**Additional Information Request # 6**

*Hydrogeological Context of Temporary Type 2 Mine Rock Stockpiles*

**Related Comments:**

CEAR #550 (Natural Resources Canada)

CEAR #547 (Environment Canada)

CEAR #557 (Ontario Ministry of the Environment)

In its response to IR 9.7, SCI provided east-west and north-south geological cross-sections (planar and sectional views) through the proposed PSMF and the proposed MRSA to provide a better understanding of the bedrock and overburden geology and the topography under the waste disposal facilities.

In its comments, Natural Resources Canada referred to SCI's preferred option of the MRSA being located on a groundwater divide, with one portion draining west towards the primary and satellite pits and the other draining east towards the Pic River. With respect to temporary PAG (Type 2) mine rock stockpiles, Natural Resources Canada noted that SCI presented seven (7) alternative options for storage (figure 4.3.1 -7 of CEAR #467) and proposed five (5) of the options for temporary PAG (Type 2) storage (A, C, E, F and G). Natural Resources Canada claims that SCI has not examined these 5 options from a hydrogeological perspective. Specifically, while SCI claims that all drainage from the temporary PAG (Type 2) stockpiles will be directed to the open pits, they have not demonstrated this through the use of maps, cross-sections or a description of groundwater flow patterns and rates of flow.

Additional information is required concerning the groundwater flow in the development of the temporary PAG (Type 2) mine rock storage options.

- Provide a map with the locations of the options for temporary PAG (Type 2) storage superimposed on groundwater flow paths. Include the locations of the options for the temporary PAG (Type 2) storage in the cross-sections through the open pit areas.
- Discuss the transport and fate of seepage from these stockpiles in a hydrogeological context, i.e. identify hydrostratigraphic unit(s) through which flow will occur, estimate rate of groundwater flow and travel times to discharge areas and indicate how all seepage will be contained / collected for treatment.
- Explain the implications of the above information on the design and location of the temporary stockpiles.

**SCI Response:**

The hydrogeological evaluation provided herein considers the five remaining options proposed for temporary PAG mine rock storage (A, C, E, F and G). Of these options, option G is located within the main pit. The main pit is a location of groundwater discharge, and if this option is pursued then there would be complete hydraulic containment of the PAG (Type 2) mine rock. Seepage from this material will flow directly into the primary pit and be managed; preventing the migration of Type 2 contact water into the subsurface. The four remaining options were further assessed for hydrogeological considerations (Options A, C, E and F) and are discussed in more detail below.

*Requested Maps*

Figure AIR 6.1 shows the locations of the five options for temporary Type 2 mine rock storage, while Figures AIR 6.2 and 6.3 show updated hydrostratigraphic cross-sections B-B1 and D-D1, respectively. These cross-sections super-impose the locations of Options C and F with respect to the underlying bedrock and the original topography, as well as the open pit. Figures AIR 6-1 through AIR 6-3 also incorporate the topographic contours in the area; the groundwater flow paths associated with each potential storage area are provided below.

*Groundwater Flow Paths*

The groundwater flow system was modelled using the regional MODFLOW model developed for the EIS and presented in SID #15 (TGCL, 2012). The groundwater flow paths, represented by tracked particles, are shown at each of the four option areas outside the pit itself and are displayed for years 1 to 3, 4 to 6 and 7 to 11 in Figures AIR 6.4 (Option A), AIR 6.5 (Option C), AIR 5.6 (Option E) and AIR 6.7 (Option F). The modelled flow paths show that all subsurface flow will occur toward the primary or satellite pits during all stages of the operation and after closure

*Transport and Fate of Seepage*

In the groundwater flow model, particles were placed around the perimeter and within each area representing the temporary Type 2 stockpile options. These particles were released within the model at the beginning of each period and their motion under the influence of the modeled groundwater flow system was tracked and displayed. In Figures AIR 6.4 to AIR 6.7, the distance between adjacent chevrons is the distance the particles traveled in one year in the model. Particle tracks terminated if they entered the drain cells representing the boundaries of the pits. Particle tracking was conducted with the MODPATH application (Pollock, 1994) applied to the results of the groundwater flow model presented in SID #15.

As shown on Figures AIR 6.4 to 6.7, groundwater flow from beneath each of the four option areas external to to pit exhibited flows towards the pits. An exception to this occurs along the western edge of option A during the first three years of mine life. However, the flow away from the pit beneath this small area of option A becomes reversed after year 3 of mining when the increased drawdown around the pit captures any earlier flow towards the west and redirects it east towards the pit for the remaining period of the operation and after mine closure.

