MABC
MINING ASSOCIATION
OF BRITISH COLUMBIA

BC Mining

Innovation Roadmap

Our pathway to leveraging BC's ESG advantage

Contents

Our destination

OUR DESTINATION

More than 150 years ago, our industry helped build our province's cities and towns. Today, BC's mining industry is playing a leadership role in helping the world transition to a cleaner future, sustainably and safely.

We are well-positioned as a world leader in sustainable mining. As greater emphasis is placed on climate change, a low-carbon footprint and responsible mining operations, BC metals and minerals can be a global brand of choice, providing ongoing employment and benefits across the province for years to come.

We are a leading supplier of low-carbon metals and minerals that are essential for clean energy vehicles, renewable energy infrastructure and consumer technologies. We also meet the highest standards of environmental, social and governance performance — for example, our sector is a leader in advancing economic reconciliation with BC's Indigenous peoples, and works within a strong regulatory framework.

We have a large concentration of industry-related expertise, a thriving technology cluster and high quality academic resources to leverage further innovation. There is broad support for BC mining to take a leadership role in helping the world transition to a cleaner future. A recent Mining Association of Canada survey found that more than 80% of respondents want to see Canada increase its role in producing critical minerals for world markets; encourage international investment in Canadian mining companies that are sustainability leaders; and draw attention to Canada's high standards of sustainability.

BC's mining industry will continue to be an integral part of our province's future. In its final report, the BC Mining Jobs Task Force (MJTF) envisions the mining industry as the backbone of an inclusive, progressive and low-carbon economy, and a desired career path for the next generation.

In the near-term, government and industry should also work collaboratively on the establishment of a risk-based regulatory system. This is a critical step to improve the ability to permit innovation through

a process that ensures applications are subject to an appropriate level of regulation based on the level of risk involved and the maturity of the technology. The goal of this approach is to have greater rigour applied to riskier projects in low technology readiness levels (TLR) and less scrutiny applied to low- or no-risk projects.

There are many challenges to improve our position in a highly competitive global industry.

However, a BC Mining Innovation Roadmap, one of MJTF's key recommendations, can help guide the province to become Canada's leader in mining innovation, commercialization and the adoption of step-change innovation to attract investment, create new jobs, and position our mining industry for the future. As the MJTF emphasizes: There is opportunity to leverage the funding, expertise and experience present in the province to build momentum and set a new path forward on innovation.

SNAPSHOT

The pathway

The creation of a BC Mining Innovation Hub is the priority recommendation of the Innovation Roadmap.

The Hub in partnership with industry, the federal and provincial governments, and academia will accelerate innovations and enhance competitiveness across a range of areas including environmental protection, clean tech, emissions reduction, and regulatory competitiveness. The Hub will provide the key functions of coordination, communication and knowledge sharing to implement and achieve the Innovation Roadmap's four goals and other 18 supporting actions. BC already has strong building blocks in the innovation ecosystem. However, the connections between groups must be further supported and developed. Throughout the process of creating the Roadmap, participants resoundingly supported the creation of the Hub as the cornerstone to build and strengthen connections between stakeholder groups.

The Innovation Roadmap's four goal areas are:

+ Foster an innovative and collaborative culture
+ Improve regulation to support innovation
+ Leverage BC's environmental, social and governance (ESG) advantage
+ Build the workforce for the future mine

We have developed an Innovation Roadmap to guide us to our destination, where BC is a globally competitive mining region with a thriving culture of innovation and collaboration, a regulatory regime that supports innovation and high environmental and safety standards, and a workforce prepared for the future. A vision underpinned by trusted relationships and shared values with the Indigenous and non-Indigenous communities, and all mining industry stakeholders.

A destination where BC is regarded as a world leader in sustainable mining.

Our origin: BC's Mining Jobs Task Force

A strong, sustainable, innovative economy that creates good-paying jobs in every corner of the province cannot be achieved without a healthy and growing mining sector, stated BC's MJTF Report. The MJTF was comprised of a diverse mix of participants from the mining sector, government, Indigenous communities, academia and labour.

One of the key recommendations of the MJTF's final report, submitted to the provincial government December 2018, recommended the development of a forward-looking BC Mining Innovation Roadmap focused on global competitiveness, industry trends and providing continued benefits to all British Columbians. The government's 2020 budget reinforced the commitment to implementing the MJTF's recommendations as well as the overall goal to strengthen the competitiveness of the mining sector.

The Innovation Roadmap outlines a path forward to increase the competitiveness, sustainability, and resilience of the BC mining ecosystem through innovation. The Innovation Roadmap is to be a guiding document for BC industry and policy makers.

Defining innovation

After consultation with participants in the development of the BC Innovation Roadmap, we defined innovation as the implementation of new and feasible offerings to create sustainable value for the mining ecosystem. Our focus was on developing new technologies and approaches that will minimize the environmental impacts of operations and enhance operational competitiveness.

In alignment with the MJTF, we took a broad view of the scope of innovation. MJTF's report stated the breadth of issues that innovation touches on reflects the interconnected nature of mining and the need for coordinated investment by all stakeholders to develop the innovative tools and technologies necessary to create a cleaner and more competitive sector. Government must invest in supporting regulatory agility to enable innovative technologies and tools, training strategies must anticipate the rapid pace of technological change and industry and academia must work to develop new technology to enhance productivity and develop new deposits.

The scope of the Innovation Roadmap spans the entire mining continuum from exploration to reclamation. This includes how innovation can increase exploration activities, bring new mines to operation, extending the life of existing mines, create long-term economic growth in Indigenous and local communities, increase the involvement of tech and clean-tech sectors, and generate new export opportunities. Innovation can also: provide new ways to improve environmental performance including GHG emission intensity, water consumption, waste and tailings management; build relationships and generate value with Indigenous and non-Indigenous communities; and ready our workforce for substantive changes to come.

Collaboration and consultation

As directed by the MJTF, the Innovation Roadmap was developed through an extensive multi-stakeholder engagement process under the guidance of a highly experienced advisory committee. Consultation involved more than 280 participants spanning the entire mining ecosystem and more than a dozen engagement events (full details of the consultation process and committee are available in Appendix B). The Innovation Roadmap answers the following questions:

- How can government and industry foster a strong and sustainable BC mining innovation ecosystem leveraging BC's innovation strengths?
- How can the regulatory framework effectively incorporate innovative technology and process adoption while upholding health and safety and environmental standards for new and operating mines?
- How do we bring value to Indigenous and local communities and what does a talented workforce look like in the future mine?

The Roadmap is strongly aligned with the MJTF Report actions. Further, there are other provincial and national initiatives relevant to the Innovation Roadmap and, whenever applicable, knowledge was shared. They include the CleanBC Plan,[1] Emerging Economy Task Force Report,[2] the province's regulatory excellence initiative, the Canadian Metals and Minerals Plan,[3] and others.

1 Government of BC. "CleanBC Plan" (2019). https://blog.gov.bc.ca/app/uploads/sites/436/2019/02/CleanBC_Full_Report_Updated_Mar2019.pdf

2 Emerging Economy Task Force Report (2020). https://www2.gov.bc.ca/assets/gov/employment-business-and-economic-development/economic-development/emerging-economy-task-force/eetf-final_report-20200511-final.pdf

3 Canadian Metals and Minerals Plan (2020). https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/CMMP/CMMP_The_Plan-EN.pdf

Where we stand today

BC is well positioned to take a stronger leadership role in global mining today, and tomorrow.

Overview

British Columbia is a leading centre of mining excellence, with a global presence that exceeds our relatively small population and geographic footprint. With rich, diverse mineral deposits in every corner of the province, the mining industry has been foundational to the province's economy for almost two centuries, and has the potential to support future generations. However, mining is an international commodity-based sector. Innovation is a requirement to remain competitive in this constantly evolving industry.

There are 14 major operating mines in BC — primarily mining copper, steelmaking coal, silver, zinc, gold, lead and molybdenum — and two smelters. Additionally, mineral exploration activities in the province are robust, establishing a strong pipeline of future potential mines. Today, BC is one of the world's leading suppliers of metals and minerals that are essential for creating the types of products needed to transition to a low carbon economy such as electric vehicles and renewable energy infrastructure, and consumer technologies we rely on every day like iPhones. Our resources are helping to fight back against the COVID-19 pandemic; BC produces 20 per cent of the world's germanium, a key component in thermal scanners. BC's mining companies meet the highest standards of environmental, social and governance performance.

Mining is a provincewide industry. Our steelmaking coal, metal and mineral producers, smelters and advanced development companies support more than 35,000 jobs in the Lower Mainland, Vancouver Island, the Interior, Southeast and Northern BC. We depend on a wide range of talent and disciplines: engineering, trades, high-tech, finance, legal, accounting, chemistry, environmental and more. We support over 3,700 small and medium sized businesses from every corner of the province that supply us with nearly $3 billion worth of goods and services annually.

Our industry alone made more than $1 billion in direct payments to governments last year, helping fund the public services that British Columbians rely on. Our sector is also a leader in advancing

economic reconciliation with BC's Indigenous peoples through numerous agreements and partnerships. Mining is the largest private sector employer of Indigenous peoples in Canada. In BC, we purchased $265 million in goods and services from 120 Indigenous businesses in 2018.

We have built a global reputation as responsible operators through all stages — from exploration, planning and permitting to development, production and reclamation. We meet some of the world's highest regulatory standards that safeguard the environment, health and safety. In BC, our industry is recognized as a leader in health and safety practices because they are deeply ingrained in our culture.

Mining in BC is largely a 'home grown' sector, with most of the major players operating in the province being based in either BC or Canada. This has contributed to building one of the largest concentrations of industry-related professionals in the world,[4] exporting our expertise and services internationally, allowing British Columbians to influence positive change in the industry far beyond our own borders.

Our success relies on continuous innovation, the focus of this roadmap. We need to embrace new technology to ensure our operations waste less, conserve more, increase safety and productivity, and optimize the responsible extraction of our resources.

Mining Innovation Developed in BC

BC's mines have a long history of adopting innovative mining methods and technologies. The province is also home to many companies who are developing new innovations to support more sustainable mining operations domestically and around the world.

LlamaZOO Interactive
Creates 3D communications and digital twinning software solutions with a focus on the future of mining. They've created MineLife VR, a software platform that fuses geospatial and mine planning data into a 1:1 scale virtual reality replica of both the current and future states of a mine site.

Saltworks Technologies
Based in Richmond, Saltworks provides innovative products and solutions for industrial wastewater treatment and desalination. They work with their customers to design solutions to specific treatment requirements, based on the chemistry, regulations and economics.

MineSense
A pioneer in digital mining solutions headquartered in Vancouver, with clients around the world, MineSense improves the profitability and sustainability of mining through its first-of-its-kind ore-waste classification technology.

4 Business in Vancouver. "Capitalizing on the B.C. advantage in mining". 2020. https://biv.com/article/2020/01/capitalizing-bc-advantage-mining

> “I’m most proud of the fact we’re pioneering a new way to communicate complex mining data that facilitates meaningful consultation and engagement with communities.”
>
> – **Eric May**
> Technical Artist, LlamaZOO

Our ecosystem

Innovation thrives with collaboration, which is an output of a strong and inter-connected ecosystem. In the context of the BC Mining Innovation Roadmap, the ecosystem includes all the organizations that have a role in the development and implementation of innovation in BC's mining sector.

BC's mining ecosystem consists of many stakeholders with unique functions, capabilities and strengths to develop, implement and benefit from innovation. We have grouped these stakeholders into six categories (see Figure 1 and Appendix A for more information about the functions of each):

- Mining and exploration
- Mining equipment, technology and services
- Funding and support
- Education, early stage research and development
- Later stage research and development, commercialization
- Government, communities, Indigenous communities, customers and supply chain

British Columbia has all the players in place to build a mining innovation ecosystem: a world-class cluster of mining and exploration companies, a strong equipment and service sector, strong research and training post-secondary institutions, well-funded and growing tech and clean tech sectors, supportive communities, reliable markets for our products, and more.

The industry players are either located within BC or contribute to the province's mining sector. Between them there can be a flow of capital and exchange of ideas. But they need to communicate with one another in order to understand the challenges that exist to develop the solutions needed for the next evolution of smart mining.

While there are existing relationships between clusters within BC's ecosystem, there is tremendous opportunity to strengthen these connections. Mining and exploration companies are central to the BC mining ecosystem, and likely have existing connections to other members of BC's mining ecosystem, but many of the other participants have room to increase their engagements across different groups of BC's mining sector, which will substantially enhance the development and implementation of innovation in our industry.

Facilitating meaningful and productive interconnectivity between these groups will be one of the roles of the proposed Mining Innovation Hub. This intermediary role could become even more important due to the increased uncertainty created by the COVID-19 pandemic, and the unknown effects it will have on our ability to develop new relationships at conferences and other traditional networking events.

FIGURE 1:

Mining Equipment, Technology & Services

+ Develop, market, and sell technology innovations
+ Develop and provide new services
+ Develop new market
+ Innovator in business models

Mining & Exploration

+ Generate economic growth and resource production
+ Investor and customer of innovation
+ Innovator in business modes, process optimization, and productivity

Funding & Support

+ Provide capital, resources and knowledge
+ Incubate and accelerate technology innovation
+ Convener of collaboration
+ Enabler of technology development, commercialization and validation

Education, R&D (TRL <5), & Other Research

+ Train qualified personnel
+ Research and development of early stage and higher risk research, skills training, and advocacy
+ Produce new technical, process, or social knowledge
+ Receiver and provider of funding

Communities, Indigenous Nations, Customers & Supply Chain

+ External stakeholders driving new mineral demand, environmental, social, and governance, and the production of responsible minerals
+ Mineral products customers
+ Supply chain companies
+ Downstream companies or customers

R&D (TRL 6+) & Commercialization

+ Research and development of mature technological innovations
+ Scale up, demonstration, technology validation
+ Innovator in business models
+ Receiver of funding

Strengths of BC's Mining Ecosystem

During the consultation process to develop the Innovation Roadmap, workshop participants developed a comprehensive SWOT analysis (strengths, weaknesses, opportunities, threats) of BC's mining ecosystem, available in Appendix D.

The SWOT was used to inform the Innovation Roadmap's goals, desired outcomes and actions. The participants established a realistic snapshot of where the industry stands today, in order to best inform how future innovation should shape mining in BC moving forward. The focus was to build on strengths and address weaknesses as needed to maximize opportunities and minimize threats.

Mining stakeholders identified British Columbia as a tier one mining jurisdiction that possesses rich and diverse minerals and metals deposits. The province is host to many mining sector head offices and suppliers, and thousands of contractors and service providers. BC has consistently had a strong economy over the last 20 years (including generally performing well in global downturns compared to other jurisdictions), and offers a politically stable operating environment.

