Preamble

Document context

Background

- The mining industry generally agrees that it is behind the curve when it comes to innovation and that a focused effort is required to create sustainability within the industry

- The Canada Mining Innovation Council (CMIC) created the Towards Zero Waste Mining innovation strategy, together with several leading mining companies, to help transform the industry through innovation and reducing the barriers to technology adoption

- CMIC is addressing these challenges by promoting an open innovation business ecosystem culture in mining, to help resolve industry issues. This model has been successfully deployed globally for a number of industries and CMIC is leveraging off of that considerable experience and make it relevant for Canadian mining companies

Document Purpose

- Define the Business Case for the Towards Zero Waste Mining strategy making relevant to both Government and Canadian mining firms (as well as other service providers and third parties to the industry)

- Attract industry and government investment for this initiative

Source Data

- This document contains information from a number of different sources (CMIC representatives, external service providers, mining companies, government repositories, and analyst insights). The business case attempts to consolidate all of these and present a compelling case to justify stakeholder participation

- In certain instances only draft documentation was available for interpretation and analysis. Therefore, it is acknowledged that some information within this business case maybe refined at a later stage once the information has been finalized. Furthermore, the business case provides quantitative measures for consideration. Assumptions and qualifications for these have been detailed on the relevant business case pages

- The relationship between CMIC and Monitor Deloitte is defined in accordance with the terms of an agreement between the parties
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Mining in Canada

- Impact to the Economy
- Current State of Mining
- Current State of Mining Innovation
- Government Perspective on the Economy and Mining
- Industry Collaborative Approach
Mining in Canada > Impact to the Economy

Mining is important to the Canadian economy both in terms of its monetary significance and geographic scale.

Mining Contributes Significantly to the Canadian Economy

- **$54B (3.4%)** Contribution to GDP (2013)
- **$6.6B** Fiscal Contribution (2012)
- **$160B** Expected Project Investment in Next 10 Years
- **$46.9B** Mineral Production (2013)
- **383K** Number of Canadians Directly Employed
- **121K** Expected Additional Employees in Next 10 Years

Top First Nations Employer

The mining industry is the largest private sector employer of Aboriginal people in Canada.

Mining Impacts the Whole Nation

Mining is one of Canada’s primary industries. Its operations impact Canadians from coast to coast.
The Canadian mining industry is at risk and needs to adapt to a new reality of increasing complexity...

Structured labour market forces, declining resource quality, and a legacy of inefficient capital allocation have led to declining productivity (i.e., declining labour productivity, increasing capital intensity, and decreasing mining intensity)

High energy consumption, elevated input costs (e.g., energy, infrastructure, labour, royalties, permitting fees, and compliance), and critical shortages in energy and water have resulted in increasing energy intensity, decreasing margins and diminishing economic feasibility of new mine developments

Concerns from multiple stakeholders including conservation and the potential environmental impacts of mineral development and mine closure have resulted in increasing government regulation and demand for heightened corporate social responsibility and stakeholder engagement

Volatile commodity prices have resulted in unpredictable margins, forcing companies to plan for the unforeseeable, and decreasing financing capital availability

Further details and analysis on the Current State of Mining in Canada is outlined in the Appendix
...which is decreasing the viability of mining in Canada

Declining Profitability
Based on current trends and future projections, costs will likely continue to increase over time. Historical cost cutting exercises (e.g., layoffs) are not sustainable and without a significant shift, margins may decrease to a point where mining operations are no longer profitable.

Underperforming Shareholder Return
With mining’s total return to shareholders underperforming other sectors, companies are under mounting pressure to boost short-term profits, often at the expense of long-term planning. Passing on long-term, possible high return investments, results in further decreasing shareholders performance.

Future of Mining Projects Increasingly Under Risk
Significant price risk exposure associated with volatile commodity prices provides little comfort to investors and rating agencies, resulting in declining equity financing and as a result firms are scaling back exploration activity. Combined with the widespread exits from exploration by the majors due to budget cuts, the long-term future supply pipeline looks increasingly under risk.

Source: (1) Société Général, 2013; (2) “Deloitte tracking the trends 2015 – the top 10 issues mining companies will face this year.”
Stagnant investment in mining innovation activities in Canada has resulted in lost ground to international competitors.

**Mining Industry Investment Gap**

Canada’s international mining competitors have invested substantially more than Canadian companies in mining innovation, research and development to address the industry wide complexities and challenges. For example, in recent years, Australian firms have invested more than four times as much in research and development as Canadian firms.

**Examples of Canadian Government R&D Spending**

1. **Mining** - $22M via. Targeted Geoscience Initiative
2. **Manufacturing** - $200M via. Advanced Manufacturing Fund (AMF)
3. **Forestry** - $100M via. Forest Investment in Forest Industry Transformation (IFIT)
4. **Automotive** - $750M via. Automotive Investment Fund (AIF)
5. **Aerospace** - $1.15B via. Strategic Aerospace and Defence Initiative (SADI)

While the Canadian government has showed initial signs of commitment to the mining industry through funding of NRCan initiatives such as the $22M allocation to renew the Targeted Geoscience Initiative, these funds will only support a subset of mining players. **There is still need to develop a structured financial support system** for innovation research and development to address other critical industry challenges.

Source: (1) OECD StatExtracts Data; (2) Canada’s Economic Action Plan; (3) Natural Resources Canada Data
Lack of investment is evident in the immature innovation agendas of Canadian mining companies...

Canadian mining companies’ innovation programs lack maturity and do not adequately address industry challenges. Studies indicate that the vast majority of Canadian mining companies have yet to successfully implement structured innovation programs to properly address mining challenges. The majority of major mining companies are sporadic with their innovation efforts.

While junior miners are more mature innovators than major miners, all companies have some distance to go before their innovation capabilities can be considered excellent or leading edge.

Scale of 1-6 (low to high maturity)

1. NOVICE
2. SPORADIC
3. COMPETENT
4. ADVANCED
5. EXCELLENT

HIGHLY RANDOM EFFORTS
- Innovation capability not considered a key strategic imperative
- No disciplined approach to innovation; haphazard processes, governance, and resourcing are the norm

FRAGMENTED EFFORTS
- Need for systemic innovation capability often recognized
- Pieces of an innovation system begin to emerge

INCREASINGLY REPEATABLE
- Systemic innovation capability is nascent, leadership is taking action to develop maturity
- Pockets of a reliable and repeatable innovation system are surfacing

SYSTEMATIZED EFFORTS
- Critical capabilities for innovation functioning as a cohesive system are being developed
- Clear innovation strategies are emerging and an innovation system is well defined

ADAPTIVE CAPABILITY
- Innovation becomes an organizational core capability
- Innovation systems are refined and specialized capabilities are created to adapt to new opportunities and accelerate outcomes

...which have yet to successfully implement innovation programs to propel the industry forward

- While some Canadian mining companies have indicated that they invest in innovation, research indicates that 80% of companies realize **below expectation results from their innovation efforts**
- In comparison to adjacent Canadian industries and global competitors, Canadian mining companies are **behind the curve** in the success of their innovation programs
- Canadian mining companies need to **work together and rethink their approach** to innovation in order to meet or exceed the success of their global mining competitors

**Research Indicates that Canadian Mining Companies Are Not Meeting Their Innovation Expectations**

![Bar chart showing the distribution of innovation expectations for mining in Canada compared to services.](chart.png)

Source: (1) Roby Stancel, VCI Monitor Deloitte.
The Canadian government acknowledges that it must ensure the prosperity of the industry within Canada and make it a priority.

**Investment in Mining is Consistent with Canada’s Stated Priorities**

The CMIC Towards Zero Waste Mining strategy addresses several federal government priorities.

**Select Canadian Government Priorities**

- Supporting Entrepreneurs, innovators, and World-Class Research
- Addressing Environmental Challenges through Clean Technology
- Ensure the use of Clean Technologies in the Resources Sector
- Increasing Aboriginal Peoples’ Participation in Canada’s Resource Economy

**Example NRCan Investment Commitments**

- $2M / year Towards Mining Innovation
- $10M / year Towards Mineral Investment
- $5M / year Targeted Geoscience Initiative
- $35M / year Geo-Mapping for Energy and Minerals
- $4M / year New Energy Supply
- $42M / year Energy Efficiency
- $126M / year Materials for Energy Technology Innovation
- $115M / year Clean Energy Science and Technology Innovation
- $7.4M / year Green Mining Technology Innovation

Source: (1) Ministerial Mandate Letters

Monitor Deloitte.
Government is in a position to help promote the sustainability of mining in Canada for years to come.

The mining industry faces several challenges including declining productivity, increasing costs, increasing license to operate, and volatility of commodity prices, all of which impact bottom line\(^1\).

The extent to which mining companies contribute to the Canadian economy, either through direct / indirect employment or taxes and royalties, depends on their ability to operate profitably\(^1\).

The mining industry is undervalued and receives little structured financial support from the Canadian government.

Considering the importance of the industry to Canada’s economy, there is need for the Canadian government to provide required financial support to overcome challenges, remain profitable, and compete on a global scale.

Source: (1) “Mining Association of Canada – Facts & Figures of the Canadian mining Industry 2014”
With the success of the Canadian mining industry at risk if current trends continue, an innovative approach is required to address these issues.

- The sustainability of the Canadian mining economy is at risk if current trends continue.
- Mining business challenges will continue to grow, resulting in decreased productivity, increased costs, difficulty maintaining a license to operate, and continued short term decision making at the expense of long-term value creation.
- As each of the main business challenges ultimately impact mining operation profitability, mining companies will find it increasingly difficult to remain profitable and continue operations in Canada.

If no action is taken there will be a significant negative impact to the Canadian economy with the resulting factors all declining in the short term.

Therefore, the industry needs to innovate.

In order to make a significant shift in improvement to address the greatest mining challenges and maintain the immense contribution that mining provides to the Canadian economy, the industry must innovate and collectively challenge existing ways of thinking, by revisiting long-standing practices and processes.
Canada Mining Innovation Council

- About CMIC
- Collaboration Model
- Why CMIC?
Canada Mining Innovation Council provides a forum for change to enhance Canada’s position as a global mining leader

CMIC is a national non-profit organization comprised of over 74 members including mineral exploration, mining companies, service providers (mining & other), academia, research labs, as well as provincial and federal governments.

Why CMIC was created?
- Formed at the request of the industry, government, and academia to provide innovation leadership to the Canadian mining industry.

What CMIC does?
- Facilitates a participant-driven industry-academic-government innovation ecosystem connected through both parallel and sequential linkages to focus joint efforts on addressing Canadian Zero Waste mining challenges.
- Coordinates industry led Research Development and Innovation (RDI) projects and programs in response to pre-competitive challenges defined by industry members.
- Drives a culture of accountability, collaboration, and innovation.

CMIC’s Mission
- Enhance the competitiveness and sustainability of the Canadian mining industry by ensuring collaborative industry led excellence in research, innovation, and commercialization with the objective of Towards Zero Waste Mining™

CMIC’s Vision
- Re-launch Canada as a global leader in the mining industry through leading edge research and innovation.

