Québec, February 10th, 2021

Mister Marc Croteau
Deputy Minister and Provincial Administrator of the James Bay and Northern Quebec Agreement
Department of environmental assessment of mining and northern projects, and strategic environmental assessment
Ministère de l'Environnement et de la Lutte contre les Changements Climatiques
675, boulevard René-Lévesque, 6e étage, boîte 83
Québec (Québec) G1R 5V7

V/Réf. : 3215-14-007

**Subject: Modification request for the certificate of authorization of the Nunavik Nickel Project, Canadian Royalties Inc. (CRI)**

**Tailing management at the Expo Mine**

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Sir,

We are submitting to you this request for modification of the certificate of authorization (CA) Nunavik Nickel Mining Project (V / Ref.: 3215-14-007) under article 201 of Chapter II of the Environmental Quality Act (EQA) for the modification of the mine tailing management plan at the Expo mine.

The mining company Canadian Royalties Inc. (CRI) has been operating the Nunavik Nickel Project (PNNi) since 2008 in Nunavik in the far North of the province of Quebec. The PNNi project was the subject to a first environmental and social impact study in 2007, which led to the obtaining of the CA relating to the whole PNNi on March 20, 2008, under article 201 of the EQA.

Condition 4.5 of the Global CA, stipulates that CRI must present to the Administrator the terms governing the use of the Expo pit for tailing management as well as the monitoring of the evolution of the water level in the pit to ensure that the flooding of tailings will be an effective measure in the short and long term to counter acid mine drainage (AMD). This modification request is part of this process.

## 1. Context

### *Object of the request*

The PNNI consists of the exploitation of polymetallic deposits whose main metals of interest are nickel (Ni) and copper (Cu). A port complex at Deception Bay as well as an industrial complex at the Expo site were developed at the end of the 2000s. The mine has a series of mineral deposits (Expo, Mesamax, Allammaq, Méquillon, Ivakkak and Puimajuq) which extend over 60 km.

The total ore reserves of the six currently authorized deposits are approximately 14,90 Mt plus the potential of an additional 2,02 Mt. Ore from each deposit is trucked to the Expo site for processing. Ore is processed at a nominal rate of 4,500 t / d. The Expo industrial site has two tailing disposal cells lined with a geomembrane (cells 1 and 2) and a waste rock disposal cell.

Taking into account all the authorized deposits as well as following the last update pertaining to resources and lifetime production of tailings, the capacity of the two cells of the tailing pond will be exceeded sooner than planned. CRI therefore wishes to modify the tailing management plan planned during the operating phase of the project in order to allow the deposition of these additional tailings in the Expo pit from 2022 to 2024. This request aims to meet the requirements of article 201 of the EQA.

We should mention that this request does not address the production of tailings that would result from the exploitation of future deposits not yet authorized for the project. These will be addressed in a subsequent modification request. The capacity of the Expo pit is more than sufficient since it theoretically could contain tailings until 2028.

***Legislative and historical framework of permits, certificates and authorizations issued***

The property is located in the portion of Quebec territory covered by the environmental impact assessment and review procedure in a northern environment north of the 55th parallel as defined in Chapter II of the Environment Quality Act (EQA). During the environmental and social impact study (April 2007, section 3.2), two alternative locations were analyzed for the tailing and waste rock disposal facility, the first located north of the Expo pit and the second to the south. The first option was chosen and integrated into the preliminary mining concept, in order to reduce costs and atmospheric emissions of pollutants linked to transport, but also, because this location offered the advantage to dispose of mining residues in the Expo pit, thus limiting footprint using the existing pit to store tailings.

The chosen concept was presented in the ESIA in order to obtain the Global CA. It implies that at the end of the mining operations of the Expo deposit, the pit would be used to collect tailings from the exploitation of the Méquillon deposit. Subsequently, the in-pit tailings deposition was specified in the request for a certificate of authorization for mining activities under article 22 submitted in November 2010 (section 5.6.7.1) and obtained by the MELCC on July 20, 2011. The tailing management plan specified the in-pit tailings deposition during the eighth year of operation, following the filling of the existing cells.

Since then, several addenda to the impact study have been made and various modifications to the Global CA have been issued, in particular for the addition of the Allammaq, Puimajuq and Expo Ouest deposits, the increase in the ore processing rate to 4,500 daily tonnes, the widening of roads, the relocation of the collection basin and the discharge point of the Méquillon satellite mine as well as the operation of various quarries and sand pits. Any additional tailings deposition related to new deposits, if any, will be included in a modification request that will be submitted for this purpose.

***Identification of the proponent***

Canadian Royalties Inc.

*Correspondence*

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*Contact person*

Mr. Stéphane Twigg
Environment Superintendent
Phone : (514) 629-7952
Email : stephane.twigg@canadianroyalties.com

A copy of the resolution of the board of directors of the mining society Canadian Royalties Inc. authorizing Mr. Stéphane Twigg to make the necessary commitments to obtain the certificates of authorization and to present the request is attached in Appendix 1. In addition, a copy of the duly signed Déclaration du demandeur ou du titulaire (Applicant's declaration) form is attached in Appendix 2.

## 2. Modification request for the certificate of authorization 3215-14-007

***Site location***

The PNNi is located in the far north of the province of Quebec, in Nunavik. More specifically, the PNNi, currently encompasses six deposits (Expo, Mesamax, Méquillon, Ivakkak, Allammaq and Puimajuq), is located approximately 80 km west of Kangiqsujuaq, 140 km southeast of Salluit and approximately 20 km south of Katinniq. The mining complex is located north of the Pingualuit National Park. The location of the Expo pit can be found in appendix 3.

The PNNi is located at the head of the Puvirnituq River watershed on Class III lands under the James Bay and Northern Quebec Agreement where the exploitation of mineral resources is allowed.

The central geographic coordinates (Degrees, NAD 83) of the Expo pit are the following:

- Latitude 61° 33' 19.75''
- Longitude 73° 26' 57.44''

***Justification of the proposed modification for tailings management***

The mine tailings production lifetime is now estimated at around 10 Mm$^3$, or around 14,90 Mt in total for mining operations until October 2024.

The total storage capacity of the current tailing pounds (cells 1 and 2) is approximately 8.10 Mm$^3$. As of August 26, 2019, the occupancy volume of the cells was 4.92 Mm$^3$. The residual storage capacity in the cells is therefore approximately 3.18 Mm$^3$ (4.72 Mt).

Based on the anticipated ore production, the storage capacity of cells 1 and 2 will be reached in July 2022. Also, when the cells will be close to complete filling, it is considered that the unloading in these cells will have to be paused to complete the pumping of the residual water before being able to resume unloading in the cells until complete filling. This operational flexibility allows to optimize the filling of the two cells, as well as to anticipate the start of the deposition of tailings in the Expo pit in May 2022.

The Expo site tailing facility design report (Golder, September 2020) describes the project and the justifications. This report is presented in Appendix 4.

Based on the currently proven ore reserve, i.e. for a production capacity up to 2024, ore production will generate an estimated surplus of tailings of 1.96 $Mm^3$ (2.91 Mt). CRI therefore wishes to manage this excess residue by depositing them in the adjacent Expo pit. The projected production of tailings from authorized deposits is presented in the table below.

**Table: Tailings yearly production**

| Years | Ore | Tailings | | Tailings deposition in cells 1 and 2 | | Tailings deposition in the Expo pit | |
|---|---|---|---|---|---|---|---|
| | (t) | (t) | ($m^3$) | (t) | ($m^3$) | (t) | ($m^3$) |
| 2019 | 686 320 | 624 252 | 445 894 | 686 320 | 445 894 | 0 | 0 |
| 2020 | 1 647 000 | 1 498 052 | 1 070 037 | 1 647 000 | 1 070 037 | 0 | 0 |
| 2021 | 1 642 500 | 1 493 959 | 1 067 114 | 1 642 500 | 1 067 114 | 0 | 0 |
| 2022 | 1 642 500 | 1 493 959 | 1 067 114 | 746 980 | 533 557 | 746 980 | 533 557 |
| 2023 | 1 642 500 | 1 493 959 | 1 067 114 | 0 | 0 | 1 642 500 | 1 067 114 |
| 2024 | 1 388 524 | 1 262 952 | 902 108 | 0 | 0 | 1 388 524 | 902 108 |
| Total | **8 649 344** | **7 867 134** | **5 619 381** | **4 722 800** | **3 116 602** | **3 778 004** | **2 502 779** |

***Considered and chosen concept***

As mentioned above, both of the chosen concept previously presented in the ESIA in order to obtain the Global CA (April 2007) as well as the tailing management plan provided for the request the CA for mining activities under article 22 (obtained July 20, 2011) included, at some point in the operation schedule, the in-pit tailings deposition.

The alternative option would be to add another cell to the existing tailing facility. It would require:

- A permanent additional land use footprint.
- A more complex structural construction, requiring the installation of a waste rock dike from satellite deposits or the production of crushed material in an authorized quarry as well as the installation of a geomembrane system and an outlet.
- The emission of GHGs and additional atmospheric contaminants for construction as well as for the transport of waste rock to the Expo site.
- No gain on the restoration and stabilization of the expo pit.

The management of additional tailings in the Expo pit was therefore presented as the most advantageous solution, since it minimizes the environmental impacts while being the least expensive.

***Pit characteristics***

According to Golder's report (2020), the Expo pit is approximately 930 m long in the east to west direction and approximately 380 m wide in the north to south direction. The pit bottom elevation is approximately at 460 m while the lowest elevation along the pit rim is at 535.4 m.

The walls of the pit are formed of 57% Metasediments, 32% Peridotite and 11% Sulphide. It should be noted that the lithologic units of Metasediments and Peridotite are both potentially acid generating and metal leaching.

***Tailings characteristics***

Tailings that will be stored in the pit are potentially acid generating and metal leaching. Contact water is acidic and contains high concentrations of sulfate and various metals. Although tailings discharged from the ore processing plant are expected to be neutral (due to the addition of lime), the controlled water in the tailing pond is acidic due to geochemical processes in the pond. Tailings stored in the Expo pit could therefore also generate acidity. The following subsection (Filling and site restoration) as well as section 4 (Mitigation, monitoring and follow-up) present the methods that will be used to counter AMD.

***Filling method and restoration measures***

Currently, tailings are pumped into cells 1 and 2. The deposition of mine tailings in the Expo pit will be similar to what is currently authorized for the cells. Indeed, tailings should be unloaded at two outlet points located at the western and eastern ends of the open pit. As the Expo pit will serve as a water storage for cells 1 and 2, the in-pit tailings deposition will be done under water in 2022.

The pit will then be filled with tailings to an elevation of approximately 484 m, ie to a thickness of approximately 35 m representing more than 1.96 $Mm^3$ (2.91 Mt). At the end of the operation, the supernatant above tailings will be treated by the water treatment unit at the Expo industrial complex. Subsequently, tailings of the pit will be submerged by 50 m of water coming from Bombardier Lake to reach an elevation of approximately 535 m in total, which is the lowest elevation along the edge of the pit.

This tailings flooding method significantly reduces the potential oxidation of tailings and metal leaching. The layer of water reduces the amount of oxygen available for sulphide minerals present in tailings. The method is based on a low solubility of oxygen in water compared to that of air.

Since restoration measures must be reviewed by the MERN, an update of the closure plan addressing the pit closure in relation to the present modification of the tailings' management method was submitted to the MERN in parallel to the current request. Following the usual process, the MERN will then seek the MELCC's opinion on the document before final approval of the plan is given. For information, highlights of the closure plan projected for the Expo pit are presented in Appendix 8. Details are also available in the design report in Appendix 4.

***Stability of the open pit walls***

Open pit wall stability analysis was carried out during various stages of the Expo in-pit tailings deposition (Golder, 2020). The analyses included different deposition stages assuming completely saturated condition in the ultramafic and metasediments rock units.

Both circular and non-circular failure modes were analyzed. Non-circular failures yielded lower results, particularly in cases where the failure occurs along the bedding in the metasediments. The safety factor calculated was more than the minimum required, which is 1.2, indicating that the pit walls will be stable.

The final pit before the start of tailings filling yielded the lowest factor of safety. The safety factor of the pit wall increased once tailings are deposited. Tailings were shown to act as a support to the pit slope and to improv the overall stability. Details of the stability assessment are presented in Appendix F Golder's report (2020).

***Considerations in relation to the local climate***

Hydrogeology

The 2007 impact study (Génivar) showed that cold temperatures keep a continuous permafrost in this region. Groundwater flow in permafrost environments is very different from that observed in regions without permafrost. Since permafrost provides an impermeable layer, groundwater movement is restricted exclusively to talik areas during the year or within unfrozen mollisol during summer. Interstitial water present in rock cracks and in surface deposits is frozen all year round except during seasonal thaws, for a thickness of the mollisol restrained to the first 2 to 3 metres. The flow of water inside the mollisol follows with the slope of the microtopology formed by the thaw front as it progresses through the soil during the summer season.

The model results show that deposition of tailings inside the pit followed by formation of a pit like will cause permafrost to thaw to a depth of about 22 cm below the base of the pit. The model also showed that the ground between the Expo pit and the tailing cells will remain mostly frozen during all times, which would prevent groundwater flow between the Expo pit and tailing areas. Although permafrost would warm up progressively in the long term, the models showed that the extent of this unfrozen zone would not increase over a period of 100 years. Figures showing the permafrost modelling are presented in Appendix E of the design report.

Precipitation

According to Golder's report (2020), the average annual total precipitation (rainfall and snowfall) for the site, from 1981 to 2019, is approximately 600 mm. The maximum average precipitation of 103 mm is reached in July. It was estimated in the impact study that the effect of climate change could increase annual precipitation by about 10% in northern Quebec (Génivar, 2007).

## 3. Impacts identification and assessment

Within the context of the work covered by this authorization request, no additional impact on the natural environment is expected. The open pit tailing management plan and tailings flooding is the option which most minimizes environmental impacts. Regarding tailings, only the final destination of the mine tailings will be changed. Tailings are currently accumulated in a tailing pond and will also be accumulated in the existing Expo pit. The conveying process of tailings will remain the same, only new pipes on the already impacted environments will be put in place. Thus, no additional effect on the natural environment is expected. Adding tailings to the pit has a positive effect on the stability of the pit walls. In addition, the risks associated with the migration of groundwater are limited by the presence of permafrost which isolates the pit from its environment. This management method has limited effects on atmospheric emissions and GHGs.

## 4. Mitigation, monitoring and follow-up measures

CRI will put in place mitigation, monitoring and follow-up measures to ensure that the tailings management method in the pit and flooding of the pit is effective and remains effective over time to counter AMD.

*Mitigation measures*

While developing the in-pit deposition method, CRI carried out modelling to ensure that the AMD was controlled and that the applicable criteria were met. In fact, modelling has shown that maintaining the hardness of the pit water at 400 mg / L eq. $CaCO_3$ helps limit the AMD and ensures that the discharge of the overflow to the tributary of the Puvirnituq River meets the applicable criteria. The maintenance of hardness will be done by adding chemicals (e.g. calcium chloride) to the pit.

It should be noted that a restoration plan is currently being revised to include in-pit tailing management.

*Monitoring of the tailing facility*

The monitoring will be carried out in accordance with the *Monitoring procedure for mining facilities, and management of tailings, waste rock and water* (PRO-NMIN-1505-01a-F, Appendix 5).

*Follow-up program*

During the operation period, ie the pit filling period, monitoring of the AMD will continue as specified in monitoring 27 of the CRI Environmental Monitoring Plan (Appendix 6). During the post-operation period, CRI will set up environmental monitoring to ensure that the measures in place are working properly.

## 5. Communications with partners and stockholders

*Nunavik Nickel Committee*

The PNNi includes a specific agreement on the repercussions and benefits for the Inuit community (better known by the acronym IBA for *Impact and Benefit Agreement*), the Nunavik Nickel Agreement, between the Makivik Corporation, the Nunaturlik landholding corporation of the northern village of Kangiqsujuaq, the Qarqalik landholding corporation of the northern village of Salluit, the northern village of Puvirnituq and Canadian Royalties Inc. It addresses the communication aspect of the project throughout its lifetime. Thus, the *Nunavik Nickel Committee* (NNC) made up of signatory members (4 members from the Inuit parties and 4 members from CRI) meets on a biannual basis to discuss issues related to the PNNi. In addition, an Inuit liaison officer employed by CRI monitors communications with the communities. In 2019, NNC met on May 3rd and November 4th at the PNNi site. Social, environmental and technical aspects related to the operations and administration of the IBA were discussed. The changes to the tailing management plan were presented during the meeting held on December 11th, 2020 (Appendix 7).

*Communication and monitoring program with communities*

A communication and monitoring program with the communities has been set up under the conditions issued by the global Board of Directors and the two follow-ups resulting from these conditions are integrated into our environmental monitoring program. The results of these monitoring are presented annually as part of the PNNi monitoring report, submitted to stakeholders.

In 2019, the Department of the Environment, with the Inuit Liaison Officer, decided to resume the visits to the communities which was a component covered by the Agreement. A visit took place on January 22nd, 2020, between the northern village of Puvirnituq and CRI. During this visit, two members of the Department of the Environment (one of whom is Inuit) presented a summary of the PNNi, i.e. the current projects, those in development, and those to come, as well as the environmental monitoring of the environmental assessments. It should be noted that the activities planned during these visits are discussed during the meetings of the NNC and the annual environmental monitoring report is sent to the members of this same committee. Also, the environment superintendent was present during the Kuujjuaq Mining Workshop held in the spring of 2019. This forum is an opportunity to meet, on an informal basis, several members of the communities covered by the Agreement. Unfortunately, planned visits to Salluit and Wakeham had not occurred due to the ongoing Covid-19 pandemic.

The transfer of information between CRI, stakeholders and targeted communities, via the NNC, is in the process of continuous improvement. CRI maintains an open and transparent approach, not only regarding environmental issues, but also future projects. We hope that the hiring of the Inuit Liaison Officer in 2017 will help maintain an open and transparent dialogue between stakeholders and it will improve communication and feedback with communities. CRI wishes the satisfaction of the Inuit members with regard to the communication of our results and consequently is open to any proposal to improve the information dissemination mechanism.

Hoping everything satisfies the requirements,
Best regards.

Stéphane Twigg
Environment Superintendent

c.c. (electronic correspondence):
Mrs. Marie-Michelle Vézina – MELCC

**List of appendices enclosed in attachments**

| | |
|---|---|
| **Appendix 1 :** | Copy of the Resolution of the Board of Directors of CRI (Résolution du conseil d'administration), September 11th, 2019 |
| **Appendix 2 :** | Copy of the applicant's declaration (Déclaration du demandeur ou du titulaire), September 12th, 2019 |
| **Appendix 3 :** | Map 1 – Project location (Golder), December 22nd, 2020 |
| **Appendix 4 :** | Report : Conceptual design of the Expo in-pit tailing facility (Golder), December 22nd, 2020 |
| **Appendix 5 :** | Monitoring procedure for mining facilities, and management of tailings, waste rock and water (CRI), 2020 |
| **Appendix 6 :** | Environmental monitoring plan V.4 – 27th Monitoring (WSP), June 2015 |
| **Appendix 7 :** | CCN committee meeting report (IBA), December 11th 2020 |
| **Appendix 8 :** | Summary of the closure plan projected for the Expo pit |

**APPENDIX 1**

Copy of the Resolution of the Board of Directors of CRI (Résolution du Conseil d'administration), September 11th, 2019

(enclosed in attachments)

**CANADIAN ROYALTIES INC.**

The undersigned, being the sole shareholder of CANADIAN ROYALTIES INC. (the "**Corporation**"), hereby consents to the following resolution:

**AUTHORIZATION TO SIGN DOCUMENTS PURSUANT TO EACH OF THE ENVIRONMENT QUALITY ACT (CQLR C. Q-2) AND THE MINING ACT (CQLR C. M-13.1) AND ALL FEDERAL LAWS REGARDING ENVIRONMENTAL MATTERS**

**WHEREAS** it is desirable that the Corporation adopt a resolution authorizing the Superintendent-Environment of the Corporation to sign on its behalf documents pursuant to each of the *Environment Quality Act* (CQLR C. Q-2), as amended, and the *Mining Act* (CQLR C. M-13.1), as amended, and all federal laws regarding environmental matters;

**WHEREAS** pursuant to a unanimous shareholder's declaration signed November 2, 2018 by JIEN INTERNATIONAL INVESTMENT LTD. ("**JIIL**"), the sole shareholder of the Corporation, the powers of the directors of the Corporation have been suspended to the fullest extent permitted by law, and therefore resolutions that would otherwise be adopted by the directors of the Corporation must be signed by JIIL;

**NOW, THEREFORE, BE IT RESOLVED:**

**TO AUTHORIZE** Mr. Stephane Twigg, Superintendent-Environment for the Corporation, to perform and to do all acts or things as, in his sole discretion, he deems necessary or desirable in order to ensure the Corporation is in compliance with all applicable environmental laws, including the execution and/or filing of any related government forms, including without limiting the generality of the foregoing, the execution and/or filing of any forms or other documents required pursuant to each of the *Environment Quality Act* (CQLR C. Q-2), as amended, and the *Mining Act* (CQLR C. M-13.1), as amended, and all federal laws regarding environmental matters.

DATED as of the 11th day of September, 2019.

**JIEN INTERNATIONAL INVESTMENT LTD.**

By: ______________________________

James Xiang
Director

**APPENDIX 2**

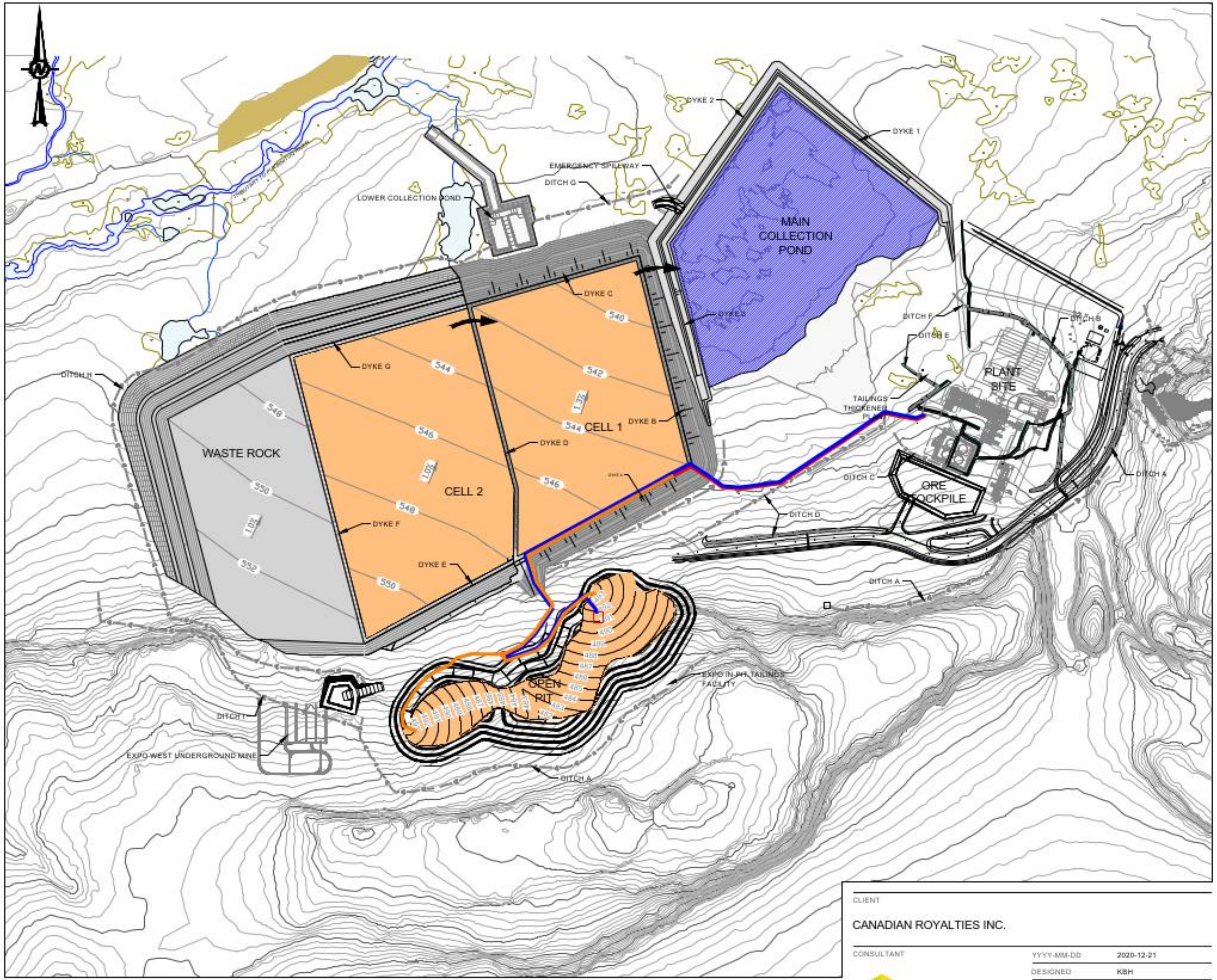
Copy of the applicant's declaration (Déclaration du demandeur ou du titulaire), September 12th, 2019

(enclosed in attachments)

**APPENDIX 3**

Map 1 – Project location (Golder), December 22nd, 2020

(enclosed in attachments)




**END OF MINE LIFE PLAN VIEW**

**LEGEND:**

- LAKE / RIVER
- POND
- DYKE
- DEPOSITED TAILINGS CONTOURS
- GROUND SURFACE CONTOURS
- EXISTING DITCHES
- WATER PIPELINE TO MILL
- 6-INCH SCH.80 CARBON STEEL PIPE
- 8-INCH RD9 4710 HDPE PIPE

**NOTES:**

1. ALL ELEVATIONS AND GRID CO-ORDINATES SHOWN ARE METRIC.

REFERENCE:

1. BASE DATA IS FROM CANADIAN ROYALTIES INC., 2007.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N.
3. PLANT SITE IS PROVIDED BY CRI Feb. 2011, FILE NAME 510_G_0100_0F.dwg.

NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**

0 250 500
1:10,000 METRES

| | |
|---|---|
| CLIENT | CANADIAN ROYALTIES INC. |
| PROJECT | NUNAVIK NICKEL MINE |
| CONSULTANT | GOLDER |
| YYYY-MM-DD | 2020-12-21 |
| DESIGNED | KBH |
| PREPARED | FZG |
| REVIEWED | YB |
| APPROVED | WPM |
| TITLE | EXPO IN-PIT TAILINGS FACILITY AND PIPELINE GENERAL ARRANGEMENT PLAN |
| PROJECT NO. | 19117253 |
| PHASE | 3000 |
| REV. | 2 |
| FIGURE | 1 |

**APPENDIX 4**

Report : Conceptual design of the Expo in-pit tailing facility (Golder), December 22[nd], 2020

(enclosed in attachments)

**REPORT**

# Conceptual Design of Expo In-Pit Tailings Facility

*Nunavik Nickel Mine, Quebec*

Submitted to:

**Canadian Royalties Inc.**

Steve Quessy, Chief Engineer
800 René Lévesque Blvd. West, Suite 410
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H3B 1X9

Submitted by:

**Golder Associates Ltd.**

6925 Century Avenue, Suite #100, Mississauga, Ontario, L5N 7K2, Canada

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Report no.: 19117253 (3000)-Rev 2

December 22, 2020

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**APPENDIX D**
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**APPENDIX G**
Spillway and Discharge Channel Sizing

# 1.0 INTRODUCTION

Canadian Royalties Inc (CRI) owns and operates the Nunavik Nickel Mine, located in Northern Quebec. The mine has two lined surface tailings disposal cells at the Expo site. Golder Associates Ltd. (Golder) has been retained by CRI to evaluate the feasibility of disposing tailings at the Expo pit once the two tailings cells are filled and mining of the open pit has ceased.

This report presents a summary of different studies carried out to show the feasibility of the Expo in-pit tailings disposal. The studies include: one dimensional tailings consolidation modelling, tailings depositional plan, water balance, water quality prediction, thermal modelling, review of pit wall stability, and hydrogeological assessment.

# 2.0 SITE BACKGROUND

## 2.1 Site Location

The Nunavik Nickel Mine is a nickel and copper mine located on the Ungava Peninsula in Northern Quebec at latitude 61°32' north and longitude 73°28' west. The site is approximately 120 km inland from Deception Bay.

The mine site is north of the tree-line in the arctic region. The topography of the area consists of low rolling hills with shallow lakes and rivers. The site is covered by dwarf tundra vegetation.

## 2.2 Meteorology

The meteorological data of the mine site is provided in Appendix A and summarized below.

The project lies within the arctic region which has eight months of cold winter (between September and May) and four months of summer. The mean annual temperature based on the Katinniq station (2000 to 2005) is -9.5 ºC. January and February are the coldest months with monthly mean temperatures of -29.2°C and - 27.8°C and July is the warmest month with a monthly mean temperature of 7.9°C.

The mean annual precipitation is about 600 mm (approximately half of it coming as snow fall) with the highest monthly precipitations in July, August and September at about 90 mm each month. The 100-year wet and dry return annual precipitations are 870 mm and 403 mm, respectively. The estimated 24-hour 100-year return precipitation event is 58.4 mm. The estimated 24-hour probable maximum precipitation (PMP) is 207 mm (Golder 2012).

The mine site is quite windy with an average annual wind speed of about 18.4 km/hr (Expo site meteorological station). The most prevalent wind directions are from the northwest, southeast, and west-southwest. Wind gusts up to 100 km/hr are common on the site.

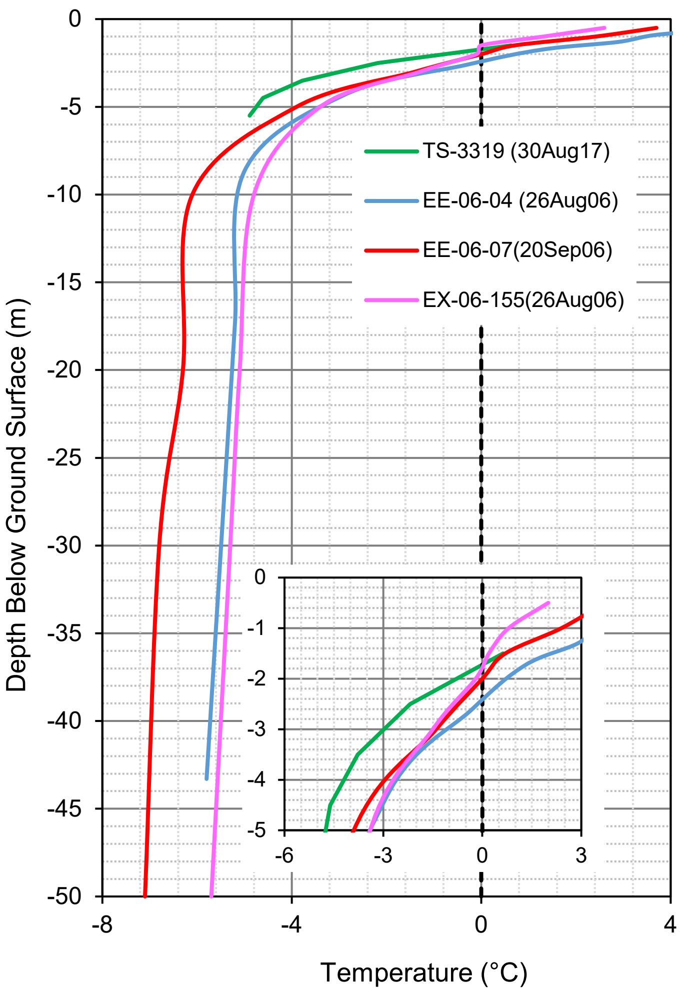
## 2.3 Geology

The mine site is located in the Ungava Belt (also known as the Cape Smith Belt) region of the Canadian shield. The 50 km wide belt is between the Superior tectonic province to the south and the Hearne tectonic province to the north, and crosses the entire Ungava Peninsula region of Nunavik, from James Bay to the Atlantic Ocean. The belt is characterized by folding and thrust faulting associated with the Ungava orogen, which occurred during the Paleoproterozoic, 2.04 to 1.83 billion years ago.

The quaternary geology consists predominantly of glacial till and glacio-marine to glacio-fluvial deposits, typically described as being between about 1 m and 3 m thick (Surface Geology Map, Sheet No. 1863A, NRC, 1997). The glacial deposits are described as consisting of variable amounts of silt, sand and gravel with frequent blocks of rock. The bedrock underlying the overburden soils comprised of the Povurngnituk Group (basalt, volcaniclastic sediment, rhyolite, minor semi-pellite and sandstone). The upper part of the bedrock is highly fractured, and the cracks are filled with overburden soils.

## 2.4 Hydrogeology

The Project lies within the arctic zone of continuous permafrost. Ground temperatures in the permafrost typically range between -4 ºC to -7 ºC. The permafrost in the region is estimated to be up to 400 m deep. The permafrost zone is essentially impervious. The active layer, which thaws each summer, is 1.5 m to 2.5 m thick as shown in Graph 1. The plots are from end of August or beginning of September, when the active zone is the thickest. Groundwater can flow, down gradient, through the active zone in the summer months. During the spring melt, a layer of ice can form at the base of the snow cover on low permeability frozen soil and water can then flow along this layer.




**Graph 1: Records of thermistors in the Expo site**

# 3.0 PROJECT BACKGROUND

The process plant and most of the mine infrastructure are located at the Expo site. The Expo site general arrangement plan is shown on Figure 1. The site has an integrated tailings and waste rock disposal facility covering a total footprint area of 110 ha. The facility contains two geomembrane lined tailings disposal cells (Cell 1 and Cell 2) and one waste rock disposal cell.

## 3.1 Tailings Production Schedule

The mine has a series of ore deposits (Expo, Mesamax, Allamaq, Mequillon, Ivakkak, and Puimajuq) that stretch over 60 km distance. The mine started operating in the first quarter of 2013. The Mesamax deposit was mined via an open pit. The Expo deposit was mined via open pit. Currently, the Mequillon deposit is mined via an open pit and the Allamaq deposit via an underground mine. Ivakkak and Puimajuq will be mined via open pit mining methods. An additional potential ore body was recently discovered west of the Expo open pit, which will be extracted through underground mining methods.

The total ore reserve from the six ore bodies is about 14.90 Mt. The mine also has an additional 2.02 Mt of ore resource, which has the potential to be converted into ore reserve after additional definition drilling. The ore from each deposit will be trucked to the Expo site for processing. The ore is processed at a nominal rate of 4,500 t/d. The life of mine tailings production is approximately 14.88 Mt, assuming tailings to ore ratio of 0.8796.

The process plant started milling in March 2013 and it will extend until October 2024. From the start of operation until August 26, 2019 approximately 8.27 Mt of ore has been processed by the Expo process plant and approximately 7.34 Mt of tailings has been generated. The remaining life of mine ore and tailings are approximately 8.65 Mt and 7.61 Mt, respectively as shown in Table 1.

**Table 1: Remaining Life of Mine Tailings Production (August 2019 to October 2024)**

| Year | Ore | Total Tailings | | Tailings to Cells 1 and 2 | | Tailings to Expo Pit | |
|---|---|---|---|---|---|---|---|
| | (t) | (t) | ($m^3$) | (t) | ($m^3$) | (t) | ($m^3$) |
| 2019 | 686,320 | 603,672 | 406,995 | 603,672 | 406,995 | 0 | 0 |
| 2020 | 1,647,000 | 1,448,666 | 976,689 | 1,448,666 | 976,689 | 0 | 0 |
| 2021 | 1,642,500 | 1,444,708 | 974,020 | 1,444,708 | 974,020 | 0 | 0 |
| 2022 | 1,642,500 | 1,444,708 | 974,020 | 1,203,923 | 811,683 | 240,785 | 162,337 |
| 2023 | 1,642,500 | 1,444,708 | 974,020 | - | - | 1,444,708 | 974,020 |
| 2024 | 1,388,524 | 1,221,316 | 823,410 | - | - | 1,221,316 | 823,410 |
| **Total** | **8,649,344** | **7,607,778** | **5,129,154** | **4,700,969** | **3,169,387** | **2,906,809** | **1,959,767** |

According to the recent exploration activities, there is a positive indication that the life of mine could extend beyond 2024. The in-pit tailings facility design will be updated once the ore reserve is confirmed.

## 3.2 Existing Tailings Facilities

### 3.2.1 Description of Cells 1 and 2

Tailings have been deposited in Cell 1 since 2013 and in Cell 2 since 2016.

### 3.2.2 Storage Capacity

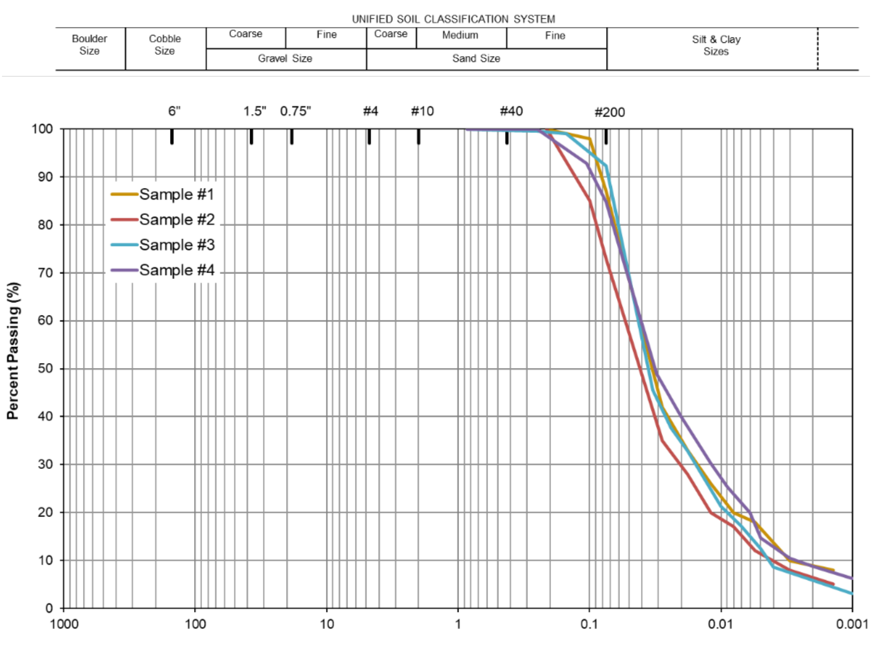
Based on the current tailings deposition strategy followed by CRI, the combined tailings storage capacities of the Expo tailings Cells 1 and 2 is approximately 8.10 $Mm^3$; Cell 1 alone can store up to 3.35 $Mm^3$ and Cell 2 up to 4.75 $Mm^3$. On August 26, 2019, CRI completed a drone survey of the tailings beaches and bathymetric survey of the tailings ponds. Based on the survey data, the total volume of tailings deposited in the two tailings cells is estimated to be approximately 4.92 $Mm^3$ (2.61 $Mm^3$ in Cell 1 and 2.31 $Mm^3$ in Cell 2). The average dry density of the deposited tailings in Cell 2 is approximately 1.483 $t/m^3$. Assuming a tailings specific gravity of 3.16, the calculated void ratio of the deposited tailings is approximately 1.13.

As of August 26, 2019, the combined remaining tailings storage capacity in Cells 1 and 2 is 3.18 $Mm^3$, corresponding to tailings tonnage of 4.72 Mt (assuming a deposited tailings dry density of 1.483 $t/m^3$) and processed ore tonnage of 5.36 Mt (assuming a tailings to ore ratio of 0.8796). The remaining tailings generated after these two tailings cells are filled, which is estimated to be 1.96 $Mm^3$ (2.91 Mt), will be deposited in the mined out Expo open pit. Deposition of tailings in the Expo open pit is anticipated to commence in November 2022.

### 3.2.3 Tailings Characteristics

The tailings are Silt to sandy Silt with about 8-27% sand, 65-85% silt and 7-9% clay sized particles (Graph 2). The tailings are non-plastic. The average specific gravity of the tailings is about 3.16 and varies between 3.01 and 3.29.

The tailings are potentially acid generating and metal leaching (Golder 2018).




**Graph 2: Grain size distribution of tailings**

### 3.2.4 Tailings Deposition Parameters

The tailings are thickened to solids content between 62% and 68% solids content. Centrifugal pumps are used to pump the tailings. In the existing tailings cells, tailings are discharged from regularly spaced spigot points.

The most recent bathymetric survey and drone survey carried on the existing tailings cells shows that the tailings beach slope varies between 1.5% to 1.7% and the tailings slope below water varies between 3.2% and 3.7%.

## 3.3 Expo Pit

The mined-out Expo open pit is approximately 930 m long in the east to west direction and approximately 380 m wide in the north to south direction. The pit bottom elevation is approximately 460 m. Maximum pit depth is approximately 110 m.

Projected geology within the pit suggests that the ultimate pit walls will predominantly be within the Metasediments (57%) and Peridotite (32%). The remaining 11% of the wall will be within sulphides as shown in Figure 2. Both the Metasediments and Peridotite are potentially acid generating and metal leaching (Golder 2018).

# 4.0 IN-PIT TAILINGS FACILITY

## 4.1 Operational Data

The operational data and tailings deposition assumptions used for the Expo in-pit tailings facility are summarized in Table 2.

**Table 2: Operational and tailings deposition data for Expo Pit tailings facility**

| Parameters | Unit | Operational Data | Reference |
|---|---|---|---|
| **Operational Data** | | | |
| Total tailings for open pit disposal (Nov 2022 to Oct 2024) | t | 2,906,809 | CRI |
| Tailings to ore ratio | - | 0.8796 | CRI |
| Annual tailings production rate | t | 1,444,708 | CRI |
| Tailings solids specific gravity | - | 3.16 | Assumed |
| Dry density of deposited tailings | $t/m^3$ | 1.483 | Assumed |
| Void ratio of deposited tailings | - | 1.13 | Calculated |
| Annual deposited tailings volume | $m^3$ | 974,020 | Calculated |
| Total tailings storage capacity of Expo pit | $m^3$ | 1,959,767 | Calculated |
| Operational years of Expo in-pit tailings facility | Years | 2.0 | Calculated |

| Parameters | Unit | Operational Data | Reference |
|---|---|---|---|
| **Tailings Deposition Assumptions** | | | |
| Tailings solids content | % | 62 to 68 | CRI |
| Tailings beach slope | % | 1.6 | Assumed |
| Tailings slope below pond | % | 3.5 | Assumed |

## 4.2 Hazard Consequence

An underground mine is proposed at the Expo site; however, it is not connected with the open pit and it is located at a fair distance from the open pit. Therefore, deposition of tailings in the open pit will not have any impact on the future underground operation. The open pit will be surrounded by permafrost, limiting seepage of tailings water to the surrounding bedrock. There is no deep water body near the Expo pit which could lead to talik condition and hydraulic connection to the open pit. Therefore, the facility has very low risk to the public, the environment, and infrastructure.

## 4.3 Tailings Deposition

The Expo pit will provide storage for approximately 1.96 $Mm^3$ (2.91 Mt) of tailings. The corresponding tonnage of ore that will be processed to generate the tailings is approximately 3.30 Mt. Tailings deposition in the Expo pit will start in November 2022, once the existing tailings Cells 1 and 2 are full. Tailings deposition in the open pit will be terminated in October 2024. Therefore, the life of the Expo in-pit facility will be approximately 2 years.

Figures 2 to 7 show the annual tailings deposition plans from August 2019 to October 2024. The figures show how tailings deposition transitions from the tailings Cells 1 and 2 to the Expo pit. Figure 9 shows the cross-section of the tailings cells and the Expo in-pit tailings facility. To maximize the filling of the existing tailings cells, tailings deposition will be switched between Cells 1 and 2 and the excess tailings water from the cells will be pumped to the Expo pit between August 2019 and October 2022.

Since the Expo pit will be used to store tailings water from Cells 1 and 2, tailings deposition in the pit will be underwater throughout the two years of operation. Tailings are planned to be end discharged from two discharge points located at the west and east ends of the open pit ramps as shown in Figures 5 to 7.

## 4.4 Tailings Delivery and Distribution System

The current tailings pipeline corridor will be used to deliver tailings to the Expo pit. Tailings will be delivered from the tailings thickener plant to the south-eastern crest of tailings Cell 1 via a 6-inch Sch.80 Carbon Steel pipe and from the southeast corner of tailings Cell 1 crest to the open pit via a 8-inch RD9 4710 HDPE pipe.

Two ramps are provided near the middle of the pit; one going to the east and the other one to the west. The tailings pipeline will be running along both the east and the west ramps. A valve station will be provided at the intersection of the west and east ramps to control the tailings discharge between the sections of the pit. At the end of each tailings distribution system a floating pipeline will be provided to discharge tailings from the pit ramp into the pit.

Two tailings pipelines will be installed along the tailings delivery and distribution system (one operating and one stand-by).

## 4.5 Return Water System

A floating pump barge will be used to reclaim water from the in-pit tailings facility. The floating pump barge will be located at the eastern section of the pit. The floating barge system will be anchored on the east ramp. The floating pump will be connected to the standby tailings pipeline to convey the reclaim water to the mill for treatment and for re-use.

