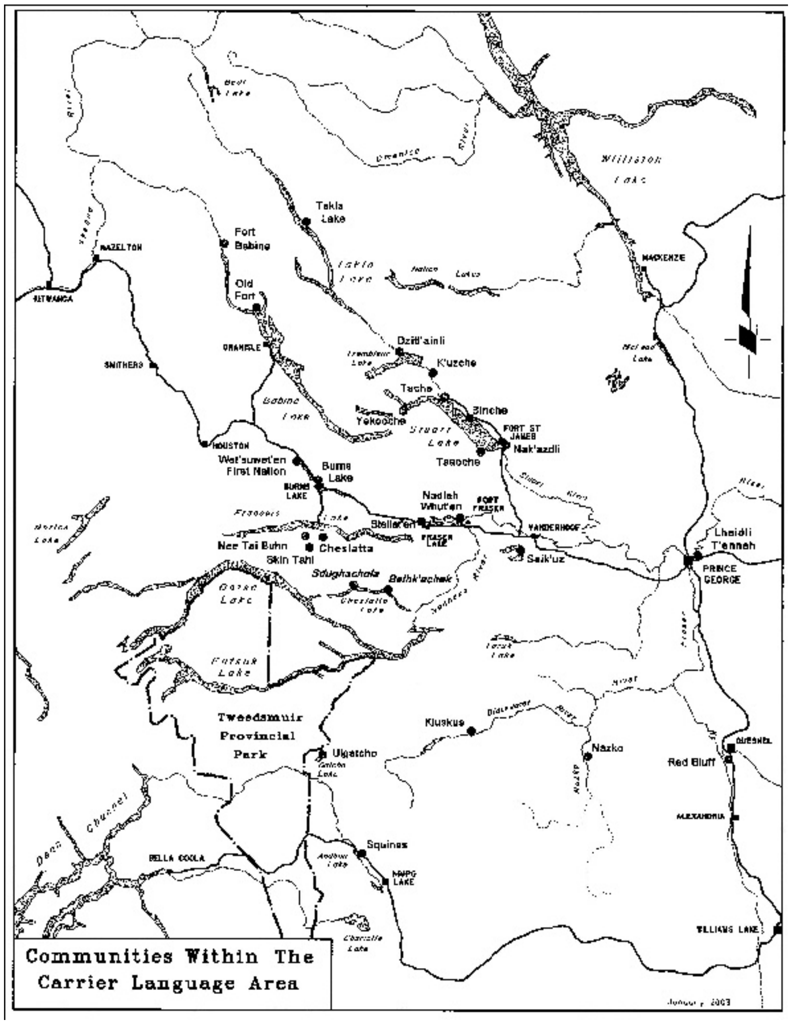
OSISKO DEVELOPMENT

Towards a More Holistic Sustainable Approach for Reclaiming Tailings Storage Facilities: The Decommissioning of Mosquito Creek TSF

Sylvie St-Jean (Osisko) and Mike O’Kane (Okane)

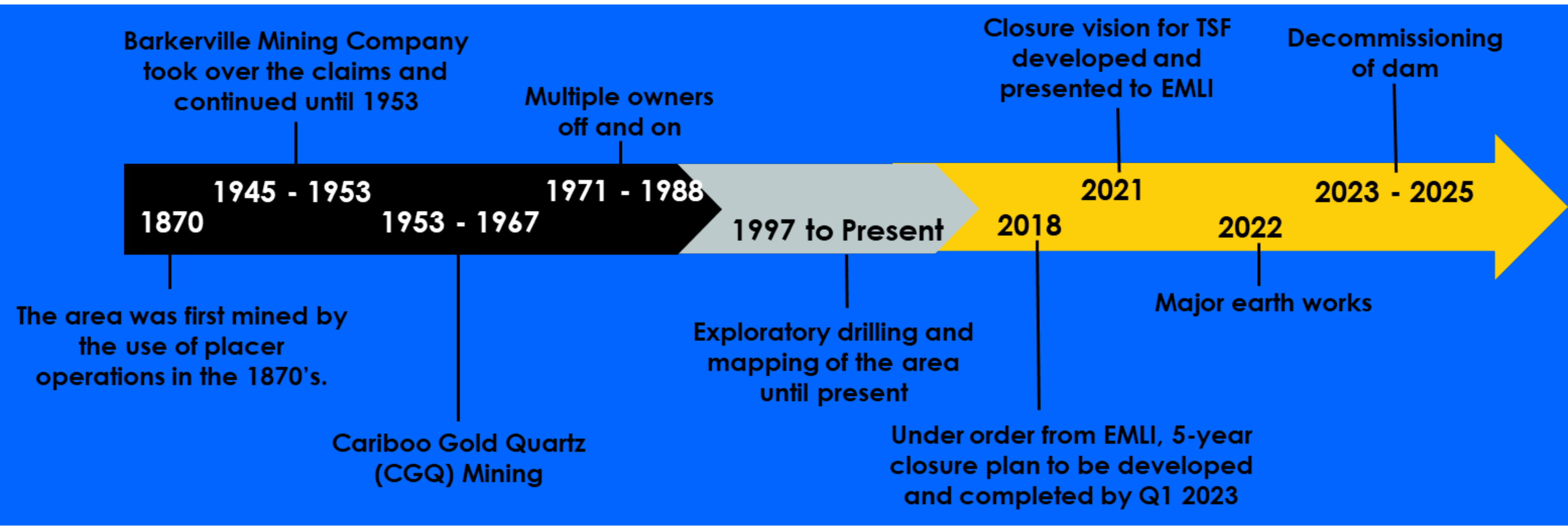
December 7, 2021

Land Acknowledgement



Osisko acknowledges that our work is within the unceded traditional territory of the Lhtako Dene Nation

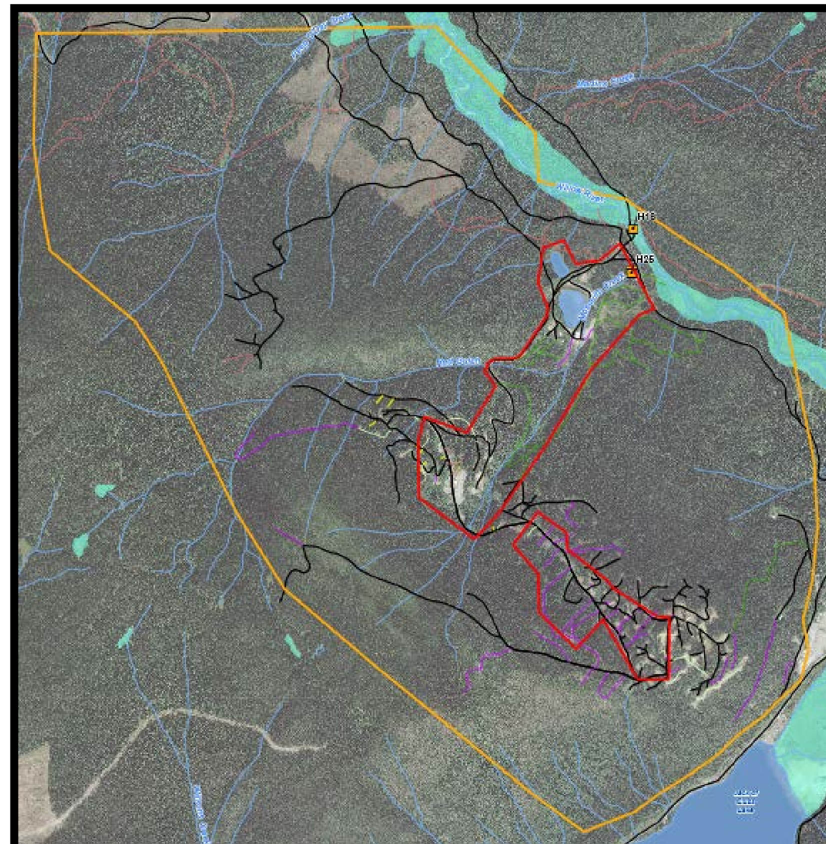
Site Evolution



Mosquito Creek Mine (MCM) Reclamation – Closure Commitments

Closure Commitments to meet End Land Use (ELU)

- **Provide safe access for people and use by wildlife**;
- Provide physically and geochemically stable landforms;
- Protect environmental resources by preventing /minimizing environmental impacts (metal leach/ARD) from mine waste, mine runoff;
- **Reclaim MCM** to the targeted ELU of functional ecosystems **with low to no maintenance** and habitat appropriate for wildlife; and
- Develop reclamation and closure activities with Indigenous nations
  - Part of the Vision
  - Build longer term capacity



Current Conditions

- **Approximately 91,000 tonnes of tailings impounded behind an earth-fill dam.**

- **Consequence rating of High**

- **An open water pond exists after freshet in April/May, but due to seepage/ evaporation:**

  TSF does not normally contain a pond

- **No active pumping of the TSF pond**, Pumping capabilities

- **Chemical seepage concentrations exceeding recommended guidelines at times for the following:**

  Aluminum (total)
  Arsenic (total)
  Copper (total)
  Iron (total)
  Molybdenum (total)

