Kevitsa Mine- Updating the closure plan

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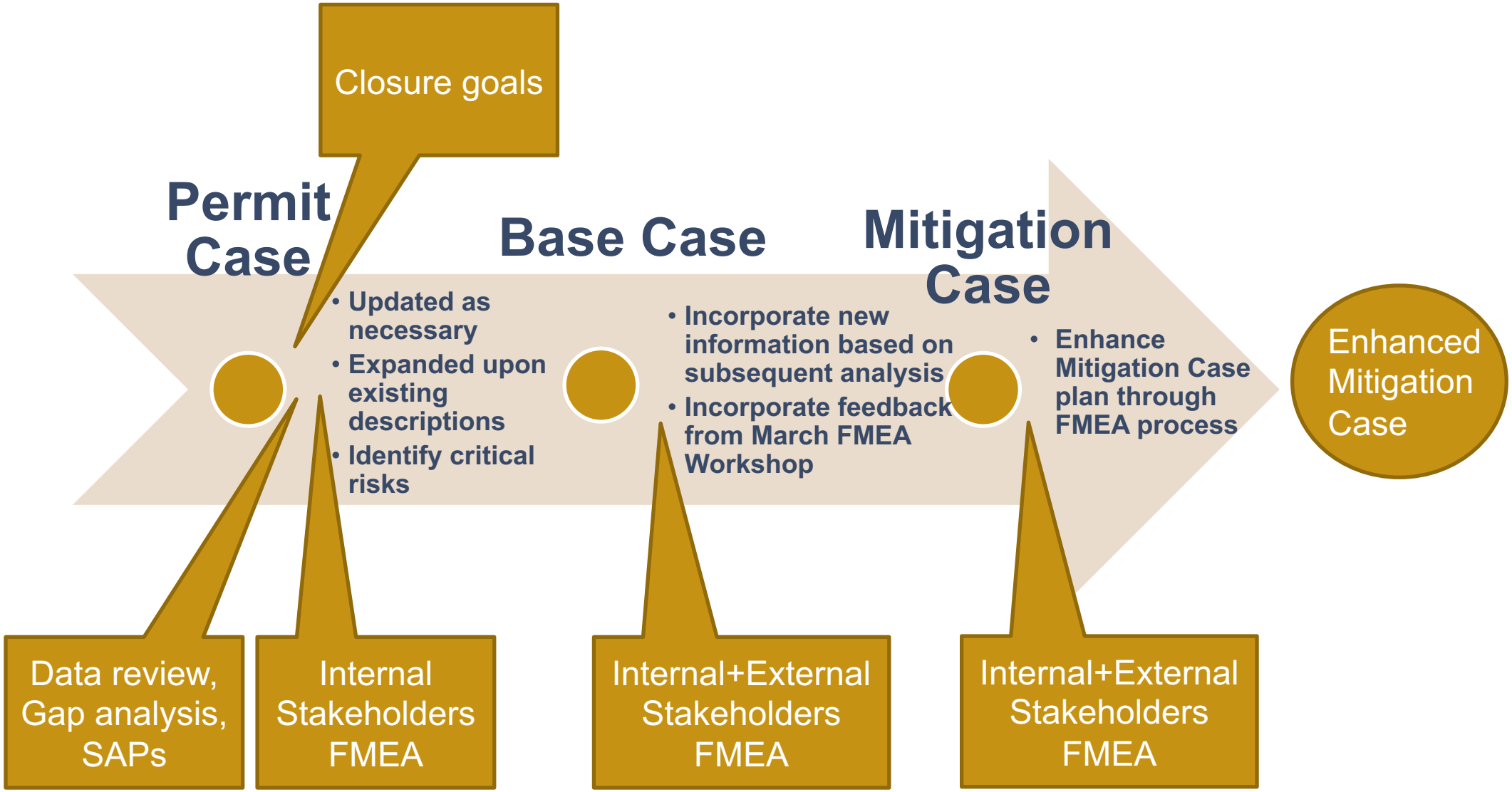
Agenda

- Iterative re-design process
- What needed doing
- Results of investigations
- Test Trials
- Challenges and opportunities

What needed to be done?

- Large quantity of geochemical testing, little to no leaching tests
- Improve understanding of the physical and chemical properties of both waste rock and tailings- neutral mine drainage, Ni mobility, behavior of different waste classes.
- Update the geohydrological model for the entire site and closure water balance
- Understand the physical and chemical properties of the current closure design
- Improve the understand of the materials balance (usable waste rock, till)
- Determine the common closure goals

Work Flow


Closure goals
Permit Case
Base Case
Mitigation Case
• Updated as necessary
• Expanded upon existing descriptions
• Identify critical risks
• Incorporate new information based on subsequent analysis
• Incorporate feedback from March FMEA Workshop
• Enhance Mitigation Case plan through FMEA process
Enhanced Mitigation Case
Data review, Gap analysis, SAPs
Internal Stakeholders FMEA
Internal+External Stakeholders FMEA
Internal+External Stakeholders FMEA

Mine Layout

- Waste Rock Storage Facility
- TSF-A and TSF-B
- Open Pit
- Water Reservoir
- Industry area

WRSF closure conceptual model

All sulfide oxidation occurs within USW zone due to diffusion control on oxygen ingress