Groundwater originating beneath the Type 2 rock temporary storage areas would primarily flow through the upper hydrostatigraphic unit (Figure AIR 6.2 and 6.3), which consists of overburden and the upper bedrock. Since the mine pits deepen with time, the zone of depression and the capture zone also expand out from the pit boundaries with time. Horizontal groundwater flow velocities (assuming an effective porosity of 0.05 in the upper bedrock) will vary between less than 5 metres per year and more than 50 meters per year, depending on the gradients that will be larger near the pit boundaries and will also increase with time. Travel times to the pit will vary from less than one year for groundwater originating near the edges of the pits to perhaps more than tens of years for groundwater originating farther from the pit.

As shown on Figures AIR 6.4 to 6.7, the drawdown created by the pit will provide hydraulic containment for all contact water entering the subsurface beneath the storage areas and flowing along groundwater pathways towards the pits. Groundwater originating beneath the storage areas will eventually discharge to the pit and will be managed with the water that collects in the pit; the majority of which will be runoff water and precipitation, as discussed in SID#15.

*Implications on Design*

Based on the hydrogeological conditions at the site, the designs and locations of all five proposed options for temporary Type 2 mine rock storage (A, C, E, F and G) are considered reasonable as they are in locations where groundwater seepage pathways will be towards the pits. Water which comes into contact with this material while it is temporarily stored at one of these locations will be collected by the pits over the life of the mine and/or post-closure (options A, C, E and F). The modelling completed for the site indicates that each of these areas lies within the area of capture of the open pits. Further, the groundwater monitoring program implemented for the project will serve to provide information on local groundwater flow conditions in the vicinity of the option adopted during final design, and mitigation measures, if required, would be implemented. In terms of managing any potential future impact of this material, in the current Conceptual Mine Plan the temporary Type 2 mine rock stockpiles will be either processed or relocated to the open pit(s) for permanent underwater storage.

**References**

Pollock, D.W. 1994. *User's Guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking postprocessing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model*: U.S. Geological Survey Open-File Report 94-464, 234 p.

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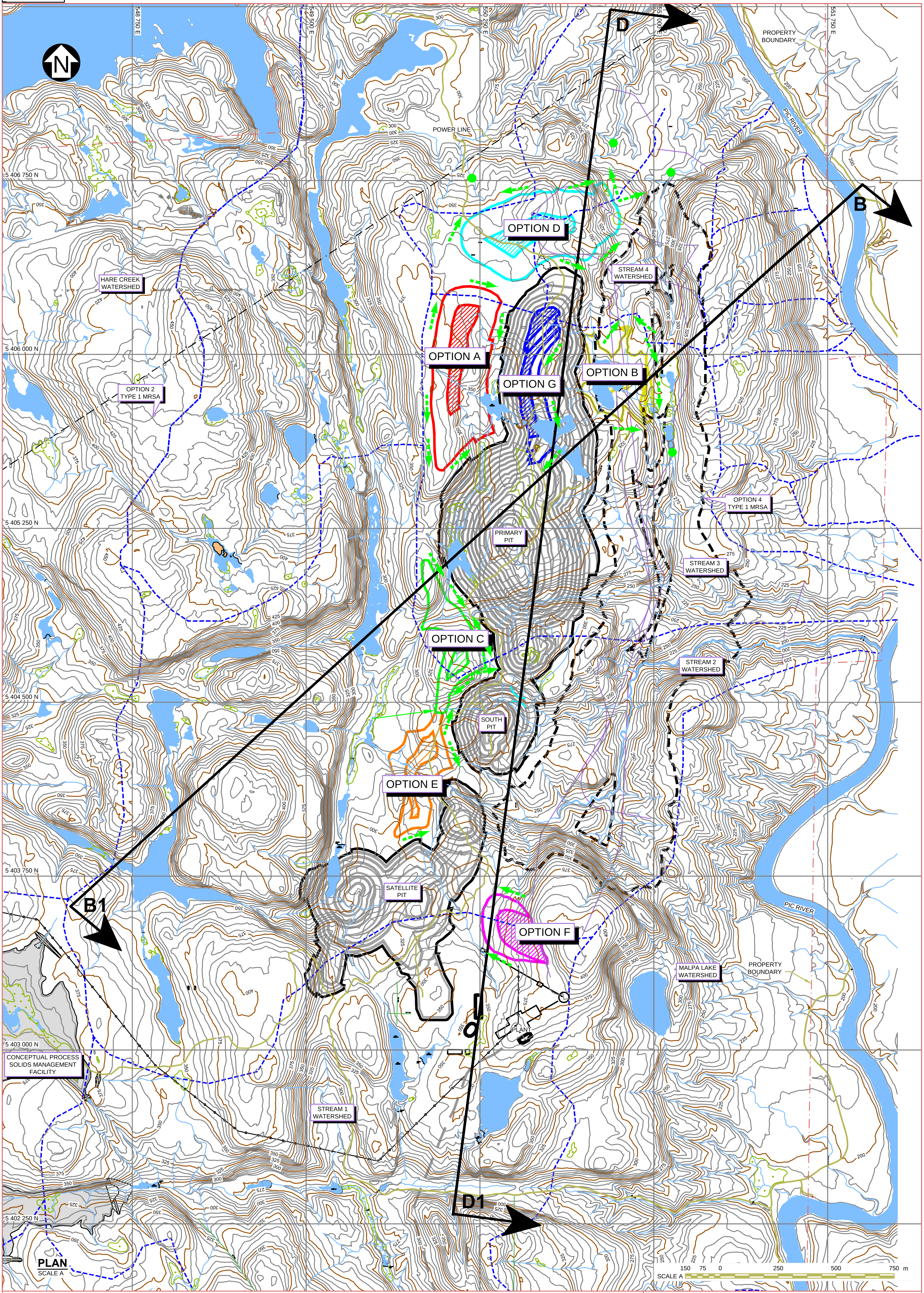