Current Identified Risks

- **Overland Flow on to and Around the TSF**
  - Overtopping of a structure which results in breach
  - Erosion issues at the toe
  - Liquefaction potential due to periodic wetting conditions of the tailings

- **Acid Mine Drainage (AMD)**
  - Surficial runoff causing release of AMD
  - Seepage potential through the structure releasing AMD

- **Other mine waste materials that could be potential AMD source**

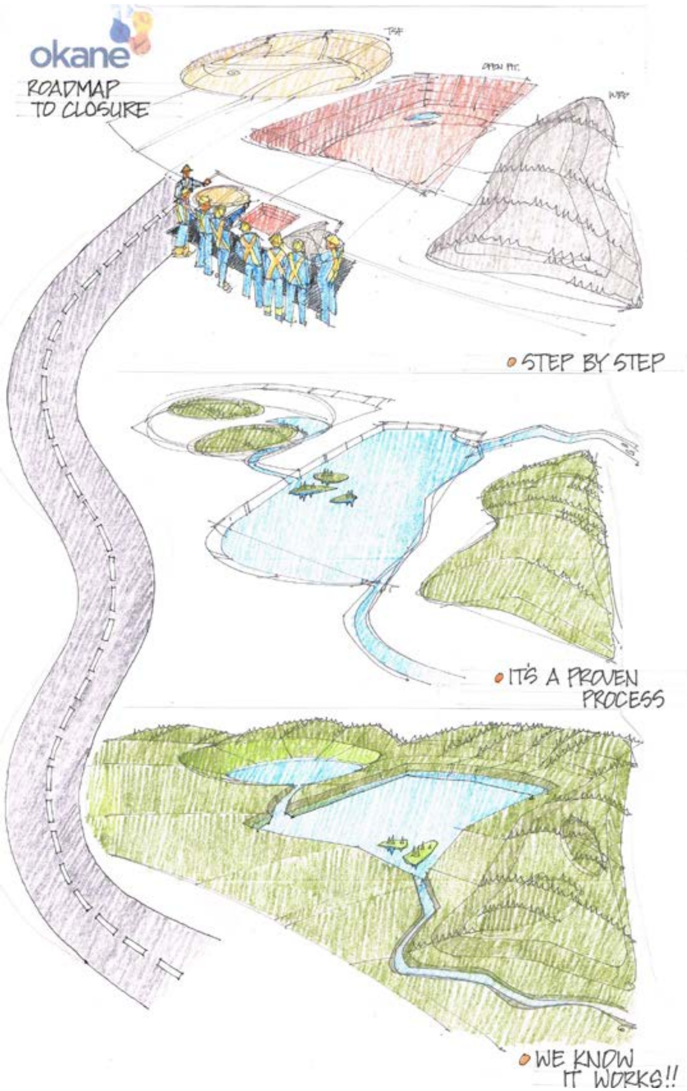
- **Other remaining mining infrastructure creating a risk to the public and their safety**

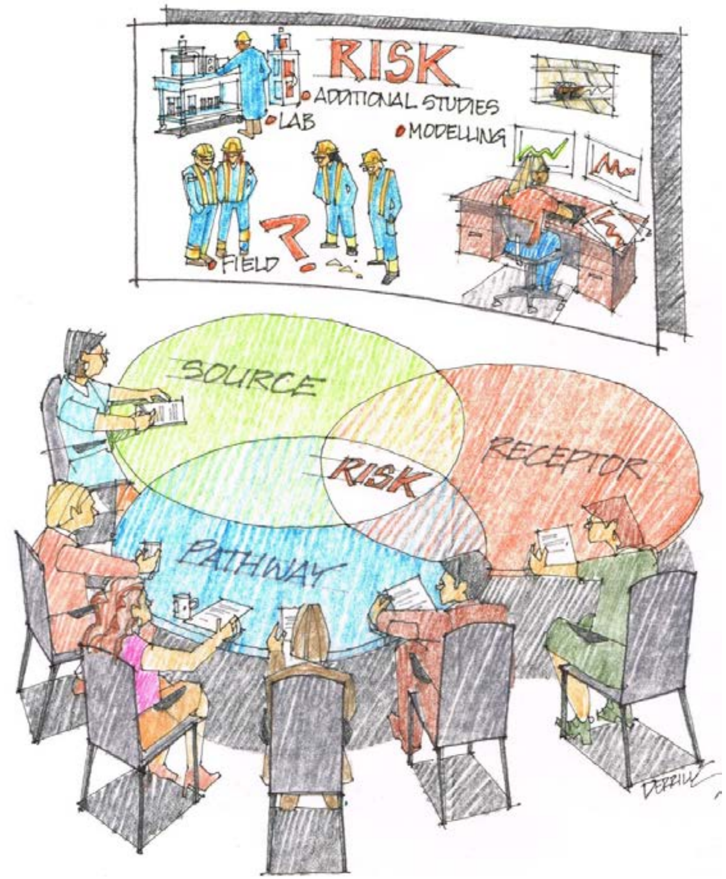
ODEV's Objectives

- Leaders in the industry
- Diminish risk for the:
  - Environment
  - Local Communities
  - The Company

- This is an important next step for the industry
- The question now is: How?

What is Closure Visioning… in general?





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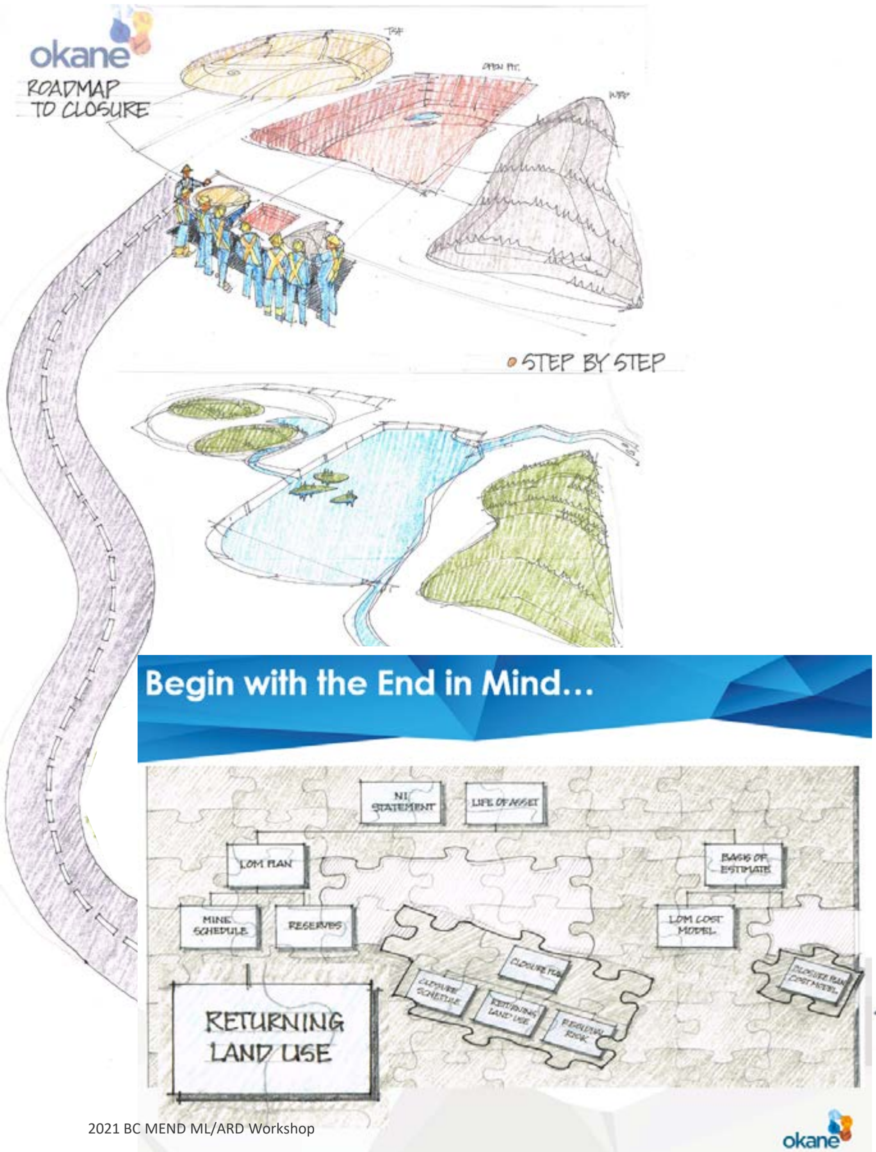