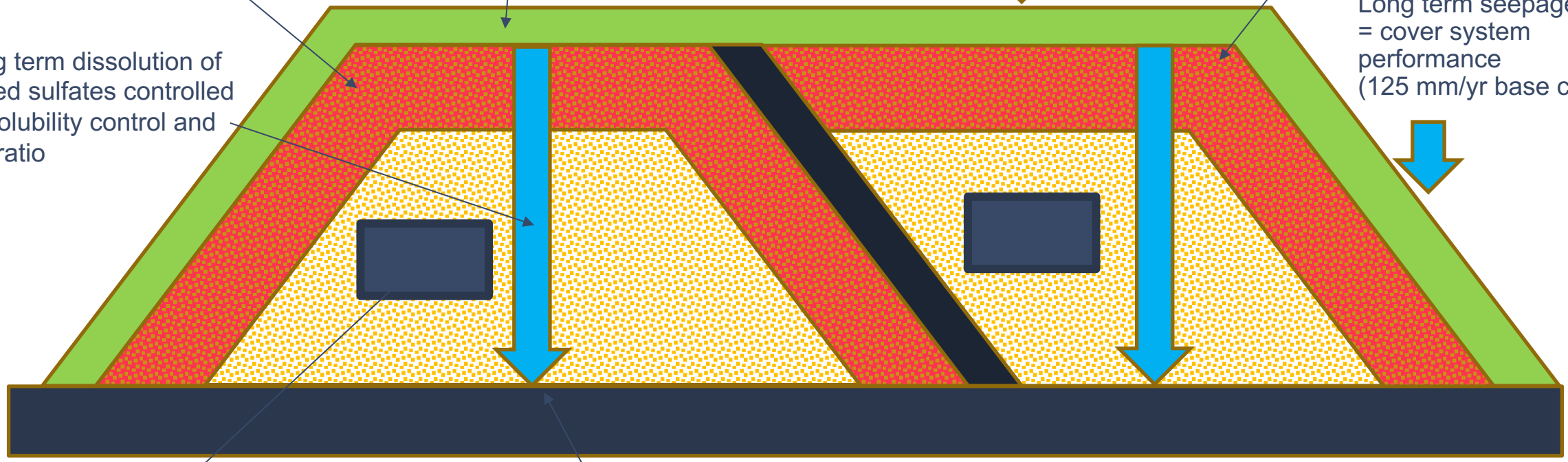
Final cover system complete over entire WRSF, oxygen ingress constrained to 3 mol/m^2/yr

Long term seepage rate = cover system performance (155 mm/yr base case)

Completion of adjacent Stage

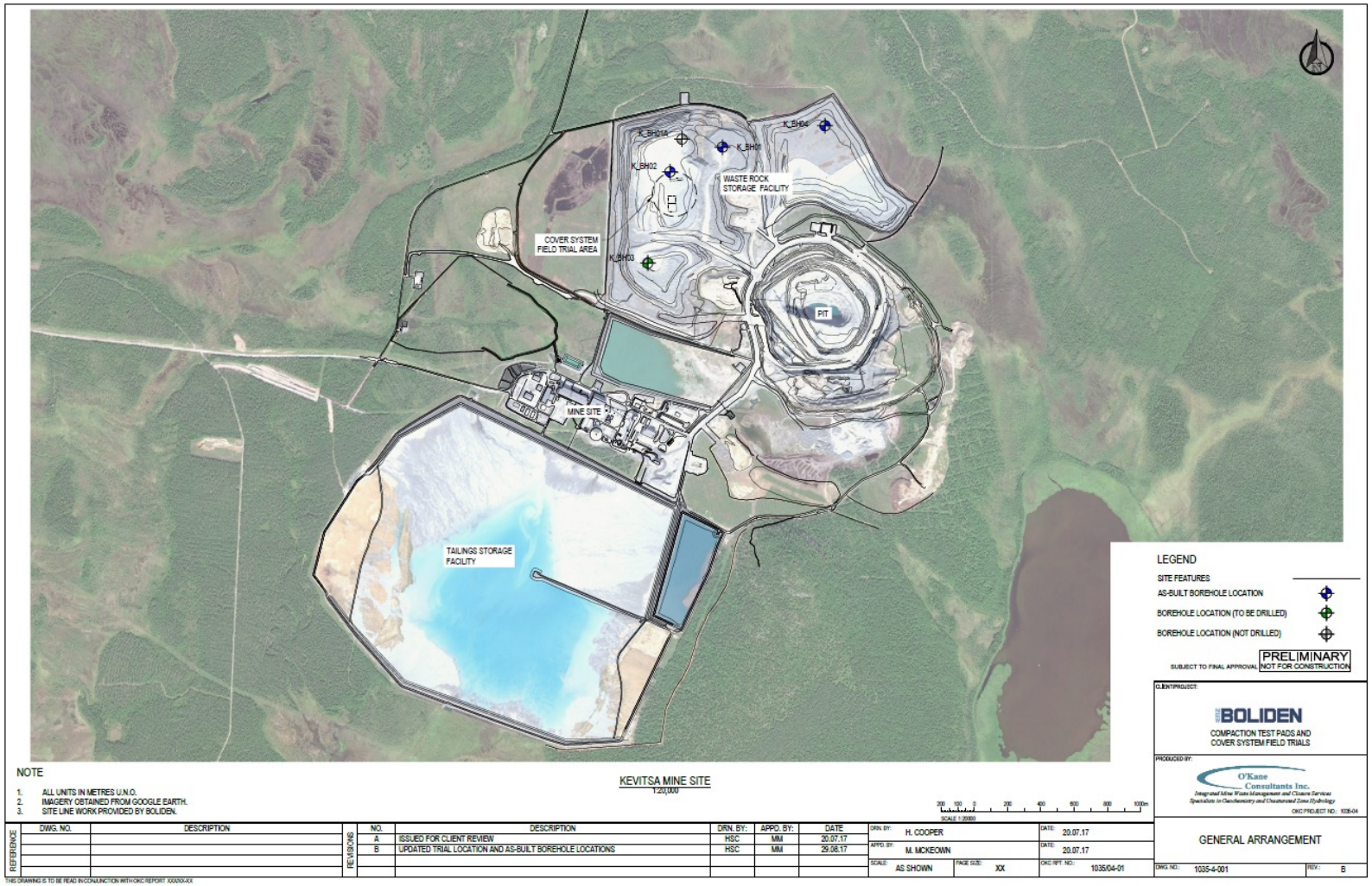
Long term seepage rate = cover system performance (125 mm/yr base case)

