



# Green Mining Innovation (GMI) Forum

## Breakout Session Summary Report from the Dec. 17, 2019 Forum

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## Our Mission

We work collaboratively with governments, Indigenous peoples, business and civil society to navigate complex challenges, develop integrated and practical solutions and support societal transitions that result in sustainable outcomes.

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## Executive Summary

On December 17, 2019, CanmetMINING hosted a forum involving members of the Green Mining Innovation Advisory Committee and a number of additional stakeholders. The forum objectives were to:

- Report on CanmetMINING Research and Development (R&D) progress made since last year and link to the new Integrated Business Plan, and
- Review model proposals for the Future of Mining, identify R&D gaps and the way forward.

To inform CanmetMINING's medium-term planning, participants were asked to provide input on the next 5 year Research Plan, the role of mining equipment suppliers, and government funding priorities. Ideas generated are summarized in Section 2. Given that only limited time was available for these break-out discussions, these ideas were not further screened or refined through group discussion.

Following a panel on the Future of Mining, break-out groups discussed elements required to support development and implementation of a model for the Future of Mining, including technological elements, policy elements, opportunities and constraints, and the process to build support for the model. Key messages related for each discussion question are summarized below.

## Technological Elements

When asked about the most important technological elements the model needs to incorporate, participants had the following suggestions:

- The long term vision for the Future of Mining could be: ***Precise, clean, (possibly continuous), in situ where possible; surface infrastructure would be modular, portable systems for processing and for developing smaller ore bodies.***
- Will require much better, more powerful and more precise exploration.
- Will require changes in the approach to mine design to focus on value extraction and zero waste.
- Operation will include precision mining, increased automation, more efficient comminution, use of intelligent systems, and greater use of emerging technologies.
- Electrification will be a big part of the Future of Mining, including decoupling the power system from the grid, use of renewable sources, and smart energy management systems.
- Technologies should enable greater value-add, and can differentiate the Canadian brand.

## Policy Elements

When asked what policy elements will need to be addressed to support realization of the Zero Waste Mine, participants suggested we should:

- Change our understanding and treatment of waste.
- Move towards more outcome-based regulation.
- Create a range of incentives for zero waste mines, including tax incentives, accelerated capital cost appreciation, fast-track for zero waste technologies and projects, changing leasing arrangements and costs to incent low waste approaches.
- Develop policies to encourage and enable urban recycling and mining of urban waste.
- Revisit valuation approaches on the cost of legacy tailings to drive reprocessing.
- Introduce more holistic environmental impact monitoring and enable use of real-time sensors to monitor and enforce regulations.

## Opportunities and Constraints

When asked what they see as the opportunities and constraints related to realizing the model, participants identified the following:

### Opportunities

- Responsible sourcing
- Government support of SME innovators
- Hosting a test mine
- Adapting and adopting technologies from other sectors
- Creating and exporting the remediation economy
- Making Canadian standards global standards
- Applying Indigenous knowledge to inform decisions

### Constraints

- Lack of a united vision
- Siloed approach (not holistic)
- Access to talent and lack of diversity
- Short-term view of Boards and investors
- CapEx dependent business model
- Restrictions on tailings reprocessing
- Restrictive definition of waste
- Restrictive disclosure requirements in NI 43-101
- Lack of IP policy across the industry
- Prescriptive and restrictive regulatory model (not agile)
- Traditional design engineering mindset
- Cost uncertainty and lack of a clear and fully costed business case
- Lack of funding for extraction and processing

## Process to Build Support

When asked how we can best obtain consensus and buy-in on the development of the model and supporting roadmap, participants shared the following ideas:

- Establish a singularity of purpose (“a mass transformative purpose”) for the industry that is value based. The vision would encourage the sector to approach all ore bodies as a zero waste mine.
- Recognize that we need to involve all stakeholders in development so that they are part of the journey including youth, academics, critics, ‘Canadian Greta’s’, etc.
- Need to engage holistically about all dimensions of zero waste mine (e.g. energy), and clearly link zero waste mining to the low carbon future.
- This shift will require a well-targeted and multi-pronged educational and marketing campaign to build awareness and support for the Future of Mining, along with visibility to the consumer.
- Need to present a compelling business case to bring the business community on board.
- There is an opportunity to showcase clean plants to help key stakeholder groups envision what the future of mining looks like in 10 years, 20 years, 30 years.
- Industry needs to ensure it closes mine sites properly to avoid future legacy sites and maintain the sector’s reputation as responsible operators.