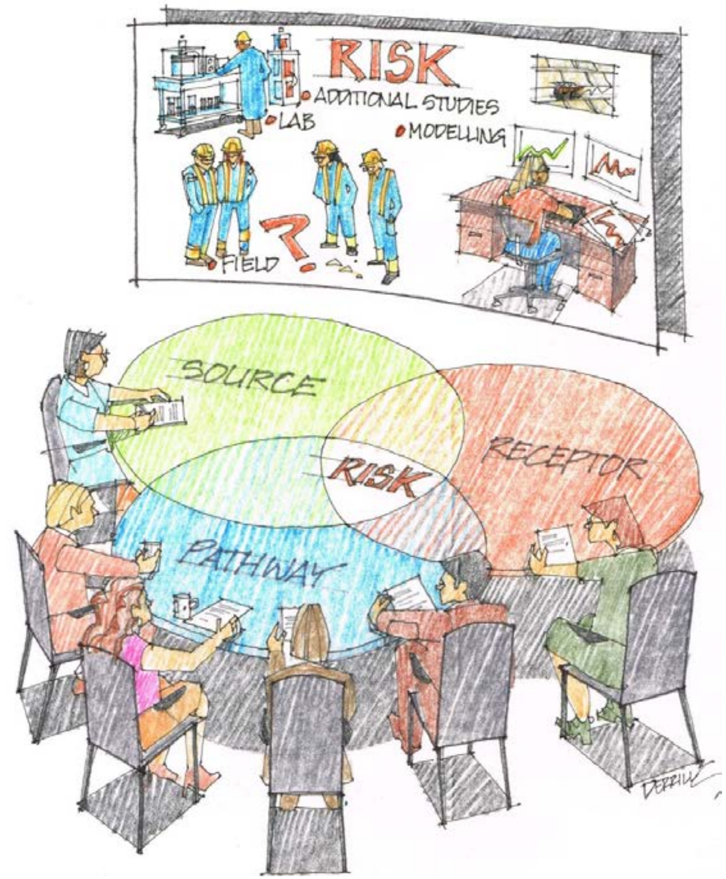

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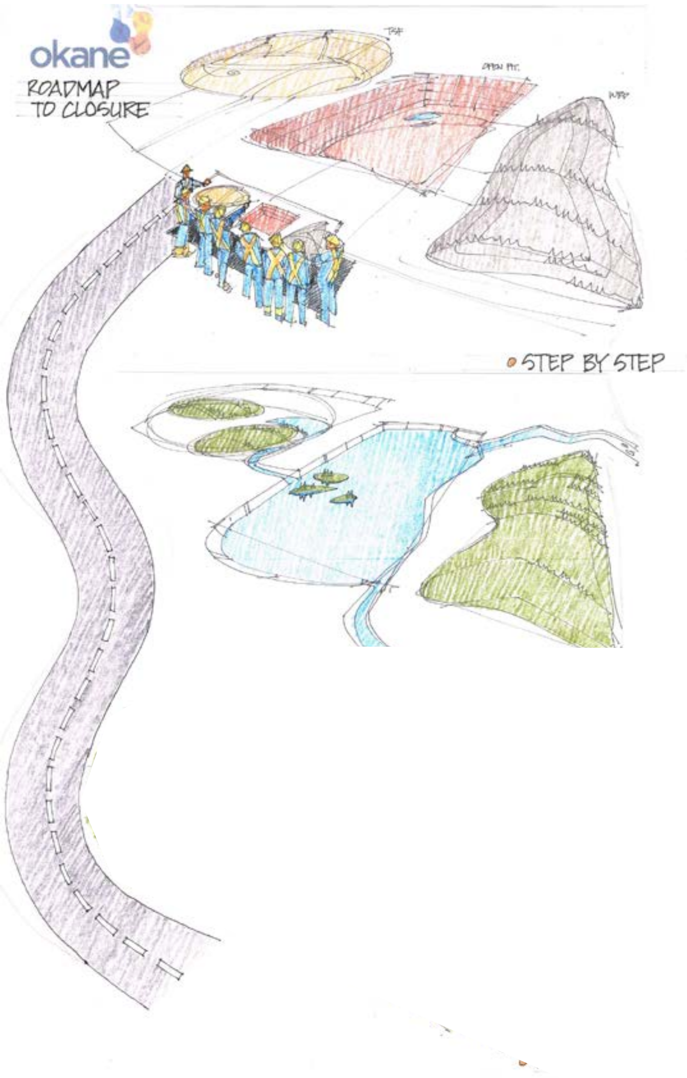