Long term dissolution of stored sulfates controlled by solubility control and L:S ratio



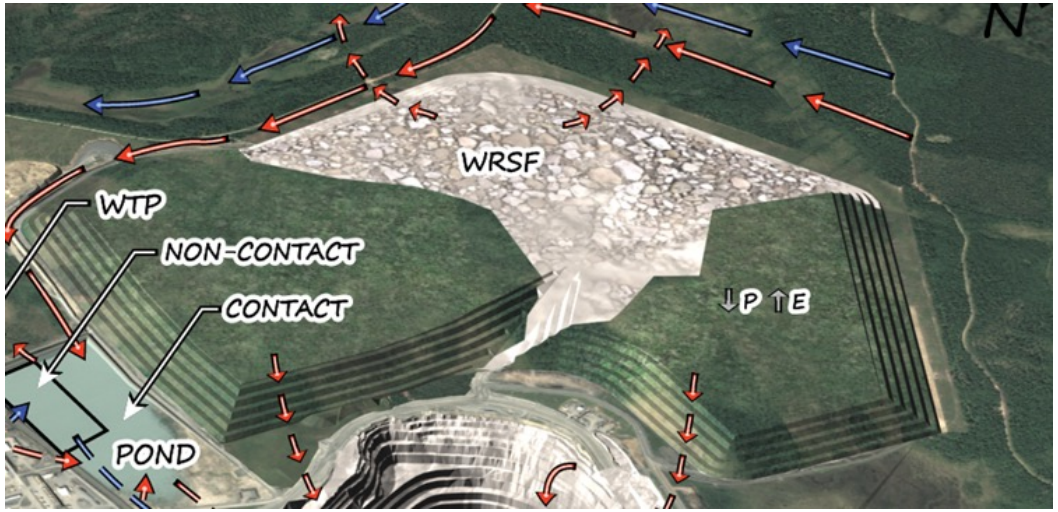
Encapsulated CW waste

Relative sulfate load removal faster than addition resulting in declining concentrations of sulfate and metals with time


K_BH04
K_BH01A
K_BH01
K_BH02
WASTE ROCK STORAGE FACILITY
COVER SYSTEM FIELD TRIAL AREA
K_BH03
PIT
MINE SITE
TAILINGS STORAGE FACILITY
LEGEND
SITE FEATURES
AS-BUILT BOREHOLE LOCATION
BOREHOLE LOCATION (TO BE DRILLED)
BOREHOLE LOCATION (NOT DRILLED)
SUBJECT TO FINAL APPROVAL
PRELIMINARY
NOT FOR CONSTRUCTION
CLIENT/PROJECT:
BOLIDEN
COMPACTION TEST PADS AND COVER SYSTEM FIELD TRIALS
PRODUCED BY:
O'Kane Consultants Inc.
Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology
OKC PROJECT NO.: 1035-04
GENERAL ARRANGEMENT
DRG. NO.: 1035-4-001
REV.: B
NOTE
1. ALL UNITS IN METRES U.N.O.
2. IMAGERY OBTAINED FROM GOOGLE EARTH.
3. SITE LINE WORK PROVIDED BY BOLIDEN.
KEVITSA MINE SITE
1:20,000
SCALE 1:20000
REFERENCE
DWG. NO. | DESCRIPTION
REVISIONS
NO. | DESCRIPTION | DRN. BY: | APPD. BY: | DATE
A | ISSUED FOR CLIENT REVIEW | HSC | MM | 20.07.17
B | UPDATED TRIAL LOCATION AND AS-BUILT BOREHOLE LOCATIONS | HSC | MM | 29.08.17
DRN. BY: H. COOPER DATE: 20.07.17
APPD. BY: M. MCKEOWN DATE: 20.07.17
SCALE: AS SHOWN PAGE SIZE: XX
OKC RPT. NO.: 1035/04-01
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH OKC REPORT XXX/XX-XX