## 4.6 Closure Plan

The closure plan for the Expo in-pit tailings facility aims to improve the long-term water quality and it will entail the following:

- Removal of tailings water (July 2023 to September 2030): Tailings water in the pit will contain metals and process reagents. Prior to flooding of the pit with clean water, all of the tailings water will be pumped for treatment and release to the environment (at a rate of 180,000 $m^3$/month from July to September). The tailings water will be pre-treated using a Fenton process to oxide the thiosalts prior to being blending with the Expo Main Collection Pond water at a ratio of 25% and 75%, respectively, and going through the full treatment at the Expo main treatment plant.
- Accelerated flooding of the pit with fresh water (October 2030 to January 2035): Once the tailings water is completely removed, active flooding of the pit with fresh water from Lac Bombardier (at a rate of 1,300,000 $m^3$/year) will commence. The active flooding of the pit will be terminated once the water level reaches elevation 535.4 m, which is the lowest elevation along the pit rim. Figures 8 and 9 show the plan view and the cross section of the Expo in-pit tailings facility after accelerated flooding, respectively.
- Outlet spillway channel construction: An outlet spillway channel will be constructed on the northeast corner of the pit and east of tailings Cell 1. Once the accelerated flooding is complete, the channel will convey the pit overflow to the Puvirnituq River tributary, which is located north of the tailings cells.
- Maintaining pit water quality hardness at 400 mg/L $CaCO_3$ equivalent (October 2030 to December 2056): Calcium Chloride will be added to the pit water during closure and post-closure to maintain the hardness at 400 mg/L.

# 5.0 DESIGN ANALYSES

## 5.1 Tailings Consolidation Analysis

One-dimensional tailings consolidation models were developed using CONDES0 (1997). The models were calibrated using the consolidation performance for the existing tailings Cells 1 and 2. The results of the analyses are presented in Appendix B. The predicted long-term average dry density of the tailings was 1.672 t/$m^3$. For the purpose of the tailings depositional planning a conservative dry density of 1.483 t/$m^3$ was used as presented in Table 2. The selected dry density of 1.483 t/$m^3$ is based on the observed density of deposited tailings in Cell 1.

## 5.2 Water Balance

A deterministic monthly water balance was developed in Excel format for the tailings deposition scenario. The water balance was set-up to include inflows such as runoff from precipitation, snow drift, and water in the discharged tailings. It also considers losses such as: water permanently trapped as ice within the tailings, water tied up in the deposited tailings voids, evaporation, and sublimation losses. The results of the water balance for an average year are presented in Appendix C and summarized below.

The average annual total inflow to and losses from the pit during deposition between 2023 and 2024 were 1.57 $Mm^3$ and 0.56 $Mm^3$, respectively. Pumping of process water to treatment begins in the summer of 2023. After tailings deposition ends in October 2024 until the Pit is emptied, the average annual inflow decreases to 0.38 $Mm^3$ and the average annual total losses (excluding pumping to treatment) decreases to 0.018 $Mm^3$. The Pit is emptied and accelerated flooding with water from Lac Bombardier begins in 2030. The average annual inflow during accelerated flooding increases to 1.69 $Mm^3$ and the average annual total losses increases to 0.028 $Mm^3$. It will take approximately 4.3 years to flood the Pit to elevation 535.4 m (i.e., lowest elevation along the pit rim). The volume of water stored in the Pit at the end of 2035 will be approximately 7.03 $Mm^3$.

## 5.3 Water Quality

Water quality predictions were generated for the operational, closure, and post-closure years using PHREEQC (Parkhurst and Appelo 2013). Details of the water quality prediction is presented in Appendix D and summarized below.

Contact water inflows to the in-pit tailings disposal facility include the exposed pit wall, natural ground runoff, and proposed tailings process water deposited with tailings in the Pit. The contact water chemistry from these sources were mixed using PHREEQC based on flow proportions defined in the water balance for each year. Water quality predictions are compared with the average monthly Quebec Directive 019 effluent limits during operations and to the Quebec surface water quality criteria (CVAC, or protection of aquatic life, chronic effects) at closure and post-closure (MEF 1998 and MDDELCC 2012).

The two main constituents that exceed applicable CVAC guidelines within the model are silver and nickel; selenium exceedance is limited to two years prior to the removal of process water, whereas silver exceedances are an artefact of using the analytical detection limit value in mill effluent process water and TSF water having below detection concentration in site data. The nickel concentration at the end of closure is predicted to be on the order of 0.15 mg/L, below the 0.169 mg/L Ni CVAC limit for a hardness of 400 mg/L $CaCO_3$ equivalent. The removal of process water causes a sharp drop in Pit water nickel concentrations from 1.0 mg/L Ni in 2030 to 0.18 mg/L Ni in 2031. The main contributor to the nickel loading at the end of closure (2031-2035) is Pit wall runoff. Accelerated flooding from Lac Bombardier significantly reduces the time necessary to fill the Pit to four years, thereby reducing the amount of Pit wall runoff contributing to the nickel loading at the end of closure.

The pH of the Pit water is predicted to remain circum-neutral, ranging from 7.0 to 7.3 while process water remains in the Pit; it is dominated by the pH of process water. Upon flooding of the Pit with Lac Bombardier water, the pH of the flooding Pit is predicted to reach 6.2.

Sulfate and thiosulfate concentrations during the operations and closure periods follow a similar trend with high concentrations of both species present during operations and the beginning of closure when loadings from mill effluent process water and TSF pond waters containing elevated levels of the two species are present and subsequently decreasing as a result of the removal of the free tailings water and the addition of Lac Bombardier water. The effect of tailings process water removal can be seen when examining the minimum concentrations of these species, which fall below 100 mg/L at that time.

The model results indicate that the predicted water quality is below CVAC guidelines for all parameters at the end of the closure period and most of post-closure provided Pit water hardness is maintained at 400 mg/L $CaCO_3$

equivalent until at least 2056, well into post-closure. CRI is proposing to add Calcium Chloride to the pit water to maintain the hardness.

## 5.4 Thermal Analyses

Thermal assessment was conducted to evaluate the effects of partial in-pit tailings deposition followed by flooding of the Expo pit on the conditions of permafrost beneath and adjacent to the pit walls. Two-Dimensional thermal models were prepared using the finite element software TEMPW2020 for operation and post closure conditions with consideration to climate change over a period of 100 years. The details of the analysis are presented in Appendix E and the results are summarized below.

The model results show that deposition of tailings inside the pit followed by formation of a pit lake will cause permafrost to thaw to a depth of about 22 m below the base of the pit. Although permafrost would warm up progressively in the long term, the models showed that the extent of this unfrozen zone would not increase over a period of 100 years. The models also showed that ground between the Expo Pit and the Tailings Cells will remain mostly frozen during all times, which would prevent groundwater flow between the Expo pit and tailings areas.

## 5.5 Hydrogeological Assessment

The main groundwater flow regime in the mine site is through the active layer near the ground surface. The thickness of the active layer around the mine site varies between 1.5 m and 2.5 m as discussed in Section 2.4. Simplified 1D thermal models were prepared to determine the effect of warm climate in 100 year on the thickness of the active layer. The model results show that the thickness of the active zone will vary between 3.5 m and 4.0 m.

During the period of late spring to end of summer, the temperatures at the mine site will be above 0°C which will cause the active layer to thaw and create a shallow groundwater flow regime. The natural ground slopes on average at 2.5% from the open pit towards north. Therefore, the groundwater in the active zone will flow to the north to the local depressions, lakes and streams which will finally drain to the Puvirnituq River.

The lowest open pit rim elevation is 535.4 m at the northeast corner. Once the open pit water quality is acceptable for discharge to the environment, a spillway discharge channel will be constructed to convey the run-off around the tailings facility and to the Puvirnituq River tributary.

## 5.6 Pit Slope Stability Analysis

The stability of the open pit wall during various stages of the Expo in-pit tailings deposition was assessed using Slide2. Details of the assessment are presented in Appendix F and summarized below.

The slope stability analysis was carried out using the geotechnical data presented in Golder (2007). The most recent inspection of the Expo pit (MDEng 2017) identified bedding planes that plunge towards the pit on the south wall. The effects of these bedding planes were included on the overall stability of the pit wall. The analyses included empty and tailings backfilled pit assuming completely saturated conditions in the ultramafic and metasediments rock units. Both circular and non-circular failure modes were analyzed.

Non-circular failures yielded lower results, particularly in cases where the failure occurs along the bedding in the metasediments. The factor of safety calculated were more than the minimum required, which is 1.2, indicating that the pit wall will be stable. The final pit before the start of tailings filling yielded the lowest factor of safety. The factor of safety of the pit wall increased once tailings are deposited. The tailings acted as a support to the pit slope and improved the overall stability.

## 5.7 Outlet Spillway and Discharge Channel

An outlet spillway channel will be constructed on the northeast corner of the Expo Pit and east of the Tailings Cell 1. Once the accelerated flooding of the Pit is complete, the channel will convey the Pit overflow to the Puvirnituq River tributary, which is located north of the tailings and waste rock facility (Figures 1 and 8). The details of the analysis are presented in Appendix G and the results are summarized as follows:

- Outlet Spillway: bottom width of 3 m, side slopes 3H:1V, and depth of 0.6 m (freeboard of 0.2 m).
- Discharge Channel: bottom width of 3 m, side slopes 2H:1V. Additional results are included in Table 3.

**Table 3: Discharge Channel Sizing Results**

| Discharge Channel | Length (m) | Average Channel Slope | Peak Flow ($m^3$/s) | Flow Depth[1] (m) | Freeboard (m) | Min. Channel Depth[2] (m) | Flow Velocity (m/s) | Min. $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|---|
| South | 350 | 2.1% | 1.46 | 0.23 | 0.3 | 0.6 | 1.8 | 150 |
| North | 1,100 | 1.1% | 1.46 | 0.28 | 0.4 | 0.7 | 1.5 | 100 |

# 6.0 CONCLUSIONS

CRI is proposing to use the Expo pit to deposit approximately 1.96 Mm$^3$ (2.91 Mt) of tailings. The Expo in-pit facility will be operated for approximately 2 year (between November 2022 and October 2024).

The tailings delivery and distribution system will consist of 6-inch Sch.80 Carbon Steel and 8-inch RD9 HDPE pipes. The pipelines will run along the Cell 1 access ramp, the crest of the south dyke of Cell 1 and then the access ramps of the Expo pit. The tailings will be deposited underwater as the pit will be used as a storage for tailings water from Cells 1 and 2 prior to the start of tailings deposition. Tailings will be end discharged from two spigot points located at the west and east ends of the pit.

A floating pump barge will be used to reclaim water from the in-pit tailings facility. The floating pump barge will be located at the eastern section of the pit. The floating pump will be connected to the standby tailings pipeline to convey the reclaim water to the mill for treatment and for re-use.

Different design analyses were completed to show the feasibility of in-pit tailings facility. The analyses include: one dimensional tailings consolidation modelling, water balance, water quality prediction, thermal modelling, hydrogeological assessment, and review of pit wall stability.

Tailings discharged into the mined-out Expo pit will undergo settling and consolidation due to self weight. The one-dimensional consolidation analyses carried out predicted dry densities of 1.672 t/m$^3$. A conservative dry density of 1.483 t/m$^3$ was used for the purpose of determining the maximum tailings elevation in the pit based on the estimated densities from tailings Cell 1.

The water balance was used to estimate the inflows and losses from the Pit. The average annual total inflow to and losses from the pit during deposition were 1.57 Mm$^3$ and 0.56 Mm$^3$, respectively. After tailings deposition ends in October 2024 until the Pit is emptied, the average annual inflow decreases to 0.38 Mm$^3$ and the average annual total losses decreases to 0.018 $Mm^3$. The average annual inflow during accelerated flooding increases to 1.69 $Mm^3$ and the average annual total losses increases to 0.028 $Mm^3$. It will take approximately 4.3 years to flood the Pit.

Water quality predictions were generated for the operational, closure, and post-closure years. The pH of the Pit water is predicted to ranging from 7.0 to 7.3 while process water remains in the Pit. Upon flooding of the Pit with Lac Bombardier water, the pH of the flooding Pit is predicted to reach 6.2. Sulfate and thiosulfate concentrations during the operations and closure periods follow a similar trend with high concentrations of both species present during operations and the beginning of closure and subsequently decreasing as a result of the removal of the free tailings water and the addition of Lac Bombardier water. The model results indicate that the predicted water quality is below CVAC guidelines for all parameters at the end of the closure period and post-closure provided Pit water hardness is maintained at 400 mg/L $CaCO_3$ equivalent until at least 2056, well into post-closure. CRI is proposing to add Calcium Chloride to the pit water to maintain the hardness.

A thermal model was developed that takes into account the operational years and 100 years post-closure and climate change. The model results show that deposition of tailings inside the pit followed by formation of a pit lake will cause permafrost to thaw to a depth of about 22 m below the base of the pit. Although permafrost would warm up progressively in the long term, the extent of the unfrozen zone would not increase over a period of 100 years.

The main groundwater flow regime in the mine site is through the active layer near the ground surface, which is typically 1.5 m to 2.5 m thick. The effect of warm climate in 100 year is to increase the active layer thickness to 3.5 m - 4.0 m. This is true for the area away from the tailings cells and waste rock cell. The models showed that the ground between the Expo Pit and the Tailings Cells will remain mostly frozen during all times, which would prevent groundwater flow between the Expo pit and tailings areas. The groundwater in the active zone will flow to the north to the local depressions, lakes and streams which will finally drain to the Puvirnituq River.

The stability of the open pit wall while it is empty and after tailings deposition is complete were assessed. The empty pit was the worst-case scenario with a factor of safety greater than 1.2. The factor of safety of the pit wall increased as more tailings were deposited. The tailings acted as a support to the pit slope and improved the overall stability.

In summary, the disposal of tailings in the Expo pit is a safe and cost-effective management of tailings with minimal long-term impact to people or the environment. The in-pit disposal also improves the stability of the pit and long-term water quality.

According to the recent exploration activities, there is a positive indication that the life of mine could extend beyond 2024. Once the additional ore reserve is confirmed, there is a need to update the in-pit tailings facility design.

# Signature Page

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https://golderassociates.sharepoint.com/sites/104972/project files/5 technical work/3000 - expo in-pit disposal/04_rev 2/19117253(3000)_expoin-pittailingsdisposal_rev2_22dec20.docx

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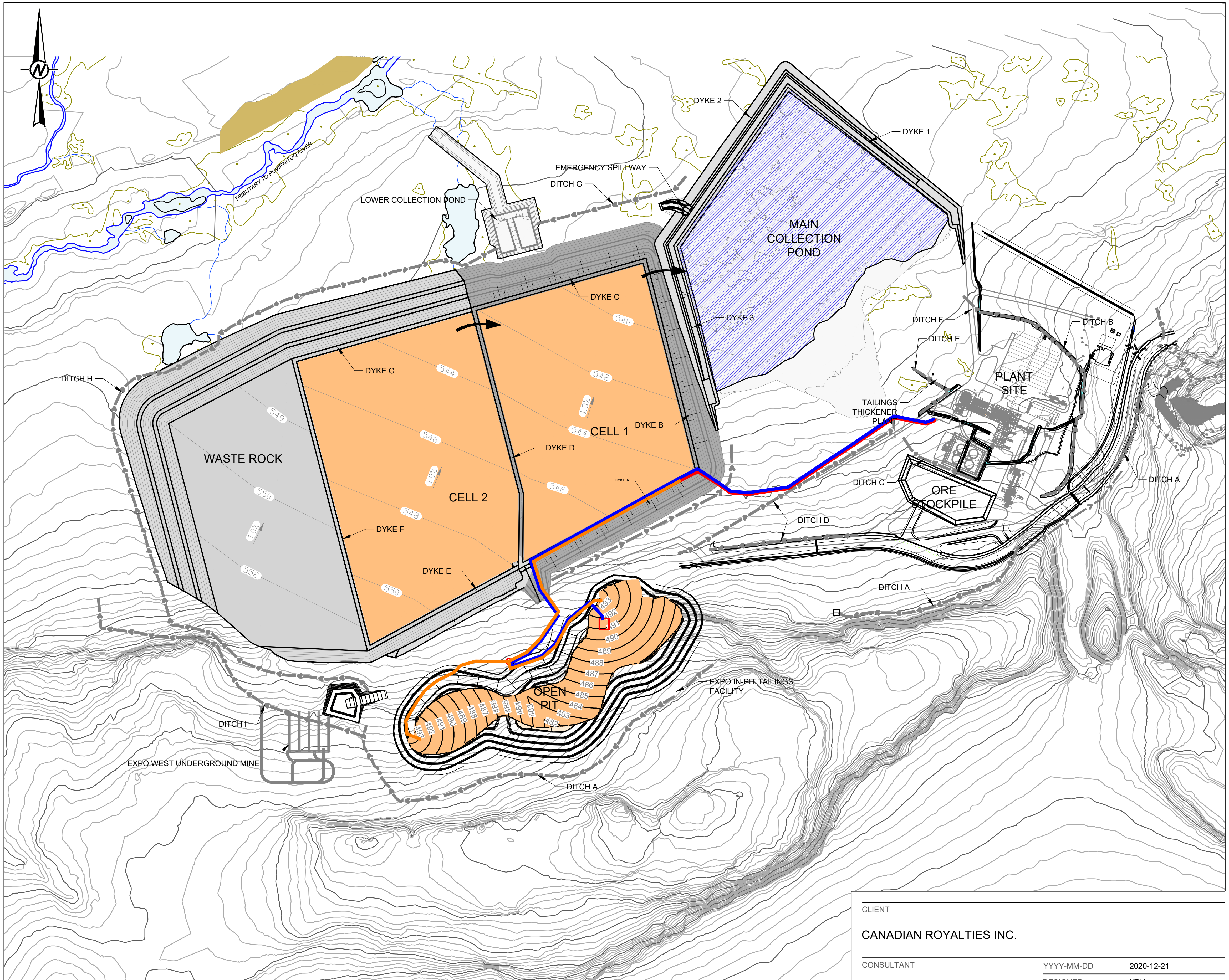
# FIGURES




## END OF MINE LIFE PLAN VIEW

**LEGEND:**

- LAKE / RIVER
- POND
- DYKE
- DEPOSITED TAILINGS CONTOURS
- GROUND SURFACE CONTOURS
- EXISTING DITCHES
- WATER PIPELINE TO MILL
- 6-INCH SCH.80 CARBON STEEL PIPE
- 8-INCH RD9 4710 HDPE PIPE

**NOTES:**

1. ALL ELEVATIONS AND GRID CO-ORDINATES SHOWN ARE METRIC.

**REFERENCE:**

1. BASE DATA IS FROM CANADIAN ROYALTIES INC., 2007.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N.
3. PLANT SITE IS PROVIDED BY CRI Feb. 2011, FILE NAME 510_G_0100_0F.dwg.

NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**

0 250 500
1:10,000 METRES

| | |
|---|---|
| CLIENT | CANADIAN ROYALTIES INC. |
| PROJECT | NUNAVIK NICKEL MINE |
| CONSULTANT | GOLDER |
| YYYY-MM-DD | 2020-12-21 |
| DESIGNED | KBH |
| PREPARED | FZG |
| REVIEWED | YB |
| APPROVED | WPM |
| TITLE | **EXPO IN-PIT TAILINGS FACILITY AND PIPELINE GENERAL ARRANGEMENT PLAN** |
| PROJECT NO. | 19117253 |
| PHASE | 3000 |
| REV. | 2 |
| FIGURE | 1 |

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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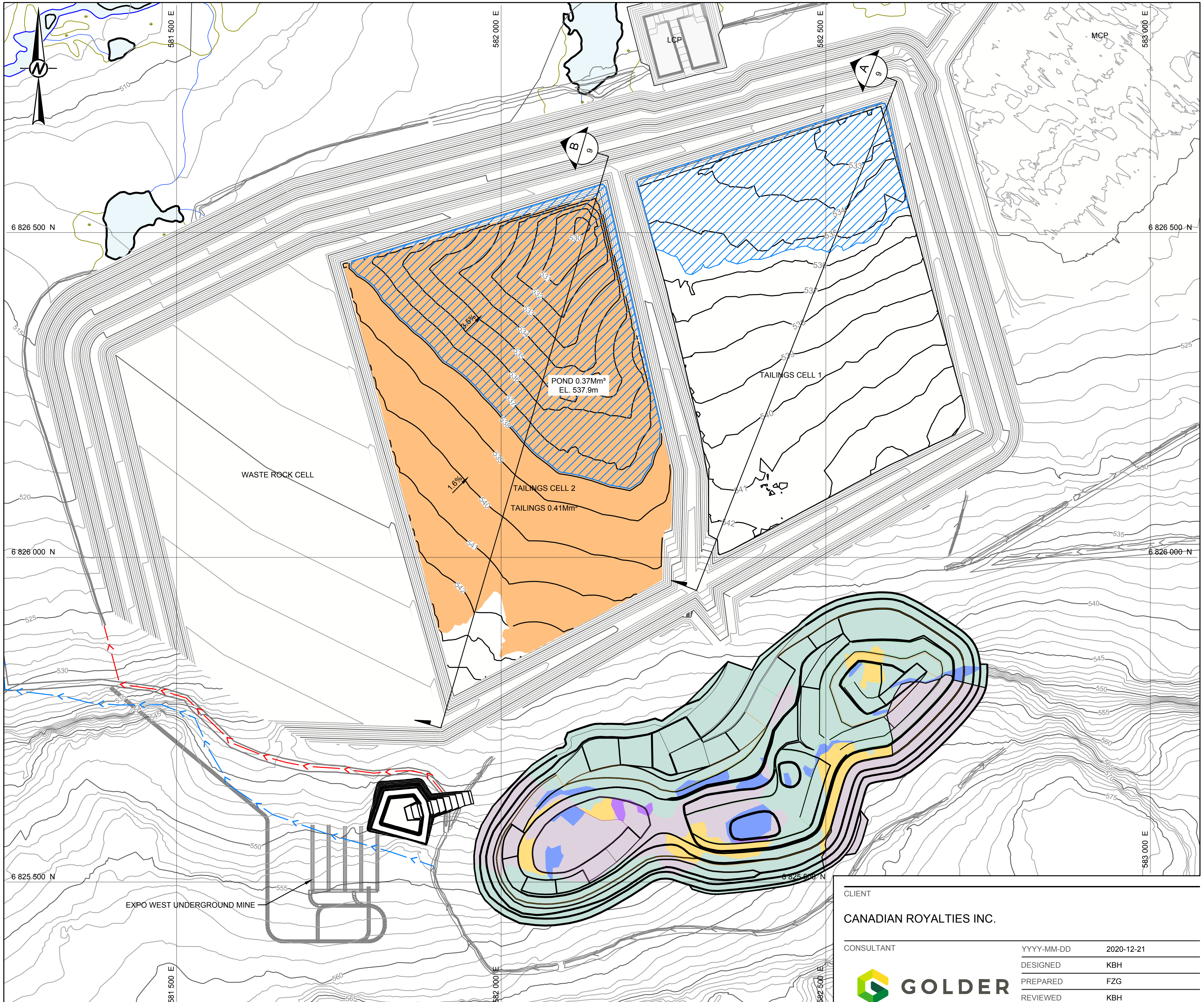



**LEGEND**

- TAILINGS DEPOSITION
- TAILINGS POND

**LITHOLOGICAL LEGEND:**

- SEDIMENTS (125699m²)
- PERIDOTITE (69970m²)
- MASSIVE SULPHIDES (1266m²)
- NET TEXTURED SULPHIDES (14692m²)
- SULPHIDES IN VEINS (9600m²)

**NOTE(S)**

1. DATUM IS UTM 83 ZONE 18.
2. NATURAL GROUND CONTOUR IS PROVIDED BY CRI AND THE CONTOUR INTERVAL IS 1m.
3. THE CONTOUR MAP OF THE TAILINGS BEACH AND TAILINGS BELOW THE POND IS PROVIDED BY CRI ON 26 AUGUST 2019.
4. THE CONTOUR MAP OF THE PERIMETER EMBANKMENTS AND WASTE ROCK CELLS ARE AS PER DESIGN.
5. GEOLOGY OF THE OPEN PIT IS PROVIDED BY CRI.
6. PRECIPITATION AND RUNOFF ENTERING THE PIT IS PUMPED TO THE MCP.
7. PROCESS RECLAIM WATER IS RECYCLED TO THE MILL FROM TAILINGS CELL 2.

NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**

0 100 200
1:3,000 METRES

CLIENT
CANADIAN ROYALTIES INC.

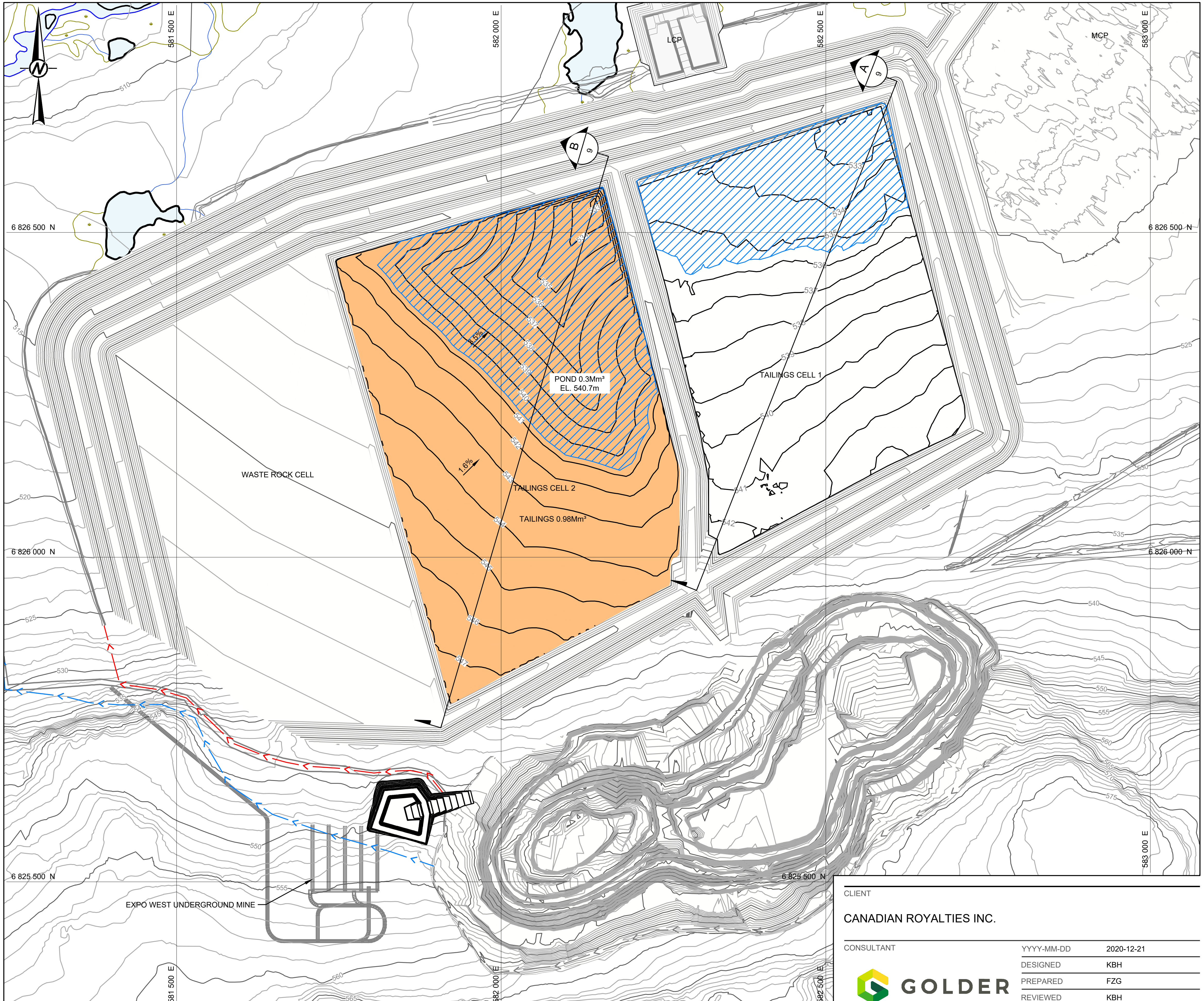
CONSULTANT
GOLDER

| | |
|---|---|
| YYYY-MM-DD | 2020-12-21 |
| DESIGNED | KBH |
| PREPARED | FZG |
| REVIEWED | KBH |
| APPROVED | WPM |

PROJECT
NUNAVIK NICKEL MINE

TITLE
**EXPO TAILINGS END OF YEAR 2019**

| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 19117253 | 3000 | 2 | 2 |




**LEGEND**

- TAILINGS DEPOSITION
- TAILINGS POND

**NOTE(S)**

1. PRECIPITATION AND RUNOFF ENTERING THE PIT WILL BE PUMPED TO THE MCP.
2. PROCESS RECLAIM WATER IS RECYCLED TO THE MILL FROM TAILINGS CELL 2.

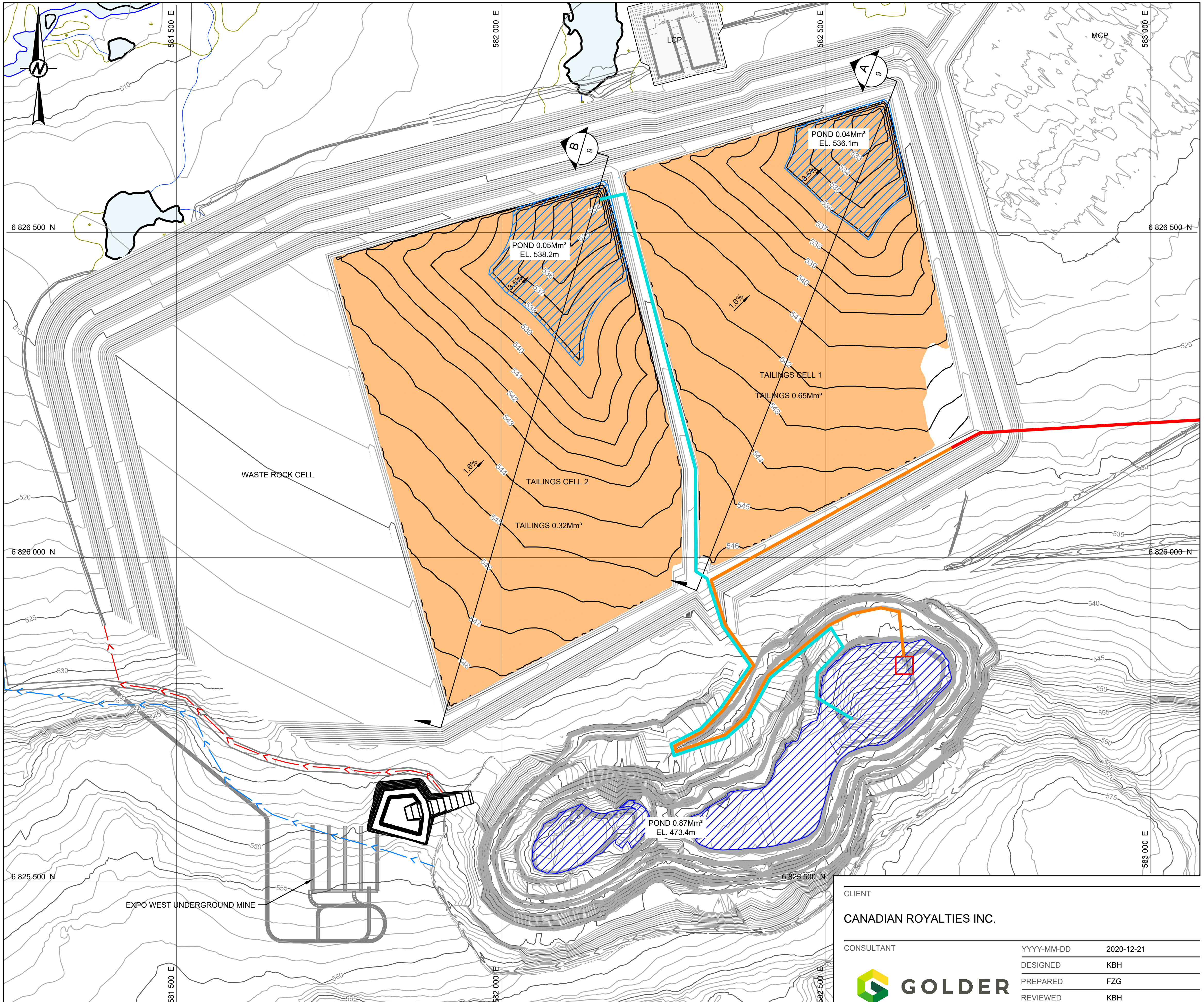
NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**

0 100 200

1:3,000 METRES

| | | | |
|---|---|---|---|
| CLIENT | CANADIAN ROYALTIES INC. | PROJECT | NUNAVIK NICKEL MINE |
| CONSULTANT | GOLDER | TITLE | **EXPO TAILINGS END OF YEAR 2020** |
| YYYY-MM-DD | 2020-12-21 | PROJECT NO. | 19117253 |
| DESIGNED | KBH | PHASE | 3000 |
| PREPARED | FZG | REV. | 2 |
| REVIEWED | KBH | FIGURE | 3 |
| APPROVED | WPM | | |




**LEGEND**

- TAILINGS DEPOSITION
- TAILINGS POND
- 6-INCH SCH.80 CARBON STEEL PIPE
- 8-INCH RD9 4710 HDPE PIPE
- FLOATING PUMP BARGE
- VALVE STATION
- WATER PIPELINE TO PIT

**NOTE(S)**

1. PUMPING OF EXCESS WATER FROM TAILINGS CELL 1 TO TAILINGS CELL 2 AND FROM TAILINGS CELL 2 TO THE PIT BEGINS IN JUNE 2021.
2. AFTER JUNE 2021, PROCESS RECLAIM WATER IS RECYCLED TO THE MILL FROM THE PIT. EXCESS PIT WATER WILL BE STORED IN THE PIT (NOT PUMPED TO THE MCP).

NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**

0 100 200

1:3,000 METRES

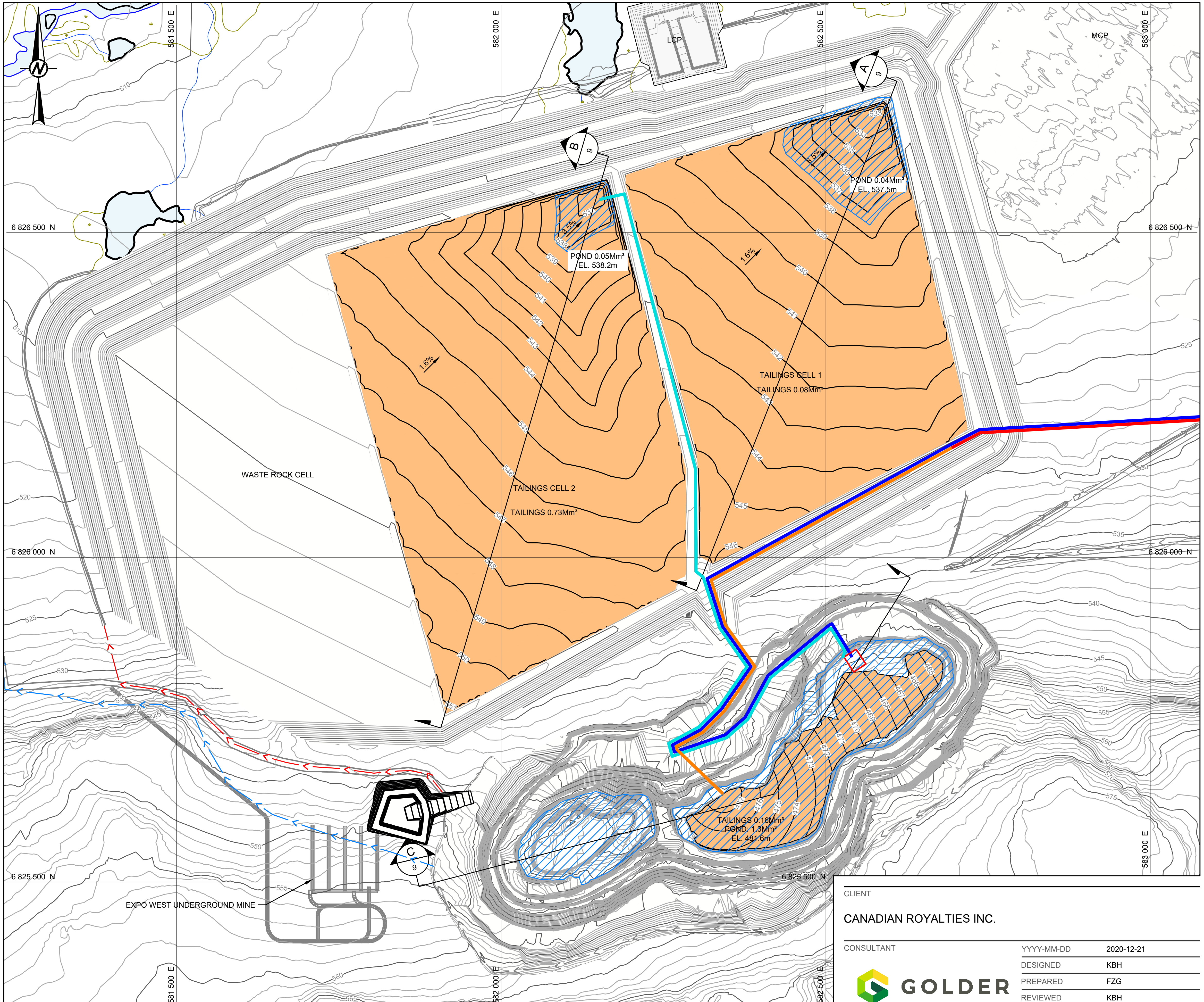
| | | | |
|---|---|---|---|
| CLIENT | CANADIAN ROYALTIES INC. | PROJECT | NUNAVIK NICKEL MINE |
| CONSULTANT | GOLDER | TITLE | **EXPO TAILINGS END OF YEAR 2021** |
| YYYY-MM-DD | 2020-12-21 | | |
| DESIGNED | KBH | | |
| PREPARED | FZG | | |
| REVIEWED | KBH | | |
| APPROVED | WPM | | |

| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 19117253 | 3000 | 2 | 4 |

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

25 mm

Path: \\golder.gds\complex\data\office\mississauga\SIM\Clients\Canadian_Royalties\Nunavik_Mine\99_PROJ\19117253\40_PROD\0010_ExpoTailingsStages\ | File Name: 19117253-0010-CM-0004.dwg | Last Edited By: fgong Date: 2020-12-22 Time:5:45:27 PM | Printed By: FGong Date: 2020-12-22 Time:6:00:11 PM




**LEGEND**

- TAILINGS DEPOSITION
- TAILINGS POND
- 6-INCH SCH.80 CARBON STEEL PIPE
- 8-INCH RD9 4710 HDPE PIPE
- FLOATING PUMP BARGE
- VALVE STATION
- WATER PIPELINE TO PIT
- WATER PIPELINE TO MILL

**NOTE(S)**

1. PUMPING OF EXCESS WATER FROM TAILINGS CELL 1 TO TAILINGS CELL 2 AND FROM TAILINGS CELL 2 TO THE PIT CONTINUES.
2. PROCESS RECLAIM WATER IS RECYCLED TO THE MILL FROM THE PIT. EXCESS PIT WATER WILL BE STORED IN THE PIT (NOT PUMPED TO THE MCP).

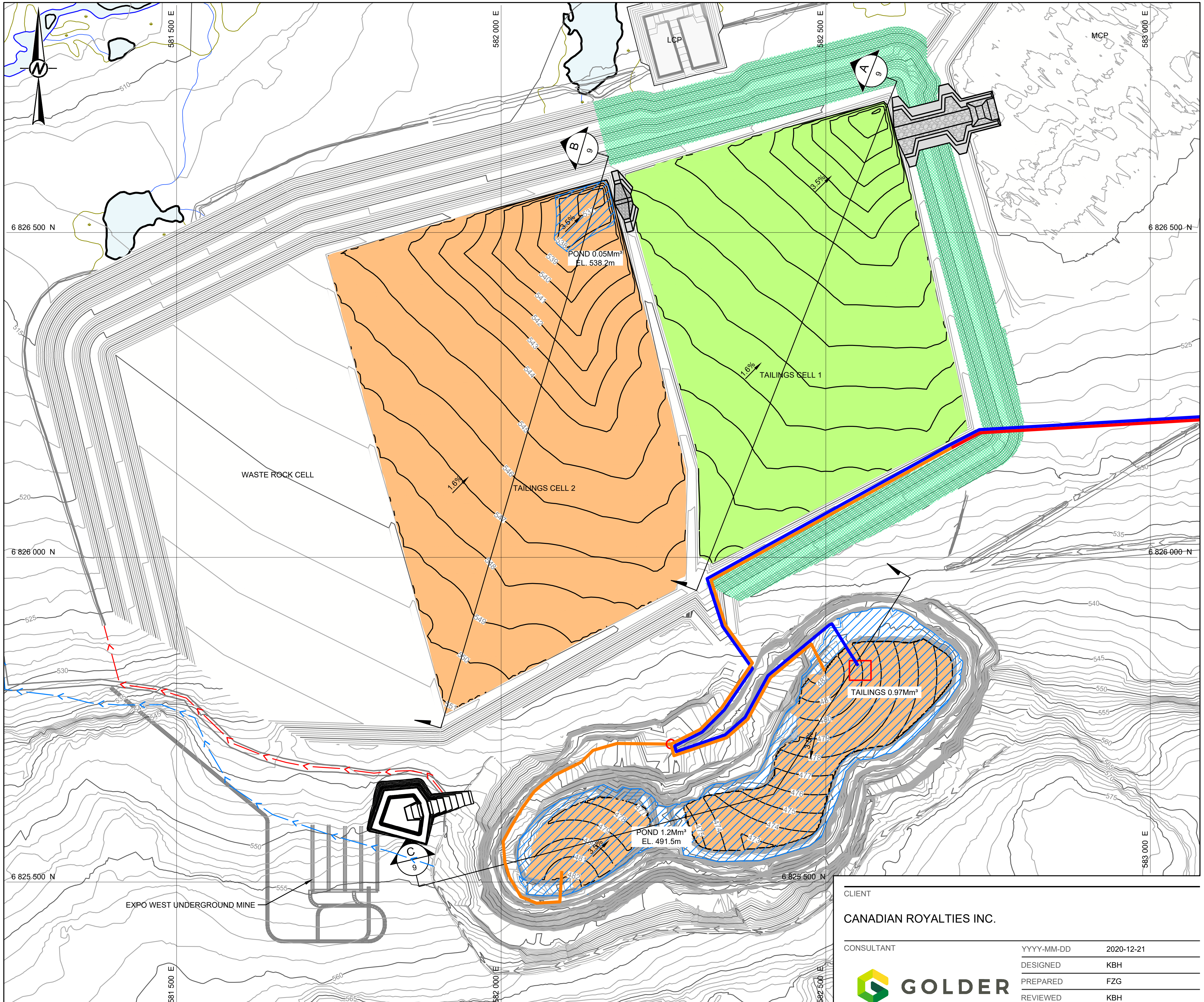
NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**

0 100 200

1:3,000 METRES

| | |
|---|---|
| CLIENT | CANADIAN ROYALTIES INC. |
| CONSULTANT | GOLDER |
| YYYY-MM-DD | 2020-12-21 |
| DESIGNED | KBH |
| PREPARED | FZG |
| REVIEWED | KBH |
| APPROVED | WPM |
| PROJECT | NUNAVIK NICKEL MINE |
| TITLE | **EXPO TAILINGS END OF YEAR 2022** |
| PROJECT NO. | 19117253 |
| PHASE | 3000 |
| REV. | 2 |
| FIGURE | 5 |




**LEGEND**

- TAILINGS DEPOSITION
- TAILINGS POND
- COVER OVER TAILINGS
- COVER OVER DOWNSTREAM SLOPE OF WASTE ROCK
- 6-INCH SCH.80 CARBON STEEL PIPE
- 8-INCH RD9 4710 HDPE PIPE
- FLOATING PUMP BARGE
- VALVE STATION
- WATER PIPELINE TO PIT
- WATER PIPELINE TO MILL

**NOTE(S)**

1. PUMPING OF EXCESS WATER FROM TAILINGS CELL 1 TO TAILINGS CELL 2 CONTINUES UNTIL THE COVER IS COMPLETED. ONCE THE COVER IS COMPLETED, RUNOFF IS DIRECTED TO THE MCP.
2. PUMPING OF EXCESS WATER FROM TAILINGS CELL 2 TO THE PIT CONTINUES.
3. PROCESS RECLAIM WATER IS RECYCLED TO THE MILL FROM THE PIT.
4. TREATMENT AND DISCHARGE OF PIT TAILINGS WATER OCCURS IN SUMMER MONTHS.

