe, to determine what improvements are required. This study is more comprehensive that a DSI and involves review of dam designs and stability assessments.
Downstream Construction	One of the three main TSF construction methods, in which tailings are at first deposited behind the starter dam with subsequent construction extending the shell further downstream as the dam is raised.
Environmental Design Flood (EDF)	The most severe flood that is to be managed without release of untreated water to the environment
Earthquake Design Ground Motion (EDGM)	The level of earthquake ground motion at the location for which a dam structure is designed or evaluated
Emergency Operations Centre (EOC)	A central command and control facility responsible for carrying out the principles of emergency preparedness
Emergency Preparedness and Response Plans (EPRP)	The emergency response structure and management system relies on establishment of a clear emergency, including both EPP and ERP sections
Emergency Preparedness Plan (EPP)	An emergency plan developed by the dam owner for external use, in an event of dam failure or passage of a major flood
Emergency Response Plan (ERP)	A formal internal plan documenting the procedures that operations staff should follow in the event of an emergency at the dam
Failure (of a dam)	An uncontrolled release of the contents of the reservoir
Failure mode	The mode in which elements or components fail, causing a loss of the system function. At a general level, there are three dam failure modes: (i) overtopping, (ii) collapse, and (iii) contaminated seepage
Flood-induced failures	One of the two conditions studied in DBI, which is defined as failures of the dam occurring coincident with a flood of magnitude greater than the dam can safely pass
Freeboard	The vertical distance between the ponds water surface in the reservoir and the lowest elevation at the top of the dam crest
Hazard	A system state or set of conditions that together with other conditions in the system environment could lead to a partial or complete failure of the system
Incremental consequences of failure	The incremental losses or damage that a dam failure might inflict on upstream areas, on downstream areas, or at the dam itself, over and above any losses or damage that would have occurred in the same event or conditions had the dam not failed
Inflow Design Flood (IDF)	The most severe inflow flood (peak, volume, shape, duration, timing) for which a dam and its associated facilities are designed

Maximum Credible Earthquake (MCE)	The largest earthquake that can be delivered by the known seismic sources
Mine Manager Letter (MML)	The mine manager letter outlining the mine commitments for completing the recommended work proposed in the DSI and TPR
Operation, Maintenance and Surveillance (OMS) Manual	A manual that documents the requirements and procedures for the safe operation, maintenance, and surveillance of a dam
Probable Maximum Flood (PMF)	An estimate of a hypothetical flood (peak flow, volume, and hydrograph shape) that is considered the most severe that is “reasonably possible” at a particular location and time of year
Site Command Post (SCP)	SCP manages the emergency in the vicinity of the dam and reservoir
Spillway	A weir, channel, conduit, tunnel, chute, gate, or other structure designed to permit discharges from the reservoir
Sunny-day failures	One of the two conditions studied in DBI, which is defined as sudden dam failures that result during normal operations and may be caused by an earthquake, mis-operation of the dam, or other event
Tailings	Generally fine-grained, residual material remaining after the valuable resources have been extracted from the ore at a mineral processing plant
Tailings dam	A dam, including foundations, water control structures, and base of the impounding basin, that is constructed to retain tailings from mining or mineral processing operations
Tailings run-out assessment	A study to estimate the extent of tailings transported downstream of the dam in an event of a hypothetical failure
Tailings Storage Facility (TSF)	Final storage area for tailings and effluent water, maybe referred to as Tailings Management Facility (TMF), or Tailings Management Area (TMA) or Tailings Storage Facility (TSF), or Tailings Impoundment Area (TIA)
Third Party Review (TPR)	A study carried out by an independent qualified third-party professional engineer to review the findings of DSI and the dam consequence classifications
Upstream Construction	One of the main three TSF construction methods, in which tailings are usually discharged from the top of the dam crest creating a beach that becomes the foundation for future embankment raises