**LEGEND:**

| | | |
|---|---|---|
| WATER | OPTION D | PROPERTY BOUNDARY |
| OPTION A | OPTION E | POWER LINE |
| OPTION B | OPTION F | WATERSHED DIVIDE (BY OTHERS) |
| OPTION C | OPTION G | TYPE 1 MRSA |
| | | RUNOFF WATER FLOW DIRECTION |
| | | POTENTIAL COLLECTION |
| | | EXISTING ACCESS ROAD |
| | | PROPOSED SITE ACCESS ROAD |

**NOTES:**

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS ON CANADA DEPARTMENT OF NATURAL RESOURCES (2009).
2. COORDINATE GRID IS UTM (NAD27) ZONE 16N AND IS IN METRES.
3. INFRASTRUCTURE BASED ON INFORMATION PROVIDED BY STILLWATER CANADA INC.
4. CONTOURS ARE IN METRES. CONTOUR INTERVAL IS 5 METRES.
5. MARATHON PGM-Cu PROPERTY BOUNDARIES PROVIDED BY STILLWATER CANADA INC. (NOVEMBER 28 2011).

STILLWATER MINING COMPANY

MARATHON PGM-Cu PROJECT

**TEMPORARY TYPE 2 MINE ROCK AND ORE STOCKPILE OPTIONS CONSIDERED**

Knight Piésold CONSULTING

| P/A NO. | REF NO. | |
|---|---|---|
| NB101-446/5 | NB13-00319 | |
| AIR 6.1 | | REV 0 |

| REV | DATE | DESCRIPTION | DESIGNED | DRAWN | CHK'D | APP'D |
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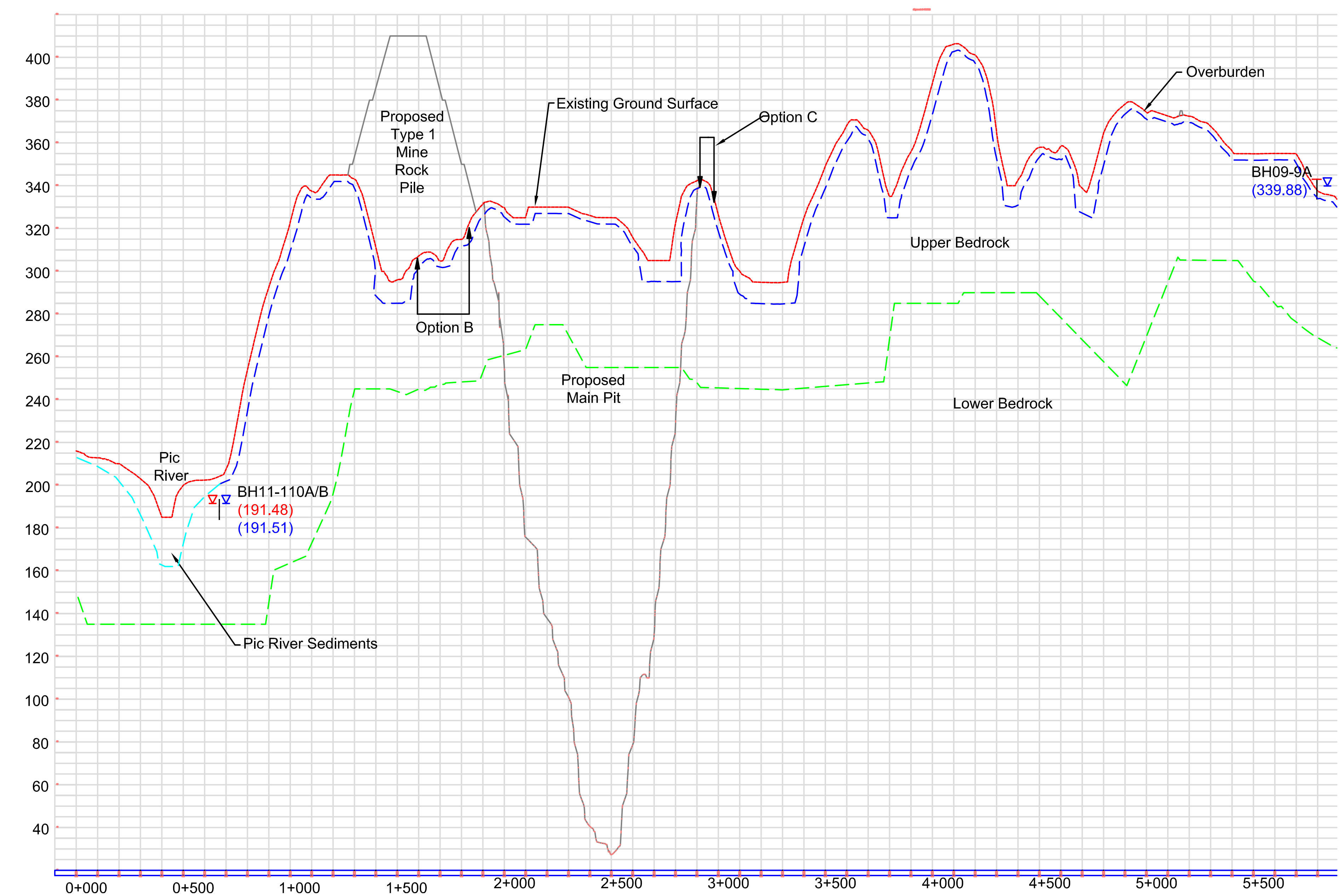
Plot Size: TABLOID




