




CANADIAN MALARTIC MINE

LARGE SCALE FIELD TRIALS OF COVER SYSTEMS AT MINE CANADIAN MALARTIC

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Presentation Summary

1. Context
2. Concept Development & Design
3. Detailed Design
4. Preparatory Works
5. Construction
6. Conclusions

ABOUT US

CANADIAN MALARTIC MINE

Canadian Malartic Mine (CMM), one of Canada's largest operating open-pit gold mines, is owned equally by Agnico Eagle Mines Limited and Yamana Gold inc. Operating since 2011, the mine is located in the Town of Malartic, an urban area, in the heart of Abitibi's Gold Belt. The Malartic Extension Project will extend the mine's life until 2027.

1- Context

CANADIAN MALARTIC MINE

AT A GLANCE

Low-grade ore deposit mined in open pit & average plant production capacity **55,000 tonnes / day**

Estimated production of **660,000 ounces** of gold in 2019

Fleet of nearly **100 equipments**

More than **750 employees and 1,100 contractor employees**

Operation **7 days a week**, 24 hours a day

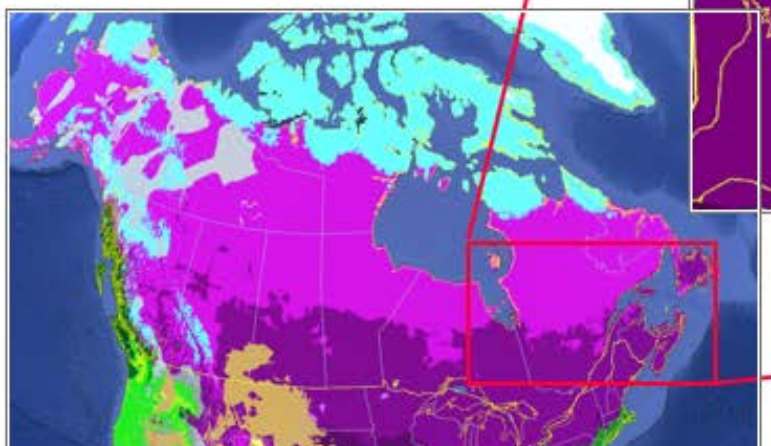
Current climate conditions

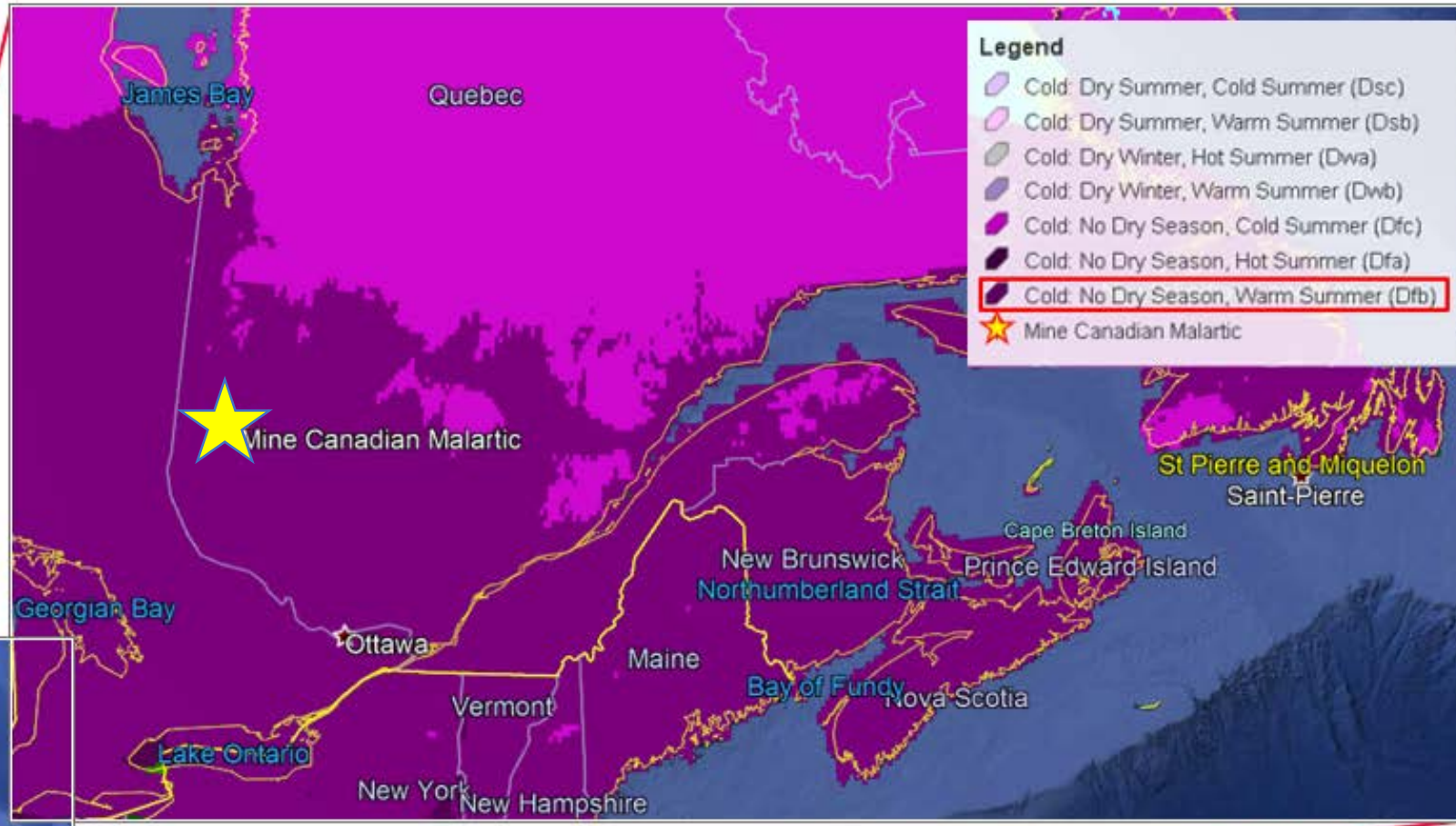
MINE CANADIAN MALARTIC

Köppen Gieger classification:

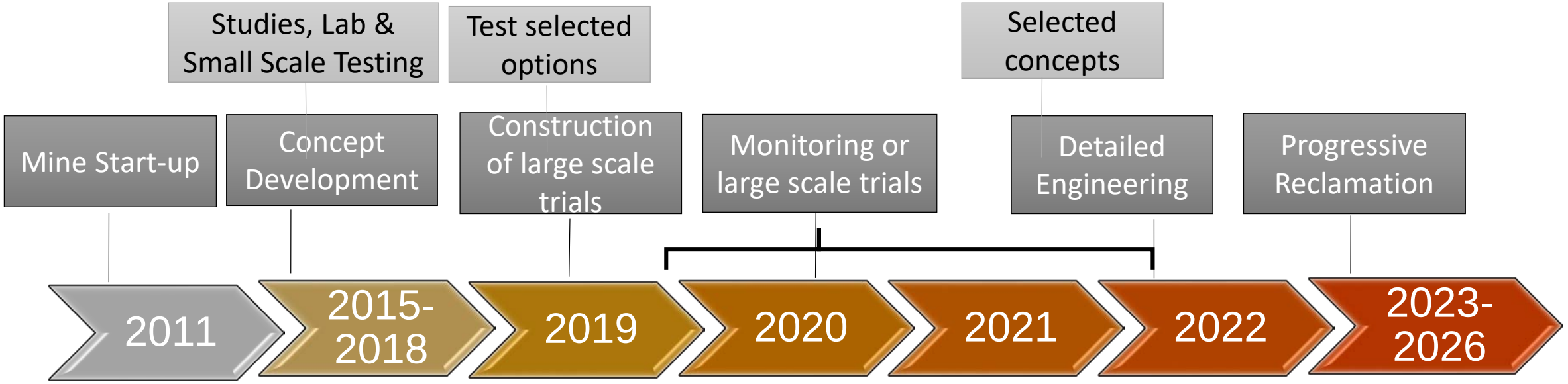
Long, cold winters & short summers with no dry season

- Precip.(900mm) > Evapotr. (650mm)
- Majority of the Evapotranspiration occurs within the summer
- Large volume during spring freshet