Appendix A
Synthesis Figures

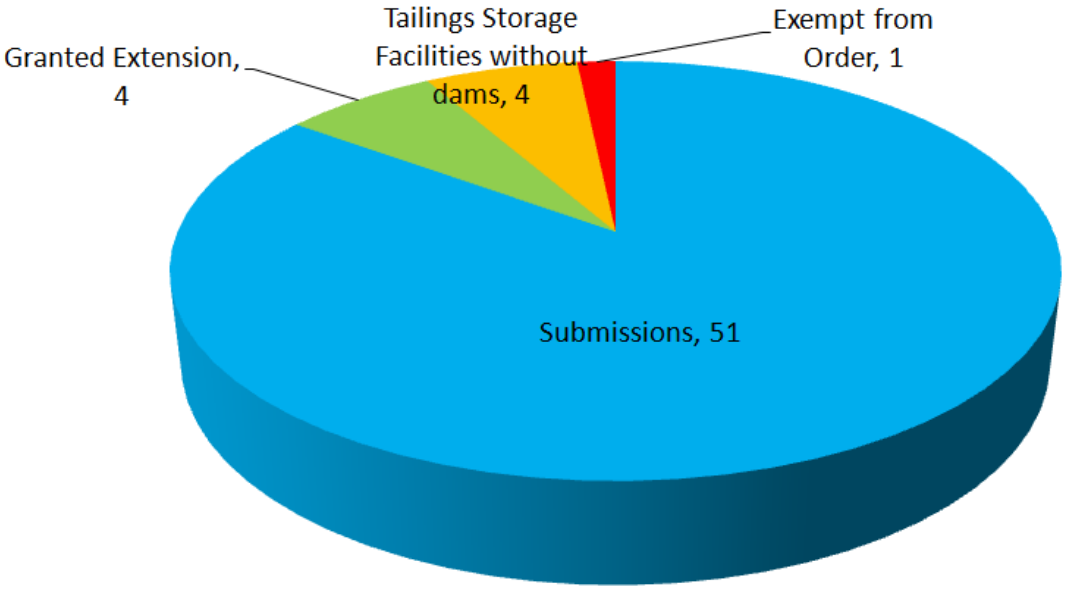

Figure 1: Submission status for 60 permitted mines

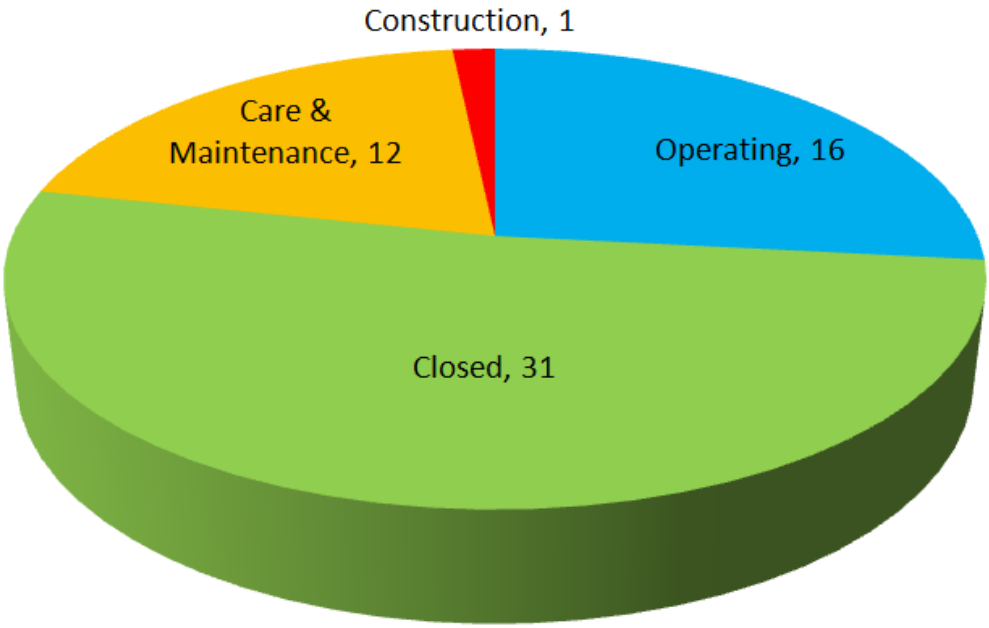

Figure 2: Operational status of mines with permitted Tailings Storage Facilities (TSF)