British Columbia has a great opportunity to strengthen its mining industry with prudent investments and forward-thinking public policy decisions. The province has world-class research universities and research institutes, a strong technology sector and established clean tech sector. These entities have the expertise and creativity to invent and adapt made-in-BC technologies and processes.

Infrastructure has been built to support natural resource development, and the need to get goods to market. British Columbia serves as North America's premier Asia Pacific gateway, with the ports, rail and road connections needed to efficiently transport products anywhere on the continent and Asia.

Strengths and opportunities indicate that BC is well-positioned, but action from all stakeholders in the mining ecosystem is needed to capture this potential. In a global industry where projects are competing for investment dollars and customers, BC needs to deliver on its innovation roadmap in order to be competitive and generate the jobs and economic benefits that support strong and growing communities.

Our landscape

Mining has a small footprint but a large economic impact in BC. As we pursue operational excellence, we must be aware of who we benefit and how we are governed.

Building Sectoral Collaboration

BC's collection of mining companies, start-ups, clean tech and technology businesses and academia is an excellent base for a regional mining innovation centre.

Innovation is a constant presence in British Columbia's mining industry. This is a function of necessity. In order to compete with jurisdictions who do not have Canada's high environmental and labour standards, mines in BC must find creative and economic ways to safely and sustainably operate to be competitive. The Innovation Roadmap's goal is to promote ongoing and increased innovation to ensure BC continues to have a robust industry.

Over the last 20 years, there has been considerable growth in British Columbia's technology and clean technology sectors. There has also been an increase in the number of universities in the province during this time. BC has continued to be a global mining centre, bringing together locally-developed expertise with leaders from around the world who have invested in British Columbia because of our strong resource base.

Historically, these groups may not have been natural allies or partners. But this is changing, particularly as the general public's expectations for low-impact natural resource operations increase. Some business relationships have been forged between these groups, where there has been a clear need or benefit for all sides. However, to date there has not been a strong organic growth of connectivity between all participants in the prospective mining ecosystem.

OPPORTUNITY AHEAD

Building bridges between mining stakeholder groups will result in better mines, and new opportunities in mining for non-traditional partner organizations.

It takes time to develop new relationships, especially where the business benefit may not be immediately recognizable. This may often be the case when it comes to innovation for mines. Not all innovative solutions implemented at a mine were originally intended for that use. For example, the invention of autonomous and remote-controlled vehicles was not mining-specific technology. But over time it has been adapted to the industry, and now there are autonomous vehicles operating in mines, including here in BC. Similarly, Bluetooth technology has been implemented in many mines to improve worker tracking and safety.

A new technology doesn't have to be designed for mining to be applied to the industry. But miners need to know about the potential of a new innovation to successfully use it on site. Events such as the annual Prospectors & Developers Association of Canada Convention and Association for Mineral Exploration's annual Round-Up help, but conferences alone are not enough. Furthermore, we do not know what long-term impact the COVID-19 pandemic will have on large conventions and business travel.

British Columbia would benefit from a coordinating body that is tasked with, among other responsibilities, bringing together companies, communities, researchers or stakeholders who not only are actively doing business in mining, but have the potential to contribute to mining.

Regulatory Framework

Regulatory systems that are strong, agile, transparent and predictable provide a competitive advantage.[5]

Mining, like any industry working on the land base in British Columbia, is subject to a rigorous and extensive regulatory framework. We meet some of the world's highest regulatory standards that safeguard the environment, health and safety, and align with community values.

However, the regulatory framework can impede rather than incent improvements in responsible mining and competitiveness. For example, issues with lengthy permitting timelines for all mine phases are frequently named as an impediment to investment in, and adoption of, innovation in mining.

BC has recognized the need to improve permitting certainty broadly and has engaged in regulatory review processes, including the revitalization of the Environmental Assessment (EA) process.

5 Natural Resources Canada. 2019. "Canadian Minerals and Metals Plan." https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/CMMP/CMMP_The_Plan-EN.pdf

“To me, mining is an industry that values sustainable practices and safe extraction of minerals for global demands. I am most proud of the environmental and social best practices that we bring to the local communities and the high standard we hold ourselves to as an industry.”

– **Angela Johnson**
Exploration Manager,
Calibre Mining Inc.

The government has also established a regulatory excellence initiative to improve efficiency and focus on more agile permitting and reconciliation initiatives within the mining sector.

Our roadmap is focused on the intersection of innovation and regulation. There is a strong opportunity to increase the adoption of new technologies or processes that improve operations by making the existing regulatory framework, where applicable, more agile and responsive.

While the number and type of authorizations required varies from mining project to mining project,[6] the three primary provincial authorizations are:

1. **BC Environmental Assessment Act and associated Reviewable Projects Regulation**

+ Mechanism for reviewing proposed major projects, including major mining projects, to assess their potential environmental, health, social, cultural and economic impacts.

2. **BC Mines Act and associated Regulations and Health Safety and Reclamation Code**

+ Includes all stages of mining from exploration to on-site activities, such as the management of water quality, waste facilities for tailings/rock and metal leaching and acid rock drainage, as well as geotechnical design and reclamation and closure planning.
+ The Chief Permitting Officer is the statutory decision maker for Mines Act permits.

3. **BC Environmental Management Act[7] and associated Waste Discharge Regulation**

+ Includes waste discharge permitting (effluent, emissions, sewage, refuse), hazardous waste and contaminated site remediation.

OPPORTUNITY AHEAD

There is the opportunity to create a dedicated process for adopting a risk-based regulatory regime.

BC's regulatory regime exists to protect the environment, and worker health and safety. However, the current regulations unintentionally discourage innovation due to a strong emphasis towards minimizing or eliminating all risk. Innovations that deviate from approved prescriptive processes are reviewed on a case-by-case basis, with no formal process in place to appropriately evaluate the risks or benefits associated with adopting new technologies or techniques.

6 BC Ministry of Energy, Mines and Petroleum Resources, Ministry of Environment and Climate Change Strategy and Environmental Assessment Office provide a comprehensive list of major mine oversight on a joint website https://mines.nrs.gov.bc.ca/. Further guidance for BC mine projects also available at: https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/permitting

7 BC Ministry of Energy, Mines and Petroleum Resources, Ministry of Environment and Climate Change Strategy and Environmental Assessment Office provide a comprehensive list of major mine oversight on a joint website https://mines.nrs.gov.bc.ca/. Further guidance for BC mine projects also available at: https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/permitting

This lack of structure means that permitting innovations can be lengthy and onerous, even when applied to low-risk or no-risk situations. The natural inertia against approving innovative solutions impacts a proponent's approach towards permitting. In order to secure financing, new mines typically take the most reliable path to obtain necessary permits, relying on proven technologies to increase certainty. A proponent may avoid innovation in their application to reduce probability of a lengthy and uncertain permitting process. Operating mines may also avoid innovation to not trigger a requirement for a permit amendment, knowing the same regulatory process is applied regardless of the level of risk.

Although the processes to obtain the necessary authorizations vary, they follow a similar path:

- Pre-application stage where the project is defined;
- Screening phase to ensure application completeness;
- Review stage where the application undergoes technical review; and
- Decision of permit issuance.

Supporting Indigenous and Local Communities

Innovation is critical to strengthening our competitive advantage and global reputation as responsible operators so that we can continue to benefit British Columbians.

The sector employs over 35,000 workers directly and indirectly and is the largest industrial employer of Indigenous peoples.[8] For example, at Pretivm's Brucejack mine and Newcrest's Red Chris mine, the workforce is over 29% Indigenous.

> *"The Tahltan Nation had 98% unemployment in the winter and 65% in the summer. And we took it to zero." – Jerry Asp, Tahltan elder, on the impact of mining (Business in Vancouver).*[9]

Of note, approximately 400 Tahltan people are employed in the mining sector; 300 in operating mines like Red Chris and 100 in exploration, creating $30 million in annual wages to the nation.[10] The BC mining sector is also a major partner to Indigenous businesses, purchasing $265 million in goods and services from 120 Indigenous-affiliated suppliers.[11]

8 Mining Association of BC. https://www.mining.bc.ca/indigenous-relations. Accessed May 2020

9 Business in Vancouver. 2020. "https://biv.com/article/2020/01/economic-success-stories-bust-myths-about-mining-and-first-nations-bc"

10 Business in Vancouver. 2020. "https://biv.com/article/2020/01/economic-success-stories-bust-myths-about-mining-and-first-nations-bc"

11 Mining Association of BC (MABC). 2019. "One Province One Economy: Benefits of British Columbia's Mining Supply Chain." https://www.mining.bc.ca/sites/default/files/OPOE%20UBCM%20Report%20Small%20File%20Size.pdf

Widely recognized for industry-leading practices, BC mining companies have signed numerous innovative Impact Benefit Agreements. Many Indigenous nations also receive mineral tax revenue from mines operating within their traditional territories — a policy that BC has led the way on. Since 2008, the Province has implemented Economic and Community Development Agreements (ECDA) with 48 First Nations at 24 major mines in BC. BC is the first province to share revenues, through 35 ECDAs, with almost $100M shared to date.[12]

In 2019, after passing unanimously in the provincial legislature, the *Declaration on the Rights of Indigenous Peoples Act (DRIPA)* came into force making BC the first province in Canada to implement the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). BC is now working to bring relevant provincial laws into harmony with DRIPA, which will ultimately be reflected in the manner that resource projects are defined, approved and implemented. BC mining companies have expressed cautious optimism that, with proper implementation, the adoption of UNDRIP principles could enable greater certainty and predictability on the land base.

OPPORTUNITY AHEAD

We can increase the number of Indigenous people in our workforce.

While their employment numbers in mining are significant, Indigenous people are underrepresented in our industry. Approximately 25% of our workforce is going to retire in the next five to 10 years. Following the Mining Jobs Task Force, the province contracted a study, which is currently being developed, to examine past Indigenous mine training programs and make recommendations for potential future programs. DRIPA also provides an opportunity to advance meaningful reconciliation, enable greater certainty on the land and advance economic reconciliation that can be mutually beneficial. Trusted relationships and shared values are key principles of the Mining Innovation Roadmap.

There is also support to identify new technologies or processes that can further strengthen sustainable and safe mining operations. The expectations of Indigenous communities and stakeholders are higher than ever before. Industry must demonstrate it is embracing and creating technological advances to maintain trust and support with Indigenous and local communities.

12 BC Government. "Declaration on the Rights of Indigenous Peoples Act Fact Sheet." https://news.gov.bc.ca/files/BC_Declaration_Act-Fact-sheet-Mining.pdf

Workforce

We must support the development of mining's next workforce and re-train existing workers.

Availability of skilled and experienced workers plays a key role in the ability of the mining industry to operate. Compared to other industries, mining is a significantly more physical labour-intensive industry. The Canadian mining sector employs almost twice as many individuals for predictable labour work compared to other industries and nearly 50% of the work done is physical work, according to a Conference Board of Canada report.[13]

However, new technologies such as automation, artificial intelligence and Internet of Things will substantially re-shape the industry's labour needs over time. The Conference Board report assessed the implications of technology on the workforce of the future. The forecasted scenario indicates that more jobs will be at risk in the resource extraction sector with digital disruption. The report suggests there are greater impacts for Indigenous workers and for men, who typically fill a higher percentage of physical jobs. While there will likely be a net job loss, new jobs and job functions will also be created.

A recent Canadian Mining Labour Market 10-Year Outlook[14] summarized the current labour landscape, trends in the mining workforce, and the training and educational level of various workforce groups. Downstream manufacturing or indirect employment was excluded from the review. Key highlights include:

- Women, immigrants and visible minorities are minority workforce participants and are highly educated;
- The sector is not as attractive to youth as other industries;
- Relatively high Indigenous participation in mining is encouraging and there are opportunities to increase training and education.

Addressing vulnerable occupations

Mining innovations most used in Canada are data and analytics, automation and electric and battery-operated vehicles, according to "The Changing Nature of Work: Innovation, Automation and Canada's Mining Workforce."[15]

The 2020 Mining Industry Human Resources Council report used an Occupational Vulnerability Index

13 The Conference Board of Canada. 2020 "Implications of Disruptive Technologies for the Natural Resources Workforce."

14 Mining Industry Human Resources Council (MiHR). 2019. "Canadian Mining Labour Market Outlook." https://www.mihr.ca/pdf/publications/WEB_MiHR_Labour_Market_Outlook_2019.pdf

15 Mining Industry Human Resources Council (MiHR). 2020. " The Changing Nature of Work: Innovation, Automation and Canada's Mining Workforce." https://mihr.ca/wp-content/uploads/2020/05/MIHR_Innovation_Report_EN_WEB.pdf

tool to assess workers who will be at risk of disruption based on 10 skills and 120 mining-related occupations. Key index findings include:

- The greater part of the mining workforce is employed in occupations with higher vulnerability to new technologies.
- The top five most vulnerable occupations are in Production Occupations. The most vulnerable occupation in this occupational category is Underground Production and Development Miners.
- Not having vocational training or post-secondary education significantly contributes to occupational vulnerability.
- Indigenous workers are especially vulnerable in several production occupations (underground production and development miners, heavy equipment operators and mine labourers).
- A large percentage of women in mining are employed in vulnerable occupations, namely administration positions.

Representation and Education Level of Workforce Groups

Workforce group	National Representation	Education Level
Indigenous	7% - highest representation in all sectors	~50% with high school or no certificates/diploma ~25% with apprenticeship or trades certificate and diploma
Youth	8% - lower end of all sectors	
Women	15% - lower end of all sectors	>60% women with college or university degrees ~35% men with college or university degrees
Immigrants	13% - lowest in all sectors	50% with university degrees
Visible minorities	9% - lowest in all sectors	60% with university degrees

Source: *Mining Industry Human Resources Council (MiHR). 2020. "The Changing Nature of Work: Innovation, Automation and Canada's Mining Workforce."*

OPPORTUNITY AHEAD

Government and industry need to work together to position mining as a desirable sector to work in with young British Columbians and to provide reskilling/upskilling opportunities for current employees.

Education and training are two important aspects to inject qualified personnel into the mining sector. In BC, there is a strong network of organizations, colleges and universities to develop skilled or highly educated workers for the mining sector. Additionally, some mining companies have internal training programs to help retrain or upskill current workforce to meet their demands. The infrastructure is in place to support the development of mining's next workforce and re-train existing workers whose roles may be impacted by technology. Collaborative work between government, industry and

“I am proud to be an Indigenous woman in mining, allowing me to influence positive change, shifts in process and ensuring mutual beneficial relationships are developed between industry and communities.”