Fundamentally Transforming Mining
CMIC facilitates interactions of parties within the mining innovation ecosystem to help them collaboratively address the highest need business challenges.

**CMIC Membership**

**General Partners** (CMIC member company representatives who):
- Determine and agree upon any pre-competitive issues
- Define and prioritize business issues / challenges and associated programs for CMIC Technical Working Groups
- Are privy to IP in one way or form derived from project activities, although not immediately

**Project Partners** (CMIC member companies who):
- Provide “in-kind” support in the form of access to mining facilities and equipment for the testing and implementing of techniques or technologies
- Are involved as either Project Test Site Leaders, Technical Expert Groups, or occasionally in the Project Management Office, and contribute to activities of project implementation and testing, ensuring adherence with the project roadmap and government regulations
CMIC’s open innovation model fosters innovation while managing complexity through a staged concept horizon and phased clarity of implementation.

**Sources of Inspiration for the CMIC Model**

- **Launched in 2012**, is now comprised of 13 oil sands producers. Focused on accelerating the pace of improvement in environmental sustainability in Canada’s oil sands **through collaborative action and innovation**

- **Created in 2001** by IBM, is now comprised of over 80 technology industry members. **Designed as a collaborative, industry led innovation network with a mission to solve key industry issues by helping members combine resources to solve common problems and decrease costs**

- **Formed in 1959**, is now comprised of 75 mining and supplier companies. **Created to develop, facilitate, and manage collaborative research projects for interested parties. Projects are funded by sponsors who choose to commit funds prior to the commencement of a relevant project**

**Clarity of Implementation**

- Stages provide logic for decision making and expedite the innovation process as aspirations are clearer.
The open innovation model means CMIC partners invest in a collaborative process which helps industry yield maximum benefits...

CMIC’s open innovation model surmounts the challenges hampering productive innovation partnerships between miners and suppliers...

Research indicates that transactional approaches and lack of aligned common understanding of project objectives hampers productivity in collaboration between miners and suppliers:

- Transactional approach to relationship, rather than value based: 28%
- Lack of aligned and common understanding of the objective for the partnership: 17%
- Lack of understanding of each other’s business models and incentives: 15%
- Processes, systems, and culture are mismatched: 14%
- Constraints on sharing information with each other: 13%
- Incentives are mismatched: 10%
- Lack of trust due to previous behaviour: 8%

... enabling the maximum benefits (qualitative and quantitative) associated with collaboration, which include:

- **Decreased Risk**: Pooled resources decreases the risk associated with investments in innovation
- **Cost Savings Gained**: Pooled investments create a larger fund to devote towards higher benefit yielding projects
- **Resources Efficiently Allocated**: Process structure and operating protocols ensure resources are best allocated
- **New Ideas Generated**: Networking opportunities and working groups create environments ripe for idea generation
- **Access to Knowledge Leaders**: Access to highly experienced and knowledgeable industry leaders to help address challenges faced by your company
- **Solutions Generated / Implemented Faster**: Through collaborative effort and extensive access to resources, solutions are generated / implemented faster

Source: (1) Roby Stancel, VCI Monitor Deloitte.
**Large Scale: Goldcorp**

In 2000, Rob McEwen, the former CEO of Goldcorp, launched the “Goldcorp Challenge” to improve an underperforming gold mine in Ontario. The Goldcorp Challenge attracted ~1,500 scientists, engineers, and geologies from more than 50 countries that all competed for the purse of ~$600,000. He recognized that engaging external innovators and experts could decrease his cost, while significantly increase his chances of success to make this mine profitable.

In just one year the previously underperforming gold mine produced ~504,000 oz at a cost $59 / oz., with a gold price of $307 / oz.

Goldcorp spent $1 million to find $3 billion worth of gold reserves.

By taking advantage of the open innovation model, Goldcorp transformed an underperforming company valued at ~$100M into the world’s second largest gold company valued at ~$6B.

**Small Scale: Dundee Precious Metals**

From 2009 to 2013, Dundee Precious Metals invested in a mine expansion project at their Chelopech Mine. The objective of the project was to change the mining method and ore handling philosophy, while keeping the equipment fleet and the workforce numbers relatively constant.

The company realized that this mine was operating below its potential, and that there was room for improvement in mining intensity; especially, in relation to mine design, technology and operating practices.

The project was focused on reducing process variation to bring the mine up to its potential capacity. To do this Dundee Precious Metals imported existing technology from the manufacturing industry to deliver real-time information to drive “Short Interval Control”.

By taking advantage of an existing technology it allowed them to create value in the short-term. Over the course of the project, the mine doubled it’s production from 1 million tons per year to 2 million tons per year.

**With this implementation**, the Chelopech mine is driving an annual benefit of over $200 million per year.

Source: (1) “The Canadian Business Journal - Open innovation and the world’s second largest gold company”; (2) Discussion with internal CMIC member (3) CMIC Case Studies: Dundee Precious metals - Chelopech Mine - Bulgaria
CMIC’s vision enhances and complements goals of other mining innovation organizations in Canada

CMIC aspires to make Canada a global leader in the mining industry through leading edge research and innovation focused on driving Towards Zero Waste Mining™. It does this by:

- Developing technical roadmaps for its initiatives
- Focusing on pre-competitive issues
- Extending its scope industry wide, across Canada
- Leveraging existing assets, people, organizations, and knowledge
- Covering the innovation spectrum with a long term focus by not being solely project based
- Forging partnerships with all of the key industry players

CMIC is working toward the above objectives in conjunction with a couple other organizations, including COSIA and NRCan:

COSIA enables sustainable growth of Canada’s oil sands. CMIC has significant alignment with COSIA’s innovation approach and areas of transferable technology

NRCan aspires to boost Canada’s economic competitiveness. CMIC is collaborating with NRCan to access funding through its 2017 budget process

FPInnovations fuels the growth and prosperity of the forest sector. CMIC & FPInnovations have formed a strategic partnership and are currently exploring opportunities in waste energy recovery.

CMIC intends to leverage expertise from other Canadian mining innovation organizations where relevant to achieving the goals of Towards Zero Waste Mining™. CMIC does not intend on serving as an umbrella organization.

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Example Canadian Mining Innovation Organizations and their Focus

- **CEMI**
  - Be the leading source of innovation for the global mining industry

- **CAMIRO**
  - Develop innovations to improve the productivity, competitiveness, safety, and environmental impact of the Canadian mining industry

- **CanmetMINING**
  - Be a world class leader in the development and deployment of green mining innovation technologies

- **COREM**
  - Serve as the largest ore processing research centre in Canada

- **iMi**
  - Position Saskatchewan as the world’s most innovative / efficient minerals jurisdiction

- **NRC Canada**
  - Provide clients and partners innovation support, strategic research, and scientific and technical services

- **Mirarco**
  - Plan and design the mines and mine waste facilities of the future that conserve environmental integrity
CMIC’s Towards Zero Waste Mining Strategy

- What's Keeping Mining Executives Up At Night?
- Strategy Overview
- Portfolio Analysis, Benefits, and Roadmap
The Towards Zero Waste Mining strategy was inspired by mining executives’ top priorities.

- Making continuous mining more economical and efficient
- Environmental footprint reduction and more effective operations
- Comminution energy reduction
- Ability to reach ore bodies that are further away faster and in a safe manner
- Energy management and becoming more efficient with it
- Mine planning and better understanding of ore bodies to allow for efficient mining
- Water usage, availability, and efficiency is a challenge
- Access to real time data – strong drive to improve the ability to make decisions and monitor operations from large data sets in real time
- Improvements in safety to benefit employees, as valued company assets

Mining executives’ top priorities can be clustered into 8 cross-disciplinary and linked Zero Waste mining issues which are keeping mining executives up at night.
The result is a Towards Zero Waste Mining strategy that will lead the transformation in the mining industry to attain future state mining objectives...

The complexities faced by the Canadian mining industry (e.g., declining productivity, increasing costs, increasingly complex license to operate, and operating with uncertainty) are broad terms which impact upon a number of areas within mining. In order to resolve these, mining companies need to practically address certain key objectives to accomplish a more efficient future mining state. These objectives are defined below and correlate to the identified pre-competitive challenges that have been defined by executives.
CMIC’s Towards Zero Waste Mining Strategy > Strategy Overview

... by initially addressing the five most pertinent Zero Waste mining issues through implementable portfolio roadmaps

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<tr>
<th>From Zero Waste mining issues...</th>
<th>...to actionable Portfolio Roadmaps</th>
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<tr>
<td>Exploration</td>
<td>Exploration is an increasingly costly exercise in terms of time and resources as grades are declining and deposit discovery is more difficult. The industry must become more efficient in finding deposits at a lower cost to increase environmental sustainability and curb erosion of shareholder margins. CMIC’s Exploration technical working group seeks to significantly reduce exploration costs</td>
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<tr>
<td>Continuous Underground Mining</td>
<td>The migration from drill and blast mining to continuous mining needs to be accelerated further as it is safer and more efficient. CMIC’s Mining technical working group is developing the Roadmap for underground mining to move away from drill and blast to continuous mining</td>
</tr>
<tr>
<td>Processing (Comminution Efficiency)</td>
<td>Comminution or processing is a highly energy intensive and largely inefficient activity which accounts for 3-4% of the world’s energy usage. CMIC’s Energy / Processing working group is scoping projects aimed at identifying the viability of waste energy recovery in comminution circuits for operating mines and also new technologies to significantly reduce energy consumption</td>
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<tr>
<td>Energy Efficiency</td>
<td>Tailings are a key environmental issue for the public and if mismanaged can create catastrophic consequences. Based on discussions and interviews with industry, CMIC extends its focus in Environmental Stewardship beyond tailings to the other environmental challenges such as Water and (Mine) Closure. The Environmental Roadmap has identified key projects within each of these categories</td>
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<td>Environmental Management</td>
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In order to implement these roadmaps, government and industry investment is required.

In order to facilitate the collaborative innovation agenda within the mining industry, CMIC and its industry members have identified a total of $89.6M in funding requirements over the first 5 years. CMIC, together with industry participants, will then prioritize projects based on actual funds received. Further funding details and breakdowns are provided in the following slides.