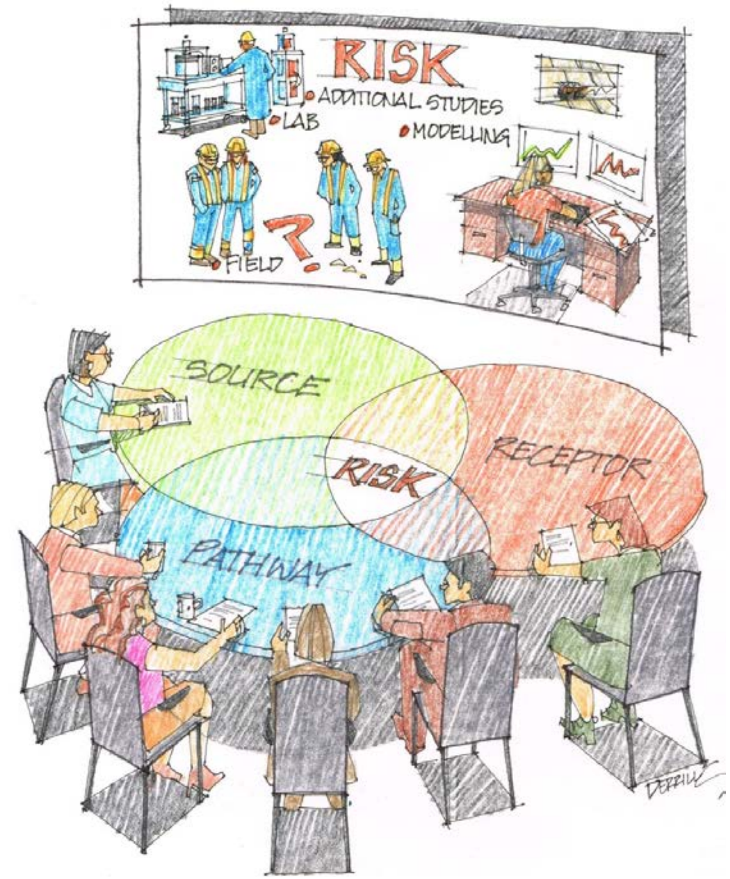

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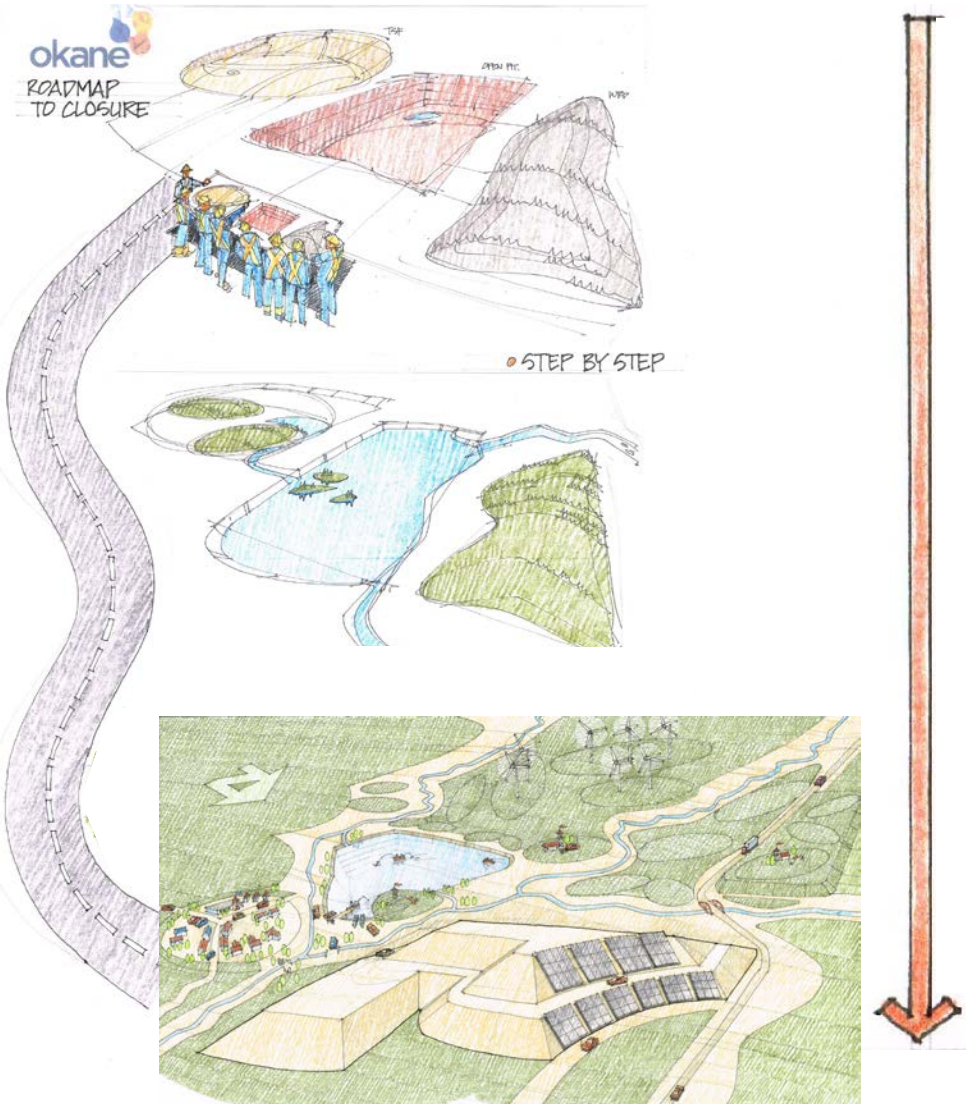
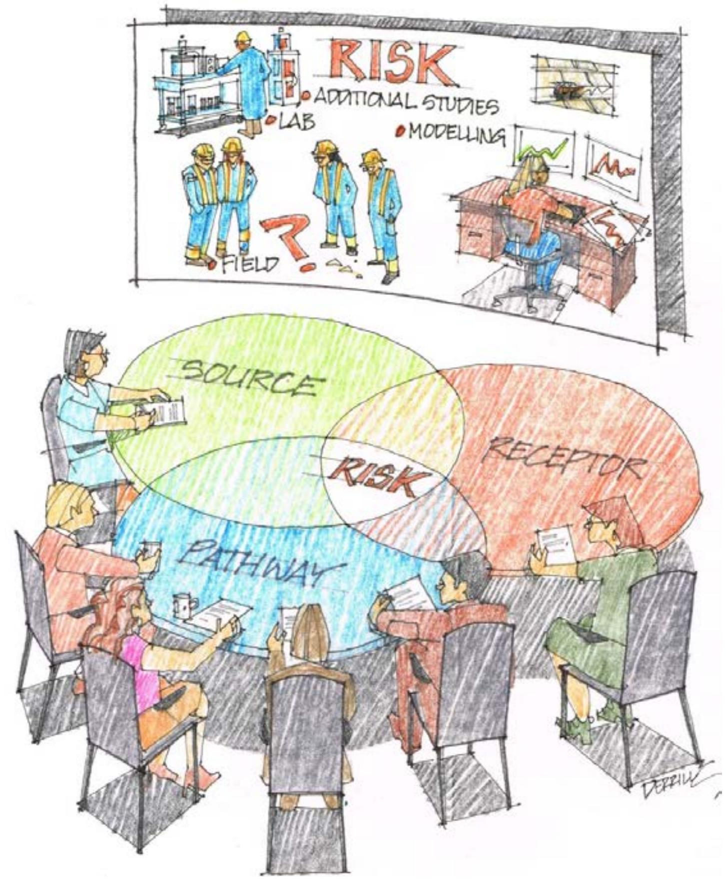
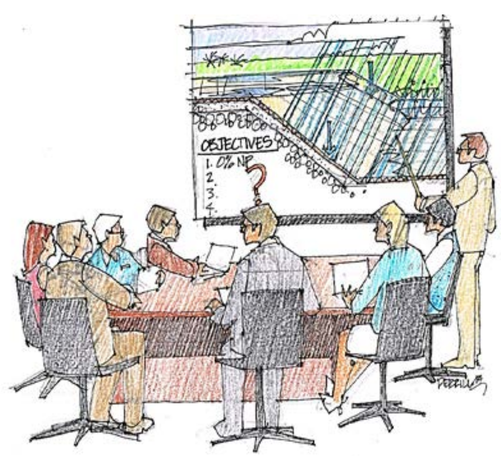


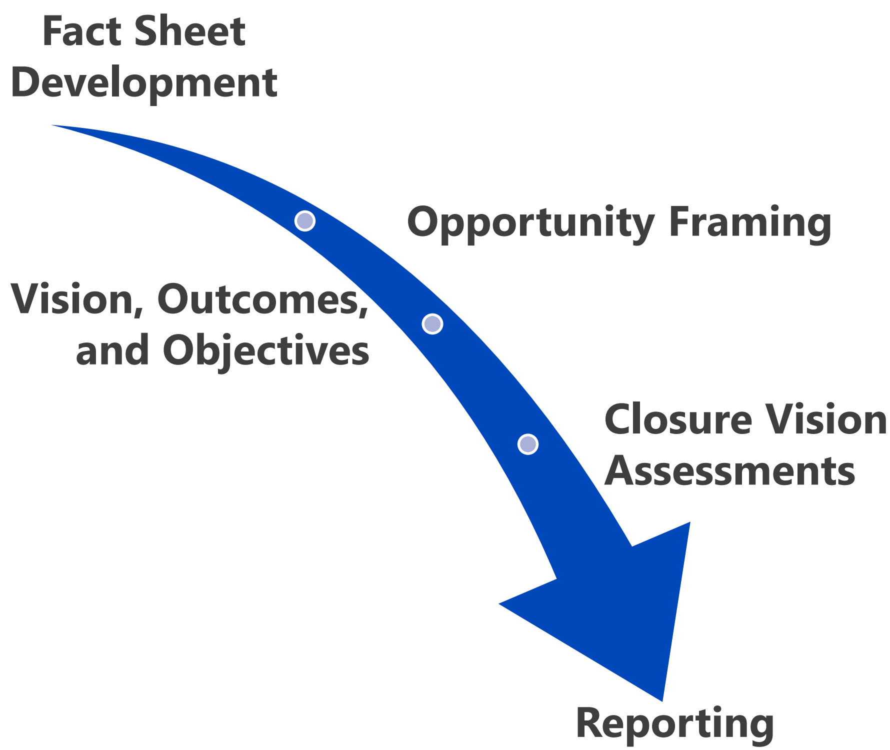


What is Closure Visioning… more specifically?

- Closure Visioning addresses the challenges in achieving desirable closure outcomes, which arise as a result of a lack of alignment on the outcome(s)
- Requires holistically incorporating all aspects of closure for the entire site… not simply a focus on singular metrics and landforms
- This project's closure vision exercise focused on strategic outcomes / objectives
  - Leave tactical decisions and optimization(s) for subsequent stages of the project



Closure Visioning using the Opportunity Framing / Assessment Tool



Rational Aim:

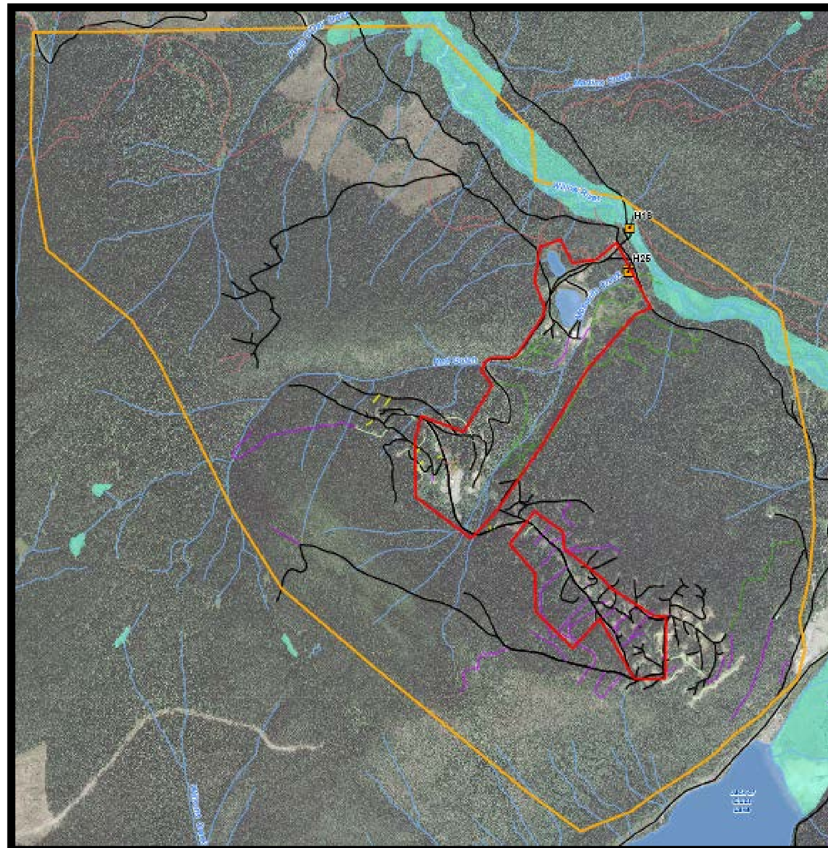
- Participants will understand what the possible closure visions and outcomes are for a successfully closed site
- Participants will be able to effectively communicate the different closure visions to stakeholders

Experiential Aim:

- Participants will feel that the suite of closure visions will help advance closure
- Participants will understand the structured and consensus building approach used in developing and assessing closure visions

Closure Visions and Risk-Based Communication

- *Closure Vision #1:*
- *Closure Vision #2:*
- *Closure Vision #3:*



Meets Commitments

Higher Risk – more active care

Lower Risk – more passive care

Current conditions | Vision #1 | Vision #2 | Vision #3

Closure Visions and Risk-Based Communication

- *Closure Vision #1:* **Site will be remediated with fully controlled access to the public**
  - Dam is maintained into perpetuity
- *Closure Vision #2:* **Site would be accessible to the public with some access limitations**
  - Open to the public with managed areas
  - For example: no structures or recreational activities on the TSF but walking trails acceptable
- *Closure Vision #3:* **Site reflects pre-disturbance capability that does not limit future land use to the greatest extent possible**
  - No restriction on public access
  - For example: no controls on land use for the TSF

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Vision #1

Vision #2

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Preferred Closure Vision:
Vision #2 – A Focus on Decommissioning Tailings Storage Facility

Closure Vision 2

A closed Mosquito Creek site would mitigate geotechnical and geochemical risk through decommissioning the TSF resulting in safe public access with some limitations.