NOT FOR CONSTRUCTION

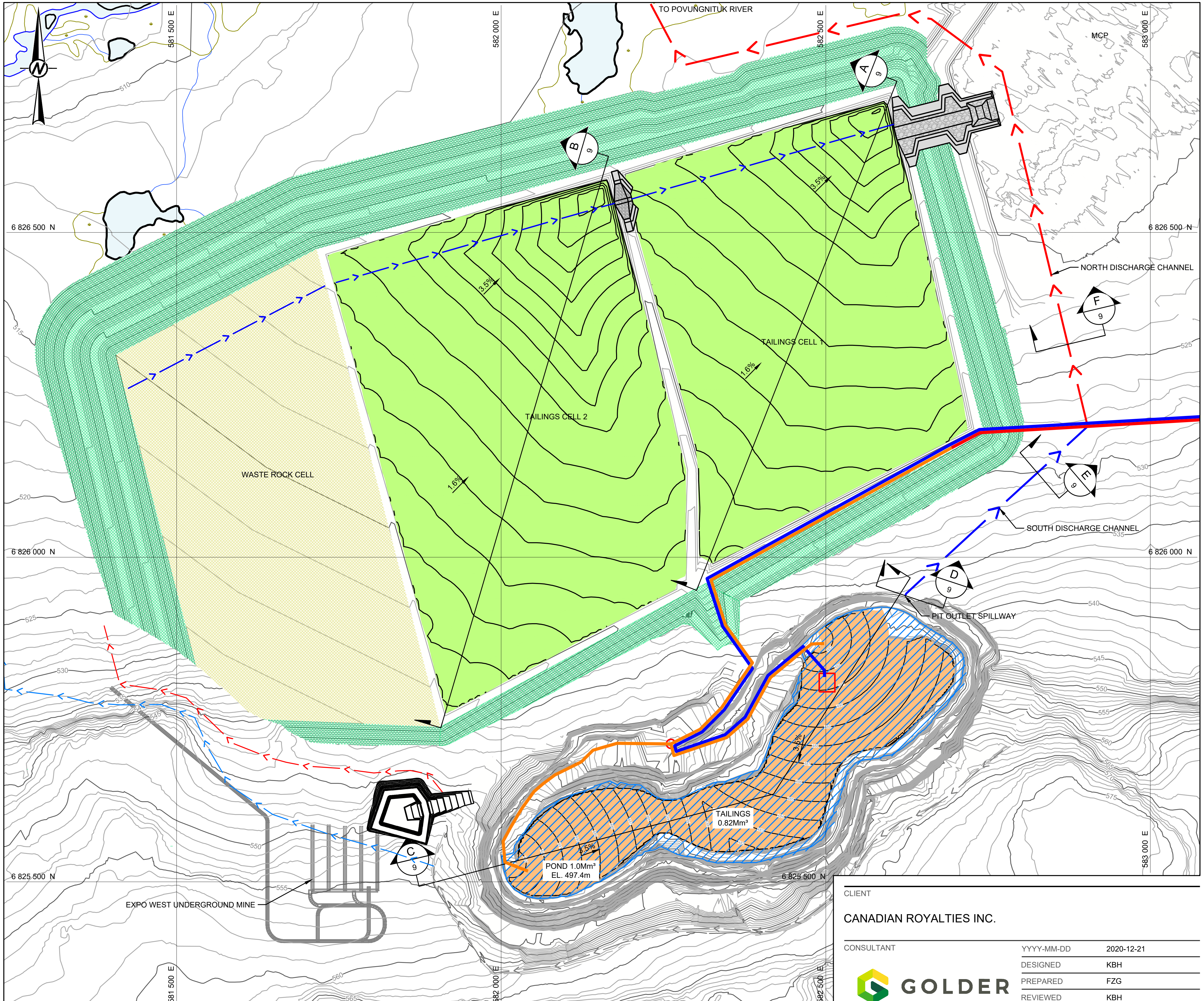
**FOR PERMITTING ONLY**

0 100 200
1:3,000 METRES

| CLIENT | | PROJECT | |
|---|---|---|---|
| CANADIAN ROYALTIES INC. | | NUNAVIK NICKEL MINE | |
| CONSULTANT: GOLDER | YYYY-MM-DD: 2020-12-21 | TITLE | |
| | DESIGNED: KBH | **EXPO TAILINGS END OF YEAR 2023** | |
| | PREPARED: FZG | | |
| | REVIEWED: KBH | | |
| | APPROVED: WPM | PROJECT NO. 19117253 · PHASE 3000 · REV. 2 | FIGURE 6 |

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

25 mm




**LEGEND**

- TAILINGS DEPOSITION
- TAILINGS POND
- COVER OVER TAILINGS
- COVER OVER DOWNSTREAM SLOPE OF WASTE ROCK
- COVER OVER TOP OF WASTE ROCK
- 6-INCH SCH.80 CARBON STEEL PIPE
- 8-INCH RD9 4710 HDPE PIPE
- FLOATING PUMP BARGE
- VALVE STATION
- WATER PIPELINE TO PIT
- WATER PIPELINE TO MILL
- SOUTH DISCHARGE CHANNEL
- NORTH DISCHARGE CHANNEL

**NOTE(S)**

1. RUNOFF FROM TAILINGS CELL 1 IS DIRECTED TO THE MCP.
2. PUMPING OF EXCESS WATER FROM TAILINGS CELL 2 TO THE PIT CONTINUES UNTIL THE COVER IS COMPLETED. ONCE THE COVER IS COMPLETED, RUNOFF IS DIRECTED TO THE MCP.
3. PROCESS RECLAIM WATER IS RECYCLED TO THE MILL FROM THE PIT.
4. TREATMENT AND DISCHARGE OF PIT TAILINGS WATER OCCURS IN SUMMER MONTHS.

NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**

0 100 200
1:3,000 METRES

CLIENT
CANADIAN ROYALTIES INC.

CONSULTANT
GOLDER

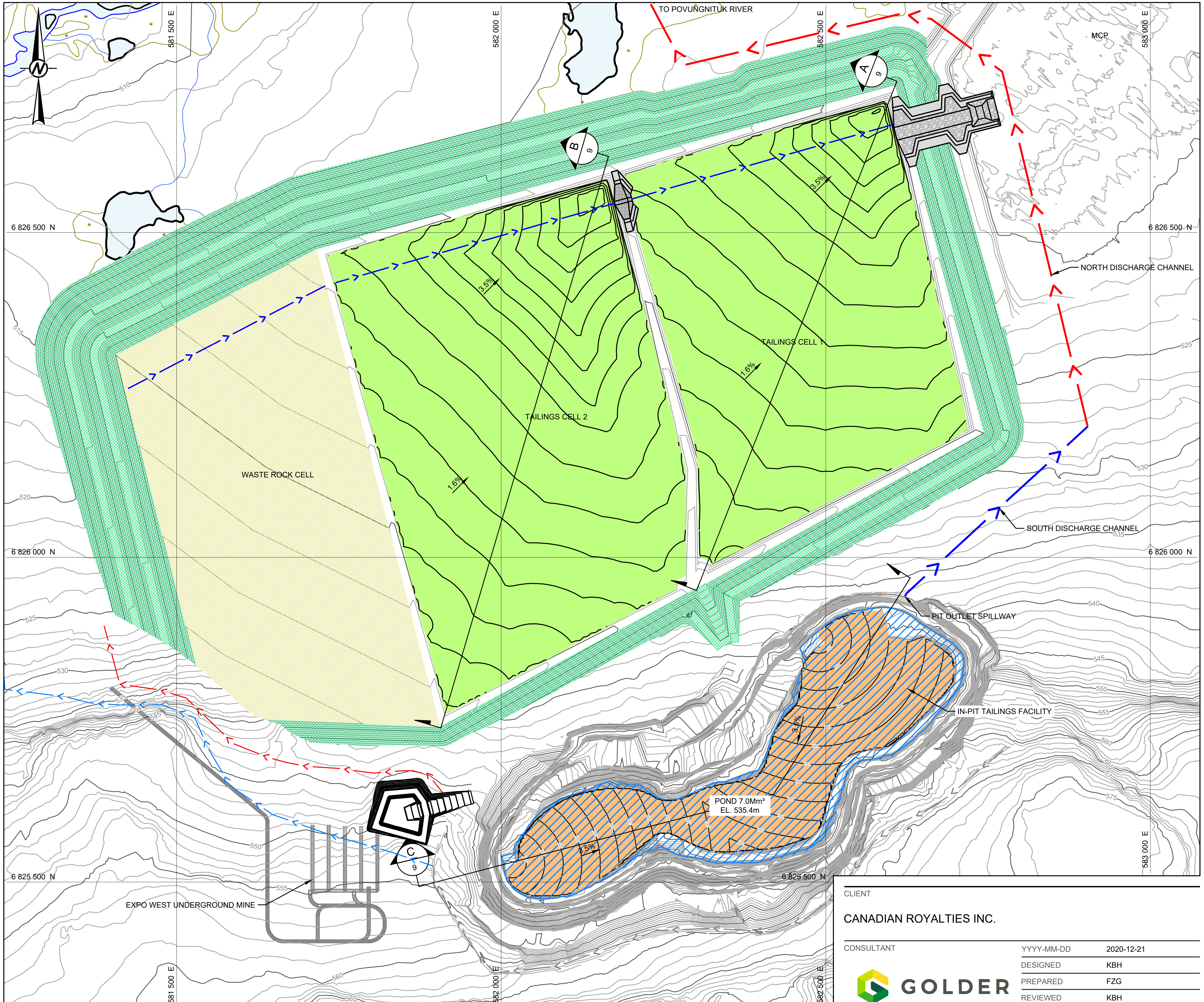
| | |
|---|---|
| YYYY-MM-DD | 2020-12-21 |
| DESIGNED | KBH |
| PREPARED | FZG |
| REVIEWED | KBH |
| APPROVED | WPM |

PROJECT
NUNAVIK NICKEL MINE

TITLE
**EXPO TAILINGS YEAR 2024 (END OF DEPOSITION)**

| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 19117253 | 3000 | 2 | 7 |

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
25 mm




**LEGEND**

- TAILINGS DEPOSITION
- TAILINGS POND
- COVER OVER TAILINGS
- COVER OVER DOWNSTREAM SLOPE OF WASTE ROCK
- COVER OVER TOP OF WASTE ROCK

**NOTE(S)**

1. RUNOFF FROM TAILINGS CELL 1 AND TAILINGS CELL 2 IS DIRECTED TO THE MCP.
2. TREATMENT AND DISCHARGE OF PIT TAILINGS WATER OCCURS IN SUMMER MONTHS UNTIL THE PIT IS EMPTIED IN 2030.
3. ONCE THE PIT IS EMPTIED, ACCELERATED FLOODING WITH WATER FROM LAC BOMBARDIER WILL BEGIN. FLOODING WILL BE COMPLETED IN 2035.
4. AFTER 2035, EXCESS WATER WILL BE ALLOWED TO DISCHARGE TOWARDS THE MCP.
5. PIT WATER HARDNESS WILL BE MAINTAINED AT 400mg/L UNTIL 2056.

NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**

0 100 200
1:3,000 METRES

CLIENT
CANADIAN ROYALTIES INC.

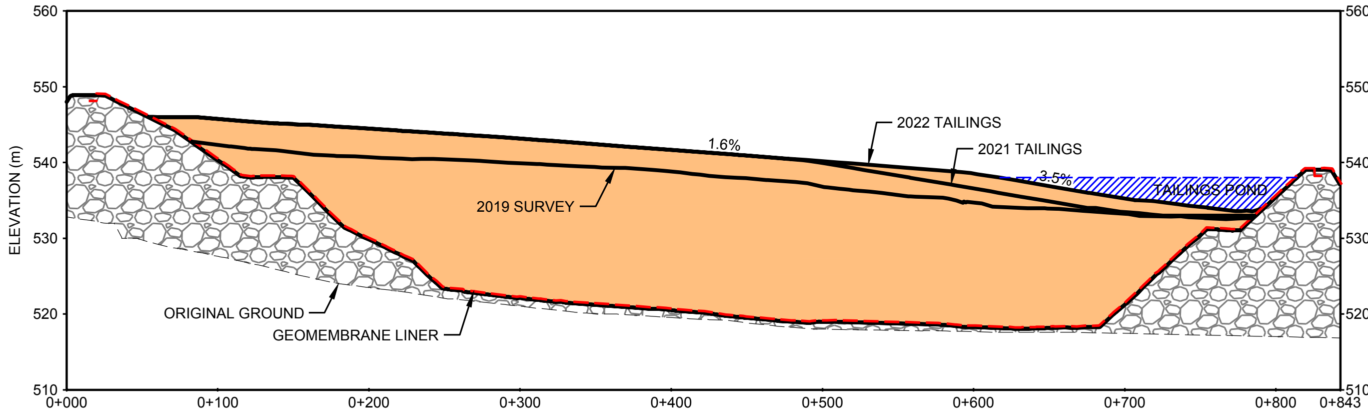
CONSULTANT
GOLDER

| | |
|---|---|
| YYYY-MM-DD | 2020-12-21 |
| DESIGNED | KBH |
| PREPARED | FZG |
| REVIEWED | KBH |
| APPROVED | WPM |

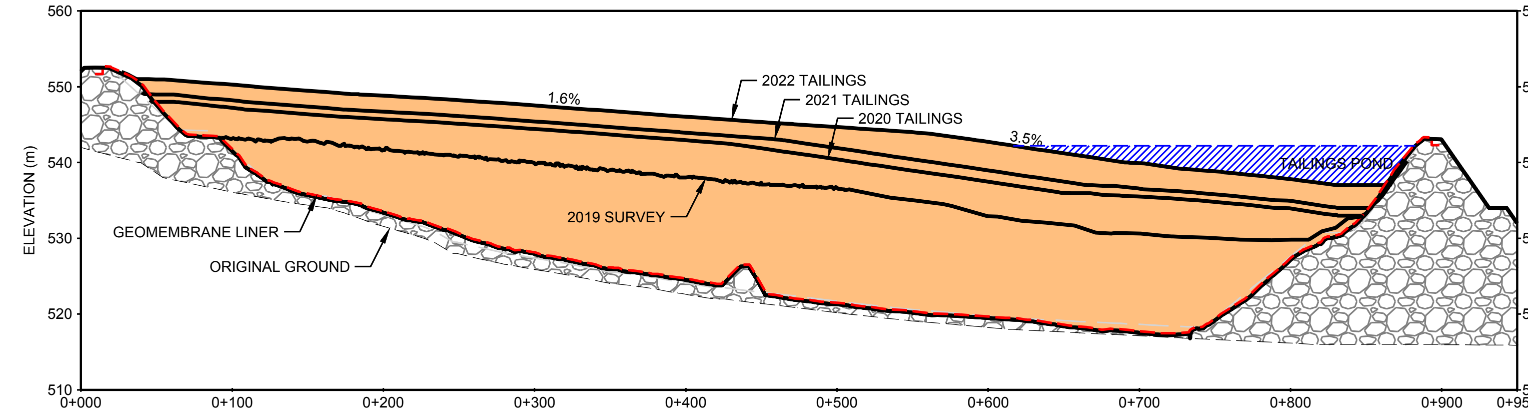
PROJECT
NUNAVIK NICKEL MINE

TITLE
**EXPO TAILINGS YEAR 2035 (END OF ACCELERATED FLOODING)**

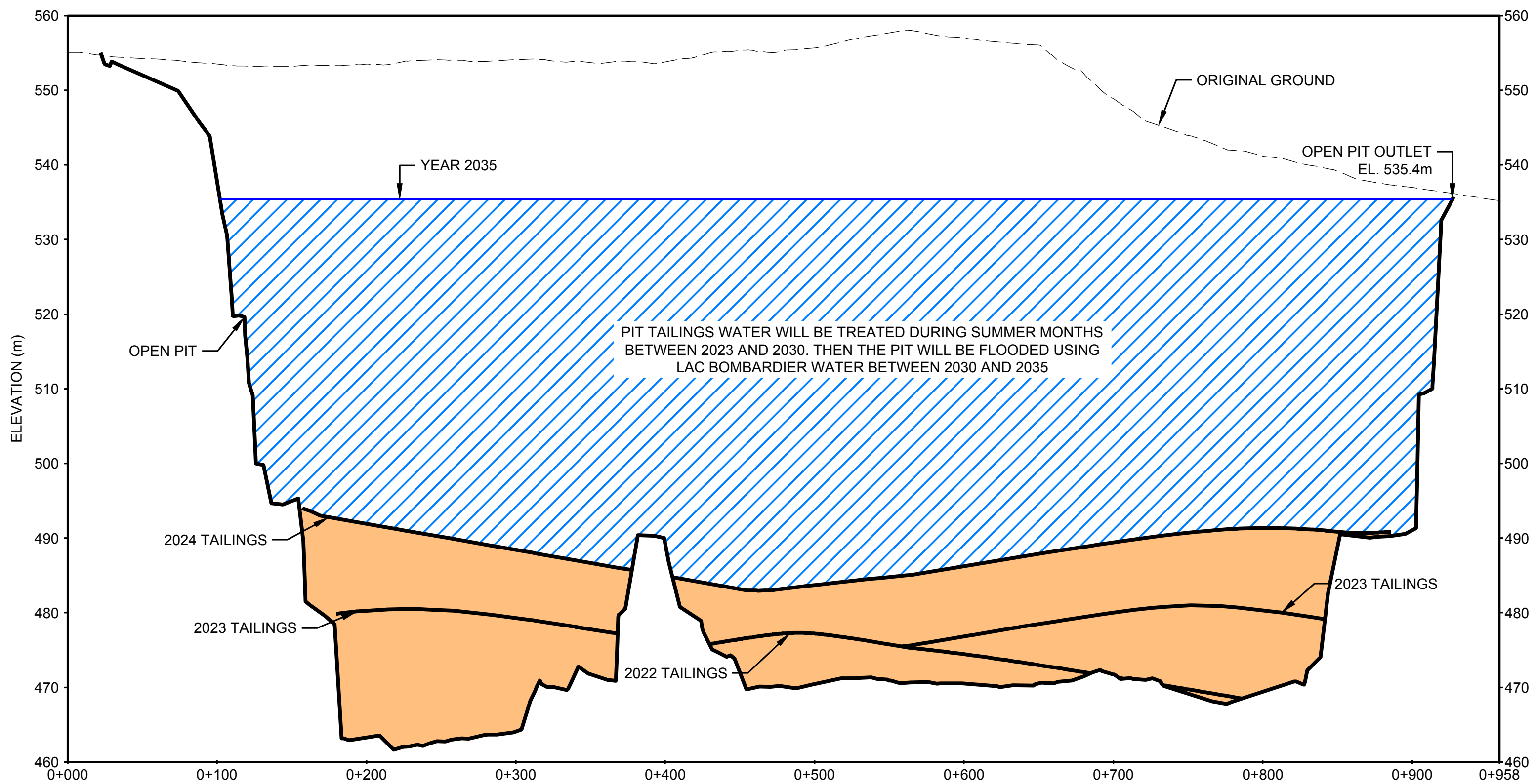
| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 19117253 | 3000 | 2 | 8 |



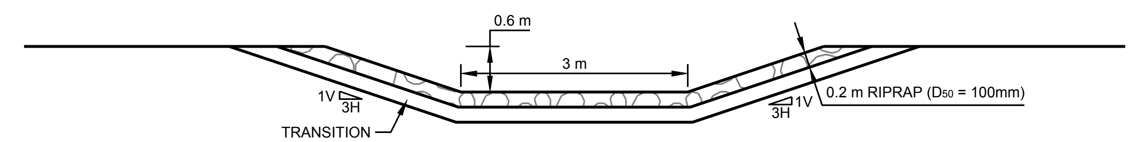

SCALE 1:2,500 m
VERT. SCALE 1:500 m
A - CELL 1 CROSS-SECTION



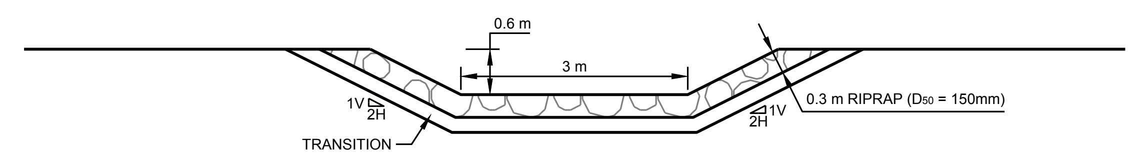

SCALE 1:2,500 m
VERT. SCALE 1:500 m
B - CELL 2 CROSS-SECTION



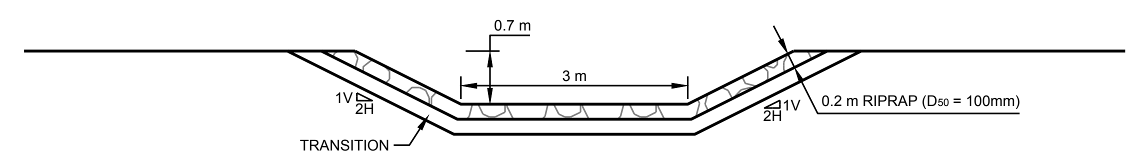

SCALE 1:2,500 m
VERT. SCALE 1:500 m
C - OPEN PIT CROSS-SECTION




SCALE 1:50 m
D / 7 - OUTLET SPILLWAY CROSS-SECTION




SCALE 1:50 m
E / 7 - SOUTH DISCHARGE CHANNEL



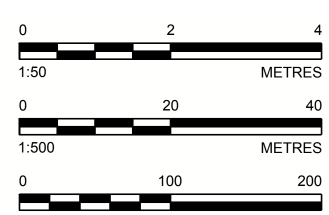

SCALE 1:50 m
F / 7 - NORTH DISCHARGE CHANNEL

**LEGEND**

- TAILINGS DEPOSITION
- TAILINGS POND

NOT FOR CONSTRUCTION

**FOR PERMITTING ONLY**




| | | | |
|---|---|---|---|
| CLIENT | CANADIAN ROYALTIES INC. | PROJECT | NUNAVIK NICKEL MINE |
| CONSULTANT | GOLDER | TITLE | **CROSS-SECTIONS OF CELLS 1 AND 2 AND IN-PIT TAILINGS CELL** |
| YYYY-MM-DD | 2020-12-21 | PROJECT NO. | 19117253 |
| DESIGNED | KBH | PHASE | 3000 |
| PREPARED | FZG | REV. | 2 |
| REVIEWED | KBH | FIGURE | 9 |
| APPROVED | WPM | | |

**APPENDIX A**

# Meteorological Data

## A.1.0 INTRODUCTION

This appendix summarizes local and regional and local meteorological data available for the site. The following are the main sources of the data:

- On-site meteorological data (located at Expo site): 2014 to 2020.
- Iqaluit A (Environment Canada station located 350 km northeast of the site): The Iqaluit A 2402590 station was replaced in February 2014 with the Iqaluit A 2402596 station. The records from both stations were combined to generate a timeseries from 1953 to 2018.
- Kuujjuaq A (Environment Canada station located 480 km east of the site): The Kuujjuaq A 7113534 station was replaced in March 2014 with Kuujjuaq A 7113535 station. The records from both stations were combined to generate a timeseries from 1947 to 2018.
- Katinniq (privately owned and operated station located 60 km north of the site): 2000 to 2005.
- Rainfall Frequency Atlas for Canada, dated 1985.

## A.2.0 AIR TEMPERATURE

A weather station was installed on the Expo Site in the summer of 2014. The mean annual average air temperature of the Expo site based on the data collected between 2014 and 2018 is -10.3°C. Table A-1 summarizes the mean monthly air temperatures for the recording period. Based on the values presented in Table A-1, the temperatures remain below zero from October to May. January and February are the coldest months with monthly mean temperatures of -26.7 and -29.5°C, and July is the warmest month with a monthly mean temperature of 8.1°C. The daily minimum, average, and maximum temperature measured at the on-site station are shown in Annex A-1.

**Table A-1: Average monthly air temperature from the Expo site weather station**

| Month | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|
| January | - | -31.8 | -23.1 | -22.6 | -29.1 | -26.7 |
| February | - | -32.4 | -27.1 | -26.3 | -32.1 | -29.5 |
| March | - | -26.4 | -24.5 | -21.9 | -16.7 | -22.4 |
| April | - | -14.4 | -16.5 | -15.3 | -15.8 | -15.5 |
| May | - | -7.0 | -5.2 | -3.6 | -10.7 | -6.6 |
| June | - | 0.2 | 1.7 | 5.3 | -1.5 | 1.4 |
| July | 7.9 | 8.0 | 9.3 | 7.7 | 7.5 | 8.1 |
| August | 9.3 | 6.4 | 8.8 | 7.2 | 4.6 | 7.3 |
| September | -1.3 | 0.6 | 2.1 | 1.7 | -1.1 | 0.4 |
| October | -4.5 | -7.2 | -7.2[(a)] | -5.1 | -8.5 | -6.5 |
| November | -14.5 | -13.1 | -12.1[(a)] | -12.4 | -12.5 | -12.9 |
| December | -20.2 | -22.0 | -21.6[(a)] | -19.0 | -18.7 | -20.3 |
| ***Average*** | **-** | ***-11.6*** | **-** | ***-8.7*** | ***-11.2*** | ***-10.3*** |

Note:
(a) Data has been infilled with data from the Parc National Des Pingualuit Environment Canada station approximately 30 km south-southwest of the Expo Site weather station.

The mean monthly temperatures measured on-site were compared to that of Iqaluit A station (1953 to 2018) and Katinniq station (2000 to 2005) as shown in Table A-2. Katinniq is a privately owned and operated station, approximately 60 km north of the Expo site with monthly temperature data between 2000 and 2005 (Genivar 2007).

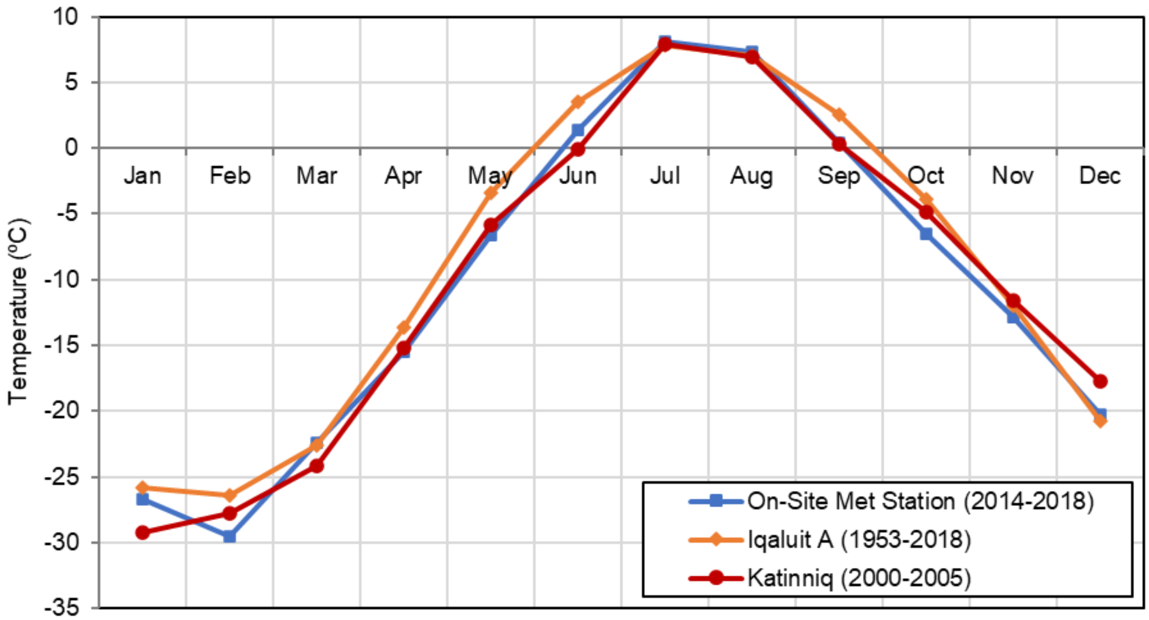



**Figure A-1: Average monthly temperature at Expo Site, Iqaluit A, and Katinniq stations**

**Table A-2: Temperature data comparison**

| Month | On-Site Station | Katinniq Station | Iqaluit A Station |
|---|---|---|---|
| January | -26.7 | -29.2 | -25.8 |
| February | -29.5 | -27.8 | -26.4 |
| March | -22.4 | -24.2 | -22.6 |
| April | -15.5 | -15.2 | -13.6 |
| May | -6.6 | -5.8 | -3.4 |
| June | 1.4 | -0.1 | 3.5 |
| July | 8.1 | 7.9 | 7.8 |
| August | 7.3 | 6.9 | 7.0 |
| September | 0.4 | 0.3 | 2.5 |
| October | -6.5 | -4.9 | -3.9 |
| November | -12.9 | -11.6 | -12.0 |
| December | -20.3 | -17.7 | -20.8 |
| ***Average*** | ***-10.3*** | ***-9.5*** | ***-8.9*** |

Since the on-site data has a similar pattern and values to the data collected from the Iqaluit A and Katinniq stations, the temperature data collected at the Katinniq station was used in the thermal analysis to be consistent with previous designs by Golder on the mine site.

## A.3.0 PRECIPITATION

The daily rainfall measured at the on-site station is shown in Annex A-1. Given the uncertainty surrounding precipitation estimates and based on the limited record available for the on-site station, data from Kuujjuaq A station was used to represent conditions at the mine site, consistent with previous designs by Golder on the Nunavik Nickel Mine. Although not close to the project (480 km distant), Kuujjuaq A receives the highest rainfall of the regional stations. The average annual total precipitation of 600 mm was used for the mine site (Golder 2012). The 1971 to 2000 climate normals for the Iqaluit A station were used in Golder (2012). The 1981 to 2010 climate normals for the Iqaluit A station have been updated to characterize the monthly distribution of annual precipitation (Table A-3). Both distributions are presented in Table A-3.

**Table A-3: Monthly precipitation for the Nunavik Nickel Mine**

| Month | Climate Normal 1971 – 2000 [1] | | Climate Normal 1981 – 2010 [1] | |
|---|---|---|---|---|
| | Precipitation (mm) | % Annual | Precipitation (mm) | % Annual |
| January | 30.7 | 5.1% | 29.3 | 4.9% |
| February | 21.8 | 3.6% | 27.8 | 4.6% |
| March | 31.7 | 5.3% | 27.8 | 4.6% |
| April | 41.1 | 6.8% | 40.9 | 6.8% |
| May | 39.2 | 6.5% | 43.4 | 7.2% |
| June | 51.0 | 8.5% | 49.0 | 8.2% |
| July | 86.5 | 14.4% | 77.1 | 12.9% |
| August | 95.7 | 15.9% | 103.3 | 17.2% |
| September | 80.1 | 13.3% | 82.0 | 13.7% |
| October | 53.4 | 8.9% | 49.5 | 8.2% |
| November | 42.4 | 7.1% | 40.4 | 6.7% |
| December | 26.5 | 4.4% | 29.6 | 4.9% |
| ***Annual*** | ***600*** | ***100%*** | ***600*** | ***100%*** |

Note:

(1) The distributions obtained from the Iqaluit A station climate normals have been used to characterize the monthly distribution of the annual precipitation

Frequency analysis for wet and dry years at the project site has been based on mean annual average total precipitation of 600 mm, and the standard deviation of annual precipitation at the Kuujjuaq A station (Golder 2012). Annual precipitation with return periods from 5 to 1,000 years was estimated using the Log-Normal probability distributions and are shown in Table A-4.

**Table A-4: Annual precipitation for wet and dry years for the Nunavik Nickel Mine**

| Return Period (years) | Annual Precipitation (mm) | |
|---|---|---|
| | Wet Year | Dry Year |
| 5 | 680 | 515 |
| 10 | 732 | 479 |
| 25 | 791 | 443 |
| 50 | 832 | 421 |
| 100 | 870 | 403 |
| 1000 | 987 | 355 |

Average rainfall depths for storms with 24-hour duration and return periods from 2 to 1000 years were estimated for Kuujjuaq station from information in the Rainfall Frequency Atlas, and values are presented in Table A-5. The values in Table A-5 are those presented in Golder (2012).

**Table A-5: Rainfall depth 24-hour duration data for the Nunavik Nickel Mine**

| Return Period (years) | Rainfall Depth (mm) |
|---|---|
| 2 | 25.4 |
| 10 | 40.1 |
| 25 | 47.4 |
| 100 | 58.4 |
| 1000 | 76.4 |
| PMP | 207 |

# A.4.0 EVAPORATION AND SUBLIMATION

Golder (2012) recommended using an annual total potential evapotranspiration of 222.5 mm, with 80% occurring between the months of June and September. Evaporation and sublimation were estimated assuming the potential evapotranspiration between June and September represents lake evaporation and losses during the months of October to May represent potential sublimation from snowfall. Table A-6 shows monthly and annual lake evaporation/sublimation estimated for the mine site.

**Table A-6: Monthly lake evaporation and sublimation at the Nunavik Nickel Mine**

| Month | Lake evaporation (mm) | Sublimation (mm) | Total (mm) |
|---|---|---|---|
| January | - | 1.6 | 1.6 |
| February | - | 2.2 | 2.2 |
| March | - | 4.3 | 4.3 |
| April | - | 9.6 | 9.6 |
| May | - | 20.5 | 20.5 |
| June | 35.1 | - | 31.5 |
| July | 73.8 | - | 73.8 |
| August | 54.9 | - | 54.9 |
| September | 14.4 | - | 14.4 |
| October | - | 4.0 | 4.0 |
| November | - | 2.1 | 2.0 |
| December | - | - | - |
| ***Annual*** | ***178.2*** | ***44.3*** | ***222.5*** |

# A.5.0 WIND SPEED AND DIRECTION

Wind speed and direction measurements collected at the on-site meteorological station between July 2014 and December 2018 were used to generate a timeseries of ten-minute average wind speed values. The daily minimum, average, and maximum wind speed measured at the on-site station is shown in Annex A-1.

Wind data was also obtained from the Iqaluit A station (1953 to 2018). A plot of the monthly average wind speed recorded at the on-site meteorological station and at the Iqaluit A station is presented in Figure A-1.

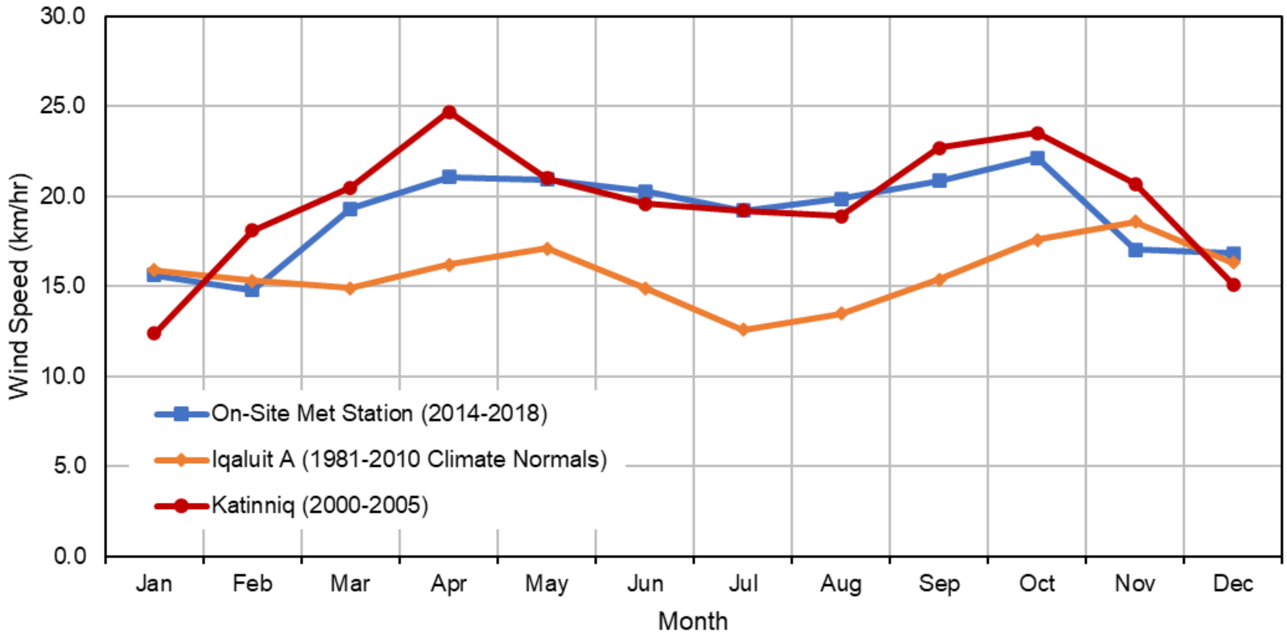



**Figure A-1: Average monthly wind speeds at Expo Site, Iqaluit A, and Katinniq stations**

The average wind speeds for the on-site, Iqaluit A, and Katinniq stations are 19.0 km/hr, 15.7 km/hr, and 20.1 km/hr, respectively.

Due to the limited record available for the on-site and Katinniq stations a frequency analysis of annual maximum hourly wind speeds recorded at Iqaluit A station between 1953 and 2018 was completed to estimate wind speeds for return periods between 2 and 1000 years as shown in Table A-7.

**Table A-7: Extreme hourly wind speeds and associated return period at Iqaluit A station (1953-2018)**

| Return Period (years) | Wind Speed (m/s) |
|---|---|
| 2 | 23.0 |
| 5 | 26.6 |
| 10 | 28.7 |
| 25 | 31.2 |
| 50 | 32.9 |
| 100 | 34.5 |
| 1000 | 39.4 |

Local wind direction can be significantly influenced by topography. A wind rose for the summer (June – September) wind speeds measured at the on-site meteorological station for the recording period is shown in Figure A-2. The wind rose shows that the most frequent winds are from the northwest, southeast, and west-southwest sectors. The most frequent directions at Katinniq were northwest and southwest (Golder 2012).

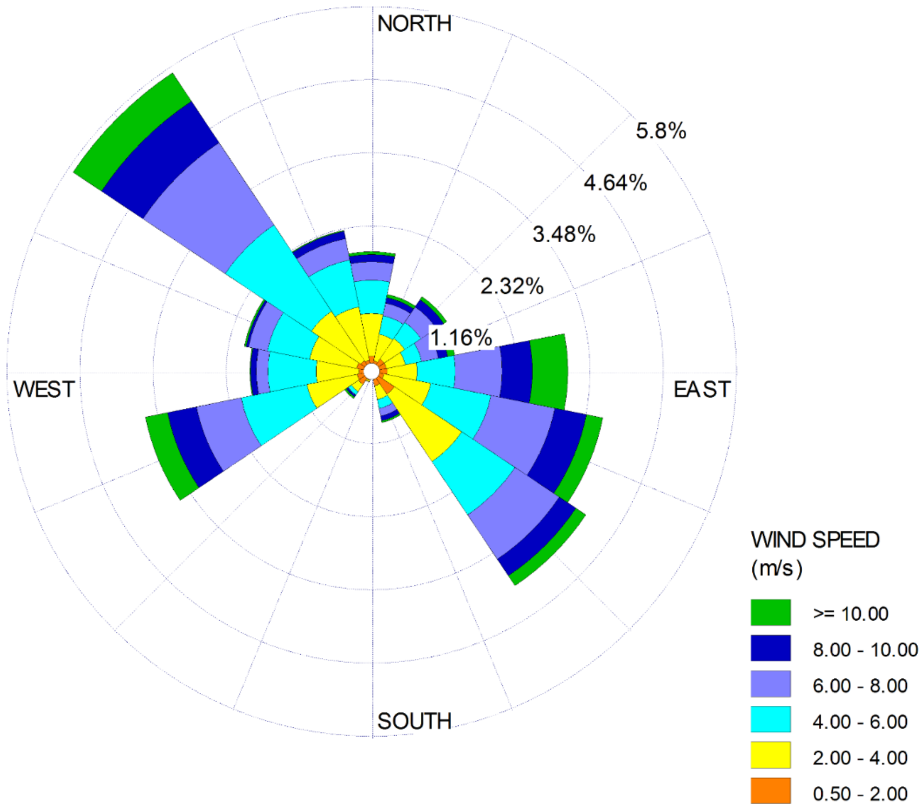



**Figure A-2: Wind rose plot (summer) for Expo site station (2014 - 2018)**

# REFERENCES

Genivar (2007), Raglan South Nickel Project – Environmental and Social Impact Assessment, Final Complementary Study, Climatology and Hydrology.

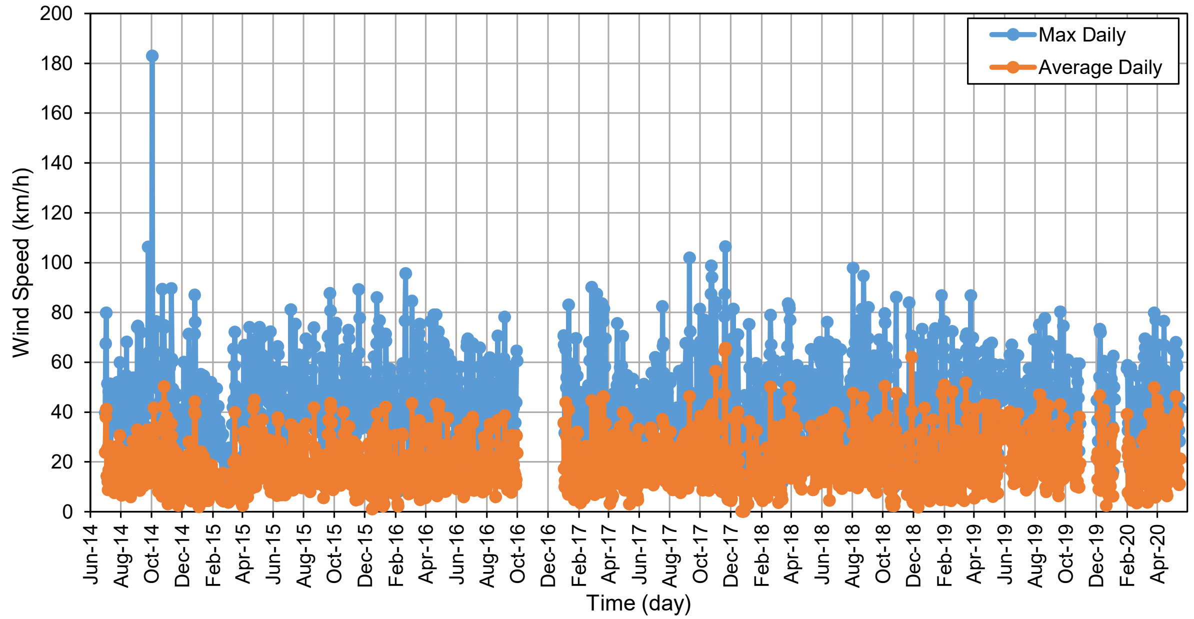
Golder (2012), Detailed Design of Expo Stage 1 Tailings and Waste Rock Disposal Facility and Water Collection Ponds - Nunavik Nickel Project, Quebec. 10-1118-0066 (5501). Submitted to: Canadian Royalties Inc. dated June 2012;

Hogg, WD & Carr, DA (1985). Rainfall Frequency Atlas for Canada, Minister of Supply & Services Canada.