– Christy Smith
Vice President, Indigenous and Stakeholder Engagement, Falkirk Environmental Consultants.

post-secondary institutions is already in progress and must continue. The Innovation Roadmap is aligned with three key recommendations from the Mining Jobs Task Force, and seeks to integrate them into the Roadmap's recommendations:

- Develop and implement an action plan to attract and retain women in mining careers;
- Introduce an integrated Indigenous Mine Training Program; and
- Create a cohesive roadmap for enhanced mining sector training to meet the mining sector's future skills and labour needs through a collaborative, inclusive, innovative and geographically focused approach.

NATIONAL CONTEXT

Canadian Minerals and Metals Plan

Canada is a mining leader. However, to remain at the forefront requires continual improvement.

The Canadian Minerals and Metals Plan (CMMP), released March 2020, provides a vision to drive industry competitiveness and long-term success. The BC Mining Innovation Roadmap is aligned with CMMP's six strategic directions of:

- Economic development and competitiveness
- Advancing the participation of Indigenous Peoples
- The environment
- Science, technology and innovation
- Communities
- Global leadership

Key principles underpinning CMMP include responsible mineral development integrating the concept of sustainability — human, social, economic, and environmental; and leveraging science, engineering and innovation to advance the competitiveness of the minerals sector and foster responsible industry practices.

Canada must take advantage of generational opportunities and improve its competitive position. The world's economy is increasingly digital and reliant upon clean technologies, and Canada is well-positioned to capitalize on these macro-economic trends.

Increased collaboration is key to improving Canada's competitive position. There is an opportunity for government, industry, Indigenous Peoples and stakeholders to work more closely together to build on our strengths, capitalize on opportunities and support a minerals industry that drives Canadian prosperity.

Where the global mining sector is moving to

Globally, the mining sector has faced market volatility and responded with a new normal where improved margins and operational excellence are business imperatives.

A World Economic Forum report has mapped several overarching trends that are influencing the mining and metals sector, key among them is the transition to a low-carbon economy. Demand for most minerals is projected to be high in order to achieve the clean energy transition, according to the report. Given that low-emission energy and transportation systems are more mineral-intensive than their fossil fuel-based counterparts,[16] the transition provides a great opportunity for the mining sector. At the same time, the mining sector will have to reduce its own emissions. Mining companies that power their operations with renewable energy, operate clean energy truck fleets and integrate recycling in their value chains will be best placed to sell low-carbon premium minerals, concludes the report.

Additional industry-specific challenges include access to world-class resources, geo-political risks, government regulation and environmental, social, and governance performance.

Overview: Trends & Opportunities

Decarbonization, sustainable mining practices, and supplying the low carbon future

Mining companies are actively addressing energy use and carbon emissions. In addition, environmental, social and governance (ESG) performance pressures are intensifying, a key theme underlined in PWC's 2019 annual report on BC's mining industry. BC's mining sector is well positioned

16 World Bank. "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition". 2020. http://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf

to capitalize on its sustainable mining practices and potential to supply the world's critical minerals in the low carbon future. At the same time, BC will continue advancing its industry decarbonization path. BC's mining operations are among the lowest GHG emission-intensive in the world. Increasing the market share of BC metals and minerals will decrease global GHG emissions. However, continuously increasing the price on carbon poses a competitiveness challenge to BC's mines and smelters that could lead to carbon leakage when our major competitors do not price carbon.

Innovation can be fostered through an agile regulatory regime.

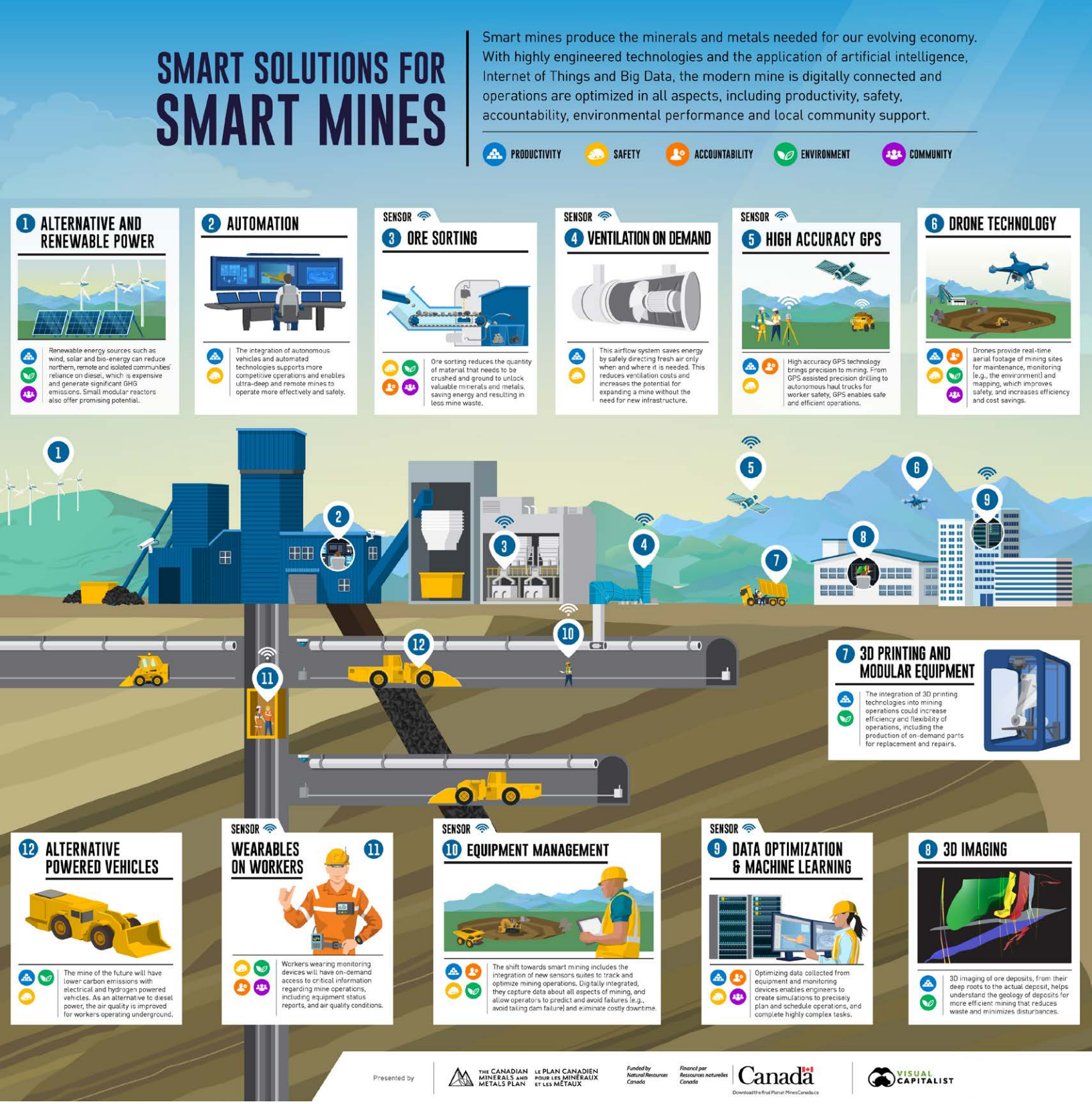
Unlocking geological potential, providing competitive advantage and attracting investment hinges on regulatory certainty. As mining jurisdictions around the world compete for the same capital, the intersection between innovation and permitting presents an opportunity for BC to distinguish itself. It is recognized the overly complex regulatory system currently in place is hampering the ability of BC's mines to compete and succeed in global markets. An Ernst & Young LLP report provided to the MJTF[17] concluded the government's primary levers to improve mining sector competitiveness are fiscal policy and an agile regulatory framework. This challenge is the focus of a number of forums including the revitalization of the Environmental Assessment process and the province's regulatory excellence initiative.

Rapid digital transformation is paving the way towards intelligent mining

BC must keep up with the pace of change in order to ensure its mines are able to quickly adopt new innovations and remain competitive. Digital technologies can enhance safety, productivity, sustainability, and fundamentally shift the way mining works. High-speed internet and communications infrastructure have become standard even in remote operations and underground mines. Coupled with increasingly affordable sensors, this means more data is collected and available, giving miners the ability to analyze and make decisions in real time like never before.

Mining companies that embraced the digital transformation early have outperformed their peers. However, more than just a technological revolution, the digital transformation is heavily affected by people and culture. The intelligent mines of the near future will incorporate and integrate technological advances such as automation, autonomous technologies, robotics, big data analytics and artificial intelligence. These changes will make our mines more efficient and lower-impact than before, and will also change the skills required to operate a mine.

17 EY. 2018. *"BC's Mining and Exploration Industry – an assessment of performance, impact, and competitiveness".*



These trends will lead to the mine of the future, which will incorporate automation, robotics, big data analytics, artificial intelligence and other emerging technologies to reduce mining's environmental footprint and achieve carbon neutrality.

CREDIT:

The Canadian Minerals and Metals Plan Secretariat - Natural Resources Canada / Visual Capitalist

(https://www.visualcapitalist.com/potential-smart-mining/)

Preparations for a workforce of the future

It is necessary to foster local talent near mine sites and support workers in urban areas. Digital and technological innovations will require different skillsets and the competition for such a workforce from other industries will be high. There is a need to both upskill the current workforce and set a path to attract new workers that better reflect the diversity of BC. The ability to attract local and highly skilled workers can be a competitive advantage. At the same time, some jobs that do not require the worker to be present at the mine site will provide the flexibility for digital workers to remain in urban centres.

Taking community relationships to the next level

Technological innovation is only one aspect of mining innovation. The movement towards shared community values and pressure to create real and long-term benefits for Indigenous and local communities is intensifying around the world. BC's mining sector is leading the advancement of economic reconciliation with the province's Indigenous communities. Technology and innovation can enable more effective engagement with Indigenous and local communities. As COVID-19 has demonstrated, technology is a critical tool to communication, consultation and engagement.

Responsible minerals and metals

There is growing awareness and demand around the world for environmentally and socially responsible metals and minerals and the products they create. However, most consumer and industrial product manufacturers do not buy directly from mines or smelters. Consequently, consumer-facing companies and manufacturers are looking at a variety of global certification programs to verify and assure their customers the metals and minerals used in their products have been produced according to high ESG performance standards. Third-party certification has been in use for some time across a number of industries to verify social and environmental outcomes, including BC's forestry sector. The BC mining sector's high environmental standards, low-carbon footprint and ongoing commitment to advance economic reconciliation with our province's Indigenous communities provides a significant opportunity to position our industry and province as a supplier of choice.

The path forward

We need to create a home for mining innovation.

The creation of a BC Mining Innovation Hub is a priority action item of the Innovation Roadmap. The Hub — in partnership with industry, the federal and provincial governments and academia — would accelerate innovations and enhance competitiveness across a range of areas including water management, clean tech, emissions reduction and environmental protection. The Hub would provide the key functions of coordination, communication and knowledge sharing to implement and achieve our innovation goals. It would also support capitalization, provide funding support for research, development and commercialization of solutions to key challenges in BC mining with a focus on environmental issues such as long-term water treatment and emission reduction with the goal of producing technologies that can be exported globally.

BC already has strong building blocks in the innovation ecosystem. However, the connections between groups must be further supported and developed. Throughout the process of creating the Roadmap, participants resoundingly supported the creation of the Hub as the cornerstone to build and strengthen connections between stakeholder groups and Indigenous communities.

The Hub would provide three core functions to accelerate innovation from ideas to adoption:

1. Coordination: Identifying challenges requiring innovative solutions and connecting solution providers, facilitating and providing funding support as appropriate, providing opportunities to test, fail and succeed.
2. Communication and promotion: Identifying and promoting BC's strengths, both within the ecosystem and externally to communities, customers and the supply chain.
3. Knowledge sharing: Maintaining and building relationships with Indigenous communities and stakeholder groups, building capacity and knowledge by sharing lessons as innovations mature.

Establishing and maintaining the Hub will help to achieve the following:

- Increased investment directed toward innovation that will solve mining's toughest challenges.
- Accelerated connections between stakeholders and Indigenous communities to establish a thriving innovation ecosystem that brings together industry, academia, technology/clean technology companies, government and others in the industry supply chain to improve collaboration.
- Facilitate initiatives that achieve the four BC Mining Innovation Roadmap goals.

INDUSTRY ANALOG

Swedish Mining Innovation

Swedish Mining Innovation (SMI) is an organization created to improve the competitiveness of Swedish mining through collaboration on research, innovation and education.

SMI is led by a board comprised of mining companies, technology producers, universities and research institutes, with day-to-day activities managed by a central program office at Luleå University of Technology. The office coordinates four types of activities in support of Swedish mining, including:

- Outreach, communication and internationalization
- Innovation projects
- Meetings and workshops
- Education

SMI manages the intake of regular calls for innovation project proposals, which can include pre-studies, full-scale projects and pilot projects. Proposals undergo a thorough review process by an external assessment team, with final decisions being determined by Vinnova, Sweden's government agency responsible for administering state funding for research and development.

SMI lists 76 projects as completed or underway, covering a diverse range of innovations from the utilization of drones for surface water flow monitoring to the use of virtual reality technology to demonstrate working in a state-of-the-art mine to youth.

Four goals. 18 action items.

The Innovation Roadmap features clear guideposts: goals, desired outcomes, actions and evaluation metrics. It also provides a path for implementation and a method for tracking progress. Strengthening the BC mining industry's ability to embrace innovation will take time and collaborative effort. While actions are primarily identified for the provincial government and MABC, the entire mining ecosystem needs to be involved to realize success.

Our four goals and 18 action items are underpinned by two central components: the creation of a BC Mining Innovation Hub and the principle of Trusted Relationships and Shared Values.

Our four goals:

1. Foster an innovative and collaborative culture
2. Improve regulation to support innovation
3. Leverage BC's ESG advantage
4. Build the workforce for the future mine

Trusted Relationships and Shared Values

Communities and the general public have more of a role in the development and operations of resource industries than ever before. Whether it is through the extensive consultations embedded in the environmental assessment process, or the ability of organizations to shape opinion and influence public policy, industries are being shaped in part by the stakeholders around them.

The concept of being a 'good corporate neighbour' is not a new idea. For generations, major employers (whether it be in mining, forestry, manufacturing, etc) have sponsored local events, youth sports and other community causes. But creating jobs and making donations is no longer enough; expectations have changed. In order to have 'social licence' to operate, communities demand that companies are demonstrate environmental, social and corporate governance principles — such as being mindful of their environmental impact, supporting local businesses, honesty and tranparency, and much more.