### Portfolio Funding Requirements

<table>
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<tr>
<th>Portfolio</th>
<th>Total Funding</th>
<th>Industry/Partners</th>
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<tbody>
<tr>
<td>Exploration</td>
<td>$18M</td>
<td>$8M</td>
</tr>
<tr>
<td>Underground Mining</td>
<td>$31M</td>
<td>$13.5M</td>
</tr>
<tr>
<td>Energy/Processing</td>
<td>$21.7M</td>
<td>$10.9M</td>
</tr>
<tr>
<td>Environmental Stewardship</td>
<td>$18.9M</td>
<td>$7.1M</td>
</tr>
</tbody>
</table>

### Funding Breakdown

- **Total Funding Requirement**: $89.6M
- **Government (56%)**: $50.0M
- **Industry: Cash (6%)**: $5.8M
- **Industry: In-Kind (30%)**: $26.7M
- **Partners (8%)**: $7.1M

2 - In addition to industry and government funding contributions, CMIC plans to leverage (and is leveraging) cash and in-kind funding input from other groups (approximately 15-20, including public sector organizations, private industry, and service providers). It is expected that additional funding from these groups will be identified when projects are further defined.
CMIC’s Exploration portfolio addresses common challenges in mining exploration

**Exploration Portfolio Overview**

- Exploration is one of CMIC’s four project portfolios. The Exploration portfolio was developed to address four common themes in mining exploration, including:
  - **Discovery criteria**: where to look and what to look for?
  - **Discovery and delineation technology**: how to detect?
  - **Data to knowledge**: how to use data to understand geological formations?
  - **Linking exploration to mining and processing**: how to more effectively use exploration data to make mining decisions?

**Key Challenges the Exploration Portfolio Addresses**

- To sustain economic benefit to the Canadian economy, the current level of *exploration needs to be sustained or increased*, as current reserves present a *significant decline especially in base metals*

- The next generation of large mineral deposits will lie in deeper environments. Attention needs to be focused on *development of better ore system models, new technologies, and software* that will allow for better knowledge of *deep, sub-surface domains* based on sparse datasets

- Mining companies find exploration in Canada difficult for the following reasons:
  - **Lack of infrastructure** (e.g., roads and rail) in much of Canada’s more remote northern areas *results in increased cost of exploration and development*
  - **Success rates are low** in many areas of thick glacial overburden, lacustrine clays, and sands. These blanket much of Canada’s northern Shield and cover large regions of highly prospective geology (due to the fact that these types of sediment tend to mask the geophysical and geochemical signals for most common exploration instrumentation and methods)
  - Systematic **regional geological mapping at an appropriate scale** by geological surveys is *limited* for many of the unexplored regions of Canada

Source: (1) CMIC – Innovation, Research and Development Needs in Mineral Exploration, April 2008

Monitor Deloitte
The Exploration portfolio’s goal is to achieve a 25-30% increase in value added versus exploration expenditure.

- An expert background paper on innovation, research, and development needs in mineral exploration has been completed. This document identifies:
  - The current state of exploration in Canada
  - Who is doing what in mineral exploration science
  - High level funding priorities
  - Potential partners for exploration research
  - Key barriers and pressure points to exploration advancement

- The final version of the strategic exploration innovation roadmap, including projects, objectives, and staged targets has been completed. While the roadmap is complete, project generation, prioritization, and implementation will be an iterative process.

- Select research projects are funded and currently in the planning and implementation phase. Estimated implementation budgets include:

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<th>Short-term (1-2 Years)</th>
<th>Medium-term (&gt;2 Years)</th>
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<tbody>
<tr>
<td>Gov’t</td>
<td>$0M</td>
<td>$10M</td>
</tr>
<tr>
<td>Industry (Cash)</td>
<td>$0.25M</td>
<td>$1M</td>
</tr>
<tr>
<td>Industry (In-kind)</td>
<td>$0M</td>
<td>$5M</td>
</tr>
<tr>
<td>Partners</td>
<td>$0M</td>
<td>$2M</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$0.25M</td>
<td>$18M</td>
</tr>
</tbody>
</table>

- The Exploration portfolio goal is to achieve a 25%-30% increase in value added vs. exploration expenditure.

- Participation in the roadmap projects will provide industry an opportunity to benefit from improved exploration criteria, technology, expertise, and exploration techniques.
The Exploration technical working group addresses select business challenges to deliver tangible objectives and outputs, staged over 10 years.

<table>
<thead>
<tr>
<th>Topic</th>
<th>1 - 3 year Target 5 – 10% Efficiencies</th>
<th>3 - 5 year Target 10 – 15% Efficiencies</th>
<th>5 - 10 year Target 25– 30% Efficiencies</th>
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<tr>
<td>Discovery Criteria (Terrane selection, area selection, and ore system vectors)</td>
<td>Identifying domain scale bedrock fertility indicators and 3D modeling of the nature and extent of major ore systems</td>
<td>Understanding pathfinder element migration paths through surficial overburden, surface water, and vegetation</td>
<td>Integrated exploration indices for domain scale fertility, ore system identification, and targeting vectors</td>
</tr>
<tr>
<td>Discovery Technologies (More effective detection; more efficient tools / protocols; and commercialization of new technologies)</td>
<td>Understanding the links between survey results and rocks</td>
<td>Semi-autonomous ground and airborne detection and sampling of overburden covered terranes</td>
<td>Unmanned, remotely sensed deep and under cover targeting, autonomous drill vectoring, and real time geochemical; geometallurgical and geotechnical analysis</td>
</tr>
<tr>
<td>Data to Knowledge (Accessible, standardized, and integrated data; cost effective visualization and modeling)</td>
<td>Scaling point source data to rock characteristics and to potential field results</td>
<td>Interoperable and relational databases incorporating potential field and point data; 3D inversion modeling of potential field and point data</td>
<td>Real time target analysis, 3D visualization, and resource modeling and definition</td>
</tr>
</tbody>
</table>
The possible savings from investment in the Exploration portfolio can be quantified based on yearly exploration expenditures.

In order to quantify the possible financial return to industry through investment in the Exploration portfolio, CMIC evaluated the 2014 financial statements of 13 mining companies and applied the expected increase in value add to industry exploration expenditure.

### Yearly Exploration Expenditure

Costs incurred in the initial search for mineral deposits with economic potential or in the process of obtaining more information about existing mineral deposits.

#### Short-Term Value Add Target (5-years):

- **Increase** the current industry wide average exploration value per dollar spent by 10-15%

#### Long-Term Value Add Target (10-15 years):

- **Increase** the current industry wide average exploration value per dollar spent by between 25-30%

<table>
<thead>
<tr>
<th>Category</th>
<th>Yearly Exploration Expenditure</th>
<th>Short-Term Value Add Target (5-years)</th>
<th>Long-Term Value Add Target (10-15 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Low Exploration Spenders’</td>
<td>$3-18M</td>
<td>$0.5-8M</td>
<td>$1-5M</td>
</tr>
<tr>
<td>‘Medium Exploration Spenders’</td>
<td>$41-80M</td>
<td>$6-12M</td>
<td>$12-24M</td>
</tr>
<tr>
<td>‘High Exploration Spenders’</td>
<td>$245-392M</td>
<td>$37-59M</td>
<td>$74-120M</td>
</tr>
</tbody>
</table>

**Assumptions and Qualifications:**

- Some expenditure figures include both “Business Development and Exploration” and are not broken down by Country, thus the increase in value add may not be relevant to the full expenditure amount.
- Value add calculations are high level and have not addressed the difference between gold / other mineral mining or greenfield / brownfield mining, thus the increase in value add may not be relevant to the full expenditure amount.
- Long-term value add targets are presented for three broad ranges based on approximate exploration expenditures.
- Exploration spend figures are reported in either USD or CAD.

*CMIC’s Towards Zero Waste Mining Strategy > Portfolio Analysis, Benefits, and Roadmap*
Underground Mining Portfolio Overview

- Underground Mining is one of CMIC’s four project portfolios. It’s mandate is to increase labour productivity and mining intensity rates through development of new technologies and optimization of existing technologies / processes. The technical working group for Underground Mining has identified five themes that will drive a technology roadmap and project development, including:
  - Continuous and automated mining
  - Ore processing and recovery
  - Real-time – Smart – Digital Mine
  - Mining in remote locations
  - Industry collaboration on technology and development

- A fundamental principle of the underground mining approach to is to focus on quick wins with existing technologies including combining technologies in new and creative ways, and then focus on technology development over the course of 5 or more years

Key Challenges the Underground Mining Portfolio Addresses

- Mining is 28% less productive today than a decade ago\(^1\)
- Many underground hard rock mines have progressed deeper in order to follow ore reserves, resulting more complex extraction, further away from the surface
- The costs of material, ventilation, and labour transport to the headings have increased and have thus decreased profit margins
- With decreased head grades, the energy required to extract minerals has increased
- With increased labor costs, decreased labour productivity, and increased capital costs, capital intensity has decreased

The Underground Mining portfolio’s vision is to increase production rates by focusing on labour productivity and mining intensity.

- **Project Objectives**
  - The Underground Mining portfolio goal is to achieve:
    - A 200% increase in labour productivity within 5 years
    - A 20% increase in mining intensity within 5 years
    - Concomitant increases in capital intensity
    - Reductions in energy and unit costs

<table>
<thead>
<tr>
<th>Stage of Development</th>
<th>Real-Time Continuous Underground Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gov’t</td>
<td>$17.5M</td>
</tr>
<tr>
<td>Industry (Cash)</td>
<td>$2.2M</td>
</tr>
<tr>
<td>Industry (In-kind)</td>
<td>$11.3M</td>
</tr>
<tr>
<td>Partners</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$31M</strong></td>
</tr>
</tbody>
</table>

- **Current stage of development**
  - A roadmap workshop in March 2015 was carried out to discuss:
    - Top down issues
    - Needs
    - Questions
    - Solutions
  - From this workshop, a preliminary roadmap was created which will be used to guide further development of the portfolio.
  - The industry working group is in the process of further defining the themes into a roadmap and potential projects. A complete roadmap is scheduled to be completed by Q4 2015.
  - Completion of the Underground Mining Roadmap requires additional time and resources (e.g., fulltime lead).
  - To date, two projects have estimated budgets required for full implementation:

CMIC’s Towards Zero Waste Mining Strategy > Portfolio Analysis, Benefits, and Roadmap

The Underground Mining technical working group will address select business challenges to deliver tangible objectives and outputs, staged over 10 years

CMIC is in the preliminary stages of developing a detailed underground mining roadmap, below is a preliminary draft of staged targets over the next 10 years

<table>
<thead>
<tr>
<th>Topic</th>
<th>1-3 year Target</th>
<th>3-5 years Target</th>
<th>5-10 years Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Develop continuous mucking based on drill and blast</strong> <em>(Dealing with over size, machine size and working with existing mine layouts)</em></td>
<td>Develop a continuous mucking process that is 3 times existing production rates</td>
<td>Commercialize and integrate with expandable ore hoisting process</td>
<td>Integrate continuous drilling and blasting into continuous mucking to create a true continuous production process</td>
</tr>
<tr>
<td><strong>Build an ore hoisting process that is expandable</strong></td>
<td>Develop a continuous and expandable hoisting processing based on existing technology. Flex up to 200%</td>
<td>Commercialize and integrate with development and continuous mucking to produce a step change in mining intensity</td>
<td>Ore transportation and hoisting system capable of flexing up to 200% with little additional capital costs</td>
</tr>
<tr>
<td><strong>Increase single heading advance rates</strong> <em>(Adopt Lean principles and sustain manager level capability. Additionally there is a need to blast at any time and for blasting to be isolated from production operations)</em></td>
<td>Develop technology &amp; work practices to increase single heading advance rates by 200%</td>
<td>Mechanical cutting for development. Step change in single heading advance rates</td>
<td>Transform all ancillary mining activities to support new continuous production and development process. Integrate with Intelligent Mining project</td>
</tr>
</tbody>
</table>
The potential savings from investment in the Underground Mining portfolio can be quantified based on two financial drivers.