# 1. Introduction

This document summarizes information and input gathered through breakout sessions held during the Green Mining Innovation (GMI) Forum. The full-day forum took place in Ottawa on December 17, 2019, guided by the following objectives:

- Report on CanmetMINING Research and Development (R&D) progress made since last year and link to the new Integrated Business Plan, and
- Review model proposals for the Future of Mining, identify R&D gaps and the way forward.

Following presentations by CanmetMINING staff that provided an overview and update on R&D progress in key streams (including Mining Value from Waste, Critical Minerals, Green Mining Innovation, and Transformative Technologies), implementation of the Integrated Business Plan and EMMC deliverables for 2020, participants were divided into three break-out groups. The breakout discussions were conducted “carousel style,” where the groups responded to one question, then moved to another room to review and build on the input received from the previous group on a different question, and so on. Participants were asked to consider the following questions related to R&D priorities and the Integrated Business Plan:

1. **Next 5 year Research Plan:** As a Federal Lab with the mandate uniquely designed to address the challenges facing the Canadian mining sector, are there areas not covered in our integrated business plan that you think CanmetMINING should address as a top priority in the next 5-year research plan?
2. **Role of Mining Equipment Suppliers:** The role of mining equipment suppliers and service industries has grown significantly in recent years and their role is evolving. What role do you see for CanmetMINING working with this group?
3. **Funding Priorities:** IF additional funding were made available for more research related to the mining sector, where would you place the priority for allocating such funding?

**Section 2** of this report summarizes the input provided during these discussions.

The morning concluded with a panel on the Future of Mining. Panelists discussed considerations for developing a model of the Future of Mining and provided insights to help frame the afternoon breakout session discussions. Participants were divided into four groups, each of which responded to the following four questions regarding the Future of Mining:

1. **Technological Elements:** The move to a Zero Waste Mine by 2030 will require a number of technologies that could either be adapted for use by the mining industry or have yet to be developed. What do you see as the most important technological elements that the model needs to incorporate?
2. **Policy Elements:** Technology alone will not allow us to realize the model of the Zero Waste Mine of the future. What policy elements will we need to address?
3. **Opportunities and Constraints:** What do you see as the opportunities and constraints related to realizing the model?
4. **Process to build support:** How can we best obtain consensus and buy-in on the development of the model and supporting roadmap?

**Section 3** summarizes the input from all of the breakout groups.

## 2. R&D priorities and Integrated Business Plan: Summary of Break-out Discussions

Participants provided the following input related to each of the discussion questions. Note that the groups only had limited time for these discussions, so while this section provides a compilation of ideas, these ideas have not been discussed in detail or debated.

### 2.1 Next 5 year Research Plan

*As a Federal Lab with the mandate uniquely designed to address the challenges facing the Canadian mining sector, are there areas not covered in our integrated business plan that you think CanmetMINING should address as a top priority in the next 5-year research plan?*