Continuing to build trusted relationships and shared values within the mining ecosystem is integral to the Roadmap and is a necessary outcome of each of the four Roadmap goals. With both Indigenous and non-Indigenous communities (including labour representatives where applicable), the mining industry works in partnership with local organizations, supporting economic development and training.

The Roadmap supports and is aligned with the government's plan to implement the principles of the *Declaration on the Rights of Indigenous Peoples Act* throughout government and in relevant legislation. Mining companies have long been a leader in BC in supporting economic reconciliation with Indigenous peoples, and will continue to build mutually beneficially relationships. Innovation in mining will support many of the government's objectives in CleanBC, specifically by adopting policies and technologies that minimize the environmental and climate impact of our mines.

Goal 1: Foster an innovative and collaborative culture

Regulators wishing to maintain existing safety and environmental health standards can be resistant to new technologies and practices. Industry and investors wishing to minimize the risk of delays in regulatory processes and potential cost increases are also wary. In addition, new or emerging technologies face barriers to being demonstrated at operating sites. A cultural shift to embrace new technologies, processes and services is needed to further strengthen efficiency and safety and reduce environmental impact.

BC has both a globally recognized mining industry and an emerging technology sector. There are few BC tech and clean tech companies specializing in mining and the sectors have only recently begun to collaborate. A carefully planned strategy, including support from the provincial government, can assist to bring these sectors together, enabling them to develop and implement new innovations in mining.

Outcomes

- Establish BC as a leader in mining innovation where investment in collaborating, testing, learning, failing and succeeding in a controlled and supported environment advances solutions from research to commercialization.
- Enhance the viability of innovation at BC mines to improve the future of BC's mining industry
- Continue building relationships and trust with Indigenous and non-Indigenous communities leading to innovative business models, partnerships and relationships that generate shared economic, social and environmental value.

INDUSTRY ANALOG

NORCAT Underground Centre

The NORCAT Underground Centre in Sudbury, Ontario could serve as a template for British Columbia's Innovation Mine. NORCAT functions as both an innovation and training centre, benefitting industry and workers. NORCAT creates a space for start-ups, small and medium enterprises and international companies to come together to develop, showcase and test technologies in an operating environment.

The Underground Centre has become a global destination to see and test emerging technologies while brokering new relationships between technology providers and mining companies.

NORCAT supports approximately 50 mining technology projects annually and hosts nearly 50 mining companies who visit to see mining's next innovations in action. The Underground Centre features three kilometres of underground tunnels (drifts) which offer real-world test conditions for innovations. Examples of success stories include: serving as a site to demonstrate the effectiveness of LTE 4G to support digital smart mining, testing new drilling technologies and helping improve safety through proving the effectiveness of worker and equipment tracking technology in an underground environment.

Action Plan

The following actions support the desired outcomes for Goal 1 to continue building an innovative and collaborative culture across BC's mining innovation ecosystem:

1. The Hub will create a repository to catalogue innovations and provide a standard and independent review of solutions. The repository will include both technologies in use elsewhere and new innovations yet to be commercialized and will require ongoing updates to stay relevant.
2. MABC will launch or participate in initiatives to enhance sectoral connections. This will increase connections between traditional partners in mining and promote increased interactions between miners/suppliers and academia, researchers, tech sector (including the BC Digital Supercluster) and others who can foster innovation.
3. The BC government, in close association with industry and academia, should investigate the establishment of an Innovation Mine. The Mine would provide an environment where innovators can test accelerating the process from concept to commercialization. A steering committee would develop the vision and scope of the Innovation Mine, identify potential sites and review business cases/budgets for similar projects globally. The Innovation Mine would also provide a valuable training and learning space to enhance safety and environmental performance.
4. Formalize an early engagement process for innovative technology that includes innovators (proponents, technology and solution providers, researchers), government, Indigenous Nations and potentially impacted and interested stakeholders (local communities and workers). Led by government, early engagement of all involved parties could ensure that innovation development plans identify all risks — regulatory requirements, technology readiness level, life-cycle considerations, milestones for acceptability and others.
5. The Hub will document, share and celebrate innovation test outcomes, highlighting successes and failures and creating education resources on emerging technologies for regulators, Indigenous people and communities. This will encourage deeper understanding of emerging technologies and their real-world application in BC mines.
6. Create a mining innovation leadership position in government to infuse a culture of embracing innovation within government. The position, potentially reporting directly to the Deputy Minister of Energy, Mines and Petroleum Resources, would support BC's overall innovation in mining agenda and accelerate innovation in mining.

SUMMARY OF ACTIONS:

Innovative and Collaborative Culture

Actions	Lead	Timeframe		
		1-2 YRS	5 YRS	10+ YRS
Prepare tools to benchmark innovations and to screen innovations	Hub / MABC	■		
Launch or participate in initiatives to enhance sectoral connections	Hub / MABC	■	■	
Take steps towards establishing an Innovation Mine	Province & University	■	■	
Formalize an innovative technology early engagement process	EMPR		■	
Document, share and celebrate innovation test outcomes	MABC & Province		■	
Create a mining innovation leadership position in government	Province	■		

Evaluation Metrics

+ Number of Demonstration Mine innovations
+ Conversion of trials to products
+ Number of groups participating
+ Investment in innovation
+ Public impression of mining
+ Sharing of success stories
+ New agreements between mining industry and communities

Goal 2: Improve regulation to support innovation

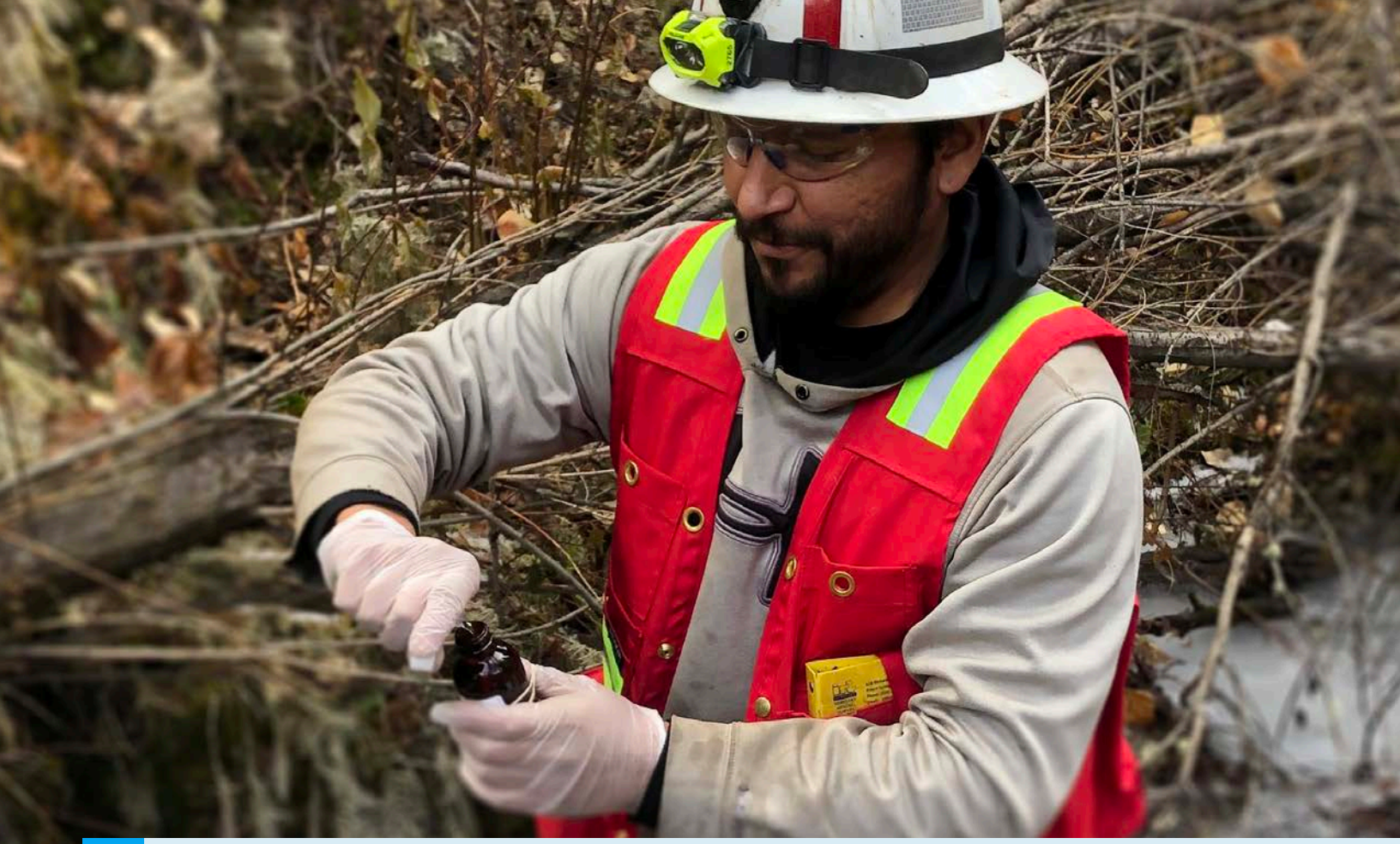
British Columbia's mining regulatory framework is a patchwork of legislation and policies designed to enhance safety, environmental protection and incorporate feedback from communities and stakeholders. Mining proponents have identified that the absence of clear regulatory pathways can impede investment in innovation and stifle attempts to address challenges in innovative ways.

The challenges of BC's complex regulatory system are not limited to the implementation of innovation. To help address these issues, the Premier instructed the Minister of Energy, Mines and Petroleum Resources in his mandate letter to "Work with your colleagues on the Environment and Land Use Committee on regulatory efficiency initiatives, with a near-term emphasis on expedited permit processing and reconciliation initiatives in the mining sector."[18]

Government and industry both recognize that embracing innovation will result in improved mines — more efficiency, enhanced safety and better environmental management. Today, many regulations stand in the way of innovative solutions to mining challenges and reform is needed to fully unlock British Columbia's potential.

There is strong support to adopt a risk-based approach that ensures applications receive an appropriate level of review. This type of regulatory regime would allow government to focus its finite resources on the highest-risk activities while enabling industry to more easily adopt low- or no-risk innovations.

18 Minister of Energy, Mines and Petroleum Resources Mandate Letter, February 11, 2020. Retrieved from https://www2.gov.bc.ca/assets/gov/government/ministries-organizations/premier-cabinet-mlas/minister-letter/ralston-mandate-2020.pdf



INDUSTRY ANALOG

Québec Environmental Quality Act

The Québec Environmental Quality Act (2018) implements a risk-based approach to environmental permitting. A streamlined assessment process ensures government efforts are focused on projects that have significant environmental impacts and provides proponents a clear, predictable and optimized review system. While the new Act aims to provide improved certainty for proponents, it has also been designed to make more information available to the public and to "take into account the new realities of environmental, social, economic, scientific and technological advances … including climate change risks."

Under the new Act, moderate risk activities will have a single ministerial authorization following review, avoiding multiple permit applications and approvals. Low- and negligible-risk activities simply complete a declaration of compliance and, in some cases, are exempt from the permitting process entirely. For example, a declaration of compliance is available for a quarry that does not exceed 10 hectares and meets the conditions set out in regulation. The proponent files a form online and activity can commence in 30 days.

Following the passing of the Act, there were a large number of comments generated by the draft regulations, which has resulted in additional government review and consultation in some cases. The rigorous public process and government analysis by Québec can provide British Columbia with a well-reviewed Act to develop our own risk-based approach.

Outcomes

- Increase the regulatory focus on identifying and achieving outcomes to reduce the emphasis on prescriptive requirements that often inhibit innovation
- Employ an enhanced risk-based approach that enables technologies with higher benefits and lower risks to be accelerated, without eroding transparency for stakeholders
- Further integration of local Indigenous peoples, community and stakeholder values

Actions

The following actions support the transition to an agile and efficient regulatory framework that supports and accelerates innovation adoption, including the implementation of outcomes-based regulation:

1. Government should consult with industry on the development of a code of practice or regulation for relevant emerging technologies to facilitate transitioning a technology from 'innovative' to 'acceptable' for permitting purposes.
2. Establish an industry and government co-led risk-based regulatory framework with a clear mandate to develop a scalable process appropriate to the innovation's risk and technology readiness level. A common understanding of risks is developed in the early engagement process to ensure that traditional Indigenous values, local community values and consultation are not sacrificed with this model
3. Create government-led regulatory sandboxes to allow innovators to conduct trials in a real-world environment with some regulations waived on a temporary trial basis. The trial does not imply regulations would be changed on a permanent basis, but rather could provide evidence to understand whether existing rules and regulations are impeding innovation and should be considered for permanent amendment
4. Shift more regulations to be outcome-based, or/or consider outcome-based permit conditions, rather than prescriptive requirements that emphasize process. Outcomes-based regulations are technology-agnostic which allows for flexibility in the process of compliance and allows for non-standard approaches to encourage innovation (especially for routine, well-understood and low-risk activities). Proceed with an outcomes-based regulation guidance document with criteria for applicability, followed by a government-led discovery process to identify, prioritize and develop an implementation plan.
5. Develop a verification process to ensure compliance with outcome-based regulations. The verification process will move measurement from predictive modelling to the monitoring of the actual results achieved and provide the opportunity for third-party verification or review.

SUMMARY OF ACTIONS:

Regulation Supports				
Actions	**Lead**	**Timeframe**		
		1-2 YRS	**5 YRS**	**10+ YRS**
Consult with industry on the development of code of practice or regulation for relevant emerging technologies	Province	■	■	
Establish an industry and government co-led risk-based regulatory framework	MABC & Province	■		
Develop a regulatory sandbox to test new regulatory approaches	EMPR	■	■	
Shift more regulations to be outcomes-based, rather than prescriptive requirements that emphasize process; and develop an outcomes-based regulation guidance document	EMPR	■	■	
Develop and implement a verification process to ensure compliance with outcome-based regulations	Province		■	
Evaluation Metrics	+ Number of innovations adopted + Training of industry and government on Indigenous culture and values			

Goal 3: Leverage BC's ESG advantage

The world is more focused on the challenge of climate change and environmental management than ever before. Prior to the COVID-19 pandemic, the previous 12 months had been headlined by global demonstrations demanding urgent action by governments to address climate change. There have also been blockades and protests across North America related to social issues and an increase in awareness of the need to have more diversity at senior leadership levels.

Institutional investors are increasingly following responsible investment strategies, placing greater emphasis on a company's environmental, social and governance performance. However, the general public's understanding of the modern mining industry is often dated, and does not reflect the high use of technology in the sector - particularly in advanced mining jurisdictions like British Columbia.