Outcomes	Objectives
• Reduce risk associated with geotechnical stability and improve liability and environmental stability	• Develop and execute a closure plan in collaboration with communities of interest
• Reclassification of dams	• Work towards passive closure to minimize long-term monitoring and maintenance in perpetuity
• Reduced long-term dam or environmental monitoring, maintenance, and inspections.	• Construct a geotechnically stable landform that is safe for people and wildlife
• Meets most commitments and end land use	• Promote a geochemically stable landform to achieve closure / post closure water quality criteria for surface and groundwater
• Public could have controlled access to the site	• Aligns with Osisko's commitments
• Improved public perception of mine site	• Construct a closure landscape that supports returning end land use

Meets Commitments

Higher Risk – more active care

Lower Risk – more passive care

Current conditions

Vision #1

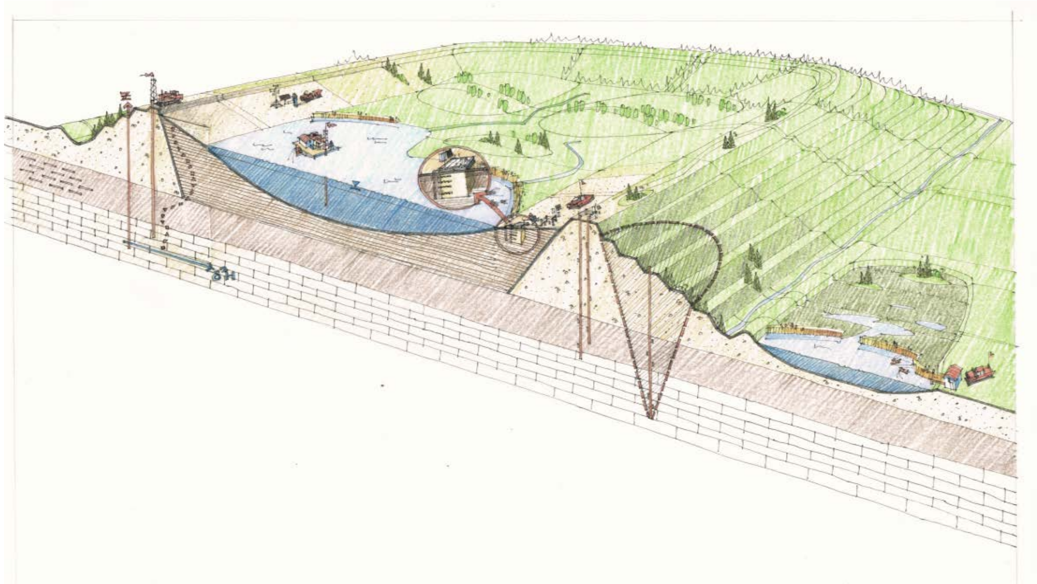
Vision #2

Vision #3

Preferred Closure Vision:
Vision #2 – A Focus on Decommissioning Tailings Storage Facility

To complete decommissioning of the TSF,
the Canadian Dam Association (CDA) require the following four (4) criteria to be met[1]:

1. **Ponded water will not propagate a failure or uncontrolled release of contents;**
2. **Contents do not and cannot flow (i.e., are not fluid like) and do not rely on a barrier structure to prevent an uncontrolled release;**
3. **Contents do not and cannot migrate or pipe through the structure or foundation; and**
4. **Considerations will not develop in the future that could violate the previous three criteria.**

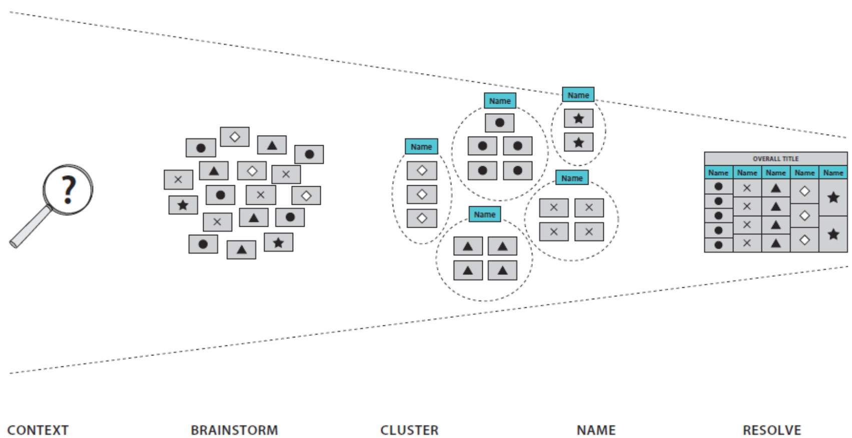


[1]CDA Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams – Revision to Section 2.4 – Draft (June 2, 2019)

Vision #2 – A Focus on Decommissioning Tailings Storage Facility

…further definition using Strategic and Tactical Optimization Tools

Opportunity Framing for Closure Visioning



Scenario Planning Tool for Strategic Management

…stay in a strategic thought space for as long as possible…

Assessment Metric	Current Conditions	Scenario 1	Scenario 2	Scenario 3
Sustainability Commitments? • *Social License*	? ? ?			
Dam Stability	? ? ?			
Surface Water	? ? ?			
Groundwater	? ? ?			
Monitoring and Maintenance Duration	? ? ?			
Closure "Intensity"	? ? ?			
Residual Risk	? ? ?			
Transition to Future Land Use	? ? ?			
Capital Expenditure	? ? ?			
Operating Expenditure	? ? ?			
	? ? ?			

Determination of Assessment Metrics and weightings to inform decision making: objectives, priorities, value drivers for the Site?

Closure Scenarios for Vision #2

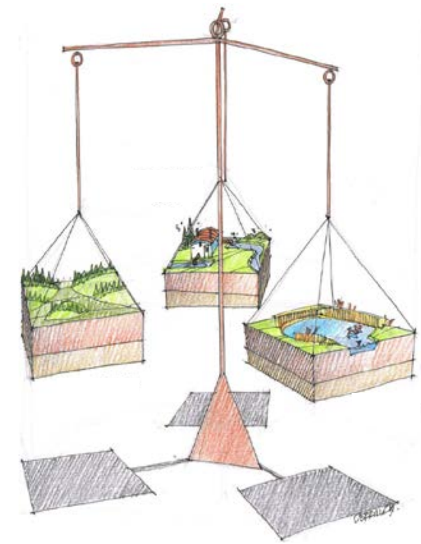
Scenario Planning Assessment Metric(s)

Red, yellow, and green light system used to assess how well the closure options fulfills the assessment metric.

There is no specific weighting for each metric. The assessment functions as a communication tool moving forward

In general:

- ✓ Green light – Metric is fully achieved within the closure scenario.
- ! Yellow light – Some elements in achieving the metric may not be met.
- ✗ Red light – Metric is not achieved within the closure scenario.



Scenario Planning Assessment Metric(s)

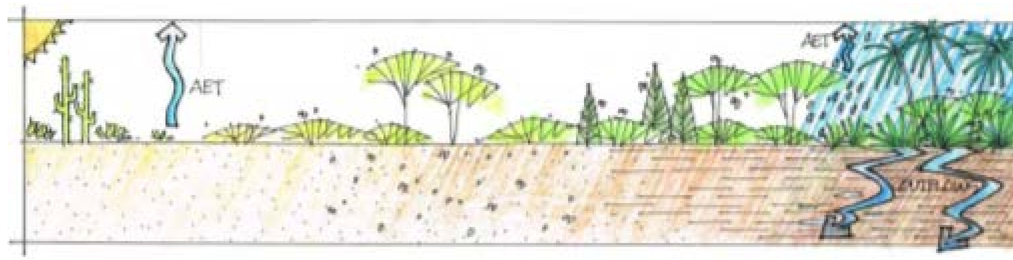
Assessment Metric	✗	!	✓
Corporate Sustainability Policy	• Does not meet corporate sustainability policies	• Partially meets corporate sustainability policies	• Meets / exceeds corporate sustainability policies
Meeting site specific ELU commitments – Safe Access	• Does not provide safe access for people and use by wildlife	• Further collaboration and consultation is required to provide safe access for people and use by wildlife	• Provides safe access for people and use by wildlife (with restrictions as required)
Meeting site specific ELU commitments – Physical stability (Geomorphic / Geotechnical)	• Inability to achieve agreement on acceptable level of residual risk • Not in compliance with HSRC	• Meets partial dam stability requirements • Liquefaction potential at acceptable level, but requires continued monitoring • Further work to establish acceptable level of residual risk	• High level of confidence to achieve agreement on acceptable level of residual risk • Meets all dam stability requirements • Has a negligible liquefaction potential. • Low risk of materials piping through the structure • In compliance with the HSRC
Meeting site specific ELU commitments – Protect environmental resources (Geochemical Stability)	• Inability to achieve BC WQG on site within 5 years for GW • Inability to achieve BC Freshwater WQG on site within 5 years for SW • Risk of not achieving WQG off site • Appropriate controls are not in place	• Inability to achieve BC WQG on site within 5 years for GW • Inability to achieve BC Freshwater WQG on site within 5 years for SW • Can achieve WQG off site • Controls in place to mitigate downstream impacts	• Ability to achieve BC WQG on site within 5 years for GW • Ability to achieve BC Freshwater WQG on site within 5 years for SW • Can achieve WQG off site
Meeting site specific ELU commitments – Monitoring and maintenance to achieve ecosystem functionality	• Functional ecosystems with high maintenance achieved	• Functional ecosystems with moderate maintenance achieved	• Functional ecosystems with low to no maintenance achieved

