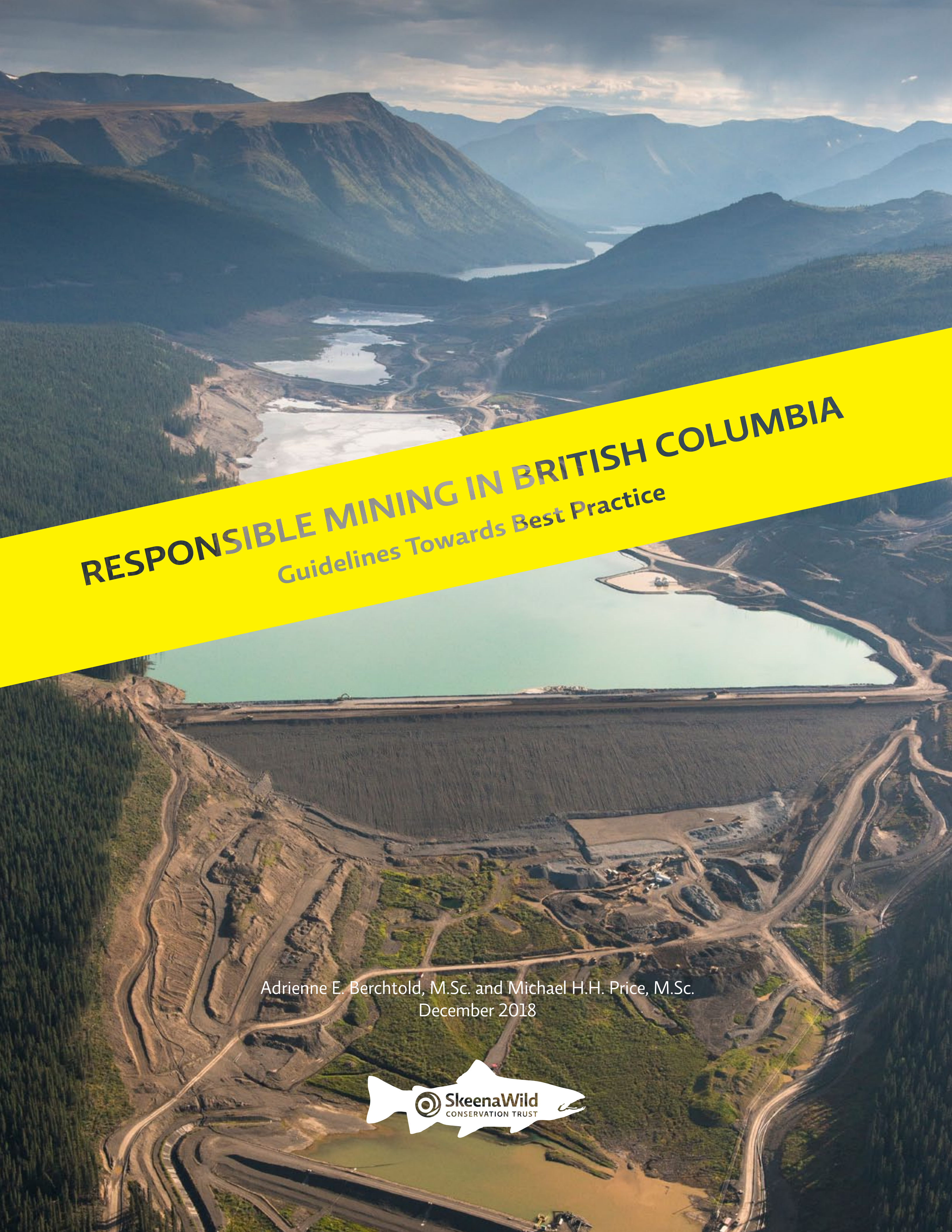

RESPONSIBLE MINING IN BRITISH COLUMBIA

Guidelines Towards Best Practice

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EXECUTIVE SUMMARY

The mining industry contributes to the colonization and alteration of land and water in British Columbia (BC), and is known to cause widespread environmental damage. Currently, mining development is rapidly expanding in northwest BC, raising concerns for the health of wild salmon and associated human communities. Too frequently, standard ways of designing and managing mine projects result in habitat loss, water pollution, catastrophic facility failure, and/or abandonment of projects with a legacy of negative environmental impacts. These problems have long plagued BC, including the recent tailings dam failure at Mount Polley mine (one of Canada's largest environmental disasters), and ongoing water contamination at Teck's Elk Valley coal mines and the abandoned Tulsequah Chief mine.

Water pollution from mines typically consists of elevated metals concentrations in the water. Fish are particularly vulnerable to metals pollution because they possess sensitive organs that are continuously in contact with the aquatic environment. Many metals can disrupt essential functions of the fish gill (responsible for gas and ion exchange), and the olfactory system (a fish's sense of smell), ultimately leading to fish death. Even relatively low concentrations of metals can cause sub-lethal effects (i.e., negative impacts that do not cause immediate or direct death) to fish. Both lethal and sub-lethal effects from metal toxicity are known to occur in salmonids.

Despite favorable financial opportunities offered by mining, such as job creation, the risks associated with mining development in BC are – we argue – increasingly unacceptable. Based on research and recommendations from government agencies, the mining industry itself, and a variety of independent experts, our report outlines leading principles, practices, and technologies that mine operators (i.e., the entities in control of mine projects) in BC can – and we argue, should – adopt for their projects, so as to become more socially and environmentally responsible guardians of our shared land and water. We conclude our report with a case study, applying our guidelines for responsible mining to the Kerr-Sulphurets-Mitchell (KSM) mine project in northwest BC. We also append a checklist that stakeholders and concerned watershed citizens can use to assess other mine projects and/or operators against responsible mining guidelines.

Essential Principles

We recommend that mine operators follow four overarching principles, which provide the necessary foundation and structure to enable responsible mine development:

1. **Build positive relationships** with affected communities and other stakeholders by obtaining broad community support and Free, Prior, and Informed Consent (FPIC) for proposed projects, and by performing meaningful stakeholder engagement.

2. **Minimize environmental harm**, especially to salmonids, by adhering to the Precautionary Principle, following a mitigation hierarchy that prioritizes harm avoidance first, and using leading best practices to assess and manage environmental impacts.

3. **Show transparency** by publicly reporting, facilitating independent monitoring programs, and undergoing a wide range of independent expert reviews.

4. **Leave positive legacies** by offering sustainable community benefits, and providing full financial assurance for the project, which will require sound reclamation and post-closure planning and implementation.

Recommended Practices & Technologies

We recommend certain practices and technologies for mine operators to implement throughout the mine life cycle, which generally minimize negative impacts to human and biological communities, especially to salmonids. Some of these include:

PROJECT DESIGN

- Avoid interaction with significant surface water and groundwater systems.
- Maintain salmon habitat.
- Restrict the scale of the mine project.

ORE EXTRACTION

- Use underground mining methods.

WASTE MANAGEMENT

- Minimize mine waste production, and maximize mine waste backfill.
- Eliminate surface water, and minimize interparticle water, from tailings storage.
- Follow a downstream design for constructing wet tailings dams.

WATER MANAGEMENT

- Minimize water consumption, generation of impacted water, and disruptions to ecologically important surface water and groundwater systems.
- Follow a non-degradation management approach.
- Avoid initial dilution zones (a.k.a., "mixing zones").
- Prioritize source controls (i.e., avoidance) of water contamination.
- Recycle impacted water and/or store it behind water-retaining dams (not with tailings).
- Use liners and underlying drainage control at all facilities containing waste and/or impacted water.
- Minimize the need for water treatment.

CLOSURE, RECLAMATION, AND POST-CLOSURE

- Practice progressive reclamation to the maximum extent possible.
- Backfill mine workings, and completely drain tailings at closure.
- Return land and water as near to pre-mining conditions as possible.
- Conduct long-term post-closure environmental and mine site monitoring.
- Hold reclamation financial securities until reclamation is effective, stable, and considered adequate by stakeholders, independent experts, and the public.
- Hold post-closure financial securities as long as post-closure activities occur.

Case Study of KSM

The KSM mine project plans to significantly alter two highly productive salmon-bearing watersheds in northwest BC. Associated with the KSM project are a number of predicted negative impacts, and major risks. Our case study outlines how well past and planned activities for KSM align with our responsible mining guidelines, and highlights numerous ways the project's social and environmental performance can (and we argue, should) be improved. Notably, KSM's operators should:

- Obtain official support/FPIC from all affected communities, and meaningfully involve stakeholders more in project oversight.
- Strictly adhere to the Precautionary Principle and the mitigation hierarchy, and more robustly consider reclamation and post-closure in decision-making.
- Solicit a broader range of independent expert reviews.
- Publicize the project's unanticipated liability estimates (e.g., costs of catastrophic accidents),

and provide financial assurance for these liabilities.

- Rely only on proven reclamation technology (i.e., for operational-scale Selenium water treatment).
- Post full financial securities for reclamation and post-closure.
- Implement responsible practices and technologies, such as: i) reduce the project's scale, ii) mine more selectively (i.e., only for high-value, concentrated ore), iii) increase underground mining, and mine waste backfilling, iv) use non-degradation water management, v) line waste rock and all tailings, vi) use downstream tailings dam construction, and vii) completely drain tailings at closure.

Need for Assurance Mechanisms

Very few of the guidelines for responsible mining described in this report are legally required of mine projects in BC. Thus, a troubling gap exists between what is known to be protective of the environment and human communities, and what mine operators are actually incentivized to practice. We strongly recommend that mine operators in BC participate in a third-party responsible mining assurance program (like the Initiative for Responsible Mining Assurance), and we encourage communities and stakeholders to require this of any projects within their influence.

BACKGROUND

BACKGROUND

History of Mining in British Columbia

The mining industry has been a driving force in the European settlement and ongoing development of important salmon-bearing regions of British Columbia (BC), beginning with gold rushes from the mid-1800s to the early 1900s, which lured prospectors into central and northern BC (MacIntyre et al. 1995). Further development of mineral deposits and the presence of prospectors stimulated further establishment and growth of prominent towns, such as Stewart (District of Stewart n.d.), Smithers (Tourism Smithers n.d.), and Hazelton (Stevenson 2013), as well as expansion by settlers of original Indigenous villages, such as Usk (Reimers & Barnes 2006). Seeking profit from mineral development motivated the British government to exact control over mainland BC (Baker 2002). Thus, mining was integral to the colonization and alteration of land and water previously occupied solely by First Nations, and the abundant wild salmon populations upon which they depended.

Mining practices have changed significantly over the last 150 years. As mining has depleted high-grade, easy-to-access mineral deposits, the industry has shifted toward extracting low-grade ore using increasingly intrusive methods (Bowker & Chambers 2015; Auditor General of BC 2016). In BC, the development of open pit mining has triggered a boom of copper extraction from large, low-grade, porphyry deposits (Baker 2002). Such large-scale, intrusive mining methods have resulted in greater environmental impacts, particularly on freshwater systems (Mining, Minerals, and Sustainable Development Project [MMSD] 2002; Auditor General of BC 2016). Of heightened concern is the damage that mining-induced degradation of freshwater habitat has had – and likely will continue to have – on ecologically, culturally, and economically important salmon populations. For example, the first significant copper porphyry deposit in northern BC was mined on the shores of Babine Lake (Baker 2002), one of the world's largest sockeye salmon producing systems (Wood 2008). Now, the two decommissioned open pit mines on Babine Lake (i.e., Granisle, 1965–1982, and Bell, 1970–1992) pose significant concerns regarding copper contamination in the lake from wastewater discharge (Price 2013).