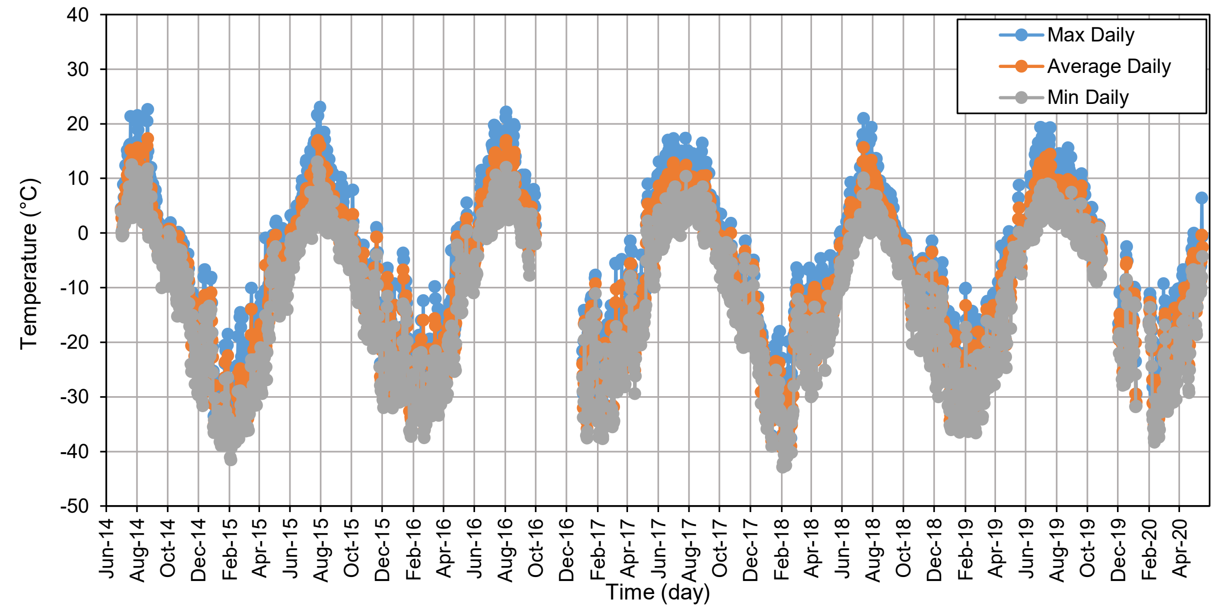
**ANNEX A-1**

# *Expo Site Meteorological Data*

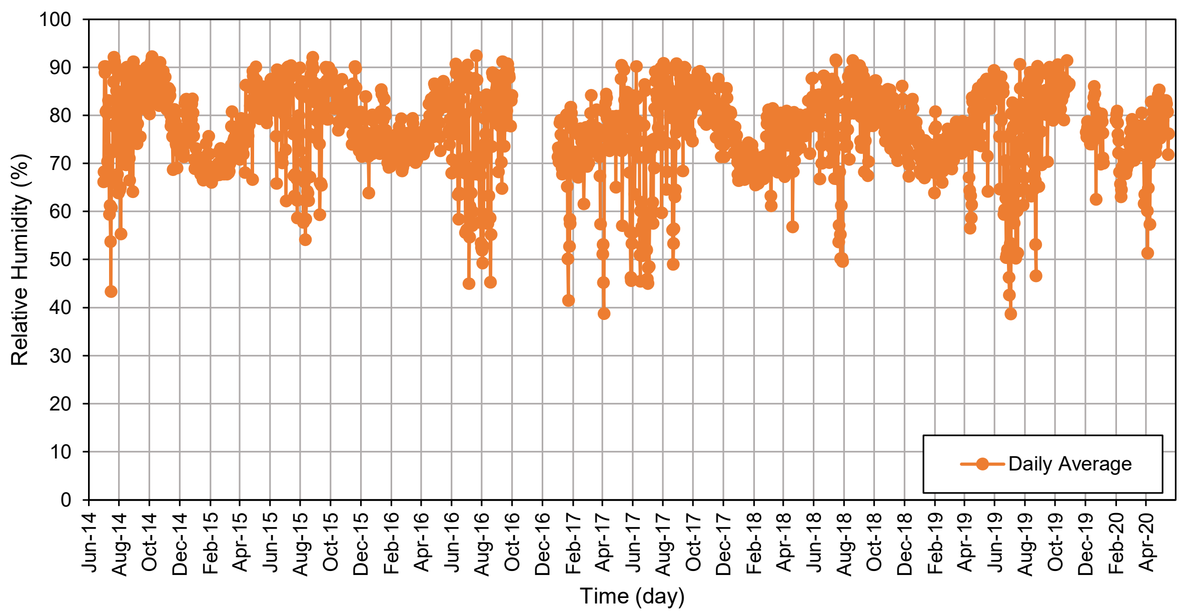
# METEOROLOGICAL DATA SUMMARY FOR ON-SITE STATION



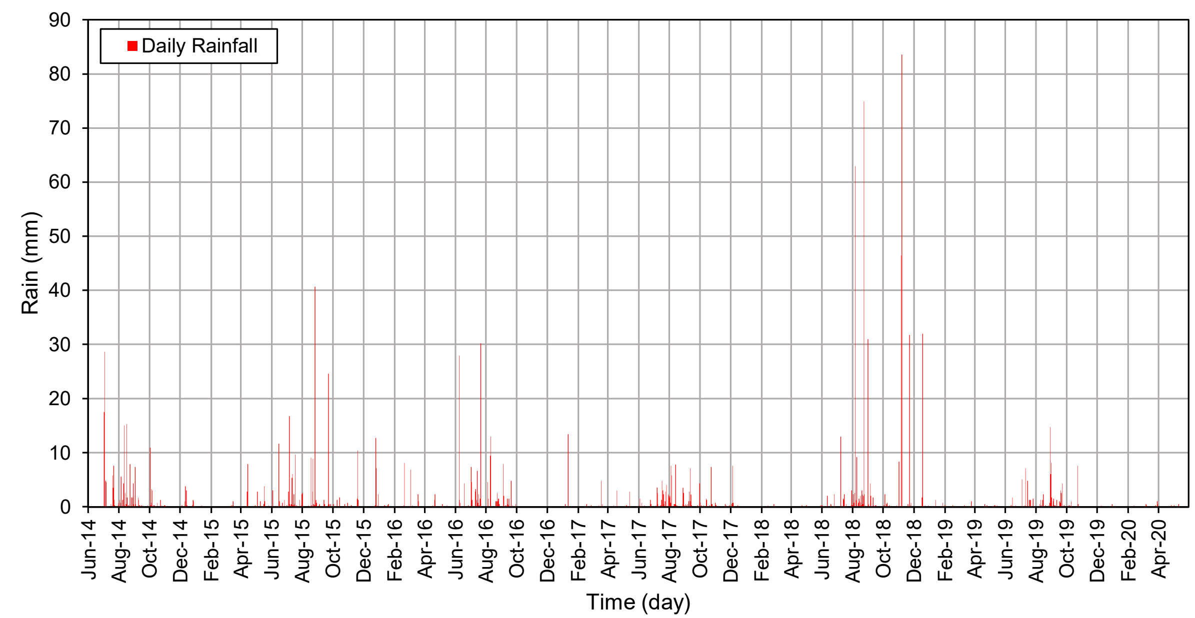

**Daily Wind Speed Data**




**Daily Temperature Data**




**Daily Relative Humidity Data**




**Daily Rainfall Data**

Source: On-Site station data obtained from Canadian Royalties Inc.

**APPENDIX B**

# Tailings Consolidation

# B.1.0 INTRODUCTION

Canadian Royalties Inc (CRI) is currently conducting a study to evaluate the feasibility of depositing tailings inside the Expo Pit at the Nunavik Nickel Mine in northern Quebec. Tailings are planned to be deposited in the lower portion of the Expo pit to an elevation of approximately 484 m. At the end of deposition, supernatant tailings water will be pumped out and the pit will be subsequently flooded with fresh water leading to a formation of a pit lake at elevation of 530.4 m.

This appendix presents the results of a large-strain consolidation modelling prepared to evaluate progressive consolidation of tailings during deposition, the final elevation of consolidated tailings inside the Expo Pit and depth of tailings pond after completion of self-weigh consolidation.

# B.2.0 CONSOLIDATION MODELS

One-dimensional (1D) large-strain consolidation models were prepared using the software CONDES0 (1997) to assess the process of tailings consolidation inside the Expo Pit during operation. The software computes one-dimensional time-dependent distribution of void ratio and layer thickness for progressive tailings deposition.

The constitutive relationships built in the CONDES0 software are:

1) One-dimensional compression void ratio/effective stress relationship:

$$e = A_1 * (\sigma' + Z_1)^{B1} \qquad (1)$$

Where: e is void ratio and σ' is vertical effective stress. $A_1$, $B_1$, and $Z_1$ are fitting parameters that are obtained from the large-strain consolidation curve.

2) Hydraulic conductivity/void ratio relationship in one-dimensional compression:

$$k = C*e^D \qquad (2)$$

Where: k is the hydraulic conductivity, e is void ratio, and C and D are fitting parameters obtained from the permeability curve determined during the large-strain consolidation tests.

## B.2.1 Model Input Parameters

Values for the empirical parameters required in the models were obtained from fitting curves applied to the results of laboratory large-strain consolidation and permeability tests performed on tailings samples as summarized in Table B-1 and shown in Figure B-1.

**Table B-1: Consolidation model input parameters defined from large-strain consolidation tests**

| Material | A1 | B1 | Z1 | C | D |
|---|---|---|---|---|---|
| Tailings | 1.386 | -0.118 | 0.06 | 3.264 | 8.059 |

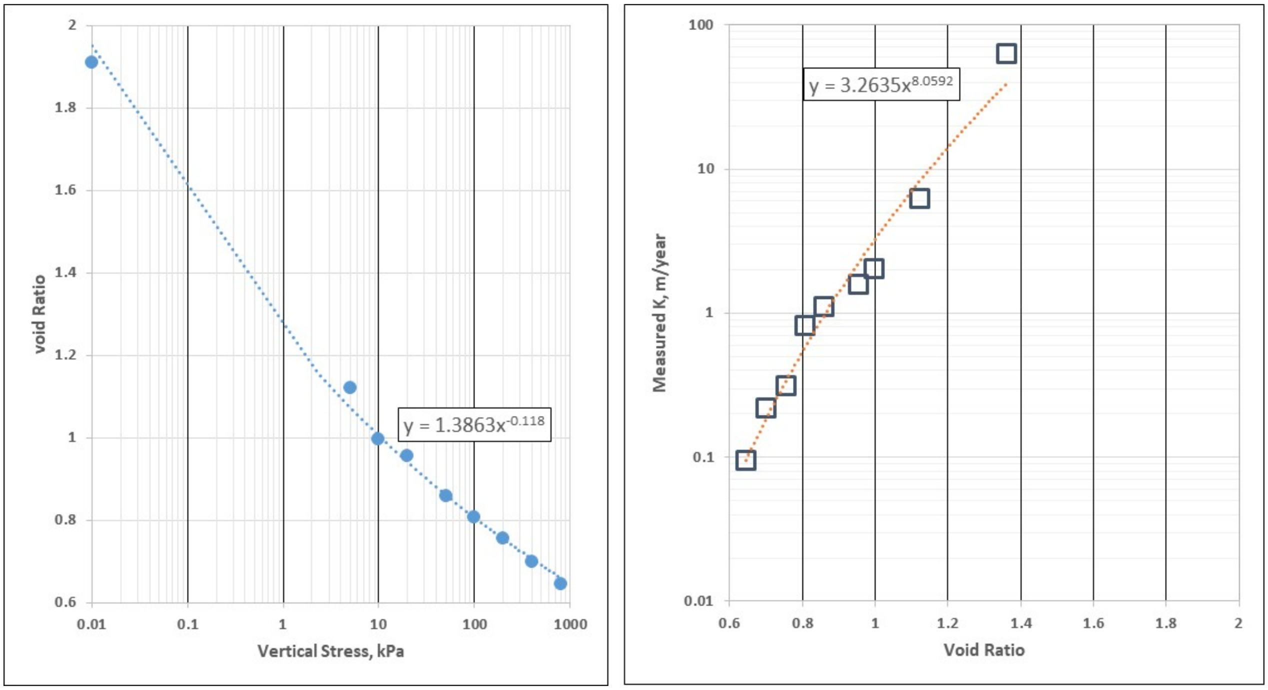



**Figure B-1: Fitting curves applied to large-strain consolidation test results for definition of model input parameters**

The consolidation model also requires the specific gravity (SG) of tailings as input parameter and the value of 3.18 measured in the laboratory was used.

In addition, the model input requires the rate of rise of non-consolidated tailings inside the pit. This was estimated based on the Expo pit storage volume and available data of tailings volume/mass during operation, using a deposition tailings solid contents of 62.3% and initial non-consolidated tailings void ratio of 1.91. Figure B-2 shows the evolution of non-consolidated tailings elevation inside the pit used to define the rate of rise.

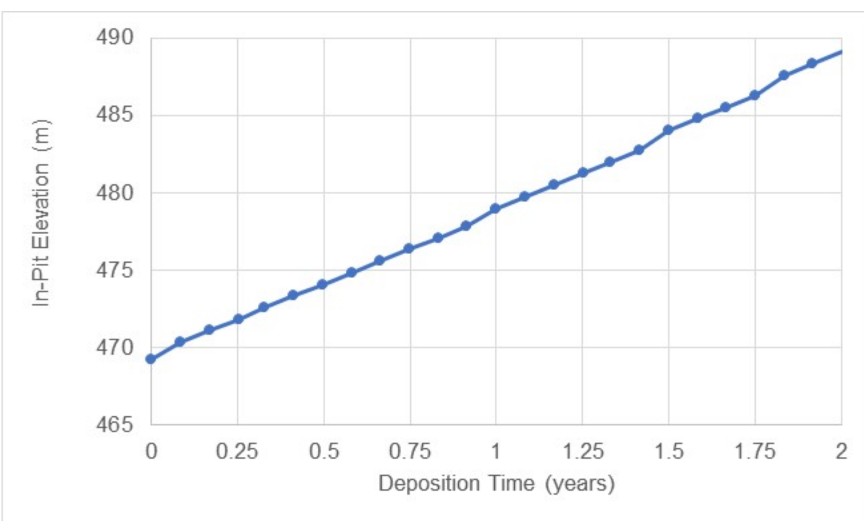



**Figure B-2: Estimated elevation of non-consolidated tailings inside the Expo Pit during operation**

### B.2.2 Model Calibration

The 1D consolidation model carries inherent limitations and does not capture the dynamics of field deposition in general, and the issue of ice-entrapment specifically. The entrapment of ice during deposition will cause tailings to attain lower consolidation rates and lower densities compared.

The consolidation process of tailings deposited in Cells 1 and 2 was modelled and results were compared to field measurements as summarized in Table B-2.

**Table B-2: General characteristics of tailings in Cells 1 and 2**

| Parameter | Cell 1 | Cell 2 |
|---|---|---|
| Maximum Thickness (m) | 17.3 | 9.8 |
| Average In-situ Dry Density (t/m$^3$) | 1.489 | 1.430 |
| Operation Time | 2013-2017 | 2016-2018 |
| Estimated average non-consolidated deposition rate (m/year) | 3.81 | 3.1 |

Tailings in Cells 1 and 2 were modelled using the input parameters presented in Table B-1 and estimated non-consolidated deposition rates as presented in Table B-2. Model results were further compared to field data to obtain correction factors to be applied to results of the in-pit tailings consolidation model as needed.

## B.3.0 MODEL RESULTS

### B.3.1 Tailings at Cells 1 and 2

Table B-3 summarizes the computed thickness and dry density of consolidated tailings in Cells 1 and 2 compared to in-situ tailings characteristics.

**Table B-3: Comparison of modelled and measured tailings characteristics in Cells 1 and 2**

| Parameter | Cell 1 | Cell 2 |
|---|---|---|
| (A) Maximum Thickness (m) | 17.3 | 9.8 |
| (B) Modelled Thickness (m) | 14.9 | 8.3 |
| Tailings Thickness Correction Factor (A/B) | 1.161 | 1.181 |
| (C) Average in-situ dry density (t/m$^3$) | 1.489 | 1.430 |
| (D) Average model consolidated dry density (t/m$^3$) | 1.699 | 1.659 |
| Dry Density correction factor (C/D) | 0.876 | 0.862 |

The model results predicted consolidated tailings thickness lower than measured in Cells 1 and 2, and values of dry density higher than the estimated in-situ tailings density. As mentioned above, this discrepancy is associated with 1D model simplification and the fact that ice entrapment is not incorporated in the models.

The correction factors presented in Table B-3 were applied to the average results of the in-pit tailings consolidation model to establish a range of possible density and settled height values. However, the process of in-pit tailings deposition will result in supernatant tailings water on top of tailings, and this is expected to reduce the chance of ice entrapment during winter deposition.

## B.3.2 In-Pit Tailings Consolidation

The evolution of consolidated tailings elevation inside the Expo Pit with time during operation (up to Year 2) and for post-deposition years is presented in Figure B-4 together with the nominal non-consolidated tailings elevation for reference. Figure B-5 shows the computed in-pit tailings void ratio and dry density at the end of operation (Year 2).

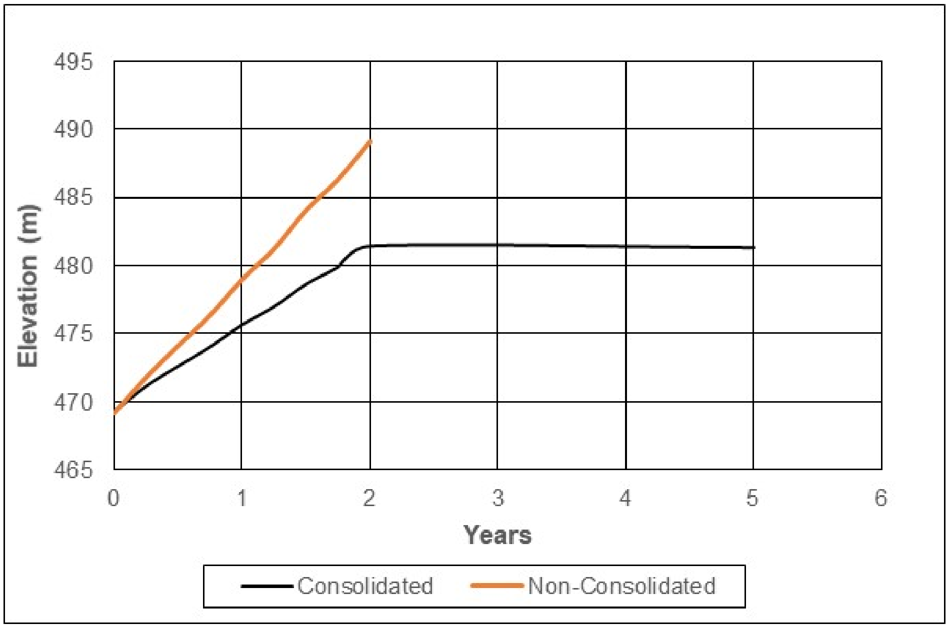



**Figure B-3: Evolution of consolidated in-pit tailings elevation with time compared to nominal non-consolidated tailings elevation (tailings deposition ends at year 2)**

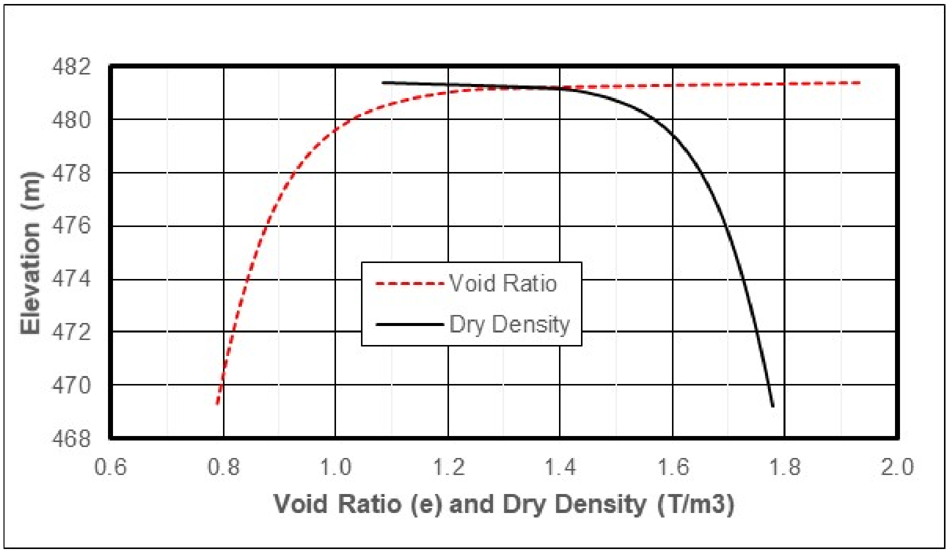



**Figure B-4: Computed in-pit tailings void ratio and dry density profiles at the end of deposition (Year 2)**

The base of the pit at the location of the 1D model column is at elevation of 469.2 m. The model predicted that the tailings body inside the pit would settle about 7.8 m and that the ultimate tailings surface elevation would be approximately 481.4 m. The model results also showed that tailings dry density increased from 1.085 t/m$^3$ at the tailings surface to 1.778 t/m$^3$ at the base of the pit, with an average non-corrected dry density of 1.672 t/m$^3$ at the end of operations.

The process of in-pit tailings deposition is less likely to cause ice entrapment due to the short deposition period (i.e. 2 years), and the presence of supernatant tailings water on top of the tailings during all times. Nevertheless, the correction factors presented in Table B-3 can be applied to estimate the range of values for certain tailings parameters that could develop inside the Expo Pit. Table B-4 summarizes the average characteristics of the tailings inside the Expo Pit after application of the correction factors.

**Table B-4: Corrected In-Pit tailings characteristics**

| Parameter (at End-of-Operation) | Model Result | Corrected Values |
|---|---|---|
| In-pit tailings thickness (m) | 12.1 | 14.2 |
| In-pit tailings surface elevation (m) | 481.4 | 483.5 |
| Average in-pit dry density (t/m$^3$) | 1.672 | 1.455 |
| Average void ratio | 0.9 | 1.19 |

## B.4.0 CONCLUSIONS

Simplified one-dimensional consolidation models were prepared to evaluate the process of tailings consolidation during deposition inside the Expo Pit.

The model results indicate that tailings inside the Expo Pit (at the location where the 1D model column was placed with base of pit at El. 469.2 m) would be about 12.1-m thick and reach a final elevation of 481.4 m, with an average dry density between 1.455 t/m$^3$ and 1.672 t/m$^3$. Ice entrapment, if present, could lead to reduction in dry density and higher tailings surface elevation, but this is less likely to occur due to the short deposition period of two years and the presence of supernatant water on top of the tailings surface during all times.

The 1D model presented in this document does not capture the dynamics of field conditions, where the pit shape, variable pit base elevation and temporal and spatial distribution of tailings deposition will affect the consolidated tailings characteristics. Therefore, the model results are general and should be used bearing these aspects in mind.

# REFERENCE

CONDES0 (1997). Numerical Solution Guide to One-dimensional Large Strain Consolidation and Desiccation by the Finite Difference Implicit Method. User’s Manual. University of Colorado, Boulder, CO 80309.

**APPENDIX C**

# Water Balance

# C.1.0 INTRODUCTION

Canadian Royalties Inc (CRI) owns and operates Nunavik Nickel Mine, which is located in Northern Quebec. The mine has two lined surface tailings disposal cells (Cells 1 and 2) and an open pit at the Expo site. This Appendix presents the results of the water balance analyses completed for the Expo Pit closure at the Nunavik Nickel Mine. The water balance analysis was carried out to determine the volume of water that is available from these facilities for re-use or treatment or discharge to the environment and estimation of flooding time at Expo Pit at closure.

A summary of the closure scenario is as follows:

- Tailings Water Removal: Process water above the tailings will be pumped to treatment at the end of operations until all the water has been removed.
- Accelerated Flooding: In addition to natural inflows, accelerated flooding of the Pit with water pumped from Lac Bombardier will occur during closure following the completion of tailings disposal and removal of process water above the tailings.
- Outlet spillway channel construction: An outlet spillway channel will be constructed on the northeast corner of the pit and east of tailings Cell 1. Once the accelerated flooding is complete, the channel will convey the pit overflow to the Puvirnituq River tributary, which is located north of the tailings cells.

# C.2.0 WATER BALANCE MODEL SET-UP

A deterministic flow model was developed to simulate the water balance of the Cell 1, Cell 2, and Expo Pit over a range of climatic conditions. The flow model was developed on linked Microsoft Excel spreadsheets and simulates flows between the various components of these facilities on a monthly basis over a period starting in August 2019 and was run until the year 2071 during post-closure.

The flow model was set up to calculate inflows to and losses from Cell 1, Cell 2, and the Expo Pit. Sources of water to the model include runoff from precipitation, melt water from snow drift that accumulates in Cells 1 and 2 and Expo Pit, and water in the discharged tailings. The losses considered in the water balance include evaporation and sublimation, water trapped as ice within the tailings, water trapped in the deposited tailings voids and water pumped back for re-use or for treatment and discharge to the environment. A flow schematic is included in Figure C-1.

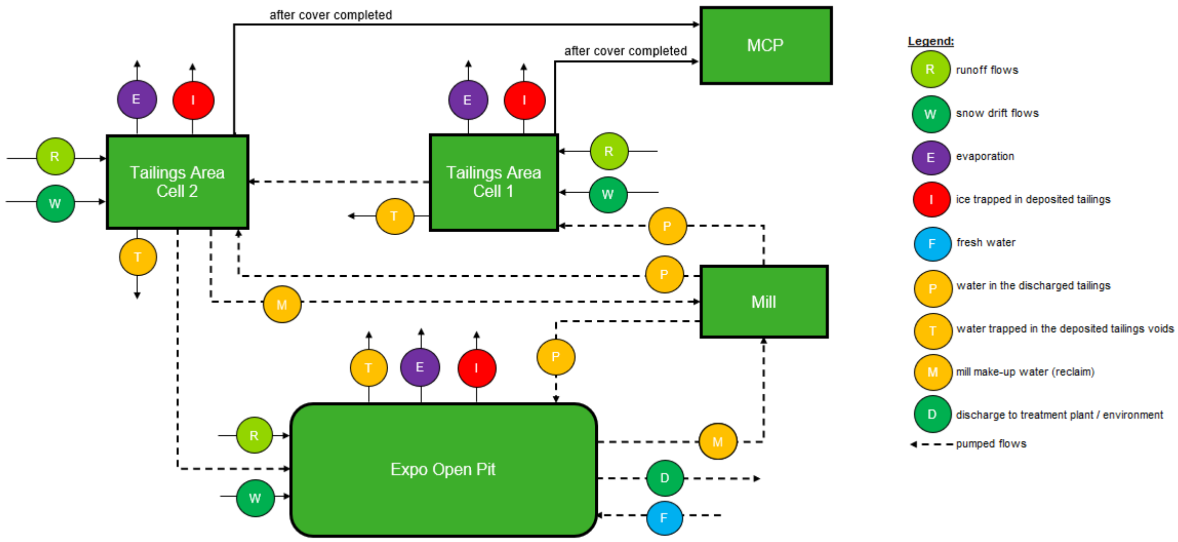



**Figure C-1: Schematic of flows used in the water balance**

The water balance model began in August 2019 to align with the updated bathymetric survey of the Cells 1 and 2 and was run until the year 2071 in post-closure.

# C.3.0 MODEL INPUTS AND ASSUMPTIONS

## C.3.1 Meteorological Data & Runoff Coefficients

### C.3.1.1 Total Precipitation

Golder (2012) carried out a hydrological study to characterize the local climate and hydrological conditions at the Nunavik Nickel Mine. During this study, an average annual total precipitation of 600 mm was proposed for the project site. Records from the on-site rain gauge are available between July 2014 and December 2019. No local snowfall or snowpack information was available from the on-site station and therefore the precipitation analysis was focused on the summer period only.

Given the uncertainty surrounding on-site precipitation estimates and the limited record available for the on-site station (i.e., summer period only), the total precipitation data from Kuujjuaq A station was used to represent conditions at the mine site, consistent with previous designs carried out by Golder at the Nunavik Nickel Mine. The mean annual average total precipitation at the Kuujjuaq A station is 600 mm. The Kuujjuaq A station is approximately 480 km from the project site and receives the highest rainfall of the regional stations. The 1971 to 2000 climate normals for the Iqaluit A station, shown in Table C-1, were previously used to characterize the monthly distribution for the project site (Golder 2012). The monthly distribution was updated in the water balance with the Iqaluit A climate normals for the period 1981 to 2010. The distributions for both periods are presented in Table C-1 for comparison purposes.

**Table C-1: Monthly precipitation for the Nunavik Nickel Mine**

| Month | Climate Normals[1] | | | |
|---|---|---|---|---|
| | 1971 – 2000 | | 1981 – 2010 | |
| | Precipitation (mm) | % Annual | Precipitation (mm) | % Annual |
| January | 30.7 | 5.1% | 29.3 | 4.9% |
| February | 21.8 | 3.6% | 27.8 | 4.6% |
| March | 31.7 | 5.3% | 27.8 | 4.6% |
| April | 41.1 | 6.8% | 40.9 | 6.8% |
| May | 39.2 | 6.5% | 43.4 | 7.2% |
| June | 51.0 | 8.5% | 49.0 | 8.2% |
| July | 86.5 | 14.4% | 77.1 | 12.9% |
| August | 95.7 | 15.9% | 103.3 | 17.2% |
| September | 80.1 | 13.3% | 82.0 | 13.7% |
| October | 53.4 | 8.9% | 49.5 | 8.2% |
| November | 42.4 | 7.1% | 40.4 | 6.7% |
| December | 26.5 | 4.4% | 29.6 | 4.9% |
| ***Annual*** | ***600*** | ***100%*** | ***600*** | ***100%*** |

Note:

(1) The distributions obtained from the Iqaluit A station climate normals have been used to characterize the monthly distribution of the annual precipitation.

A frequency analysis for wet and dry years at the project site was carried out based on mean annual average total precipitation of 600 mm, and the standard deviation of annual precipitation at the Kuujjuaq A station (Golder 2012). Annual precipitation with return periods from 5 to 1,000 years for wet and dry years was estimated using the Log-Normal probability distribution and shown in Table C-2.

**Table C-2: Annual precipitation for wet and dry years for the Nunavik Nickel Mine**

| Return Period (years) | Annual Precipitation (mm) | |
|---|---|---|
| | Wet Year | Dry Year |
| 5 | 680 | 515 |
| 10 | 732 | 479 |
| 25 | 791 | 443 |
| 50 | 832 | 421 |
| 100 | 870 | 403 |
| 1000 | 987 | 355 |

Source: Golder (2012)

### C.3.1.2 Evaporation and Sublimation

Golder (2012) recommended using an annual total potential evapotranspiration of 222.5 mm, with 80% occurring between the months of June and September. Evaporation and sublimation were estimated assuming that the potential evapotranspiration between June and September represents lake evaporation and losses during the months of October to May represent potential sublimation from snowfall. Table C-3 shows monthly and annual lake evaporation and sublimation estimated for the mine site.

**Table C-3: Monthly lake evaporation and sublimation at the Nunavik Nickel Mine**

| Month | Lake Evaporation (mm) | Sublimation (mm) | Total (mm) |
|---|---|---|---|
| January | - | 1.6 | 1.6 |
| February | - | 2.2 | 2.2 |
| March | - | 4.3 | 4.3 |
| April | - | 9.6 | 9.6 |
| May | - | 20.5 | 20.5 |
| June | 35.1 | - | 35.1 |
| July | 73.8 | - | 73.8 |
| August | 54.9 | - | 54.9 |
| September | 14.4 | - | 14.4 |
| October | - | 4.0 | 4.0 |
| November | - | 2.1 | 2.1 |
| December | - | 0 | 0 |
| ***Annual*** | ***178.2*** | ***44.3*** | ***222.5*** |

### C.3.1.3 Runoff Coefficients

Runoff coefficients for the calculation of monthly runoff volumes from the different types of surfaces are shown in Table C-4. These runoff coefficients were obtained from Golder (2012), with the exception of those for dry beach which was estimated for the site based on professional experience. The runoff coefficient is defined as the percentage of the precipitation that runs off and ends up in Cell 1, Cell 2, or Expo Pit ponds.

**Table C-4: Runoff coefficient from various surfaces**

| Month | Runoff Coefficient (%) | | | | |
|---|---|---|---|---|---|
| | Natural Ground | Dry Beach | Open Pit Walls | Ponds & Wet Tailings | Covered Tailings |
| Winter (October to May) | 80% | 60% | 80% | 100% | 90% |
| Summer (June to September) | 70% | 80% | 75% | 100% | 85% |

## C.3.2 Operating Data

The operating data used in the water balance model is summarized in Table C-5. Processing is assumed to occur through October 2024. The tailings deposition plan is discussed in Section 4.0. The water balance model was run from August 2019 until the year 2071 in post-closure.

**Table C-5: Operating data for the Expo in-pit disposal options**

| Parameters | Unit | Value | Source |
|---|---|---|---|
| Total tailings for open pit disposal (Nov 2022 to Oct 2024) | t | 2,906,809 | CRI |
| Tailings to ore ratio | - | 0.8796 | CRI |
| Annual tailings production rate | t | 1,444,708 | CRI |
| Tailings slurry density after thickening | % solids | 62.5 | CRI water balance |
| Tailings solids specific gravity | - | 3.16 | Golder Laboratory Tests |
| Dry density of deposited tailings | $t/m^3$ | 1.483 | Estimated from CRI bathymetric and UAV survey and historical tailings production records |
| Void ratio of deposited tailings | - | 1.13 | Calculated |
| Annual deposited tailings volume | $m^3$ | 974,020 | Calculated |
| Total tailings deposited in Cells 1 and 2 | $m^3$ | 3,169,387 | Calculated |
| Total tailings deposited in Expo Pit | $m^3$ | 1,959,767 | Calculated |
| Deposition years in Cells 1 and 2 | Years | 3.2 | Calculated |
| Deposition years in Expo Pit | Years | 2.0 | Calculated |
| Total tailings tonnage in Cells 1 and 2 | Mt | 4.701 | Calculated |
| Total tailings tonnage in Expo Pit | Mt | 2.907 | Calculated |
| Total ore reserve to produce total tailings in Expo Pit | Mt | 3.305 | Calculated |

## C.3.3 Mine & Tailings Deposition Plan

The ore reserve to be processed in each year was provided by CRI and is included in Table C-6.

**Table C-6: Mine Plan for the Expo Site**

| Year | Ore Reserve (tonnes) | Tailings (tonnes) | Tailings Volume ($m^3$) |
|---|---|---|---|
| 2019 (Aug-Dec) | 686,320 | 603,672 | 406,995 |
| 2020 | 1,647,000 | 1,448,666 | 976,689 |
| 2021 | 1,642,500 | 1,444,708 | 974,020 |
| 2022 | 1,642,500 | 1,444,708 | 974,020 |
| 2023 | 1,642,500 | 1,444,708 | 974,020 |
| 2024 (Jan-Oct) | 1,388,524 | 1,221,316 | 823,410 |
| **Total** | **8,649,344** | **7,607,778** | **5,129,154** |

The operating data included in Table C-6 were used to estimate the volume of tailings to be deposited each year. The deposition plan is summarized in Table C-7 and Figure C-2.

**Table C-7: Tailings Deposition Plan for the Expo Site**

| Deposition Location | Start Month (inclusive) | End Month (inclusive) | Tailings Volume Deposited ($m^3$) | Cumulative Tailings Volume Deposited at Location [1] ($m^3$) |
|---|---|---|---|---|
| Cell 2 | Aug-2019 | Apr-2021 | 1,708,357 | 1,708,357 |
| Cell 2 | Feb-2022 | Oct-2022 | 730,515 | 2,438,872 |
| Cell 1 | May-2021 | Jan-2022 | 730,515 | 730,515 |
| Expo Pit | Nov-2022 | Oct-2024 | 1,959,767 | 1,959,767 |

Note:

(1) The cumulative volume of tailings deposited at the respective location at the end of the time period.

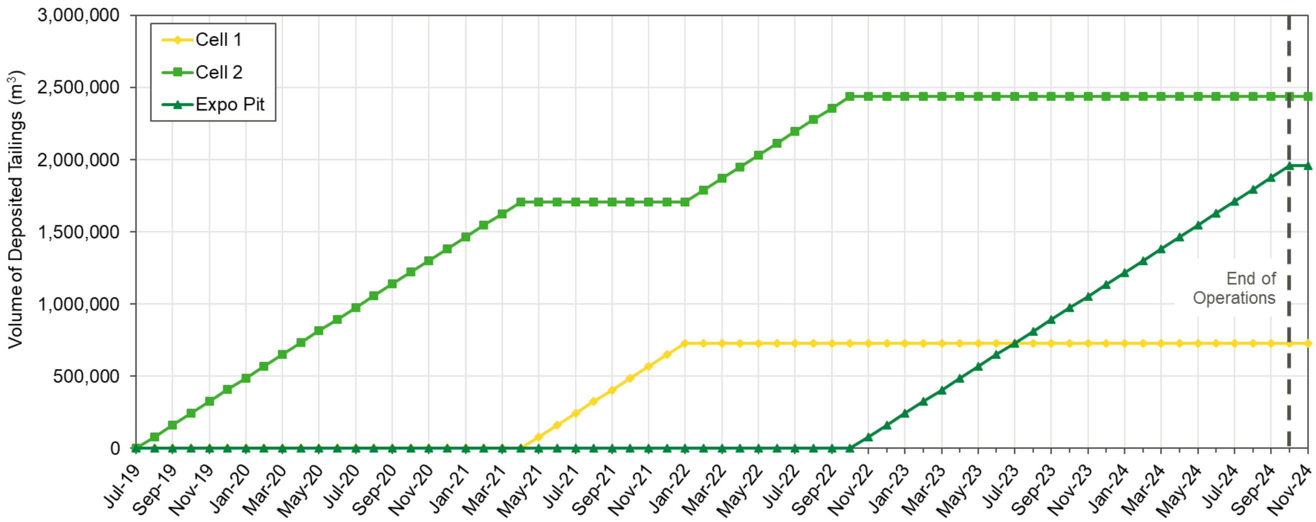



**Figure C-2: Cumulative Volume of Deposited Tailings in Cell 1, Cell 2, and Expo Pit Through Operations**

Cover construction at Cells 1 and 2 was assumed to begin the month of June following the completion of tailings deposition, which corresponds to June 2022 in Cell 1 and June 2023 in Cell 2. Cover construction was assumed to be completed two summers later in Oct 2023 and Oct 2024, respectively.

In the winter months (October to May) during tailings deposition, 30% of the supernatant water entering the tailings facility with the tailings is assumed to be permanently lost as ice – buried within the deposited tailings.

## C.3.4 Pumping Strategy

The assumed pumping between facilities is as follows:

- Process reclaim water is recycled from Cell 2 from August 2019 to June 2021 and from the Expo Pit from July 2021 to October 2024. Assumed rates are provided in Table C-8. The average pumping rate is 55,500 $m^3$/month (21 L/s).
- Pumping of remaining storage from Cell 1 to Cell 2 and from Cell 2 to Expo Pit begins in June 2021. It is assumed that the storage in both Cell 1 and Cell 2 is removed to the minimum pond volume of 37,500 $m^3$ and 50,000 $m^3$, respectively, and any further inflows are also pumped out until the cover is completed (Oct 2023 and Oct 2024, respectively). Once the cover is completed, inflows to the Cells 1 and 2 are assumed to be

conveyed to the Main Collection Pond (MCP). The assumed maximum allowable pumping rates from Cell 1 to Cell 2 and from Cell 2 to Expo Pit were 265,000 $m^3$/month (100 L/s) and 360,000 $m^3$/month (137 L/s), respectively.

- Inflows to the Expo Pit prior to June 2021 (when the transfer of water from Cell 2 begins) are pumped to the MCP.
- Removal of process water above the tailings to the treatment plant begins in July 2023 and continues each summer until the Pit is emptied. Pumping to treatment plant is assumed to begin in July at a rate of 250 $m^3$/hr for 90 days (540,000 $m^3$/year).
- Accelerated flooding of the pit with fresh water from Lac Bombardier commences in October 2030 at a rate of 1,300,000 $m^3$/year (108,330 $m^3$/month). The active flooding of the pit was terminated once the water level reached elevation 535.4 m, which is the lowest elevation along the pit rim.

**Table C-8: Reclaim water sent to the mill from Cell 2 and Expo Pit**

| Month | Required Process Makeup Water ($m^3$/tonnes-ore) | Tailings Water Sent to Nano Filtration ($m^3$/tonnes-ore) | Total Reclaim Water ($m^3$/tonnes-ore) |
|---|---|---|---|
| January | 0.171 | 0.210 | 0.381 |
| February | 0.171 | 0.210 | 0.381 |
| March | 0.171 | 0.210 | 0.381 |
| April | 0.171 | 0.210 | 0.381 |
| May | 0.171 | 0.210 | 0.381 |
| June | 0.171 | 0.273 | 0.444 |
| July | 0 | 0.353 | 0.353 |
| August | 0 | 0.353 | 0.353 |
| September | 0.171 | 0.353 | 0.524 |
| October | 0.171 | 0.305 | 0.476 |
| November | 0.171 | 0.210 | 0.381 |
| December | 0.171 | 0.210 | 0.381 |

## C.3.5 Watershed Areas

The main land use types used in the water balance are natural ground, pit wall, tailings beach (i.e., dry beach), wet tailings beach, and pond surface. These areas vary in size with time as the Cell 1, Cell 2, and Expo Pit are filled with tailings. The total watershed area used for Cell 1 and Cell 2 were 247,645 $m^2$ and 322,216 $m^2$, respectively.

The total watershed area used for the Expo Pit watershed was 489,865 $m^2$. The area of the Expo Pit itself was estimated to be 221,500 $m^2$. The total watershed area includes the area south of the Expo Pit that may be captured by the diversion ditch (196,965 $m^2$). Throughout operations and closure, it is assumed that the diversion ditch is 60% effective; directing 60% of the non-contact water away from the Expo Pit into the environment. As a result, 40% of this natural ground area (78,790 $m^2$) is assumed to enter the pit.

During operations, 10% of the exposed tailings areas were assumed to be dry tailings beach and the remainder were assumed to be wet tailings or pond surface. At closure, once the covers are placed on Cells 1 and 2, the land use type was changed to covered tailings.

### C.3.6 Snow Drift

An additional volume of snow was assumed to enter Cells 1 and 2 as well as the Expo Pit in form of snow drift during the winter. The snow drift was estimated to fill up to 7% and 20% of the storage capacity of the Expo Pit and Cells 1 and 2, respectively, based on engineering judgement and observations on similar sites. A water equivalent ratio of 30% was used. The water balance models have been set to account for winter snow accumulation and snowmelt by entering a runoff distribution as a percentage of the total accumulated to date. It has been assumed that no runoff occurs during the winter (October – May). It is assumed that 50% of the accumulated drifted snow melts in June, and the remainder melts in July, when temperatures are above freezing. The snow drift parameters and volume of drifted snow, in water equivalent, are shown in Table C-9 by facility.

**Table C-9: Estimated volume of water due to snow drift at Cell 1, Cell 2, and Expo Pit**

| Facility | Unit | Open pit | Cell 1 | Cell 2 |
|---|---|---|---|---|
| Total estimated volume ($V_t$) | $m^3$ | 9,956,679 | 978,160 | 2,761,088 |
| Percent filled with snow (*s*) | % | 7% | 20% | 20% |
| Volume filled with snow ($V_F = s*V_t$) | $m^3$ | 696,968 | 195,632 | 552,218 |
| Ratio of melted water to volume of snow (r) | - | 0.3 | 0.3 | 0.3 |
| Volume of water (melted snow) ($r* V_F$) | $m^3$ | 209,090 | 58,690 | 165,665 |

## C.4.0 WATER BALANCE RESULTS

The results of the water balance model for the average precipitation condition (600 mm), are summarized below.

Results for Operations, Closure, and Post Closure are summarized below. Annual results are included in Annex C-1.

### C.4.1 Operations

Tailings deposition in the Pit ends in October 2024. An annual water balance during operations (2019 – 2024) is included in Table C-10. Figure C-3 show the volume of available water in Cell 1, Cell 2, and Expo Pit until the end of operations.

As shown in Figure C-3, storage decreases throughout the winter months as the demand for mill reclaim water is greater than the inflows. Snow melt (including the drifted snow) occurs in June and July, resulting in an increase to the available water volume. The stored volume in the Pit begins to decrease when removal of all water above the deposited tailings to treatment begins in July 2023. The average annual total inflow to and losses from the pit during deposition between 2023 and 2024 were 1.57Mm$^3$ and 0.56 Mm$^3$, respectively. At the end of deposition there is approximately 1.01 Mm$^3$ of water stored in the Expo Pit.

**Table C-10: Annual water balance at Expo Pit during operations**

| Parameters | | Volume ($m^3$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year | | | | | |
| | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
| Inflows | Water in Discharged Tailings | 0 | 0 | 0 | 144,470 | 866,825 | 732,790 |
| | Total Runoff & Snow Drift | 50,260 | 366,200 | 367,210 | 373,535 | 379,175 | 380,310 |
| | Pumped from Cell 2 | 0 | 0 | 839,505 | 675,635 | 465,955 | 317,480 |
| | Pumped from Lac Bombardier | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Inflow** | | **50,260** | **366,200** | **1,206,715** | **1,193,640** | **1,711,955** | **1,430,580** |
| Losses | Retained in Tailings Voids | 0 | 0 | 0 | 86,140 | 516,835 | 436,915 |
| | Evaporation | 0 | 0 | 1,940 | 12,110 | 19,500 | 19,895 |
| | Lost to Ice | 0 | 0 | 0 | 17,500 | 70,000 | 53,255 |
| Total Losses | | 0 | 0 | 1,940 | 115,750 | 606,335 | 510,065 |
| **Net Inflow** | | **50,260** | **366,200** | **1,204,775** | **1,077,890** | **1,105,620** | **920,515** |
| Pumped Flows | To Mill Reclaim Water | 0 | 0 | 337,670 | 658,885 | 658,885 | 562,705 |
| | To MCP | 50,260 | 366,200 | 0 | 0 | 0 | 0 |
| | To Treatment Plant | 0 | 0 | 0 | 0 | 540,000 | 540,000 |
| Discharge to Environment (No Treatment) | | 0 | 0 | 0 | 0 | 0 | 0 |
| Storage at End of Year | | 0 | 0 | 867,105 | 1,286,110 | 1,192,845 | 1,010,655 |

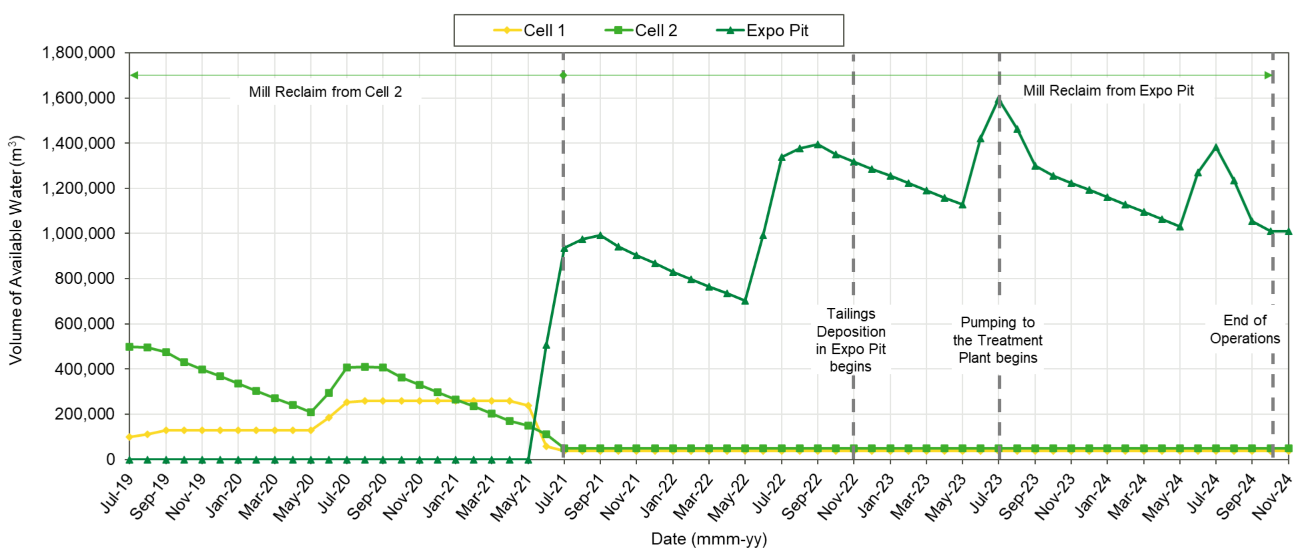



**Figure C-3: Volume of available water during operations**

## C.4.2 Closure

Once tailings deposition in the Pit is complete, the remaining process water stored above the deposited tailings will be removed, prior to accelerated flooding with natural inflows and water pumped from Lac Bombardier.