Scenario Planning Assessment Metric(s)

Assessment Metric	✗	!	✓
COI and stakeholder acceptance (Regulator / FN)	• Does not leverage community's interest in the site • Does not improve COI's utility • Stakeholder will not accept closure option	• Further collaboration and optimization on execution is needed for COI to accept closure option • Not all elements of COI's utility are improved • Further collaboration and optimization on execution is needed for stakeholder to accept closure option	• Leverages community's interest in the site • Measurably improves COI's utility • Stakeholders fully endorse closure option
Residual risk and Long-term Care	• Does not provide opportunity to reduce Osisko's residual risk and liability • Status quo maintained • Site is proactively managed post-closure	• Further consultation, collaboration, and/or optimization is required to quantify the reduction in residual risk and liability • Site is reactively managed post-closure	• Provides opportunity to significantly reduce Osisko's residual risk and liability • Site is fully divested after execution and monitoring.
Capacity to develop closure plan	• > 24 months to develop closure plan that is ready to execute	• 12 – 24 months to develop closure plan that is ready to execute	• < 12 months to develop closure plan that is ready to execute
Closure Intensity (execution + monitoring)	• > 7 years to execute closure works and perform active closure adaptive management and monitoring	• 5 to 7 years to execute closure works and perform active closure adaptive management and monitoring	• < 5 years to execute closure works and perform active closure adaptive management and monitoring
Capacity to Execute	• Internally Osisko is unable to commit required resources to execute on the closure works as per schedule	• Further optimization and understanding is required for Osisko to commit the required resources to execute the closure works as per schedule	• Internally Osisko commits resources required to execute the closure works as per schedule

Closure Scenarios for Vision #2

- ***Scenario A:***
  - Manage Water on Landform,
  - No run-on



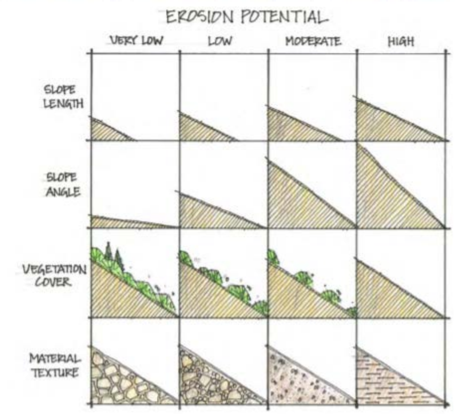


Figure 4-3. Potential erosion control mechanisms for cover system design.

- ***Scenario B:***
  - Allow run-on from surrounding watershed

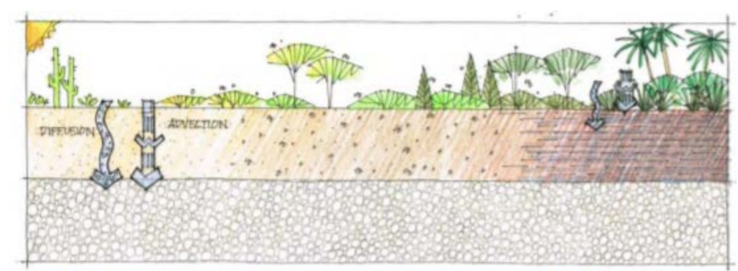


Figure 4-2. Conceptual dominant mechanism contributing to oxygen ingress based on climatic regime.

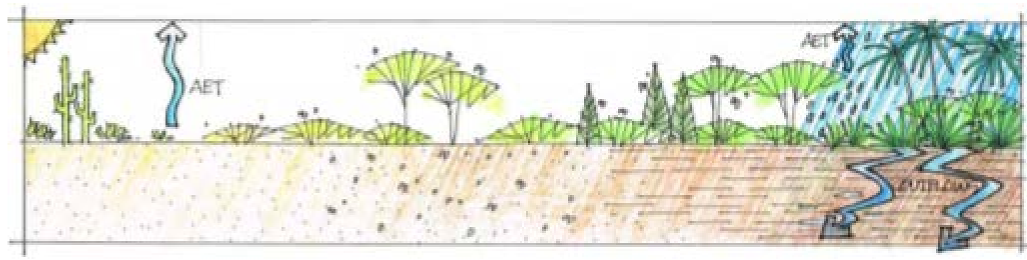
- ***Scenario C:***
  - Full / Partial Tailings Removal

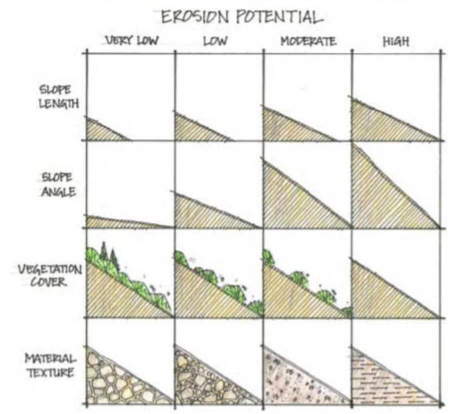
Scenario Evaluation

Assessment Metric	Scenario A	Scenario B	Scenario C
Corporate Sustainability Policy	!	!	✓
Meeting site specific ELU commitments – Safe Access	!	!	✓
Meeting site specific ELU commitments – Provision of physical stability (Geomorphic / Geotechnical)	!	!	✓
Meeting site specific ELU commitments – Protect environmental resources (Geochemical Stability)	!	!	✓ !
Meeting site specific ELU commitments – Monitoring and maintenance to achieve ecosystem functionality	! ✗	!	✓
COI and stakeholder acceptance (Regulator / FN)	!	!	! ✗
Residual risk and Long-term Care	!	✓ !	! ✗
Capacity to develop closure plan	✓	✓	!
Closure Intensity (execution + monitoring)	✓	✓	!
Capacity to Execute	✓	✓	! ✗

Closure Scenarios for Vision #2

- ***Scenario A:***
  - Manage Water on Landform,
  - No run-on
  Potential Optimizations:
  - Moderate to Very Low NP cover system
  - Buttress dam
  - Semi-Passive treatment (constructed wetlands)
  - Upgrade spillway
  - Maximize diversion of clean surface water runoff
  - Wick drains to enhance consolidation
  - Active water treatment in the short-term to collect / treat seepage water
  - Ditching to increase recoverable / unrecoverable seepage ratio
- ***Scenario B:***
  - Allow run-on from surrounding watershed
  - Same optimizations as #1
- ***Scenario C:***
  - Full / Partial Tailings Removal
  - Reprocessing for Economic Benefit





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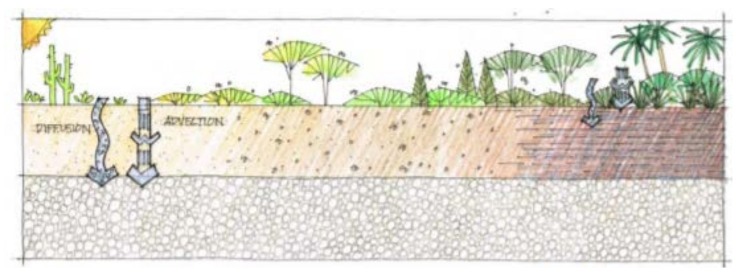
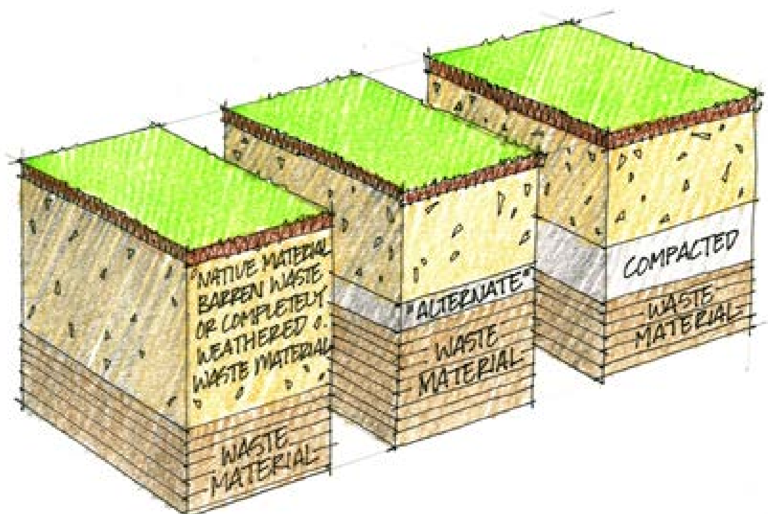


Figure 4-2. Conceptual dominant mechanism contributing to oxygen ingress based on climatic regime.