- Majority of NP will occur during spring





Timeline


Studies, Lab & Small Scale Testing
Test selected options
Selected concepts
Mine Start-up
Concept Development
Construction of large scale trials
Monitoring or large scale trials
Detailed Engineering
Progressive Reclamation
2011
2015-2018
2019
2020
2021
2022
2023-2026

Mining

- Total mine site footprint: 1500 ha
- Tailings Storage Facility:
  - Flat areas = 369 ha
  - Raises = 211 ha
- Thickened tailings
  - 65% solid

Tailings geochemistry

- Characterized as Potentially Acid Generating (PAG) and Metal Leaching (ML)
  - RPN-Carb: approx. 1.1
  - S (total): approx. 1%

2- Concept Development

Concept development
from small scale…

- Small scale experimental field cells (10 m x 10 m)
- Various mining waste considered as cover materials: tailings, waste rock, paste rock with and without amendment, amended tailings.

Concept development
…to large scale

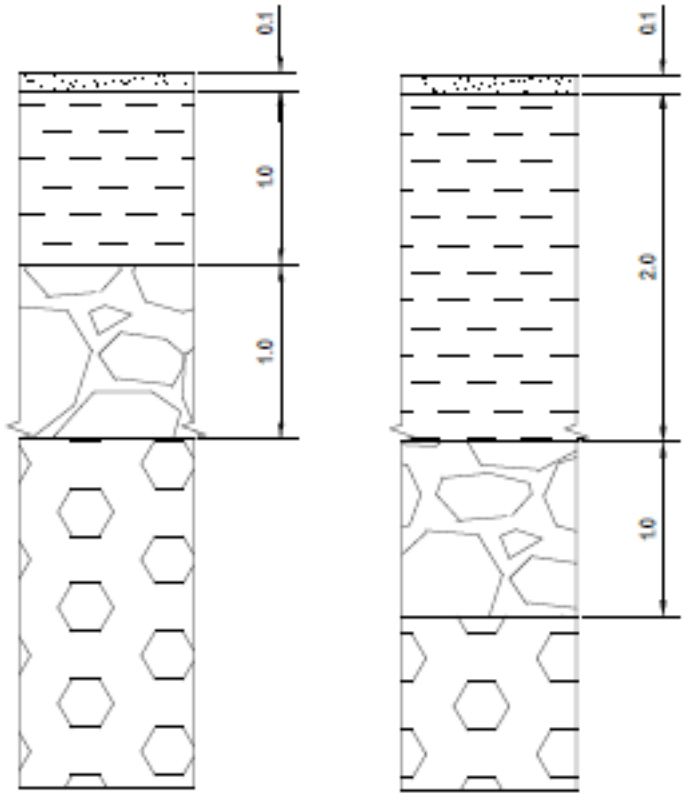
- Why large scale?
  - ➢ To make informed decisions for full scale reclamation
- Risk-based approach (FMEA):
  - ➢ Overall question addressed : *What is MCM's water quality risk profile at closure in terms of meeting regulatory requirements at the discharge points?*
  - ➢ Systematical approach to identify and rank failure modes for operations, closure, and post-closure periods
  - ➢ Selection of cover systems to test on a larger scale