An annual water balance for the Pit during closure (2025 – 2035) is included in Table C-11. Figure C-4 show the volume of available water in the Pit until the end of closure.

**Table C-11: Annual water balance at Expo Pit during closure**

| Parameters | | Volume (m³) Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
| Inflows | Water in Discharged Tailings | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total Runoff & Snow Drift | 380,065 | 379,515 | 378,965 | 378,415 | 377,850 | 377,100 | 379,300 | 383,670 | 387,865 | 390,155 | 391,525 |
| | Pumped from Cell 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pumped from Lac Bombardier | 0 | 0 | 0 | 0 | 0 | 325,000 | 1,300,000 | 1,300,000 | 1,300,000 | 1,300,000 | 77,130 |
| Total Inflow | | 380,065 | 379,515 | 378,965 | 378,415 | 377,850 | 702,100 | 1,679,300 | 1,683,670 | 1,687,865 | 1,690,155 | 468,655 |
| Losses | Retained in Tailings Voids | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Evaporation | 19,365 | 18,595 | 17,830 | 17,060 | 16,265 | 15,405 | 19,780 | 25,840 | 31,200 | 34,200 | 35,640 |
| | Lost to Ice | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Losses | | 19,365 | 18,595 | 17,830 | 17,060 | 16,265 | 15,405 | 19,780 | 25,840 | 31,200 | 34,200 | 35,640 |
| Net Inflow | | 360,700 | 360,920 | 361,135 | 361,355 | 361,585 | 686,695 | 1,659,520 | 1,657,830 | 1,656,665 | 1,655,955 | 433,015 |
| Pumped Flows | To Mill Reclaim Water | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | To MCP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | To Treatment Plant | 540,000 | 540,000 | 540,000 | 540,000 | 540,000 | 478,040 | 0 | 0 | 0 | 0 | 0 |
| Discharge to Environment (No Treatment) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 355,885 |
| Storage at End of Year | | 831,355 | 652,275 | 473,410 | 294,765 | 116,350 | 325,005 | 1,984,525 | 3,642,355 | 5,299,020 | 6,954,975 | 7,032,105 |

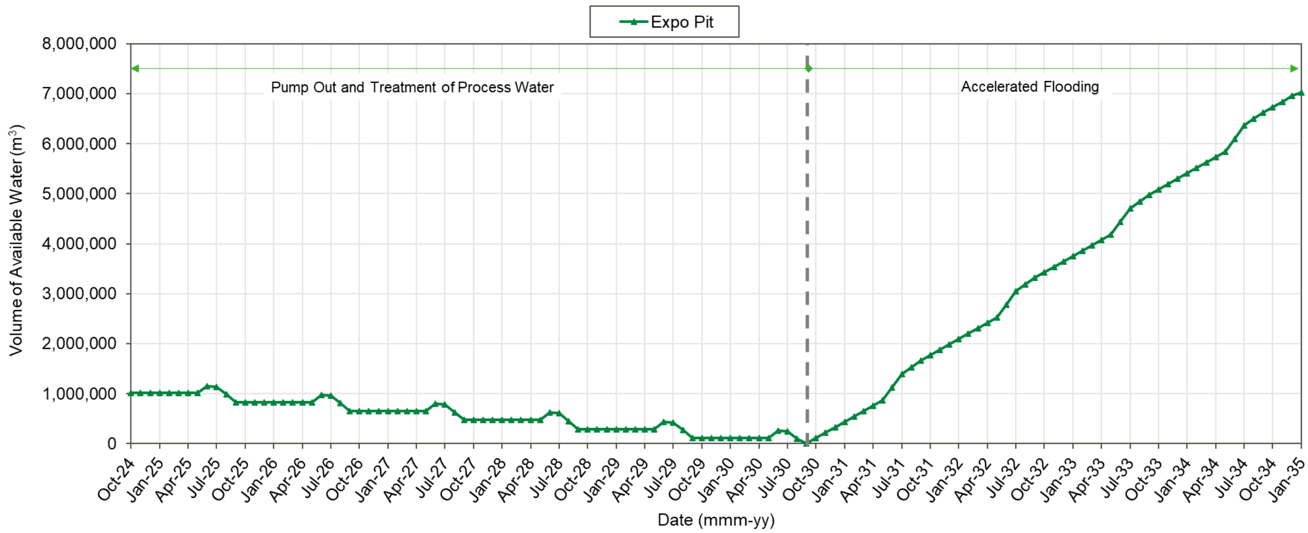



**Figure C-4: Volume of available water during closure**

As shown in Figure C-4, removal of process water to treatment water occurs in July to September, resulting in a general decreasing trend until the Pit is empty in September 2030. Storage remains constant throughout the winter months as any precipitation is accumulated as snow and mill reclaim water is no longer required. Snow melt (including the drifted snow) occurs in June and July, resulting in an increase to the available water volume.

Accelerated flooding of the Pit begins in October 2030. Flooding of the Pit is completed in January 2035. At the end of closure there will be approximately 7.03 $Mm^3$ of water stored in the Expo Pit.

## C.4.3 Post Closure

Once accelerated flooding is complete (Pit is filled), water will be allowed to discharge to the environment through a spillway on the northeast side of the Pit.

Average annual total inflow to and losses from the Pit are 0.39 $Mm^3$ and 0.03 $Mm^3$, respectively. Therefore, the outflow to the environment in an average year is 0.36 $Mm^3$.

# REFERENCE

Golder (Golder Associates Ltd.). 2012. Detailed Design of Expo Stage 1 Tailings and Waste Rock Disposal Facility and Water Collection Ponds. Report 10-1118-0066 (5501). Doc 085 Prepared for Canadian Royalties Inc. June 2012.

**ANNEX C-1**

# *Annual Water Balance Results*

## WATER BALANCE - Cell 1 (Annual Summary)

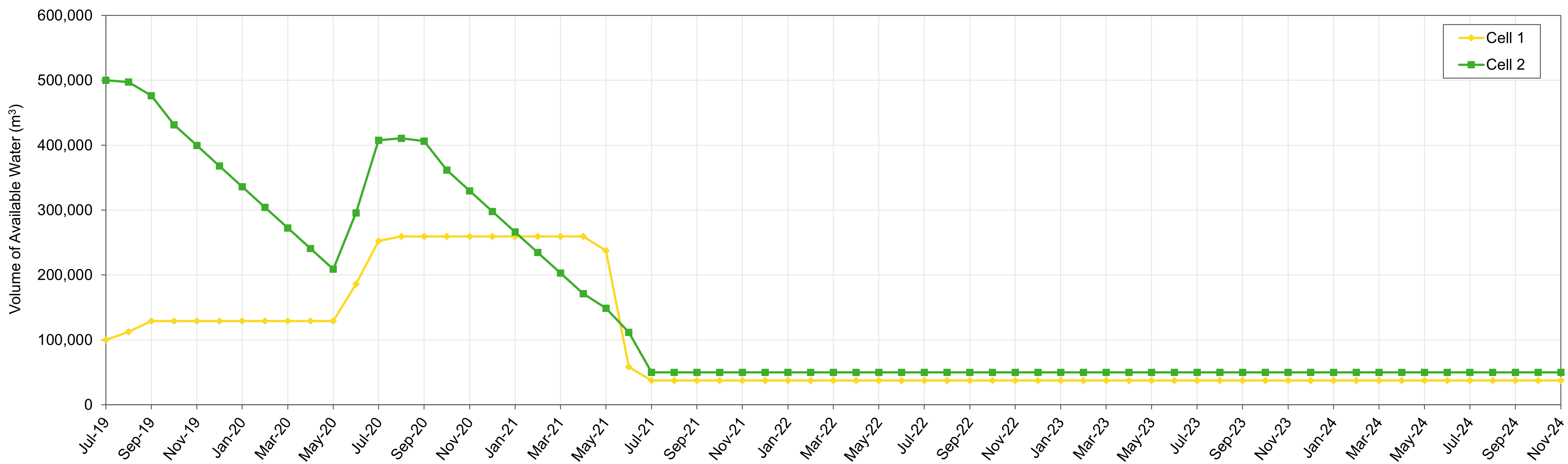
| | |
|---|---|
| Initial Volume in pond ($m^3$) | 100,000 |

| Year | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Water in Discharged Tailings | 0 | 0 | 577,883 | 72,235 | 0 | 0 |
| Total Runoff & Snow Drift | 45,301 | 193,298 | 192,544 | 191,276 | 182,157 | 178,688 |
| ***Total Inflow*** | 45,301 | 193,298 | 770,427 | 263,511 | 182,157 | 178,688 |
| Water Retained in Tailings Void | 0 | 0 | -344,556 | -43,070 | 0 | 0 |
| Evaporation | 16,074 | 40,512 | 39,717 | 36,565 | 6,797 | 0 |
| Volume Lost to Ice | 0 | 0 | 34,999 | 8,750 | 0 | 0 |
| ***Total Losses*** | 16,074 | 40,512 | -269,840 | 2,245 | 6,797 | 0 |
| ***Net Inflow*** | 29,227 | 152,786 | 351,154 | 175,127 | 175,359 | 178,688 |
| **Pumped to Cell 2** | 0 | 22,553 | 573,192 | 175,127 | 175,359 | 0 |
| **Pumping / Runoff to MCP (Cell 1 Covered)** | 0 | 0 | 0 | 0 | 0 | 178,688 |
| **Storage in Cell 1** | 129,227 | 259,460 | 37,423 | 37,423 | 37,423 | 37,423 |

## WATER BALANCE - Cell 2 (Annual Summary)

| | |
|---|---|
| Initial Volume in pond ($m^3$) | 500,000 |

| Year | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Water in Discharged Tailings | 362,203 | 869,200 | 288,942 | 650,119 | 0 | 0 | 0 |
| Total Runoff & Snow Drift | 58,854 | 341,770 | 340,653 | 339,566 | 338,179 | 326,308 | 321,798 |
| Pumped from Cell 1 | 0 | 22,553 | 573,192 | 175,127 | 175,359 | 0 | 0 |
| ***Total Inflow*** | 421,057 | 1,233,523 | 1,202,787 | 1,164,811 | 513,538 | 326,308 | 321,798 |
| Water Retained in Tailings Void | 215,960 | 518,250 | 172,278 | 387,626 | 0 | 0 | 0 |
| Evaporation | 20,720 | 54,282 | 51,677 | 51,677 | 47,584 | 8,826 | 0 |
| Volume Lost to Ice | 26,324 | 70,190 | 66,078 | 49,874 | 0 | 0 | 0 |
| ***Total Losses*** | 263,004 | 642,722 | 290,033 | 489,176 | 47,584 | 8,826 | 0 |
| **Net Inflow** | 158,053 | 590,801 | 912,754 | 675,634 | 465,954 | 317,482 | 321,798 |
| **Pumping to Mill Reclaim Water** | 290,193 | 660,693 | 321,217 | 0 | 0 | 0 | 0 |
| **Pumping to Expo Pit** | 0 | 0 | 839,506 | 675,634 | 465,954 | 317,482 | 0 |
| **Pumping / Runoff to MCP (Cell 2 Covered)** | 0 | 0 | 0 | 0 | 0 | 0 | 321,798 |
| **Storage in Cell 2** | 367,860 | 297,969 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 |

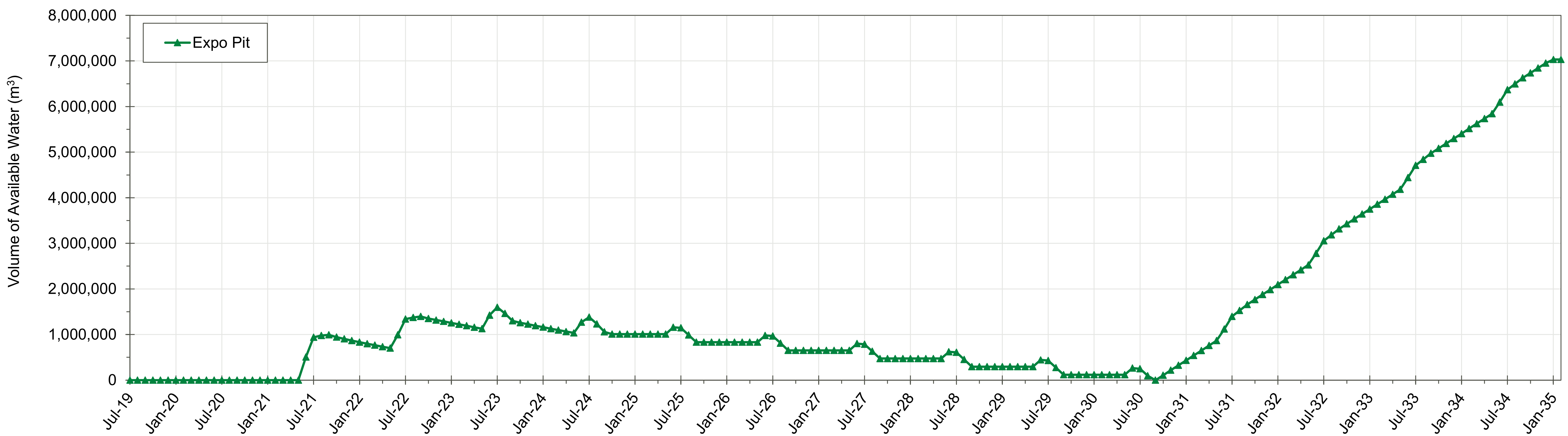


GOLDER

## WATER BALANCE - Open Pit (Annual Summary)

| | |
|---|---|
| Initial Volume in pond ($m^3$) | 0 |

| Year | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036-2071 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water in Discharged Tailings | 0 | 0 | 0 | 144,471 | 866,825 | 732,790 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Runoff & Snow Drift | 50,261 | 366,200 | 367,209 | 373,534 | 379,176 | 380,310 | 380,067 | 379,516 | 378,966 | 378,414 | 377,849 | 377,099 | 379,300 | 383,670 | 387,865 | 390,153 | 391,527 | 391,543 |
| Pumped from Cell 2 | 0 | 0 | 839,506 | 675,634 | 465,954 | 317,482 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pumped from Lac Bombardier | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 325,000 | 1,300,000 | 1,300,000 | 1,300,000 | 1,300,000 | 77,131 | 0 |
| ***Total Inflow*** | 50,261 | 366,200 | 1,206,715 | 1,193,640 | 1,711,954 | 1,430,582 | 380,067 | 379,516 | 378,966 | 378,414 | 377,849 | 702,099 | 1,679,300 | 1,683,670 | 1,687,865 | 1,690,153 | 468,657 | 391,543 |
| Water Retained in Tailings Void | 0 | 0 | 0 | 86,139 | 516,834 | 436,917 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Evaporation | 0 | 0 | 1,941 | 12,112 | 19,501 | 19,894 | 19,366 | 18,597 | 17,829 | 17,058 | 16,264 | 15,407 | 19,779 | 25,842 | 31,202 | 34,200 | 35,640 | 35,640 |
| Volume Lost to Ice | 0 | 0 | 0 | 17,500 | 69,998 | 53,257 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Total Losses*** | 0 | 0 | 1,941 | 115,750 | 606,334 | 510,068 | 19,366 | 18,597 | 17,829 | 17,058 | 16,264 | 15,407 | 19,779 | 25,842 | 31,202 | 34,200 | 35,640 | 35,640 |
| **Net Inflow** | 50,261 | 366,200 | 1,204,774 | 1,077,889 | 1,105,621 | 920,514 | 360,702 | 360,919 | 361,137 | 361,355 | 361,585 | 686,692 | 1,659,521 | 1,657,829 | 1,656,662 | 1,655,953 | 433,017 | 355,903 |
| **Pumping to Mill Reclaim Water** | 0 | 0 | 337,670 | 658,887 | 658,887 | 562,704 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Pumping to MCP** | 50,261 | 366,200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Pumping / Runoff to Treatment** | 0 | 0 | 0 | 0 | 540,000 | 540,000 | 540,000 | 540,000 | 540,000 | 540,000 | 540,000 | 478,039 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Discharge to Environment (No Treatment)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 355,887 | 355,903 |
| **Storage in Pit at End of Period** | 0 | 0 | 867,104 | 1,286,106 | 1,192,839 | 1,010,649 | 831,351 | 652,270 | 473,407 | 294,762 | 116,347 | 325,000 | 1,984,521 | 3,642,350 | 5,299,012 | 6,954,965 | 7,032,096 | 7,032,096 |



**APPENDIX D**

# Water Quality Analysis

# D.1.0 INTRODUCTION

A water quality model (WQM) was developed to assist with the evaluation of anticipated water quality of the proposed Expo in-pit tailings facility at the end of closure and all of post-closure. The selected closure concept for the facility is removal and treatment of all tailings water, accelerated flooding of the pit by pumping freshwater from Lac Bombardier during closure, and natural overflow to the environment during post-closure. This closure scenario was selected based on previous assessments which considered the following:

- Four closure options (presence or absence of tailings cover, presence or absence of accelerated flooding);
- Average year and 25-year dry precipitation scenarios;
- Best estimate and possible poor-end case water quality inputs; and
- Geochemical process of adsorption of metals onto ferrihydrite particulates in Pit water.

This appendix presents the results of the WQM developed for the closure scenario involving removal of free standing tailings water after cessation of tailings deposition, accelerated flooding of the pit with fresh water from Lac Bombardier to its maximum water level prior to allowing it to overflow, no tailings cover prior to submergence, a water balance with an average precipitation climate scenario, possible poor-end case water quality inputs, no consideration of the potential attenuating effects of adsorption of chemicals onto ferrihydrite in pit waters and no water treatment.

The objective of the WQM was to provide an estimate of the water quality in the Expo in-pit facility contact water upon closure and filling of the Pit to its final outflow water level (EL. 535.4 m), to evaluate the long term dilutive effects after Pit filling on Pit water quality, and to identify the constituents of potential concern (COPCs) that may require attenuation/treatment. Particular focus is placed on predicting concentrations of nickel in the scenario as it is identified as the main COPC. The WQM also serves to assess the effectiveness of the engineering measures considered towards reducing the concentrations of COPCs in the Pit water. These measures include the accelerated flooding of the Pit using fresh water from Lac Bombardier in order to reduce the effects of Pit wall runoff which contributes to the overall chemical loading of water in the Pit and the commitment by CRI to maintain the Pit water hardness at 400 mg/L until 2056 by adding Calcium Chloride.

This appendix describes the modelled scenario (Section D.2.0), the model construction (Section D.3.0), the inputs and assumptions for the model (Section D.4.0), the approach to modelling (Section D.5.0), the results (Section D.6.0), risk and opportunities (Section D.7.0), recommendations (Section D.8.0), report limitations (Section D.9.0), and the conclusions of the WQM (Section D.10.0).

## D.1.1 Supporting Studies and Information

The selected closure scenario builds upon the results of studies carried out in support of a conceptual-level tailings deposition options analysis since 2018. The following data obtained for this analysis was received from CRI:

- Tailings storage facility water quality and process water quality results (excel worksheet; "*Classeur1*") received on August 8, 2019;
- Expo Pit sump water quality received on August 2, 2019;

- CRI-developed an algorithm in MSExcel for predicting TSF and process water qualities from 2018-2024 (excel worksheet; "*2019-10-30 Plan de pompage 2019 V1 for Golder V2*") received on November 30, 2019;
- Natural runoff results (excel worksheet; "*DEV-1*") received on March 8, 2020;
- Operational and engineering processes to be considered for the model received on March 8, 2020 (described herein);
- Proportions of ultramafic and sedimentary units exposed in the final Expo Pit 530 bench received on March 9, 2020; and
- Expo Camp potable water pH measurements from April to December 2019 received on July 14, 2020.

## D.2.0 CLOSURE SCENARIO

A summary of the scenario considered in this appendix is provided in Table D-1. In this scenario Pit water is recycled to the mill during operations and tailings are deposited from the east and west corners of the pit, mostly underwater. The rationale behind each of the points presented in Table D-1 is as follows:

- **Tailings Barrier Cover**: A tailings barrier cover is not added above the tailings disposed of in the Pit. The results of diffusion modelling discussed in Section D.6.3 demonstrate that nickel diffusion rates are sufficiently low such that the associated benefits to Pit water quality of adding the cover would be minimal.
- **Tailings Water Removal**: Tailings water contains metals and process reagents. Process water removal (pre-treatment using a Fenton process, treatment at the Expo main treatment plant and discharge of the effluent to the environment) will take place prior to flooding by natural inflows and pumped fresh water from Lac Bombardier. The tailings water removal will take place between July 2023 and September 2030 at a rate of 180,000 $m^3$/month from July to September every year.
- **Accelerated Flooding**: This scenario incorporates, in addition to natural inflows, the accelerated flooding of the Pit with fresh water pumped from Lac Bombardier during closure at a rate of 1,300,000 $m^3$/year (108,330 $m^3$/month) following the completion of tailings disposal and removal of process water above the tailings. This rate of pumping is the maximum permitted from Lac Bombardier and improvements in the Pit water quality are expected to arise from the reduction of exposure of Pit wall to runoff as a result of the faster filling of the Pit during accelerated flooding. The Pit wall runoff source term was recognized prior to the commencement of modelling to contain high nickel concentrations with 4.7 mg/L nickel in the Pit sump water quality source term used during operations and closure (Table D-8). The decrease in time towards filling the Pit is substantial with Pit filling occurring in less than 5 years as compared to taking more than 15 years with solely natural inflows.
- **Climate**: Average climactic data from the past 25 years that assumes an average annual precipitation of 600 mm was used to generate the water balance as this scenario models a relatively long time period (from operations in 2021 to the year 2071 during post-closure) which is anticipated to represent overall average climate conditions.
- **Inputs**: The chemistries of source terms used are well to poorly constrained. Whereas the precipitation water quality is well constrained using available precipitation monitoring data, the chemistry of Pit wall runoff remains uncertain but is a significant contributor to Pit water quality COPC concentrations. Conservative poor-end source terms were used in this scenario, whose development is discussed further in Section D.4.2.

- **Adsorption and precipitation**: The effects of adsorption of nickel and other metals onto ferrihydrite at elevated pH (>7) and the precipitation of chemicals as solids in the water column were evaluated outside of this modelling exercise. The effect of adsorption onto concentrations of COPC's was found to be minimal and therefore was not incorporated into this model. Mineral precipitation is modelled to control iron (Section D.5.0).
- **Hardness**: An additional engineering control added to this model is the commitment by CRI to maintain Pit water quality hardness at 400 mg/L during closure and post-closure until, at least 2056. As the CVAC limit for Ni is hardness dependent the CVAC Ni limit will be 0.169 mg/L during this time.
- **Water treatment**: During the end of operations from July to September, while process water above the tailings is being removed, 180,000 m$^3$/month of Pit water will be pumped to the treatment plant. No treatment of Pit water is modelled during closure and post-closure. The impact of treatment during closure was assessed to be minimal with the treatment of water being offset by increased amounts of nickel contaminated Pit wall runoff during a longer Pit filling time. A modest reduction in Pit water constituent concentrations is expected were treatment considered during post-closure, but as the results of the scenario modelled in this appendix without water treatment are favorable, water treatment during post-closure was not considered.

**Table D-1: Scenario Considered in WQM**

| Scenario Consideration | Input | Associated Value(s) |
|---|---|---|
| Tailings cover barrier | No tailings barrier | - |
| Accelerated flooding from Lac Bombardier | Maximum flooding rate during closure (2030-2035) | 1,300,000 m$^3$/year (108,330 m3/month) |
| Climate | Average climate scenario | 600 mm/year precipitation |
| Inputs | Poor-end inputs | Outlined in Section D.4.2 |
| Precipitation of secondary mineral salts | Credible mineral phases outlined in Section D.5.0 | Outlined in Section D.6.1 |
| Hardness | Maintained by CRI during closure and post-closure until 2056 | 400 mg/L |
| Water treatment | Of free water above tailings prior to flooding. No water treatment after process water removal during closure nor post-closure | 180,000 m$^3$/month from July to September |

## D.2.1 Supporting Studies and Information

Two sets of criteria were applied to the results of the WQM and are shown in Annex D-1. The effluent treatment limits stated in Directive 019 guidelines (MDDELCC, 2012) are applicable to the operations period.
This comparison is for information only if CRI does not expect to release any effluents during operations.

WQM results were also compared to Provincial surface water quality criteria applicable to an open water body accessible to wildlife: the CVAC (critères provinciaux de protection de la vie aquatique, effets chroniques).

Other criteria typically used in mining studies and stated in Directive 019 such as the groundwater criteria for consumption (EC; eau de consommation) and groundwater seeping into surface waters (RES: eau souterraine en résurgence dans l'eau de surface) are not applicable to this site since there is no groundwater to speak of, the site being underlain by continuous permafrost.

## D.3.0 WATER QUALITY MODEL

The WQM was developed using the software PHREEQC Interactive (PHREEQCi) version 3.5.0 (Parkhurst and Appelo 2013) with inputs to PHREEQC prepared in Microsoft Excel. This software and code were developed by the United States Geological Survey (USGS) for aqueous geochemical modelling and have widespread acceptance for use in consulting and academic applications. The WQM was set up and executed on a yearly timestep by following these steps:

- **Inflow and mixing proportions**: In order to calculate the proportions of the different source term inputs to mix during every year in the model, from operations to closure, the water balance (Appendix C) derived for the WQM was used to calculate the proportions of each inflow to the Pit, relative to the proportion of water that had already accumulated in the Pit. The details of this process are presented in Section D.4.1.
- **Source term chemistry**: The chemical composition of each of the source terms to be mixed in the model were developed using all available geochemical data, including that provided by CRI and outlined in Section D.1.1, along with predictive modelling and geochemical interpretation, in order to develop the most appropriate source terms. The development of the source terms and the rationale behind their selection is discussed further in Section D.4.2.
- **PHREEQC model calculation**: Mixing proportions derived using the water balance and source term input chemistries are combined in Microsoft Excel to produce a PHREEQC input file, which is then executed in PHREEQC and the output of the model is interpreted in Microsoft Excel. A detailed of the calculation steps followed in PHREEQC is provided in Section D.5.0.
- **Post-closure nickel concentrations**: The effects of diffusion from the in-pit tailings and the dilution of the Pit water by natural inflows on Pit water nickel concentrations are evaluated in Microsoft Excel. The calculations performed for diffusion and dilution are summarized in Section D.5.0.

## D.4.0 WATER QUALITY MODEL INPUTS AND ASSUMPTIONS

The source term inputs and assumptions used in generating the inputs for this WQM are outlined throughout Section D.4.0.

### D.4.1 Water Balance

The water balance used for this scenario is presented in detail in Appendix C. The water balance evaluated the monthly inflows and losses of water from various areas going to the Expo in-pit tailings facility during operations, closure, and post-closure. The inflows to the facility and the source terms assigned to each inflow, which are detailed in Section D.4.2, and are shown in Table D-2.

In order to perform water quality modelling two calculation steps were performed in order to convert monthly inflows into yearly proportions of source term inputs:

1) The total annual inflow to the Pit was calculated for each inflow source; and

2) The proportion of each inflow to the Pit contributing to the overall quantity of water in the Pit in any given year was calculated as follows:

$$Inflow\ proportion = \frac{yearly\ inflow\ (m^3, given\ year)}{all\ inflows\ (m^3, given\ year) + total\ pond\ volume\ (m^3, previous\ year)}$$

In addition, the proportion of water in the Pit lake remaining from the previous year, termed cumulative water, was calculated for each year. The sum of the proportions of all annual inflows and the proportion of cumulative water in any given year was equal to one. These proportions were used to mix the selected source terms using the calculated proportions on a yearly time step.

**Table D-2: Water Balance Inflows and Associated Water Quality Source Terms**

| Period | Water Balance Inflow | Representative Water Quality Source Term |
|---|---|---|
| Operations - Closure | Runoff from natural ground | Natural ground runoff |
| | Runoff from open Pit walls | Pit wall contact water runoff |
| | Water in discharged tailings | Process water |
| | Runoff from wet tailings | Process water |
| | Runoff from tailings beach | Process water |
| | Pumping from Cell 2 | TSF water |
| | Precipitation on tailings surface | No charge |
| | Precipitation on Pit lake surface | Precipitation |
| | Melt of snow drift in open Pit | Precipitation and Pit wall contact water runoff |
| | Pumping from Lac Bombardier | Lac Bombardier |
| Post-closure | Runoff from natural ground | Natural ground runoff |
| | Runoff from open Pit walls | Pit wall contact water runoff |
| | Melt of snow drift in open Pit | Precipitation and Pit wall contact water runoff |

## D.4.2 Water Quality Source Term Inputs

The inputs to the various scenarios were selected using water quality data collected at the site which was provided by CRI. Concentrations of all considered constituents were calculated during operations and closure. All constituents other than nickel were not considered in post-closure (“NC”). Concentrations below the detection limit were conservative assigned detection limit values.

The development of each source term and the associated assumptions are discussed herein.

#### D.4.2.1 Precipitation

The chemical composition of precipitation is summarized in Table D-3. This composition is calculated by averaging the composition of samples in the Environment Canada CapMon precipitation monitoring station dataset (CapMon, 2012) in Northern Ontario and is assumed to remain constant throughout the WQM’s.

The precipitation water quality source term is assigned to three flows in the water balance:

- Precipitation on the pond surface;
- Operations: 90% of the melt of snow drift in the open Pit with the remaining 10% assigned to Pit wall runoff water quality during operations-closure; and
- Post Closure: 99% of the melt of snow drift in the open Pit with the remaining 1% assigned Pit wall runoff water quality during post-closure.

Following the end of tailings deposition this is volumetrically the most significant input during closure and post-closure.

A precipitation temperature of five degrees Celsius was calculated using the average monthly air temperature recorded at the Expo site weather station during the months of July to September when the monthly average air temperature was above zero degrees. This temperature was applied to all other source terms for the purpose of geochemical equilibrium modelling in PHREEQC (Section D.5.0).

**Table D-3: Precipitation Input Water Quality**

| Parameter[1] | Units | Value |
|---|---|---|
| Temperature | °C | 5.0 |
| pH | s.u. | 5.1 |
| Redox | mV | 600 |
| Sulphate | mg/L | 0.82 |
| Cl | mg/L | 0.10 |
| Na | mg/L | 0.050 |
| Ca | mg/L | 0.15 |
| Mg | mg/L | 0.020 |
| K | mg/L | 0.040 |

Note:

[1] Concentrations for parameters not shown, including trace metals, assumed to be zero.

#### D.4.2.2 Lac Bombardier

The chemical composition of Lac Bombardier water in shown in Table D-4. The pH of the water was taken to be the average of the measured pH of Expo Camp potable water from April to December 2019, which is taken directly from Lac Bombardier. Concentrations of arsenic, copper, iron, manganese, nickel, and uranium were measured directly from a Lac Bombardier sample. Concentrations of other constituents were taken to be the same as that for precipitation.

**Table D-4: Lac Bombardier Input Water Quality**

| Parameter[1] | Units | Value |
|---|---|---|
| Temperature | °C | 5.0 |
| pH | s.u. | 6.5 |
| Redox | mV | 600 |
| Sulphate | mg/L | 0.82 |
| Cl | mg/L | 0.10 |
| Na | mg/L | 0.050 |
| Ca | mg/L | 0.15 |
| Mg | mg/L | 0.020 |
| K | mg/L | 0.040 |
| As | mg/L | 0.0010 |
| Cu | mg/L | 0.0014 |
| Fe | mg/L | 0.060 |
| Mn | mg/L | 0.0036 |
| Ni | mg/L | 0.0020 |
| U | mg/L | 0.0010 |

Note:

[1] Concentrations for parameters not shown, including trace metals, assumed to be zero.

### D.4.2.3 Natural Ground Runoff

The water balance assumes that the diversion ditch is 60% effective, meaning that 40% of the natural runoff in the watershed south of the Expo Pit is not captured by the diversion ditch and reports to the Pit. The poor end natural runoff source term was developed using surface water quality data from a 2018 monitoring station providing water quality related to the diversion ditch.

The natural runoff source term during operations represents mine-affected site contact water quality. It consists of the latest two measurements of natural runoff water quality (location EX- DEV 1) taken in June and September 2019 by CRI. Concentrations of Ni and Fe exceed their respective 400 mg/L water hardness CVAC criteria. Concentrations of these two metals were set to CVAC limit concentrations based on a commitment by CRI to reduce measured metal concentrations below their 400 mg/L water hardness CVAC limit Concentrations for metals not analyzed for were taken from the poor-end natural runoff source term of Golder (2020). The chemistry of this source term during operations and closure is shown in Table D-5 (Natural runoff: operations – closure). During post-closure only nickel concentrations were modelled and CRI has committed to reducing the natural runoff nickel concentration to the lowest possible nickel CVAC limit of 0.007 mg/L Ni during this time, as shown in Table D-5.

This source term is typically second in abundance to precipitation during post-closure.

**Table D-5: Natural Runoff Water Quality Input**

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Units</th><th colspan="2">Value</th></tr>
<tr><th>Operations - Closure</th><th>Post-closure</th></tr>
<tr><td>pH</td><td>s.u.</td><td>7.0</td><td rowspan="11">NC</td></tr>
<tr><td>Alkalinity</td><td>mg/L $CaCO_3$</td><td>10</td></tr>
<tr><td>Al</td><td>mg/L</td><td>0.019</td></tr>
<tr><td>As</td><td>mg/L</td><td>0.0010</td></tr>
<tr><td>Ba</td><td>mg/L</td><td>0.0020</td></tr>
<tr><td>Ca</td><td>mg/L</td><td>1.0</td></tr>
<tr><td>Cd</td><td>mg/L</td><td>0.000030</td></tr>
<tr><td>Co</td><td>mg/L</td><td>0.00010</td></tr>
<tr><td>Cu</td><td>mg/L</td><td>0.016</td></tr>
<tr><td>K</td><td>mg/L</td><td>2.8</td></tr>
<tr><td>Fe</td><td>mg/L</td><td>1.3</td></tr>
<tr><td>Ni</td><td>mg/L</td><td>0.17</td><td>0.007</td></tr>
<tr><td>Pb</td><td>mg/L</td><td>0.00052</td><td rowspan="4">NC</td></tr>
<tr><td>Sulphate</td><td>mg/L</td><td>7.6</td></tr>
<tr><td>V</td><td>mg/L</td><td>0.00010</td></tr>
<tr><td>Zn</td><td>mg/L</td><td>0.022</td></tr>
</table>

Note:

NC: “Not considered”, during post-closure only Ni is modelled

### D.4.2.4 Tailings Pond Water/Mill Effluent Process Water

The water quality of the process water originating from the mill and the water quality within the void spaces of the deposited tailings as well as the quality of tailings pond water (from tailings Cells 1 and 2) pumped to the Expo Pit from 2021 to 2024 were modelled over the period of 2018-2024 using an algorithm in MSExcel provided by CRI which was modified by Golder to implement geochemically reasonable constraints on tailing contact water quality.

The CRI algorithm calculates tailings pond water and mill effluent process water constituent chemistries on a monthly time step by considering the water balance of mill effluent pumped to the tailings cells and tailings water being recirculated back to the mill, contributing to the evolving mill effluent water quality.

The model was initiated in August 2018 with initial concentrations of constituents taken from a tailings pond water analysis on July 30, 2018 and a process water analysis completed on March 28, 2019. The tailings pond water analysis was assumed to be representative of the tailings water quality in July 2018 and the process water analysis was assumed to be representative of the water quality of process water in August 2018, in the absence of previous process water analyses with analyzed thiosulfate concentrations. These initial concentrations are shown in Table D-6 and Table D-7. Using these starting concentrations, the concentration of each chemical constituent in the tailings pond water was calculated on a monthly basis until July 2021 as follows (TW: tailings water, PW: process water, Precip: Precipitation):

$$TSF\ concentration\ (month) = \frac{\left(PW\ concentration \times TW\ added\ (L) + \left(Precip\ Cell\ 1\ (L) + Precip\ Cell\ 2\ (L)\right) \times 0\ \frac{mg}{L} + TSF\ water\ (L) \times TSF\ concentration\ (previous\ month)\right)}{\left(TW\ added\ (L) + Precip\ Cell\ 1\ (L) + Precip\ Cell\ 2\ (L) + TSF\ volume\ (L)\right)}$$

In the period preceding July 2021 water within the tailings cells is found both as free water above the tailings as well was water within the pore space of the tailings. In June 2021 water stored in Cell 2 is pumped to the Expo pit and the remaining water in the facility is tailings porewater. From July 2021 to December 2023 the concentration any given constituent in the facility porewater is therefore calculated as follows:

$$TSF\ porewater\ concentration\ (month) = \frac{\left(PW\ concentration \times TW\ added\ (L) + \left(Precip\ Tailings\ (L)\right) \times 0\ \frac{mg}{L} + TSF\ water\ (L) \times TSF\ concentration\ (previous\ month)\right)}{\left(TW\ added\ (L) + Precip\ Tailings\ (L) + Precip\ Cell\ 2\ (L) + TSF\ volume\ (L)\right)}$$

The concentration of a given constituent in the mill effluent process water was calculated in September 2018 and every month thereafter, until December 2023, as follows:

$$\begin{aligned} Process\ water\ concentration\ (month) \\ &= Process\ water\ concentration\ (previous\ month) + TSF\ concentration\ (previous\ month) \\ &- TSF\ concentration\ (two\ months\ prior) \end{aligned}$$

This calculation assumes that the change in the tailings pond water quality, whether an increase or decrease in the constituent concentration, is then reflected in the mill effluent process water quality as tailings pond water is recirculated back to the mill.

To set geochemically appropriate lower limit concentrations below which constituent concentrations could not fall, results from a process water analysis in October 2018 was assumed to be representative of process water prior to extensive recirculation. Lower limits for the process water quality in any given month were assigned in the model based on this analysis and are reported in Table D-7. Exceptions to this method of establishing lower limits are listed as follows:

- **Detection Limits**: Lower limits for constituents for which either a process water or tailings pond water analysis fell below the analytical detection limit were set as being the detection limit.
- **Charge Balance**: Analyses of magnesium, chloride, and sulfate were elevated in the 2018 process water sample and in the absence of an accompanying thiosulfate measurement the use of these concentrations in the model led to large charge imbalances. As a result, the starting concentrations of these three constituents were taken from the 2019 process water sample. These concentrations were lower than the 2018 process water sample and can therefore be reasonably expected to be attained in the model.
- **Alkalinity**: The measured alkalinity in the 2018 process water was elevated (50 mg/L as $CaCO_3$) and its use in the model would lead to unreasonably elevated alkalinities. As a result, the maximum observed alkalinity in the Expo Pit waste rock HCT's (10 mg/L as $CaCO_3$) was used.
- **Elevated concentrations**: Constituents for which measured concentrations were higher in the 2018 process water sample utilized a lower limit based on the lower measured concentrations of the 2019 process water

sample. This step was followed as lower concentrations are generally not expected following recirculation, but where observed have to be considered in establishing lower limits.

Runoff water quality from the tailings facility area is assumed to be improved by the construction of the cover over the tailings Cell 2 which will begin in June 2023 and finishes in October 2024. During this time the exposed tailings surface area progressively decreases while the contribution of natural inflows from the tailings facility area increases. To maintain the conservatism of the model, inputs of process water and tailings pond water in 2024 identical to those calculated in 2023 were assumed, despite the lower exposed tailings surface area in 2024.

**Table D-6: Calculated Tailings Facility Water Quality**

| Parameter | Units | Annual Concentration | | | | |
|---|---|---|---|---|---|---|
| | | 2018 | 2021 | 2022 | 2023 | 2024 |
| pH | s.u. | 7.8 | 7.1 | 6.9 | 6.9 | 6.9 |
| Alkalinity | mg/L $CaCO_3$ | 34 | 11 | 10 | 10 | 10 |
| Ag | mg/L | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 |
| Al | mg/L | 0.260 | 0.030 | 0.021 | 0.021 | 0.021 |
| As | mg/L | 0.0012 | 0.00033 | 0.00021 | 0.00021 | 0.00021 |
| Ba | mg/L | 0.036 | 0.15 | 0.21 | 0.21 | 0.21 |
| Ca | mg/L | 440 | 950 | 1200 | 1200 | 1200 |
| Cd | mg/L | 0.00020 | 0.00020 | 0.00020 | 0.00020 | 0.00020 |
| Cl | mg/L | 300 | 930 | 1300 | 1300 | 1300 |
| Co | mg/L | 0.0081 | 0.031 | 0.042 | 0.042 | 0.042 |
| Cr | mg/L | 0.0098 | 0.0013 | 0.00092 | 0.00092 | 0.00092 |
| Cu | mg/L | 0.027 | 0.011 | 0.011 | 0.011 | 0.011 |
| K | mg/L | - | - | - | - | - |
| F | mg/L | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Hg | mg/L | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 |
| Mg | mg/L | 100 | 60 | 67 | 67 | 67 |
| Mn | mg/L | 0.038 | 0.015 | 0.016 | 0.016 | 0.016 |
| Mo | mg/L | 0.013 | 0.018 | 0.022 | 0.022 | 0.022 |
| Fe | mg/L | 1.6 | 0.18 | 0.12 | 0.12 | 0.12 |
| Na | mg/L | 140 | 360 | 470 | 470 | 470 |
| Ni | mg/L | 0.50 | 0.59 | 0.69 | 0.69 | 0.69 |
| P | mg/L | 0.018 | 0.016 | 0.018 | 0.018 | 0.018 |
| Pb | mg/L | 0.00050 | 0.00050 | 0.00050 | 0.00050 | 0.00050 |
| Se | mg/L | 0.0063 | 0.0063 | 0.0072 | 0.0072 | 0.0072 |
| Sb | mg/L | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 |
| Sulphate | mg/L | 530 | 920 | 1200 | 1200 | 1200 |
| Zn | mg/L | 0.019 | 0.0026 | 0.0019 | 0.0019 | 0.0019 |
| Thiosulfate | mg/L | 880 | 1700 | 2200 | 2200 | 2200 |

Note:

- Not analyzed

**Table D-7: Calculated Process Water Quality**

| Parameter | Units | Process Water Minimum | Annual Concentration | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2018 | 2021 | 2022 | 2023 | 2024 |
| pH | s.u. | - | 7.2 | 6.9 | 6.8 | 6.8 | 6.8 |
| Alkalinity | mg/L $CaCO_3$ | 10[1] | 29 | 10 | 10 | 10 | 10 |
| Ag | mg/L | 0.0010[2] | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 |
| Al | mg/L | 0.021 | 0.057 | 0.021 | 0.021 | 0.021 | 0.021 |
| As | mg/L | 0.00020 | 0.0010 | 0.00021 | 0.00020 | 0.00020 | 0.00020 |
| Ba | mg/L | 0.071 | 0.12 | 0.23 | 0.29 | 0.29 | 0.29 |
| Ca | mg/L | 680 | 900 | 1400 | 1700 | 1700 | 1700 |
| Cd | mg/L | 0.00020[2] | 0.00020 | 0.00020 | 0.00020 | 0.00020 | 0.00020 |
| Cl | mg/L | 790[3] | 790 | 1400 | 1700 | 1700 | 1700 |
| Co | mg/L | 0.011 | 0.025 | 0.047 | 0.058 | 0.058 | 0.058 |
| Cr | mg/L | 0.00094 | 0.0050 | 0.00094 | 0.00094 | 0.00094 | 0.00094 |
| Cu | mg/L | 0.013[4] | 0.013 | 0.013 | 0.014 | 0.014 | 0.014 |
| F | mg/L | 0.060 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Hg | mg/L | 0.00010[2] | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 |
| Mg | mg/L | 75[3] | 75 | 77 | 84 | 84 | 84 |
| Mn | mg/L | 0.018[4] | 0.018 | 0.018 | 0.019 | 0.019 | 0.019 |
| Mo | mg/L | 0.0042 | 0.020 | 0.025 | 0.028 | 0.028 | 0.028 |
| Fe | mg/L | 0.12 | 0.15 | 0.12 | 0.12 | 0.12 | 0.12 |
| Na | mg/L | 200 | 320 | 530 | 640 | 640 | 640 |
| Ni | mg/L | 0.71[4] | 0.71 | 0.80 | 0.89 | 0.89 | 0.89 |
| P | mg/L | 0.020[4] | 0.020 | 0.021 | 0.023 | 0.023 | 0.023 |
| Pb | mg/L | 0.00050[2] | 0.00050 | 0.00050 | 0.00050 | 0.00050 | 0.00050 |
| Se | mg/L | 0.0080[4] | 0.0080 | 0.0083 | 0.0091 | 0.0091 | 0.0091 |
| Sb | mg/L | 0.0010[2] | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 |
| Sulphate | mg/L | 940[3] | 940 | 1300 | 1600 | 1600 | 1600 |
| Zn | mg/L | 0.0020 | 0.0070 | 0.0020 | 0.0020 | 0.0020 | 0.0020 |
| Thiosulfate | mg/L | 1700 | 1700 | 2400 | 2900 | 2900 | 2900 |

Notes:

Exceptions to the use of the 2018 process water sample for setting lower limit values, as discussed in Section D.4.2.4 are as follows:

[1] Expo Pit HCT alkalinity minimum.

[2] Analytical detection limit minima.

[3] 2018 process water minimum not used due to charge imbalances.

[4] 2018 process water minimum not used to higher concentrations in this sample than 2019 process water.

### D.4.2.5 Pit Wall Contact Runoff

Two data sources were considered in the estimation of Pit wall runoff water quality:

- Pit sump water quality: used to represent Pit wall runoff during operations and closure; and,
- Humidity cell leachate composition: used to calculate nickel Pit wall runoff concentrations during post-closure.