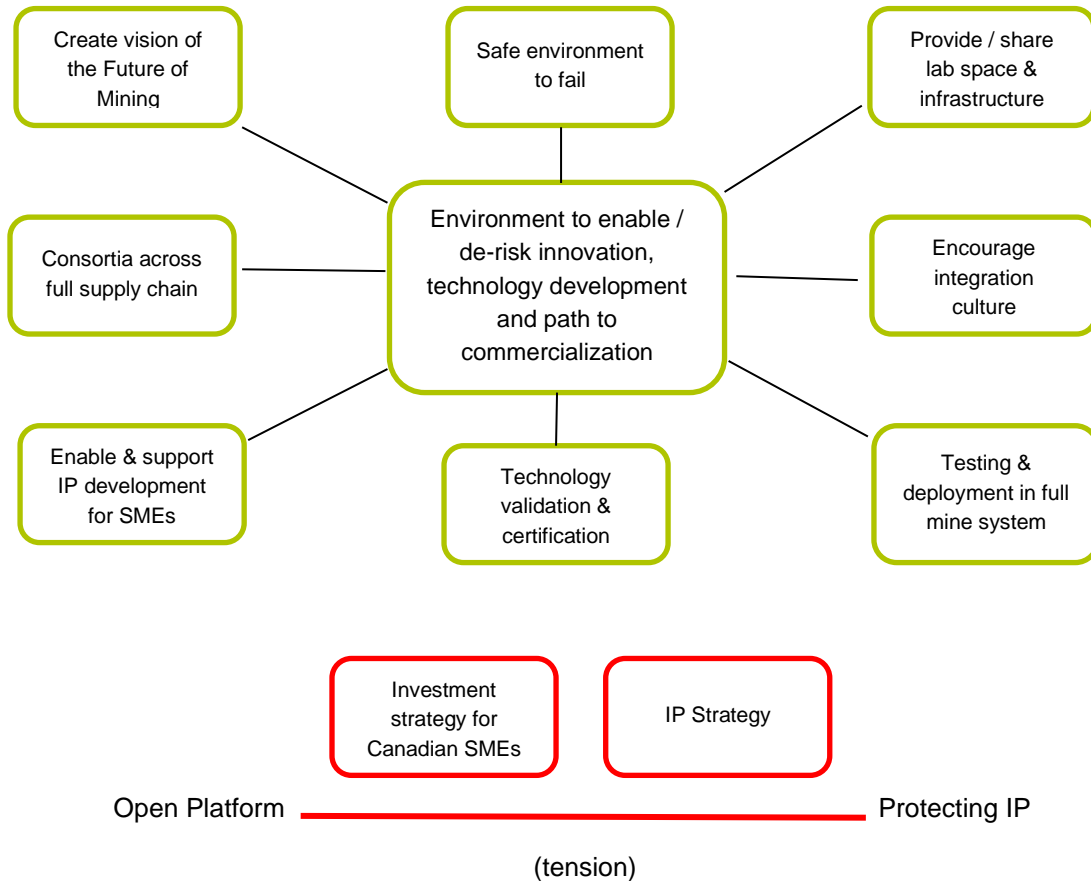
- Net Zero would be a good umbrella for the research plan
- Encourage engagement with SMEs, suppliers and innovators
- May need to do more on tailings (stability, dam stability, monitoring ... and step change to avoid liability)
- Power and fuel use: electrification of mines; power supply off-grid, SMRs
- In-situ mining (higher precision mining)
- Decarbonization across the whole value chain, using clean technology
- Supply chain for critical minerals (extraction, refining, integration into marketplace ... may need to expand into recovery i.e. the “urban mine”)
- Tailings management, including engineering of tailings facilities
- Dry processing to reduce water use
- Monitoring issues and sensors
- Bio engineering
- Market expansion
- Downstream processing
- Recycling
- On-going engagement with SME's to maintain relevance over the course of the plan



## 2.2 Role of Mining Equipment Suppliers

The role of mining equipment suppliers and service industries has grown significantly in recent years and their role is evolving. What role do you see for CanmetMINING working with this group?

The following figure depicts a number of the elements raised during the discussion.



Additional points raised during the discussion include:

- Need clarity of vision. There is a role for someone to help articulate to suppliers and manufacturers what the Mine of the Future will look like:
  - Road maps
  - Provide the framework within which suppliers can participate and help to realize this vision (they can bring economic incentive to bear)
  - Encourage first movers
- Some participants emphasized that Canmet's most important role is to create an environment to de-risk technologies
- Jointly identify and share projects to address any issues. Especially if there is a path to commercialization; focus on needs
- Encourage the integration culture (transcend silos). How do we integrate technologies in a mining system?
  - Start with the full mine system
  - Need physical environment
  - Government funding is required to support this

- Need an integration culture from concept / idea through to commercialization
- Role of integrator above OEMs
- One participant suggested that equipment suppliers should stay away from Canmet because they are focused on the mine of the past, not the mine of the future
  - Will not change direction of OEMs
  - Can influence Canadian SMEs
- Canmet should maintain its role for technology validation and certification and work with suppliers to give reassurance; this is currently a non-tariff trade barrier
- Participants frequently discussed challenges associated with Intellectual Property (IP). There were mixed views about the role of government in IP
  - OEMs don't want to bring others on board
  - How can we create an environment to bring in all the right people, ideas and organizations to drive ideas forward?
  - Talent doesn't want to work together and share IP
  - Canmet could play a role in enabling development of IP for some SMEs because this is tough for them due to resource constraints. Partner with SME to advance and own / share IP; provide access to sites
  - Gov't role in IP is questionable; maybe work with other organizations on consolidated Canadian IP strategy
- Need an investment strategy for Canadian SMEs
- It was noted that there were few to no suppliers or university representatives at the Forum; we need to figure out how to bring them to the table
- Canmet and equipment suppliers could work together, do tests in each others' labs. This could involve partnering (depending on the stage of research), and testing equipment
- Labs can provide specialized, research infrastructure to support SMEs to get ideas to fruition
- Consider a dedicated Strategic Investment Fund (SIF) program for commercialization of technologies