British Columbia currently is Canada's leading producer of copper and exporter of coal, and the industry continues to grow, especially in northwest BC (Clarke et al. 2018). Significant coal exploration and mine project development is occurring in the Groundhog coalfields, and the Telkwa Coal project has just initiated its environmental assessment process. Additionally, hard-rock mining for metals is rapidly expanding in northwest BC: recent openings have occurred at Red Chris (2015) and Brucejack (2017) mines; environmental assessments have been approved for the Kerr-Sulphurets-Mitchell (KSM) and Kitsault mine projects, and are being prepared or are under review for a handful of other projects (e.g., Red Mountain, Schaft Creek, and Galore Creek); and at least 60 other hard-rock exploration projects were active in the northwest region in 2017 (Clarke 2018). Such large-scale coal and hard-rock mining development could cause widespread and irreversible damage to freshwater systems, wild salmon, and associated human communities; it therefore demands close examination and scrutiny.

Life Cycle of a Mine and Associated Impacts

Every hard-rock and coal mine project in BC follows a similar life cycle: i) exploration and feasibility, ii) planning, iii) construction, iv) operation, v) closure and reclamation, and vi) post-closure. During each phase, mine project operators[1] make decisions, and take actions, that influence the project's overall impact. Major project concepts and initial plans are developed early to determine project feasibility (Environment Canada 2009). More detailed planning follows, and eventually an environmental assessment is performed, during which regulators evaluate the project's social and environmental impacts and mitigation measures, and mine operators are legally required to consult with affected communities and to inform the public about the project (BC Environmental Assessment Office [EAO] n.d.). Once in operation, the industrial-scale extraction of ore (i.e., mining) produces large volumes of waste rock and tailings that contain an array of environmental contaminants (MMSD 2002; Miranda et al. 2005; Environment Canada 2009; International Network for Acid Prevention [INAP] 2009; Skeena Watershed Conservation Coalition [SWCC] 2012; Hatch 2013; Auditor General of BC 2016; European Commission 2016; Initiative for Responsible Mining Assurance [IRMA] 2018); these mine wastes need to be handled and disposed of in ways that remain protective of the natural environment long after the mine is closed. Water that contacts the walls of a mine opening, mine wastes, or other exposed mineralized material on the mine site (a.k.a., "mine-impacted water") is likely to be contaminated by metals leaching (ML) – which includes both metals (e.g., Copper, Cadmium, and Mercury), and non-metals (e.g., Arsenic and Selenium) – and possibly by acid rock drainage (ARD), which can accelerate ML contamination (INAP 2009; Hatch 2013). Release of this mine-impacted (i.e., contaminated) water back to natural water bodies is supposed to be controlled, often using water treatment, to meet defined water quality parameters (BC Ministry of Environment [MOE] 2003; Environment Canada 2009). After operations cease, the mine site is decommissioned and reclaimed, though it never fully returns to its former state (MMSD 2002). Water treatment, and long-term monitoring and maintenance, are increasingly relied on indefinitely after mine closure to address ongoing risks (Auditor General of BC 2016).

Mine projects can cause a wide range of negative impacts, the most common – and often, the most severe – of which being pollution to nearby freshwater (MMSD 2002; Miranda et al. 2005; Auditor General of BC 2016). Salmonids are extremely vulnerable to pollution by waterborne metal and non-metal toxicants from mining because fish have sensitive organs that are continuously in contact with the aquatic environment, and because many of these toxicants are highly soluble in water. High concentrations of many metals can damage the gill structurally, and cause suffocation and death (Mallat 1985); even relatively low concentrations of heavy metals can fatally impair physiological functions of the gill, and impair fish (Wood 1992). Heavy metals also can interfere with a fish's olfaction (i.e., sense of smell), which plays an essential role in the survival of fish, initiating behaviours such as food gathering, predator avoidance, schooling, defense, navigation between ocean and freshwater habitats, and reproduction; low concentrations of contaminants can alter these essential behaviours, thereby indirectly reducing survival (Sandahl et al. 2007; McIntyre et al. 2008; Tierney et al. 2010; Price 2013). In northwest BC, many mineral deposits are potentially acid-generating (PAG), so freshwater pollution from ML/ARD – and associated lethal and sub-lethal impacts to wild salmon – is of particular concern in this region (Day & Harpley 1992; SWCC 2012). Water pollution by Selenium – which has caused near population collapse of Westslope Cutthroat trout near Teck's coal mines in the Elk River Valley (Lemly 2014) – is now a concern near Red Chris mine,[2] and could cause problems at proposed

1 Throughout this report, we refer to the entity in control of a mine project as its "operator", regardless of what life cycle stage (i.e., planning, operation, post-closure, etc.) the project is in.

2 Selenium levels in fish tissue have risen in nearby Ealue Lake since Red Chris began operations (Hume 2016).

KSM[3] and Telkwa[4] mines. Given the importance of salmon in BC, possible harms to them from mining-induced water pollution have worrying ecological, social, and economic implications.

In addition to water pollution, mine projects inevitably alter the land- and waterscape, often causing habitat loss and disruption (MMSD 2002; Hatch 2013). Another major risk of mining development is the potential failure of tailings storage facilities, the consequences of which continue to increase (Bowker & Chambers 2015). When the Mount Polley mine experienced a catastrophic tailings dam failure in 2014, most of the 25 million m^3 of escaped wastewater and tailings spilled into Quesnel Lake (Petticrew et al. 2015; Chambers 2016), one of BC's most productive sockeye salmon nursery lakes (Shortreed et al. 2001). Other risks arise if a mine operator declares bankruptcy and/or abandons the project. For example, if the mine operator's financial securities for a given project prove inadequate (which often occurs), taxpayers and local residents are burdened either with having to pay to manage the project's environmental impacts (e.g., Britannia mine[5]), or having to suffer the consequences if impacts go unmitigated (e.g., Tulsequah Chief mine[6]; Stano et al. 2013; Bowker & Chambers 2015; Allan 2016). Other social impacts, such as livelihood displacement and cultural degradation, also can be associated with mine development (IRMA 2018). The potential damage caused by large-scale mining development in BC clearly is a serious risk.

3 Elevation concentrations of Selenium are predicted in KSM's wastewater, and its receiving waters (KSM 2013).

4 Telkwa is a proposed coal mine project. Coal is a major source of Selenium (CH2M HILL 2010).

5 Taxpayers now contribute $3 million annually for a water treatment plant, which will operate in perpetuity, at the abandoned Britannia mine (Auditor General of BC 2016).

6 Tulsequah Chief mine has had two separate operators declare bankruptcy in the last 60 years, during which time it has continuously leaked unmitigated ARD into the salmon-rich Taku River system (Plourde & Zeidler 2017).

Need for Improved Practice

Society depends in part on the minerals and metals that mines provide (though re-use and recycling can greatly diminish our need for raw materials). Mine development also creates jobs and opportunities for financial gain in areas where economic growth is desired, and mine operators may make other investments toward community development that are considered beneficial (Stano et al. 2013; IRMA 2018). Importantly, mines don't necessarily need to irreversibly degrade the environment or negatively impact local communities. It is possible for mine operators to proactively mitigate harm, and to reclaim affected land and water back to safe, productive uses (MMSD 2002; Miranda et al. 2005; IRMA 2018). It even is possible for mine projects to improve surrounding water quality, rather than diminish it (Hatch 2014; IRMA 2018). In BC, however, harm to terrestrial and aquatic communities by mine projects is not uncommon (SWCC 2012; Allan 2016; Auditor General of BC 2016), and the risks associated with standard mining practices are – we argue – becoming increasingly unacceptable. Based on research and recommendations gathered from government agencies, the mining industry itself, and a variety of independent experts, we outline in the following section a collection of principles, practices, and technologies that mine operators in BC can – and we argue, should – adopt for their projects, so as to become more socially and environmentally responsible guardians of our shared land and water. We focus specifically on providing guidelines for mine development that will protect freshwater quality, wild salmon, and the cultural, physical, and economic health of affected communities.

RESPONSIBLE MINING GUIDELINES

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RESPONSIBLE MINING GUIDELINES

Essential Principles

Every mine project resides within unique social and environmental contexts. What follows are four overarching principles, applicable across all contexts, that provide the necessary foundation and structure to enable responsible mine development.

1. BUILD POSITIVE RELATIONSHIPS WITH AFFECTED COMMUNITIES & OTHER STAKEHOLDERS

Mining can negatively affect local communities, often posing significant threats to their physical health, and their social and economic well-being (Stano et al. 2013; IRMA 2018). Conversely, Indigenous and non-Indigenous communities, and other stakeholders, can influence the viability and performance of a given mine project; the Ajax copper-gold mine, for example, was ultimately cancelled due to opposition from residents of Kamloops and local First Nations[7]. Responsible mining requires that the rights and aspirations of affected Indigenous[8] and non-Indigenous communities are respected, and that mine operators work towards positive outcomes for the project and for affected communities, by obtaining broad community support and Free, Prior, and Informed Consent (FPIC) for the proposed project, as well as by performing meaningful stakeholder engagement.

7 The Ajax mine's environmental assessment application was provincially rejected in 2017 (CBC News 2017).

8 Indigenous Peoples' right to control the use and development of their traditional territories has been enshrined by international agreements (e.g., the United Nations Declaration on the Rights of Indigenous Peoples, to which Canada is a signatory). The Canadian Constitution Act (1982, s.35) also protects the Aboriginal and treaty rights of Aboriginal Peoples of Canada.

COMMUNITY SUPPORT & FREE, PRIOR, AND INFORMED CONSENT (FPIC)

Broad community support is essential for developing a truly successful mine project (INAP 2009; International Council on Mining & Metals [ICMM] 2013; IRMA 2018). Additionally, mine operators should respect internationally recognized rights of Indigenous Peoples by obtaining FPIC from First Nations and other Indigenous Peoples wherever mine-related activities could affect their rights or interests (ICMM 2013; Stano et al. 2013; IRMA 2018). Both broad community support and FPIC first should be sought early on – ideally, prior to mineral exploration (Stano et al. 2013), and certainly well in advance of initiating the environmental assessment process – and then be explicitly maintained throughout the mine project's life (Stano et al. 2013; IRMA 2018). Operators might work towards obtaining FPIC by designing their project in adherence with First Nations Land Use and Resource Management Plans, and by negotiating Access Agreements and Impact Benefits Agreements (Stano et al. 2013). For example, the Kemess Underground mine (originally opposed by local First Nations, until after its design changed from open pit to underground mining methods) has signed an Impacts Benefits Agreement with all three First Nations on whose traditional territory the project resides (Peebles 2017). Lastly, we consider it essential that FPIC-related agreements, or other formal commitments made by mine operators to affected communities, be reviewed regularly to ensure that they are upheld (IRMA 2018).

Affected Indigenous and non-Indigenous communities may choose to withhold support for a project until other stakeholders – representing social and environmental interests and/or possessing relevant expertise – have been consulted on the potential positive and negative impacts of the project (Miranda et al. 2005; Stano et al. 2013); affected communities also may choose to require that a mine project obtain certification from an independent assurance provider (such as the Initiative for Responsible Mining Assurance [IRMA])[9] as a condition of their support.

STAKEHOLDER ENGAGEMENT

Stakeholders include those who may be directly affected by the mine project, but also those parties who have an interest in and/or potential to affect the project (e.g., government officials, non-governmental organizations/civil society groups, public health agencies, etc.; IRMA 2018). Engagement with stakeholders can help mine operators to obtain and maintain community support and FPIC, and to more effectively identify and manage risks and impacts of their project (INAP 2009; SWCC 2012; IRMA 2018). To achieve these benefits, stakeholder engagement should be accessible, inclusive, and culturally appropriate (INAP 2009; ICMM 2013; IRMA 2018). Above all, stakeholder engagement should be meaningful; meaningful stakeholder engagement consists of two-way dialogue wherein: i) the mine operator is considerate of, and responsive to, stakeholder concerns, ii) relevant stakeholders are involved in actual decision-making regarding the project, and iii) the operator strictly follows through on its commitments (ICMM 2013; Stano et al. 2013; IRMA 2018).