In order to quantify the possible financial return to industry through investment in the Underground Mining portfolio, CMIC reviewed three case studies where mining companies have achieved significant returns on investments focused primarily on labour productivity and mining intensity. Secondary benefits of energy and unit cost reduction as well increases in capital intensity have not been quantified.

<table>
<thead>
<tr>
<th>Underground Mining Unit Costs</th>
<th>Short-Term Value Add Target (3 - 5 years):</th>
<th>Long-Term Value Add Target (10 - 15 years):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Cost (base metals)</td>
<td>$55-89 / t</td>
<td>$11-18 / t</td>
</tr>
<tr>
<td>Unit Cost (gold)</td>
<td>$800 – 1,000 / oz</td>
<td>$160 – 200 / oz</td>
</tr>
<tr>
<td>Unit Cost (uranium)</td>
<td>$28 / lb</td>
<td>$6 / lb</td>
</tr>
</tbody>
</table>

Assumptions and Qualifications:
- The information from the financial statements is not specifically attributable to underground mining, therefore these figures will need to be confirmed prior to finalization of the business case.
- Long-term value add targets are presented for three broad ranges based on approximate unit costs for base metals, gold, and uranium from the financial statements.
CMIC’s Energy / Processing portfolio addresses common challenges in mining energy and processing

**Energy / Processing Portfolio Overview**

- Processing is one of CMIC’s four project portfolios. Its mandate is to **develop solutions to achieve more efficient mineral liberation using less energy and lower capital and operating costs**. The technical working group for Energy / Processing independently identified two streams to address common mining energy and processing challenges:
  - **Energy in Comminution** – Focused on reducing the waste energy in comminution by identifying new, viable technologies to significantly reduce energy consumption in comminution
  - **Waste Energy Recovery** – Focused on determining the cost effectiveness, benefits, and risks of existing and future waste energy recovery methods including demonstration studies of selected technologies
- A **technology roadmap and energy matrix tool** was completed identifying waste energy recovery technologies, application, efficiencies, and returns.
- An initial project to measure energy flows in a variety of grinding circuits commenced in June 2015 as a means to identify energy capture opportunities and potential technologies that may be implemented / tested
- As the projects develop, CMIC technical working groups will consider innovation research and development for new technologies when needs are identified by industry

**Key Challenges the Energy / Processing Portfolio Addresses**

- Comminution consumes approximately 3-4% of the world’s energy and up to 50% of the total energy consumed at a mine site. This is of particular concern given that **communion has an energy efficiency of approximately 5%**

- With energy accounting for an average of 15-22% of total mine operating costs, **significant innovation advances in comminution alone can yield major advances in energy efficiency, cost reduction, and possibly footprint reduction** with the use of new technologies

- Although progress has been made in **comminution technologies** over the past 40 years (e.g., HPG & Isamill), **energy efficiency is still an issue and a major concern** for the industry

- Energy recovery will **significantly increase energy efficiency in existing comminution circuits**

- The **roadmap** for this portfolio will be **finalized in Q4 of 2015**

Source: (1) CMIC: White Paper DRAFT Feb 3; (2) Tim Napier-Munn, U. Queensland / Coalition for Eco-efficient Comminution, 2012
The Energy / Processing portfolio’s goal is to achieve a 45% increase in comminution efficiency through energy consumption.

**Stakeholder Consultation**
- Engagement of industry stakeholders throughout the background research, roadmap development, and project implementation will be essential to the success of the projects.

**Background Research**
- A draft prefeasibility study and technology matrix for low grade waste energy recovery technologies has been completed. These documents outline existing technologies, costs, and possible ROI.

**Roadmap Development**
- A scoping study was launched and will be completed in Q1 2016. This study will identify technology opportunities to drive comminution efficiency.

**Project Implementation**
- An initial project to measure energy flows and determine the greatest opportunities for waste energy capture in a variety of grinding circuits will be completed in Q1 2016.

**Estimated budgets required for project implementation include:**

<table>
<thead>
<tr>
<th>Energy Efficient Comminution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gov't</td>
</tr>
<tr>
<td>Industry (Cash)</td>
</tr>
<tr>
<td>Industry (In-kind)</td>
</tr>
<tr>
<td>Partners</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
</tr>
</tbody>
</table>

- The Energy / Processing portfolio goal is to increase comminution efficiency from the current state of 5% to 50% in 10-15 years.
- Identify and pilot technologies for waste energy recovery in comminution circuits.
- Identify and pilot technologies to significantly improve the efficiency of grinding circuits.
- Participation in the projects will provide industry an opportunity to benefit from improved comminution efficiency and decreased energy and capital costs.


1. Comminution Technology Appraisal Study, CMIC Dec 2015
The possible savings from investment in the Energy / Processing portfolio can be quantified based on daily energy use.

In order to quantify the possible financial return to industry through investment in the Processing portfolio, CMIC acquired grinding circuit data from three operations and applied the expected reduction in energy use.

<table>
<thead>
<tr>
<th>Processing Capacity</th>
<th>Energy Use</th>
<th>Short-Term Value Add Target (5-years):</th>
<th>Long-Term Value Add Target (10-15 years):</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Small Mill Capacity’</td>
<td>8,000 t / day</td>
<td>11 MWh</td>
<td>2.2 MWh</td>
</tr>
<tr>
<td>‘Medium Mill Capacity’</td>
<td>80,000 t / day</td>
<td>93 MWh</td>
<td>18.6 MWh</td>
</tr>
<tr>
<td>‘High Mill Capacity’</td>
<td>&gt; 130,000 t / day</td>
<td>2,300 MWh</td>
<td>460 MWh</td>
</tr>
</tbody>
</table>

Assumptions and Qualifications:
- Long-term value add targets are presented for three broad ranges based on approximate energy consumption.
- Current energy efficiency is 5%, therefore 95% of energy put into grinding circuits is lost as waste.
- Different types of grinding circuits are represented in the three mill capacities incorporating SAG, SABC, AG / SAG / IsaMill.
CMIC’s Environmental Stewardship portfolio addresses common environmental challenges in mining

Environmental Stewardship Portfolio Overview

- Environmental Stewardship is one of CMIC’s four project portfolios. Its mandate is to develop solutions to the myriad environmental, sustainability, and competitiveness issues facing the Canadian minerals industry. The Environmental Stewardship working group members have identified three main focus areas through a scoping study and stakeholder surveys. The focus areas represent the greatest expenditures / long-term cost provisions related to environmental management. These include:
  - **Closure**: progressive rehabilitation, “walk-away” technologies / systems, and relinquishment
  - **Tailings**: technologies and strategies to produce benign tailings and enable in situ treatment of tailings
  - **Water**: baseline data, volumes, optimization, recycling, treatment, discharge, monitoring, and regulatory compliance
  - **Data Management / Data to Knowledge**: databases / knowledge repositories of environmental data; development of analytical / modeling tools to predict environmental performance and associated costs / liabilities.

Key Challenges the Environmental Stewardship Portfolio Addresses

- **Closure**: incremental reductions in long-term closure provisions and bonding requirements; reduction in in-perpetuity closure management; advancement in closure completion and relinquishment; prevention of abandoned / orphaned mines; advancement of “net positive impact”
- **Tailings**: reduction in environmental footprints / land use requirements; reduction in contaminant liabilities; initiative will link technical groups to develop whole-system approach, thereby preventing a “silied” approach
- **Water**: typically considered the most material sustainability issue from a social license perspective, especially with increasing water scarcity; achieve compliance with increasing regulatory requirements; advancement of “water neutrality”
- **Data Management**: reduction in variance between up-front planning and outcomes; more robust prediction of bonding requirements; increased data access and preservation for industry and stakeholders
The Environmental Stewardship portfolio’s vision is to achieve a 25% reduction in costs and liabilities for environmental management and compliance.

Background Research
- Specific projects within the larger program / portfolio have been defined and prioritized
- Feasibility studies are completed for the following projects:
  - **Water**: National Knowledge Hub for geospatial water quality data; Remote, real-time sensors for water quality monitoring
  - **Closure**: Standardized closure criteria for mine site relinquishment
- Feasibility studies are required for:
  - **Closure**: ARD management
  - **Tailings**: to be led by a cross-disciplinary committee involving all technical groups

Roadmap Development
- Final version of Environmental Roadmap including water, closure, and tailings objectives and staged targets has been completed

Project Implementation
- To date, three projects have estimated budgets required for full implementation:

<table>
<thead>
<tr>
<th></th>
<th>Knowledge Hub</th>
<th>Water Sensor</th>
<th>Closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gov’t</td>
<td>$7.0M</td>
<td>$2.4M</td>
<td>$2.2M</td>
</tr>
<tr>
<td>Industry (Cash)</td>
<td>$0.6M</td>
<td>$0.4M</td>
<td>$0.1M</td>
</tr>
<tr>
<td>Industry (In-kind)</td>
<td>$1.6M</td>
<td>$1.6M</td>
<td>$0.1M</td>
</tr>
<tr>
<td>Partners</td>
<td>$2.5M</td>
<td>$0.4</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$11.7M</strong></td>
<td><strong>$4.8M</strong></td>
<td><strong>$2.4M</strong></td>
</tr>
</tbody>
</table>

CMIC’s Towards Zero Waste Mining Strategy > Portfolio Analysis, Benefits, and Roadmap

The Environmental technical working group will address select business challenges to deliver tangible objectives and outputs, staged over 10 years.

<table>
<thead>
<tr>
<th>Themes</th>
<th>1-3 year Target Industry Needs Assessment 5% Cost Reductions</th>
<th>3-5 years Target Technology Acceleration 10-15% Cost Reductions</th>
<th>5-10 years Target Commercialization 20-25% Cost Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tailings (benign tailings, in situ treatment)</td>
<td>Linking CMIC technical groups and tailings technology clusters to develop whole-system approaches</td>
<td>Reduction in contaminant loadings; contaminant removal; ARD management; ML management; saleable waste products</td>
<td>25% reduction in tailings disposal and treatment costs; widespread reduction in environmental footprint</td>
</tr>
<tr>
<td>Water (volumes, process management, discharge, monitoring)</td>
<td>Mapping technology development / management approaches to optimize water consumption and treatment</td>
<td>Real-time monitoring; water re-use / recycling; closed-loop / zero-discharge operations; treatment with resource recovery</td>
<td>25% reduction in water management costs and liabilities; reductions in water use towards “water neutrality”</td>
</tr>
<tr>
<td>Closure (&quot;walk-away&quot; technologies / systems; relinquishment)</td>
<td>Iterative stakeholder consultation process to determine industry, regulatory, and government risk requirements</td>
<td>Passive systems; natural landform / applied geomorphological approaches; bio- and phyto-remediation; standardized criteria for relinquishment</td>
<td>25% reduction in closure liabilities and bonding requirements; advancement towards “net positive impact”</td>
</tr>
<tr>
<td>Environmental Data Management (data access, analysis, and preservation)</td>
<td>Assessment of current platforms, gaps, and needs; integration with existing modeling software; pilot-scale databases of environmental data</td>
<td>Analytical tools for determining environmental effects / impacts; scaled-up databases in major mining jurisdictions</td>
<td>Improved accuracy of predicted and actual environmental performance, costs and liabilities; comprehensive, national data portals linked to environmental data</td>
</tr>
</tbody>
</table>

Monitor Deloitte.
The possible savings from investment in the Environmental portfolio can be estimated based on different environmental expenditures

In order to quantify the possible financial return to industry through investment in the Environmental portfolio, CMIC evaluated the 2014 financial statements of 13 mining companies to determine areas of environmental expenditure and then applied the expected cost savings of 20%. Environmental expenditure varies widely across firms due to type of mining and different regulatory requirements depending on mine life stage and location.