## 2.3 Funding Priorities

*If additional funding were made available for more research related to the mining sector, where would you place the priority for allocating such funding?*

- Collecting and sharing of data, including environmental effects monitoring
- Technology adoption to move existing technologies forward, especially those with greatest positive impact
- Moving towards carbon neutrality and decarbonization
  - Energy intensity in mine construction
  - Energy reduction and GHG reduction / remote sites
  - SMRs (renewable)
- Safe tailings management (management, reclamation, reprocessing)
- Responsible sourcing and safety – including establishment and promotion of Canada's brand
- Critical minerals value chain; find end use for critical minerals
- Batteries / minerals – test facility (sandbox)
- In-situ mining
- Mining productivity and efficiency, including autonomous mining
- Shared risk and funding for full ecosystem program (e.g. mining cluster)
- Cyber physical modelling capability
- Support innovation ecosystem; invest in SMEs and supply services; skills training
- Maximum value extraction

- Mining value from waste
- Recycling (metal and battery)
- Mining certification
- Consolidation of existing programs
- More science tools

### 3. Future of Mining: Summary of Break-out Discussions

Prior to participants breaking into discussion groups, four invited speakers made presentations to help set the context for the mine of the future. The presentations introduced the participants to the approach needed to build a model for the future of mining, considerations for roadmap development, and two perspectives on the future direction: one from the equipment suppliers and services sector perspective and the other from a mining company perspective.

Each of the presenters challenged conventional thinking and prompted the participants to consider what the future of mining could look like, what would be required on the part of various stakeholders to achieve a new vision for mining, and the potential benefits that taking such an approach would bring in the near to medium term. Participants were asked to consider what the future might look like, how to do things differently (not just better) and how to adopt a more integrated, comprehensive evaluation of new technologies when making decisions about future mine design and development.

This section provides the consolidated input generated from the four breakout groups for each of the four questions.

#### 3.1 Technological Elements

*The move to a Zero Waste Mine by 2030 will require a number of technologies that could either be adapted for use by the mining industry or have yet to be developed. What do you see as the most important technological elements that the model needs to incorporate?*

##### Long-term vision

- Precise, clean, (possibly continuous), in situ where possible; surface infrastructure would be modular, portable systems for processing and for developing smaller ore bodies

##### Exploration

- Much better, more powerful exploration (e.g. 10x better drilling, 10x faster, deeper, and more powerful characterization, etc.)
- Precision exploration (real-time characterization and delineation) to enable us to minimize or eliminate waste and waste ore

##### Design

- Design systems based on ore bodies / liberations / value extraction rather than tonnage
- Much more in-situ mining (will require further in situ technologies), and potentially no more open pit mines
- Ability to target and extract from lower grades (access to smaller ore bodies, and more modular & moveable)
- Design and operate for closure ... design the closure plan at the outset and operate to that design
- Infrastructure (e.g. roads, renewable energy) should benefit communities post mining

## Operation

- Design mine with technologies that enable progressive closure
- Opportunities for smaller mine openings by using smaller automated equipment
- Precision mining (real-time characterization and delineation) to enable us to minimize or eliminate waste and waste ore
- Increased automation (trucks, continuous mining, etc.) coupled with targeted extraction to “mill only ore”
- More efficient comminution; efficient rock breaking; smart use of data: machine learning, artificial intelligence; using structural effects in rock breaking
- Greater use of technologies and approaches including:
  - Alternate explosives
  - Dry processing
  - Hydrofracturing to enable targeting processing
  - Selective leaching / bio-leaching
  - Hydro air vehicles / airships
- Intelligent systems, including use of multi-parameter sensors
- Cyber security will likely be an essential component (as we rely more on big data, automation)
- More efficient energy management (e.g. capture and use of exothermic energy for processing and operations)