The World Bank Group's recent report "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition"[19] found a low carbon future, as outlined in the Paris Agreement, will require a significant increase in minerals because many clean energy technologies require more materials compared to fossil-fuel power options. According to the report, graphite, lithium and cobalt production will need to be increased by more than 450 percent compared to 2018 levels to meet the demand for energy storage technologies. Steelmaking coal, a significant export for BC, will continue to be critical in a low carbon economy to build wind turbines and transmission infrastructure.

BC is well-positioned to emerge as a leader in providing the sustainable-sourced materials required to support the transition of the global economy. Our province has an abundant and reliable source of clean electricity thanks to historic investments in hydro-electricity infrastructure, is recognized for leadership in implementing forward-thinking climate policy and hosts a growing clean technology sector. Furthermore, BC's mine operators are committed to respectful and strong relationships with Indigenous and non-Indigenous communities, consistent with the principles of UNDRIP.

Due to the BC mining sector's commitment to responsible operations, our mines are already performing well against mines in other jurisdictions. For example, copper and steelmaking coal produced in BC has a significantly lower carbon footprint compared against global benchmarks. But there's still more that can be done, and embracing innovative and new technologies will allow BC's mines to remain competitive — minimizing the risk for carbon leakage should investors decide to back projects elsewhere.

19 http://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf

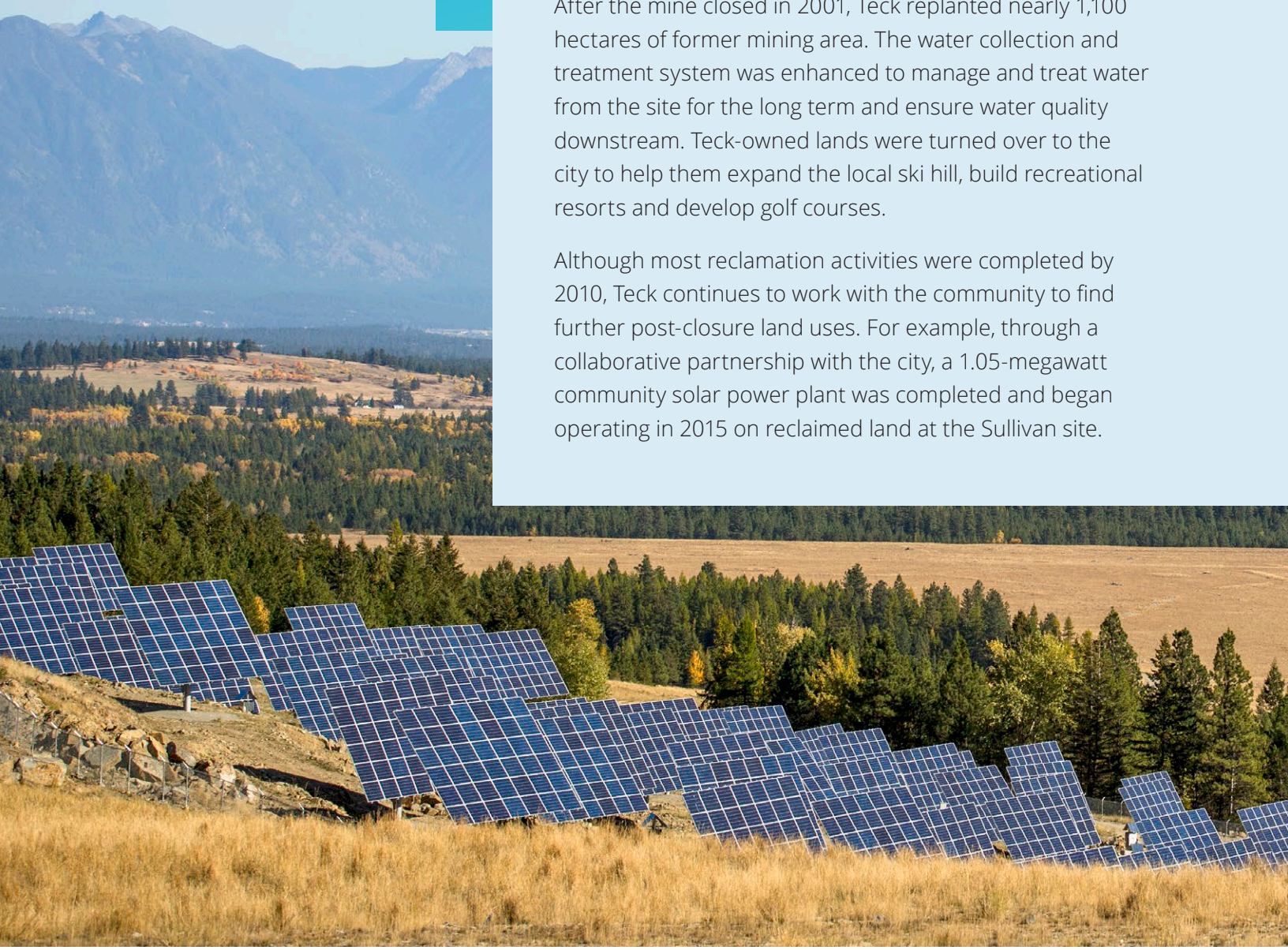
INDUSTRY ANALOG

Reclamation, resorts and ski runs

In BC, lasting community benefits can extend past mine production. With a focus on sustainability, Teck Resources' former Sullivan mine in Kimberley, BC, is a great example of successful mine closure and reclamation.

After the mine closed in 2001, Teck replanted nearly 1,100 hectares of former mining area. The water collection and treatment system was enhanced to manage and treat water from the site for the long term and ensure water quality downstream. Teck-owned lands were turned over to the city to help them expand the local ski hill, build recreational resorts and develop golf courses.

Although most reclamation activities were completed by 2010, Teck continues to work with the community to find further post-closure land uses. For example, through a collaborative partnership with the city, a 1.05-megawatt community solar power plant was completed and began operating in 2015 on reclaimed land at the Sullivan site.



BC is building from a strong base of established research and development collaborations that are already focused on environmental management innovations in mining, including: cleaning and managing tailings, minimizing water use and minimizing waste production. BC's mining industry can make important contributions toward global sustainability through export of knowledge, services, solutions and materials for use in clean and green technologies. By expanding our reach, BC can contribute to the achievement of the UN Sustainable Development Goals while enhancing the mining industry's economic competitiveness.

Outcomes

- BC's mining producers and suppliers are positioned as leaders in climate change and responsible mining – our operations have a lower green-house (GHG) gas intensity than most global competitors.
- The entire mining continuum (from exploration through reclamation) continues its partnership with Indigenous and non-Indigenous communities to be stewards of the land, exploring innovative approaches and technologies to mitigate impacts and increase resilience to a changing climate.

Actions

The following actions will help further BC's leadership in responsible and sustainable mining, including developing and adopting leading technologies, services and processes. Successful innovations could be exported to support sustainable mining globally. Actions include:

1. Taking advantage of BC's thriving clean tech sector and sustainability focused academic institutes, the mining industry will define the challenges for meeting climate and sustainability objectives and conduct a review of existing transferable and/or conceptual technology that could address these challenges.
2. Recognizing BC's GHG emissions reduction target, MABC and government should encourage the industry to report broadly on the sustainability performance of the sector in a streamline manner. MABC and government will evaluate existing industry leading protocols and work with mines to identify existing metrics and reporting activities that respond to environmental, social and governance performance. The industry profile will serve to attract investment and talent, while demonstrating BC's expertise that can be exported to support a global shift toward more sustainable mining.

3. Where Indigenous people and local communities are interested in a more active role in monitoring and stewardship, government and industry will consider the development of new local stewardship programs to actively monitor environmental, social and cultural well-being, and provide a forum to regularly communicate feedback. This builds on existing programs such as the Indigenous Guardians Pilot Program[20] and the BC's Coastal First Nations Land Stewardship program.[21]
4. In keeping with the recommendation of the MJTF, the government will create a market development strategy that profiles the low carbon minerals producers and technology/services developed in BC for export to global markets. These innovative technologies and services will increase BC's presence at leading international forums, leading to exports of these solutions to support sustainable mining around the world. Work from the Innovation Roadmap will also support the Canadian Minerals and Metals Plan.[22]

SUMMARY OF ACTIONS:

Sustainability Leadership				
Actions	**Lead**	**Timeframe**		
		1-2 YRS	**5 YRS**	**10+ YRS**
Define the challenges for meeting climate and sustainability objectives and conduct a review of existing transferable and/or conceptual technology	MABC	■		
Support reporting and communication on sustainability performance of the BC mining sector	MABC & Province	■		
Support development of local stewardship programs and learn from traditional knowledge	Province & MABC		■	
Support the creation of a responsible metals and minerals market development strategy	MABC support		■	■
Evaluation Metrics	+ Energy use + Water use + GHG emissions	+ Piloted technology + Adopted technology + Minerals for low carbon communities		

20 https://www.canada.ca/en/environment-climate-change/services/environmental-funding/indigenous-guardians-pilot-program.html

21 Coastal First Nations. Great Bear Initiative. https://coastalfirstnations.ca/our-land/land-stewardship/

22 Natural Resources Canada. 2019. "Canadian Minerals and Metals Plan." https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/CMMP/CMMP_The_Plan-EN.pdf

Goal 4: Build the workforce of the future mine

The ideal future mine will be more digitally connected, enabling broad use of automation and autonomy, robotics, big data analytics and artificial intelligence. It will also be electrified and have a smaller environmental footprint.

The future is now in BC: many of our mines already have some of these attributes. These features bring benefits to governments, workers and operators, contributing to a safer, healthier and more efficient operation that will open doors for developments that were previously technically and/or economically impractical.

As this evolution in mining occurs, the workforce profile will evolve — shifting away from a heavy reliance on unskilled and physical labour toward a focus on information technology, data analytics and technical expertise. These new skillsets will require higher levels of education and graduates from historically atypical mining degrees, such as social sciences and mathematics.

There will continue to be good local jobs for those with the right skills at a mine site, but some jobs will transition off-site. These changes are already underway in the global mining industry. For the BC mining sector to remain competitive, innovative approaches to building a workforce — attracting new skilled/educated workers, retaining skilled workers and re-skilling existing workers — is vital.

Today, women, new Canadians and visible minorities working in the mining sector have higher levels of education than the general workforce.[23] However, they comprise a lower percentage of workers. The evolving skills needed to operate future mines will create improved opportunities for currently under-represented demographic groups. At the same time, mining will continue to be a major partner to Indigenous businesses.

There is a strong need to position mining as an ascending sector and communicate to the next generation the exciting opportunities available in future mines that are innovative, clean and play a vital role in a more sustainable future for BC.

23 Mining Industry Human Resources Council (MiHR). 2020. "The Changing Nature of Work: Innovation, Automation and Canada's Mining Workforce."

Outcomes

- BC's mining workforce is inclusive, diverse, skilled and has the capacity to support innovation.
- Young British Columbians see the mining industry as an innovative and attractive industry to work in.
- Mines in BC support the development of local capacity, skills and services, which mutually boost and benefit from thriving, resilient local economies.
- There is increased participation of Indigenous people in all aspects of the mining industry, including ownership, skilled mine operations, monitoring and impact mitigation, and the provision of services.
- Mining programs, like the Norman B. Keevil Institute of Mining Engineering, are thriving.

Actions

Developing, educating, training and up-skilling workers for the future mine requires a multi-faceted approach across industry and government ministries. The following actions support the goal of ensuring British Columbia has workers with the skills needed operate tomorrow's mines:

1. Building on Mining Industry Human Resources Council's *The Changing Nature of Work: Innovation, Automation and Canada's Mining Workforce* (May 2020), BC's mining industry will assess the current workforce's vulnerability index in order to develop occupational profiles for jobs in the future mine. This will enable a mapping of gaps in the current labour market in BC, provide the basis for a vulnerability assessment and inform development of a transition plan for the work force.
2. Industry will promote mining innovations, the vision of the future mine and future mining jobs through educational opportunities, youth engagement projects and outreach to academic programs, such as collaborating with the current MineralsEd program for new content development and partnerships with the Norman B. Keevil Institute of Mining Engineering. New learning tools such as virtual reality, augmented reality and mixed reality should also be considered.
3. MABC will support the development of the training roadmap that the provincial government is currently preparing with industry, Indigenous communities and non-Indigenous communities. MABC may canvass members to provide priorities on industry's transition plans. As part of the process, government and mining industry members will engage with Indigenous communities to assess where barriers to participation exist and identify opportunities for mentorship and development.

SUMMARY OF ACTIONS:

Workforce of the Future Mine				
Actions	**Lead**	**Timeframe**		
		1-2 YRS	**5 YRS**	**10+ YRS**
Assess current workforce's vulnerability index and develop occupational profiles for jobs in the future mine	MABC	■		
Promote mining innovations, the vision of the future mine and future mining jobs for youth	MABC	■		
Support the development of a training roadmap that can be customized and executed locally	MABC to support	■	■	
Evaluation Metrics	+ Occupational profiles defined + Training programs delivered + Change in skill levels of workforce + Local participation in mining work force + Indigenous participation in mining work force			

INDUSTRY ANALOG

Norman B. Keevil Institute of Mining Engineering

The Norman B. Keevil Institute of Mining Engineering, at the University of British Columbia, is one of North America's most advanced centres for mining engineering, education and research. The institute offers undergraduate and graduate students opportunities to participate in leading edge research in all aspects of mining, from technical to social and environmental, including:

+ **Canada Research Chair in Mine Water Management and Stewardship:** studying methods for the design of mine water infrastructure to create mining and mineral processing technologies that use less water and reduce risk to surrounding environments.
+ **Canada Research Chair in Advanced Mine Energy Systems:** investigating renewable energy technologies to improve energy efficiency and sustainability in the mining industry. This includes everything from geothermal and waste heat recovery, to the benefits of using renewable such as hydrogen fuel cells and wind power.
+ **Digital Technology Frontiers:** developing and applying new digital technologies in the mineral resources sector, including artificial intelligence, digital twins, automation and robotics, Internet of Things, edge and cloud computing, and 5G technologies.

INDUSTRY ANALOG

Skills toolbox for Mining 4.0

The Québec Mining Association, the Comité sectoriel de main-d'œuvre de l'industrie des mines and the Institut national des mines du Québec released a collection of tools designed to help mining companies and workers transition to "Mining 4.0" — the next digital evolution of the industry.