Scenario B – Path Forward

1. **Cover system and landform design to promote clean runoff**
   - Likely will take the form of a drainage swale and sloping to have runoff exit the structure at a specific location;
   - Unlikely we will rely on 'sheet' flow across the structure.
   - This will be accomplished through a surficial landform design and analysis to determine the most effective design for short- and long-term.

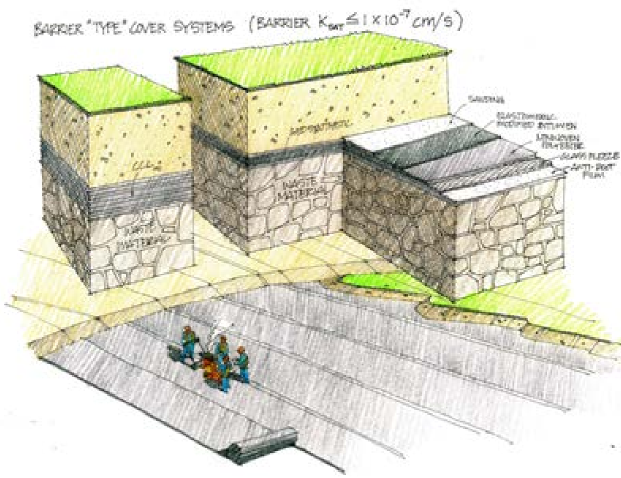
2. **Create opportunity to maximize recoverable seepage in Short-Term**
   - Treat the water through passive or active methods until groundwater meets acceptable criteria and no longer an issue



Scenario B – Path Forward

3. Move toward **decommissioning TSF**

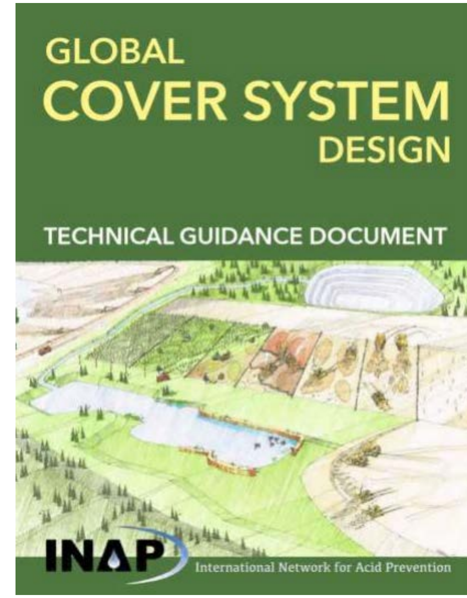
- Seepage analyses to determine cover system and landform design to classify structure as a landform
  - Initially, utilize a cover system with a 'moderate' net percolation rate, while still maintaining capacity to create a 'high probability' for clean runoff, if
  - This moderate NP rate does not provide for sufficient influence/ trend on tailings mass pore-water pressure regime (e.g., lowering of phreatic surface), then
  - A Cover system and landform design that reduces net percolation rates to 'low' to 'very low' will be evaluated (e.g., incorporating compacted 'clayey' material and/or a geosynthetic liner)
- Liquefaction potential analyses to ensure tailings is stable
- Stability analyses of downstream slope
- Surficial armoring of downstream slopes to minimize effects of flood events in Mosquito Creek
- Wick drains and other methods to promote required trends in pore-water pressure regime



Scenario B Base Case

Conceptual Cover System Design – Path Forward

- Moderate NP Cover System
  - Optimizations:
    - Ensure clean surface runoff
    - Optimize recoverable / unrecoverable ratio
    - Enhance consolidation (i.e., wick drains)
    - Manage pore-water pressure regime in underlying tailings



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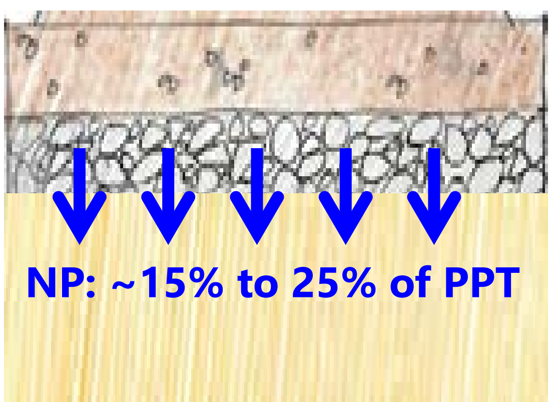

Cover Material (water holding capacity): texture/depth

Working Platform (bearing capacity): texture/depth

Tailings: pore-water pressure, texture, stored acidity, etc.

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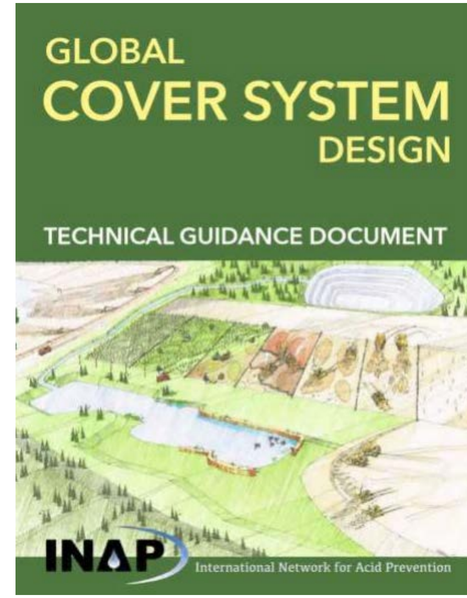

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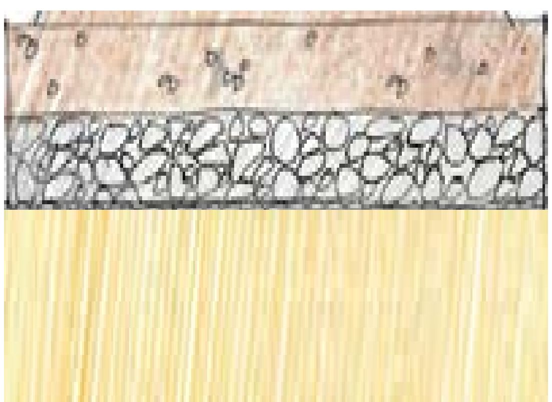


Cover Material (water holding capacity): texture/depth

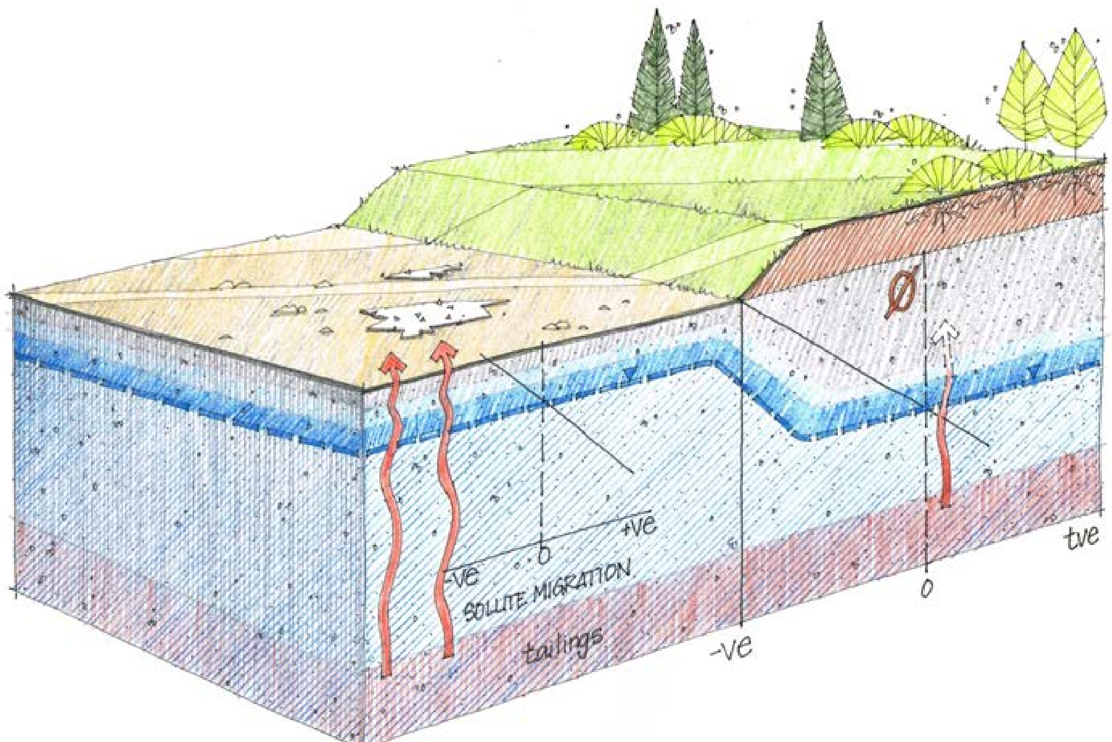
Working Platform (bearing capacity): texture/depth

geotextile

Tailings: pore-water pressure, texture, stored acidity, etc.