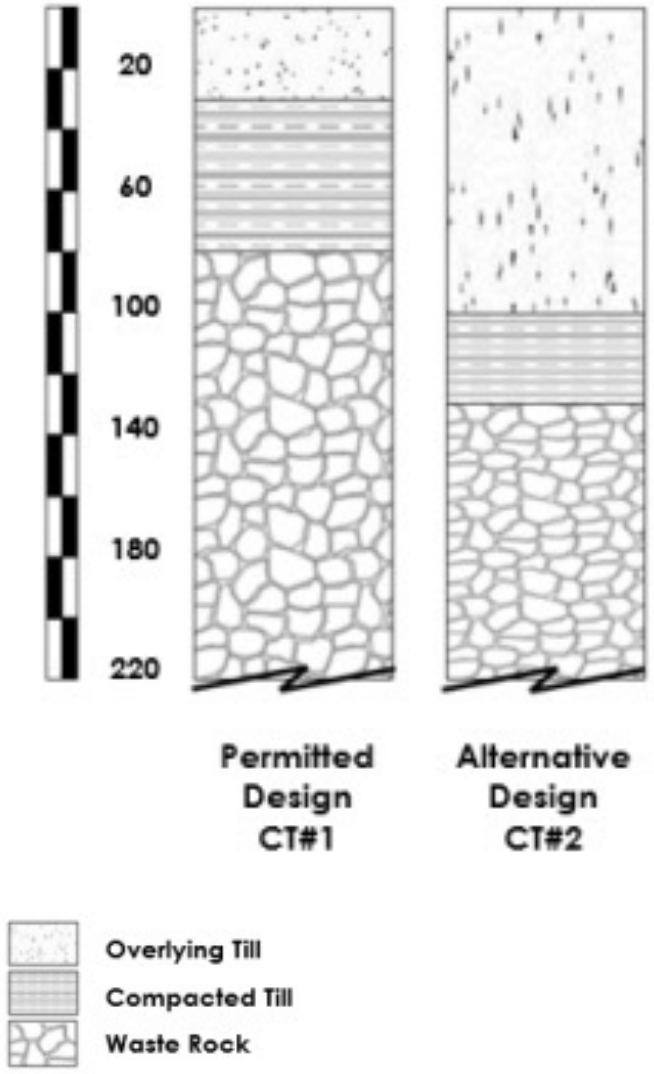
WRSF Cover System Objectives

- Manage oxygen ingress to the underlying waste rock;
- Manage net percolation of meteoric waters to underlying waste rock
- Rate of reclamation is a key input



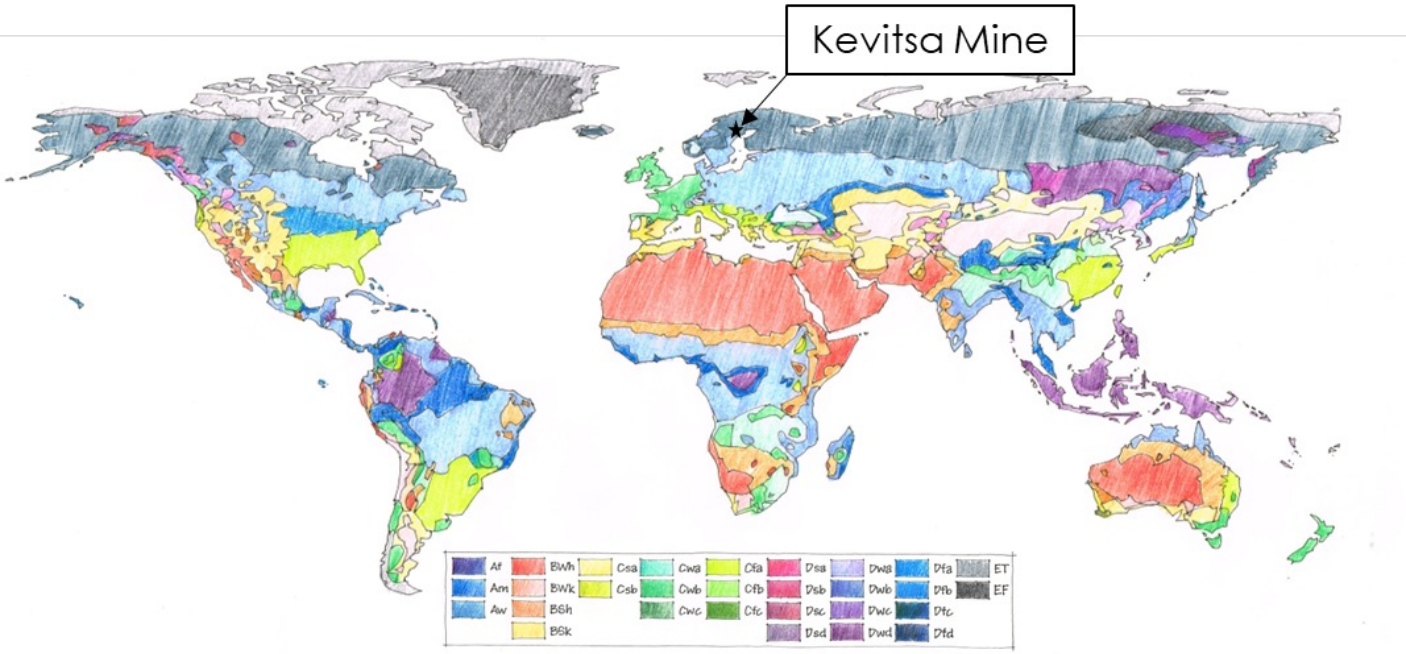
1A Cover System Field Trials

- Outcomes & Findings:
  - Freezing extended through compacted layer of permitted design
  - Wet / dry cycling more prominent for permitted design
  - Net percolation ranges were on the higher end of conceptual model range(35 to 42%)
  - Alternative design outperformed Permitted design in primary objectives
  - Data supported updated cover system design