Described as a change management toolbox, the project pinpointed 11 key jobs that will undergo a major transformation as well as the 23 digital skills widely applicable across these positions. The skills are grouped into six themes that allow easy visualization of the digital shift. Designed to be a step-by-step practical guide to ensure digital transformation is a success, it includes:

+ Job descriptions and current and future skills profiles
+ Skills development plan for each of the targeted positions
+ Human resources management tools
+ Training and skills development plans

Developed with the support of human resources operational teams from Quebec mine sites, these tools could provide a template output for BC's training roadmap.

Next steps

MABC is committed to working collaboratively with government and other partners to take the recommended actions to achieve the goals of the Innovation Roadmap.

Key among these goals is launching the BC Mining Innovation Hub.

MABC has requested funding from the provincial government to fund the planning, launch and capitalization of the Hub. The funds will be used to develop a comprehensive framework, governance structure and budget for the Hub, as well as make initial hires and secure physical space for the Hub (if the initial work determines an independent office location is needed). The goal is to launch the Hub in early 2021 with funding to support activities for five years. Getting the Hub up and running is an urgent priority as it will have a lead or supporting role in the delivery of multiple action items and can assist in the post-pandemic recovery of the provincial economy.

The second key action needing immediate attention from government and industry is to work collaboratively on the establishment of a risk-based regulatory system. This is aligned with the province's regulatory excellence initiative and is a critical step to improve the ability to permit innovations through a process that ensures applications are subject to an appropriate level of regulation based on the level of risk involved. The goal of this approach is to have greater rigour applied to riskier projects and less unnecessary review of low- or no-risk projects. Appendix C contains a proposed framework for a risk-based regulatory regime.

Goals and actions outlined in this Roadmap need to be implemented in a coordinated approach. The key recommendation to create a mining hub, as well as the 18 actions and the owner, timelines and priority of each action is summarized in Table 1. MABC has identified the creation of a mining hub and 10 of the actions as priority items; each priority is summarized for their rationale and a set of next steps in Tables 2 to 11. Next steps for the adoption of a risk-based regulatory framework are outlined on page 58 (a more detailed description of a potential regulatory framework is included in Appendix C).

In addition to the action items, we recommend the following:

- Develop a 2020-2022 implementation plan to support the execution of the priority actions. It expands on priority actions summarized in the Roadmap that drive towards the outcomes outlined in the four goals.
- Publicly launch the Roadmap to increase awareness of the initiative. There is a strong desire to lead, support and act from the province, MABC and stakeholders who participated in the Roadmap process. Launching the completed Roadmap will demonstrate progress and help maintain momentum. Although COVID-19 has created uncertainty across the economy, there is no doubt that innovation needs to be central to British Columbia's efforts to support and grow the mining sector.
- Conduct a regular review and update of the Roadmap and the implementation plans to keep pace with emerging innovations, priorities and realities. It will ensure the Roadmap remains relevant and pivots as needed. An initial set of evaluation metrics has been identified for each goal of the Roadmap. Monitoring progress toward the Roadmap goals will involve tracking, reporting and responding to the results of these metrics as implementation progresses.

TABLE 1:

Summary of all Goals and Actions and Recommended Priorities

	Actions * = PRIORITY	Lead	Timeframe		
			1-2 YRS	5 YRS	10+ YRS
Hub	**Establish the BC Mining Innovation Hub** *	MABC	■	■	
1-Innovative and Collaborative Culture	**A.** Prepare tools to benchmark innovations and to screen innovations	Hub / MABC	■		
	B. Launch or participate in initiatives to enhance ecosystem connections *	Hub / MABC	■		
	C. Establish an Innovation Mine *	Province & University	■	■	
	D. Formalize an innovative technology early engagement process	EMPR		■	
	E. Document and celebrate innovation (success and failure) and provide a platform to share successes *	MABC & Province	■	■	
	F. Create a mining innovation leadership position in government	Province	■		

Summary of all Goals and Actions and Recommended Priorities

	Actions * = PRIORITY	Lead	Timeframe		
			1-2 YRS	5 YRS	10+ YRS
2-Regulation Supports Innovation	**A.** Consult with industry on the development of code of practice or regulation for relevant emerging technologies	Province	■	■	
	B. Establish an industry and government co-led risk-based regulatory framework *	MABC & EMPR	■		
	C. Develop a regulatory sandbox to test new regulatory approaches	EMPR	■	■	
	D. Shift prescriptive regulatory requirements to identifying and achieving desired outcomes; and develop an outcomes-based regulation guidance document *	EMPR	■	■	
	E. Develop and implement a performance verification process	Province		■	
3-ESG Advantage	**A. Define the challenges for meeting climate and sustainability objectives and conduct a review of existing transferable and/or conceptual technology** *	MABC	■		
	B. Support report and communication on ESG performance of the BC mining sector *	MABC & Province	■		
	C. Support development of local stewardship programs and learn from traditional knowledge	Province & MABC		■	
	D. Support the creation of a responsible metals and minerals market development strategy	MABC to support		■	
4-Workforce of the Future Mine	**A. Assess current workforce's vulnerability index and develop occupational profiles for jobs in the future mine** *	MABC	■		
	B. Promote mining innovations, the vision of the future mine and future mining jobs for youth *	MABC	■	■	
	C. Support the development of a training roadmap that can be customized and executed locally	MABC to support	■	■	

Next Steps on Priority Actions

The following tables summarize the rationale and next steps to plan, evaluate and execute the priority actions.

TABLE 2:

Establish BC's Mining Innovation Hub			
Action	**Owner**	**Priority**	**Timeline**
Establish BC's Mining Innovation Hub	MABC	1	1-5 years
Rationale	+ A dedicated mandate to coordinate, communicate and share knowledge on innovation and the Roadmap to ensure that goals and actions and moving forward. + Highly recommended by all stakeholders during the engagement process. + Aligns with BC Innovation Commissioner's Final Recommendations. + The Hub can be scalable and can start small and as a digital platform. + The Hub can become a self-sufficient organization in 3-5 years.		
Next Steps	+ Set up a steering committee and develop the vision and outline the scope of the Hub in the medium term (up to 5 years). + Prepare a budget. Engage with potential funding agencies, all levels of government, partnering organizations and potential private sector sponsors.		

TABLE 3:

Launch or Participate in Collaborative Initiatives			
Action	**Owner**	**Priority**	**Timeline**
Launch or participate in initiatives to enhance sectoral connections (1B)	Hub	1	1-5 years
Rationale	+ Collaboration with intention to solve big challenges defined by the industry is needed. + A focused approach to leverage BC's strengths in research, clean tech, tech start-ups and the BC Digital Supercluster accelerates mining innovation. + Shared risks among funding partners and pooled resources to amplify impacts. + The collaboration type can take several forms and can be scalable.		
Next Steps	+ Review existing collaboration programs (challenges, research topics, and piloting opportunities) and industry problem statements from relevant organizations to identify high-impact and low-cost opportunities in the short term (1-2 years).		

TABLE 4:

Establish a Innovation Mine			
Action	**Owner**	**Priority**	**Timeline**
Establish an Innovation Mine in BC (1C)	Province & University	1	1-5 years

Rationale	+ A proven niche to accelerate innovation commercialization and adoption, testing innovations too risk or too ready for operation; a collaborative space to succeed and fail. + Opportunities to attract new talent, technologies, companies and investment to BC. + Possible funding from all levels of government, research institutions, mining suppliers, mining companies and other stakeholders.
Next Steps	+ Set up a steering committee and develop the vision and outline the scope of the Demonstration Mine in the medium term (up to 5 years). + In the short term (Year 1-2), evaluate the feasibility: – Assess potential Demonstration Mine sites, ideally options include an inactive area in an existing operating mine, a closed site and other creative sites such as the Britannia Mine Museum. – Review business cases and operating budget of other similar organizations in Canada (Norcat) and internationally. – Conduct a survey to confirm interest in the BC mining ecosystem. – Critically assess if the there is a business case and if there are other organizations to partner with to achieve the same outcome.

TABLE 5:

Document, Share and Celebrate Innovation Test Outcomes			
Action	**Owner**	**Priority**	**Timeline**
Document and celebrate innovation (success and failure) and provide a platform to share successes (1E)	MABC & Province	2	1 – 5 Years
Rationale	+ A knowledge sharing culture results in a more engaged ecosystem, fosters innovation, and encourages collaboration and feedback. + Some failures can be a valuable catalyst for learning and innovating and should be celebrated. + A platform for Indigenous leaders to share learnings and identify additional opportunities are important for stakeholders to gain knowledge on Indigenous culture and traditions.		
Next Steps	+ Set up an ad-hoc committee to determine the priority on content development and to review and confirm 2-3 top platforms for knowledge sharing. + Develop a plan to create and publish contents and events on a regular basis, including written articles/newsletters, webinars, podcasts, and others.		

TABLE 6:

Establish Risk-based Regulatory Framework			
Action	**Owner**	**Priority**	**Timeline**
Establish an industry and government co-led risk-based regulatory framework (2B)	MABC & EMPR	1	1-2 years
Rationale	+ Unanimously agreed by participants as the highest value action to accelerate innovation requiring regulatory approval. + A clear path for all parties involved and a consistent way to permit an innovation based on risk and technology readiness level (i.e. low risk, high TRL innovation follows a different process compared to a high risk, high TRL innovation). + Preliminary work has been done (Appendix C) and mining companies are keen to continue leading this work. + A risk-based framework is fundamental and critical to innovation adoption through the BC regulatory regime. + Defining risks and benefits as early as possible accelerates innovation adoption, even if a regulatory process is not required.		
Next Steps	+ Develop a working group to refine and finalize the risk-based framework scope. Identify resources and experts required to support the work in addition to the working group. + Confirm the regulatory pathway for the adoption of the framework.		

TABLE 7:

Develop a Formalized Early Engagement Process			
Action	**Owner**	**Priority**	**Timeline**
Shift prescriptive regulatory requirements to identifying and achieving desired outcomes (2D)	EMPR & MABC	1	1-2 years
Rationale	+ Many participants identified this as a high value action to accelerate innovation requiring regulatory approval. + In developing a clear path to permit an innovation based on risk and technology readiness level (i.e. low risk, high TRL innovation follows a different process compared to a high risk, high TRL innovation) – the process needs to focus on desired outcomes not a prescriptive process + Requiring a detailed prescriptive process hinders innovation and the focus needs to be on the desired outcomes + Defining the desired outcomes will allow for creativity, innovation and the utilization of a range of solutions potentially unknown to the regulator		
Next Steps	+ The risk-based framework working group will inform the scope of work for this action. + Establish champions from the government and the industry to co-develop the scope of work.		

TABLE 8:

Support Reporting on ESG Performance			
Action	**Owner**	**Priority**	**Timeline**
Support report and communication on ESG performance of the BC mining sector (3B)	MABC & Province	2	1 – 2 Years
Rationale	+ Demonstrating a low carbon footprint of BC's mining operations is a competitive advantage and can contributes to the knowledge sharing action on success and failures. + Some mining companies can take advantage of the industry support to improve transparency and improve disclosure efficiency. + BC's mining industry can recommend the best industry leading protocol for disclosure as a collective.		
Next Steps	+ Review and summarize the reporting practice of BC mining companies and develop a data consolidation strategy to minimize additional resources to collect, quantify, or clarify data from existing disclosure options. + Establish an industry-government working group to discuss and recommend a disclosure protocol, communications strategy, and key outputs and product (i.e. a report card). + Develop a tool to demonstrate the agreed industry-wide ESG performance report and address gaps. + Launch the BC mining sector ESG performance and continue with an annual update.		

TABLE 9:

Launch or Participate in Collaborative Initiatives			
Action	**Owner**	**Priority**	**Timeline**
Define the challenges for meeting climate and ESG objectives and conduct a review of existing transferable and/or conceptual technology (3A)	Hub	1	1-5 years
Rationale	+ Collaboration with intention to solve big challenges defined by the industry is needed. + A focused approach to leverage BC's strengths in research, clean tech, tech start-ups and the BC Digital Supercluster accelerates mining innovation. + Shared risks among funding partners and pooled resources to amplify impacts. + The collaboration type can take several forms and can be scalable.		
Next Steps	+ Define the key challenges facing industry in achieving ESG goals. + Conduct a review of the technology currently available to assist with achieving the ESG goals.		

TABLE 10:

Assess Current Workforce's Vulnerability Index			
Action	**Owner**	**Priority**	**Timeline**
Assess current workforce's vulnerability index and develop occupational profiles for jobs in the future mine (4A)	MABC	1	1-2 years
Rationale	+ Understanding the job profiles of the future is a key ask in the engagement process. + Mining Industry Human Resources Council has developed a tool that can be adopted for BC's landscape on the vulnerability of workers in BC. + This work can help direct the Roadmap's next action plan and be an input to the Training Roadmap underway.		
Next Steps	+ Connect with MiHR and develop a work plan to adopt the tool for BC's landscape. + Develop a working group including the government, MABC and consultant who is developing the training roadmap to ensure that the work plan is relevant. + Secure funding and execute the project.		

TABLE 11:

Promote Mining Innovations and the Future Mine to Engage with Youth			
Action	**Owner**	**Priority**	**Timeline**
Promote mining innovations, the vision of the future mine and future mining jobs for youth (4B)	MABC	2	2-5 years
Rationale	+ Increasing youth participation in the mining sector is necessary to address future labour requirements. + Incorporating innovation in mining and the future mine vision in existing educational materials, such as MineralsEd, is a logical starting point. Other innovative channels such as social media and youth-centric platforms will be equally important.		
Next Steps	+ Develop material, through the Hub or from other sources including universities, mining and exploration companies directly, and consortia such as Canadian institute of mining and metallurgy (CIM), Global Mining Group (GMG), Canada Mining Innovation Council (CMIC), Centre for Excellence in Mining Innovation (CEMI) and others.		

Appendices

Appendix A | BC Mining Ecosystem Map

The following table summarizes BC's mining ecosystem members.