## Zero Waste

- Keep everything underground within a closed system
- Understanding minerals to extract all of the value (including multiple minerals, and identifying other uses for ‘waste’ materials) – before and during mining & processing
- Think broadly about waste – solid (biggest challenge), energy (hydrogen, electricity, nuclear – including at remote sites), other (water)
- It’s important to understand the water / energy / solid waste nexus.
- Strive for zero surface waste
- Importance of dealing with tailings to achieve a zero waste system

## Tailings

- What can enable the vision of no tailings? Placing a value on tailings (e.g. BASF Germany reprocessing). However, it was noted that tailings are heavy and have low value which may preclude different uses; it’s often better to backfill (e.g. use slag for rock well insulation)
- Eliminating tailings in 30 years is very ambitious. The interim steps to achieving this need (e.g. filtering tailings) to be addressed. Policy change is also needed to drive this.
- Look for opportunities for tailings reprocessing and processing
- Strive for 100% water reuse

## Electrification and Decarbonization

- Electrification will be a big part of the Future of Mining since it will allow other things to happen
- Decouple power system from the grid (e.g. hydrogen, battery, supplemented by wind)
- Small modular reactions and other practical renewable energy sources may well have a role in the Future of Mining
- Smart energy management systems will help to reduce energy intensity

## Value Add

- Focus on greater value-add to minerals and metals (e.g. use this to differentiate the Canadian brand)

## 3.2 Policy Elements

*Technology alone will not allow us to realize the model of the Zero Waste Mine of the future. What policy elements will we need to address?*

### Change understanding and treatment of waste

- We will need to redefine “waste”
- Need incentives to minimize waste or reuse waste
- Current regulations for closure planning allow you to have waste on surface; regulations need to discourage waste from being left on surface and covered

### Outcome-based regulation

- Consider moving to more outcome-based regulatory processes

### Create incentives for zero waste mines

- Look at tax regime to incent miners to be more efficient (with respect to royalties – revenue based taxes)
- Incentivize adoption of clean technology (tax breaks or other incentives) that move towards zero waste
- Treat mining projects that are moving towards zero waste differently than those that are not; allow more rapid deployment of desired technologies
- More incentives to advance mining and adoption of new & desirable technologies
- Accelerated Capital Cost Appreciation – mining didn’t benefit from this the way other sectors did; this would be a good policy measure
- Installed capital base – need to incentivize writing off legacy equipment for new innovative equipment
- Opportunity to fast track approvals and permits and decrease time to market for first movers to encourage adoption of socially and environmentally preferable approaches and technologies
- Change leasing arrangements and costs (increase) to incent low waste approaches
- Introduce fees for placing waste on the land (in addition to lease cost)
- Require companies to return waste rock to pits (recognizing that this will require zero carbon/low carbon excavation technology to be feasible)

### Recycling and urban mining

- We need more policies to push and enable urban recycling / mining of urban waste in Canada
- Enabling policy could create value on e-waste to encourage recycling

### Traceability across the value chain

- Map the value chain to link zero waste mines with sustainable products
- Enable traceability across the value chain

### Contaminated sites

- We need to revisit valuation approaches on the cost of legacy tailings in order to drive reprocessing of tailings. These approaches will need to get around NPV
- We need to see more risk sharing on cleaning up of contaminated sites (between investor and current owner) and reclassifying current sites (without requiring an EA)

### Tri-partite relationship

- Needs to be a tri-partite relationship across companies, government and communities; government has to provide the right skills and expertise (both hard and soft) on the ground to engage alongside companies to enhance judicial resilience

### Investment program criteria

- Don't link government support to the number of jobs created; instead, consider criteria that encourage training and re-training, and focus on contribution to climate change targets

### Monitoring and enforcement

- Use of real-time sensors to monitor and enforce regulations (e.g. rather than environmental assessment or to supplement traditional enforcement and use third party auditors)
- Introduce more holistic environmental impact monitoring (i.e. cumulative impacts / speciation vs discrete metrics like pH)

### General comments

- We need an agile regulatory policy
- Constraints have to be balanced with compensation (e.g. carbon pricing)
- Jurisdictions could prevent development of low grade / high sulphide deposits and create incentives/ regulatory preference for the most desirable/lowest impact types of development
- Be careful that regulatory changes do not negatively affect the investment flow into Canada (use incentives)
- May require stricter discharge criteria/mine specific discharge criteria to force action
- Regulations are better when cross-sectoral
- Our natural resource base can't be outsourced. The policy construct needs to value mining as an anchor industry. It should consider how to use mining as the hub for AI and other emerging technologies (i.e. mining as a value added, economic driver)
- We will need policies and regulations for SMRs if go there
- Consider revenue neutral policies that channel mining revenues paid to government back into technology innovation
- Government should support certification programs that help support the Canadian brand
- Better understand public (particularly youth) perspectives/opinions of mining
- Do a better job of connecting mining with the products and technologies that people use and rely on; address the disconnect between the perception of mining and perception of technology companies that use minerals
- Regulate consumer products to contain prescribed amounts of sustainably mined materials to drive change