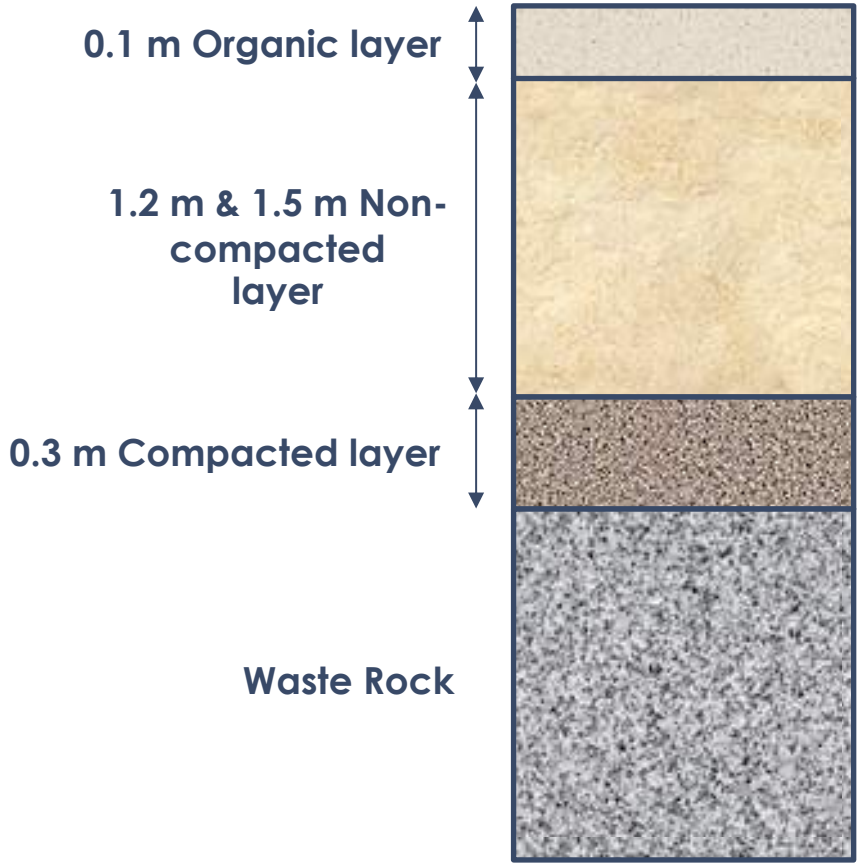


Climate Setting

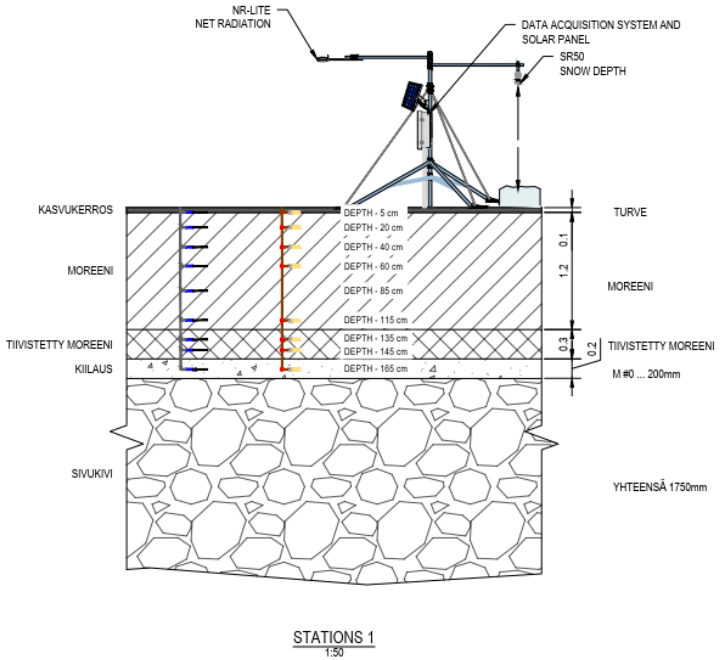
- Köppen-Geiger climate classification: Dfc
  - Cold climate with no distinct dry season and a cold summer
  - Average annual precipitation ~480 mm/yr
  - Average annual potential evapotranspiration ~300 mm/yr
  - RCP 4.5 and 8.5 modelled