## Section B-B1

LEGEND

BH11-105 Monitoring Well Location

Bedrock Interface

(191.48) Shallow Groundwater Elevation (m)

(191.51) Deep Groundwater Elevation (m)

Approximate Interface between Overburden and Upper Bedrock

Approximate Interface between Upper Bedrock and Lower Bedrock

Approximate Interface between Pic River Sediments and Upper Bedrock

Potential Temporary PAG Mine Rock Storage Area Options

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**Conceptual Cross Section B-B1 with Temporary PAG Mine Rock Storage Area Options**

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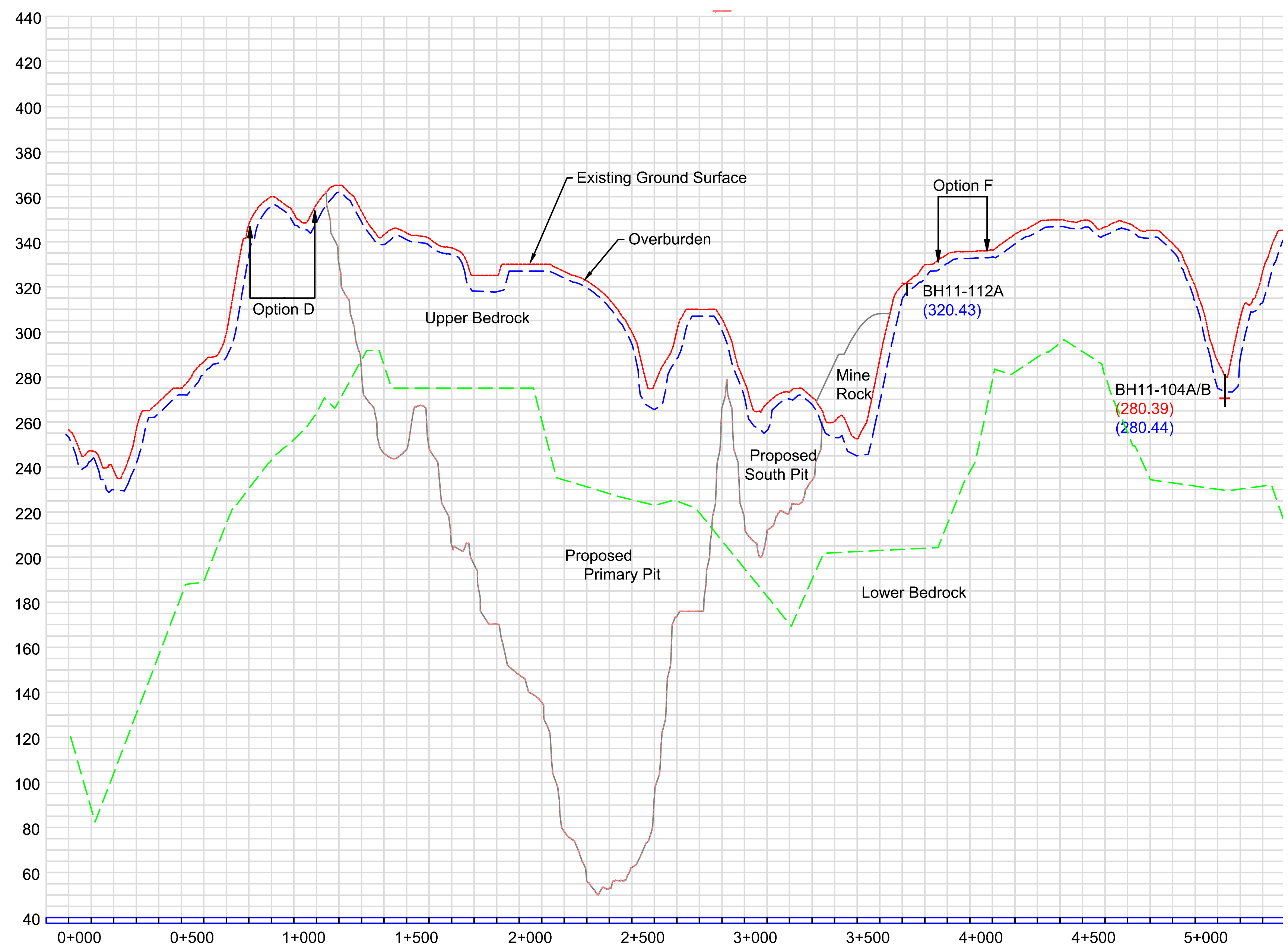
| 13-317-28 | AIR 6.2 | 02 |