Key Stakeholders in BC's Mining Innovation Ecosystem			
Node	**Primary Roles and Activities**	**Stakeholder Type**	**Examples of Stakeholders**
Mining & Exploration	+ Primary generator of economic growth and resource production + Provider of funding + Procurement and piloting of new technological innovations + Producer of process innovation + Implementation of new business models and process optimization	+ Explore, develop, mine, operate and manage closure sites + Directly downstream industry - refine mining products of otherwise limited value	+ Members of Mining Association of BC + Members of Association of Mineral Exploration BC + Smelters
Mining Equipment, Technologies & Services	+ Production and sale of technological innovations and related services + Producer and provider of new services + Market development + Implementation of new business models	+ Equipment manufacturers and suppliers + Technology firms + Engineering consultants + Construction/contract miners + Management consultants + Legal services	+ Members of Mining Suppliers Association of BC members (e.g. Finning) + Technology companies (e.g. MineSense, Finger Foods, UAViation, Motion Metrics) + Engineering consultants (e.g. Hatch) + Construction/contract miners (E.g. McCue Engineering) + Management consultants (e.g. EY) + Legal services (e.g. Bennett Jones)

Key Stakeholders in BC's Mining Innovation Ecosystem

Node	Primary Roles and Activities	Stakeholder Type	Examples of Stakeholders
Funding, Enablers & Other Support	+ Provider of capital, resources and knowledge + Incubation and acceleration of technological innovation + Convener of collaboration + Enabler of technology development, commercialization and validation	+ Government + Venture capital + Incubators/accelerators + Associations + Consortia + Centres of excellence + International organizations	+ Government (e.g. Natural Resources Canada; Innovation, Science and Economic Development Canada; BC Ministry of Energy, Mines and Petroleum Resources; and BC Ministry of Jobs, Economic Development) + Consortia (e.g. Mining Association of BC, Global Mining Group, Mining Suppliers Association of BC, Association of Mineral Exploration, Mining Association of Canada) + Private funding (Chrysalix Venture Capital, Evoke Innovation) + International Council on Mining and Metals

Key Stakeholders in BC's Mining Innovation Ecosystem

Node	Primary Roles and Activities	Stakeholder Type	Examples of Stakeholders
Education, R&D (TRL <5) & Other Research	+ Training of qualified personnel + Research and development of early stage and higher risk research, skills training, and advocacy + Producer of new technical knowledge and new process knowledge + Producer of advocacy research + Receiver and provider of funding	+ Academic institutions + Training institutions + Not-for-profit/research organizations + Government entities	+ University of British Columbia, Simon Fraser University, BC Institute of Technology, Centre of Training Excellence in Mining, College of the Rockies + The Bradshaw Research Initiative for Minerals and Mining, Mineral Deposit Research Unit, Canadian International Resources and Development Institute. + Geoscience BC + Natural Resources Canada, National Research Council of Canada + MineralsEd
R&D (TRL >=6) & Commercialization	+ Research and development of mature technological innovations + Scale up, demonstration, technology validation + Development of new business models + Receiver of funding	+ Consortia of mining firms or contract researchers + Government entities with focus on later stage technology development	+ Centre for Excellence in Mining Innovation, Canada Mining Innovation Council + BC's Digital Technology Supercluster

Key Stakeholders in BC's Mining Innovation Ecosystem

Node	Primary Roles and Activities	Stakeholder Type	Examples of Stakeholders
Communities, Customers, and Supply chain	+ External stakeholders driving new mineral demand, environmental stewardship, corporate social responsibility, responsible and ethical mining practices, and the production of responsible and conflict-free minerals + Mineral products customers + Supply chain stakeholders	+ Supply Chain + Customers + Investors + Local and Indigenous communities (provide human resources and share land with miners)	+ Apple, Tesla, BMW + Millennials, Gen Z + Impact investors + Elk Valley + Tahltan Nation

Notes:

1. The examples of stakeholders given by no means represent all companies, organizations and groups in their category.
2. Some stakeholders perform multiple functions within a node and across two or more nodes.

Appendix B | Roadmap Development Process

Overview

A multi-stakeholder approach guided the development of the Roadmap, beginning with the establishment of a highly experienced advisory committee. The BC Mining Roadmap Advisory Committee (Advisory Committee) was instrumental in the development of the Roadmap.

TABLE B- 1:

Advisory Committee Members			
Name	**Position**	**Representing**	**Ecosystem Node**
Alan Winter	BC Innovation Commissioner (former)	BC Government	Funding and Support Organizations
Brent Davis	Vice President Mining Solutions, Finning (Canada)	Mining Suppliers Association of BC	Mining Equipment, Technology, and Services provider
Jill Tipping	CEO, BC Tech Association	Tech sector	Mining Equipment, Technology, and Services provider
John Steen	Associate Professor Norman B. Keevil Institute of Mining Engineering, University of British Columbia	Academia	Education, R&D (TRL <5), & Other Research
Kalev Ruberg	Vice President and Chief Innovation Officer, Teck Resources	Mining	Mining and Exploration Companies
Lindsay Kislock	Vice President Corporate Affairs, Mining Association of BC	Mining Association of BC	Funding and Support Organizations
Ryan Todd	Director Blackwater Project, New Gold	Mining	Mining and Exploration Companies
Stephen de Jong	CEO, VRIFY	Association of Mineral Exploration	Mining and Exploration Companies

Project Timeline

FIGURE B- 2: DEVELOPING THE ROADMAP

October 2019	+ Project begins
December 2019	+ Fostering innovation ecosystem track workshop #1 + Agile and efficient regulatory track workshop #1
January 2020	+ Fostering innovation ecosystem track workshop #2 + Agile and efficient regulatory track workshop #2
February 2020	+ Communities and Workforce of the future mine workshop #1 + Fostering innovation ecosystem track workshop #3 + Agile and efficient regulatory track workshop #3
March 2020	+ Communities and Workforce of the future mine workshop #2
April – May 2020	+ Roadmap Development and Revision + Socializing Goals and Actions with MABC and BC Government
May 2020 forward	+ Public engagement on the Roadmap + Roadmap Implementation

Roadmap Development Approach

A staged and facilitated consultation process was used to ensure that interested, relevant, and experienced innovation stakeholders could collaborate in an open forum to interact and shape the Roadmap. The engagement process spanned five months and was organized into three tracks. Each track focused on one of the three following questions which the Roadmap would answer:

+ **Track 1: Fostering Innovation Ecosystem**
  How to foster a strong and sustainable BC mining innovation ecosystem leveraging BC's innovation strengths?
+ **Track 2: Agile and Efficient Regulatory Framework**
  How to augment the current regulatory framework to effectively incorporate innovative technology and process adoption while upholding health and safety and environmental standards?
+ **Track 3: Communities and Workforce of the Future Mine**
  How does mining bring value to Indigenous and local communities and what does a talented workforce look like in the future mine?

For each track, a series of two or three workshops were designed. The objectives of the workshops are summarized in Figure B- 3.

FIGURE B- 3: WORKSHOP SUMMARIES

Workshop #1	Workshop #2	Workshop #3
+ Understand current status + What does success look like + Identify and discuss potential focus areas in breakout groups + Confirm research required to make decisions	+ Review research + Confirm success + Identify goal areas + Breakout groups + Identify preliminary goal statement, strategy, actions	+ Review goal statements + Breakout groups + Set actions + Prioritize actions + Assign ownership + Evaluation metrics

Participants were encouraged to attend and/or provide input and feedback on as many tracks as they wished. Additional engagement sessions were organized as requested for ecosystem nodes or stakeholders who were unavailable to participate in the workshops. Participants were provided with relevant background material and summaries of the workshops were circulated for comment.

Once the engagement process was complete, all feedback was organized into cohesive and comprehensive sets of goals and associated actions. Clear themes emerged across the three tracks, which allowed the project team to align and consolidate the goals into four key goal areas (described in Section 4 – Goals and Actions).

Engagement Process

Overall, the workshops were well-attended and the feedback received was positive. Key statistics related to the engagement process are summarized in Figure B- 4. Many participants attended more than one session in the same track or in multiple tracks and therefore participant totals below are not necessarily unique i.e. may include double or triple counting in some cases.

FIGURE B- 4: ENGAGEMENT PROCESS SUMMARY

8 Workshops	**5** Special Engagement Sessions	**875** Invitations sent	**281** Participants
51 Mining / Exploration Participants	**79** BC Government Participants	**12** Indigenous Participants	**150+** Suggestions/ Actions

Conscientious effort was made to include all stakeholders in the BC mining ecosystem. The engagement process included:

1. Industry-wide invitation: Mining Association of BC (MABC), Mining Suppliers Association of BC (MSABC), and the Association of Mineral Exploration (AME) reached out to their memberships throughout the process.
2. The Advisory Committee reached out to their networks and other relevant industry associations to invite stakeholders who may not be involved with the mining and exploration companies. Social media was used particularly to engage with the BC tech sector and clean technology companies.
3. Through the BC Ministry of Energy, Mines and Petroleum Resources (EMPR), the invitation reached multiple BC Government Ministries and resulted in strong participation and the opportunity to discuss with other participants.
4. Project schedules were adapted to enable broader engagement with community, workforce and Indigenous organization representatives.
5. Participation was sought by stakeholders outside of Metro Vancouver. They included Indigenous communities and organizations, local communities, training organizations, and support organizations. Although not everyone was able to travel to participate in the workshops, their inclusion was represented in several ecosystem nodes.
6. Relevant national and international organizations and government partners were engaged throughout the process. While some attended the workshops in person, others participated through conferencing options, email or phone.

Details of the participating organizations at workshops in all three tracks are shown in the following three tables.

TABLE B- 5:

Workshop Attendees in Fostering Innovation Ecosystem Track		
Ecosystem Node	**Participants**	
Mining and Exploration Companies	+ FPX Nickel + Margaux Resources + New Gold	+ Sherritt International + SSR Mining + Teck Resources
Mining Equipment, Technology, and Services Companies	+ Alacris Innovation Consulting + BQE Water + Finger Food Studios + Finning (Canada) + Hemmera + Independent Consultants + MacLean Engineering + McCue Engineering + Minerva Intelligence	+ Minesense + Motion Metrics + Newtrax + PetraScience Consultants + Rockmass Tech + Schneider Electric + UAViation Aerial Solutions + Wenco
Funding and Support Organizations	+ BC Ministry of Advanced Education, Skills & Training + BC Ministry of Environment, Mines, and Petroleum Resources + BC Ministry of Jobs, Economic Development and Competitiveness + BC Office of the Innovation Commissioner + BC Tech Association + Centre for Excellence in Mining Innovation + Centre of Training Excellence in Mining	+ Coalition for Eco-Efficient Comminution + Canada's Oil Sands Innovation Alliance + First Nations Energy and Mines Council + First Nations Technology Council + Foresight Cleantech Accelerator + Global Mining Guidelines Group + Métis Nation BC + Mining Association of BC + Mining Suppliers Association of BC + National Research Council + Natural Resources Canada
Education, R&D (TRL <5), & Other Research	+ Genome BC + Geoscience BC	+ University of British Columbia
R&D (TRL 6+) & Commercialization	+ Chrysalix + Evok Innovations	+ NORCAT + Shell Ventures

TABLE B- 6:

Workshop Attendees at Agile and Efficient Regulatory Framework Track		
Ecosystem Node	**Participants**	
Mining and Exploration Companies	+ FPX Nickel + Gigametals Corporation + HD Mining + Kutcho Copper Corp + Margaux Resources + New Gold	+ North Coal + Pretivm Resources + Seabridge Gold + Skeena Resources + Teck Resources
Mining Equipment, Technology, and Services Companies	+ Alacris Innovation Consulting + Bennett Jones + BQE Water + Hemmera + Independent Consultants	+ MacLean Engineering + McCue Engineering + SRK Consulting + UAViation Aerial Solutions
Funding and Support Organizations	+ Association for Mineral Exploration BC + BC Environmental Assessment Office + BC Ministry of Advanced Education, Skills & Training + BC Ministry of Environment, Mines, and Petroleum Resources + BC Ministry of Environmental Protection & Sustainability + BC Ministry of Forests, Land, Natural Resource Operations and Rural Development	+ BC Ministry of Jobs, Economic Development and Competitiveness + Centre of Training Excellence in Mining + First Nations Energy and Mines Council + Foresight Cleantech Accelerator + Global Mining Guidelines Group + Mining Association of BC + Natural Resources Canada
Education, R&D (TRL <5), & Other Research	+ Genome BC	+ University of British Columbia + National Research Council

TABLE B- 7:

Workshop Attendees at 'Communities and Workforce of the Future Mine' Track		
Ecosystem Node	**Participants**	
Mining and Exploration Companies	+ FPX Nickel + HD Mining + New Gold	+ North Coal + Teck Resources
Mining Equipment, Technology, and Services Companies	+ Alacris Innovation Consulting + BBA + Career Mobility Group + Centre for Innovation in Mineral Resource Engineering	+ Mafalda Arias and Associates + Lana Eagle Consulting + PetraScience Consultants
Funding and Support Organizations	+ Association for Mineral Exploration BC + BC Environmental Assessment Office + BC Ministry of Advanced Education, Skills & Training + BC Ministry of Environment, Mines, and Petroleum Resources + BC Ministry of Environmental Protection & Sustainability + BC Ministry of Forests, Land, Natural Resource Operations and Rural Development + BC Ministry of Indigenous Relations and Reconciliation + BC Ministry of Jobs, Economic Development and Competitiveness	+ Centre of Training Excellence in Mining + First Nations Energy and Mines Council + First Nations Technology Council + Global Mining Guidelines Group + Industry Training Authority of BC + Métis Nation BC + Mining Association of BC + Mining Industry Human Resources Council Canada + Mitacs + Natural Resources Canada + Québec Mining Association
Education, R&D (TRL <5), & Other Research	+ Intergovernmental Forum on Mining, Minerals, Metals, and Sustainable Development	+ University of British Columbia
R&D (TRL 6+) & Commercialization	+ Digital Technology Supercluster	+ NORCAT

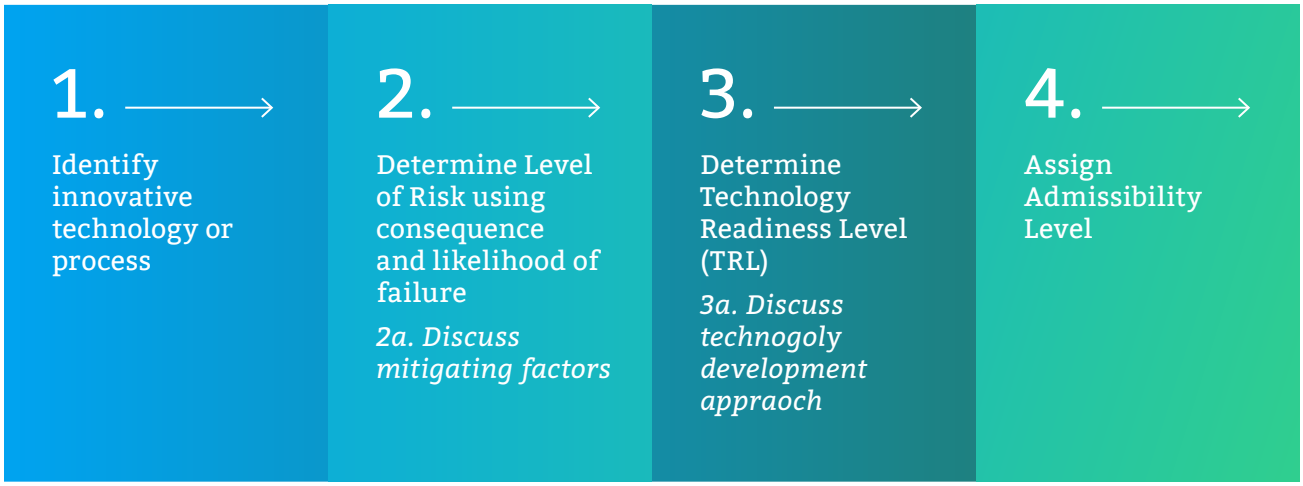
Appendix C | Risk-based Regulatory Framework

Overview

The ability to permit innovations through a process appropriate for the risk and technology readiness of the innovation was identified as an important area of focus as part of the Agile and Efficient Regulatory goal. Specifically, the development of a risk-readiness matrix was identified as a tool that could help determine the appropriate regulatory process for innovative technologies or processes at varying levels of readiness for implementation and associated risks.