<table>
<thead>
<tr>
<th>Types of Environmental Costs</th>
<th>Cost Ranges</th>
<th>Potential Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Remediation</td>
<td>$5-20M</td>
<td>$1-4M</td>
</tr>
<tr>
<td>Minor environmental cleanup; may be ongoing or once a mine has closed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Rehabilitation / Protection</td>
<td>$50-80M</td>
<td>$10-16M</td>
</tr>
<tr>
<td>Moderate environmental cleanup; may be ongoing or once a mine has closed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mine Reclamation Provisions</td>
<td>$30-200M</td>
<td>$6-40M</td>
</tr>
<tr>
<td>Major environmental cleanup; usually once a mine has closed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Possible Long-Term Yearly Savings: R&D and technology commercialization can lead to 20% reduction in costs and liabilities for environmental management and regulatory compliance.

Assumptions and Qualifications:
- Spend figures taken from company financial statements will need to be confirmed prior to finalization of the business case.
- Long-term value add targets are presented for three broad ranges based on approximate environmental costs.
- Environmental spend figures are reported in either USD or CAD.
CMIC incorporates multiple, agile project delivery models that leverage knowledge, facilities and investments...

1. **CMIC managed research consortia:** Our current exploration project is the largest geoscience consortia in North America, addressing explicit research needs for the industry.

2. **Project integration/coordination:** This clusters existing new mining projects, adds potential new project elements and accounts for multi-million investments being made by companies. This will be one component of our underground mining program.

3. **Technology Demonstration:** This accounts for new technology that is not developed far enough and is typically too costly for a single company to test. In the case of energy efficient processing we are examining 3-5 new technologies in this genre.

4. **CMIC Directed, Partner Delivered:** These projects typically occur on the initial stages of larger, consortia-based project to prove an idea or provide a baseline of data, information and models on which we need to proceed.

5. **CMIC Instigated with “Ecosystem” Participation:** These are either very difficult technical challenges that have broad applicability and interest or where there are significant groups working on elements yet need to be stimulated to move in the right direction. Environmental monitoring technologies. Low grade waste energy recovery is one example.

6. **Mini-Consortia:** Evolve around needs of a select group of companies and include two nascent projects in genomic based sensors for environmental monitoring and hybrid air vehicles for alternative transportation.
CMIC’s Towards Zero Waste Mining Strategy > Portfolio Analysis, Benefits, and Roadmap

The savings for each portfolio outline only the financial benefits; in addition to these, there are qualitative measures which will aid industry transformation.

| Create collaborative mechanisms at a scale never seen before by the industry | Move towards solving the greatest challenges facing the industry | Re-shape the industry |
| Create a sustainable innovation culture for the industry | Accelerate technology development, adoption and deployment | Reduce technology development, adoption, and deployment cost and risk |
| Move marginal projects closer to viability | Enhance the relationship with the federal government | Create a greater buffer against market cycles |

Provide a framework to align innovation activities to financial drivers of the industry | Improve public perception | Provide innovation strategy and focus |

Monitor Deloitte.
Practical Considerations for Implementing the Strategy

- Implementation, Collaboration, and Value Sharing
CMIC will track the trajectory of technology adoption maturity for its Towards Zero Waste Mining strategy in a phased and staged manner...

**STAGES:** The development or evolution of a technology that facilitates a significant shift in maturity towards improving daily mining operations

**PHASES:** Clear and realistic implementation timelines which depict the sequencing of projects across a 10 year time horizon

The overall objective is to ensure the gradual progression (Phase 1 – 3) and adoption of innovative technologies (Stages 1 – 3) which allow for more efficient and sustainable operations while promoting shareholder value.
...with the funding process for the various portfolios, from investment to IP sharing, clearly defined

<table>
<thead>
<tr>
<th>Government</th>
<th>Industry Members</th>
<th>CMIC Board</th>
<th>CMIC</th>
<th>Technical Working Groups</th>
</tr>
</thead>
</table>

Oversight and Governance

No – Revise prioritization
Yes

Practical Considerations for Implementing the Strategy > Implementation, Collaboration, and Value Sharing
The investment timeline regarding how member investments will be used...

**Members generate set of priority initiatives**

- Members are entitled to withdraw funding up until this point

**Member investments are made and budget is allocated**

- Q3 investments are eligible for projects beginning Q1 of the following year which ensures adequate planning, finalization, and fund allocation can execute projects the following quarter.
- Investments are held in an interest bearing account until committed to a project

**Roadmaps for new initiatives are finalized in Q4**

- Project plans and roadmaps are shared with industry participants, to decide upon priority projects to execute in Q1, 2016
- Initiatives currently underway are focused on: *Exploration* (2 years in); *Continuous Underground Mining* (to complete Sept 2015); *Comminution / Energy Efficiency* (to complete end of 2015); *Energy Efficiency* (to complete Jan 2016); *Benign Tailings* (yet to commence, but is a common long term outcome applicable to all CMIC roadmaps)

**Technical Working Groups lead and execute projects**

- CMIC’s board provides oversight and strategic direction
- Technical working groups select projects to generate value in next cycle
- Project partners manage the day-to-day activities for project development / testing / implementation that occurs on their sites

**Project members derive immediate IP benefits**

- Project sponsors own intellectual property and have exclusive access for the first 12 months after which the IP will then be shared holistically across all members

- All projects are in service towards the goal of Net Zero Waste in 10-20 years

---

CMIC has requested funding for their technical innovation projects which are focused on dealing with the largest mining industry cost-drivers to help stimulate and boost mining efficiencies across the industry.
Project governance uses a multi-level matrix system, with individuals being nominated and approved/appointed by relevant parties.

<table>
<thead>
<tr>
<th>Project Directorate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition</strong>: Industry and CMIC Technical Working Groups</td>
</tr>
<tr>
<td><strong>Appointments</strong>: Persons are nominated by the Technical Working Groups and appointments made by industry</td>
</tr>
<tr>
<td><strong>Function</strong>: To provide subject matter expertise and project stewardship</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Management Office</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition</strong>: Industry members, CMIC and its Technical Working Groups, service providers and/or other external experts. In addition, the PMO may comprise of a single individual depending on the size of the project</td>
</tr>
<tr>
<td><strong>Appointments</strong>: Person(s) is/are nominated by the Project Directorate and appointments made by industry</td>
</tr>
<tr>
<td><strong>Functions</strong>: 1) Act as the liaison between the Project Test Site Leaders and Technical Expert Groups; and 2) Responsible for overall project management and reporting to stakeholder groups</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Test Site Leaders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition</strong>: Industry members, CMIC and its Technical Working Groups, service providers and/or other external experts</td>
</tr>
<tr>
<td><strong>Appointments</strong>: Persons nominated by the Project Management Office and appointments made by the Project Directorate</td>
</tr>
<tr>
<td><strong>Functions</strong>: 1) Manage day-to-day activities associated with project execution; 2) Ensure all activities are focused towards achieving their intended roadmap outcomes; and 3) Generate regular reports, detailing project progress, risks and issues, as well as items for resolution to the Project Management Office</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical Expert Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition</strong>: Industry members, CMIC and its Technical Working Groups, service providers and/or other external experts</td>
</tr>
<tr>
<td><strong>Appointments</strong>: Persons nominated by the Project Management Office and appointments made by the Project Directorate</td>
</tr>
<tr>
<td><strong>Function</strong>: To provide technical direction, oversight, and monitoring in accordance with the roadmaps</td>
</tr>
</tbody>
</table>
**Reporting occurs at regular intervals to stakeholders, providing them with both project insights and the generated IP**

### Reporting Structure and Cadence

CMIC will conduct **regular monitoring, evaluating, and reporting** of projects on a monthly, quarterly and annual basis. Additionally, when **key project decisions are made** (e.g., project is initiated), an announcement will be made through the appropriate channels to project sponsors and other CMIC members (where relevant).

<table>
<thead>
<tr>
<th>Monthly</th>
<th>Quarterly</th>
<th>Annually / Project Closeout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Test Site Leaders will lead an <strong>internal teleconference discussion</strong>, allowing project participants to discuss project progress against roadmap objectives and targets. Minutes from these meetings will be captured and a <strong>monthly status report</strong> will be developed by the Project Test Site Leaders and forwarded to the Project Management Office.</td>
<td>The Project Management Office will develop a <strong>dashboard</strong>, which will be provided to CMIC members and other stakeholders through a link on CMIC’s website. It will be a <strong>short concise summary</strong> of the progress to date and will be supported by a detailed report. This detailed report will be accessible to CMIC members and other stakeholders via additional websites links.</td>
<td>The Project Management Office will lead the development of a <strong>written report</strong> consolidating project activities, results, timelines, and project progress against the technical roadmap. These reports will be detailed and supported by the quarterly reports. They will focus on the sharing of IP together with any benefits realized on an annual basis. The project closeout report will feature the same information above, with the only difference being the timing associated with closing out a project.</td>
</tr>
</tbody>
</table>
### CMIC’s IP policy for each project specifically outlines the obligations and IP rights

#### Background Intellectual Property

*Owned by a Project Sponsor who has developed or licensed it. May be licensed by owners to members who are not Project Sponsors*

#### CMIC Project

- Sponsors (who provide financial or in-kind support) get exclusive access to generated IP for 12 months, after which it is circulated to the rest of CMIC’s members.
- Non-sponsoring members may join an ongoing project if they pay a catchup fee.

#### Project Intellectual Property

*Created by a project participant(s) as a direct result of a Project and remains owned by creator(s) unless otherwise transferred*

#### Developed IP

- **Invention**: Participants must disclose to Project Sponsors if a patentable invention is created so Sponsors may acquire an undivided joint interest and corresponding rights. CMIC will not participate in patent rights / costs.
- **Software**: If developed as part of Project IP will be deemed owned by developer.
- **Data**: If generated as part of a Project is considered jointly owned by participants.