Concept development
…Large scale trials objectives

- Objectives of large scale trials were defined in function of identified risks:
  - ✓ Measure performance (O_2 ingress and NP)
  - ✓ Evaluate constructability (understand cover functionality for full scale design and construction feasibility)

Concept design
… Large scale trials options

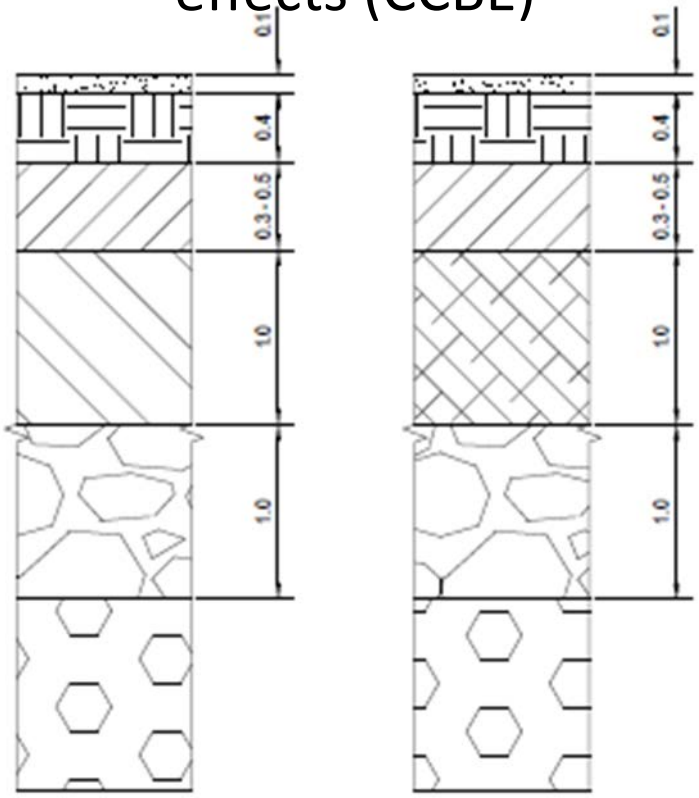
Option 1 : Monolayer cover system



1A : 1m of overburden

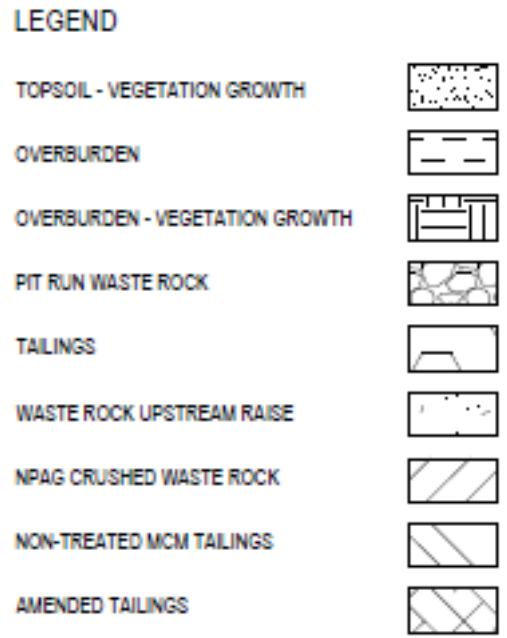
1B : 2m of overburden

Option 2 : Cover with capillary break effects (CCBE)