The Expo Pit sump water quality of June 12, 2019, was used to represent exposed Pit wall runoff during the operation and closure periods, including exposure of ore material. These waters were analyzed for a limited suite of constituents (Al, As, Cr, Co, Cu, Fe, Ni, Pb, Zn, Alkalinity, Cl, SO4, pH, conductivity); the concentration of select constituents not analyzed (Ca, Mg, Fe) was assigned based on results from HCT tests. Specifically, the concentrations of calcium, magnesium and potassium in the Pit sump water were estimated based on the concentration of these elements in the HCT test cells for the same rock types multiplied by a scaling ratio calculated as the concentration of aluminum in the wall washing station vs the concentration of aluminum in the HCT. This uses the reasonable assumption that the proportion of chemicals in HCT contact water is the same as in Pit wall runoff for the same lithology.

It should be noted that the measured nickel concentration of 4.7 mg/L in the Expo Pit sump water of June 12, 2019 is among the lowest nickel concentration measured historically (Figure D-1). The average nickel concentration from the nine measurements of 2017-2018 (used in Golder, 2019a) were 9.9 mg/L nickel, while previous measurements have exceeded 60 mg/L nickel. It is considered by CRI that measurements taken previously were in an environment where sulphide-rich ore material was exposed and stored at the bottom of the Pit, thereby likely increasing the concentrations of measured nickel in the sump water.

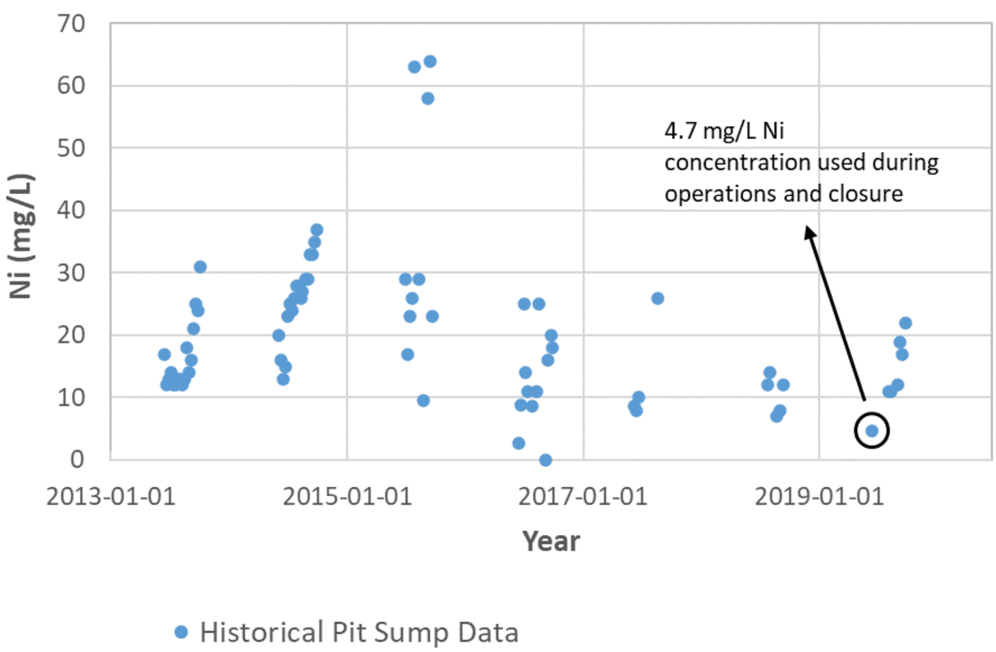



**Figure D-1: Historical Pit Sump Ni Concentrations**

During post-closure it was assumed that lesser amounts of ore material would be exposed and that as such, the long-term leaching rate of nickel would be similar to that of nickel leached from humidity cells which were carried out on non-mineralized waste rock. Therefore, for this period the average nickel concentrations of the last two cycles of kinetic testing from each of the three Expo ultramafic samples tested (EX-109-03, EX-49-02, EX-31-03) and each of the three Expo sedimentary samples tested (EX-02-01, EX-84-01, EX-76-01) were used to derive the post-closure nickel Pit wall runoff concentration (from Golder, 2013). This resulted in an overall average ultramafic rock nickel concentration of 8.0 mg/L and sedimentary rock nickel concentration of 0.45 mg/L. The overall post-closure Pit wall runoff nickel concentration was then calculated to be 2.62 mg/L using the proportions of ultramafic and sedimentary rock exposed in the Pit highwall (EL. 530 m bench), which were calculated by CRI to be 28.8% ultramafic rock and 71.2% sedimentary rock.

The calculated water quality for Pit wall runoff for operations, closure, and the nickel concentration of post-closure runoff are summarized in Table D-8.

This historical variability and the difference between concentrations measured in Pit sump water and wall washing station leachates yield uncertainty in this input parameter for the model and consequently, in the effect of Pit wall runoff on flooded Pit water quality in the long-term.

**Table D-8: Expo Pit Wall Water Quality**

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Units</th><th>Expo East Pit Sump</th><th>Sedimentary Waste Rock HCT Long-Term Average</th><th>Ultramafic Waste Rock HCT Long-Term Average</th><th>Pit Sump/Wall Washing Proportional Mix[1]</th></tr>
<tr><th>Operations – Closure</th><th>Ni Post-Closure (71%[1])</th><th>Ni Post-Closure (29%[1])</th><th>Post-closure</th></tr>
<tr><td>pH</td><td>s.u.</td><td>7.4</td><td rowspan="19">NC</td><td rowspan="19">NC</td><td rowspan="19">NC</td></tr>
<tr><td>Alkalinity</td><td>mg/L $CaCO_3$</td><td>14</td></tr>
<tr><td>Ag</td><td>mg/L</td><td>-</td></tr>
<tr><td>Al</td><td>mg/L</td><td>0.29</td></tr>
<tr><td>As</td><td>mg/L</td><td>0.0010</td></tr>
<tr><td>Ba</td><td>mg/L</td><td>-</td></tr>
<tr><td>Ca</td><td>mg/L</td><td>15</td></tr>
<tr><td>Cd</td><td>mg/L</td><td>-</td></tr>
<tr><td>Cl</td><td>mg/L</td><td>36</td></tr>
<tr><td>Co</td><td>mg/L</td><td>0.21</td></tr>
<tr><td>Cr</td><td>mg/L</td><td>0.0050</td></tr>
<tr><td>Cu</td><td>mg/L</td><td>0.10</td></tr>
<tr><td>Hg</td><td>mg/L</td><td>-</td></tr>
<tr><td>K</td><td>mg/L</td><td>29</td></tr>
<tr><td>Mg</td><td>mg/L</td><td>55</td></tr>
<tr><td>Mn</td><td>mg/L</td><td>-</td></tr>
<tr><td>Mo</td><td>mg/L</td><td>-</td></tr>
<tr><td>Fe</td><td>mg/L</td><td>1.9</td></tr>
<tr><td>Na</td><td>mg/L</td><td>-</td></tr>
<tr><td>Ni</td><td>mg/L</td><td>4.7</td><td>0.45</td><td>8.0</td><td>2.6</td></tr>
<tr><td>Pb</td><td>mg/L</td><td>0.00050</td><td rowspan="3">NC</td><td rowspan="3">NC</td><td rowspan="3">NC</td></tr>
<tr><td>Se</td><td>mg/L</td><td>-</td></tr>
<tr><td>Sb</td><td>mg/L</td><td>-</td></tr>
</table>

| Parameter | Units | Expo East Pit Sump | Sedimentary Waste Rock HCT Long-Term Average | Ultramafic Waste Rock HCT Long-Term Average | Pit Sump/Wall Washing Proportional Mix[1] |
|---|---|---|---|---|---|
| | | Operations – Closure | Ni Post-Closure (71%[1]) | Ni Post-Closure (29%[1]) | Post-closure |
| Sulphate | mg/L | 310 | | | |
| Zn | mg/L | 0.058 | | | |
| Thiosulfate | mg/L | - | | | |

Notes:

- no result reported, assumed to have a concentration of 0 mg/L

NC: "Not considered"

[1] Constituents other than nickel were not modelled in post-closure.

### D.4.2.6 Diffusion of Nickel from Stored Tailings Pore Water

The amount of diffusion added Ni each year during post-closure is calculated as follows:

$$Diffusion\ added\ Ni\ \left(\frac{mg}{L}\right) = \frac{Tailings\ volume\ contributing\ Ni\ from\ pore\ water\ (1905.4\ m^3) \times (2024\ process\ water\ Ni\ concentration\ \left(0.89\frac{mg}{L}\right) - pit\ water\ Ni\ concentration\ (\frac{mg}{L})}{cumulative\ water\ stored\ in\ pit\ (7{,}031{,}964\ m^3)}$$

The tailings active diffusion volume is calculated for the post-closure period by multiplying the tailings surface area (95,270 m$^2$) by an assumed 5 cm thickness of tailings over which all nickel would be lost each year to diffusion and the tailings porosity of 50%. This model conservatively assumes that all nickel in process water retained in the tailings within ever deeper 5 cm thick layers would continue to diffuse into the overlying Pit water.

The complete removal of nickel by diffusion from such a layer was calculated using Fick's First Law (Geller et al. 2012):

$$J_z = \frac{D°\,J}{F}\phi\frac{dC}{dz}$$

where:

Jz is the rate of arsenic flux across the Pit surface-water interface (mg /(cm$^2$ s))

D°J is the temperature-dependent diffusion coefficient of arsenic, assumed to be 6.23 x 10$^{-6}$ cm$^2$/s (Martin et al. 2003)

F is the formation factor (Manheim, 1970), assumed to be equal to 1

$\phi$ is the formation porosity, assumed to be 0.5 (consistent with tailings)

*d*C is the change in concentration across the Pit surface-water interface (mg/cm$^3$)

dz is the distance over which the change in concentration occurs, assumed to be 5 cm

The concentration gradient was calculated iteratively using the initial Ni Pit water concentration at post-closure (0.10 mg/L), and the initial Ni concentration of process water in the tailings (0.89 mg/L). These calculations demonstrated that diffusion would remove all nickel in a 5-centimeter-thick tailings layer initially containing process water.

## D.5.0 MODEL APPROACH

The WQM was run using PHREEQC Interactive (PHREEQCi) version 3.5.0 with a modified version of the minteq.v4 thermodynamic database that is well suited for modelling mining environments. This model assumes equilibrium conditions occur, which is an appropriate assumption given the annual modelling steps (annual average conditions are modelled). To incorporate thiosulfates, the master species of $S_2O_3^{-2}$ was added to this database. The equilibrium constants relating thiosulfate to other sulfate species were adjusted to negate the breakdown of thiosulfate and to model its abundance in the WQM's in a mass-conservative manner. Thiosulfate can be unstable and break down to sulfate and acidity, which can decrease water pH and may affect Pit water quality. However, this reaction is complex and the coding of it is outside the scope of this work.

For each step in the PHREEQC model, thermodynamic equilibrium is achieved with all aqueous species in the thermodynamic database and the speciation of the solution is obtained. Where specified, the input solution can also be brought into thermodynamic equilibrium with plausible mineral phases (that could form at atmospheric temperature and pressure) and atmospheric gases, thereby simulating the precipitation of secondary mineral phases. A list of the mineral assemblages that are brought into equilibrium with the solution that is obtained following mixing during every yearly timestep in the WQM's is shown in Table D-9.

As stated in Section D.2.0, adsorption was previously considered but had no effect on nickel concentration and therefore not modelled in this scenario.

**Table D-9: Mineral Assemblages and Compounds Considered in the WQM**

| Name | Ideal Mineral Formula |
|---|---|
| Gibbsite | $Al(OH)_3$ |
| Otavite | $CdCO_3$ |
| Malachite | $Cu_2(OH)_2CO_3$ |
| Azurite | $Cu_3(OH)_2(CO_3)_2$ |
| Ferrihydrite | $Fe(OH)_3$ |
| Siderite | $FeCO_3$ |
| Melanterite | $FeSO_4$ $7H_2O$ |
| Rhodochrosite | $MnCO_3$ |
| Birnessite | $MnO_2$ |
| Manganite | MnOOH |
| Zinc hydroxide | $Zn(OH)_2$ |
| Smithsonite | $ZnCO_3$ |
| Goslarite | $ZnSO_4 \cdot 7H_2O$ |
| Gypsum | $CaSO_4 \cdot 2H_2O$ |
| Calcite | $CaCO_3$ |

| Name | Ideal Mineral Formula |
|---|---|
| Magnesite | $MgCO_3$ |
| Barite | $BaSO_4$ |
| Fluorite | $CaF_2$ |
| Cobalt carbonate | $CoCO_3$ |
| Cerussite | $PbCO_3$ |
| Chromite | $FeCr_2O_4$ |
| Nickel hydroxide | $Ni(OH)_2$ |
| Copper hydroxide | $Cu(OH)_2$ |

The calculation steps for the closure and post-closure periods are summarized as follows:

**Closure Period (Pit Flooding)**

1) Each of the source terms listed in Table D-2, with the water qualities outlined in the tables of Section D.4.0, is brought to thermodynamic equilibrium with the modified minteq.v4 thermodynamic database.

2) The source terms are mixed according to the proportions of total pit inflow determined in the water balance, using the method described in Section D.4.1 to obtain the Pit water quality prior to secondary mineral phase precipitation.

3) The Pit water quality is allowed to equilibrate with the minerals listed in Table D-9 and with $CO_2$ (gas).

4) Steps 2 and 3 describe the closure period (pit flooding); they are repeated for each year of the model until the end of the closure period, which is defined as the year during which the Expo Pit water level reaches EL. 535.4 m.

**Post Closure Period**

5) The Pit water Ni concentration supplied to the pit is calculated during post-closure on a yearly timestep as follows:

$$Pit\ water\ Ni\ concentration\ \left(\frac{mg}{L}\right) = \frac{\left(\begin{array}{c} pit\ water\ Ni\ concentration\ \left(previous\ year, \frac{mg}{L}\right) \times cumulative\ water\ stored\ in\ pit\ (7{,}031{,}964\ m^3) + \\ yearly\ natural\ inflow\ average\ Ni\ concentration\ \left(\frac{mg}{L}\right) \times yearly\ natural\ inflow\ (355{,}903\ m^3) \end{array}\right)}{yearly\ natural\ inflow\ (355{,}903\ m^3) + cumulative\ water\ stored\ in\ pit\ (7{,}031{,}964\ m^3)} + diffusion\ added\ Ni\ \left(\frac{mg}{L}\right)$$

where the yearly natural inflows average Ni concentration is calculated as follows:

$$Yearly\ natural\ inflow\ average\ Ni\ concentration\ \left(\frac{mg}{L}\right) = \frac{\left(\begin{array}{c} pit\ wall\ runoff\ Ni\ concentration\ \left(2.62\ \frac{mg}{L}\right) \times (yearly\ pit\ wall\ runoff\ inflow\ (9{,}223\ m^3)\ +\ 0.01\ \times \\ (yearly\ snow\ melt\ pit\ contact\ water\ (209{,}090\ m^3)\ )\ +\ yearly\ natural\ ground\ runoff\ average\ Ni\ concentration\ \left(0.007\ \frac{mg}{L}\right) \\ \times\ yearly\ natural\ ground\ runoff\ inflow\ (62{,}089\ m^3) \end{array}\right)}{yearly\ natural\ inflow\ (355{,}903\ m^3)}$$

6) The water hardness is assumed to be maintain at 400 mg/L $CaCO_3$ equivalent by CRI using engineering controls until the end of 2056. Subsequent Pit water hardness is calculated as being diluted with a yearly natural inflow volume of 355,903 $m^3$, assumed to have a hardness of 0 mg/L, flowing into a full Pit lake containing 7,031,964 $m^3$ of water.

## D.5.1 Water Quality Model Assumptions

The following sections outline the assumptions that were developed for the purposes of completing the WQM.

- The source term water quality and chemical loading inputs adequately represent each input sources and will continue to be representative in the future.
- Measured water quality constituents with concentrations less than the analytical detection limit were conservatively assumed to be have constituent concentrations equal to the detection limit.
- The concentrations of constituents considered in source terms that were not analyzed for, but considered in the model, were assumed to be 0 mg/L. Select elements of interest including Ni and Cu had input values for all inflows. Input values for selenium are not present for all inflows and could therefore be underestimated. Thiosulfate values are only available for tailings process water but are not expected to be elevated in other source terms. Concentrations of constituents of interest in the source terms are shown in Annex D-1, Table D-1 and input values equal to zero indicate input values for which concentrations were not available. These missing input values are expected to have low concentrations and not significantly affect model results.
- Minerals that precipitate in each modelled yearly time step are assumed to settle out of the water column at the bottom of the Pit and are brought to geochemical equilibrium with subsequent inflows, allowing them to re-solubilize in water.
- There is complete mixing of all water sources in the Expo Pit; no stratification develops.
- Groundwater inflows to the Expo Pit are assumed to be negligible because the Pit is fully contained in permafrost. It is assumed that upon flooding and in post-closure, permafrost melt from the presence of open water is not significant to the point of opening access to the sub-permafrost aquifer.
- Modelled solutions were equilibrated with atmospheric $CO_2$ concentrations but not oxygen as this would result in thiosulfate dissociation and potentially unrealistic decreases in pH prior to flooding with Lac Bombardier water. Therefore, modelled solutions are not as well oxygenated as might be encountered in the open Pit.
- The water temperature of all inputs is calculated to be 5 degrees Celsius (°C).
- The climactic conditions are assumed to persist indefinitely and do not account for climate change. Over the long term and in post-closure, climatic conditions are assumed to converge to average conditions.
- The model simulates dissolved constituent concentrations, not total concentrations. Total suspended solids (TSS) are not considered. If elevated, TSS can impart dissolved chemical mass to water. This process is not modelled.
- The model is run on a yearly timestep and does not consider month to month variabilities in geochemical concentrations. Potential for dilution from high flow of spring freshet, potential for evapo-concentration from

mid summer dry conditions and cryo-concentration under ice in winter are likely to affect water quality resulting in concentrations that can vary from the annual average concentrations predicted.

- The concentrations of thiosulfates were modelled using a mass balance approach and did not consider any geochemical reactions that may involve thiosulfates. The breakdown of thiosulfate species may result in pH changes in the Pit water. The commitment by CRI to adjusting the Pit water hardness may result in pH increases counteracting this effect.
- The model reflects anticipated conditions proposed by CRI and the results of the water quality prediction are estimates rather than precise values, which are based on the current site knowledge, anticipated closure conditions stated in this report, CRI commitment, and reasonable assumptions stated.

## D.6.0 RESULTS

Water quality model results for the flooded Expo Pit are presented in Annex D-1 Tables D1-1 and D1-2 in units of mg/L. Model prediction results were compared to the CVAC (critères provinciaux de protection de la vie aquatique, effets chroniques) provincial water quality guidelines for a water hardness of 400 mg/L $CaCO_3$ equivalent associated with each input and are also shown in Annex D-1. A summary of the most relevant results for the operations and closure periods, and the predicted nickel content of post-closure period flooded water quality is presented in Table D-10.

The concentration of dissolved nickel in Expo Pit water at closure when the Pit water level reaches 535.4 m is predicted to be on the order of 0.15 mg/L, the concentration when the Pit water hardness stops being maintained in 2057 is 0.11 mg/L, and the concentration at the end of the model in year 2071 is predicted to be in the order of 0.10 mg/L. The nickel concentration is below the CVAC nickel limit for a water hardness of 400 mg/L $CaCO_3$ equivalent during closure from year 2033 after process water is removed and during the entire post-closure period until year 2069. These concentrations are annual averages that vary depending on climactic conditions and are subject to uncertainties on the input parameters previously stated in Section D.5.1.

The CVAC nickel criterion is hardness dependent. For a water hardness of 10 mg/L $CaCO_3$ equivalent (the lowest that can be considered under CVAC guidelines) the CVAC nickel criterion is 0.007 mg/L. The Pit water hardness will be maintained at 400 mg/L $CaCO_3$ equivalent until 2056 to allow for the maximum CVAC nickel criteria of 0.169 mg/L. From 2057 onwards dilution with natural inflows is expected to decrease the water hardness significantly which would also decrease the CVAC limit for nickel.

During the post-closure period a calculated total yearly inflow of natural inputs of 355,903 $m^3$ is assumed to dilute the Pit water and excess water is assumed to overflow the Pit. This overflow has calculated nickel concentrations below the applicable CVAC guidelines for the time period considered during the model (Figure D-2, Annex D-1 Table D1-2).

The pH of the Pit water is predicted to remain circum-neutral, ranging from 7.0 to 7.3 while process water remains in the Pit; it is dominated by the pH of process water. This water is removed prior to flooding. Upon flooding of the Pit with lake Bombardier water, the pH of the flooding Pit is predicted to reach 6.2.

Sulfate and thiosulfate concentrations during the operations and closure periods follow a similar trend with high concentrations of both species present during operations and the beginning of closure when loadings from mill effluent process water and tailings pond waters containing elevated levels of the two species are present and subsequently decreasing as a result of the removal of the free tailings water and the addition of Lac Bombardier water. The effect of tailings process water removal can be seen when examining the minimum concentrations of these species, which fall below 100 mg/L at that time.

The trends for pH as well as nickel, copper, and selenium concentrations are shown in Figure D-2. and the trend in nickel concentrations is discussed in Sections D.6.2. Results for Pit water selenium concentrations are also presented as selenium concentrations are predicted to briefly exceed the CVAC selenium limit during operations as a result of elevated selenium concentrations in tailings pond water and process water. This exceedance is limited to a short period (fewer than three years) when no discharge occurs. Selenium concentrations decrease steadily once natural runoff or precipitation inflows dilute the Pit water.

The mineral assemblage found to precipitate in this model is gibbsite ($Al(OH)_3$), ferrihydrite ($Fe(OH)_3$), birnessite ($MnO_2$), and barite ($BaSO_4$). The precipitated minerals were allowed to redissolve if the phases became unsaturated in the flooded Pit waters in subsequent years. As a result, the re-dissolution of all the afore mentioned minerals apart from ferrihydrite is observed.

### D.6.1 Constituents exceeding criteria other than nickel

As shown in Table D-10, the two main constituents that exceed applicable CVAC guidelines within the model are silver and nickel; selenium exceedance is limited to two years prior to the removal of process water, whereas silver exceedances are an artefact of using the analytical detection limit value in mill effluent process water and tailings pond water having below detection concentration in site data. The analytical detection limit for silver (0.001 mg/L) is greater than the CVAC silver guideline (0.0001 mg/L). Further analyses of these samples with an analytical technique providing greater precision would be necessary to determine if silver could exceed applicable guidelines in these samples. Following the completion of process water removal from the Pit, silver, selenium and nickel exceedances are not observed, provided a hardness of 400 mg/L $CaCO_3$ equivalent is maintained until 2056

**Table D-10: Water Quality Model Results for Operations and Closure**

| Stage | Period | Description | Predicted Ni Range (mg/L) | Hardness (mg/L) | pH Range | Sulphate Range (mg/L) | Thiosulfate Range (mg/L) | Parameters > CVAC[1] | Predicted Mineral Precipitation |
|---|---|---|---|---|---|---|---|---|---|
| Operations | 06-2021 to 10-2024 | Pumping from Cell 2, tailings deposition | 0.85-0.87 | 400 | 7.2-7.3 | 670-1000 | 1200-1900 | Ag[2], Ni, Se | gibbsite, ferrihydrite, birnessite, barite |
| Closure | 11-2024 to 09-2030 | Process water removal | 0.85-1.0 | | 7.0-7.2 | 180-760 | 220-1400 | Ag[2], Ni | |
| | 10-2030 to 01-2035 | Pit flooding using Lac Bombardier | 0.15-0.18 | | 6.2 | 18-36 | 14-45 | - | |
| Post-Closure | 02-2035 to 12-2056 | Natural dilutive inflows, hardness maintained | 0.11-0.14 | | NC | NC | NC | - | NC |
| | 01-2057 to 12-2070 | Natural dilutive inflows, hardness not maintained | 0.10-0.11 | Decreasing to 200 | | | | - | |

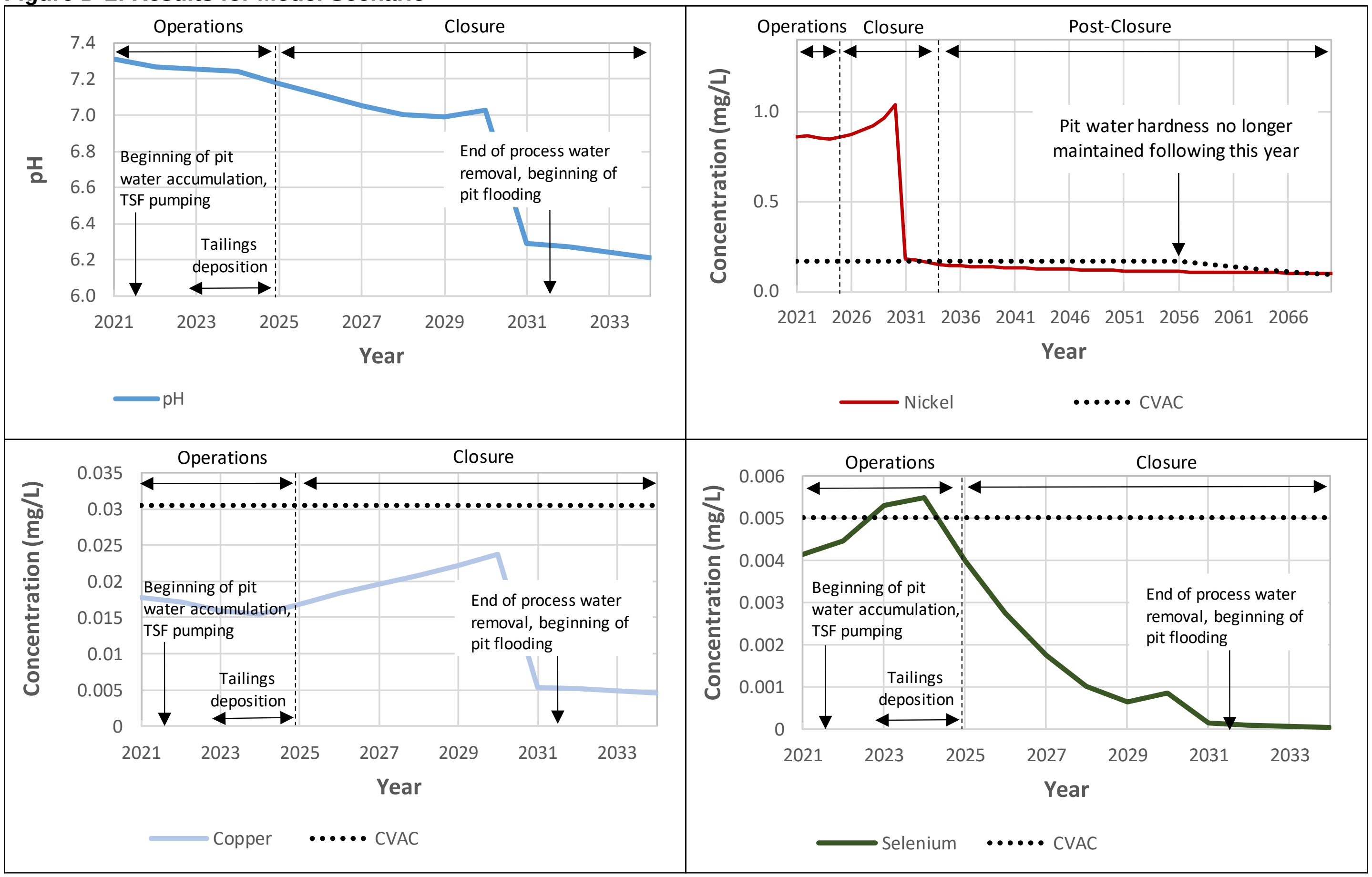
Notes:

NC: “not considered”

[1] Provincial surface water criteria for the protection of aquatic life, chronic effects (critères de protection de la vie aquatique, effets chroniques; CVAC), (MEF 1998; 2019 version). Only parameter considered during post-closure is nickel.

[2] Source term detection limits for process water and TSF silver analyses (0.001 mg/L) are above the silver CVAC guideline (0.0001 mg/L)

**Figure D-2: Results for Model Scenario**




Notes:

1. CVAC limits shown in figures are for a water hardness of 400 mg/L CaCOR3R equivalent except from 2057 onwards.
2. The concentration minima at year 2031 correspond to September 2030 when all process water has been removed. The yearly timestep in the model was adjusted to match the removal of process water.

## D.6.2 Nickel concentrations at closure

The nickel concentration at the end of closure is predicted to be on the order of 0.15 mg/L, below the 0.169 mg/L Ni CVAC limit for a hardness of 400 mg/L $CaCO_3$ equivalent. The removal of process water causes a sharp drop in Pit water nickel concentrations from 1.0 mg/L Ni in 2030 to 0.18 mg/L Ni in 2031. The main contributor to the nickel loading at the end of closure (2031-2034) is Pit wall runoff. Accelerated flooding from Lac Bombardier significantly reduces the time necessary to fill the Pit to four and a half years, thereby reducing the amount of Pit wall runoff contributing to the nickel loading at the end of closure. Treating water during the end of closure was found to be ineffective at reducing the Pit water nickel concentrations as reductions in the nickel loading due to treatment are offset by increases in the nickel loading due to an extended period of Pit wall exposure.

## D.6.3 Evolution of nickel concentration in Pit water post-closure

The chemical loads from the Pit wall runoff and natural runoff source terms during post-closure are assumed to be reduced from those during operations and closure as discussed in Sections D.4.2.2 and D.4.2.5. The Pit wall runoff is predicted to contribute 2.6 mg/L Ni to the Pit water and the natural runoff, 0.007 mg/L Ni in perpetuity post closure. These sources of water represent 20.6% of total annual inflows to the Pit (highwall runoff and snowmelt 3.2%, and natural ground runoff 17%, respectively) with the remaining 79% of the natural inflows predicted to having no chemical load (precipitation and remainder of snow melt). Together, the annual inflows to the Pit average a concentration of 0.085 mg/L Ni. As the nickel concentration at the beginning of post-closure is 0.11 mg/L the Pit water nickel concentration remains virtually unchanged during post-closure, only decreasing slightly, as shown in Figure D-2. This result falls below the CVAC limit while the water hardness is maintained at 400 mg/L. However, were the water hardness allowed to fall below ~200 mg/L, the Pit water quality would no longer meet the CVAC limit.

The nickel concentration of the Pit water is predicted to increase by 0.00027 mg/L on a yearly basis due to diffusion. This chemical loading slows the rate at which nickel concentrations are diluted by the natural inflow water quality but this contribution is not sufficient to significantly affect the Pit water quality. In the absence of diffusion added nickel, Pit water nickel concentrations are predicted to be 0.0105 mg/L at year 2056 rather than the 0.109 mg/L with diffusion in the current model. This diffusion estimate is also conservative in that it assumes equal amounts of nickel will be extractable from the tailings on a yearly basis despite the nickel being sourced from ever deeper portion of the tailings pile. Given the negligible effect to flooded Pit water quality by diffusion of nickel from the process water, covering of the tailings prior to flooding is not deemed to be noticeably advantageous to water quality.

The Pit water nickel concentration during post-closure is highly sensitive to the input nickel concentrations of the Pit wall runoff and the natural runoff. In consideration of the uncertainty associated with these input values and the commitments to nickel source term control by CRI, monitoring of Pit wall contact water quality and natural runoff water quality will be necessary to validate the predictions. Should nickel or other element concentrations be higher than assumed herein, this is likely to affect the long-term Pit water quality.

## D.7.0 RISK AND OPPORTUNITIES

The WQM included poor-end source terms that predict Pit water qualities during the operations, closure, and post-closure periods according to the assumptions described in this report. This model was built to replicate the closure scenario and CRI commitments described herein and uses reasonable input parameters and assumptions to describe anticipated future conditions yielding the predicted water quality. Notwithstanding this, model uncertainties related to the following could lead to different water quality and possible additional guideline exceedances than those predicted in this report:

- The nickel concentrations in Pit wall runoff remain the largest mass load uncertainty in the WQM. Historical nickel concentration measured in Pit sump measurements have varied widely which CRI expects is due to the presence of ore stockpiles in the open Pit and exposure to Pit contact water. The input value selected for this model assumes that contribution from exposed ore material and particulate matter will be less during closure and will be minimal in post-closure such that post-closure runoff quality would be similar to contact water quality from waste rock HCT's previously completed. Should nickel concentrations in Pit wall runoff be higher than expected due to continued exposure of ore material in the Pit walls, nickel concentrations in the Pit water may increase significantly.
- It is currently assumed that nickel concentrations in the natural runoff will be maintained at 0.169 mg/L Ni or lower during operations and closure, and will be further decreased to 0.007 mg/L Ni (the CVAC nickel limit at 10 mg/L $CaCO_3$ equivalent hardness) during post-closure based on a commitment by CRI to use engineering controls to achieve these nickel concentrations in natural runoff to the open Pit. If these concentrations cannot be achieved, this input would have to be re-evaluated and nickel concentrations in the Pit water would need to be re-evaluated.
- The water hardness will be maintained by CRI at 400 mg/L $CaCO_3$ equivalent in the Pit water until 2056. If the water hardness could not be maintained, the CVAC limit would be lower than predicted and Pit water nickel concentrations would exceed the limit.
- The WQM assumes that the Expo Pit is found within continuous permafrost and that no groundwater or seepage flows into the Pit. If this were to change, the inflows to the Pit would have to be re-examined.

## D.8.0 RECOMMENDATIONS

On the basis of the results presented in this appendix the following investigations are suggested in order to decrease uncertainties identified:

- Meeting the nickel CVAC guidelines is dependent upon the Pit water hardness, as shown in Figure D-2. An evaluation of site-specific criteria for nickel may be considered to further assess the need to maintain this hardness level.
- The Pit will be filled using water pumped from Lac Bombardier over a four-year period from 2030 to 2034. Direct measurements of the Pit water quality during this time could be compared to those from the model in this report to verify the model's accuracy. Any discrepancies in the observed concentrations could be evaluated in order to adjust the model and/or closure methods to ensure that the Expo pit flood waters meet the required concentration limits for nickel and all other constituents. In-situ monitoring during the closure period would allow validation of the long-term steady state concentration trends in the Pit water the effectiveness of the mitigation strategies outlined in this report.
- Additional investigation into current and probable future Pit wall runoff should be undertaken to decrease the uncertainty of this WQM input. One means to obtain additional information includes additional wall washing stations and leachate analyses on older rock exposures and rock exposures having various sulphide mineral content to document the effect of these variables on contact water quality.

- The impact of thiosulfates on Pit water quality, particularly during operations and during the early stages of closure could be refined using more detailed site information on their degradation rate in process water (which are site specific) and/or using ageing tests that would measure in-situ changes in water quality arising from the mixing of process water, tailings pond water, and natural inflows. The long-term effect of thiosalts in process water is considered negligible since the process water will be removed prior to flooding and alkalinity will be controlled in the open pit.

## D.9.0 REPORT LIMITATIONS

This report was prepared for the exclusive use of Canadian Royalties Inc. The report, which specifically includes all tables, figures and appendices, is based on data gathered by Golder Associates Ltd., and information provided to Golder Associates Ltd. by others. The information provided by others has not been independently verified or otherwise examined by Golder Associates Ltd. to determine the accuracy or completeness. Golder Associates Ltd. has relied in good faith on this information and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the information as a result of omissions, misinterpretation or fraudulent acts of the persons who provided the information. Golder Associates Ltd. shall not be held responsible for damages resulting from unpredictable or unknown Pit conditions, from erroneous information provided by and/or obtained from sources other than Golder Associates Ltd., and from ulterior changes in the site conditions unless Golder Associates Ltd. has been notified by Canadian Royalties Inc. of any occurrence, activity, information or discovery, past or future, which would modify the Pit conditions described herein, and have had the opportunity of revising its interpretations and comments. Golder Associates Ltd. shall not be held responsible for damages resulting from any future modification to the applicable regulations, standards and criteria. Any use of this report and its content by a third party is the responsibility of such third party. Golder Associates Ltd. shall not be held responsible for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

The WQM described herein is designed to provide a reasonably conservative forecast of annual average water quality. However, in natural systems and complex man-made systems, observed conditions (particularly seasonally and daily) will almost certainly vary with respect to estimated conditions. Water quality modelling requires the use of many assumptions due to the uncertainty related to determining the physical and geochemical characteristics of a complex system. The prediction of water quality is based on several inputs, all of which have inherent variability and uncertainty. Given all the inherent uncertainties, the results of the WQM should be used as a tool to aid in the design of closure planning, to develop mitigation strategies, and to outline potential risks rather than to provide absolute concentrations. Concentrations provided should be viewed as orders of magnitude estimates rather than absolute values. As such, concentrations of constituents that are slightly above or below a criterion may or may not exceed that criterion on average or at a more discrete time step (monthly, weekly, daily).

In addition, the solubility controls imposed by equilibrium reactions consider the saturation state of the selected mineral phases and only indicate which reactions are possible thermodynamically, not necessarily which reactions are likely to occur in the environment. Kinetic barriers may inhibit many mineral precipitation reactions from taking place. Furthermore, significant uncertainty remains for the chemistries of certain source terms, particularly Pit wall runoff.

The services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and geoscience professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the findings of this report, and to provide amendments as required.

This report provides a professional opinion in light of the information available at the time of this report and therefore no warranty is either expressed, implied, or made as to the conclusions, advice or recommendations offered in this report.

## D.10.0 CONCLUSIONS

A predictive assessment of water quality at the Expo Pit was made on an average yearly timestep using a model that considers an average climate, no tailings cover, and accelerated Pit flooding, and assuming the closure scenario and CRI commitments described herein.

Results of modelling suggest that no constituents are predicted to exceed CVAC guidelines at the end of the closure period and most of post-closure provided Pit water hardness is maintained at 400 mg/L CaCO3 equivalent until at least 2056, well into post-closure.

The water quality of Pit wall and natural runoff remain the largest uncertainties in accurately predicting Expo Pit water qualities and current modelling demonstrates the potential usefulness of developing site-specific CVAC water quality limits. Furthermore, the results of this model are dependent upon the success of engineering controls and activities proposed by CRI to reduce chemical loadings to the Pit from what site water quality data demonstrates at the time of modelling. Additional site information would assist in refining these input parameters and therefore, in the accuracy and certainty of the water quality forecast.

## D.11.0 CLOSURE

The reader is referred to the Model Limitations and Uncertainty section, which forms Section D.9.0 and is an integral part of this report. We trust that the information in this appendix meets your current requirements. Please contact the undersigned with questions or comments.

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https://golderassociates.sharepoint.com/sites/104972/project files/5 technical work/3000 - expo in-pit disposal/04_rev 2/appd_waterquality/appd_waterquality.docx

Annexes:
Annex D-1: WQM Inflows and Results

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**ANNEX D-1**

# *WQM Inflows and Results*

Appendix D-1 Table D1-1
Scenario Inflows
CRI - Expo Pit, Quebec

| Parameter | Units | Directive 019 Average Monthly[1] | Directive 019 Maximum Acceptable[1] | CVAC[2] | Inflow water quality: Precipitation | Natural Ground Runoff | TSF Water 2021 | TSF Water 2022 | TSF Water 2023 | TSF Water 2024 | Process Water 2022 | Process Water 2023 | Expo East Pit Sump |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | - | 6.0 to 9.5 | *6.0 to 9.5* | - | 5.1 | 7.0 | 7.1 | 6.9 | 6.9 | 6.9 | 6.8 | 6.8 | 4.5 |
| Alkalinity | mg/L $CaCO_3$ | - | - | - | 0 | 10 | 11 | 10 | 10 | 10 | 10 | 10 | 14 |
| Silver | mg/L | - | - | **0.0001** | 0 | 0 | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | 0 |
| Aluminum | mg/L | - | - | **0.087** | 0 | 0.019 | 0.03 | 0.021 | 0.021 | 0.021 | 0.021 | 0.021 | **0.29** |
| Arsenic | mg/L | 0.2 | *0.4* | **0.15** | 0 | 0.0010 | 0.00033 | 0.00021 | 0.00021 | 0.00021 | 0.0002 | 0.0002 | 0.0010 |
| Barium | mg/L | - | - | **1.9** | 0 | 0.002 | 0.15 | 0.21 | 0.21 | 0.21 | 0.29 | 0.29 | 0 |
| Calcium | mg/L | - | - | - | 0.15 | 1.0 | 954 | 1245 | 1245 | 1245 | 1681 | 1681 | 15 |
| Cadmium | mg/L | - | - | **0.00076** | 0 | 0.00003 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0 |
| Chloride | mg/L | - | - | - | 0.10 | 0.5 | 928 | 1256 | 1256 | 1256 | 1719 | 1719 | 36 |
| Cobalt | mg/L | - | - | **0.1** | 0 | 0.0001 | 0.031 | 0.042 | 0.042 | 0.042 | 0.058 | 0.058 | **0.21** |
| Chromium | mg/L | - | - | **0.011** | 0 | 0 | 0.0013 | 0.00092 | 0.00092 | 0.00092 | 0.00094 | 0.00094 | 0.005 |
| Copper | mg/L | 0.3 | *0.6* | **0.031** | 0 | 0.016 | 0.011 | 0.011 | 0.011 | 0.011 | 0.014 | 0.014 | **0.1** |
| Iron | mg/L | 3 | *6* | **1.3** | 0 | **1.3** | 0.18 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | **1.9** |
| Mercury | mg/L | - | - | **0.00091** | 0 | 0 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0 |
| Nickel | mg/L | 0.5 | *1* | **0.169** | 0 | 0.17 | **0.59** | **0.69** | **0.69** | **0.69** | **0.89** | **0.89** | **4.7** |
| Lead | mg/L | 0.2 | *0.4* | **0.019** | 0 | 0.00052 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |
| Sulphate | mg/L | - | - | - | 0.82 | 7.6 | 922 | 1167 | 1167 | 1167 | 1556 | 1556 | 310 |
| Selenium | mg/L | - | - | **0.005** | 0 | 0 | **0.006** | **0.0065** | **0.0065** | **0.0065** | **0.0082** | **0.0082** | 0 |
| Zinc | mg/L | 0.5 | *1* | **0.39** | 0 | 0.022 | 0.0026 | 0.0019 | 0.0019 | 0.0019 | 0.002 | 0.002 | 0.058 |
| Thiosulfate | mg/L | - | - | - | 0 | 0 | 1686 | 2165 | 2165 | 2165 | 2903 | 2903 | 0 |

**Notes:**
CVAC criteria applies only to the final closure year and was calculated using a maximum hardness value of 400 mg/L $CaCO_3$.