Engagement opportunities should be provided to stakeholders regarding any aspect of the project that could have social or environmental repercussions, at a scale appropriate to the magnitude of those potential repercussions, and should occur from the time of project conception through to the post-closure period (Stano et al. 2013; IRMA 2018). Broadly, relevant stakeholders who choose to participate should be meaningfully involved in developing the overall project design, identifying and assessing potential risks and impacts, and developing, implementing, evaluating, and revising social and environmental management plans (including impact mitigation and monitoring strategies; IRMA 2018). Effective stakeholder engagement includes: i) co-operating with independent experts that are hired by stakeholders (Miranda et al. 2005; IRMA 2018), ii) collaborating to form mechanisms for stakeholders to oversee the project's performance (such as advisory committees, co-management agreements, etc.; IRMA 2018), iii) offering assistance (including funding) to remove barriers to meaningful stakeholder engagement (Miranda et al. 2005; ICMM 2013; Stano et al. 2013; IRMA 2018), and iv) providing a site-level mechanism for stakeholders to file grievances regarding the project and seek resolution (IRMA 2018).

2. MINIMIZE ENVIRONMENTAL HARM

Mining is an extractive activity that, by definition, alters the natural environment. While environmental damage cannot be avoided entirely, responsible mine operators can greatly minimize the risks of such damage. In BC, protection of water, salmonids, and salmonid habitat is of critical importance. Mine operators can minimize the environmental harm that their project causes by adhering to the Precautionary Principle, following an appropriate hierarchy of mitigation strategies, and using leading best practices to assess and manage the project's environmental impacts.

PRECAUTIONARY PRINCIPLE

Canada has committed to implementing the Precautionary Principle, which states: *Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.* [10]Essentially, the Precautionary Principle implies that developers have a social responsibility to

9 IRMA will begin certifying socially and environmentally responsible mine projects in 2019 (IRMA 2018).

10 Canada first adopted the Precautionary Principle in the UN Rio Declaration on Environment and Development (1992, Principle 15); the principle is also entrenched in domestic legislation, such as the Canadian Environmental Protection Act (1999, Preamble).

protect the environment from exposure to harm when scientific investigation has found plausible risk. This internationally-adopted principle is highly relevant to the development of a responsible mine project because scientific uncertainty pervades the environmental impacts of a number of mine-related practices, such as in the following examples: i) water-borne contaminants released from mines and related facilities may mix together or bio-accumulate to cause amplified toxic effects on fish and other aquatic life that are not well understood, nor addressed by current regulations (Price 2013), ii) metals leaching (ML) and acid rock drainage (ARD) are challenging to accurately predict (Miranda et al. 2005, INAP 2009; European Commission 2016), and – owing to underestimation of predicted impacts and/or (more commonly) overestimation of mitigation effectiveness (Kuipers & Maest 2006) – actual ML/ARD impacts often are worse than the projects' environmental assessments originally predict (Kuipers & Maest 2006; SWCC 2012; Auditor General of BC 2016), iii) no technology for removing Selenium from mine-impacted water has yet been demonstrated as effective at large operational scales and feasible long-term (CH2M HILL 2010, 2013; Hatch 2014), iv) to accommodate increasing waste production, some mine waste disposal facilities are reaching unplanned and/or unprecedented scales, at which uncertainty regarding their physical stability is increased (Bowker & Chambers 2015; Chambers 2016), and v) the common inadequacy of financial securities provided by mine operators in BC for reclamation and post-closure costs, and for costs of accidental environmental harm, creates uncertainty regarding mine operators' ability to fulfill their environmental mitigation obligations (SWCC 2012; Stano et al. 2013; Bowker & Chambers 2015; Allan 2016; Auditor General of BC 2016). The Precautionary Principle guides mine operators to err on the side of extreme caution with regards to these and other practices that have uncertain, but potentially very serious, environmental impacts (MMSD 2002; Auditor General of BC 2016). Practicing such caution could include: i) using conservative estimates of risk, ii) avoiding practices that carry environmental risk wherever possible, iii) implementing only practices and technologies that are demonstrated not to cause significant harm, and iv) implementing only mitigation measures that are demonstrated to be effective.

MITIGATION HIERARCHY

The most effective way to protect from environmental damage is to avoid causing such damage at the outset. Thus, mine operators should follow a mitigation hierarchy that prioritizes avoidance of environmental harm first (i.e., during project design), then focuses on reduction of negative impacts, and transitions to restoration of negative impacts only after avoidance and reduction options have been exhausted (MMSD 2002; Environment Canada 2009; INAP 2009; European Commission 2016; IRMA 2018). The goal of environmental mitigation is to leave zero residual negative impacts; thus, compensation or offsetting measures should not be considered part of the normal mitigation hierarchy (Hart & Coumans 2013), and should only be relied on in special cases where stakeholders agree to their use after all avoidance, reduction, and restoration strategies have been fully exhausted (IRMA 2018). Adherence to this mitigation hierarchy may require operators to use practices and technologies that are more costly or require greater upfront investment than the current norm; however, as stated by a panel of independent experts tasked with investigating Mount Polley's catastrophic tailings dam failure, "Safety attributes should be evaluated separately from economic considerations, and cost should not be the determining factor" (Mount Polley Independent Expert Engineering Investigation and Review Panel [Mount Polley Expert Panel] 2015 p. 125; emphasis added).

General targets for the mitigation of environmental harm by mine projects should consist first of avoiding, and second of reducing:

- destruction and alteration of habitat, especially of ecologically rich habitat such as salmon-bearing waters,
- disruption and exposure to air and water of mineralized rock, particularly mine walls, waste rock, and tailings,
- production of waste, especially waste rock, tailings, and water treatment residuals,
- consumption of freshwater,
- generation and release of mine-impacted (i.e., contaminated) water, and
- chemical and physical instability of the mine(s) and all mine-related facilities.

We discuss specific strategies to achieve the above-mentioned general targets in greater detail below under "Recommended Practices and Technologies."

ASSESSMENT AND MANAGEMENT OF ENVIRONMENTAL IMPACTS

The minimization of environmental harm requires thorough evaluation – in collaboration with stakeholders – of the project's potential impacts, and options for mitigating such impacts. Early in the planning stage, watershed-based alternatives assessments must evaluate different project designs and mitigation strategies, so as to choose a mine plan that best avoids significant adverse impacts, and that best protects current and potential future land and water uses (INAP 2009; SWCC 2012; Stano et al. 2013; Mount Polley Expert Panel 2015; BC Ministry of Energy and Mines [MEM] 2016, 2017; Environment Canada 2016; IRMA 2018). Protection of salmonids and their habitat should be prioritized during alternatives assessments. Additionally, reclamation outcomes, reclamation and post-closure costs, and long-term impacts of each alternative project design should be considered in a way that avoids biased decision-making towards short-term economic benefits (Hart & Coumans 2013; Mount Polley Expert Panel 2015; Allan 2016). Costs and consequences of each alternative in worst-case scenarios (e.g., catastrophic facility failure) should be considered (Miranda et al. 2005; Mount Polley Expert Panel 2015; IRMA 2018). Impact assessments, performed based on the chosen project plan, should detail potential residual impacts – including cumulative impacts – throughout affected watersheds at all stages of the mine's life, including post-closure (INAP 2009; SWCC 2012; Stano et al. 2013; IRMA 2018). Though detailing predicted impacts is a required component of each project's environmental assessment application, some mines, such as Red Chris,[11] could (and we argue, should) do so more comprehensively. Alternatives and impact assessments should be transparent and scientifically robust, meaning they be based on adequate baseline data, and include sensitivity analyses and other discussions of uncertainty (INAP 2009; Stano et al. 2013; BC MEM 2016; Environment Canada 2016; IRMA 2018). To facilitate the best possible mitigation, alternatives and impact assessments should be performed before project construction begins (IRMA 2018); engaging in operations prior to performing an environmental assessment – as the Telkwa Coal project originally intended to do[12] – does not represent responsible practice (Stano et al. 2013).

Careful management and robust monitoring of potential adverse impacts is required to ensure that chosen mitigation strategies are implemented as designed, and that they are effective. A

11 Red Chris mine's environmental assessment application did not provide specific water quality predictions for the Klappan River, which contains high value fish habitat, despite the project's plan to discharge mine-impacted water into the Klappan's tributaries (Red Chris 2004).

12 The Telkwa Coal project initially planned to begin operating its open pit coal mine at a production level just below the environmental assessment reviewable limit (Allegiance Coal 2017a); however, local community concern has prompted the BC government to require that the project undergo an environmental assessment, regardless.

project's environmental management program should be adaptive, meaning that it: i) is based on clearly identified mitigation objectives (e.g., receiving water quality objectives), ii) includes comprehensive monitoring for early indicators and/or trigger levels to track whether those objectives are being met, and iii) quickly implements pre-planned corrective actions if monitoring indicates objectives are not being met (INAP 2009; Stano et al. 2013; Mount Polley Expert Panel 2015; BC MEM 2016; IRMA 2018). Management plans should be integrated across the mine site (lack of which was a contributing factor in the Mount Polley disaster[13]), and cover the entirety of the mine life cycle (including reclamation and post-closure; INAP 2009; European Commission 2016; IRMA 2018). Management plans also should include budgets and plans for financing management activities, based on conservative cost estimates (IRMA 2018). It is important that impact predictions, mitigation strategies, and management and monitoring plans be reviewed regularly, and revised when necessary, such as with updated results from monitoring, major changes to the mine plan (e.g., mine expansions), or availability of new predictive tools (Miranda et al. 2005; INAP 2009; Stano et al. 2013; IRMA 2018). To ensure corporate accountability, approval and oversight of environmental management should occur at the highest company levels, such as by a CEO or Board of Directors (INAP 2009; Mount Polley Expert Panel 2015; IRMA 2018).

Mine waste, water, and reclamation/post-closure deserve particularly rigorous impact assessment, mitigation planning, and management and monitoring; further recommendations related to these activities are detailed throughout our report.

13 Lack of integration between mine waste management and water management at Mount Polley resulted in the tailings facility's embankment slope being steeper than designed, which was one of the proximate causes of failure (Mount Polley Expert Panel 2015).

3. SHOW TRANSPARENCY

Transparency is essential for creating lasting trust between mine operators and communities, and allowing such communities to make informed choices regarding projects that may affect them. Transparency also can connect mine operators with outside expertise, which may ultimately improve their project's social and environmental performance. Three key practices involved in mine project transparency are: i) public reporting, ii) independent monitoring programs, and iii) independent expert reviews.

PUBLIC REPORTING

Mine operators should publicly report on all aspects of the project that may impact the public, such as alternatives assessments, project designs, impact assessments (including short- and long-term predicted impacts, and the uncertainty associated with these predictions), mitigation strategies, management and monitoring plans, baseline and monitoring data, reclamation and post-closure plans, and reclamation progress updates (Miranda et al. 2005; Environment Canada 2009; Stano et al. 2013; Allan 2016; Auditor General of BC 2016; IRMA 2018). Importantly, the project's estimated reclamation and post-closure costs, estimated liability for unexpected events or catastrophic accidents, and financial assurance details (including total financial securities, and liability insurance policies) should be publicly available (Stano et al. 2013; Allan 2016; Auditor General of BC 2016). Public reporting should begin during the project conception/early planning stage, be updated regularly as new or revised information becomes available, and continue into post-closure (Stano et al. 2013; Allan 2016; IRMA 2018). Where applicable, information should be provided in both long-form (e.g., raw monitoring data) and written and/or graphical summary formats (SWCC 2012; IRMA 2018). Lastly, we consider it essential that mine operators report regularly on the project's performance against defined standards, including legal requirements, and any other standards the project has committed to (e.g., stakeholder agreements, mitigation targets, independent assurance provider standards, etc.; INAP 2009; Stano et al. 2013; IRMA 2018); operators also should describe any corrective actions taken in situations where the project is not meeting these standards (IRMA 2018).