Scenario B – Path Forward

4. **Determine success criteria (when the dam is decommissioned)**
   - Monitoring?
   - Risk analysis?
   - FMEA?
5. **Monitoring as we transition from a dam to a waste structure**



Vision #2 – A Focus on Decommissioning Tailings Storage Facility

…further definition using Strategic and Tactical Optimization Tools

Use the

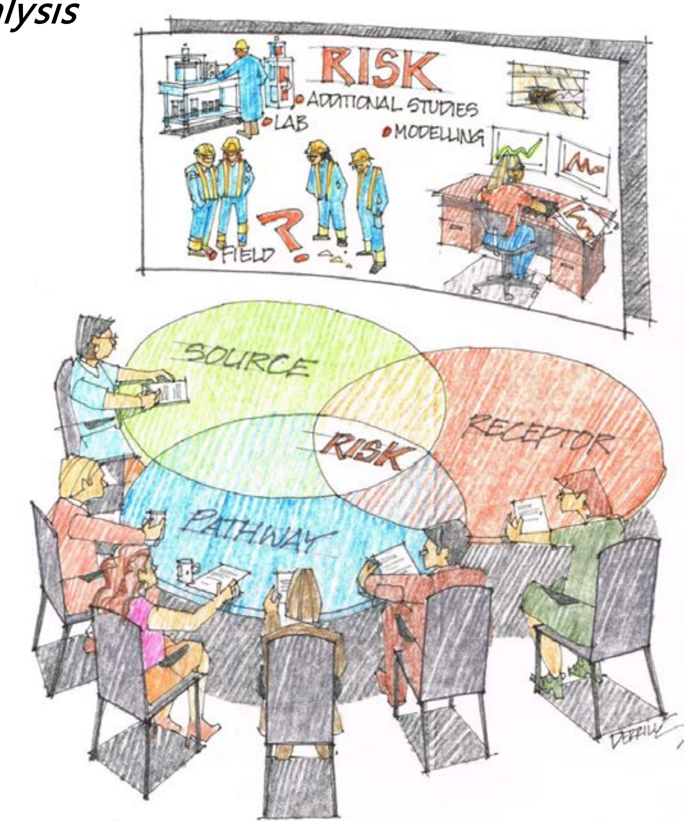
Failure Modes and Effects Analysis (FMEA)

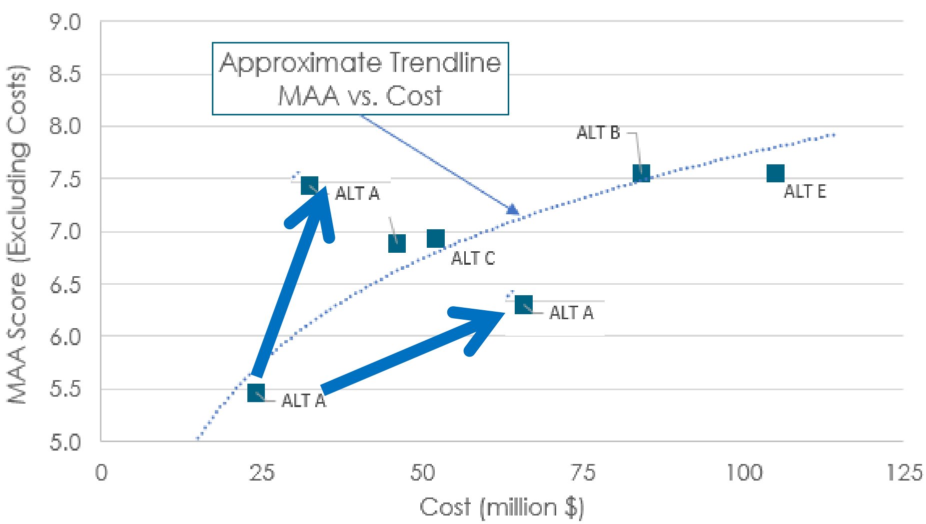
as a tool

to inform on

Engineering Design…

… Throughout a Project





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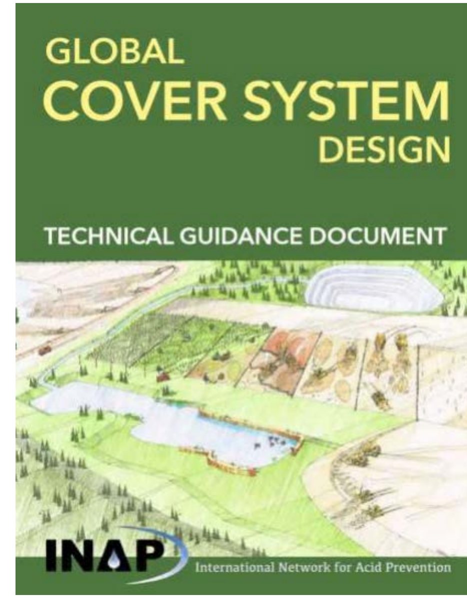

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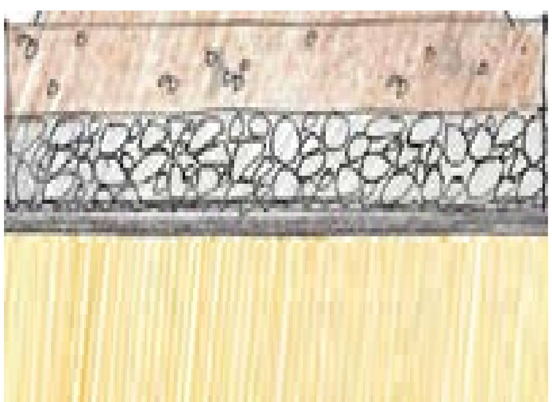


Cover Material (water holding capacity): texture/depth

Working Platform (bearing capacity): texture/depth
geotextile

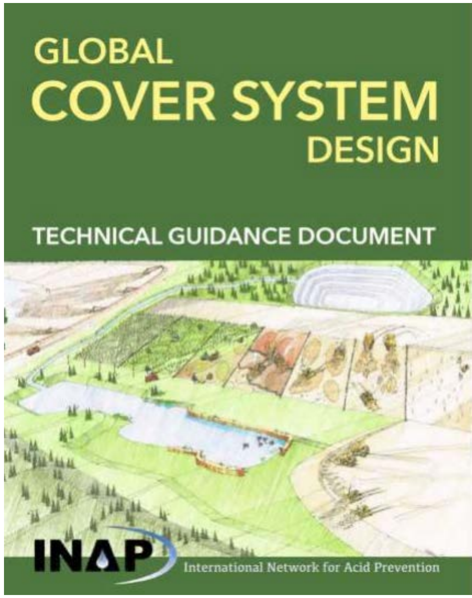
Geomembrane (low permeability)

Tailings: pore-water pressure, texture, stored acidity, etc.

Scenario B Base Case

Conceptual Cover System Design – Path Forward

- Moderate NP Cover System
  - Optimizations:
    - Ensure clean surface runoff
    - Optimize recoverable / unrecoverable ratio
    - Enhance consolidation (i.e., wick drains)
    - Manage pore-water pressure regime in underlying tailings



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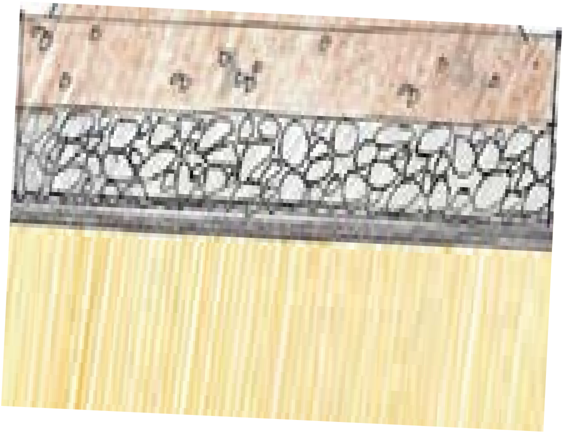

Cover Material (water holding capacity): texture/depth

Working Platform (bearing capacity): texture/depth

geotextile

Geomembrane (low permeability): lateral drainage

Tailings: pore-water pressure, texture, stored acidity, etc.

Schedule and Next Steps

Year	Activities
Planning and Design: Q1 / Q2 2022	**MAA / FMEA** **Collaboration / Consultation** **Additional geotechnical and geochemical characterization** **Numerical modelling** **Detailed cover system and landform design** **IFC drawings**
Active Closure: Q3 2022 – Q1 2023	Implement cover and landform design Active monitoring and maintenance
Passive Closure: Q2 2023 to 2027	Monitoring and Maintenance Annual visual inspections of TSF, compliance with HSRC SW (schedule TBD) GW (schedule TBD)
Post Closure: 2028	Monitoring and Maintenance

Thank you!

Please contact info@okc-sk.com for any follow up questions.

OSISKO DEVELOPMENT

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25 Years Advancing Mine Closure Solutions