### 3.3 Opportunities and Constraints

*What do you see as the opportunities and constraints related to realizing the model?*

#### Opportunities

**Responsible sourcing:** growing markets for certified products enable traceability via block chain. Socially responsible metals can be marketed (e.g. MBW, Apple), and responsible sourcing provides a significant opportunity for Canada. Leverage the Future of Mining model as part of the Canadian brand; this is a differentiator we can use to market Canadian goods and services to the world.

**Support SME innovators and suppliers:** through, for example, commercialization SVCs, funding, network and HQP; creating more challenges like the Crush It Challenge to spark innovation; learn from other cutting-edge industry in Canada (e.g. A1 Hub in Montreal).

**Host a test mine:** Own a test mine (an operating mine) and build it as a mine of the future; use it for technology testing, and incorporate zero waste, local equity; use it as a living lab; use innovation prizes or other competitive models (e.g. Dragon's den) to attract entrepreneurs and new technologies. We could also use orphaned and abandoned mine sites to build sensor capacity.

**Adapt and adopt from other sectors:** Look inside and outside our industry to look at existing technologies that we can adapt and deploy in the mining sector

**Remediation economy:** create and export the remediation economy. This is a way to codify and sell Canadian expertise and help other countries address legacy sites.

**Make Canadian standards global standards:** creating the 'benchmark' for good practice would create conditions for Canada to export its technologies, practices and know-how. This was noted both as an opportunity and a constraint.

**Enhance credibility through independent audit:** Use independent ESG audit to certify claims and performance to enhance credibility and acceptance

**Indigenous knowledge:** there is an opportunity for the industry to apply traditional ecological knowledge to inform planning and operational decisions.

**Public acceptance:** there is an opportunity to enhance public confidence and acceptance in mining through multi-stakeholder approaches to policy development.

#### Constraints

**Lack of united vision:** the lack of a common vision for mining is constraining our ability to move towards the Zero Waste Mine.

**Siloed approach:** the lack of a holistic view presents a major constraint to implementation. We tend to look at components, rather than the whole system.

**Pace of change:** the rapid pace of change is a constraint.

**Access to talent:** this is a constraint, particularly as our work force ages. How do we make this sector attractive for younger generations (e.g. brand mining as sustainable /develop flexible/better working conditions)? How does education (e.g. engineering curriculum) need to change?

**Lack of diversity:** the lack of diversity within the industry is a significant constraint.

**Lack of funding for extraction and processing:** The Government of Canada spends a lot of money on geosciences to find deposits but far less on supporting extraction and processing.

**Short-termism:** Board members of mining companies focus on short-term return and are often not thinking holistically and long-term.

**Current business model:** Our CapEx-dependent economic business model is a constraint, as we consistently underestimate the future of CapEx.

**Restrictions on tailings reprocessing:** current restrictions on reprocessing of tailings are very limiting (i.e. reprocessing requires a new mining operation and may involve taking on site liability).

**Restrictive definition of waste:** the current definition of waste in the regulatory regime is a constraint that we need to address.

**Restrictive disclosure requirements:** National Instrument 43-101 on the *Standards of Disclosure for Mineral Projects* has a restriction on adoption of technologies.

**Lack of IP policy:** The lack of an IP policy across the industry prevents us from moving towards this Future of Mining model.

**Lack of incentives to shift exports towards zero waste products:** Suppliers have business opportunities to export lower-standard products (e.g. high emissions). We need to incent them to export lower emission products.

**Prescriptive and Restrictive Regulatory Model:** The regulatory model can require two field seasons of data rather than allowing for the use of AI and predictive analysis. There is an opportunity to move to complementary virtual modelling, however there are some concerns with the processing of site data.

**Design engineering mindset:** Mining engineers will need to change their mindset in design (e.g. to have no tailings in the mine).

**Increased cost uncertainty:** A mine of the future may cost more to design and operate. There is a lack of a full business case for the lifecycle of a mine of the future.