INDEPENDENT MONITORING

Monitoring programs that are run by community and/or civil society groups allow affected communities and other stakeholders to verify the impacts of a mine project, and the effectiveness of the project's mitigation and management strategies. Mine operators should facilitate independent monitoring programs by allowing access to the project site, co-operating with any independent experts hired by such programs, and offering program-related funding (Miranda et al. 2005; IRMA 2018).

INDEPENDENT EXPERT REVIEW

Independent expert review is increasingly recommended to prevent catastrophic accidents, and to hold mine projects and their operators socially and environmentally accountable (MMSD 2002; Mount Polley Expert Panel 2015; BC MEM 2016, 2017; IRMA 2018). Certification of a project by an independent assurance provider will likely require regular audits of the project's social and environmental performance (IRMA 2018). Additionally, mine operators should willingly participate in (and offer funding for) independent expert reviews deemed necessary by relevant stakeholders (IRMA 2018). Topics that stakeholders might deem necessary for review include: alternatives assessments, impact assessments, facility designs and operation, personnel performance, mitigation strategies and implementation, management and monitoring systems, baseline studies, monitoring results, and cost estimates (Miranda et al. 2005; INAP 2009; Stano et al. 2013; IRMA 2018). Topics considered essential for independent expert reviews, performed regularly throughout the mine life cycle, are: i) mine waste management and associated facilities, ii) water management and associated facilities (especially if long-term water treatment is proposed), iii) closure, reclamation, and post-closure, and iv) management of important species (e.g., salmonids) and biodiversity (MMSD 2002; INAP 2009; Stano et al. 2013; Mount Polley Expert Panel 2015; BC MEM 2016, 2017; IRMA 2018). In all cases, mine operators should publicize the recommendations that they receive from independent expert reviewers, along with action plans to incorporate such recommendations and rationales for any recommendations that they choose not to follow (Mount Polley Expert Panel 2015; IRMA 2018).

4. LEAVE POSITIVE LEGACIES

Current mine practices too often offer short-term economic benefits in exchange for lasting social, environmental, and economic damage to affected communities and watersheds (SWCC 2012; Stano et al. 2013; Allan 2016). Responsible projects should instead ensure positive legacies by: i) following the three preceding Essential Principles, ii) offering sustainable benefits to affected communities, and iii) providing financial assurance for all anticipated and unanticipated project costs, which will partly require sound mine reclamation and post-closure planning and implementation.

SUSTAINABLE COMMUNITY BENEFITS

Minimizing adverse social impacts is an important component of delivering benefits to communities on behalf of a mine project. Following a similar framework to that for minimizing environmental harm, mine operators should perform thorough social impact assessments prior to construction, mitigate social harm according to the mitigation hierarchy, and develop and implement adaptive management plans related to social impacts (Stano et al. 2013; IRMA 2018). As with environmental mitigation, practices and technologies that are more effective at minimizing social harm should be implemented, even if they are more costly than the current norm.

To truly constitute positive development, however, projects must go beyond simply minimizing social harm. Mine operators should deliver positive benefits to affected communities by practicing local procurement of goods and services, and by contributing to local, self-sustaining development initiatives that are guided by the communities themselves (Stano et al. 2013; IRMA 2018).

FINANCIAL ASSURANCE & RECLAMATION/ POST-CLOSURE MANAGEMENT

Environmental regulation in BC ostensibly follows the "Polluter Pays" Principle[14], which means that companies who cause environmental harm ultimately are financially responsible for the necessary mitigation of that harm (Environment Canada 2004). Indeed, mine operators in BC can be required by the government to post financial security, and to continue contributing to this financial security throughout mine operations, in order to receive project permits (BC MEM 2017). However, the financial securities that mine operators provide frequently are insufficient to pay the project's full long-term costs of environmental mitigation, or clean-up costs in the event of a major accident; this standard unfairly leaves the public at risk of paying these costs instead (SWCC 2012; Stano et al. 2013; Allan 2016; Auditor General of BC 2016). Building from legislation in Quebec[15] and Alaska[16], we suggest that responsible mining requires mine operators to post financial securities (a.k.a., "reclamation securities"), prior to construction, that cover all anticipated costs of mine reclamation and post-closure activities, including long-term water treatment and post-closure monitoring and maintenance (Miranda et al. 2005; Allan 2016; Auditor General of BC 2016; IRMA 2018). In addition to financial securities for anticipated project costs, financial assurance that covers a project's unanticipated liabilities also is needed (a need that has been legally recognized for energy projects in BC, but not for mines; Allan 2016). To address this need, mine operators should acquire public liability insurance, or post additional financial securities, to cover costs of unexpected events or catastrophic accidents, such as chemical spills or tailings dam failures (Allan 2016; Auditor General of BC 2016; IRMA 2018). Financial securities posted for mine projects should only be in forms of "hard security" (i.e., forms that are reasonably liquid, and have relatively certain value), which include cash, certified cheques, irrevocable letters of credit, government bonds, and independently guaranteed sureties (Allan 2016). Mine operators should not post physical assets, such as buildings and mining equipment, as financial security because these assets have less certain value and generally depreciate over time (Allan 2016). See Allan (2016) for a detailed discussion of financial responsibility in BC's mining industry.

To ensure that adequate financial securities are posted, and that reclamation and long-term environmental mitigation efforts are effective, thorough, scientifically robust, and transparent reclamation and post-closure planning is required. Reclamation objectives should ensure long-term physical and chemical stability of mine facilities, and should integrate First Nations' and other local Land and Water Use Plans (Stano et al. 2013; IRMA 2018). A detailed reclamation and post-closure plan that is based on rigorous impact assessments and mitigation and management planning should be developed prior to construction. In addition to reclamation and post-closure objectives, and detailed strategies for achieving them, this plan should include anticipated completion schedules, and conservative cost estimates for all activities, including any ongoing operations (e.g., water treatment), monitoring, and maintenance (Miranda et al. 2005; Auditor General of BC 2016; IRMA 2018). In the spirit of the Precautionary Principle, plans for reclamation and post-closure should be based only on proven technologies (IRMA 2018).

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14 The "Polluter Pays" Principle is entrenched federally in the Canadian Environmental Protection Act (1999, Preamble), and in BC by the Environmental Management Act (2003).

15 In Quebec, full reclamation bonding must be provided within the first three years of mining operations (Quebec Mining Act, M-13.1 s.232.4 and M-13.1 r.2 s.113).

16 In Alaska, mining operations cannot begin until full reclamation bonding is provided (Alaska Administrative Code, 11 AAC 97.300 and 11 AAC 97.400).

Mine projects' reclamation and post-closure plans, and financial assurance (i.e., financial securities and liability insurance), should be reviewed and updated at a pre-determined frequency (e.g., every five years), as well as with any major changes to the mine plan, and following any unexpected environmental impacts (Miranda et al. 2005; Stano et al. 2013; IRMA 2018). The design and implementation of mine closure, reclamation, and post-closure, the adequacy of the project's financial assurance, and the adequacy of reclamation before securities are returned to the mine operator should all be approved by stakeholders and independent experts (Stano et al. 2013; IRMA 2018).

Recommended Practices and Technologies

Fulfilling many of the recommendations in the previous section (e.g., stakeholder engagement, independent expert review, etc.) is required before the most responsible practices and technologies for any particular project can be adequately defined. However, some practices and technologies do minimize negative impacts better than others across most, if not all, contexts. Importantly, the prevention of harm to wild salmon and salmon-bearing systems should be a high priority objective in the development of all mine projects in BC. Outlined below, therefore, are generally applicable guidelines for responsible mining practices and technologies, with a specific focus on those that protect aquatic ecosystems and wild salmon.

PROJECT DESIGN

Mines and related infrastructure (e.g., buildings, waste disposal facilities, roads, pipelines, etc.) should be located so as to be least disruptive to important aquatic and terrestrial resources. Generally, project design should avoid development on or near environmentally and/or socially significant surface water and groundwater (Blodgett & Kuipers 2002; Environment Canada 2009, 2016; INAP 2009; Stano et al. 2013). For example, some facilities (e.g., waste rock heaps, tailings dry stacks, and ore stockpiles) can be placed such that natural barriers (e.g., natural clay layers, or higher elevation) reduce their contact with surface water and/or groundwater (Davies 2011; Hatch 2014; European Commission 2016). To adequately protect salmon, projects should not be built overtop of, divert, or otherwise physically disrupt habitat utilized by salmonids. Additionally, project design should avoid withdrawal of freshwater from, or release of impacted water into, salmon-bearing drainages.

In some cases, responsible design may best be achieved by simply restricting the scale of a mine project. For example, Brucejack mine, a relatively small operation in northwest BC, is able to keep its infrastructure and foreseeable environmental impacts out of key watersheds (Brucejack 2014). In the case of large mineralized areas, project designs that focus on selectively extracting only minerals in large abundance, of high value, and/or in high concentration might achieve significantly reduced physical footprints and/or waste production compared to projects that are more expansive.

CONSTRUCTION

Mine project construction should not begin until social and environmental impact assessments are performed, adaptive management plans are underway, a reclamation and post-closure plan is developed, and financial assurance instruments are in place. During construction: i) explosive use should be minimized (Environment Canada 2009), ii) explosives that leave the least amount of nitrogen-based residue (i.e., packaged, rather than bulk, explosives) should be used, especially in sensitive areas (Hatch 2014), iii) cleared overburden should be stockpiled for later reclamation (Miranda et al. 2005; Environment Canada 2009; Stano et al. 2013; BC MEM 2017; IRMA 2018), and iv) surface water and groundwater control (i.e., clean water diversion, and runoff and erosion prevention) should be implemented (Environment Canada 2009; INAP 2009; Hatch 2013; IRMA 2018).

ORE EXTRACTION

Mine walls and waste rock (both created during ore extraction) are two major sources of water contamination (MMSD 2002; Miranda et al. 2005; Environment Canada 2009; INAP 2009; Hatch 2013; Auditor General of BC 2016; IRMA 2018). Compared to open pit mines, underground mines leave mine walls less exposed to water (thereby reducing ML/ARD potential), produce far less waste rock, and disturb a smaller area of habitat (Environment Canada 2009; European Commission 2016). For these reasons, ore should be extracted using underground methods (when technically feasible), particularly those methods that: i) are more resistant to subsidence (Blodgett & Kuipers 2002), and ii) allow for backfilling at closure (Blodgett & Kuipers 2002; Miranda et al. 2005; Environment Canada 2009; INAP 2009). Brucejack mine and the larger Kemess Underground and Red Mountain mine projects – all in northern BC – will entirely use underground extraction methods.

Responsible ore extraction also entails: i) minimizing explosive use, and using explosives that leave the least amount of nitrogen-based residue (Environment Canada 2009; Hatch 2014), ii) keeping ore stockpiles from contacting air and/or water, and minimizing their retention time before processing (INAP 2009; Hatch 2014), iii) minimizing the amount of surface water and groundwater entering mine workings (i.e., via water diversion structures; Environment Canada 2009; INAP 2009; Hatch 2014), and iv) collecting, monitoring, and recycling all water that contacts mine workings and ore stockpiles (INAP 2009; Hatch 2014; IRMA 2018).