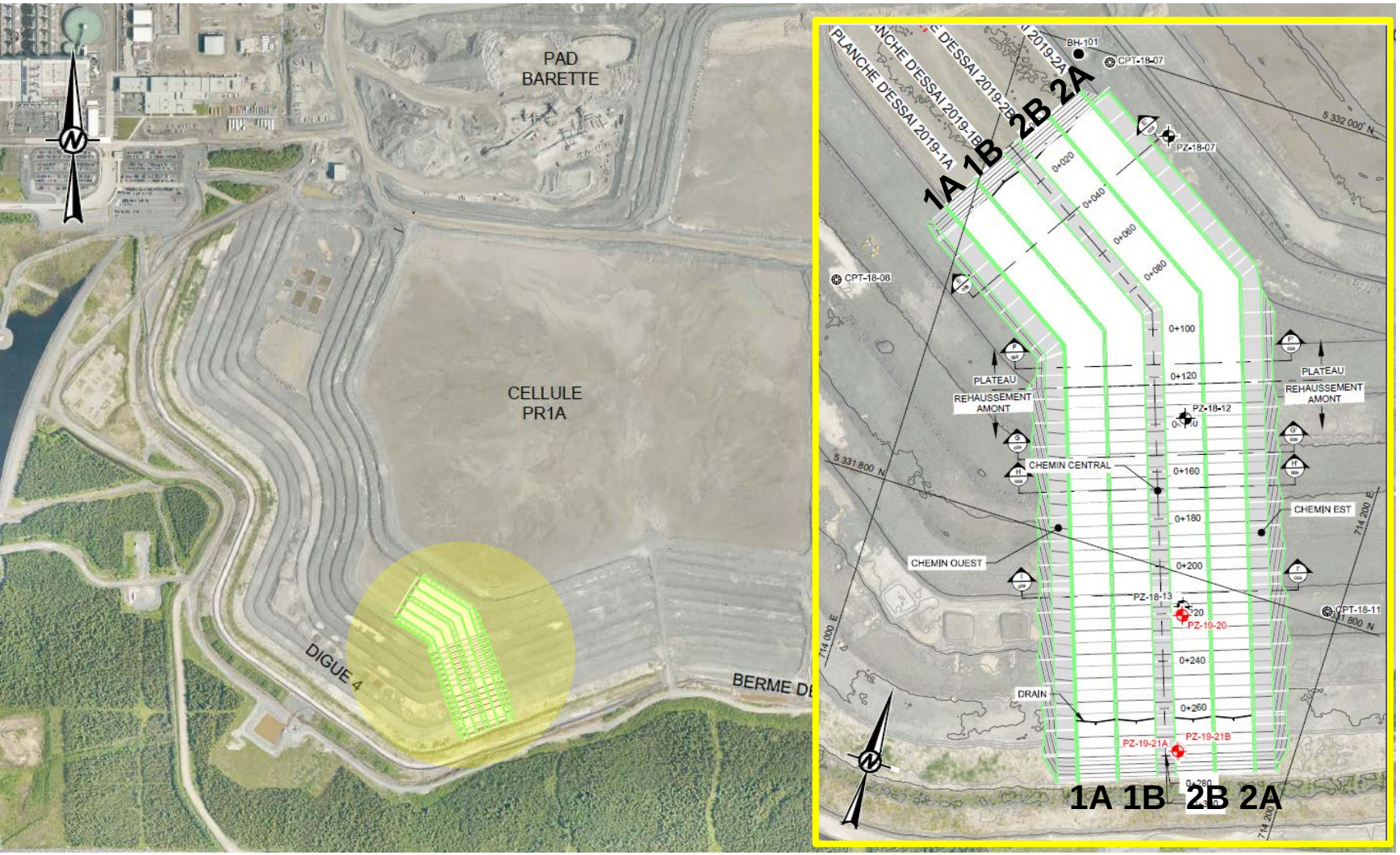
2A : 1m of MCM tailings

2B : 1m of amended tailings



Concept design

… Large scale trial location

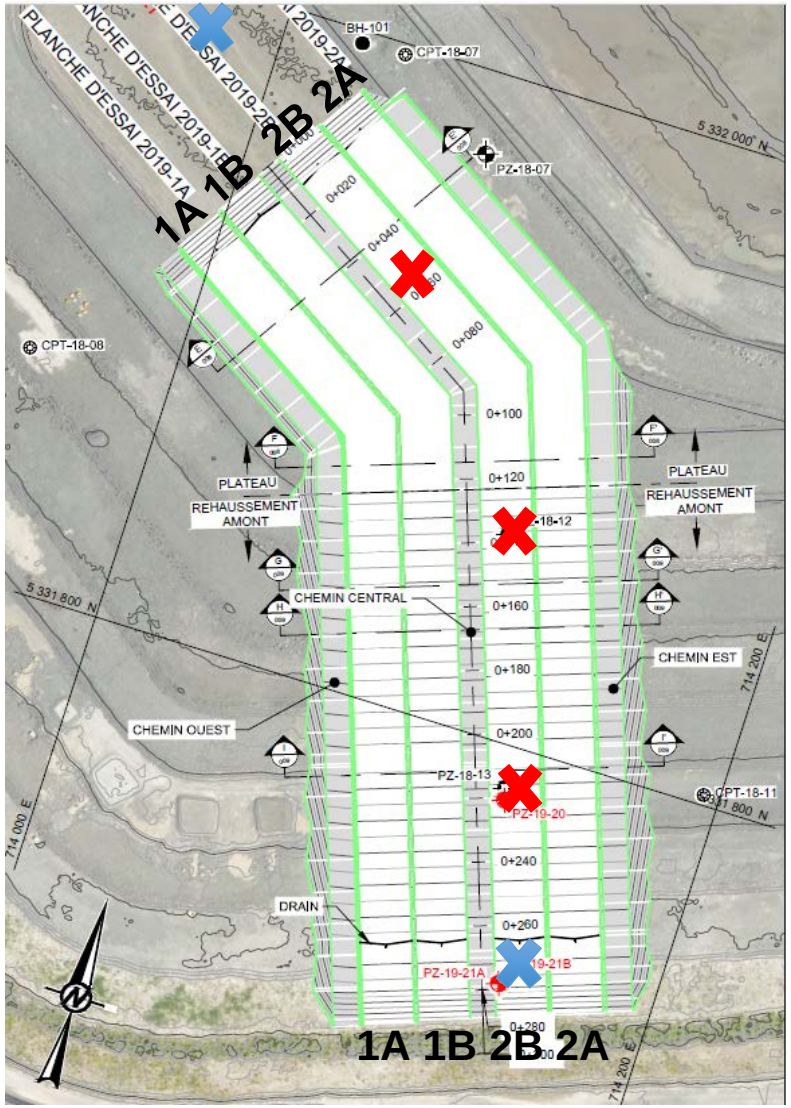


- 4 cells of 16 m X ~ 280 m
  - 1A and 1B : Overburden
  - 2A and 2B : CCBEs
- 1/3 on flat area, 2/3 on TSF slope
- Total area of 1.8 ha