### 3.4 Process to Build Support

*How can we best obtain consensus and buy-in on the development of the model and supporting roadmap?*

**Singularity of purpose:** we want to establish a singularity of purpose (“a mass transformative purpose”) for the industry, that is value based. The vision would encourage the sector to approach all ore bodies as a zero waste mine.

**Model development is a journey:** we will need to involve all stakeholders in development so that they are part of the journey. We need to think of how to involve those we want to attract to the industry (diversity, youth, etc.), as well as how to understand and engage with our critics. We should reach out and involve the “Canadian Gretas”; that is, those with a sincere desire to change and chart the future. Our goal is to raise the bar for everyone in the industry progressively on the journey towards 2050.

**Overall approach should be ambitious:** “Think big. Test small, scale fast.”

**Broad vision:** Need to engage holistically about all dimensions of zero waste mine (e.g. energy), and clearly link zero waste mining to the low carbon future. Mining as an important contributor to the low carbon economy (‘you can’t fight climate change without mining’).

**Envision future conditions:** the 2050 world will be different than today. We will have mine feedstock, reprocessed tailings and urban mining; urban mining requires a definition so that concentrates of a certain quality are achieved and can be fed into processes.

**Need for an education and marketing campaign:** Canmet could act as a leader to inform and influence government decision makers (e.g. Finance). This will require an educational program targeting both the new generation and the old generation, policy makers and producers.

**Build from and communicate successes to date:** we should communicate all the good the industry is doing in order to help promote industry and the Canada brand. This can build from existing CMMP and MAC campaigns. Urbanities and millennials are important target audiences.

**Consider visibility to the consumer:** The Future of Mining has to be visible to the consumer and understood. This will require education, a roadshow, and marketing campaign with a broad range of stakeholders including ‘opponents’ (e.g. Mining Watch).

**Consider branding for the non-mining community:** how do we sell this concept to the non-mining industry, to investors (e.g. Elon Musk, James Dyson), to bankers (who operate on a life cycle basis rather than minimal CapEx)?

**Compelling business case:** to bring the business community on board, we will need to present a compelling business model that demonstrates this vision makes sense; that sustainability is profitable. This will involve quantification of all aspects. The business case should consider mines of all sizes.

**Define the client and objective to drive investment into the sector:** clients would include governments, investors, and the public (communities). (It was noted that mining companies can have difficulty agreeing on things.) There is an opportunity for the Canadian government to take a leadership position in bringing the mining innovation ecosystem together.

**Showcase clean plants:** can we show people what a clean Canadian mining operation is today? And what it will be in 10 years? In 20 years? This is one way to “make mining cool again” and can be

shown to university students from a range of programs.

**Ensure strong closure practices:** as an industry, we have to ensure we close mine sites properly along the way and deal with legacy issues.

## 4. Conclusion

CanmetMINING appreciates the participants' contributions and high level of engagement throughout the forum. The CanmetMINING team will carefully review the input received during the forum to inform next steps, including scoping the Future of Mining model. Canmet will also consider whether and how to include additional perspectives in future meetings and work on the model (e.g. youth).