ORE PROCESSING

Best practices and technologies for the processing of ore will depend on factors such as deposit composition, and the specific minerals being targeted (Environment Canada 2009; European Commission 2016). However, projects should generally strive to maximize the processing mill's efficiency, an objective that can be both environmentally and financially beneficial. Namely, the amount of water and chemical reagents consumed, and the volume of tailings produced, during ore processing should be minimized (MMSD 2002; Miranda et al. 2005; Environment Canada 2009; European Commission 2016; IRMA 2018). Strategies for achieving these targets include: using selective ore extraction methods, carefully pre-sorting waste rock from valuable ore before processing, using processing methods that require smaller volumes of water and/or chemical reagents, de-watering tailings and ore concentrates, and recycling/re-using process water and reagents (MMSD 2002; Miranda 2005; Environment Canada 2009; INAP 2009; Davies 2011; European Commission 2016).

Mitigation of chemical leakage and/or spills is important during ore processing. The transport and storage of reagents and process water, and the ore processing itself, should be performed in contained structures (e.g., tanks or vats) that have secondary containments to control spills if the primary containments fail (Environment Canada 2009; IRMA 2018). Heap leaching does not align with these guidelines, so should not be practiced. Reagent recovery and destruction treatments should be performed on tailings before tailings exit the mill, so that chemical reagents can be recycled more efficiently, and do not end up in tailings storage facilities (where they would be more environmentally exposed; Miranda et al. 2005; Hatch 2014; European Commission 2016). If cyanide is used, the project should adhere to the International Cyanide Management Code (Environment Canada 2009; IRMA 2018); however, additional measures to address cyanide by-products (i.e., cyanate and thiocyanate) also should be implemented (Miranda et al. 2005; IRMA 2018).

WASTE MANAGEMENT

Mine wastes are major sources of environmental pollution (especially water contamination), and can result in catastrophic consequences if their containments fail (MMSD 2002; Environment Canada 2009; INAP 2009; Bowker & Chambers 2015; Petticrew et al. 2015; Allan 2016; Auditor

General of BC 2016; European Commission 2016; IRMA 2018). Because waste rock and tailings are large sources of these risks, both require careful mitigation and management in collaboration with stakeholders and independent experts (Miranda et al. 2005; INAP 2009; Hatch 2013; European Commission 2016; IRMA 2018). The first priority in responsible mine waste management is to minimize waste production. Then, waste disposal (a.k.a., "storage") methods should be used, which minimize chemical (i.e., pollution) and physical (i.e., failure) risks. Mine wastes, and associated facilities, should undergo rigorous assessments, mitigation planning and implementation, and adaptive management (which includes thorough monitoring), all of which should begin during project conception.

Underground disposal of mine wastes maximizes their physical and chemical stability, and reduces the area of land disturbed; therefore, waste rock and/or tailings should be disposed of as backfill in both underground and open pit mines (Blodgett & Kuipers 2002; MMSD 2002; Miranda et al. 2005; Environment Canada 2009, 2016; INAP 2009; Hatch 2014; Mount Polley Expert Panel 2015; BC MEM 2016; European Commission 2016). Wastes that possess greater potential to pollute (e.g., wastes that are more potentially acid-generating [PAG], Selenium-rich, contain processing reagents, etc.) generally should be prioritized for backfill disposal (INAP 2009) and, ideally, backfilling should occur progressively over the life of the mine (MMSD 2002). When backfilling an underground mine, mixing cement with mine waste further reduces ML/ARD potential, and enhances physical stability (Blodgett & Kuipers 2002; Environment Canada 2009; European Commission 2016). With a few exceptions (e.g., Brucejack[17] and Telkwa[18]), mine projects in BC do not practice waste backfilling despite clear regional evidence of environmental damage related to above ground waste storage (e.g., ML/ARD at Johnny Mountain and Tulsequah Chief mines, and Teck's Selenium pollution in the Elk Valley[19]).

For tailings and waste rock that cannot be accommodated as backfill, the method of their disposal should be decided based on alternatives assessments of different facility locations, designs, and, if applicable, different forms that waste could take (e.g., filtered vs. wet tailings; BC MEM 2016, 2017; Environment Canada 2016; IRMA 2018). Co-disposal (i.e., disposing of waste rock and tailings together) should be considered, because it can reduce physical disposal footprints, and enhance physical and chemical stability of waste materials (MMSD 2002; INAP 2009; Hatch 2014; Caldwell & Crystal 2015; European Commission 2016). Importantly, two tailings dams that contain surface water along with tailings are predicted to fail every ten years in BC (Mount Polley Expert Panel 2015 p. 118). To reduce this failure risk, we strongly recommend that surface water be eliminated, and inter-particle water be minimized, from tailings stored above ground (MMSD 2002; Hart & Coumans 2013; Mount Polley Expert Panel 2015; European Commission 2016). For these reasons, filtered tailings storage (i.e., dry stacks) should be prioritized over wet (a.k.a., "slurry") tailings storage (Davies 2011; Hatch 2013; Caldwell & Crystal 2015; Mount Polley Expert Panel 2015; Allan 2016; European Commission 2016). The Kemess East project, for example, plans to dry stack a portion of its tailings (Golder 2017). If a project must store wet tailings, wet tailings storage facilities should be designed for completely drained (a.k.a., "dry") closure (INAP 2009; Mount Polley Expert Panel 2015; Chambers 2016; European Commission 2016), tailings should be deposited such that tailings beaches grow wider over time (D. Chambers pers. comm. July 24, 2018), and wet tailings containment dams should be built:

17 The Brucejack project will backfill underground voids with waste rock and cemented tailings paste (BC EAO 2015).

18 The Telkwa Coal project proposes to backfill waste rock into at least one of its open pits (Allegiance Coal 2017b).

19 In all three cases, pollution of receiving water is at least partly due to contaminated drainage from above ground waste rock heaps (SWCC 2012; Teck 2014; SLR Consulting 2017).

Underground disposal of mine wastes maximizes their physical and chemical stability, and reduces the area of land disturbed. Photo: Brucejack Mine (© Garth Lenz).

With a few exceptions, mine projects in BC do not practice waste backfilling despite clear regional evidence of environmental damage related to above ground waste storage. Photo: Red Chris Mine (© Garth Lenz).

i) following a downstream (not centerline or upstream) design, and ii) to withstand Maximum Credible Earthquake and Maximum Probable Flood events (Chambers 2016). Worryingly, at least four large mine projects in BC (i.e., Red Chris, Kerr-Sulphurets-Mitchell [KSM], Galore Creek, and Schaft Creek) have chosen not to follow these recommended best practices for their wet tailings facility designs (Chambers 2016)[20].

Regardless of the waste disposal method(s) used, mine operators should ensure accurate risk assessment and effective environmental mitigation by characterizing waste materials, and evaluating the chemical and physical risks, at each disposal facility using industry leading practices (INAP 2009; Mount Polley Expert Panel 2015; Allan 2016; BC MEM 2016; IRMA 2018). These practices include: using the best available predictive tools and models for determining ML/ARD potential, developing comprehensive water (both surface water and groundwater) and chemical mass balances, and evaluating risks based on both short- and long-term waste placement plans (Miranda et al. 2005; INAP 2009; Mount Polley Expert Panel 2015; BC MEM 2016, 2017; European Commission 2016; IRMA 2018). Importantly, waste storage facilities should be assessed, mitigated, and managed according to the severity, rather than the likelihood, of their potential impacts and/or failure consequences (Stano et al. 2013; BC MEM 2016; IRMA 2018). Physical risks can be mitigated by compacting waste, and by constructing shallow containment slopes and sufficient buttresses/benches around facilities (Davies 2011; Mount Polley Expert Panel 2015; BC MEM 2016, 2017; European Commission 2016); if properly practiced, such mitigation measures could have lessened the impact of the Mount Polley tailings dam failure (Mount Polley Expert Panel 2015). Chemical risk mitigation can be directly performed on mine wastes, such as via waste compaction, separate handling and disposal of high-risk wastes, desulphurization and/or neutralization of PAG waste, and progressive reclamation (i.e., phased reclamation, carried out while the mine project is operational) of waste disposal facilities (Miranda et al. 2005; Davies 2011; Environment Canada 2009, 2016; INAP 2009; Stano et al. 2013; Hatch 2013; Caldwell & Crystal 2015; European Commission 2016).

20 Currently, the tailings storage plans at all four projects use centerline, rather than downstream, dam construction, and plan to leave tailings covered by water at closure, rather than completely draining them (Chambers 2016). Red Chris is already operational, but the other three projects are pre-construction, so could still change their tailings facility designs to better follow best practices.

WATER MANAGEMENT

Water pollution is the most prevalent and serious environmental issue associated with mining (Miranda et al. 2005; Environment Canada 2009; Hatch 2013; Auditor General of BC 2016; IRMA 2018); depletion and/or permanent flow alteration of surface water and groundwater by mine development also are major concerns (MMSD 2002; Blodgett & Kuipers 2002; Miranda et al. 2005; SWCC 2012; Hatch 2013; European Commission 2016; IRMA 2018). It is essential that stakeholders are engaged, and independent monitoring and expert review is performed, at all relevant stages in developing and implementing a water management strategy that is based on current and potential future water uses.

The aims of responsible mine water management are to minimize the volume of mine-impacted (i.e., contaminated) water generated, and minimize disruptions to important surface water and groundwater systems (Blodgett & Kuipers 2002; MMSD 2002; Miranda et al. 2005; Environment Canada 2009; INAP 2009; Hatch 2013, 2014; Stano et al. 2013; European Commission 2016). Impacts to water quality and quantity should be predicted, and continuously reviewed and updated based on comparison with monitoring data, using leading tools and models that are transparent and scientifically robust (i.e., they discuss parameter derivations, discuss uncertainty, and perform sensitivity analyses; Miranda et al. 2005; INAP 2009; Stano et al. 2013; BC MEM 2016; IRMA 2018). Baseline sampling, and ongoing monitoring, is needed on any groundwater, springs/seeps, and surface water systems (including fish tissue, invertebrates, vegetation, and sediment) that could be affected by the mine project (INAP 2009; Stano et al. 2013; IRMA 2018). Monitoring programs should be extensive: they should range from contamination source locations within the mine site throughout key points of receiving watersheds (Miranda et al. 2005; INAP 2009; European Commission 2016; IRMA 2018), and they should address all contaminants of concern – even those that are not regulated or initially expected to appear at the project (Miranda et al. 2005; IRMA 2018). All monitoring should look for pre-determined trigger levels, or other early indicators (i.e., warning signs) of environmental harm, so that corrective actions can be implemented before significant negative impacts occur (INAP 2009; BC MEM 2016; IRMA 2018).

Regarding mitigation strategies, mine project design should minimize clean water consumption. Additionally, all water withdrawals and releases should avoid sensitive habitat (Miranda et al. 2005; Environment Canada 2009, 2016; INAP 2009; Stano et al. 2013; European Commission 2016), which includes salmon-bearing waterways. (This recommendation is particularly relevant in northwest BC as many of the region's largest mine projects are located atop important salmon-bearing systems, such as the Stikine, Unuk, and Nass watersheds[21].) Any intentional water withdrawals and releases should be scheduled to maintain natural flow patterns, and measures should be implemented to minimize groundwater drawdown (Blodgett & Kuipers 2002; INAP 2009; Miranda et al. 2005; Hatch 2013; IRMA 2018).

All mine projects will generate, and need to release, impacted water. In managing these releases, mine operators should follow a non-degradation (a.k.a., "anti-degradation") approach, whereby intended and unintended releases of impacted water are managed such that receiving surface water and groundwater parameters are kept at baseline (i.e., pre-mining) conditions (Miranda et al. 2005; IRMA 2018). While the goal of non-degradation has been integrated into federal and state laws in the United States[22], it unfortunately has not been integrated into Canadian law. Mine operators also can (and should) choose water quality objectives that improve receiving water quality (IRMA 2018). Importantly, using initial dilution zones (a.k.a., "mixing zones"), in which receiving water dilutes impacted water to an acceptable state, does not align with non-degradation standards, so should not be practiced (Miranda et al. 2005). Despite its discouragement by Canadian regulators[23], reliance on dilution zones to meet water quality objectives currently is very common at mine projects in BC[24]; Mount Polley's dilution zone, for example, is located inside Quesnel Lake (BC MOE 2017).