## Section D-D1

LEGEND

BH11-105 Monitoring Well Location

Bedrock Interface

(191.48) Shallow Groundwater Elevation (m)

(191.51) Deep Groundwater Elevation (m)

Approximate Interface between Overburden and Upper Bedrock

Approximate Interface between Upper Bedrock and Lower Bedrock

Approximate Interface between Pic River Sediments and Upper Bedrock

Potential Temporary PAG Mine Rock Storage Area Options

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**Section D-D1 with Temporary PAG Mine Rock Storage Area Options**

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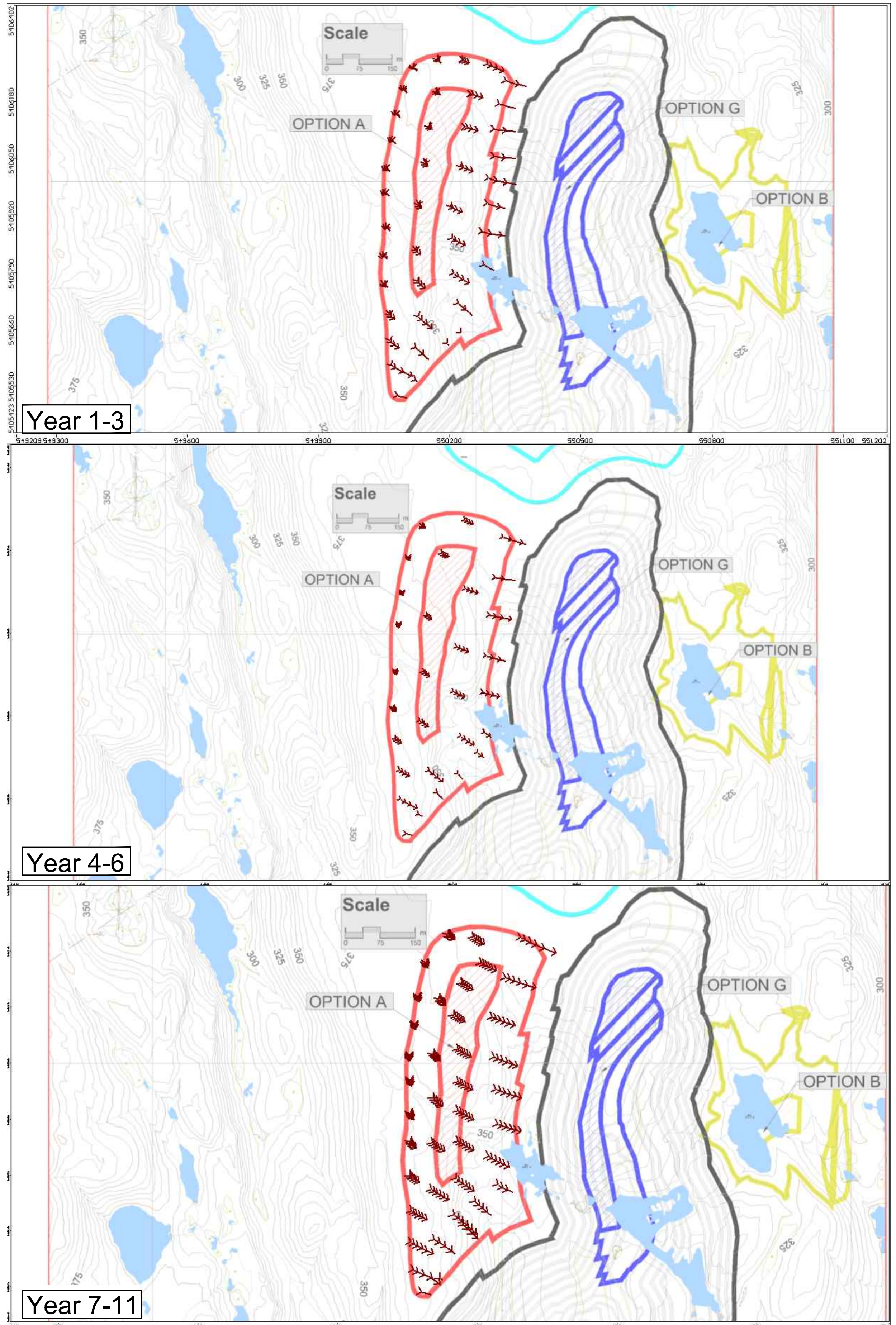
| 13-317-28 | AIR 6.3 | 02 |