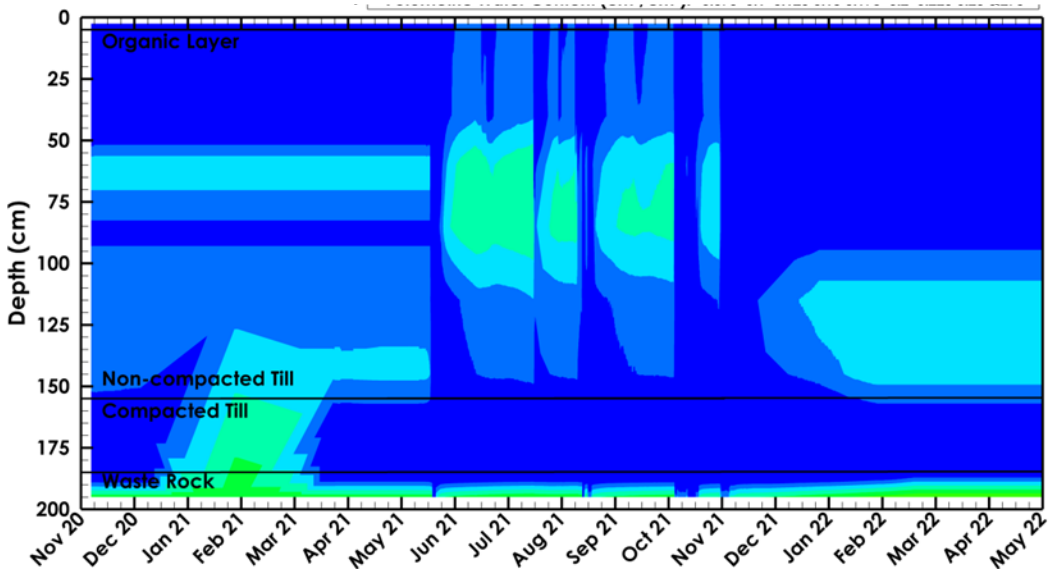
Enhanced store and release cover system

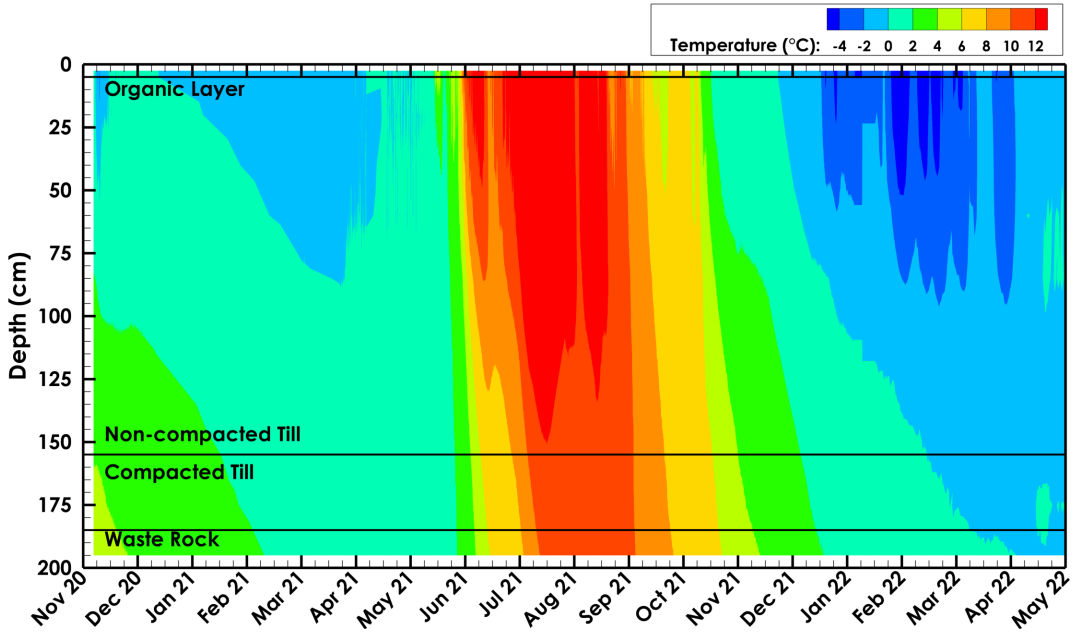


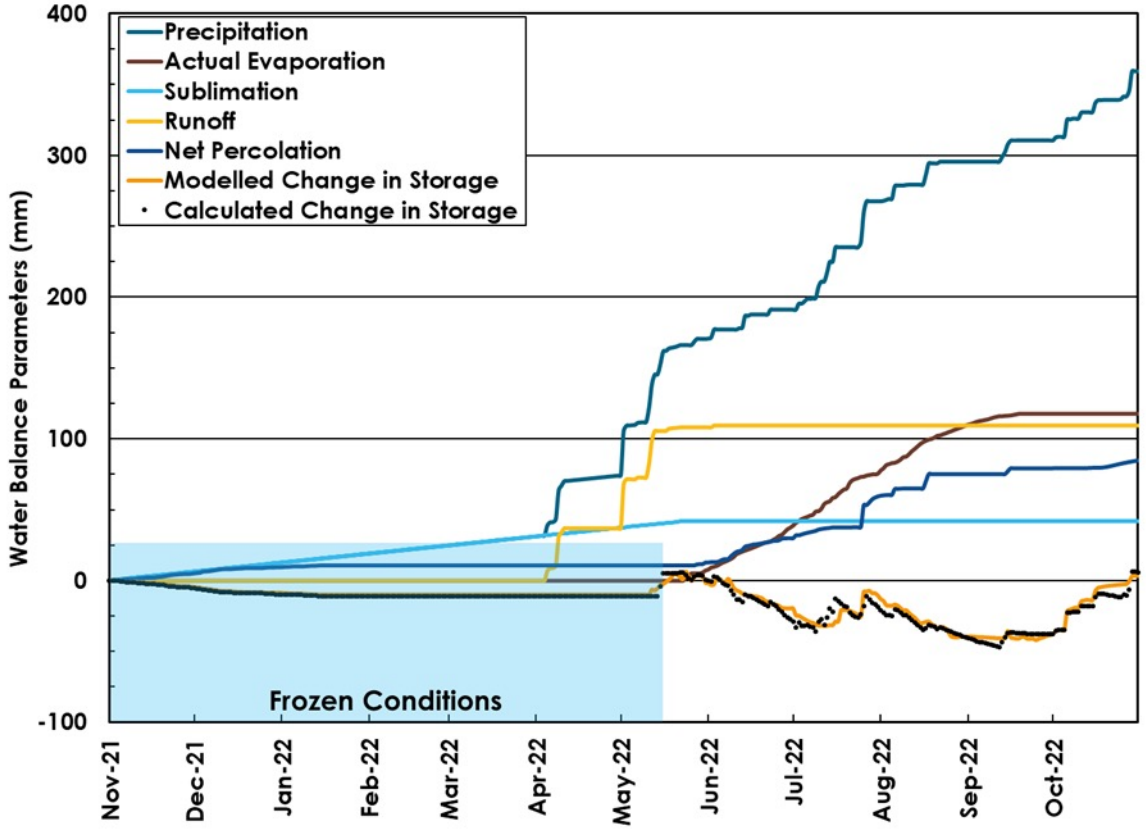
Performance Monitoring Systems



Pilot-scale Field Trials Performance Monitoring





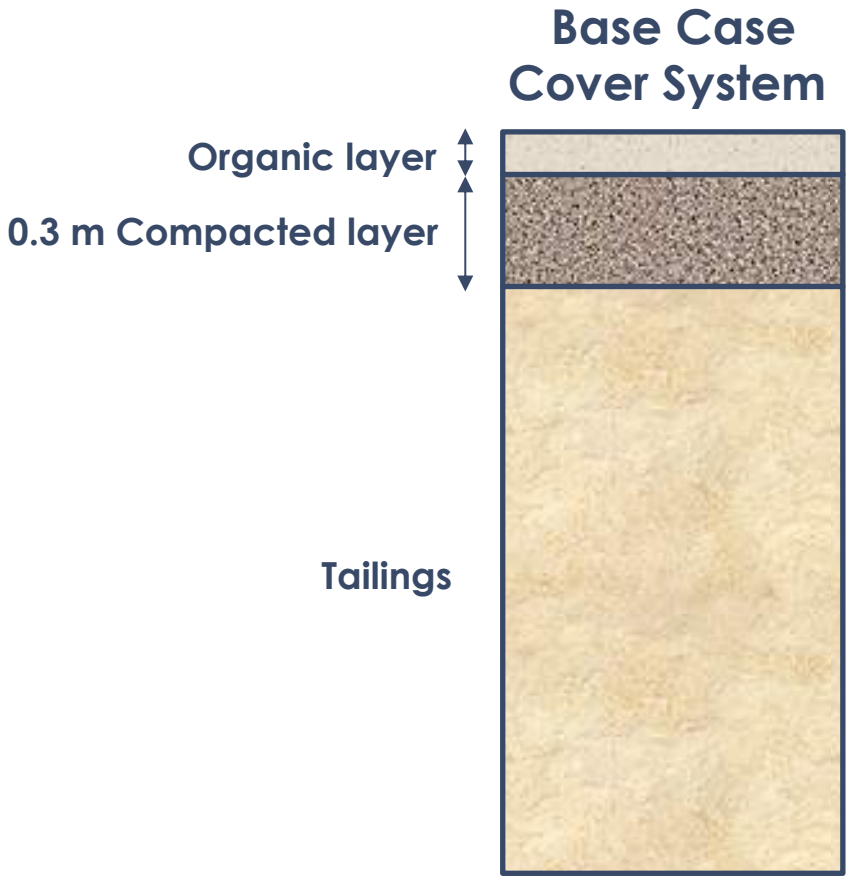


WRSF Cover System Field Trial Takeaways (So Far)

- Permitted cover system design needed updating
- Compacted till cover systems are performing as expected to date with respect to primary objectives
- Additional considerations: Material availability and variability, carbon emissions, quality control, freeze/thaw cycling, rate of reclamation