  → 0.3 % of the TSF

3- Detailed Design

Detailed Design

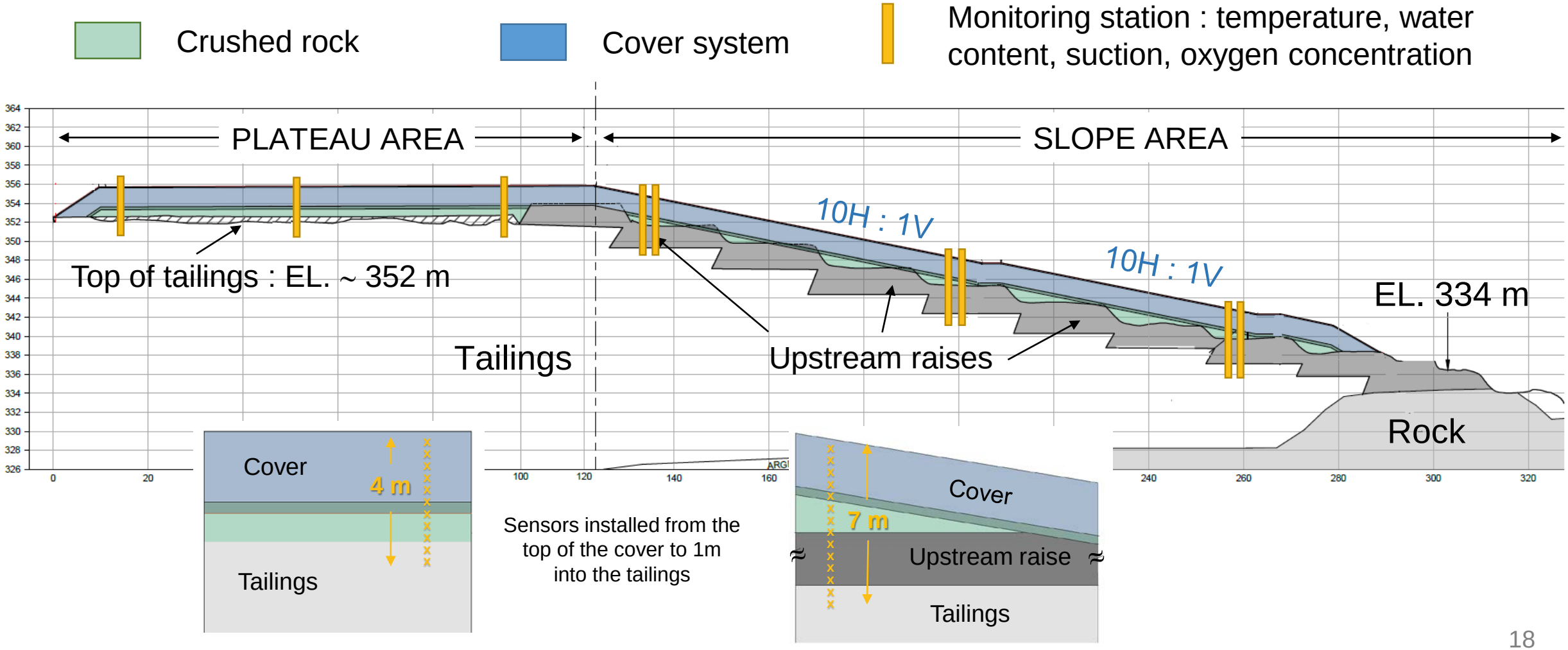


Geotechnical monitoring

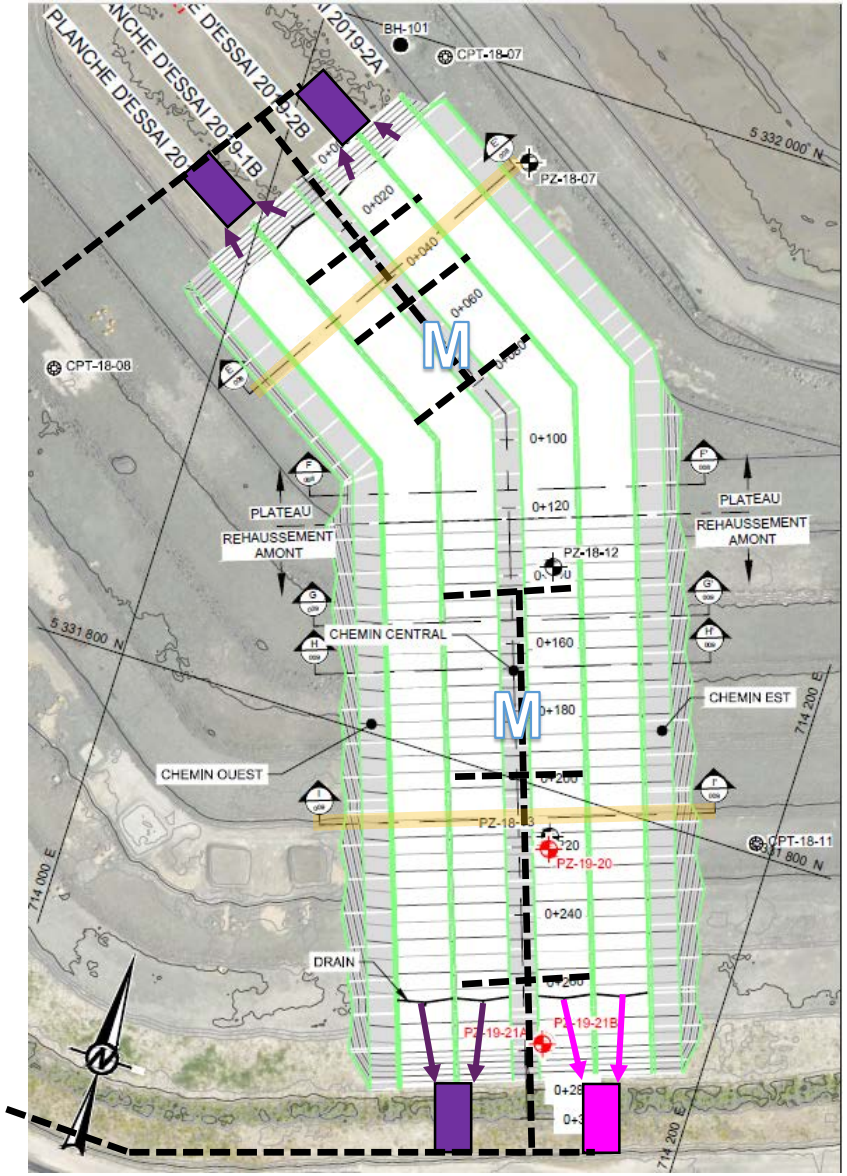
- Instrument installation at depth of 6 to 18 m below the surface of the TSF
  - ✖ Vibrating wire piezometers
  - ✖ Push-in pressure cells
- Monitoring of the excess pore pressure generated by the construction