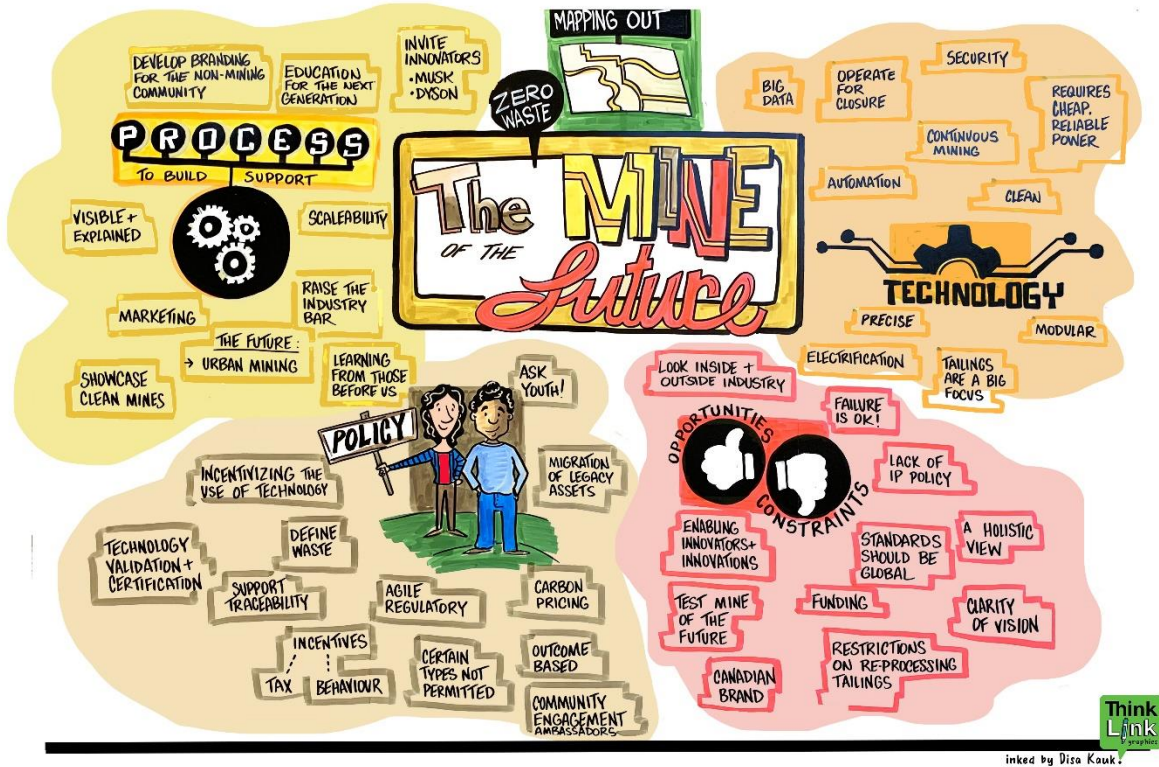
## Appendix 1: Participant Agenda

### Draft Agenda - Green Mining Innovation Forum December 17, 2019 | Room 221 – 555 Booth Street, Ottawa, Ontario

<p><b>Theme:</b></p> <ul style="list-style-type: none"> <li>• <b>The Future of Mining</b></li> </ul> <p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>• Report on CanmetMINING R&amp;D progress made since last year &amp; link to the new Integrated Business Plan</li> <li>• The Future of Mining: review model proposals, identify R&amp;D gaps and way forward</li> </ul>
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08:00 - 08:30	Registration - <i>Please note that you will need valid I.D. to present to the Commissionaires in the lobby</i>
08:30 - 08:40	Opening Remarks <ul style="list-style-type: none"> <li>• <i>Magdi Habib, Director General, CanmetMINING, Natural Resources Canada</i></li> <li>• <i>Pierre Gratton, President and CEO, Mining Association of Canada</i></li> </ul>
08:40 - 09:20	Update of CanmetMINING R&D and progress under the new Integrated Business Plan <ul style="list-style-type: none"> <li>• <i>Impact and Key Initiatives of CanmetMINING – Magdi Habib</i></li> <li>• <i>Integrated Business Plan implementation &amp; EMMC Deliverables for 2020 – Patrick Chevalier</i></li> <li>• <i>Transformative Technologies and the New Frontiers – Kristie Tarr</i></li> <li>• <i>Mining Value from Waste, Critical Minerals and Green Mining Innovation – Janice Zinck</i></li> </ul>
09:20 - 09:50	Breakout Session – R&D priorities and Integrated Business Plan – way forward for CanmetMINING
09:50 - 10:20	Breakout session reports and plenary discussion
10:20 - 10:35	Health Break and Networking
10:35 - 12:15	The Future of Mining – Models, Road Maps and Perspectives 10:35 – 10:45 Future of Mining – Setting the Stage: Magdi Habib 10:45 – 11:05 Adriaan Davidse – Deloitte 11:05 – 11:25 Roby Stancel - VCI 11:25 – 11:45 Ryan McEachern - Mining Suppliers Trade Association Canada 11:45 – 12:05 Nathan Stubina – Sherritt International 12:05 – 12:15 Q&A
12:15 - 13:15	Lunch Break and CanmetMINING Innovation room (Room 323) - open visit
13:15 - 14:45	Breakout Session—building the elements of an integrated approach to future mine development
14:45 - 15:00	Health Break and Networking
15:00 - 16:00	Breakout session reports and plenary discussion
16:00 - 16:15	Co-Chair summaries and closing Remarks

## Appendix 2: Graphic Recorder Images



inked by Dina Kauk.



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