Practices for mitigating water contamination should follow the appropriate hierarchy, which prioritizes: i) source control measures, then ii) migration control measures, and, finally, iii) water treatment (INAP 2009; IRMA 2018). Source control measures aim to avoid generation of contaminated water; these measures include underground mining, waste backfilling, waste desulphurization and/or neutralization, and diversion measures (e.g., covers) to keep clean water away from potential sources of contamination (Blodgett & Kuipers 2002; Miranda et al. 2005; Environment Canada

21 Red Chris, Schaft Creek, and Galore Creek projects are located in the Stikine watershed, Brucejack is located in the Unuk watershed, and KSM spans the Unuk and Nass watersheds (Salmon Beyond Borders 2017).

22 The United States Clean Water Act requires state governments to adopt non-degradation policies. Alaska's Water Quality Standards contain a recently updated "Antidegradation policy" (Alaska Administrative Code, 18 AAC 70.15).

23 The Canadian Council of Ministers of the Environment (CCME) has stated, "mixing zones should not be used as an alternative to reasonable and practical pollution prevention, including wastewater treatment" (CCME 2003 p. 38).

24 Major projects that are using, or planning to use, initial dilution zones include: Red Chris (Red Chris 2004), Mount Polley (BC MOE 2017), KSM (KSM 2013), Kemess Underground (Kemess Underground 2016), as well as the closed Bell mine on Babine Lake (BC MOE 2014).

2009; INAP 2009; Hatch 2013, 2014; European Commission 2016; IRMA 2018). In controlling water migration (i.e., movement): i) impacted water should be recycled/re-used, and ii) synthetic, low-permeability liners, and underlying drainage systems (to limit and collect seepage) should be placed under facilities containing mine waste and/or impacted water (Miranda et al. 2005; Environment Canada 2009; INAP 2009; Davies 2011; Hatch 2013; Caldwell & Crystal 2015; European Commission 2016). Use of liners and drainage systems may have reduced the amount of Selenium-polluted water entering the Elk Valley from Teck's waste rock heaps. In cold regions with high precipitation, such as northwest BC, water diversion and migration control measures should be designed to manage impacted storm water and snowmelt (INAP 2009; Davies 2011; European Commission 2016; IRMA 2018). If impacted water needs to be stored prior to being recycled, treated, and/or released, it should be kept behind a conventional water-retaining dam (MMSD 2002; Mount Polley Expert Panel 2015); impacted water should not be stored in tailings storage facilities (Mount Polley Expert Panel 2015; Chambers 2016), which unfortunately is practiced by multiple projects in BC[25].

Treatment of mine-impacted water involves long-term risks, and should only be relied on after all other available mitigation has been implemented (Environment Canada 2009; INAP 2009; Hatch 2014; Caldwell & Crystal 2015; Auditor General of BC 2016; European Commission 2016; IRMA 2018). Some experts and legislators support banning the use of long-term water treatment at mines entirely (Miranda et al. 2005; Stano et al. 2013; Auditor General of BC 2016); however, where mineral deposits are low-grade and sulphide-rich (i.e., much of northwest BC), at least some water treatment will likely be necessary (SWCC 2012; Auditor General of BC 2016). Additionally, water treatment may be required to facilitate other high-priority mitigation measures (such as removing excess water from tailings; Mount Polley Expert Panel 2015). If water treatment is needed, mine operators should prioritize use of systems that: i) are active, and equipment-based (at least during operations; Hatch 2014; European Commission 2016), ii) also target non-regulated contaminants (e.g., thiocyanate; Miranda et al. 2005), and iii) produce more chemically stable and/or smaller volumes of waste (a.k.a, "residuals"; Environment Canada 2009; INAP 2009; Hatch 2014). To meet non-degradation standards, water polishing treatments (e.g., ion exchange, reverse osmosis, or nanofiltration) may need to be used (CH2M HILL 2013; Hatch 2014). Even with these recommendations, concerns regarding adverse impacts of water treatment remain. For example, no technology has yet been proven effective at large operational scales and feasible long-term, for the removal of Selenium from mine-impacted water (CH2M HILL 2013; Hatch 2014). There also are many unanswered questions regarding the stability and proper disposal of some water treatment residuals, which ultimately need to be answered during project planning if water treatment is proposed (Environment Canada 2009; INAP 2009; CH2M HILL 2013; Hatch 2014).

CLOSURE, RECLAMATION, AND POST-CLOSURE

To prevent lasting damage from mining development, responsible mine operators should develop and implement plans for closure, reclamation, and post-closure that are based on proven technologies, maximize the physical and chemical stability of all project facilities, and – as quickly as possible – return affected land and water to the end uses desired and agreed upon by relevant stakeholders. Progressive reclamation should be practiced to the maximum extent possible (Stano et al. 2013; Hatch 2014; BC MEM 2016; European Commission 2016; IRMA 2018). Additionally, reclamation securities (provided in full prior to project construction) should not be

25 Red Chris (Red Chris 2004) and Mount Polley (BC MOE 2017) mine projects both store impacted water in their wet tailings storage facilities; other projects, such as Kitsault mine (Kitsault 2012) intend to do the same.

returned to operators until project reclamation: i) is demonstrated as effective and stable, and ii) is reviewed, and considered adequate, by stakeholders, independent experts, and the public (Stano et al. 2013; IRMA 2018).

To facilitate future site stability, both underground and open pit mine workings should be backfilled at closure, rather than left to flood with water (which likely will become contaminated; Blodgett & Kuipers 2002; MMSD 2002; Miranda et al. 2005; Environment Canada 2009, 2016; INAP 2009; Hatch 2014; Mount Polley Expert Panel 2015; BC MEM 2016; European Commission 2016). Additionally, tailings should be completely drained of water at mine closure (if not progressively during operations) to ensure their long-term physical stability (INAP 2009; Mount Polley Expert Panel 2015; Chambers 2016), a recommendation that some large-scale projects in BC, like Red Chris and KSM, are not following (Chambers 2016). Another beneficial mine closure practice is the placement of oxygen-limiting and/or low-permeability covers over waste rock heaps, tailings facilities, and backfilled open pits; these covers reduce exposure of mineralized materials to air and/or water, thereby reducing ML/ARD potential (Environment Canada 2009; INAP 2009; Hatch 2013, 2014; Caldwell & Crystal 2015; Mount Polley Expert Panel 2015; European Commission 2016).

Natural habitats on and around the mine site should be restored as closely as possible to pre-mining conditions (while also aligning with agreed upon future land and water uses) by implementing the following practices: i) all unnecessary infrastructure – including access roads – should be removed from the site, or closed and re-vegetated (Environment Canada 2009; SWCC 2012; Stano et al. 2013; BC MEM 2017; IRMA 2018), ii) original overburden should be replaced over closed facilities (Miranda et al. 2005; Environment Canada 2009; Stano et al. 2013; BC MEM 2017; IRMA 2018), iii) native species should be used for re-vegetation, and planted in a manner that re-establishes natural succession, and other ecological processes (Miranda et al. 2005; INAP 2009; Stano et al. 2013; IRMA 2018), iv) surface waters should be returned to natural flow paths and patterns, and streambanks should be rehabilitated (Stano et al. 2013; BC MEM 2017), and v) erosion control measures should be implemented (Miranda et al. 2005; Environment Canada 2009; Davies 2011; Stano et al. 2013; European Commission 2016; BC MEM 2017). While mining often permanently alters groundwater levels and flows, practices such as sealing underground mines at closure, and recharging aquifers, can return them closer to pre-mining conditions (Blodgett & Kuipers 2002; INAP 2009; Hatch 2013).

Some mining-related activities – namely the collection and treatment of impacted water – may continue long after mine closure (sometimes, in perpetuity). These post-closure activities clearly require the same rigorous level of oversight and adaptive management as when the mine was operational. Additionally, post-closure financial securities should be held as long as post-closure activities occur. Even if post-closure water management isn't required, and all best practices have been followed, lingering risks from the project will still remain. Regular, long-term monitoring and maintenance therefore is essential at all mine sites to ensure its physical and chemical stability; so too is monitoring of aquatic and terrestrial resources to track and mitigate any post-closure environmental damage (Miranda et al. 2005; INAP 2009; SWCC 2012; Stano et al. 2013; Auditor General of BC 2016; BC MEM 2016, 2017; European Commission 2016; IRMA 2018).

CASE STUDY OF KSM

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CASE STUDY OF KSM

The Kerr-Sulphurets-Mitchell (KSM) project is one of many large-scale mine projects under development in northwest BC. The KSM project received environmental assessment approval in 2014, but has not yet begun major construction (BC Mine Information n.d.). Below, we summarize the project's approved plans, and its predicted impacts. We then outline how well both past and planned future activities related to KSM align with the Essential Principles of responsible mining we have described, with relevant discussion of Recommended Practices and Technologies. Throughout, we highlight many improvements that KSM's operators could make to potentially reduce the project's negative impacts.

KSM Project Summary

The KSM project, owned by Seabridge Gold Inc. ("Seabridge"), aims to develop one of the world's largest copper-gold-silver-molybdenum ore bodies (KSM 2013 p. 1-6), located 65 km northwest of Stewart, BC and 30 km from the BC-Alaska border (KSM 2013 p. 1-19). Seabridge plans to locate KSM's facilities in two productive, salmon-bearing watersheds: the Unuk River and Nass River systems (KSM 2013 pp. 4-2, 15-43 to 15-46).

The KSM project is planned to be one of the largest mining operations in Canada[26], processing an average of 130,000 tonnes of ore per day (KSM 2013 p. 1-23). Plans for ore extraction consist of three open pits – one of which, the Mitchell pit, would be the deepest in the world[27] – and two underground block cave mines, all located in the Unuk watershed (KSM 2013 pp. 4-3, 4-21). Seabridge plans to backfill a portion of KSM's waste rock into an open pit (KSM 2013 p. 4-67); however, most of the project's 3 billion tonnes of waste rock, the majority (at least 71%) of which is potentially acid-generating (PAG; KSM 2013 p. 4-22), is planned to be stored above ground in waste rock heaps (KSM 2013 pp. 4-22 to 4-24). Seabridge also plans to store the project's impacted water in a dammed creek (KSM 2013 p. 4-137), and treat it for metals (KSM 2013 pp. 4-149, 4-155 to 4-156); a portion of impacted water is predicted to require removal of Selenium (KSM 2013 p. 4-157), the special treatment plant for which Seabridge does not plan to commission until five years into mine operations (BC EAO 2014a p. 9). Release of treated water is planned such that it drains into Sulphurets Creek (KSM 2013 p. 4-117), which is home to Dolly Varden trout (KSM 2013 p. 15-42), a species of concern (BC Conservation Data Centre 2011). From Sulphurets Creek, drainage continues to the Unuk River, which provides habitat for multiple Pacific salmon and trout species (KSM 2013 p. 15-42). Even if all impacted water collection and treatment is successful as planned, Seabridge's assessments predict that some contaminant concentrations still will be elevated in the receiving environment throughout KSM's lifespan, including post-closure. Notably, Selenium concentrations in Sulphurets Creek, where water quality already is poor (KSM 2013 pp. 14-2 to 14-11), are predicted to become worse, potentially reaching levels more than twice that of the BC Water Quality Guidelines for the protection of aquatic life (BCWQGs; BC EAO 2014b p. 64). Selenium concentrations in the Unuk River also are predicted to rise above baseline levels as far as Alaska (BC EAO 2014b p. 65); in the predicted worst-case scenario, Selenium concentrations could even exceed BCWQGs in the upper Unuk River (BC EAO 2014b p. 64).