Detailed Design

Typical Longitudinal Profile



Detailed Design

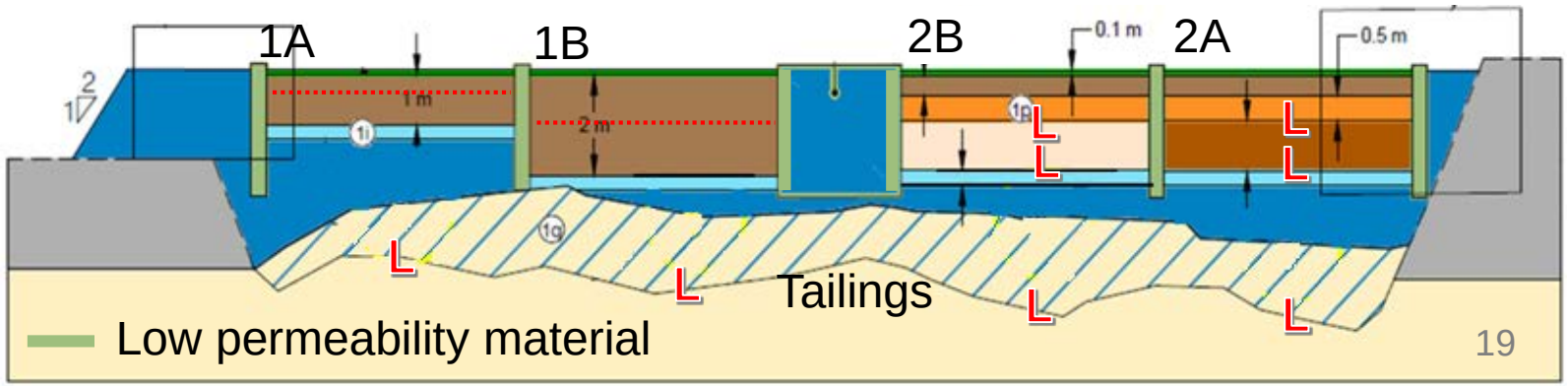


Plan View

- Runoff monitoring station
- Runoff and interflow monitoring stations
- M — Meteorological stations
- Electricity supply and remote connection network

Cross Section

L — 2 X 8 Suction lysimeters (in the tailings)