(1) Directive 019 Guidelines for the mining industry for average monthly discharge (MDDELCC 2012)

(2) Des critères de protection de la vie aquatique effets chronique (CVAC) - Surface water criteria for the protection of aquatic life, chronic effects (MEF 1998; 2019 version)

**Simulated water quality:**

| **Parameter** | **Units** | Directive 019 Average Monthly[1] | Directive 019 Maximum Acceptable[1] | **CVAC[2]** | Year 2021 | Year 2022 | Year 2023 | Year 2024 | Year 2025 | Year 2026 | Year 2027 | Year 2028 | Year 2029 | Year 2030 | Year 2031 | Year 2032 | Year 2033 | Year 2034 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | - | 6.0 to 9.5 | *6.0 to 9.5* | - | 7.3 | 7.3 | 7.3 | 7.2 | 7.2 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 6.3 | 6.3 | 6.2 | 6.2 |
| Alkalinity | mg/L $CaCO_3$ | - | - | - | 8.9 | 8.3 | 8.3 | 8.1 | 6.7 | 5.5 | 4.6 | 3.9 | 3.7 | 4.1 | 0.68 | 0.64 | 0.59 | 0.54 |
| Silver | mg/L | - | - | **0.0001** | **0.0007** | **0.00069** | **0.00074** | **0.00074** | **0.00054** | **0.00037** | **0.00024** | **0.00013** | 0.000083 | **0.00011** | 0.000016 | 0.0000097 | 0.0000066 | 0.000005 |
| Aluminum | mg/L | - | - | **0.087** | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0022 | 0.0022 | 0.0023 | 0.0023 | 0.0022 | 0.0052 | 0.0053 | 0.0056 | 0.0058 |
| Arsenic | mg/L | 0.2 | *0.4* | **0.15** | 0.00038 | 0.00031 | 0.00027 | 0.00025 | 0.00028 | 0.0003 | 0.00032 | 0.00034 | 0.00036 | 0.00038 | 0.00088 | 0.00086 | 0.00085 | 0.00085 |
| Barium | mg/L | - | - | **1.9** | 0.0089 | 0.0087 | 0.0083 | 0.0082 | 0.0088 | 0.0096 | 0.011 | 0.012 | 0.013 | 0.012 | 0.035 | 0.043 | 0.05 | 0.057 |
| Calcium | mg/L | - | - | - | 665 | 807 | 1026 | 1087 | 791 | 546 | 349 | 201 | 131 | 177 | 27 | 17 | 11.7 | 8.9 |
| Cadmium | mg/L | - | - | **0.00076** | 0.00014 | 0.00014 | 0.00015 | 0.00015 | 0.00011 | 0.000077 | 0.000051 | 0.000031 | 0.000021 | 0.000026 | 0.0000041 | 0.0000029 | 0.0000024 | 0.000002 |
| Chloride | mg/L | - | - | - | 649 | 807 | 1039 | 1106 | 806 | 557 | 358 | 207 | 137 | 185 | 28 | 18 | 12.6 | 9.6 |
| Cobalt | mg/L | - | - | **0.1** | 0.041 | 0.045 | 0.048 | 0.049 | 0.046 | 0.044 | 0.043 | 0.042 | 0.043 | 0.047 | 0.0081 | 0.0077 | 0.007 | 0.0063 |
| Chromium | mg/L | - | - | **0.011** | 0.0014 | 0.0012 | 0.001 | 0.00098 | 0.00096 | 0.00095 | 0.00095 | 0.00097 | 0.001 | 0.0011 | 0.00019 | 0.00018 | 0.00016 | 0.00015 |
| Copper | mg/L | 0.3 | *0.6* | **0.031** | 0.018 | 0.017 | 0.016 | 0.015 | 0.017 | 0.018 | 0.02 | 0.021 | 0.022 | 0.024 | 0.0053 | 0.0052 | 0.0049 | 0.0046 |
| Iron | mg/L | 3 | *6* | **1.3** | 0.0011 | 0.0013 | 0.0013 | 0.0014 | 0.0015 | 0.0017 | 0.0019 | 0.0021 | 0.0021 | 0.002 | 0.01 | 0.01 | 0.011 | 0.012 |
| Mercury | mg/L | - | - | **0.00091** | 0.00007 | 0.000069 | 0.000074 | 0.000074 | 0.000054 | 0.000037 | 0.000024 | 0.000013 | 0.0000083 | 0.000011 | 0.0000016 | 0.00000097 | 0.00000066 | 0.0000005 |
| Nickel | mg/L | 0.5 | *1* | **0.169** | **0.86** | **0.87** | **0.86** | **0.85** | **0.86** | **0.87** | **0.89** | **0.92** | **0.97** | **1.0** | **0.18** | **0.18** | 0.16 | 0.15 |
| Lead | mg/L | 0.2 | *0.4* | **0.019** | 0.00042 | 0.00041 | 0.00042 | 0.00042 | 0.00035 | 0.0003 | 0.00026 | 0.00023 | 0.00021 | 0.00023 | 0.000041 | 0.000039 | 0.000037 | 0.000035 |
| Sulphate | mg/L | - | - | - | 671 | 788 | 977 | 1028 | 764 | 544 | 369 | 238 | 178 | 223 | 36 | 27 | 21 | 18 |
| Selenium | mg/L | - | - | **0.005** | 0.0041 | 0.0045 | **0.0053** | **0.0055** | 0.004 | 0.0027 | 0.0018 | 0.0010 | 0.00064 | 0.00085 | 0.000128 | 0.000079 | 0.000054 | 0.000041 |
| Zinc | mg/L | 0.5 | *1* | **0.39** | 0.0083 | 0.0075 | 0.006 | 0.0055 | 0.0079 | 0.0099 | 0.012 | 0.013 | 0.014 | 0.015 | 0.0027 | 0.0027 | 0.0026 | 0.0024 |
| Thiosulfate | mg/L | - | - | - | 1173 | 1407 | 1779 | 1882 | 1368 | 942 | 601 | 343 | 222 | 300 | 45 | 28 | 19 | 14 |

**Notes:**

CVAC criteria applies only to the final closure year and was calculated using a maximum hardness value of 400 mg/L $CaCO_3$.

(1) Directive 019 Guidelines for the mining industry for average monthly discharge (MDDELCC 2012)

(2) Des critères de protection de la vie aquatique effets chronique (CVAC) - Surface water criteria for the protection of aquatic life, chronic effects (MEF 1998; 2019 version)

| Parameter | Units | Directive 019 Average Monthly[1] | Directive 019 Maximum Acceptable[1] | CVAC[2] | Year 2035 | Year 2036 | Year 2037 | Year 2038 | Year 2039 | Year 2040 | Year 2041 | Year 2042 | Year 2043 | Year 2044 | Year 2045 | Year 2046 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | |
| pH | - | 6.0 to 9.5 | *6.0 to 9.5* | - | | | | | | | | | | | | |
| Alkalinity | mg/L $CaCO_3$ | - | - | - | | | | | | | | | | | | |
| Silver | mg/L | - | - | **0.0001** | | | | | | | | | | | | |
| Aluminum | mg/L | - | - | **0.087** | | | | | | | | | | | | |
| Arsenic | mg/L | 0.2 | *0.4* | **0.15** | | | | | | | | | | | | |
| Barium | mg/L | - | - | **1.9** | | | | | | | | | | | | |
| Calcium | mg/L | - | - | - | | | | | | | | | | | | |
| Cadmium | mg/L | - | - | **0.00076** | | | | | | | | | | | | |
| Chloride | mg/L | - | - | - | | | | | | | | | | | | |
| Cobalt | mg/L | - | - | **0.1** | | | | | | | | | | | | |
| Chromium | mg/L | - | - | **0.011** | | | | | | | | | | | | |
| Copper | mg/L | 0.3 | *0.6* | **0.031** | | | | | | | | | | | | |
| Iron | mg/L | 3 | *6* | **1.3** | | | | | | | | | | | | |
| Mercury | mg/L | - | - | **0.00091** | | | | | | | | | | | | |
| Nickel | mg/L | 0.5 | *1* | **0.169** | 0.14 | 0.14 | 0.14 | 0.14 | 0.13 | 0.13 | 0.129 | 0.127 | 0.126 | 0.124 | 0.122 | 0.121 |
| Lead | mg/L | 0.2 | *0.4* | **0.019** | | | | | | | | | | | | |
| Sulphate | mg/L | - | - | - | | | | | | | | | | | | |
| Selenium | mg/L | - | - | **0.005** | | | | | | | | | | | | |
| Zinc | mg/L | 0.5 | *1* | **0.39** | | | | | | | | | | | | |
| Thiosulfate | mg/L | - | - | - | | | | | | | | | | | | |

**Notes:**

CVAC criteria applies only to the final closure year and was calculated using a maximum hardness value of 400 mg/L $CaCO_3$.

(1) Directive 019 Guidelines for the mining industry for average monthly discharge (MDDELCC 2012)

(2) Des critères de protection de la vie aquatique effets chronique (CVAC) - Surface water criteria for the protection of aquatic life, chronic effects (MEF 1998; 2019 version)

| Parameter | Units | Directive 019 Average Monthly[1] | Directive 019 Maximum Acceptable[1] | CVAC[2] | Year 2047 | Year 2048 | Year 2049 | Year 2050 | Year 2051 | Year 2052 | Year 2053 | Year 2054 | Year 2055 | Year 2056 | Year 2057 | Year 2058 | Year 2059 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | - | 6.0 to 9.5 | *6.0 to 9.5* | - | | | | | | | | | | | | | |
| Alkalinity | mg/L $CaCO_3$ | - | - | - | | | | | | | | | | | | | |
| Silver | mg/L | - | - | **0.0001** | | | | | | | | | | | | | |
| Aluminum | mg/L | - | - | **0.087** | | | | | | | | | | | | | |
| Arsenic | mg/L | 0.2 | *0.4* | **0.15** | | | | | | | | | | | | | |
| Barium | mg/L | - | - | **1.9** | | | | | | | | | | | | | |
| Calcium | mg/L | - | - | - | | | | | | | | | | | | | |
| Cadmium | mg/L | - | - | **0.00076** | | | | | | | | | | | | | |
| Chloride | mg/L | - | - | - | | | | | | | | | | | | | |
| Cobalt | mg/L | - | - | **0.1** | | | | | | | | | | | | | |
| Chromium | mg/L | - | - | **0.011** | | | | | | | | | | | | | |
| Copper | mg/L | 0.3 | *0.6* | **0.031** | | | | | | | | | | | | | |
| Iron | mg/L | 3 | *6* | **1.3** | | | | | | | | | | | | | |
| Mercury | mg/L | - | - | **0.00091** | | | | | | | | | | | | | |
| Nickel | mg/L | 0.5 | *1* | **0.169** | 0.119 | 0.118 | 0.116 | 0.115 | 0.114 | 0.113 | 0.112 | 0.111 | 0.11 | 0.109 | 0.108 | 0.107 | 0.106 |
| Lead | mg/L | 0.2 | *0.4* | **0.019** | | | | | | | | | | | | | |
| Sulphate | mg/L | - | - | - | | | | | | | | | | | | | |
| Selenium | mg/L | - | - | **0.005** | | | | | | | | | | | | | |
| Zinc | mg/L | 0.5 | *1* | **0.39** | | | | | | | | | | | | | |
| Thiosulfate | mg/L | - | - | - | | | | | | | | | | | | | |

**Notes:**

CVAC criteria applies only to the final closure year and was calculated using a maximum hardness value of 400 mg/L $CaCO_3$.

(1) Directive 019 Guidelines for the mining industry for average monthly discharge (MDDELCC 2012)

(2) Des critères de protection de la vie aquatique effets chronique (CVAC) - Surface water criteria for the protection of aquatic life, chronic effects (MEF 1998; 2019 version)

| Parameter | Units | Directive 019 Average Monthly[1] | Directive 019 Maximum Acceptable[1] | CVAC[2] | Year 2060 | Year 2061 | Year 2062 | Year 2063 | Year 2064 | Year 2065 | Year 2066 | Year 2067 | Year 2068 | Year 2069 | Year 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | - | 6.0 to 9.5 | *6.0 to 9.5* | - | | | | | | | | | | | |
| Alkalinity | mg/L $CaCO_3$ | - | - | - | | | | | | | | | | | |
| Silver | mg/L | - | - | **0.0001** | | | | | | | | | | | |
| Aluminum | mg/L | - | - | **0.087** | | | | | | | | | | | |
| Arsenic | mg/L | 0.2 | *0.4* | **0.15** | | | | | | | | | | | |
| Barium | mg/L | - | - | **1.9** | | | | | | | | | | | |
| Calcium | mg/L | - | - | - | | | | | | | | | | | |
| Cadmium | mg/L | - | - | **0.00076** | | | | | | | | | | | |
| Chloride | mg/L | - | - | - | | | | | | | | | | | |
| Cobalt | mg/L | - | - | **0.1** | | | | | | | | | | | |
| Chromium | mg/L | - | - | **0.011** | | | | | | | | | | | |
| Copper | mg/L | 0.3 | *0.6* | **0.031** | | | | | | | | | | | |
| Iron | mg/L | 3 | *6* | **1.3** | | | | | | | | | | | |
| Mercury | mg/L | - | - | **0.00091** | | | | | | | | | | | |
| Nickel | mg/L | 0.5 | *1* | **0.169** | 0.105 | 0.105 | 0.104 | 0.103 | 0.103 | 0.102 | 0.102 | 0.101 | 0.10 | 0.10 | 0.10 |
| Lead | mg/L | 0.2 | *0.4* | **0.019** | | | | | | | | | | | |
| Sulphate | mg/L | - | - | - | | | | | | | | | | | |
| Selenium | mg/L | - | - | **0.005** | | | | | | | | | | | |
| Zinc | mg/L | 0.5 | *1* | **0.39** | | | | | | | | | | | |
| Thiosulfate | mg/L | - | - | - | | | | | | | | | | | |

**Notes:**

CVAC criteria applies only to the final closure year and was calculated using a maximum hardness value of 400 mg/L $CaCO_3$.

(1) Directive 019 Guidelines for the mining industry for average monthly discharge (MDDELCC 2012)

(2) Des critères de protection de la vie aquatique effets chronique (CVAC) - Surface water criteria for the protection of aquatic life, chronic effects (MEF 1998; 2019 version)

**APPENDIX E**

# Thermal Analysis

# E.1.0 INTRODUCTION

Canadian Royalties Inc (CRI) is currently conducting a study to evaluate the feasibility of depositing tailings inside the Expo Pit, followed by flooding of the pit at the Nunavik Nickel Mine in northern Quebec. The initial deposition of warm tailings inside the pit will cause the permafrost adjacent to the pit to thaw, and subsequent flooding of the pit will lead to the formation of a 50 m deep pit lake on top of tailings that will also affect permafrost conditions.

This appendix presents the results of thermal modelling prepared to evaluate the effects of in-pit tailings deposition and subsequent pit flooding on the permafrost conditions during operation and for post-closure in the long term with considerations of climate change in the long term.

# E.2.0 SITE CONDITIONS

## E.2.1 Climate and Ground Temperature

The site is located on the Ungava Peninsula in Nunavik, northern Quebec, at latitude 61°32’ north and longitude 73°28’ west. Climate data collected from on-site weather station between 2014 and 2018 indicate a mean annual average air temperature of -10.3°C (Appendix A). Table E-1 summarizes the average monthly air temperature measured on site.

**Table E-1: Average monthly air temperature at the Nunavik Nickel Mine**

| Month | Average (2014-2018) |
|---|---|
| January | -26.7 |
| February | -29.5 |
| March | -22.4 |
| April | -15.5 |
| May | -6.6 |
| June | 1.4 |
| July | 8.1 |
| August | 7.3 |
| September | 0.4 |
| October | -6.5 |
| November | -12.9 |
| December | -20.3 |
| ***Average*** | **-10.3** |

The site is in a zone of continuous permafrost. The permafrost in the region is estimated to be up to 400 m deep, but information about the actual depth of permafrost is not available. Legacy data from thermistors installed in 2006 (i.e. EL-06-4, MXE-06-1 and EX-06-155), showed ground temperature of -5.7°C to a maximum installation depth of 50 m below the surface. No data was available from these thermistors after 2006. More recent data obtained from thermistor TS2030, which is installed downstream of the perimeter dyke of Tailings Cell 1, show that ground temperatures 5 m below the surface fluctuated in the range of -5.4°C and -4.1°C between July 2015 and August 2018.

In addition, there are several thermistors installed at the interface of tailings and rockfill along the upstream face of the perimeter dykes of Tailings Cells 1 and 2. Most recent data from some of these thermistors in August 2018 indicate that, in general, tailings temperature is below or around 0°C, with some spatial and temporal variation.

Currently there are no thermistors installed in the Expo Pit and thermal conditions below the bottom of the pit are unknown.

### E.2.2 In-Pit Tailings Deposition and Pit Flooding

Based on a conceptual estimation of tailings volumes and pit storage capacity, tailings would be deposited into the Expo Pit over a period of 2 years and have an average ultimate elevation of 484 m, or thickness of approximately 35 m. After completion of tailings deposition supernatant tailings water will be pumped out of the pit during a period of six years, and the pit will then be flooded with fresh water to an elevation of 535.4 m, leading to the formation of a 50 m deep pit lake above the 35 m thick tailings body. Table E-2 summarizes the estimated evolution of in-pit tailings and water elevations over time.

**Table E-2: Conceptual evolution of water and tailings elevations in the Expo Pit**

| Time | Water Elevation (m) | Tailings Elevation (m) |
|---|---|---|
| July 2020 to December 2022 | 482 | - |
| January to December 2023 | 492 | 474 |
| January to October 2024 | 497 | 484 |
| October 2024 to September 2030 | 484 | 484 |
| September 2030 to January 2035 | 535 | 484 |

Based on information provided by CRI, tailings are reported to leave the mill with temperatures of about 30°C or higher. It is assumed that tailings deposited into the Expo Pit would have initial temperatures between 20°C in winter and 25°C in summer.

## E.3.0 THERMAL MODELLING

### E.3.1 Model Geometry

Two-Dimensional (2D) thermal models were prepared using the finite element software TEMPW2020, developed by Geoslope International Ltd. The model geometry was defined from a cross section of the Expo Pit that included part of the tailings Cell 2 to the north and extended to a depth of 350 m below the base of the Expo Pit (i.e. El. 100 m). An initial steady state model was run to define initial ground temperature conditions, followed by transient sequential models prepared to account for progressive deposition of tailings in the pit, with tailings and water added to the model geometry following the deposition schedule presented in Table E-2. Figure E-1 illustrates the model geometry at post-closure condition with tailings and the pit lake at their ultimate elevations. Alignments A and B in Figure E-1 represents reference locations were temperature profiles are obtained to illustrate the model results.

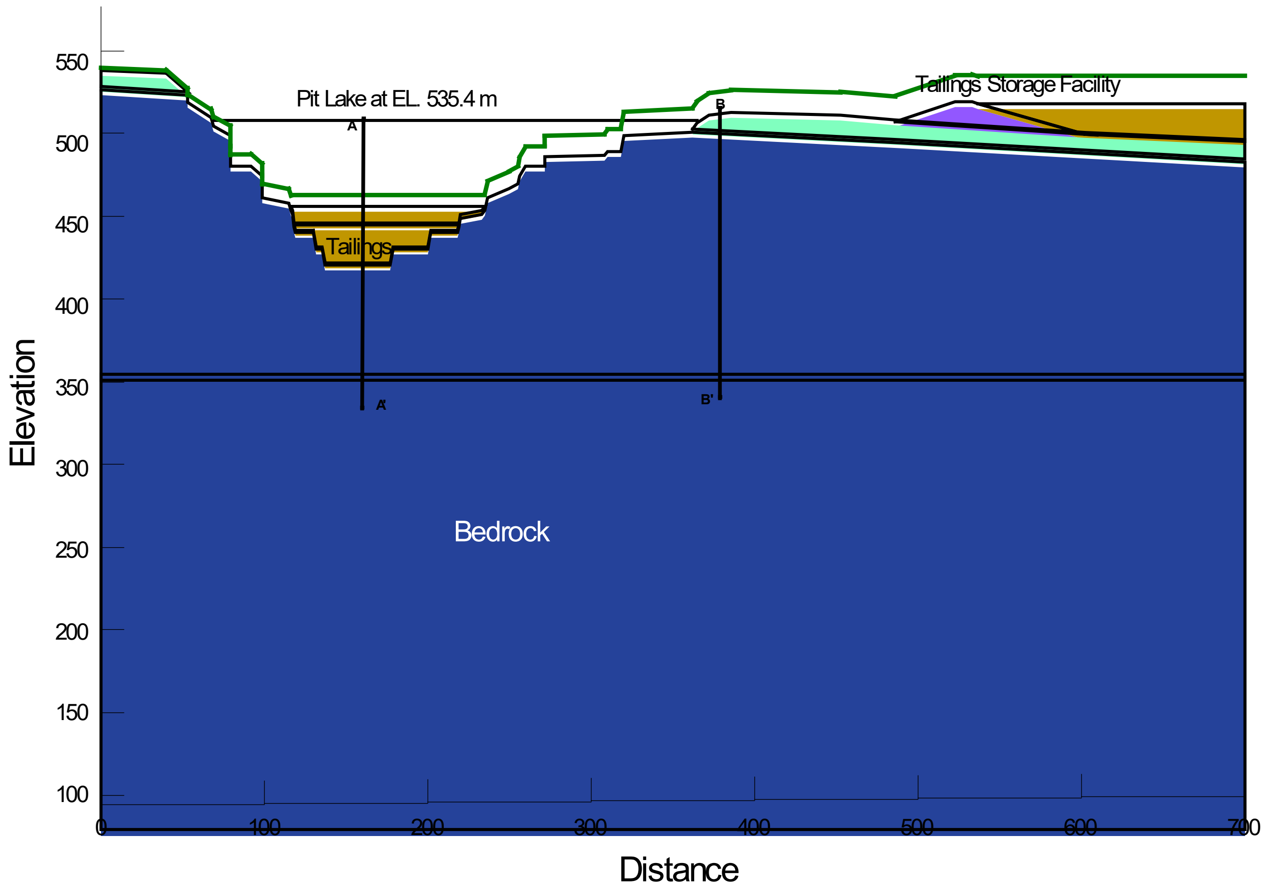



**Figure E-1: Model geometry for post-closure conditions with in-pit tailings and the pit lake at their ultimate elevations**

## E.3.2 Model Scenarios and Initial Conditions

Sequential model scenarios were defined for operation and post-closure conditions as follows:

- Initial steady-state: Considering a dry Expo Pit before commencing of tailings deposition. This model was used to define initial ground temperature conditions.
- July 2020 to December 2021: No tailings and water at El. 473 m
- January to December 2022: No tailings and water at El. 482 m
- January to December 2023: Tailings at El. 474 m and water at El. 492 m
- January to October 2024: Tailings at El. 484 m and water at El. 497 m
- November 2024 to September 2030: Tailings at El. 484 m, and water at El. 484 m (tailings water pumping-out period)
- October 2030 to January 2035: Tailings at El. 484 m and pit lake at El. 535.4 m

- January 2035 to January 2120: Tailings at El. 484 m and pit lake at El. 535.4 m.

The model initial conditions were defined in the steady state analysis that included the following temperature distribution:

- Initial surface temperature of -6.4°C applied to ground, pit walls and bottom of the Expo Pit. This value is the average annual ground surface temperature defined for the models as described in Section E.3.3;
- Ground temperature of -5.7°C at 50 m below the ground surface in areas away from the pit, as measured by legacy thermistors;
- A heat flux boundary of 0.048 J/s/$m^2$ was applied to the base of the model geometry to represent a geothermal gradient of 0.016°C/m, which was defined as discussed in Section E.3.3; and
- Tailings temperature in the tailings Cell 2 was defined as 0°C.

For the transient models, the initial tailings deposition temperature in the Expo Pit was assumed to be 22°C, and pond water temperature was between 2 and 4°C, based on depth as described below.

## E.3.3 Model Boundary Conditions

A geothermal gradient of 0.016 °C/m, equivalent to an upward heat flux of 0.048 J/s/$m^2$ based on the assumed bedrock thermal conductivity of 3 W/m/°C, was applied to the base of the model geometry. This geothermal gradient was defined assuming a 400-m thick permafrost with temperature increasing from -5.7°C at depth of 50 m below surface (as measured by legacy thermistors) to 0°C at depth of 400 m below surface.

The thermal effect of pit lake water on the pit walls and on top of tailings was incorporated in the model by applying constant temperature boundary conditions based on lake depth, as follows:

- 0 to 20 m in depth pit lake water at 2°C,
- 20 to 40 m in depth pit lake water at 3°C, and
- Pit lake water at 4°C for depths greater than 40 m.

Ground surface temperatures are typically warmer than air temperature due to the process of energy absorption, radiation and heat transfer from the ground to the atmosphere. For this feasibility-level study, a simplified approach was adopted to estimate the ground surface temperature function based on multipliers (N-factors) between 0.75 (winter) and 1.3 (summer), which are typical values used in general practice when ground surface temperature is not measured nor modelled using more sophisticated techniques.

Climate change has been included in the models based on future climate projections from the Intergovernmental Panel on Climate Change (IPCC, 2013) Fifth Assessment Report (AR5) for the emission scenario RCP6, which projects an increase in air temperature of 5.3°C over 100 years for areas near the artic. The ground surface temperature function was adjusted linearly to incorporate an increase in temperature in the same order of projected increases in air temperature. Table E-3 summarizes monthly average air and ground surface temperatures used in the models.

**Table E-3: Ground temperature used in the thermal models**

| Month | Average On-Site Air Temperature (°C) | Defined Ground Temperature (°C) | 100-Year Ground Temperature (°C) |
|---|---|---|---|
| January | -26.7 | -20.0 | -14.7 |
| February | -29.5 | -22.1 | -16.8 |
| March | -22.4 | -16.8 | -11.5 |
| April | -15.5 | -11.6 | -6.3 |
| May | -6.6 | -5.0 | 0.3 |
| June | 2.4 | 3.1 | 8.4 |
| July | 8.2 | 12.3 | 17.6 |
| August | 7.9 | 11.9 | 17.2 |
| September | 0.7 | 1.1 | 6.4 |
| October | -4.4 | -3.3 | 2.0 |
| November | -15.7 | -11.8 | -6.5 |
| December | -21.8 | -16.3 | -11.0 |
| *Average* | *-10.3* | *-6.6* | *-1.3* |

## E.3.4 Material Properties

A sample of tailings was shipped to the Golder laboratory in Calgary for measurements of thermal properties (i.e. thermal conductivity and heat capacity) for frozen and unfrozen conditions. Grain size distribution, specific gravity, thermal conductivity, and heat capacity tests were carried out on tailings sample obtained from the mine site. The results of these laboratory tests are included in Annex E-1. The thermal properties of the other materials included in the models were assumed based on Golder experience with similar studies and using estimation equations proposed by Johansen (1977). Table E-4 summarizes the material properties adopted for this modelling exercise.

**Table E-4: Material properties used in the thermal models**

| Material | Volumetric Water Content ($m^3/m^3$) | Saturation (%) | Volumetric Heat Capacity ($MJ/m^3/°C$ | | Thermal Conductivity (W/m/°C) | |
|---|---|---|---|---|---|---|
| | | | Frozen | Unfrozen | Frozen | Unfrozen |
| Tailings | 0.35 | 100 | 2.5 | 2.9 | 2.7 | 1.9 |
| Rockfill | 0.06 | 20 | 1.5 | 1.7 | 1.4 | 1.3 |
| Overburden | 0.29 | 90 | 1.9 | 2.4 | 1.8 | 1.5 |
| Bedrock | 0.02 | 100 | 2.0 | 2.0 | 3.0 | 3.0 |

### E.3.5 Model Limitations

The thermal models contain a number of assumption and limitations as follows:

- Information about permafrost depth and recent data about ground temperatures in depth (i.e. deeper than 50 m) was not available. This information is used to determine initial ground temperatures and the geothermal gradient, which play an important role in the heat transfer process. A higher geothermal gradient would result in faster thawing of permafrost below the Expo Pit, while a lower geothermal gradient would lead to slower permafrost thawing.
- Information about ground temperature at and below the base of the Expo Pit was not available. As the Expo Pit is excavated it will be exposed to air temperature and ground will become colder with time. Although the models assumed colder temperatures at the base of the pit, the extent of colder temperatures in the bedrock below the pit is unknown.
- Ground surface temperatures were assumed using a simplified method that does not incorporate, for instance, accumulation of snow on ground. Snow on ground has an insulation effect and the average ground surface temperature in winter will be warmer compared to a no-snow scenario. Warmer ground surface temperatures would accelerate the process of permafrost thawing in the long term.
- Results of laboratory tests on samples of process water showed that tailings water contains approximately 2090 mg/L of salts concentration. This salinity level could cause the freezing point of tailings water to between -0.1 and -0.25 °C, depending on stress conditions (Andersland and Ladanyi, 2004). This is not considered significant and, for this feasibility-level thermal evaluation, freezing point depression was not included in the models.

## E.4.0 MODEL RESULTS

Figure E-2 shows the initial ground temperatures obtained from the steady state model considering a dry pit and before the beginning of in-pit tailings deposition.

Figure E-3 shows temperature contours computed at the end of the tailings-water pumping process (i.e. September 2030) with tailings at elevation of 484 m and no pond, and Figure E-4 shows temperature contours after completion of the Expo Pit flooding (i.e. January 2035), with the pit lake at elevation of 535 m. Figures E-5 and E-6 show long-term temperature contours computed for Years 2073 and 2120, respectively.

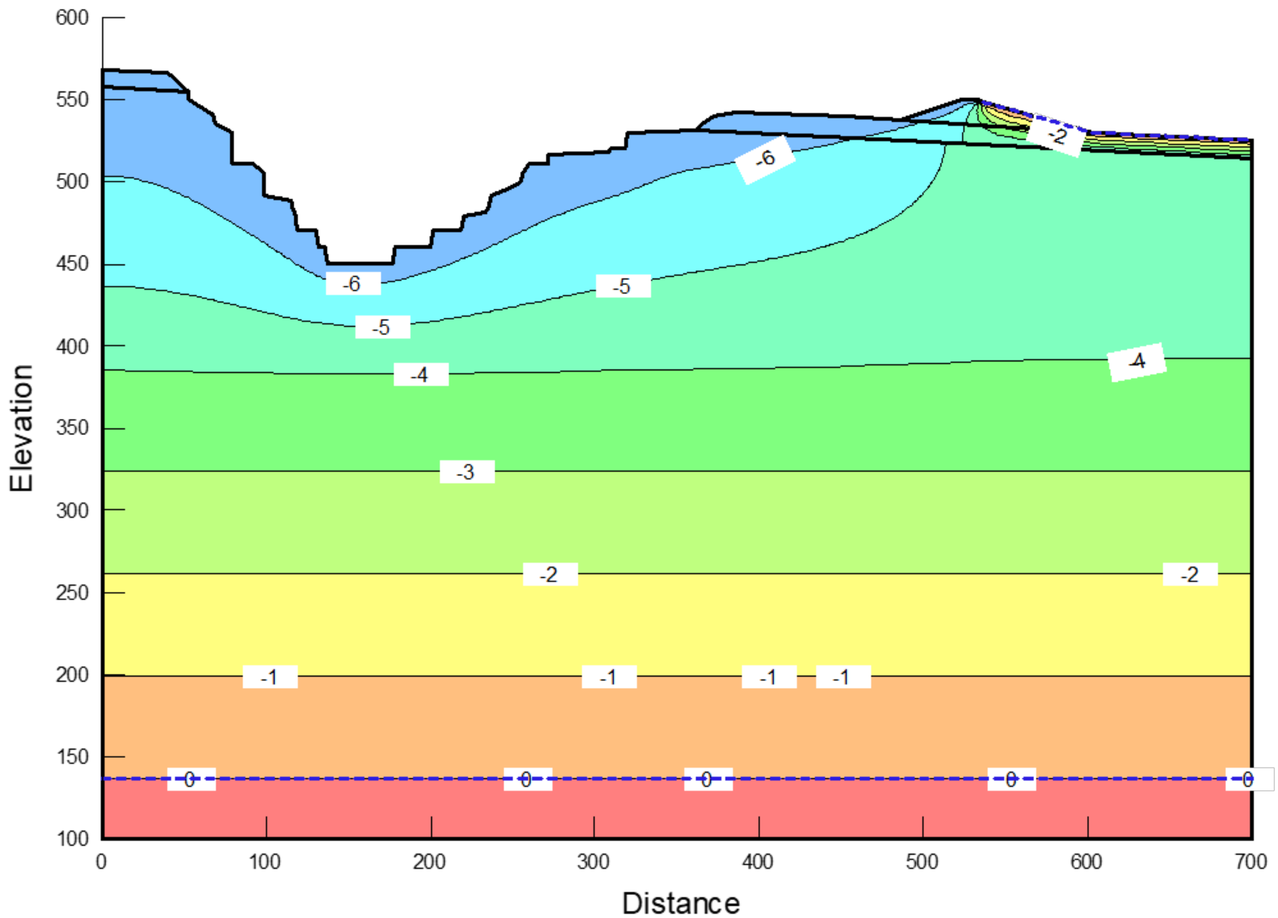



**Figure E-2: Initial ground temperatures with a dry Expo Pit before the beginning of tailings deposition**

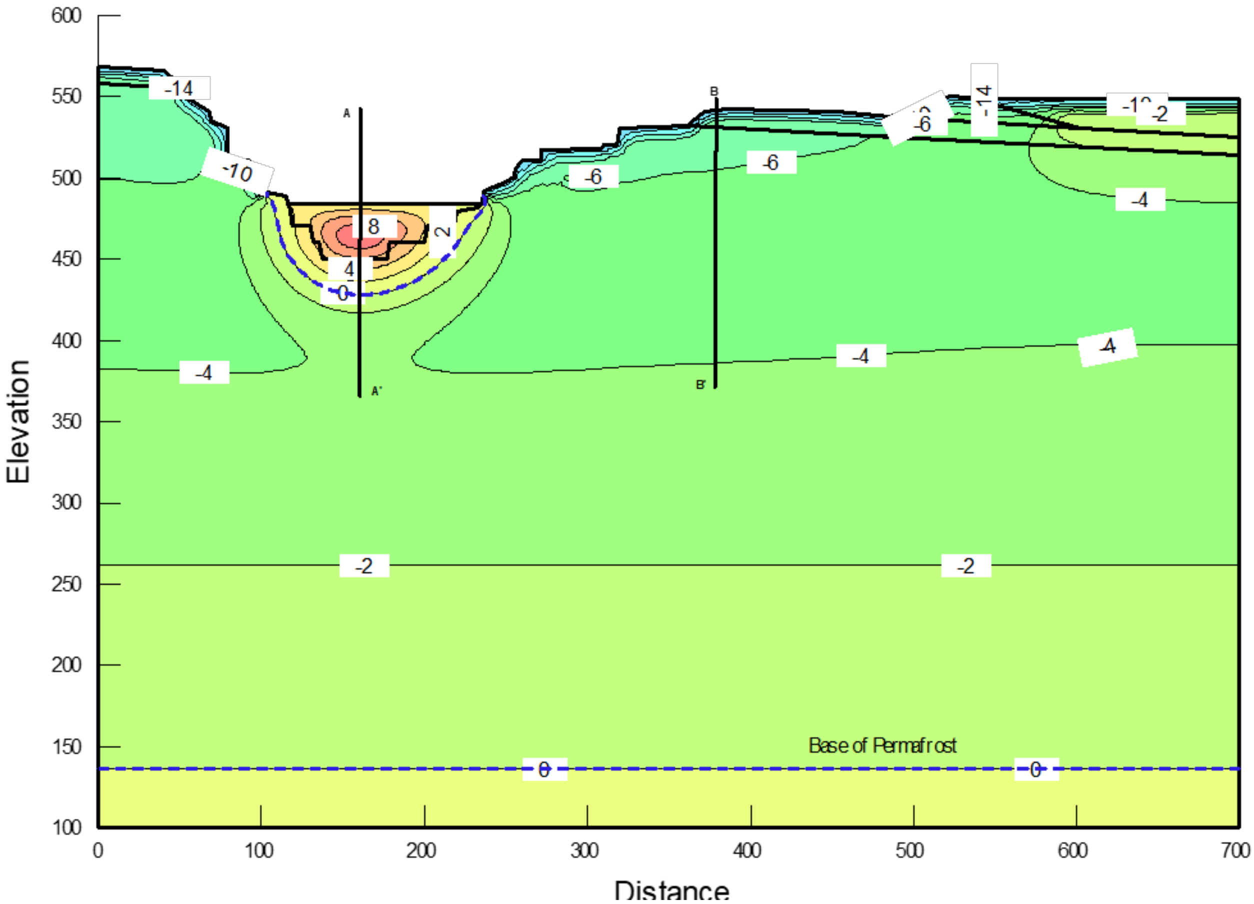



**Figure E-3: Temperature contours computed at the end of operations (September 2030) with no pit lake**

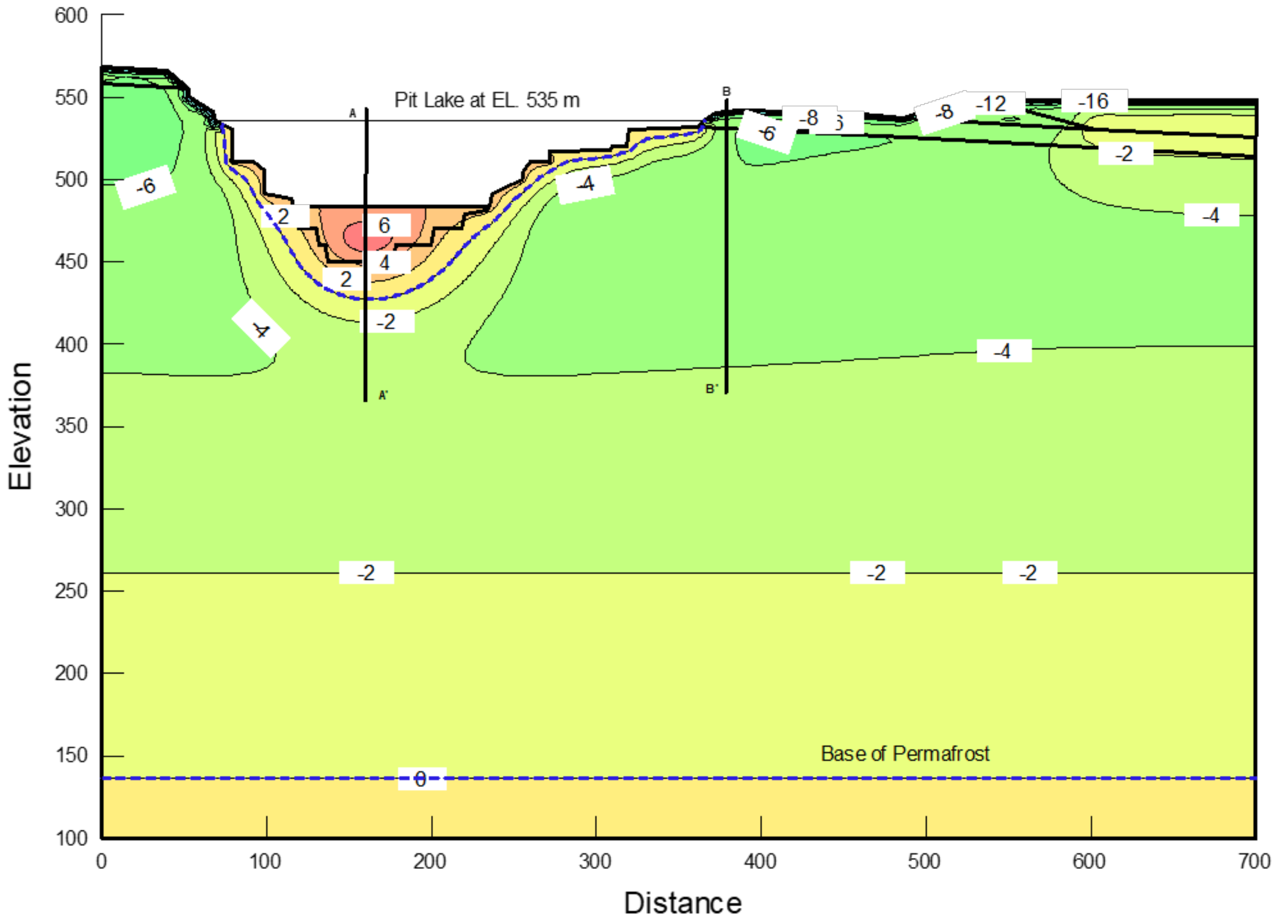



**Figure E-4: Temperature contours computed at completion of pit flooding with the pit lake at elevation of 535.4 m (January 2035)**

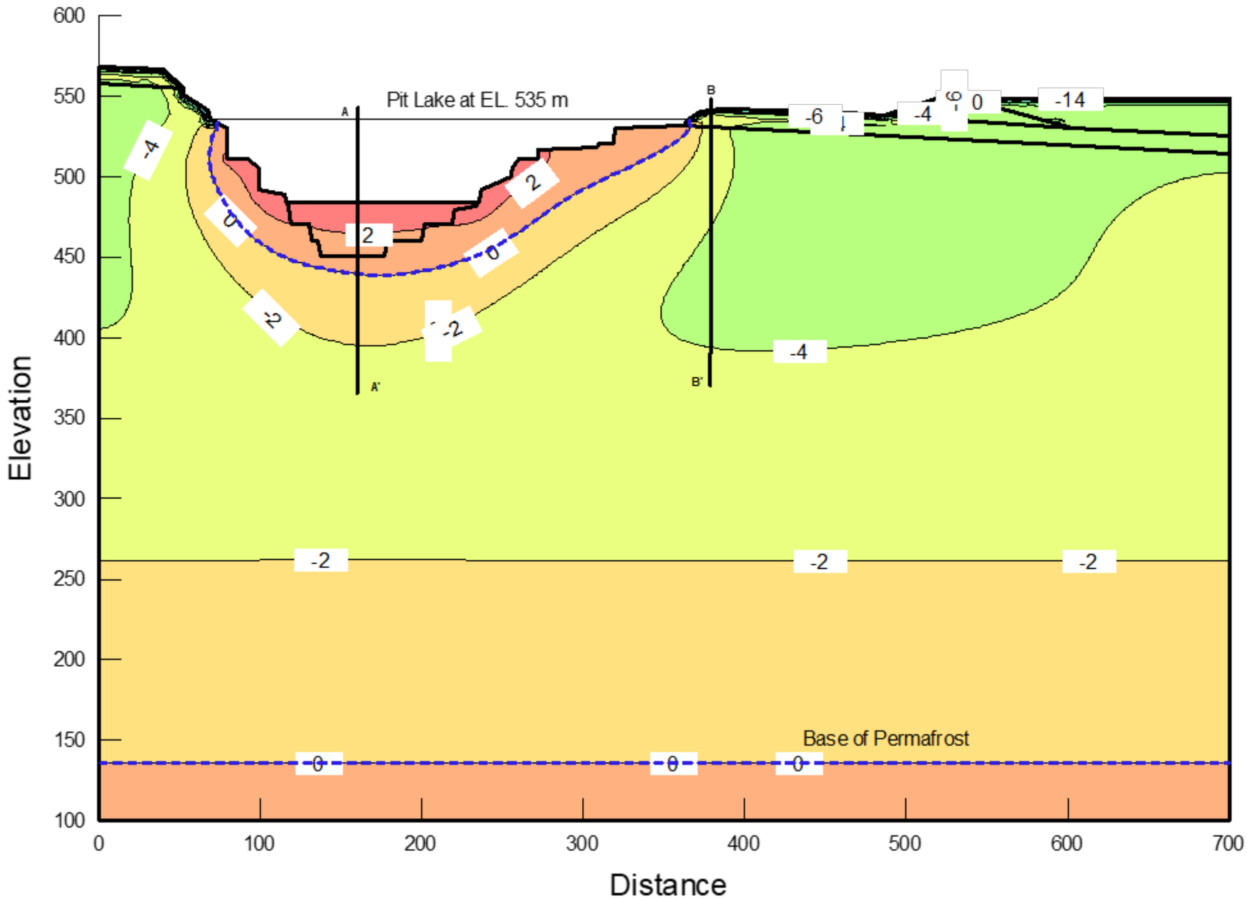



**Figure E-5: Temperature contours for post-closure condition computed in Year 2073**

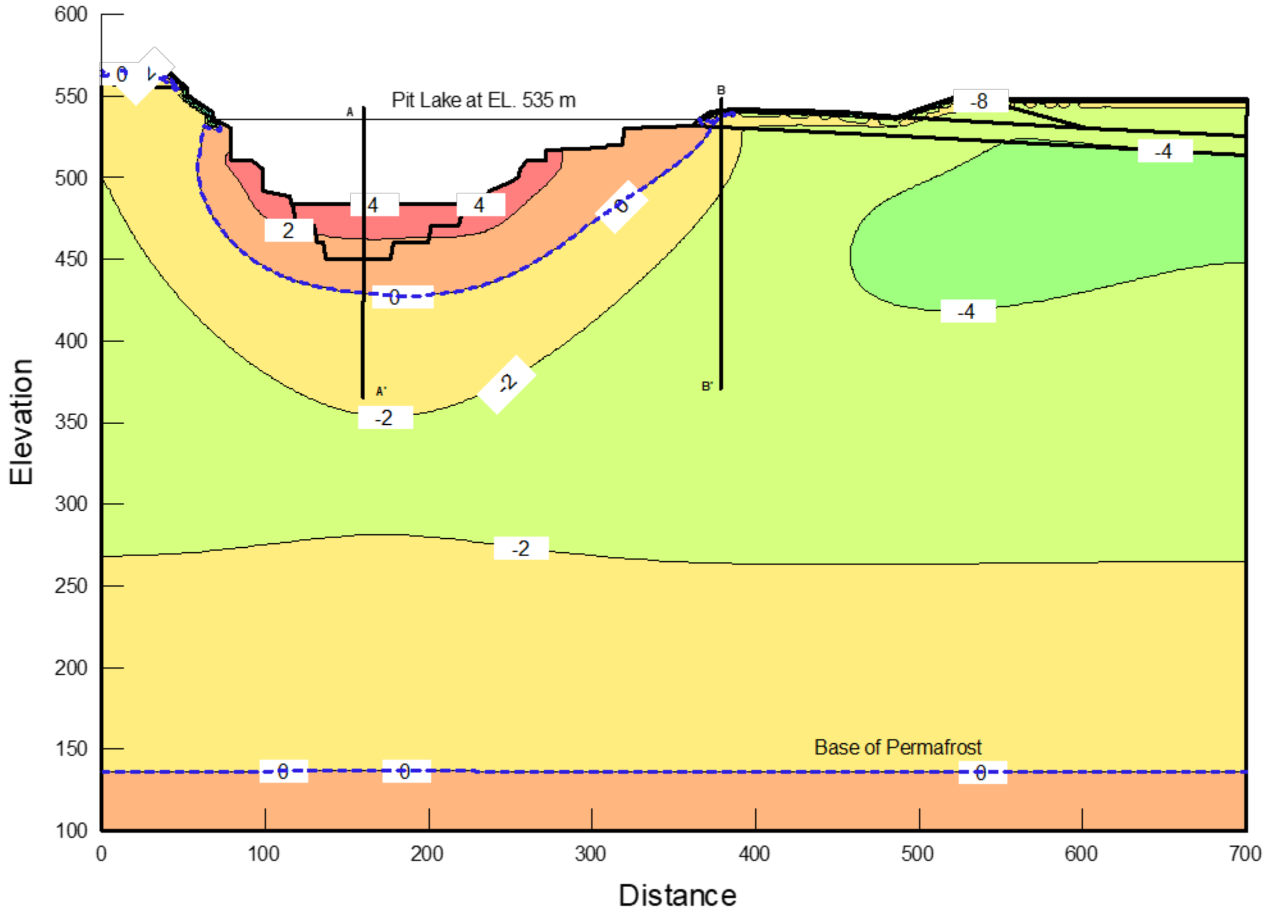



**Figure E-6: Temperature contours for post-closure condition in Year 2120**

Figures E-7 and E-8 show temperature profiles inside the pit (along alignment A) and adjacent to the Expo Pit (along alignment B), respectively, for operation and post-closure scenarios.