#### Licensing IP

- Owner of new Project IP should be deemed to have granted access for internal purposes to all project Sponsors.
- May be licensed to members who are not Project Sponsors though this will not include the right to sublicense or create any modifications, derivatives thereof, in any commercial process or services.
- After the agreed upon exclusivity period, IP owners may license to non-members.
Way Forward

- What are the Alternatives?
- Next Steps
**Way Forward > What are the Alternatives?**

Industry has other investment options; however, CMIC has the potential to create the best long term value by collaboratively addressing common issues.

<table>
<thead>
<tr>
<th>Investment Options</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Invest in Property, Plant, and Equipment (PPE)</strong></td>
<td>• Addresses current challenges by investing in PPE designed to <strong>target the specific issue</strong> (e.g., larger trucks to increase productivity)</td>
<td>• Only addresses <strong>specific issues</strong> which have <strong>already been solved</strong> by PPE suppliers</td>
</tr>
<tr>
<td></td>
<td>• Possibly generates <strong>additional revenue</strong> or <strong>increased margins</strong> (i.e., increase output or decrease production cost)</td>
<td>• <strong>Addresses short-term margin decrease</strong>, but ignores long-term systematic challenges</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <strong>Investment depreciates</strong></td>
</tr>
<tr>
<td><strong>Independently Invest in Innovation Research and Development</strong></td>
<td>• <strong>Addresses industry challenges</strong>, through internal (e.g., existing staff) or external (e.g., research facilities, product / service providers, and specialty mining consultants) resources with a focus on <strong>long-term value</strong></td>
<td>• Requires <strong>substantial financial investment</strong> with no sharing of costs with other mining firms</td>
</tr>
<tr>
<td></td>
<td>• Provides <strong>sole access to any IP / patents developed</strong>, providing a <strong>possible competitive advantage</strong></td>
<td>• Requires <strong>extensive resource and time</strong> commitment, taking away from mining production activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Provides access to <strong>limited talent pool</strong> (i.e., internal or hired experts)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <strong>Imposes significant risk</strong> for the time and money invested</td>
</tr>
<tr>
<td><strong>Address Operational Expenditure Pressure Points</strong></td>
<td>• <strong>Improves liquidity and cash flow</strong> in the short-term, helps fund other priority investments, and provides <strong>additional security</strong> in case of a drop in commodity price</td>
<td>• <strong>Addresses short-term</strong> challenges at the expense of business growth and long-term value creation</td>
</tr>
<tr>
<td></td>
<td>• <strong>Reduces debt</strong> and / or meets <strong>key financial ratios</strong></td>
<td>• <strong>Does not provide direct return on investment</strong></td>
</tr>
</tbody>
</table>

**Monitor Deloitte.**
Way Forward > What are the Alternatives?

If the government does support industry through investment in innovation, it must acknowledge both the direct and indirect implications of that decision.

Lack of government investment will decrease available funds to address common mining challenges.

<table>
<thead>
<tr>
<th>Direct Impact</th>
<th>Indirect Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Confidence in the Mining Industry</td>
<td>Effects on Industry, the Economy, and Job Creation</td>
</tr>
<tr>
<td>- Perception that government sees the value of investing in the Canadian mining sector</td>
<td>- Solved mining challenges result in positive impact to the economy and enable further growth of tech and clean tech economy</td>
</tr>
<tr>
<td>More Investment by Firms</td>
<td>License to operate</td>
</tr>
<tr>
<td>- Industry investment will have greater investment incentive if not matched by governments</td>
<td>- Addressed environmental and community concerns will enable further growth of the resource economy</td>
</tr>
</tbody>
</table>
Way Forward > Next Steps

A number of steps are still required prior to executing the Towards Zero Waste strategy, with CMIC looking to industry and government to get involved.

1. Agree on Portfolios:
   Agree internally on the implementation of project portfolios and present to CMIC board for approval.

2. Present Business Case:
   Share the Business Case with industry and government stakeholders to solicit buy-in and investment commitment.

3. Continue with Roadmap Development:
   Obtain outstanding funding and resources required in order to finalize technical working group roadmaps for the different portfolios. Update the relevant stakeholder group with the finalized roadmap and inform CMIC members of roadmap status.

4. Share Roadmaps:
   Share finalized roadmaps and project plans with industry participants to allow for investment allocation and project prioritization.

5. Obtain Funding:
   Finalize investment allocations with industry participants and other stakeholders no later than the end of Q1 2016.

6. Budget Approval:
   Finalize government budgeting process and keep both industry and government informed regarding project executions.

7. Execute Projects:
   Execute projects in accordance with Business Case requirements and signed IP policies.

8. Align with FPIinnovations, COSIA (and others):
   Align with COSIA (and other organizations) in terms of IP sharing, collaboration, and membership fees should industry participants invest in mutually beneficial portfolios.

9. Commence Next Planning Cycle:
   Compile industry insights from current projects and use as a basis to develop / revise roadmaps, obtain additional funding, and prioritize and initiate new projects.
Appendix

- Detailed Analysis of Business Issues and Challenges
- Company Specific Toward Zero Waste Priorities
- Additional Toward Zero Waste Mining Themes
- Case Studies – Eclipse, COSIA, and AMIRA
- List of Abbreviations
Declining productivity is impacting mining companies’ ability to operate profitably...

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explanation</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Market Trends</td>
<td>With a high percentage of the industry’s workforce nearing retirement, there exists a <strong>talent shortage</strong> of skilled workers[^1]</td>
<td>Structural market trends <strong>push up labour costs</strong> and apply greater pressure on existing staff to do more with less, <strong>reducing employee productivity</strong></td>
</tr>
<tr>
<td>Declining Resource Quality</td>
<td>As high grade deposits are depleted, the weighted average <strong>head grade / yield</strong> of metals are <strong>decreasing</strong></td>
<td><strong>Declining head grade / yield</strong> leads to a rise in <strong>production cost</strong> for each ounce or tonne of resource produced</td>
</tr>
<tr>
<td>Inefficient Capital Allocation</td>
<td>In the past, many companies have sunk significant resources into <strong>marginal mines</strong> that can <strong>no longer produce profitably</strong> in today’s lower commodity price environment</td>
<td><strong>Loss-making mining operations</strong> need to be <strong>temporarily or permanently closed</strong>, resulting in the inability to extract profits from the assets</td>
</tr>
</tbody>
</table>

[^1]: 1. Source: (1) “Deloitte Mining Spotlight on: Sliding Productivity and Spiraling Costs, 2014”; (2) SRSocco compiled data from Company Annual & Sustainability reports

---

### Labour Productivity is Declining while Labour Costs are Rising

Quarrying, and Oil and Gas Extraction[^2]

<table>
<thead>
<tr>
<th>Year</th>
<th>Labour Productivity Index</th>
<th>Hourly Compensation (CAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>2008</td>
<td>85</td>
<td>65</td>
</tr>
<tr>
<td>2009</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>2010</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>2011</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>2012</td>
<td>65</td>
<td>85</td>
</tr>
<tr>
<td>2013</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>2014</td>
<td>55</td>
<td>95</td>
</tr>
</tbody>
</table>

---

### The Average Yield from the top 5 Gold Producers has Decreased Significantly over the Years[^2]

<table>
<thead>
<tr>
<th>Year</th>
<th>Gold Production</th>
<th>Average Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>30</td>
<td>2.0</td>
</tr>
<tr>
<td>2007</td>
<td>25</td>
<td>1.9</td>
</tr>
<tr>
<td>2009</td>
<td>20</td>
<td>1.8</td>
</tr>
<tr>
<td>2011</td>
<td>15</td>
<td>1.7</td>
</tr>
<tr>
<td>2013</td>
<td>10</td>
<td>1.6</td>
</tr>
</tbody>
</table>
...especially since costs are continuously increasing

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explanation</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated Input Costs</td>
<td><strong>Input and production costs are increasing.</strong> For example: infrastructure, labour, contractor rates, equipment, taxes, land royalties, permitting fees, and environmental / regulatory compliance</td>
<td>Based on current trends and future projections, costs will likely continue to increase over time. Historical cost cutting exercises (e.g., layoffs) are not sustainable and without a step change, margins may decrease to a point where mining operations are no longer profitable</td>
</tr>
<tr>
<td>Critical Shortages in Energy &amp; Water</td>
<td><strong>Mining projects are competing with local communities for limited water and energy resources.</strong> In addition, the costs associated with building regulatory-compliant water infrastructure are rising</td>
<td>The future availability and financial viability of access to water and energy resources is decreasing. Without sustainable infrastructure and operations, future site development and metal extraction could become unviable and / or unprofitable</td>
</tr>
</tbody>
</table>

For example, Blended RPP Ontario Hydro Rates Have Far Outpaced Annual Inflation Over the Years

Source: (1) Ontario Hydro – Ontario’s Historical RPP Rates; Société Général, 2013
Miners must find ways to proactively address increasing stakeholder demands...

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explanation</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholder Engagement</td>
<td>A license to operate requires negotiations with local communities, government, non-government organizations, workers’ unions, local labor forces, environmental groups, industry associations, and vocal shareholders.</td>
<td>As the number and variety of stakeholders increase, failing to proactively address concerns can lead to delays in permitting / project approval, and possible loss of license to operate.</td>
</tr>
<tr>
<td>Conflicting Stakeholder Interests</td>
<td>There are fundamental conflicts between stakeholder interests (e.g., government looks to create jobs, corporate looks to maximize profit, and communities look for access to education).</td>
<td>Investors are becoming increasingly conscious of the reputation and level of corporate social responsibility of mining companies. Companies that do not effectively manage the competing needs of stakeholders run the risk of losing access to capital.</td>
</tr>
<tr>
<td>Government Regulations</td>
<td>Government rules and regulations are becoming more stringent and are constantly changing. For example, the Mineral Exploration Tax Credit for investors was extended for an additional year.</td>
<td>If miners don’t address their OpEx and CapEx challenges now in anticipation of the impending tax liability, the sustainability of mining operations, particularly for juniors, could be compromised.</td>
</tr>
<tr>
<td>Environmental Compliance</td>
<td>New mines and major expansions are subject to the increasing regulations, including the Canadian Environmental Assessment Act (CEAA), Fisheries Act (FA), and Navigation Protection Act (NPA).</td>
<td>Amendments to the FA places increasing responsibility on miners, including reporting potential harmful activities. Miners must proactively monitor water quality to ensure compliance and prevent penalties which can include permanent mine closure.</td>
</tr>
</tbody>
</table>

Source: (1) “Mining Association of Canada – Facts & Figures of the Canadian mining Industry 2014”
...in the face of volatile commodity prices that make committing to long-term investments difficult and result in decreasing availability of financial capital