- Bentonitic cover systems may provide an opportunity to reduce material requirement – needs to be assessed through continued monitoring
- Erosion and physical stability. Consideration for optimized slope angle/lengths, revegetation strategy, surface water management structures
- Changes to WRSF water balance need to be considered

TMF SPA modelling

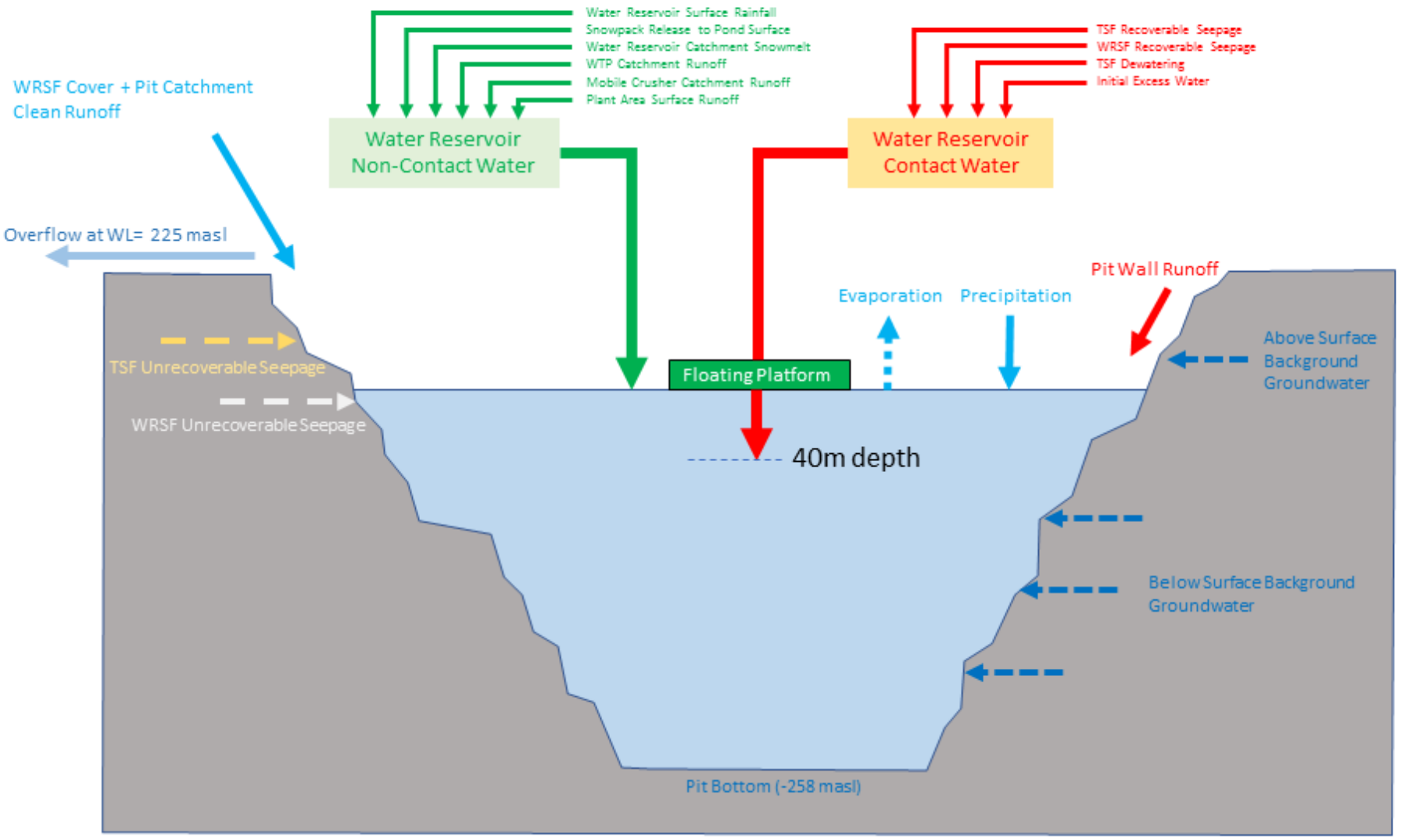
- Permitted design evaluated in 2019
- Objectives (2019): Physical separation from tailings, ability to pond and shed from waterway
- Secondary objectives: net percolation and vegetation
- Conceptual model is supported by recent kinetic testing