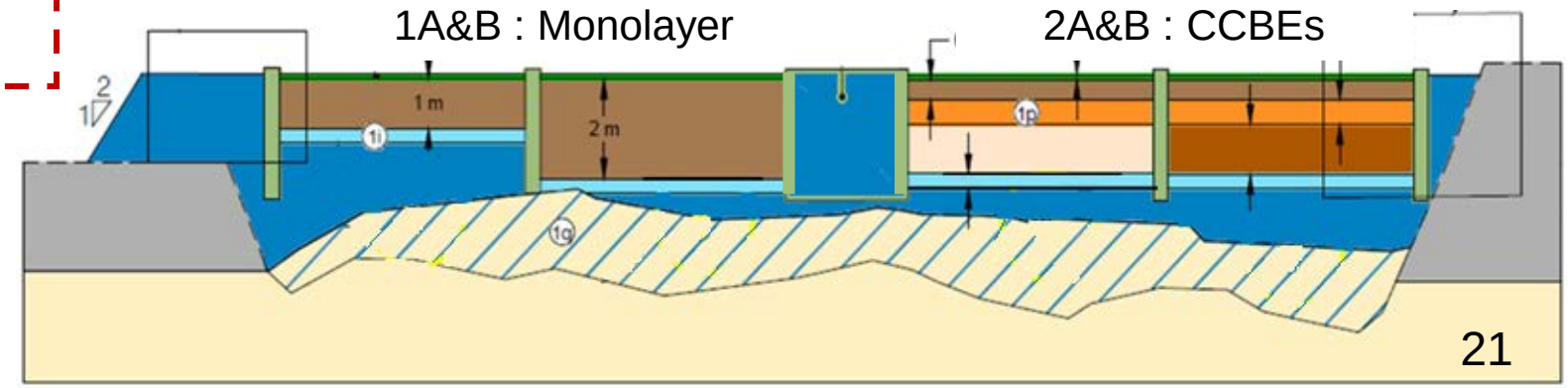


4- Preparatory Works

Preparatory Works

Material used for cover systems:

- Crushed waste rock (pit run and 0-100 mm)
- Crushed NPAG waste rock (0-50 mm) (CCBEs)
- MCM tailings (CCBEs) :
  - Non-amended
  - Amended
- Overburden
- Low permeability material
- Topsoil



Preparatory Works

Tailings preparation

- 15 000 m³ needed
- Excavation of the tailings directly from the TSF in July
- Tailings put in piles to dry
- Evolution of the water content (ω) :
  - Excavated tailings: 20-25 %
  - After 2 months of drying : 18-22 %

Preparatory Works

Amended tailings preparation

- Objective : ↑ NPR of the tailings > 2
- Amendment with grinded calcareous rock
  - Ratio selected : 7 %

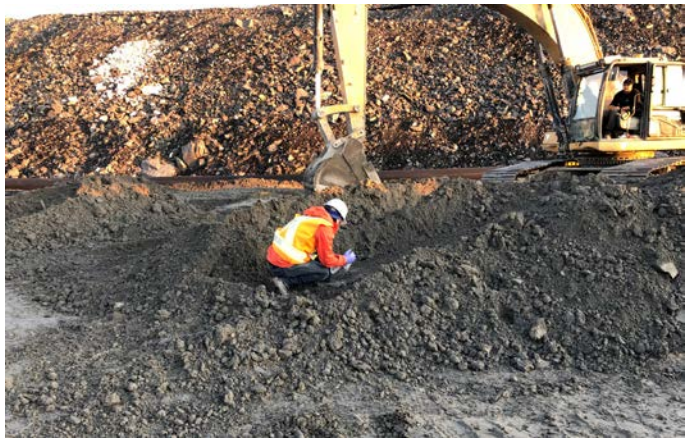
- Amending method selected : Pugmill
  - Simple to operate
  - Controlled rate of amendment
  - Good production rate (120-150 tph)
  - Could be used at full scale

Preparatory Works

Amended tailings preparation

- Lesson learned :
  - Pugmill cannot handle rocks > 75 mm
    - → Tailings screening required
    - → Reccuring breakdown of the screening machine

- Back to basics :
  - Batch mixing with an excavator
  - Production rate of 80-90 tph
  - QC ⇒ NPR > 2 for all samples



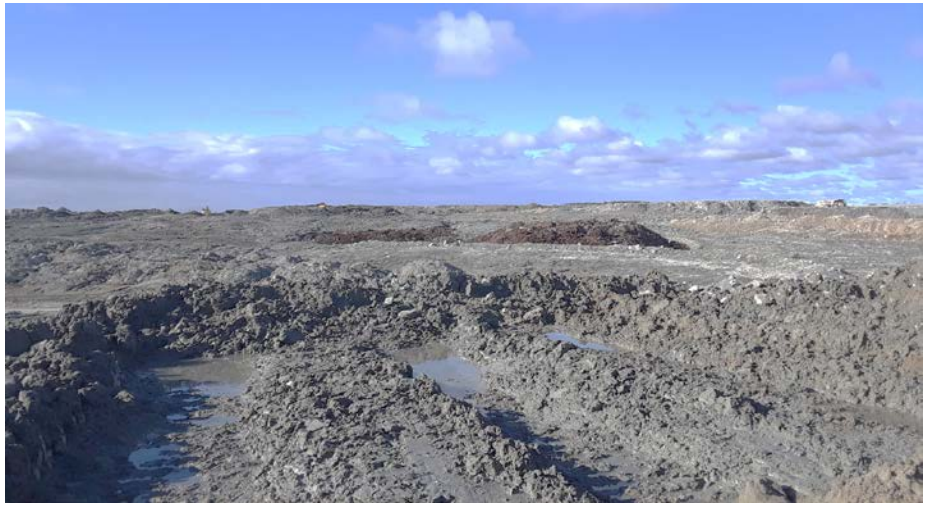
Preparatory Works

Overburden and low permeability material

- Source : Overburden stockpile
  - Soil stripped since Fall 2018, from the extension of the mine site