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explanation</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short Term Planning</strong></td>
<td>With mining’s total return to shareholders underperforming other sectors, companies are under mounting <strong>pressure to boost short-term profits</strong>, often at the expense of long-term planning</td>
<td>Miners are impelled to ignore investments that may deliver long-term upside in favor of dodging investor ire by remaining cash positive. <strong>Passing on long-term, possible high return investments</strong>, results in further <strong>decreasing shareholders performance</strong></td>
</tr>
<tr>
<td><strong>Decreased Financial Capital</strong></td>
<td><strong>Significant price risk exposure</strong> associated with volatile commodity prices provides little comfort to investors and rating agencies, resulting in <strong>declining equity financing</strong></td>
<td>A decline in the number and proceeds of equity issues results in explorers scaling back exploration activity. Combined with the widespread exits from exploration by the majors due to budget cuts, the <strong>long-term future supply pipeline looks increasing under risk</strong></td>
</tr>
</tbody>
</table>

**Commodity Prices are Volatile**

Source: (1) “Deloitte tracking the trends 2015 – the top 10 issues mining companies will face this year”; (2) Bank of Canada, Commodity Price Index – Monthly; (3) A-Mark Precious Metals Inc. – Data; (4) SNL Data
### Company Specific Toward Zero Waste Mining™ Priorities

**Mining executives have identified their top priority initiatives to drive Towards Zero Waste (1 / 3)**

<table>
<thead>
<tr>
<th>Company</th>
<th>Top Priority Initiatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hecla Mining Company</strong></td>
<td>• <strong>Continuous mining</strong> in order to sustain their Lucky Friday operation in a safe and economic manner  &lt;br&gt; • Dealing with <strong>seismicity</strong> and <strong>ventilation</strong> at depths, including cooling and diesel ventilation as well as maintaining <strong>continuous production</strong>  &lt;br&gt; • Mine planning and <strong>better understanding of ore bodies</strong> to allow for efficient mining  &lt;br&gt; • <strong>Operation efficiency and control</strong> as well as <strong>benign tailings</strong></td>
</tr>
<tr>
<td><strong>Agnico Eagle</strong></td>
<td>• <strong>Energy management</strong> and becoming more efficient with energy  &lt;br&gt; • <strong>Water usage</strong> and efficiency is a current challenge  &lt;br&gt; • <strong>Automation</strong> of mining process (continuous mining)  &lt;br&gt; • <strong>Environmental footprint</strong> reduction</td>
</tr>
<tr>
<td><strong>Alloycorp</strong></td>
<td>• Become more effective and efficient with their energy and power usage (<strong>energy efficiency</strong>)  &lt;br&gt; • <strong>Access to real time data</strong>, strong drive to improve the ability to make decisions and monitor operations from large data sets in real time  &lt;br&gt; • <strong>Environmental footprint</strong> reduction, particularly water usage and waste as they have been experiencing pressure from First Nations</td>
</tr>
</tbody>
</table>

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*Appendix > Company Specific Toward Zero Waste Mining™ Priorities*
**Mining executives have identified their top priority initiatives to drive Towards Zero Waste (2 / 3)**

<table>
<thead>
<tr>
<th>Company</th>
<th>Top Priority Initiatives</th>
</tr>
</thead>
</table>
| **newgold**     | • Making **continuous mining** more economical and efficient  
                   • **Energy management** and becoming more efficient with energy usage  
                   • Addressing **tailings deposition** and **managing waste** more effectively  
                   • Increased effort to promote **remote mining**  
                   • Improving the **accuracy of exploration** |
| **Hudbay**      | • **Energy management** and becoming more efficient with energy  
                   • **Environmental footprint** reduction  
                   • **Reducing reputational costs** and engaging stakeholders, particularly **First Nations** better  
                   • **Managing waste** and associated costs as well as **tailings**  
                   • **Improving exploration** efforts to ensure business continuity and sustainability |
| **Teck**        | • **Water treatment** and the efficiency thereof  
                   • **Tailings management**  
                   • **Energy management** and becoming more efficient  
                   • **Material stewardship** and improving the continuous mining process  
                   • Dealing with **dust and further air quality** issues, together with how these impact upon relationships with communities and stakeholders |
Mining executives have identified their top priority initiatives to drive Towards Zero Waste (3 / 3)

<table>
<thead>
<tr>
<th>Company</th>
<th>Top Priority Initiatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>McEwen Mining</td>
<td>- Exploration efficiency, reducing the <strong>time required to find deposits</strong> as well as reducing the time to <strong>acquire permits</strong>, which can take up to 5 years</td>
</tr>
<tr>
<td></td>
<td>- <strong>Real-time monitoring and data analytics</strong> of things like <strong>water quality</strong>, and financial data accessible on devices such as an iPad</td>
</tr>
<tr>
<td></td>
<td>- <strong>Environmental footprint reduction</strong> and more effective operations</td>
</tr>
<tr>
<td></td>
<td>- <strong>Energy efficiency</strong> and reducing consumption of <strong>both energy and water usage</strong></td>
</tr>
<tr>
<td></td>
<td>- <strong>Comminution</strong> energy reduction</td>
</tr>
<tr>
<td>Glencore</td>
<td>- <strong>Ability to reach ore bodies</strong> that are further away faster and in a safe manner</td>
</tr>
<tr>
<td></td>
<td>- <strong>Energy efficiency</strong> to decrease costs from ventilation and equipment</td>
</tr>
<tr>
<td></td>
<td>- Management of <strong>tailings</strong> as they have the potential to damage the environment</td>
</tr>
<tr>
<td></td>
<td>- <strong>Water usage and efficiency</strong></td>
</tr>
<tr>
<td>Kinross</td>
<td>- Dealing with <strong>comminution</strong>, as it is an Achilles heel in many of their operations</td>
</tr>
<tr>
<td></td>
<td>- <strong>Energy Efficiency</strong> and management in order to reduce costs and maintain operations</td>
</tr>
<tr>
<td></td>
<td>- Improvements in <strong>safety</strong> to benefit employees, who determine the success of their mines</td>
</tr>
</tbody>
</table>

Appendix > Company Specific Toward Zero Waste Mining™ Priorities
Appendix > Additional Toward Zero Waste Mining™ Themes

Zero Waste mining issues require urgent attention for different reasons

**Chemistry research and development** such as hydrology and geochemistry (e.g., ability to predict effluent chemistry and waste rock seepage chemistry) is lagging as identified in a gap analysis report for Acid Rock Drainage (ARD) management mandated by the MAC, Environment Canada and Natural Resources Canada (Stephen, 2002)¹

Better Chemistry

Much of **mining equipment** in use is not as technologically sophisticated as in comparable peer industries. Encouraging mining-related enterprises to flourish and produce state-of-the-art information products and services will create thousands of high-tech jobs in the mine equipment and supply sectors

Equipment

Mine planning is a lengthy, capital intensive process that needs to be expedited and streamlined. As ability to raise capital can be improved through integrated operations, CMIC uses an integrated waste elimination strategy that reduces operational and environmental footprint, liability, and risk. CMIC’s unique life of mine approach creates integrated solution pathways. The CMIC technical roadmap for Towards Zero Waste in mining targets 0 waste and an 80% reduction in closure costs

Mine Planning

Other

- Job creation
- Public image
- License to operate

- Cultural change (internally within the mining industry)
- Commodity price

Source: (1) CMIC: “Environmental Analysis of the Mining Industry in Canada,” Hatch 2013
Case study 1 – The software industry’s use of the Eclipse open innovation model

Background Information
Eclipse is an open source, collaborative industry led innovation network. Its design allows for multiple corporations to work co-operatively when product-ready open source software is developed. Eclipse is part of The Eclipse Foundation, which is a not-for-profit and member supported corporation. The goal was to create both a community and an ecosystem of complementary products and services.

Business Model
Eclipse provides an open source platform for the development of software; where the original source code is made freely available. The software is redistributed through a number of channels, led by industry, to be modified and rewritten to suit company needs. The open source approach promotes universal access, via a free license to a product’s design or blueprint, and universal redistribution of that design or blueprint, including subsequent improvements to it by anyone. This thereby ensures the continuous development of the source code and software for use by the industry.

Investment Structure (all $ amounts in USD, taken directly from Eclipse website)
1. Strategic Members
   • Strategic Developers
     – Are major contributors of technology to Eclipse
     – Each SD will have at least 8 developers assigned full time to developing Eclipse technology
     – Annual dues: 0.12% of revenue (min $25K, max $250K)
     – [Max: Annual corporate revenues > $208.4 million, fee: $250K]
   • Strategic Consumers
     – Are major users of Eclipse technology
     – Annual dues: 0.2% of revenues (min $50K, max $500K)
     – Can reduce by contributing developers (125K per)
     – [Max: Annual corporate revenues > $250 million, fee $500k]

Source: “Eclipse’s website – http://eclipse.org”
Investment Structure (continued)

2. Enterprise Members
- Generally larger organizations (>1,000 employees)
- Rely heavily on Eclipse technology as a platform
- Want to influence & participate in the development of the Eclipse ecosystem
- Annual dues: $125K

3. Solutions Members
- Comprised of software vendors, innovative software start-ups, information and publishing organizations, education and service providers and influential research and standards organizations
- Express public support for the foundation as well as plan to make available a commercial Eclipse-based offering within 12 months of joining, can be either a product (build using Eclipse tools, or on top of Eclipse projects) or service (such as training, consulting, or a hosted web services)
- Annual dues: (tiered based on annual corporate revenue)
  - < $ 1 million and < 10 employees and contractors; $1,500
  - < $ 10 million ; $5,000
  - < $ 50 million ; $7,500
  - < $ 100 million ; $10,000
  - < $ 250 million ; $15,000
  - > $ 250 million ; $20,000

4. Associate Members
- Non-voting, but can submit requirements, participate in all project reviews and participate fully in the annual meeting of the membership at large, as well as scheduled quarterly update meetings
- Allows them to understand plans, directions, and to network with other members
- Annual dues:
  - Free for non-for-profit, standards bodies, universities, research institutes, media and publishing, governments
  - All other organization $5,000

5. Committer Members
- Those people who through a process or meritocracy are able to contribute and commit code to their Eclipse projects
- To become a committer, you must be nominated by another committer
  - To get recognized, start with well-formed bug reports
- One of the benefits is that you are eligible to vote in the elections for the Committer Representatives on the Eclipse Board of Directors
- No dues

Source: “Eclipse’s website – http://eclipse.org”
Case study 1 – IP management and the relevance of this model to CMIC

Intellectual Property (IP) Management
In order to ensure open and fair transfer of the intellectual property, the Eclipse Foundation established both IP policies and Working Groups to manage the IP. The Working Groups are established as part of the IP policies to ensure the availability of all open source software that are created in Eclipse projects for use by anyone, including developers of commercial software products. In addition the Working Groups perform a due diligence on any software developed to verify that it meets certain standards prior to it being distributed.

As a result of their participation in Eclipse projects, The Eclipse Foundation, Members, Committers and other parties are encouraged to exchange information. All of the shared information is considered non-confidential and provided under terms consistent with the IP Policies. Where there is a need to share information which is confidential in nature, the Eclipse Foundation requires its members to enter into confidentiality agreements prior to that information being disclosed.