Legend

- Modelled Groundwater Particle Tracks
- Distance Travelled by Modelled Particle in 365 Days

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**Modelled Groundwater Flow Paths, Temporary Type 2 Mine Rock Storage Area Option A**

| PROJECT NUMBER | DRAWING NO. | REVISION |
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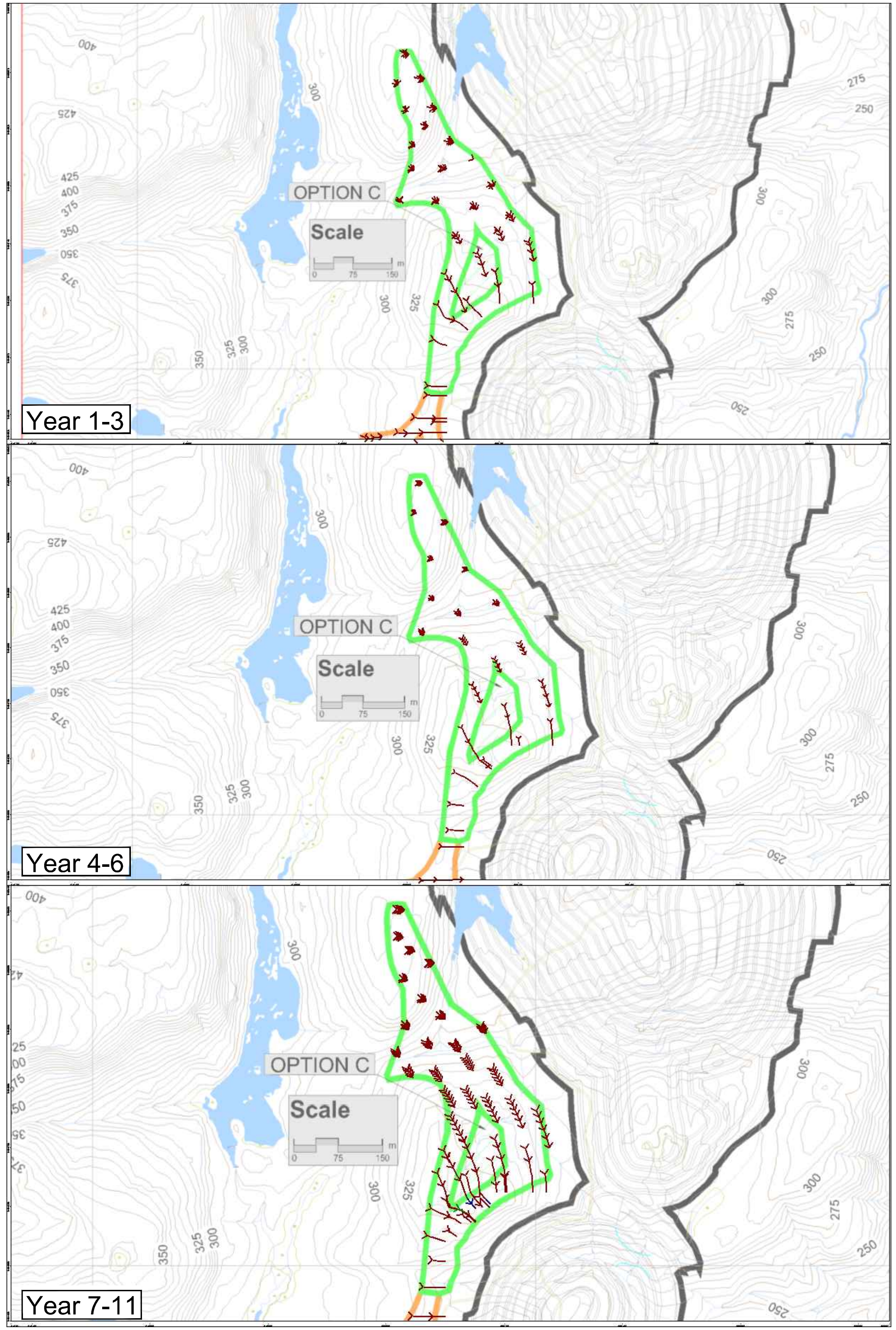
| 13-317-28 | AIR 6.4 | 01 |