- Characterterization of surface soil (10-50 cm) :
  - Silty clay to sandy silt
    - Water content : 12-46%, average of 26%
  - Overburden very variable within a small sector

    ⇒ Material segregation is not realistic at full scale



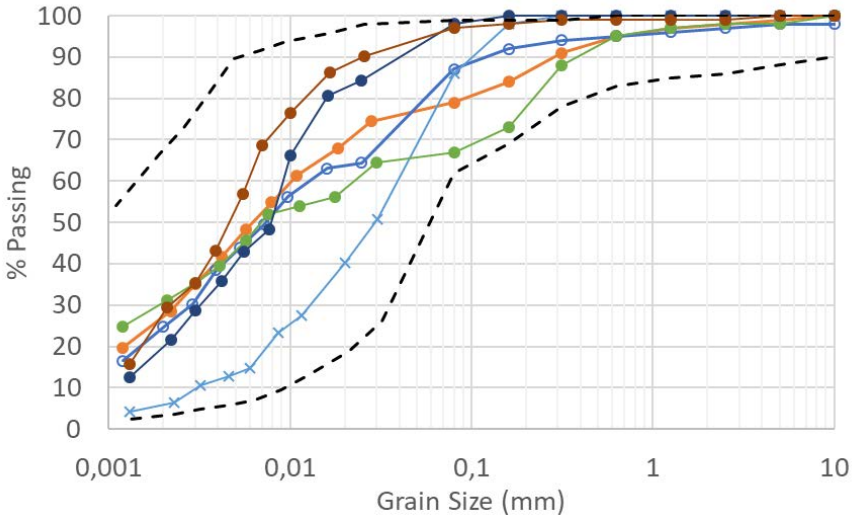
Preparatory Works

Overburden selected for cells 1A&B:

From a sector with

- Intermediate range of grain size distribution
- In the low range of water content (19-22 %)

⇒ Thought to be ready to place



Low permeability material selected for walls between cells:

- No overburden with adequate grain size distribution and water content found in sufficient amount

⇒ Use of a geomembrane

Preparatory works

Compaction tests

- Tailings results:
  - If ω < ~21% $\rightarrow$ adequate compacted
  - Lifts of 500 mm can be used for construction
- Overburden results :
  - « Ready to place » material
    - Minimum level of compaction required not reached
    - Constructability issue due to low bearing capacity
- Lessons learned :
  - The overburden for cells 1A and 1B needs preparation (drying)
  - Construction postponed to 2020

5- CONTRUCTION

Construction

1. Construction of the foundation on the plateau

While drilling in the slope to install the instruments in the upstream raises and underlying tailings

Construction

2. Reprofiling of the upstream raises

Construction

3. Placement of geomembrane, amended tailings, non amended tailings and instruments on the plateau

Construction

Sinkholes observed after heavy rainfall

- Cause : Remaining voids in the material after placement
- Lesson learned :

  Construction method will need to be improved, to break down clumps

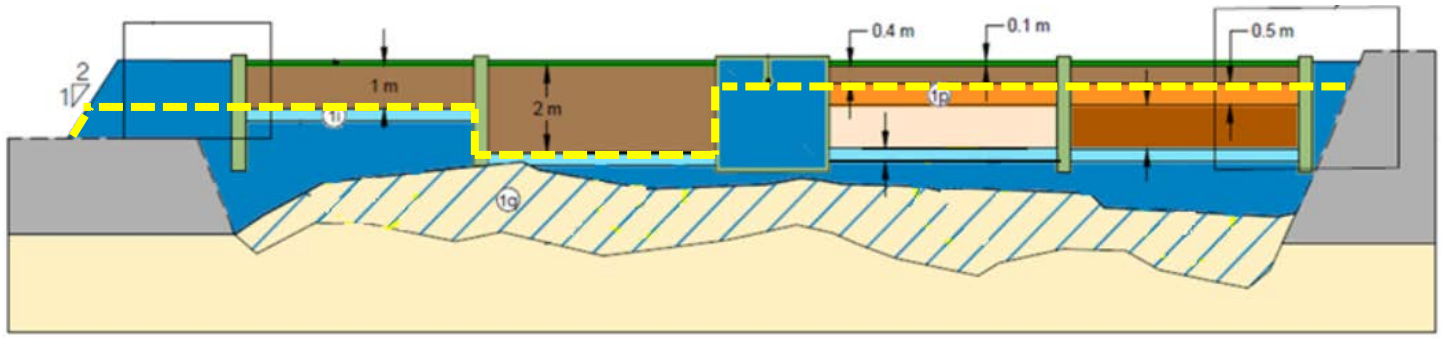
Construction

4. Placement of geomembrane, amended tailings, non amended tailings on the slope

Construction

5. Placement of the NPAG crushed rock layer over the tailings

6. End of 2019 Construction season



6- CONCLUSIONS

Lessons learned… so far

- An efficient systematic approach to selecting cover trials options is supported by good background information
- Clear objectives prior to conceptual design of cover trials
- Keep full scale construction in mind when planning the trials
- Construction of trials have so far provided good information for the full scale project

Thanks to all our collaborators

- Université du Québec en Abitibi-Témiscamingue (UQAT)
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- Okane Consultants
- Miller Group

THANK YOU

Questions or comments