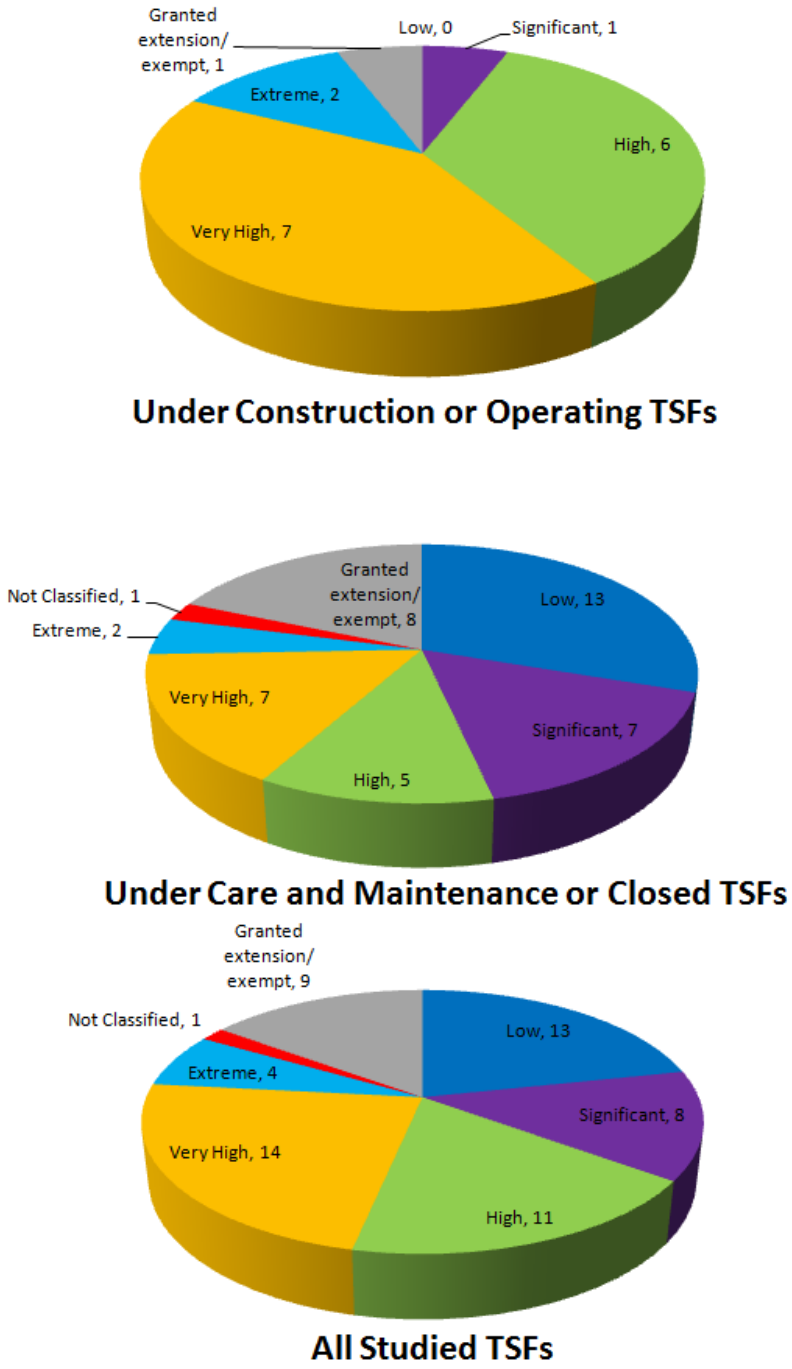

Figure 3: Highest dam consequence classification status for studied Tailings Storage Facilities (TSF)