A proposed Risk Based Regulatory Process (RBRP) and draft risk-readiness matrix for scaling regulatory approach with the risk level and readiness level was proposed. The process consists of 4 steps, as identified in Figure C -1. After an innovation is identified (Step 1), the characterization of risk level based on a Failure Modes Effects Assessment (FMEA) approach (Step 2) in combination with characterization of the readiness based the Technology Readiness Level (TRL) scale (Step 3) can be used to assess the ease of permitting of an innovation based on the Admissibility Matrix (Step 4). Each step, along with 2 examples are described. Examples are loosely based on experience within the BC mining community.

FIGURE C- 1: RISK-BASED REGULATORY FRAMEWORK PROCESS



Step 1: Identity Innovative Technology or Process

The first step is to identify a new technology or process as innovative. A screening process could be employed at this stage to determine if:

- If a change in technology or process is innovative
- If the innovation requires regulatory approval, and
- If the innovation should be permitted through this process.

Step 2: Determine Level of Risk

The following process would be applied to define the risk level associated with the failure of an innovative technology or process.

Failure Mode and Effectiveness Analysis (FMEA) is a standard part of many design projects used to identify and rate risks. Robertson and Shaw[24] describe the FMEA as "a top down/ expert system approach to risk identification and quantification, and mitigation measure identification and prioritization." It combines the likelihood of failure with the consequences of a failure to express the outcome as a risk.

Failures can have multiple types of consequences, including health and safety, environmental, regulatory and legal, public concern and reputation, and cost. For an innovation, the severity of the consequence can be assessed separately in each of the different consequence types. For example, a failure of a tailings dam spillway could have environmental consequences as well as consequences for public concern and reputation. Sample definitions for the severity of each consequence is provided in Table C- 2. Defining the potential consequence types and definitions for severity would be an initial step in developing common language around risk for a given innovation.

The likelihood of the failure would be classified using a 5 class system, ranging from very unlikely to expected (Table C- 3). Several definitions of likelihood have been presented. The number of classes can be adapted to best suit a specific innovation.

24 Robertson, A. MacG. and Shaw, S.C. (2003). Risk management for major geotechnical structures on mines. In proceedings of Computer Applications in the Mineral Industries (CAMI), Calgary, Alberta, Canada, 8-10 September 2003.

The consequence types, severities and likelihood should be identified based on multiple lines of evidence. Where a quantitative analysis is not possible due to limited data, a qualitative assessment of the risk could be undertaken, including reliance on professional judgement from Qualified Professionals. After the consequence and likelihood of an innovation's failure has been characterized, a level of risk can be assigned based on the risk matrix (Table C- 4). Mitigating factors (Step 2a) may address the severity and likelihood of a failure's consequence. Mitigating factors should be considered in the characterization of risk.

Although multiple consequence types can be considered, leading to multiple risk ratings, the highest risk rating would be carried forward in subsequent steps.

TABLE C- 2:

Consequence Type and Severity					
Severity	**Health and Safety**	**Environ-mental**	**Regulatory and Legal**	**Public Concern and Reputation**	**Direct Cost**
Extreme	Fatality	Catastrophic impact	Unable to meet regulatory obligations; shut down or severe restriction of operations	Local, international, and/or non- governmental organization (NGO) outcry and demonstrations; severe restrictions of "license to operate"; large compensational payments, etc.	> $100M
High	Severe injury or disability likely; some potential for fatality	Severe impact	Regularly (more than once per year) or severely fail regulatory obligations or expectations; large increasing fines and loss of regulatory trust	Local, international, and/or NGO activism resulting in political or financial impacts on "license to operate;" requiring major procedure or practice changes	$ 10M to 100M
Moderate	Lost time or injury likely; some potential for serious injury	Significant impact	Occasionally (less than once per year) or moderately fail regulatory obligations or expectations; fined or censured; heightened regulatory concern	Occasional local, international, and/or NGO attention; requiring minor procedure or practice changes and additional focus on public relations and communication	$ 1M to 10M
Low	First aid required; small risk of serious injury	Minor impact	Seldom or marginally fail regulatory obligations or expectations; some loss of regulatory tolerance, increasing reporting.	Infrequent local, international, and/or NGO attention addressed by normal public relations and communication	$ 100,000 to 1M
Negligible	No health and safety concern	No measurable impact	No regulatory obligations or expectations are failed	No local international, and/or NGO attention	< $ 100,000

TABLE C- 3:

Likelihood			
Likelihood	**Description**	**Probability of Occurrence (over 100-year timeframe)**	**Frequency of Occurrence**
Expected	Happens often	98%	High (more than once every 5 years)
Likely	Could easily happen	75%	Does happen, has a history (once every 15 years)
Possible	Could happen and has happened elsewhere	40%	Occurs once every 40 years
Unlikely	Hasn't happened yet, but could	10%	Occurs once every 200 years
Very unlikely	Conceivable, but only inextreme circumstances	2%	Occurs once every 1000 years

FIGURE C- 4:

Risk Matrix						
		Consequence Severity				
		Negligible	**Low**	**Moderate**	**High**	**Extreme**
Likelihood	**Expected**	Moderate	Moderately High	High	Very High	Very High
	High	Moderate	Moderate	Moderately High	High	Very High
	Moderate	Low	Moderate	Moderately High	High	High
	Low	Low	Low	Moderate	Moderately High	Moderately High
	Not Likely	Low	Low	Low	Moderate	Moderately High

Step 3: Technology Readiness Level

Technology readiness level (TRL) is a widely accepted and applied scale against which an innovation's maturity can be estimated. TRLs are based on a scale from 1 to 9 with 1 being the least ready and 9 being already used in real-life conditions. The use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology.

In the proposed RBRP, a technology's TRL would be determined during a technology readiness assessment. The information requirements for a technology readiness assessment would be agreed upon between regulators and the proponent.

Figure C- 5 presents the TRL scale provided by Innovation, Science and Economic Development Canada (ISED 2020). NASA, who originally developed the TRLs in the 1970s and the UK have TRL scales with very similar wording.

FIGURE C- 5: TECHNOLOGY READINESS LEVELS FROM INNOVATION, SCIENCE AND ECONOMIC DEVELOPMENT CANADA[25]

Level 9	Actual technology proven through successful deployment in an operational setting
Level 8	Actual technology completed and qualified through tests and demonstrations
Level 7	Prototype ready for demonstration in an appropriate environment
Level 6	System/subsystem model or prototype demonstration in a simulated environment
Level 5	Component and/or validation in a simulated environment
Level 4	Component and/or validation in a labratory environment
Level 3	Analytical and experimental critical function and/or proof of concept
Level 2	Technology concept and/or application formulated
Level 1	Basic principles of concept are observed and reported

25 Innovation, Science and Economic Development Canada, Technology Readiness Level, https://www.ic.gc.ca/eic/site/ito-oti.nsf/eng/00849.html

Step 4: Admissibility Matrix

Once a risk rating and TRL is assigned to an innovation, the level of ease of permitting is assigned based on the admissibility matrix (Figure C- 6). In this matrix, bands of admissibility (or ease of permitability) were proposed, ranging from low to high. Note the matrix starts at TRL 3. TRLs of 3 and lower are early in the concept development and considered low on the admissibility scale.

Mining projects are highly variable and site-specific conditions including geology, climate, receiving environment characteristics are vital to determining the readiness of an innovation. For this reason, innovations with TRL 5 or lower are considered to have low admissibility.

FIGURE C- 6:

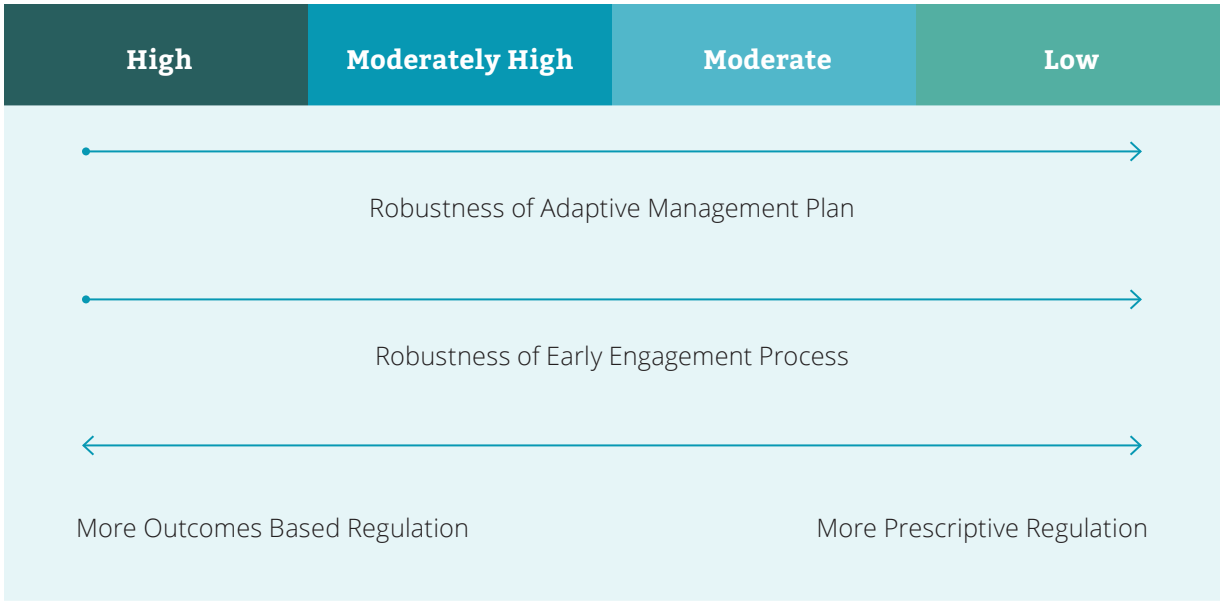
Admissibility Matrix

Risk Rating	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
Very high	Low	Low	Low	Low	Low	Moderate	Moderate
High	Low	Low	Low	Low	Moderate	Moderate	Moderately High
Moderately High	Low	Low	Low	Low	Moderate	Moderately High	Moderately High
Moderate	Low	Low	Low	Moderate	Moderate	Moderately High	High
Low	Low	Moderate	Moderate	Moderate	Moderately High	Moderately High	High
	Technology Readiness Level						

Using the bands of admissibility, options to modify the permitting process based on the level of admissibility were presented above. Medications could include increased robustness of an adaptive management plan and increased robustness of an early engagement process for low admissible innovations. Alternatively, for highly admissible innovations, regulations related to the innovation may be more outcomes oriented rather than descriptive.

Although each step of the proposed RBRP may be somewhat subjective, the FMEA process demonstrates that agreement on classifications can generally be achieved. Where assigned qualities for consequence severity, likelihood or TRL would results in crossing an admissibility matrix boundary, additional evidence could be sought to get broader consensus on classifications.

FIGURE C- 7: OPTIONS TO MODIFY THE PERMITTING PROCESS FOR VARYING DEGREES OF ADMISSIBILITY



Example of Application

An example is discussed to illustrate the application of this process. The use of an evaporation retardant in an environment with a negative water balance (i.e., more evaporation than precipitation) could help preserve water within a Tailings Storage Facility for reclaim rather than drawing process water from a freshwater source. Evaporation retardants have undergone previous regulatory scrutiny and have been approved for use in Canada, however, use of evaporation retardants for mining applications have not previously been permitted.

TABLE C- 8:

Admissibility Rating for Evaporation Retardant on Tailings Storage Facility

Classifications	Ratings	Rationale
Consequence Severity	Low	Possible environmental consequence rated to uncontrolled release of retardant, however have been deemed safe for use in Canada.
Likelihood	Low	Not likely due to containment within TSF.
Overall Risk Rating	Low	Based on Risk Matrix.
Technology Readiness Level	8	Evaporation retardants are currently available for use in Canada, however have not previously been used for the proposed application.
Admissibility Rating	High	Based on Admissibility Matrix.

The evaluation of evaporation retardants indicates that a high admissibility rating is appropriate. The ease of which an evaporation retardant is permitted could be modified to reflect this evaluation.

Appendix D | SWOT Analysis

BC's Mining Ecosystem SWOT Analysis

Strengths

- Rich minerals and metals deposit
- Established mining sector
  - Existing operating mines and pipeline of new projects
  - Many mining headquarters and suppliers
  - Industry leaders and technical experts
- Asia Pacific gateway
- Infrastructure: ports, rail, roads
- Energy cost / clean energy
- Attractive place to live and work
- World-class universities and research institutes
- Strong technology and clean-tech sectors

Weaknesses

- Complex regulatory environment
- Scale up in innovation and adoption slow
- Risk and innovation appetite at C-level
- Lack of ecosystem connections
- Lack of mining awareness in urban areas
- Insufficient local mining capital investment
- Insufficient innovation investment
- Lack of proving and testing grounds
- Need more quantity of digital workforce
- Innovation and technology adoption for junior miners difficult
- Low affordability in BC

Opportunities

- Demand for innovation is strong
- Suppliers of the low carbon future
- Leverage the strong technology base, clean tech sector, and the Digital Technology Supercluster
- Leverage universities & research institutes
- Leverage think tanks, incubators, accelerators, venture capitalists in and outside of mining
- Export mining solutions to adjacent sectors & industries
- Incentives for early adopters vs. fast followers
- Be a region of sustainable mining expertise
- Improve education and professional development to include innovation

Threats

- Lack of flexibility of regulation
- Innovation laggard
- Negative reputation of industry
- Perception of high risk
- Lack of well-funded and flexible funding programs
- Capacity of highly skilled workers entering mining
- Infrastructure gap — connectivity in remote areas
- Jobs threatened by innovation
- Inclusion and diversity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