The KSM project is planned to include an ore processing mill and wet tailings storage facility, both located in the Nass watershed (KSM 2013 pp. 4-3, 4-176), which is one of BC's largest salmon-producing systems. The tailings facility is designed to store approximately 2.3 billion tonnes (KSM

26 Only Highland Valley Copper (located near Logan Lake, BC) is designed for slightly greater production (133,000 tonnes per day; KSM 2013 p. 1-35).

27 The Mitchell pit is planned to be 1260 m deep (KSM 2013 p. 4-25); currently, the deepest open pit mine is Bingham Canyon in Utah (at ~1200 m; Rio Tinto Kennecott n.d.).

2016a p. IV-A-1) of wet tailings, all of which is expected to contain residual contaminants (KSM 2013 pp. 10-28 to 10-34). The facility's design comprises four centerline-constructed dams, the highest at 239 m (KSM 2016a p. IV-A-7). This tailings facility design is 6 times taller, and has the capacity to contain 28 times more waste, than the failed Mount Polley facility (Chambers 2016). Additionally, the planned location for KSM's tailings facility displaces a population of 30,000 Dolly Varden (KSM 2013 p. 15-177; Rescan 2013 p. 9). Lastly, discharged water from the tailings facility is predicted to alter water quality in Treaty and Teigen Creeks, both of which make valuable contributions to the Nass watershed's total salmon production by providing important spawning and rearing habitat (Department of Fisheries and Oceans 2014). Seabridge is planning for KSM's tailings facility discharge to meet water quality objectives only after initial dilution by receiving creek water (BC EAO 2014a pp. 5 to 6), and Selenium and other contaminants are predicted to intermittently rise above baseline conditions in both Treaty and Teigen Creeks during multiple phases of the project (KSM 2013 pp. 14-199, 14-220 to 14-232).

To close the KSM project, Seabridge plans to progressively backfill one open pit during operations (KSM 2013 p. 27-35), but plans either to flood the other mines or leave them as mined-out and/or subsided craters (KSM 2013 pp. 27-33, 27-40, 27-43). Discharge of impacted water from KSM's water treatment and tailings facilities (to the Unuk and Nass watersheds, respectively) is expected to continue after mine closure (KSM 2013 pp. 26-215, 26-234 to 26-235); Seabridge's plan assumes that active water treatment will be required for 200 years (KSM 2013 p. 4-150). Monitoring and maintenance of the water storage and tailings facilities also is expected to be necessary for at least 250 years (KSM 2013 pp. 26-46, 26-57, 27-95; BC EAO 2014b p. 35). Seabridge does not plan to completely drain KSM's tailings at closure (KSM 2013 pp. 27-62, 27-72), but rather to leave tailings covered by water in perpetuity (KSM 2013 p. 26-234). This tailings closure strategy will leave a permanent risk that a tailings spill could occur, potentially damaging fisheries in the Nass watershed (KSM 2013 pp. 35-26, 35-56).

Has KSM Built Positive Relationships with Affected Communities and Stakeholders?

The environmental assessment process for the KSM project began in April 2008 (KSM 2013 p. 2-1), years after mineral exploration and project conceptualization had commenced (KSM 2013 p. 1-10). However, Seabridge began meeting with potentially-affected First Nations only two months prior to this date (February 2008; KSM 2013 pp. 3-14, 3J-1, 3M-1), and waited until after initiating the environmental assessment process to meet with non-Indigenous local governments (September 2008; KSM 2013 pp. 3P-12) and other public/stakeholder groups (October 2009; KSM 2013 p. 3R-1). Free, Prior, and Informed Consent, and other community support, should have been sought much earlier for the project. Thus far, KSM has received formal support from Terrace City Council (Terrace Office of the Mayor 2013) and the Gitxsan Hereditary Chiefs (Gitxsan Treaty Society 2013), and has signed a Benefits Agreement with the Nisga'a Nation (Seabridge 2014a). The project has received only conditional support from Smithers Town Council (Town of Smithers 2013). Additionally, the KSM project does not have official consent/support from some notable affected groups, such as the Gitanyow Nation, who traditionally harvest in the Nass watershed, yet struggled to be included in KSM's consultation process (Gitanyow Hereditary Chiefs 2014). Aboriginal tribal entities in southeast Alaska whose water may be impacted by KSM (KSM 2013 pp. 2-24, 14-159), such as the Metlakatla, Saxman, and Ketchikan communities, also have not offered official support for the project.

Seabridge has executed (and provided some funding for) a stakeholder engagement program regarding KSM (KSM 2013 pp. 3-1 to 3-42), and has altered the project's design in response to some, but not all, stakeholder concerns (KSM 2013 pp. 29-18 to 29-21, 30-28 to 30-34, 3K-1 to 3K-12, 3N-1 to 3N-34, 3Q-1 to 3Q-19, 3S-1 to 3S-8). We are concerned that Seabridge denied stakeholder requests that it establish a grievance mechanism (KSM 2013 p. 3N-2), and has not released plans for an official stakeholder oversight mechanism for KSM. Both grievance and stakeholder oversight mechanisms are important components of our guidelines for effective stakeholder engagement that Seabridge should implement. Seabridge also could register KSM in an independent assurance program, such as that offered by the Initiative for Responsible Mining Assurance (IRMA), to demonstrate to affected communities and other stakeholders that it is committed to mining responsibly.

Is KSM Minimizing Environmental Harm?

The KSM project involves practices that, we argue, contradict the Precautionary Principle, and do not follow the appropriate mitigation hierarchy. The project's scale is a considerable problem: its planned operational scale creates inherent uncertainty, as it could amplify negative impacts in ways that are challenging to predict or manage, and its planned spatial scale spreads impacts across two salmon-producing watersheds, which does not align with prioritizing impact avoidance. Additionally, Seabridge's plans for KSM consist of "the largest and most complex water management and water treatment system ever proposed for a BC mine project, [which] will be very challenging to implement" (BC EAO 2014b p. 100). This water management/treatment system, which is planned to proceed essentially in perpetuity, relies on technology for Selenium removal that currently is unproven at operational scale (BC EAO 2014b p. 59), and could fail to meet KSM's mitigation objectives – like Teck's Selenium treatment plant did in the Elk Valley[28]. Even if all attempts to mitigate water pollution at KSM work as planned – a situation that does not occur at 64% of mines (Kuipers & Maest 2006 p. 189) – the project is predicted to still elevate concentrations in receiving waters of Selenium (KSM 2013 pp. 14-199, 14-220 to 14-232; BC EAO 2014b pp. 64 to 65), as well as Aluminum (KSM 2013 pp. 14-130, 14-151 to 14-154), Mercury (KSM 2013 p. 14-199), nitrate (KSM 2013 pp. 14-151 to 14-159, 14-188, 14-189 , 14-224 to 14-226) and sulphate (KSM 2013 pp. 14-151 to 14-159, 14-188 to 14-191, 14-224 to 14-226), which could have unanticipated synergistic or bio-accumulative effects on aquatic life (Price 2013; BC EAO 2014b pp. 154, 156). Other problematic aspects of the KSM project include: i) the widespread water contamination, habitat destruction, and/or fisheries impacts that could occur in the event of a catastrophic dam failure (KSM 2013 pp. 35-26, 35-34, 35-56 to 35-61; BC EAO 2014b pp. 74 to 75), or if impacted water from the project is inadequately predicted, collected, or treated (KSM 2013 pp. 35-18, 35-20, 35-26, 35-30, 35-34, 35-35; BC EAO 2014b p. 70), and ii) the displacement, and potential loss (BC EAO 2014b p. 137), of an at-risk salmonid (Dolly Varden) population that will occur if the tailings facility is built as is currently planned (KSM 2013 p. 15-177).

Seabridge could better minimize the KSM project's potential environmental impacts by increasing its use of underground mining methods (preferably by a method other than block cave mining, which is not subsidence-resistant; Blodgett & Kuipers 2002), mining more selectively (such as by reducing, or excluding entirely, extraction of the Mitchell deposit, which is low-grade and widely dispersed; KSM 2013 pp. 4-18 to 4-19), and by increasing backfill of mine wastes. Together, these changes should reduce the project's water

28 Teck's first Selenium water treatment facility caused a fish kill within the first six months of operation and was shut down temporarily (Teck 2015); more recent updates from the company mention a continued "challenge related to Selenium compounds in discharge water" at the re-opened facility (Teck 2017 p. 1).

management/treatment needs, as well as its financial liability, and they might enable Seabridge to locate KSM's waste storage facilities further away from salmonid-bearing habitat and/or to restrict KSM's footprint to only a single watershed. Seabridge also could place liners under KSM's waste rock heaps and the entire tailings storage facility[29], and implement non-degradation water quality objectives (including eliminating the project's use of dilution zones), to avoid negative impacts on receiving groundwater and surface water quality. Finally, we strongly recommend that Seabridge improve KSM's tailings facility design by using downstream dam construction and completely drained closure, to reduce the likelihood and severity of a tailings dam failure.

During project planning, Seabridge did perform alternatives assessments (KSM 2013 pp. 33-1 to 33-144; KSM 2016a pp. 50-73); however, these assessments did not consider all of the practices and technologies we have recommended above, and were not used to select the project's plans for closure and reclamation (KSM 2013 pp. 33-2, 33-4). More comprehensive alternatives assessments should have been performed for the KSM project, including assessments to determine its closure and reclamation design. Additionally, reclamation and post-closure costs should have been more heavily considered when selecting amongst alternative project plans. These costs were weighted as less important than up-front costs in the tailings facility alternatives assessment (KSM 2013 p. 33-32; KSM 2016a pp. 67), and were not clearly included as economic considerations at all in some other assessments (KSM 2013 pp. 33-9, 33-49 to 33-50, 33-84, 33-101 to 33-102). Fully integrating closure, reclamation, and post-closure design and cost considerations when assessing project plans could have resulted in a final KSM project design with fewer potential negative impacts.

29 Seabridge's current plan is to only line the section of KSM's tailings facility holding the most potentially toxic materials (KSM 2016a pp. IV-A-7 to IV-A-8), despite the fact that all of the project's tailings are expected to contain residual metals and other contaminants (KSM 2013 pp. 10-28 to 10-34).

Is KSM Showing Transparency?

A variety of documents are publicly available regarding the KSM project, such as descriptions of alternatives assessments, and baseline studies; major project updates also are available in summary format on the project's community website. However, some information that our guidelines recommend that mine operators disclose is absent from KSM's public record. For example, KSM's liability estimates for facility failures or malfunctions, including catastrophic accidents, have not been released (KSM 2013 pp. 35-13, 35-15). Though not legally required to disclose such information, withholding these liability estimates prevents the public from fully knowing, and evaluating, the risks associated with the project. As the project moves forward, its public reporting will need to be ongoing, continuing into post-closure. Importantly, environmental management plans and monitoring reports (including raw monitoring data), and detailed updates of how well KSM is upholding formal agreements made with affected communities, should be shared publicly. (The project's environmental assessment application only explicitly commits to sharing certain reports with First Nations or other stakeholders; KSM 2013 pp. 26-280, 26-335).

The Gitanyow Nation has signed an agreement with Seabridge to perform independent monitoring of KSM's impacts to wildlife, fish, and water quality in the Nass watershed (Seabridge 2014b). This is a positive start; however, more extensive independent environmental monitoring, occurring throughout the project site itself, and in the Unuk watershed, would greatly improve project oversight.