Relevance of the Eclipse model to CMIC
Eclipse operates within the software industry and this open innovation model has proved successful for that industry. It has been successful because the participants lead and participate in the innovation platform, while working collaboratively for the betterment of the industry. Information is shared amongst those participants freely and openly, except in certain instances.

CMIC are using this same concept, in the hope that it not only fosters collaboration, but also promotes a cultural change towards innovation in the mining industry. Currently mining companies are averse to change and this open ecosystems approach allows them to have control and reduce their financial exposure, but still realize the benefits of participating in industry lead innovation initiatives.

Source: “Eclipse’s website – http://eclipse.org”
Background Information

Canada’s Oil Sands Innovation Alliance (COSIA) is an alliance of oil sands producers, which was formed on March 1, 2012. The alliance was established when representatives of 13 companies came together in Calgary to sign the COSIA charter. Presently, COSIA member companies have shared 777 district technologies and innovations that cost over $950 million to develop.

Business Model

The primary objective is to improve the environmental performance of oil sands producers by bringing together leading thinkers from industry, government, academia and the wider public to share and generate ideas on pressing matters. The open innovation model promotes collaboration across a wide stakeholder base thereby accelerating the pace of improvement in environmental performance. In addition to performance, the model develops outputs aimed at improving measurement and accountability in:

- Tailings
- Water
- Land
- Greenhouse gases

Consequently, only the most pressing industry matters are addressed through a planning framework that is used to define collective priorities. The criteria for this framework consider:

- Overall scientific and technical merit of the proposed research
- Approach to proof of concept Economic potential of concept
- Respondent’s capabilities and related experience
- Realism of the proposed plan and cost estimates

Ultimately, the business model attempts to reduce barriers to innovation by identifying, developing and applying solutions-oriented innovation to the collective priorities. The progress of which is reported on publicly to ensure a transparent exchange of information.

Source: “COSIA’s website – www.cosia.com”
**Investment Structure**

COSIA charges *membership fees* in order to *fund daily operational activities*. These include administrative costs, salaries for the Chief Executive and the Environmental Priority Area (EPA) Directors. Furthermore, the membership *fees cover the EPA operating budgets*; however, they are *not allocated to project execution*. Instead COSIA choses to adopt a different investment approach when executing the many projects that fall within the different EPA’s. Member investments are split across these projects according to a specific criteria. 50% of the budget is shared equally by all of the member companies and the other 50% is shared based on the amount of oil sands each company produced the previous year. This *allows certain companies to allocate funds to projects they find more beneficial*, whilst still contributing to promoting environmental performance as a whole. This weighted system approach is utilized to ensure that *companies who contribute the most get a larger say*. To ensure all COISA members are contributing equitably to the development of technology, their equitable contribution is assessed on a periodic basis, so to improve environmental performance of the oil sands.

COSIA’s direction is determined by a Shareholder Steering Committee which is made up of *vice president level representatives from each of COSIA’s member companies*. 

Source: “COSIA’s website – www.cosia.com”
Appendix > Case Studies

Case study 2 - Intellectual property is shared across all projects but only to those members who in a particular EPA

**Intellectual Property (IP) Management**
As a paying member of COSIA, each company is requested to participate in the technology development for the projects associated with their chosen EPA (as mentioned previously this share of investment is determined on the company’s production in the previous year).

Due to the number of members and the potential for investment options to overlap, technologies are developed within each EPA through discrete Joint Industry Projects (JIP). This segmented approach to technology development means that only those members of that particular JIP have access to the IP that is generated. In order to promote a more open innovation platform, the COSIA model promotes the sharing of IP to other members who were not part of that JIP, provided that they are part of the EPA. That is the limitation and boundary of the IP sharing within COSIA. Therefore members do not have access to IP for EPAs which they are not a part of, but they do have access to all the IP that is generated by the JIP within an EPA. This arrangement is governed through a Joint Venture Agreement amongst participating members within that EPA.

**Relevance to CMIC**
The COSIA model is focused on improving environmental efficiencies for oil sands producers. It takes this broader industry pain point, as identified in the planning framework criteria and identifies technology developments on specific projects. The approach is one which resonates with CMIC given the success with COSIA. CMIC members have also identified their pain points into broad categories and CMIC have begun the planning process to establish roadmaps to deal with technology implementations / demonstrations. The rest of the COSIA model fits in with CMIC’s overall approach.

The difference however, is that CMIC’s is operating in a larger environment (mining in Canada) and with more than just environmental issues (exploration, continuous mining, waste energy recovery, amongst others).

Source: “COSIA’s website – www.cosia.com”
Appendix > Case Studies
Case study 3 – AMIRA International, an open innovation model in the mining industry

Background Information
The Australian Mineral Industries Research Association became AMIRA International Limited in 2000. They have 75 members and engage with researchers on every continent.

AMIRA founders realized that in order to remain competitive, they needed continuous technological improvement across a wide range of areas (e.g., geoscience for discovery, mine engineering for development and production, mineral processing and extractive metallurgy to produce a marketable product at globally competitive prices, along with continuously improved occupational health and safety, and ways to identify and address the emerging issue of sustainability). AMIRA further understood that it was risky and costly for a single company to be continuous innovating for all priority areas in isolation.

Working collaboratively results in improved practice, community acceptance and financial reward for all. In addition, there is a far wider space for pre-competitive collaboration in the minerals industry compared to many others.

Business model
AMIRA’s objectives are to develop, broker, facilitate and manage collaborative research projects, that address real problems that their members have. AMIRA therefore sees itself as a way through which members can leverage their R&D budgets to address common business challenges. Members are required to direct and co-fund the scientific research and engineering developments that create the solutions for their commercial benefit. This model has been very successful to date, because it allows for collaboration without compromising the proprietary research, but also because it has resulting in 700 projects that attracted over $578 million of investment from their members. Their primary method of soliciting participation has been through developing projects through an industry-pull mechanisms but, they do also consider a researcher-push approach too.

They classify projects into five broad categories depending on the nature of the outputs and impact:

1. Optimization of processes and development of tools
2. Technology development, demonstration and deployment
3. Informational and databases
4. License to operate
5. Business enabling

Investment Structure
AMIRA International’s membership structure is designed around how members can utilize project IP in their business (all $ amounts in AUD, taken directly from AMIRA’s website).

- **Individual member**, voting right at annual general meetings, access to the projects and reports database, annual membership dues AUD $9,000.
  - Company capitalization < US $1 Billion
  - Any explorer or producer
- **Group member (A)**, voting right at annual general meetings, access to the projects and reports database, annual membership dues AUD $9,000.
  - Company capitalization < US $2 Billion
  - Any explorer or producer
- **Group member (B)**, voting right at annual general meetings, access to the projects and reports database, annual membership dues AUD $36,000.
  - Company capitalization > US $2 Billion up to US $10 Billion
  - Any explorer or producer
- **Group member (C)**, voting right at annual general meetings, access to the projects and reports database, annual membership dues AUD $72,000.
  - Company capitalization > US $10 Billion
  - Any explorer or producer
- **Group member (E)**, no voting right at annual general meetings, no access to the projects and reports database, annual membership dues AUD $2,250.
  - Must be an explorer with no current mining operations anywhere in the world
- **Group member (S)**, voting right at annual general meetings, access to the projects and reports database, annual membership dues AUD $9,000.
  - Mineral equipment, technology and services suppliers only
- **Group member (K)**, no voting right at annual general meetings, no access to the projects and reports database, annual membership dues AUD $2,250.
  - Must be a mineral equipment, technology and services suppliers only

Note: Company Capitalization is the size of the company. Therefore which member you are depends on the size of your company for individual and A,B,C, and what type of company you are for E, S, K (explorer only, supplier, different industry).

**Note:** 1 Australian Dollar equals 0.76 US Dollars
Case study 3 – IP management and the relevance of this model to CMIC

**Intellectual Property (IP) Management**

**Individual Members:** For those companies that register only one business entity with AMIRA, they are entitled to use any generated IP within that entity alone. Those companies are not entitled to transfer, distribute or otherwise share any of the IP generated through participation with AMIRA, to their subsidiaries or parent companies.

**Group Members:** These members are permitted to share the Project IP with all related subsidiaries and with a parent company as long as they have 50% controlling interest in the subsidiary and the parent has 50% controlling interest in the member. A subsidiary may be an Incorporated Joint Venture in which two or more members collectively have 50% controlling interest.

**Relevance to CMIC**

CMIC and AMIRA both realize that “collaborative research is a divider of costs but a multiplier of benefits”. For example, if five companies share the cost of research, they each carry 20% of the cost but they each receive access to 100% of the knowledge derived. Equally, if all five companies apply the knowledge, the total benefit delivered by the research is increased five-fold.

With this understanding it is evident how much CMIC can utilize this model as part of their open innovation business ecosystems approach. More specifically, the strategic nature with which AMIRA grew, by starting with a few members and focusing on certain technology adoptions. This allowed AMIRA to both establish quick wins, build credibility and garner support. Similarly CMIC should consider its current member requirements, against funds committed and what it is able to successfully deliver.

The two key differences between AMIRA and CMIC are 1) the scale of CMIC’s projects, AMIRA’s projects are smaller whereas CMIC is targeting projects with sub-components, and 2) CMIC’s business model uses the business ecosystem approach that requires ownership and commitment (including delivery) by participants. This model increases the amount of collaboration thus significantly reducing the cost and risk. CMIC overlays an open innovation approach to this that short circuits the time to bring solutions online as they look outside of the mining industry for existing solutions.

List of Abbreviations

- **AIF**: Automotive Investment Fund
- **AMF**: Advanced Manufacturing Fund
- **AMIRA**: Australian Mineral Industries Research Association
- **ARD**: Acid Rock Drainage
- **AUD**: Australian Dollar
- **B**: Billion
- **CAD**: Canadian Dollar
- **CEAA**: Canadian Environmental Assessment Act
- **CMIC**: Canada Mining Innovation Council
- **COSIA**: Canada’s Oil Sands Innovation Alliance
- **CSR**: Corporate Social Responsibility
- **EPA**: Environmental Priority Area
- **FA**: Fisheries Act
- **GDP**: Gross Domestic Product
- **IBM**: International Business Machines Corporation
- **IFIT**: Investment in Forest Industry Transformation
- **JIP**: Joint Industry Project
- **K**: Thousand
- **LA-ICP-MS**: Laser Ablation Inductively Coupled Plasma Mass Spectrometry allows the sample to be directly analyzed by ablating with a pulsed laser beam
- **lb**: Pound
- **MAC**: Mining Association of Canada
- **ML**: Metal Leaching
- **M**: Million
- **MWh**: Megawatt Hour
- **NPA**: Navigation Protection Act
- **NRCan**: Natural Resources Canada
- **Oz**: Ounce
- **PPE**: Property, Plant, and Equipment
- **RDI**: Research Development and Innovation
- **ROI**: Return on Investment
- **SADI**: Strategic Aerospace and Defense Initiative
- **t**: Ton
- **TBD**: To Be Determined
- **USD**: United States Dollar