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Legend

- Modelled Groundwater Particle Tracks
- Distance Travelled by Modelled Particle in 365 Days

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**Modelled Groundwater Flow Paths, Temporary Type 2 Mine Rock Storage Area Option C**

| PROJECT NUMBER | DRAWING NO. | REVISION |
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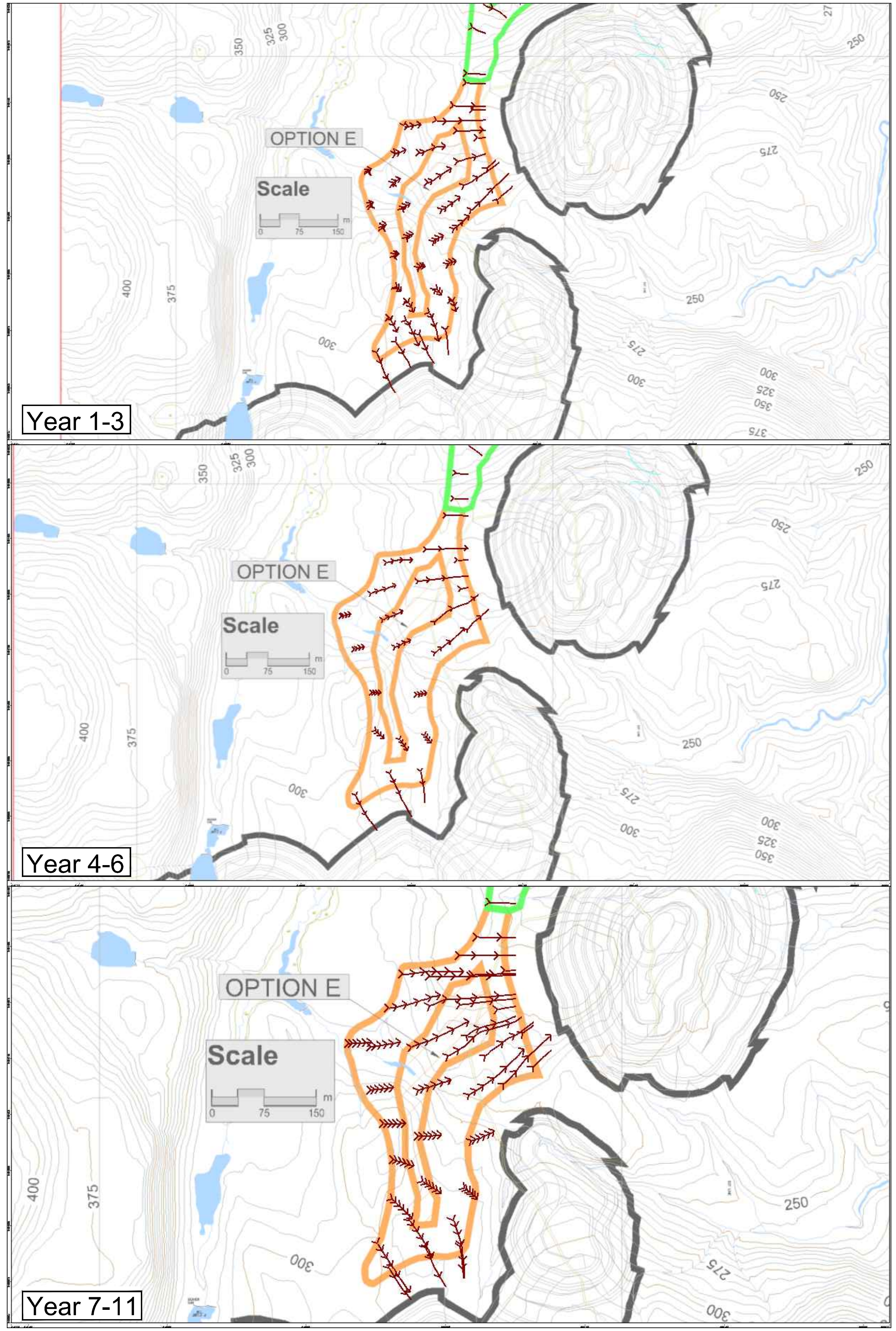
| 13-317-28 | AIR 6.5 | 01 |