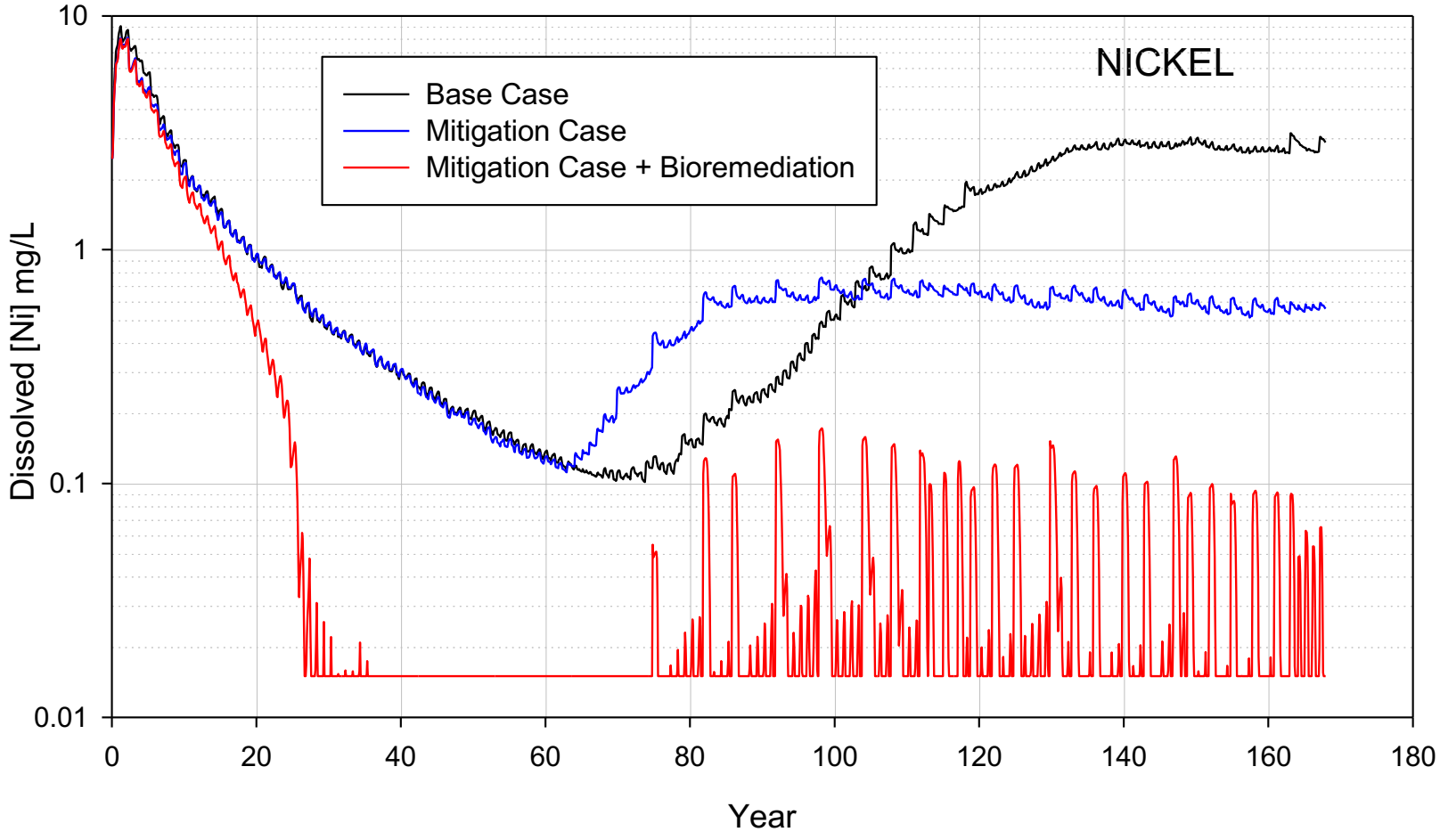
OPEN PIT

- A key component of all modelled closure scenarios is the collection of recoverable mine waters from the TMF and WRSF and conveyance of this water to depth in the pit lake
- The objective of this management strategy is to:
  - Engineer permanent stratification (meromixis) in the water column;
  - Permanently isolate high-concentration waters in the bottom of the pit; that may otherwise require treatment;
  - Decrease potential need for water treatment in closure; and
  - Ultimately improve long-term water quality conditions in lake surface waters.

Mitigation Case Model Inputs



Bioremediation – WQ Results: Nickel



Concluding Remarks

- Progressive closure on the WRSF combined with placing “captured waste” in cells will effectively reduce the metals to manageable concentrations.
- Open pit with bioremediation should lead to an acceptable surface water discharge.
- Challenges and Opportunities
  - Site materials balance- Managing material production and use now through closure.
  - Groundwater and seepage
  - Potential benefits of co-deposition waste rock and tailings
  - Potential of size fraction control
  - Strong evidence of Ni attenuation in peat

What is going on now?

- Never really stopped updating the knowledge base
- Continuous testing of the cover systems and learning
- Groundwater, surface water, geochemistry, geotechnical investigations ongoing
- Required delivery of update closure plan 2024-2025


Thank You