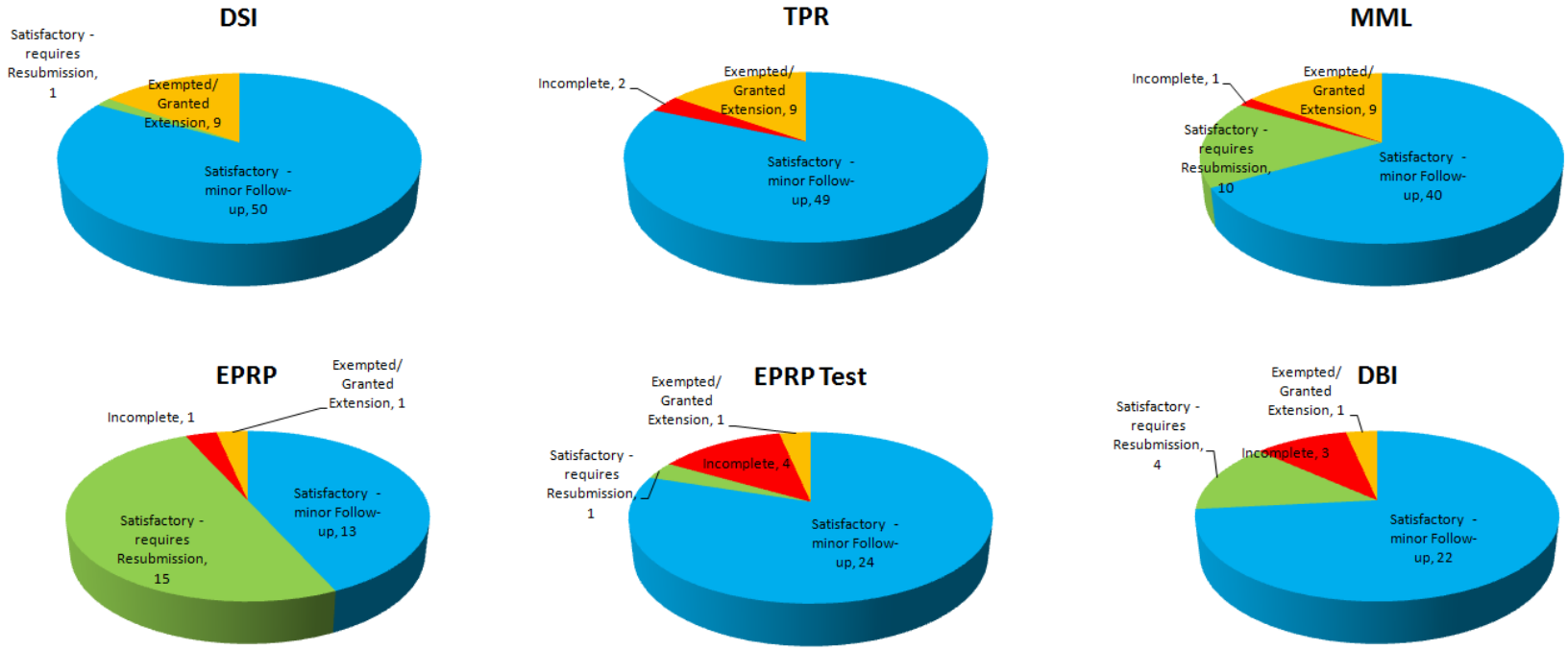

Figure 4: Compliance status for 60 permitted mines, by report type

Legend:
DSI: Dam Safety Inspection report
TPR: Third Party Review report
MML: Mine Manager Letter
EPRP: Emergency Preparedness and Response Plan
DBI: Dam Break Inundation study

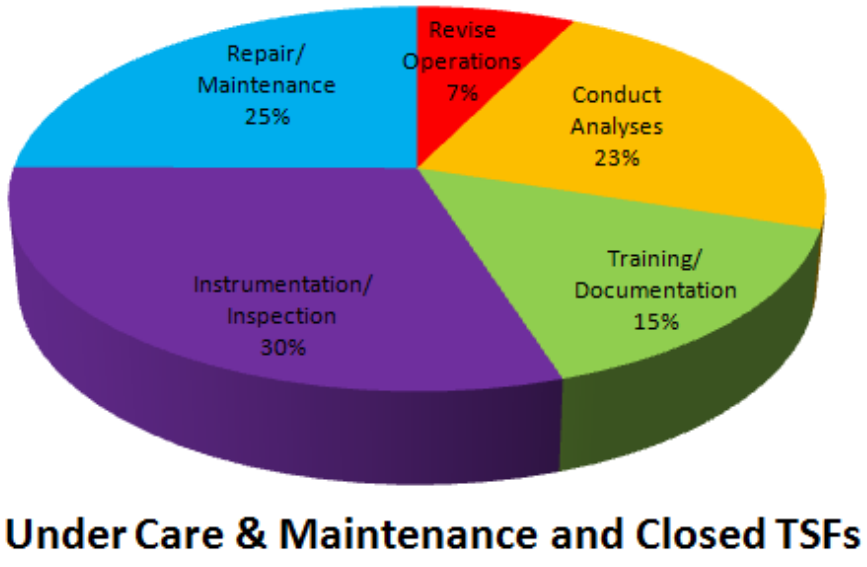

Figure 5: Types of recommendations provided by DSI or TPR studies

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