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Legend

- Modelled Groundwater Particle Tracks
- Distance Travelled by Modelled Particle in 365 Days

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| 13/10/23 | For Review | MS | LN | MS | LN |

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**Modelled Groundwater Flow Paths, Temporary Type 2 Mine Rock Storage Area Option E**

| PROJECT NUMBER | DRAWING NO. | REVISION |
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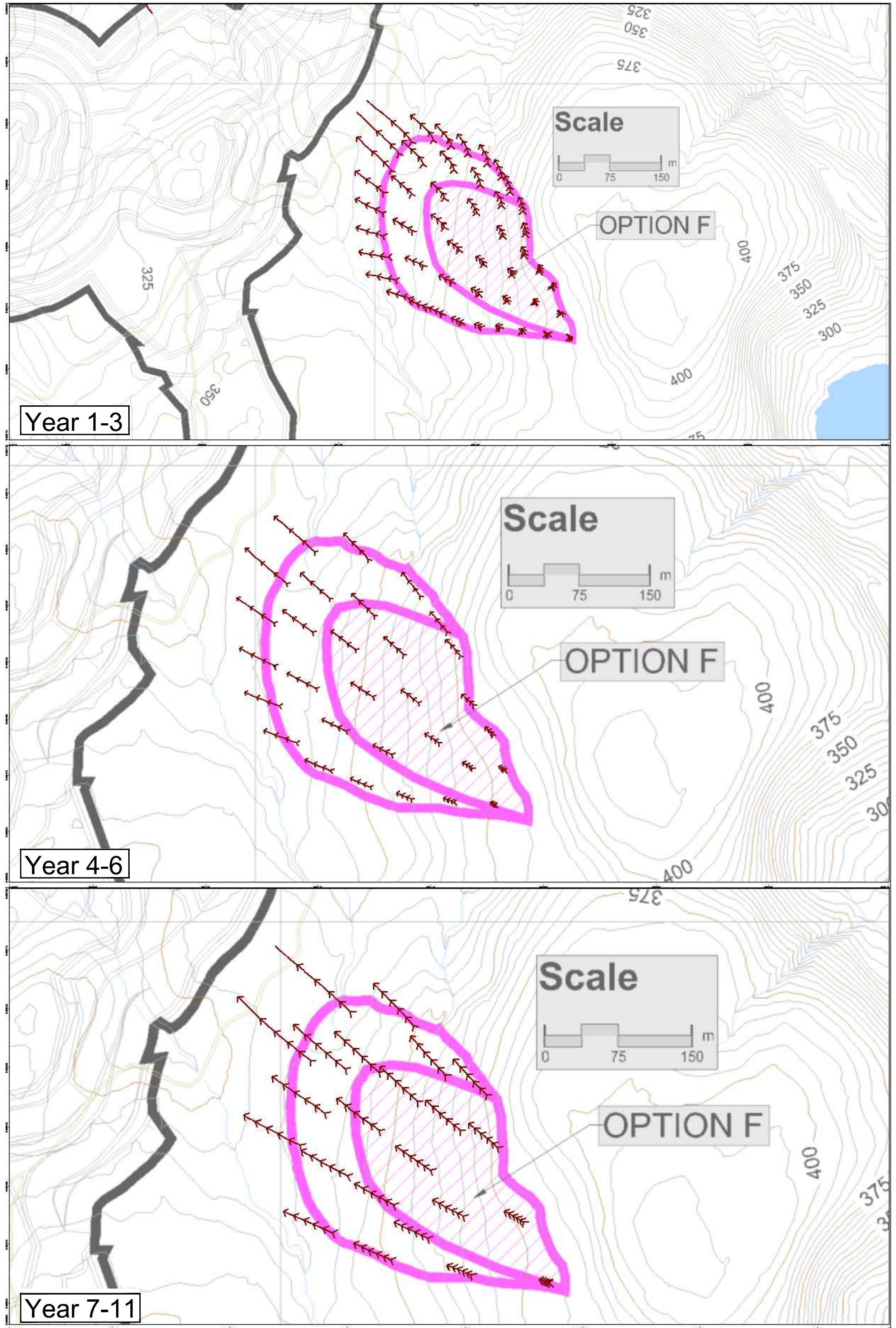
| 13-317-28 | AIR 6.6 | 01 |

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Legend

- Modelled Groundwater Particle Tracks
- Distance Travelled by Modelled Particle in 365 Days

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**Modelled Groundwater Flow Paths, Temporary Type 2 Mine Rock Storage Area Option F**

| PROJECT NUMBER | DRAWING NO. | REVISION |
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| 13-317-28 | AIR 6.7 | 01 |