Regarding independent expert review, Seabridge has created an Independent Geotechnical Review Board (IGRB), which makes recommendations regarding technical aspects of the KSM project's tailings storage facility and water storage dam, and related topics like water management and treatment; Seabridge's response to the IGRB's recommendations is eventually published in the IGRB's subsequent reports (e.g., IGRB 2018 pp. 7-1 to 7-2). Independent expert review of the project's geotechnical aspects is important, but is not enough; independent expert review also should be performed on other aspects of the project, like reclamation plans and implementation, financial assurance, and salmon management and monitoring.

Will KSM Leave a Positive Legacy?

Seabridge has demonstrated some willingness to deliver benefits to communities affected by the KSM project, by committing to practice local employment and local procurement of goods and services (KSM 2013 pp. 20-59 to 20-61), and providing some community sponsorships (KSM 2013 pp. 3-9, 3-18 to 3-19, 3-22, 3-39 to 3-40; KSM Community Site n.d.). However, it remains to be seen whether this trend will continue over successive stages of the project. Additionally, some of the benefits derived by communities from KSM likely will be negated if the project is not adequately reclaimed, it experiences a catastrophic accident, or its financial assurance proves inadequate.

We consider reclamation failure at KSM, resulting in a negative social and environmental legacy, to be a serious and frightening possibility. The project's reclamation and post-closure plan relies on water treatment technology that, according to the BC Environmental Assessment Office, is unproven at operational scale (BC EAO 2014b p. 59) and "should be considered an uncertainty" (BC EAO 2014b p. 85). Yet, Seabridge does not plan to test this technology at full operational scale until after contaminated water has accrued for five years (BC EAO 2014a p. 9). Based on current plans, successful reclamation at KSM also relies on permanent stability of a massive tailings storage facility that will contain surface water (KSM 2013 pp. 26-234, 27-72), despite the known – and we argue, unacceptable – likelihood that two such facilities will fail every ten years in BC (Mount Polley Expert Panel 2015 p. 118). Seabridge should commission, and demonstrate the effectiveness of, an operational-scale Selenium water treatment plant prior to beginning operations, and should perform completely drained tailings facility closure, to improve KSM's likelihood of a positive legacy. Lastly, KSM's costs are estimated at $132 million for closure (KSM 2013 pp. 27-108 to 27-109), and, by our calculations, $5.4 billion for post-closure (based on 200 years of water treatment operations; KSM 2013 pp. 27-109 to 27-110). However, the amount Seabridge has proposed to post as financial security for KSM (USD$688 million, or about CAD$900 million; Seabridge 2016) is only a small fraction (about 16%) of these estimated closure and post-closure costs. Seabridge plans to pay this security in increments over the project's 50+ year operational life, rather than paying it up front (BC EAO 2014b p. 316; Seabridge 2016). Additionally, there is no evidence that Seabridge plans to obtain public liability insurance for KSM. Though this financial assurance strategy for KSM satisfies regulatory requirements, it does not represent responsible practice. To ensure costs are not borne by society, Seabridge should post full financial securities for reclamation and post-closure before construction of KSM begins, and should obtain insurance, or post additional securities, to cover the project's unanticipated liability estimates.

Can KSM's Social and Environmental Responsibility Be Improved?

Before further major development occurs, Seabridge intends to sell all, or a large portion, of the KSM project (KSM 2013 p. 4-305). It will be up to both Seabridge and regulators to ensure that any new KSM operators uphold Seabridge's past commitments, and are financially capable of assuming the project's anticipated costs.

New ownership may introduce changes; however, regulators, stakeholders, and Seabridge itself also can improve the KSM project now. The project requires a number of government permits and associated approvals (e.g., of its water treatment designs, closure and reclamation plans, and environmental management plans) before major project construction and/or operations can commence (BC EAO 2014a pp. 4 to 16). Opportunities exist for regulators and engaged stakeholders to demand improved social and environmental responsibility from the KSM project in meeting these regulatory requirements. More importantly, Seabridge still can make large-scale improvements to the KSM project. The company can choose to adopt more responsible practices for KSM, such as: i) obtaining official consent/support from all potentially affected groups, and increasing stakeholder oversight, ii) reducing use of open pits, and focusing on extracting high-value, concentrated ore bodies, iii) improving the long-term stability of the tailings facility design, iv) using non-degradation water quality objectives, and v) providing greater financial assurance for the project. Seabridge itself recently released a preliminary assessment report detailing an alternative KSM project design that uses primarily underground mining, resulting in smaller surface disturbances, significantly less waste production, and fewer water treatment needs (KSM 2016b pp. 1-56 to 1-58, 1-62, 24-53, 24-69 to 24-70, 24-75). This demonstrates that a more responsible KSM project – one that "substantially shrink[s] the project's footprint and its environmental impact" (KSM 2016b p. 1-62) – is technically feasible; thus, we argue that it should be pursued.

NEED FOR ASSURANCE MECHANISMS

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NEED FOR ASSURANCE MECHANISMS

Very few of the responsible mining guidelines described in this report are legally required of mine projects in BC. Thus, a troubling gap exists between what is known (by the government, the mining industry, and/or independent experts) to be protective of the environment and human communities, and what mine operators actually are incentivized to practice. Because responsible mining development can be more logistically and financially demanding than the current standard, mine operators may not commit to, or follow through on, mining responsibly without the presence of an assurance mechanism to hold them accountable. Even when mine operators genuinely want to practice responsible development, assurance mechanisms are needed to provide a structured means for doing so by offering guidance regarding implementation of responsible standards, auditing mine operators' performance against these standards, and administering consequences when standards are not met. Assurance mechanisms that are organized by an independent third party (as opposed to those organized by government or mine-industry entities, both of which have a potentially conflicting mandate to encourage mine developments forward) are likely to be more effective at ensuring responsible project development because they have greater freedom to objectively balance social, environmental, and economic considerations. The Initiative for Responsible Mining Assurance (IRMA) provides a third-party verification system, which is lead by a wide range of stakeholders, and based on its own set of responsible mining standards. We strongly recommend that mine operators in BC participate in a third-party responsible mining assurance program (like IRMA), and we encourage communities and stakeholders to require this of any projects within their influence.

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RESPONSIBLE MINING CHECKLIST

This checklist can be used to assess mine projects and/or operators, and identify ways they can improve. This is not an exhaustive list, but rather summarizes the key guidelines for responsible mining contained in our report. The order of guidelines in this checklist is not prioritized. Please consult the main text of our report for more detailed information regarding these and other responsible mining guidelines, and strategies recommended to achieve them.

THE MINE PROJECT/OPERATOR...		
1	Participates in an independent third-party responsible mining assurance program	☐
2	Obtains and maintains broad community support	☐
3	Obtains and maintains Free, Prior, and Informed Consent (FPIC)	☐
	Performs stakeholder engagement that:	
4	*i) is meaningful,*	☐
5	*ii) is ongoing, and*	☐
6	*iii) covers all aspects of the project that could have social/environmental repercussions.*	☐
7	Adheres to the Precautionary Principle	☐
8	Follows the mitigation hierarchy	☐
	Performs alternatives assessments and environmental impact assessments that:	
9	*i) use industry-leading tools,*	☐
10	*ii) are transparent and scientifically robust,*	☐
11	*iii) prioritize salmon conservation,*	☐
12	*iv) do not prioritize short-term economic benefits over long-term considerations,*	☐
13	*v) consider costs and consequences of worst-case scenarios, and*	☐
14	*vi) are completed before project construction begins.*	☐
	Practices adaptive environmental management, including:	
15	*i) thorough, long-term management plans that are integrated across the mine site,*	☐
16	*ii) extensive monitoring for early warning signs of negative impacts,*	☐
17	*iii) implementation of pre-planned corrective actions when early warning signs are detected, and*	☐

18	*iii) frequent review and revision of impact predictions (e.g., based on comparison with monitoring data), mitigation strategies, and management/monitoring plans.*	☐
19	Performs particularly rigorous assessment, mitigation planning, and environmental management/monitoring related to mine waste, water, and reclamation/post-closure	☐
20	Publicly reports on all aspects of the project that may impact the public, including unanticipated liability and reclamation/post-closure cost estimates, and financial assurance details	☐
21	Facilitates independent monitoring programs	☐
22	Undergoes a wide range of independent expert reviews (especially of waste management, water management, reclamation/post-closure, and management of important species/biodiversity)	☐
23	Publicizes independent review findings/recommendations, and responses to them	☐
24	Thoroughly assesses, mitigates, and manages the project's social impacts	☐
25	Practices local employment and local procurement of goods and services	☐
26	Contributes to self-sustaining, community-driven development initiatives	☐
27	Posts financial security (in the form of hard security), prior to construction, to cover all anticipated reclamation and post-closure costs	☐
28	Acquires public liability insurance, or posts additional securities, to cover costs of unexpected events and/or catastrophic accidents	☐
29	Creates detailed reclamation/post-closure plans, prior to construction, that are based on proven technologies	☐
30	Frequently reviews and updates reclamation/post-closure plans, and associated financial security	☐
31	Subjects reclamation/post-closure plans and implementation, adequacy of financial assurance, and return of financial securities, to stakeholder engagement and independent expert review	☐
32	Avoids development on or near, or other disruption of, significant surface water and groundwater	☐
33	Avoids building over top of, diverting, or otherwise physically disrupting salmonid habitat	☐
34	Avoids withdrawing water from, or releasing impacted water into, salmon-bearing drainages	☐
35	Restricts the scale of the project to reduce its negative impacts	☐
36	Extracts ore by underground methods	☐

	During ore processing:	
37	*a) Minimizes consumption of water and chemical reagents.*	☐
38	*b) Minimizes the volume of tailings produced.*	☐
39	*c) Minimizes exposure of chemical reagents to the environment.*	☐
40	Minimizes waste production (especially of waste rock and tailings)	☐
41	Maximizes disposal of mine wastes as mine backfill	☐
42	Eliminates surface water and minimizes inter-particle water from tailings stored above ground (e.g., by using filtered tailings, or by completely draining wet tailings)	☐
	Uses wet tailings containment dams that are built:	
43	*i) following a downstream (vs. centerline, or upstream) design, and*	☐
44	*ii) to withstand Maximum Credible Earthquake and Maximum Probable Flood events.*	☐
45	Manages waste facilities based on the severity (vs. the likelihood) of their potential impacts	☐
46	Effectively mitigates physical and chemical risks from mine wastes using leading tools/strategies	☐
47	Minimizes clean water consumption	☐
48	Minimizes generation of impacted water	☐
49	Follows a non-degradation approach to water management	☐
50	Avoids using initial dilution zones (a.k.a., "mixing zones")	☐
51	Follows the appropriate hierarchy for mitigating water contamination, including relying on water treatment as little as possible	☐
52	Maximizes recycling of impacted water	☐
53	Installs liners, and underlying drainage systems, under facilities containing mine waste and/or impacted water	☐
54	Stores impacted water behind a conventional water-retaining dam, not in a tailings facility	☐
	Uses water treatment technology that:	
55	*i) minimizes residual impacts (e.g., produces little waste, meets baseline conditions, etc.), and*	☐
56	*ii) is proven effective at full operational scale, and feasible long-term.*	☐
57	Practices progressive reclamation to the maximum extent possible	☐
	Holds reclamation securities in place until reclamation	
58	*i) is demonstrated as effective and stable, and*	☐

59	*ii) is reviewed, and considered adequate, by stakeholders, independent experts, and the public.*	☐
	At closure:	
60	*i) Backfills mine workings.*	☐
61	*ii) Completely drains tailings (if not already done during operations).*	☐
	After closure:	
62	*i) Restores natural habitats as closely as possible to pre-mining conditions.*	☐
63	*ii) Holds post-closure securities as long as post-closure activities occur.*	☐
64	*iii) Performs regular, long-term site monitoring/maintenance, and environmental monitoring.*	☐