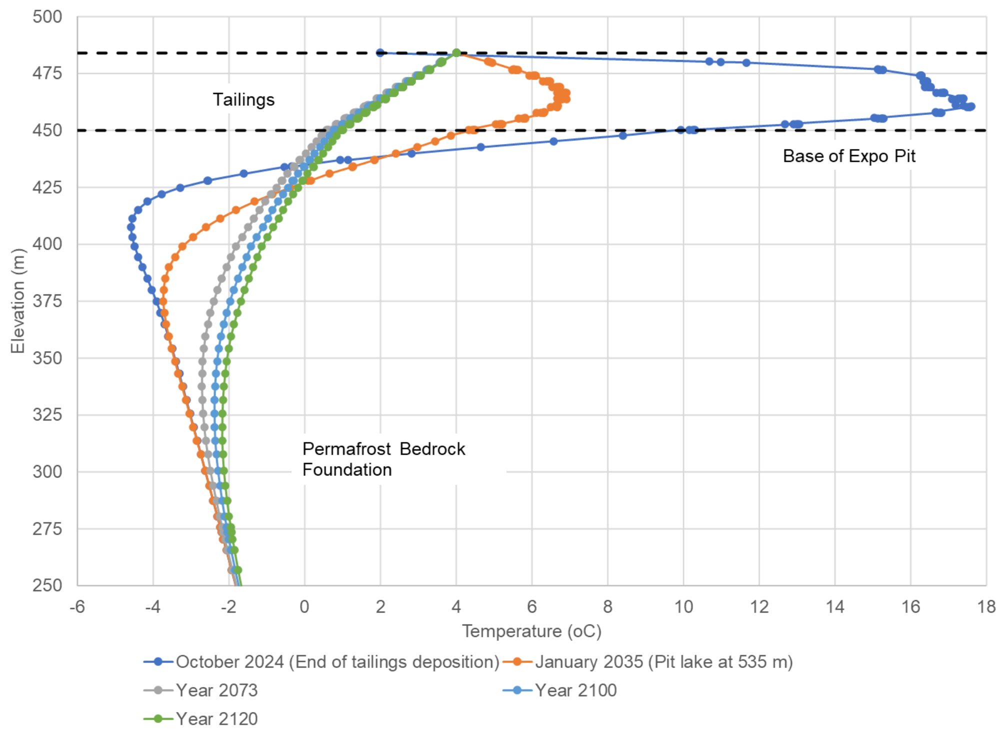



**Figure E-7: Temperature profiles computed along alignment A inside the Expo Pit**

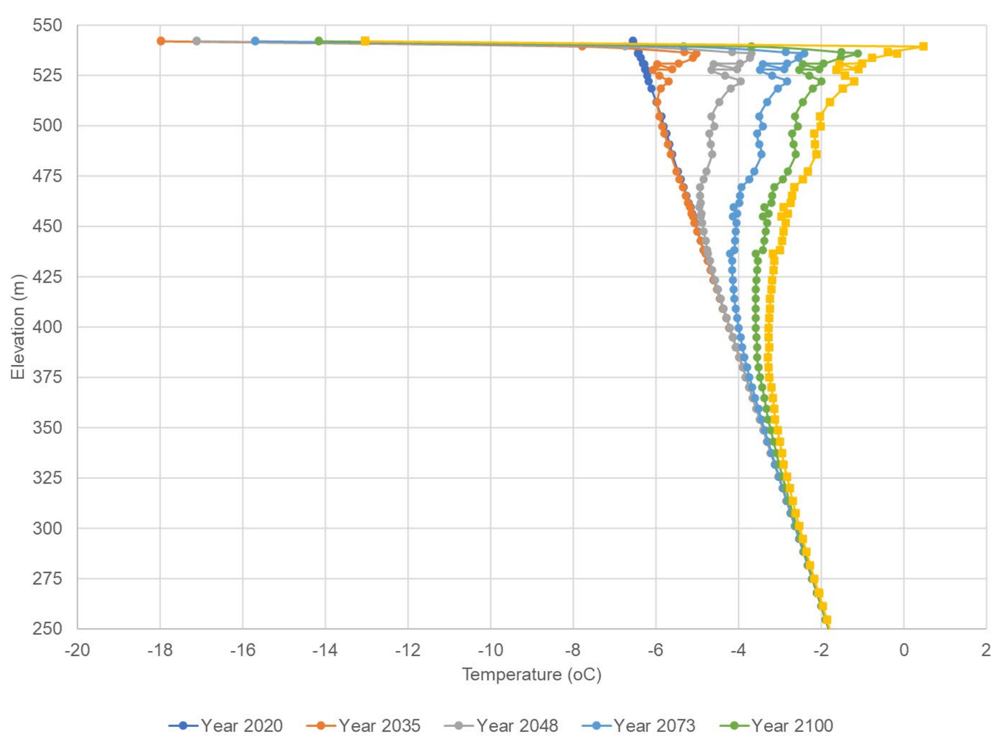



**Figure E-8: Temperature profiles computed along alignment B adjacent to the Expo Pit**

The model results suggest that by October 2024, when tailings deposition is expected to have been completed with tailings surface elevation at 484 m and pond water at elevation of 497 m, the thawing front would have advanced into permafrost to a depth of about 15 m below the base of the pit (i.e. El. 435 m). By the time flooding of the Expo Pit is completed to the planned elevation of 535.4 m in January 2035, the model results show the thawing front will have deepened another 8 m into the permafrost to a depth of 23 m below the base of the pit (i.e. El. 427 m). However, as the tailings temperature cools down and stabilizes due to the effect of the pit lake, the portion of permafrost below the pit that is thawed in the long term remains within about 20 m below the base of the pit up to the year of 2120.

As seen in Figure E-7, in-pit temperatures profiles along alignment A, the models show that the permafrost will warm up progressively over time, specially down to an elevation of about 300 m, but overall negative temperatures will still prevail.

Along alignment B, between the Expo Pit and the Tailings Cell 2 (Figure E-8), the model results show that ground temperatures will remain below freezing during all times, although a warming trend is predicted mostly to a depth of 200 m below the ground surface (i.e. approximate El. 340 m). This indicates that groundwater flow would not occur between the pit lake and the tailings facility area.

## E.5.0 CONCLUSIONS

A thermal assessment was conducted to evaluate the effects of tailings deposition in the Expo Pit on the conditions of permafrost beneath and adjacent to the pit walls. Two-dimensional transient models were conducted for operation and post closure conditions with consideration of climate change over a period of 100 years.

The model results show that deposition of tailings inside the pit followed by formation of a pit lake will cause permafrost to thaw to a depth of about 22 m below the base of the pit. Although permafrost would warm up progressively in the long term, the models showed that the extent of this unfrozen zone would not increase over a period of 100 years.

The models also showed that ground between the Expo Pit and the Tailings Cells will remain mostly frozen during all times, which would prevent groundwater flow between the Expo pit and tailings areas.

Variations in depth of the active layer subject to seasonal freeze and thaw were not evaluated in this model due to the large model scale. The depth of the active layer is expected to increase in response to the effects of climate change but would likely still be limited to near surface. Preparation of a specific one dimensional (1D) model would be required to evaluate the long term behaviour of the active layer.

It is recommended that deep thermistors be installed adjacent to the Expo Pit to monitor the evolution of ground temperatures in the long term. This information could be used later to refine and calibrate the models as required.

# REFERENCES

Andersland, O.B. and Ladanyi, B. (2004). Frozen Ground Engineering. 2nd edition, John Wiley & Sons, Inc.

IPCC (2013). The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Johansen, O. (1975). Thermal conductivity of Soils. Ph.D. diss., Norwegian Technical Univ., Trondheim; also, U.S. Army Cold Reg. Res. Eng. Lab. Transl. 637, July 1977.

**ANNEX E-1**

# *Laboratory Test Results*

GOLDER

**PRAIRIES AND NORTH LABORATORIES**

**ATTN:** Fernando Junqueira, D.Sc., M.Sc., P.Eng.
Senior Geotechnical Engineer
Golder Associates Ltd.

**Received:** 03-Oct-18
**Report Date:** 01-Nov-18
**Version:** Final

# Geotechnical Laboratory Testing Report

**Client:** Canadian Royalties Inc.
**Project Title:** CRI/2018 DSI/Nunavik - CRI Pit Backfill Study
**Golder Billing:** 18101259.1000
**Lab Schedule No.:** C904

**Matthew Becker**
Geotechnical Laboratory Manager
Calgary Geotechnical Laboratory
Golder Associates Ltd.



**Golder Associates Ltd., Bay 8, 820 28th Street NE, Calgary Alberta, Canada T2K 6K1**
**Tel. (403) 248-6386 Fax. (403) 248-6387**

GOLDER

# GENERAL LAB TESTING SUMMARY

Project No.: 18101259 Phase: 1000
Short Title: CRI/2018 DSI/Nunavik - CRI Pit Backfill Study Sched: C904
Tested By: DS Date: 1-Nov-18

| **Sample Identification** | | **Laboratory Test Results** | | | | |
|---|---|---|---|---|---|---|
| Sample | Lab No. | Water Content (%) (Decanted Process Water) | | | Water Content (%) (Mixed with Process Water) | Specific Gravity (Gs) |
| | | Bottom | Top (Trial 1) | Top (Trial 2) | | |
| Eav Praede - USINE CRI - 2018-08-31 9h30 | C904-01 | 16.9 | 16.7 | 16.0 | 23.6 | 3.18 |

GOLDER

# THERMAL PROPERTIES LAB TESTING SUMMARY

Project No.: 18101259
Short Title: CRI/2018 DSI/Nunavik - CRI Pit Backfill Study
Tested By: FC

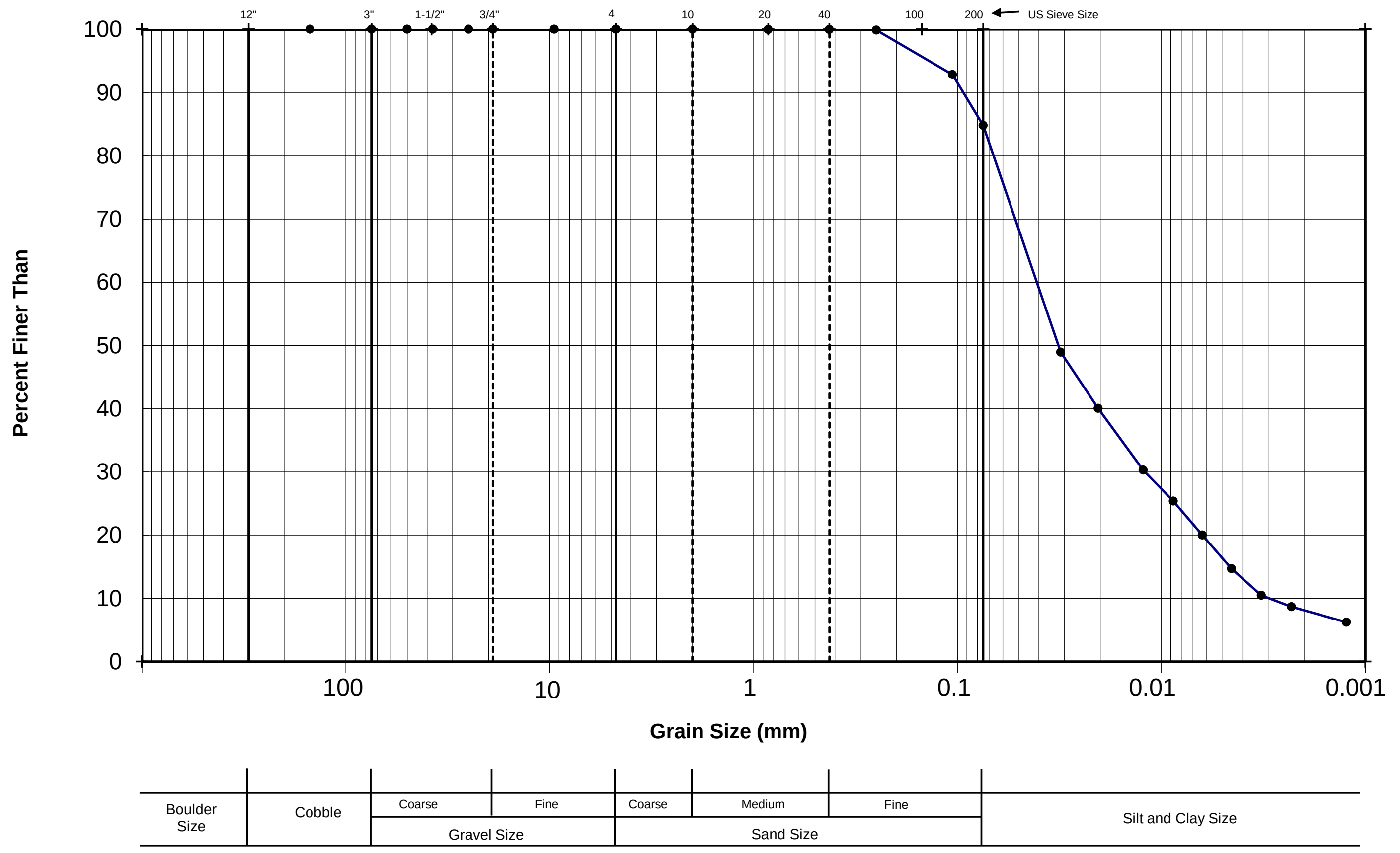
Phase: 1000
Sched: C904
Date: 1-Nov-18

| Sample Identification | | Laboratory Test Results | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Lab No. | Remolded Dry Density (kg/m$^3$) | Water Content (%) | Thermal Conductivity | | | Volumetric Specific Heat Capacity | | | |
| | | | | Average Temperature (°C) | Avg. Thermal Conductivity, K (W/m•K) | Avg. Thermal Resistivity, R (m•K/W) | Average Temperature (°C) | Avg. Volumetric Specific Heat Capacity, C mJ/(m³·K) | Avg. Thermal Diffusivity, D (mm$^2$/s) |
| Eav Praede - USINE CRI - 2018-08-31 9h30 | C904-01 | 1933 | 19.3 | 5.1 | 1.869 | 0.535 | 5.3 | 2.911 | 0.627 |
| | | | | -5.6 | 2.680 | 0.373 | -5.1 | 2.521 | 0.961 |

Project No.: 18101259.1000 Lab No.: C904-01
Project Title: CRI/2018 DSI/Nunavik - CRI Pit Backfill Study
Sample: Eav Praede - USINE CRI - 2018-08-31 9h29
Depth: -
Date Tested: 04-Oct-18 By: DS

# PARTICLE SIZE ANALYSIS OF SOIL

(ASTM D422)




| Diameter of Sieve (mm) | Percent Passing (%) |
|---|---|
| 150.0 | 100.0 |
| 75.0 | 100.0 |
| 50.0 | 100.0 |
| 37.5 | 100.0 |
| 25.0 | 100.0 |
| 19.0 | 100.0 |
| 9.50 | 100.0 |
| 4.75 | 100.0 |
| 2.00 | 100.0 |
| 0.850 | 100.0 |
| 0.425 | 99.9 |
| 0.250 | 99.9 |
| 0.106 | 92.9 |
| 0.075 | 84.8 |
| 0.031 | 48.9 |
| 0.020 | 40.0 |
| 0.012 | 30.3 |
| 0.009 | 25.3 |
| 0.006 | 20.0 |
| 0.005 | 14.7 |
| 0.003 | 10.5 |
| 0.002 | 8.7 |
| 0.001 | 6.2 |

**Comments:**

PERCENT GRAVEL, SAND, SILT AND CLAY OF SAMPLE

| COBBLE | GRAVEL | | SAND | | | SILT / CLAY |
|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | |
| | 0.0% | 0.0% | 0.0% | 0.1% | 15.2% | 84.8% |
| 0.0% | 0.0% | | 15.2% | | | 84.8% |

GOLDER

# THERMAL CONDUCTIVITY OF SOIL BY THERMAL NEEDLE PROBE

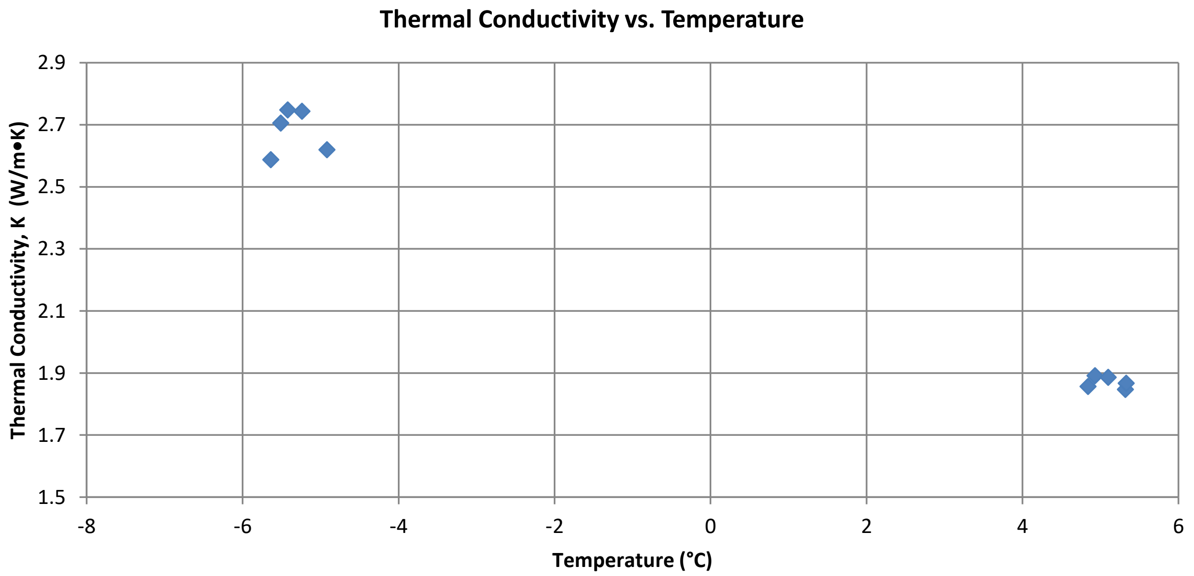
(ASTM D5334-08)

Project No.: 18101259 Phase: 1000
Short Title: CRI/2018 DSI/Nunavik - CRI Pit Backfill Study Lab No.: C904-01
Tested By: FC Date: 01-Nov-18

| | | | |
|---|---|---|---|
| **Location:** | Eav Praede - USINE CRI | **Undisturbed or Remolded:** | Remolded |
| **Sample No.:** | 2018-08-31 9h30 | **Wet Density ($kg/m^3$):** | 2307 |
| **Height (mm):** | 201.27 | **Water Content (%):** | 19.3 |
| **Diameter (mm):** | 101.92 | **Dry Density ($kg/m^3$):** | 1933 |
| **Mass (g):** | 3788.10 | **Void Ratio:** | 0.645 |
| **Thermal Probe No.:** | TR-1 | **Saturation (%):** | 95.3 |
| **Probe Length (mm):** | 50.0 | **$G_s$:** | 3.2 |

**Test Results:**

| Trial No. | Temp. (°C) | Avg. Temp. (°C) | Thermal Conductivity, K (W/m•K) | Avg. Thermal Conductivity, K (W/m•K) | Thermal Resistivity, R (m•K/W) | Avg. Thermal Resistivity, R (m•K/W) |
|---|---|---|---|---|---|---|
| 1 | 4.84 | 5.10 | 1.856 | 1.869 | 0.539 | 0.535 |
| 2 | 4.93 | | 1.891 | | 0.529 | |
| 3 | 5.10 | | 1.886 | | 0.530 | |
| 4 | 5.32 | | 1.847 | | 0.541 | |
| 5 | 5.33 | | 1.867 | | 0.536 | |
| 1 | -4.92 | -5.6 | 2.619 | 2.680 | 0.382 | 0.373 |
| 2 | -5.24 | | 2.743 | | 0.365 | |
| 3 | -5.42 | | 2.748 | | 0.364 | |
| 4 | -5.51 | | 2.705 | | 0.370 | |
| 5 | -5.64 | | 2.587 | | 0.387 | |



# VOLUMETRIC SPECIFIC HEAT CAPACITY OF SOIL BY THERMAL NEEDLE PROBE

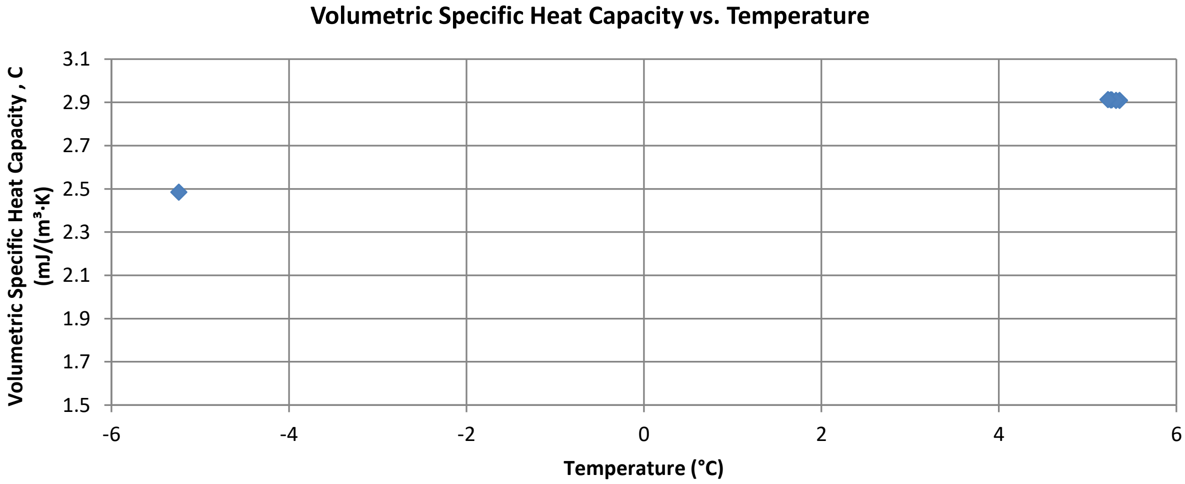
(ASTM D5334-08)

| | |
|---|---|
| Project No.: 18101259 | Phase: 1000 |
| Short Title: CRI/2018 DSI/Nunavik - CRI Pit Backfill Study | Lab No.: C904-01 |
| Tested By: FC | Date: 01-Nov-18 |

| | | | |
|---|---|---|---|
| **Location:** | Eav Praede - USINE CRI | **Undisturbed or Remolded:** | Remolded |
| **Sample No.:** | 2018-08-31 9h30 | **Wet Density (kg/m$^3$):** | 2307 |
| **Height (mm):** | 201.27 | **Water Content (%):** | 19.3 |
| **Diameter (mm):** | 101.92 | **Dry Density (kg/m$^3$):** | 1933 |
| **Mass (g):** | 3788.10 | **Void Ratio:** | 0.645 |
| **Thermal Probe No.:** | SH-1 | **Saturation (%):** | 95.3 |
| **Probe Length (mm):** | 50.0 | **$G_s$:** | 3.2 |

**Test Results:**

| Trial No. | Temp. (°C) | Avg. Temp. (°C) | Volumetric Specific Heat Capacity, C mJ/(m³·K) | Avg. Volumetric Specific Heat Capacity, C mJ/(m³·K) | Thermal Diffusivity, D (mm$^2$/s) | Avg. Thermal Diffusivity, D (mm$^2$/s) |
|---|---|---|---|---|---|---|
| 1 | 5.36 | | 2.909 | | 0.626 | |
| 2 | 5.27 | | 2.912 | | 0.626 | |
| 3 | 5.26 | 5.3 | 2.911 | 2.911 | 0.627 | 0.627 |
| 4 | 5.32 | | 2.909 | | 0.627 | |
| 5 | 5.23 | | 2.913 | | 0.628 | |
| 1 | -5.24 | | 2.484 | | 0.974 | |
| 2 | -5.06 | | 2.542 | | 0.957 | |
| 3 | -5.10 | -5.1 | 2.507 | 2.521 | 0.965 | 0.961 |
| 4 | -4.99 | | 2.529 | | 0.956 | |
| 5 | -4.90 | | 2.545 | | 0.951 | |



**APPENDIX F**

# Expo Pit Slope Stability

# F.1.0 INTRODUCTION

This Appendix provides the details of the pit slope stability analysis performed as part of the conceptual evaluation of Expo in-pit tailings disposal. The slope stability assessment was carried out to evaluate the potential for pit slope instability during various filling stages of the open pit. The following sections describe the method of analyses, the cases analyzed, input parameters and assumptions and the results of the analysis.

# F.2.0 BACKGROUND

Expo pit was in operation between 2013 and April 2020. The mined-out Expo open pit is approximately 850 m long in the east to west direction and approximately 330 m wide in the north to south direction. The pit bottom elevation is approximately 460 m. Maximum pit depth is approximately 105 m.

Projected geology within the ultimate pit wall suggests that approximately 57% of the wall will be within the Metasediments rock unit and 32% of the walls in the ultramafic rock unit as shown in Graph F-1.

In 2006, a total of four orientated boreholes were drilled in the Expo pit (Golder 2007). The thickness of the overburden was found to vary between 1.6 m and 4.4 m and can even be up to 13 m thick in some locations. The thickness of the active layer in the Expo site varies between 1.5 m to 2.5 m. The overburden is included in the slope stability analysis.

The slope stability analysis was carried out using the geotechnical data presented in Golder (2007). The most recent inspection of the Expo pit (MDEng 2017) identified bedding planes that plunge towards the pit. The effects of these bedding planes were included on the overall stability of the pit wall. The analysis included various filling stages of the open pit assuming fully thawed and frozen conditions in the metasediments rock unit. Circular failure mode was analyzed.

# F.3.0 STABILITY ANALYSIS

## F.3.1 Method of Analysis

Overall slope design and bench stability in open mining are controlled by kinematics (structural stability) and overall slope failure (rock mass stability). The commercially available two-dimensional (2-D) limit equilibrium modelling program Slide (RocScience 2018) was used for the pit slope stability analysis.

## F.3.2 In-put Parameters and Critical Cross-Section

The slope stability analysis was carried out using the geotechnical data presented in Golder (2007). The Expo Pit contains two main geotechnical units: ultramafic and metasediment. The geotechnical parameters used for the stability analysis are presented in Table F-1.

**Table F-1: Geotechnical Parameters**

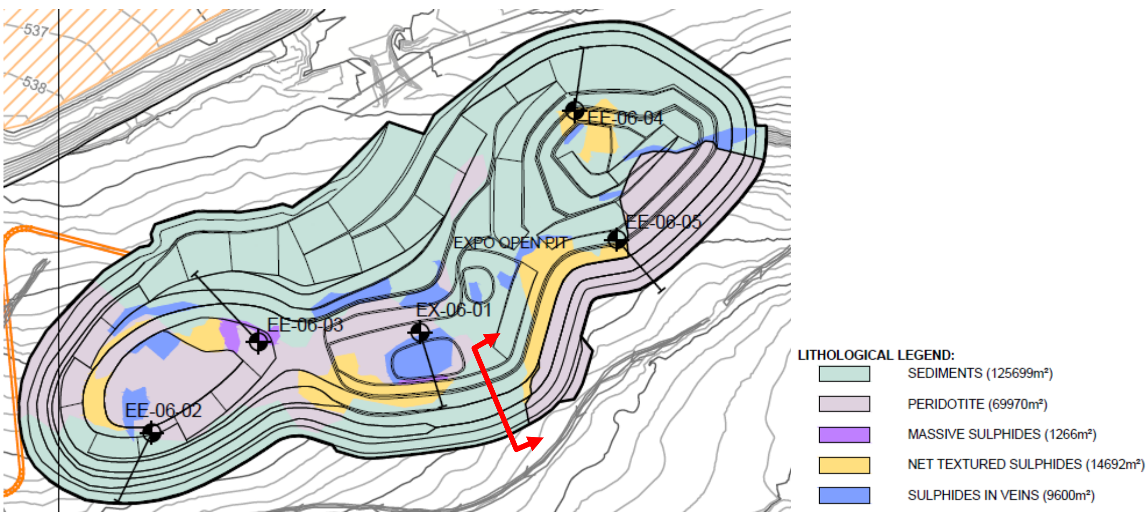
| Geotechnical Unit | Density (kN/m3) | UCS (MPa) | $RMR_{76}$ | m | s | c (kPa) | Φ (°) |
|---|---|---|---|---|---|---|---|
| Ultramafic[1] | 30 | 200 | 77 | 3.6751 | 0.0216 | - | - |
| Metasediments[1] | 27 | 150 | 77 | 3.4817 | 0.0216 | - | - |

| Geotechnical Unit | Density (kN/m3) | UCS (MPa) | $RMR_{76}$ | m | s | c (kPa) | Φ (°) |
|---|---|---|---|---|---|---|---|
| Overburden[2,4](Active Layer) | 19 | - | - | - | - | 0 | 30.0 |
| Mine tailings[2] | 20 | - | - | - | - | 0 | 32.0 |
| Bedding[3] | 27 | - | - | - | - | 180 | 32.4 |

Notes:

1. Parameters used in previous pit slope design (Golder 2007)
2. Parameters used in previous Expo Tailings Cell 2 design (Golder 2015)
3. Bedding cohesion parameter from back-analysis
4. The overburden under the active zone is considering completely frozen and behaves like rock

The stability analysis was carried out on the most critical section of the open pit. The location of the modeled cross-section is shown in Graph F-1. This cross-section has the steepest slope and primarily containing metasediment unit as it is the weakest of the two main rock units.



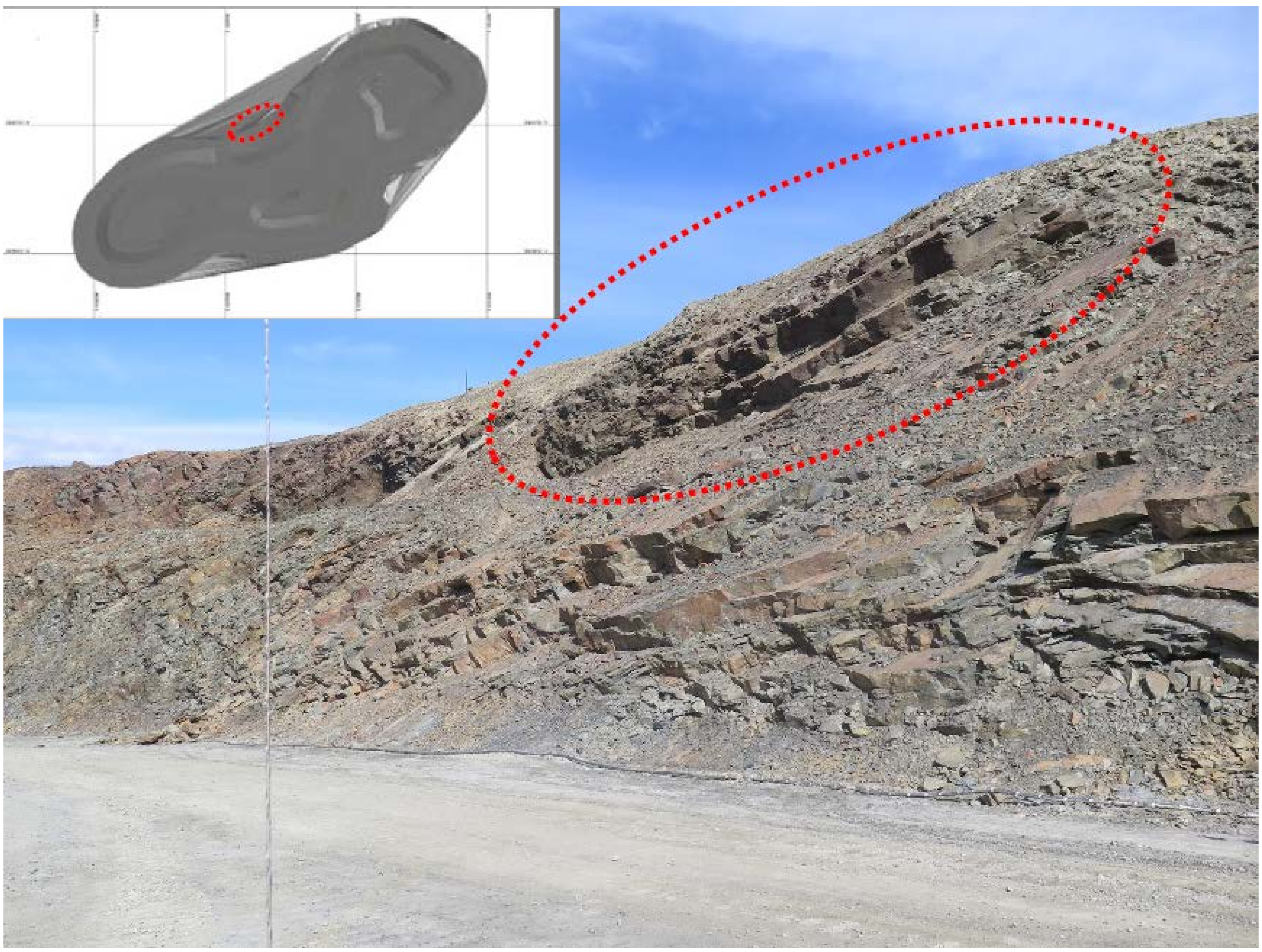

**Graph F-1: Expo Pit Section used in the Slope Stability Analysis**

The most recent inspection of the Expo pit (MDEng 2017) identified bedding planes that plunge towards the pit. The effects of these bedding planes were included on the overall stability of the pit wall.

The original pit design (Golder 2007) did not consider the impact of the bedding on the overall stability of the wall. The consideration of the bedding in the stability analysis included the worst-case scenario: planar rupture due to thawed permafrost from heat of the tailings.

The metasediment unit is an east-west syncline. The bedding plunges towards the pit with angles between 20° and 40° according to stereonets interpretation carried out in 2007, following the description of the structures encountered in the drillholes. According to the laboratory test results, the bedding has a cohesion of 0 kPa and a friction angle of 32.4° (Golder 2007). In order to validate the cohesion, a back analysis has been carried out.

The back analysis for planar failure shows that for a bedding dip of 40°, a cohesion around 180 kPa is needed to achieve a factor of safety of 1.0 considering a water table behind the slope. For a dry rock mass, a cohesion of approximately 100 kPa is needed. From the examination of the pit wall photos, as shown in Graph F-2 from the MDEng Inspection report of 2017, the actual continuity along the bedding joint appears to have enough rock bridges for shear strength to be greater than 180 kPa (which is equivalent to about 2% of the strength of intact rock bridges along the joints and constitutes a reasonably low strength assumption).



**Graph F-2: Photos of the North Wall (MDEng 2017)**

### F.3.3 Scenarios Analyzed

Slope stability analyses were carried out to identify potential stability problems during backfilling. The stability analysis considered the empty pit (prior to backfilling) and once the pit is filled to the ultimate tailings elevation. The stability analysis was completed to evaluate the overall pit slope stability under static loading conditions.

The analysis involved limit equilibrium solutions to calculate Factors of Safety (FoS) for potential slip surfaces based on evaluation of the engineering properties of the different lithological units. Circular failures were analyzed. The slope stability analysis was conducted using an assumed phreatic surface.

### F.3.4 Minimum Factor of Safety

A minimum Factor of Safety (FoS) of 1.2 was selected to be an appropriate target for pit slopes based on the level of risk that is commonly acceptable in a mining environment (Golder 2007).

## F.4.0 SLOPE STABILITY RESULTS

Table F-2 summarize the results of the slope stability analysis for a circular failure with over-conservative slope condition in order to frame the potential for instability at the ultimate open pit and the relative increase in FoS with tailings backfill.

**Table F-2: Expo Pit Rock Mass Stability Analyses Results – Assumed Worst Case – Water Table and No Frozen Ground**

| Case | Calculated FOS - Circular | Back Analysis FoS Required - Assuming no permafrost providing resistance to instability | Percent increase in FoS with backfilling |
|---|---|---|---|
| Empty Pit | 1.30 | 1.2 | NA |
| Tailings backfilled pit | 1.86 | 1.2 | 43% |

This slope stability model is overconservative. The ultimate pit slope will be frozen and not saturated. With frozen ground there would be no water pressure and the RQD of the rock mass would be effectively 100%.

A more representative analysis was carried out assuming the rock and the soil surrounding the pit are frozen as predicted by the thermal model (Appendix E). Table F-3 and Figure F-1 summarize the results of the slope stability analysis for a circular failure. The ultimate pit prior to backfilling has the lowest FoS. The backfill acts as a support to the slope and improves the overall stability. No potential slope stability problems during the intermediate backfilling stages were identified.

In summary, the stability of the pit slope improved with tailings backfilling regardless of the potential changes in the permafrost, slope of the pit or phreatic surface. The potential for kinematic failure was evaluated using very low assumed strengths.

**Table F-3: Expo Pit Rock Mass Stability Analyses Results – Assumed Permafrost Case**

| Case | Calculated FOS - Circular | FoS Required - Assuming no permafrost providing resistance to instability (dry slope model) | Percent increase in FoS with backfilling |
|---|---|---|---|
| Empty Pit | 1.44 | 1.2 | NA |
| Pit filled to elevation 485 m | 1.90 | 1.2 | 32% |

## F.5.0 CONCLUSIONS

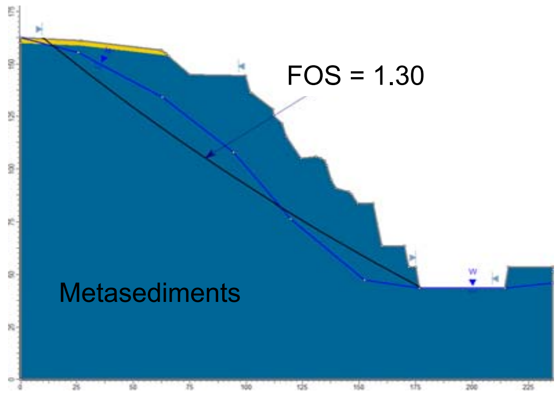
The stability of the open pit was analyzed under fully thawed and frozen conditions. The potential for kinematic failure was evaluated using very low assumed strengths. Regardless of the case analyzed, the final pit before the start of tailings backfilling yielded the lowest FoS. The FoS of the pit wall increased once tailings are deposited. The tailings acted as a support to the pit slope and improved the overall stability. Under fully thawed condition, which is an overconservative scenario, the calculated FoS varied between 1.30 and 1.86. Under permafrost condition, which is representative of the field condition, the calculated FoS varied between 1.44 and 1.90, indicating that the open pit wall will be stable.

# REFERENCES

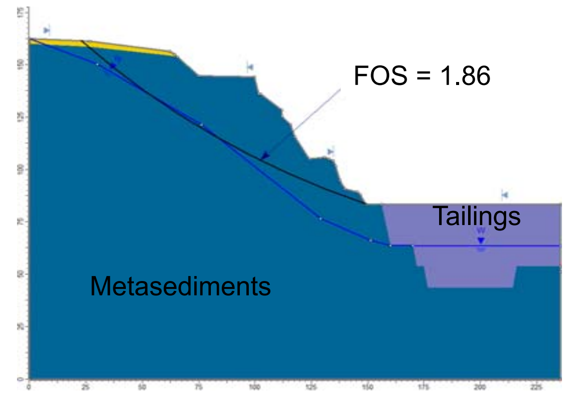
Golder Associates Ltd. (Golder), (2007). Slope design recommendations, Expo and Mesmax ultimate open pits, Raglan South nickel project. Ref. No. 05-1117-055

Mine Design Engineering (MDEng), (2017). 2017 Site Inspection for Expo Pit, and Allammaq Underground Works Nunavik Nickel, Quebec. Report #17019-101.

**Assumed Worst Case - Water table and no frozen ground**

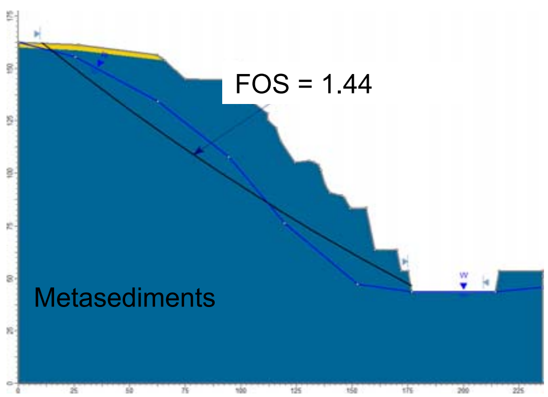



Empty Pit

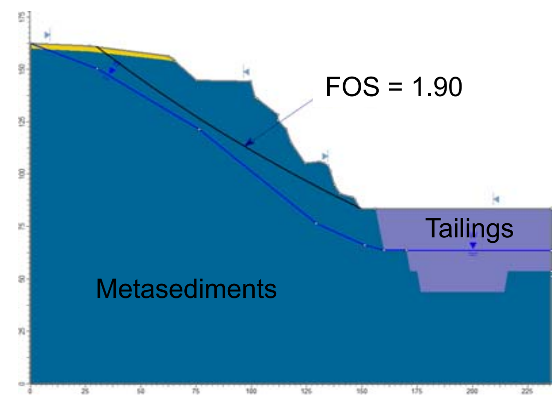



Tailings Backfilled Pit

**Assumed Permafrost Case - Frozen ground, water table not applied to the rockmass**




Empty Pit




Tailings Backfilled Pit

GOLDER

| | | | |
|---|---|---|---|
| Scale: | N.T.S | **Slope Stability Analysis - Empty Pit and Tailings Backfilled Pit**<br>**Static Conditions in Metasedimentary Rock** | |
| Date: | Jul-20 | | |
| Design: | SC | | |
| Check: | KBH | **NUNAVIK NICKEL MINE, QUEBEC** | FIGURE F-1 |
| Review: | | | |

| Project No. | 19117253 | | Version | 1 |
|---|---|---|---|---|

APPENDIX G

# Spillway and Discharge Channel Sizing

# G.1. INTRODUCTION

An outlet spillway channel will be constructed on the northeast corner of the Expo Pit and east of the Tailings Cell 1. Once the accelerated flooding of the Pit is complete, the channel will convey the Pit overflow to the Puvirnituq River tributary, which is located north of the Tailings and waste rock facility. This appendix summarizes the criteria and assumptions used to size the outlet spillway and discharge channel for the Expo Pit.

## G.1.1 Hydraulic Modelling

A hydrologic analysis was completed to support the design of the spillway and discharge channel. The hydraulic routing exercise was modelled using the U.S. Army Corps of Engineers HEC-HMS 4.3 modelling software. The following criteria were adopted for the spillway sizing:

- The 24-hr probable maximum precipitation (PMP) event corresponding to 207 mm. To account for climate change, an 18% loading factor was used as per MTMDET (ministère des Transports, de la Mobilité et de l'Électrification des transports) for watershed sizes less than 25 $km^2$. Therefore, the storm selected for the spillway sizing corresponds to 244 mm.
- Losses were determined using the U.S. Soil of Conservation Service (SCS) curve number method and assigning a CN number of 93.4 for natural ground and no losses for the pond area.
- Catchment areas of 22.15 ha and 26.83 ha corresponding to pit pond water surface and natural ground, respectively.
- The lag time used in the model for the catchments was estimated to be 40 minutes for the natural ground area, using the SCS method, which is based on parameters such as path length and slope.
- The Type II distribution developed by the SCS was used to represent the precipitation time sequence of the event.

The HEC-HMS model was run to estimate the peak inflow to the Expo Pit resulting from the design event. The peak inflow into the Main Collection Pond (MCP) under the design event is 23.5 $m^3/s$.

## G.1.2 Spillway Sizing

The outlet spillway will be located on the northeast side of the Expo Pit. The assumptions and inputs for sizing the spillway at the Expo Pit are as follows:

- The invert of the spillway was assumed to be at elevation 535.4 m, corresponding to the lowest elevation along the pit rim;
- The initial water level was assumed to be at the invert elevation of the spillway (535.4 m); and
- Side slopes of 3H:1V.

With a bottom width of 3.0 m, the peak flow through the emergency spillway is 1.46 $m^3/s$. The peak flow depth through the spillway under the design event (24-hr PMP) is 0.4 m, providing a freeboard of 0.2 m relative to the crest elevation. The maximum flow velocity through the spillway chute is estimated to be 1.1 m/s. Rip-rap with $D_{50}$ of 0.1 m to prevent erosion will be placed above a layer of transition material.

The Expo Pit outlet spillway details are included on Figure 9.

## G.1.3 Discharge Channel Sizing

The discharge channel will flow by gravity around the east side of the Tailings Cell 1 to the Puvirnituq River tributary. Two segments of discharge channel were considered:

- South Discharge Channel: The discharge channel extends from the Outlet Spillway to the southeast corner of tailings Cell 1. The channel is about 350 m long with an approximate gradient of 2.1%.
- North Discharge Channel: The discharge channel extends from the southeast corner of tailings Cell 1 to the Lower Collection Pond Spillway channel. The channel is about 1,100 m long with an approximate gradient of 1.1%.

Manning's equation for open channels was used for sizing the discharge channel. The rip rap was sized using the US Army Corp of Engineers methodology (USACE 1991). The results of the analyses are included in Table G-1.

**Table G-1: Discharge Channel Sizing Results**

| Discharge Channel | Length (m) | Base Width (m) | Side Slope | Average Channel Slope | Peak Flow ($m^3/s$) | Flow Depth[1] (m) | Min. Channel Depth[2] (m) | Flow Velocity (m/s) | Required Min. $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|---|---|
| South | 350 | 3.0 | 2H:1V | 2.1% | 1.46 | 0.23 | 0.6 | 1.8 | 150 |
| North | 1,100 | 3.0 | 2H:1V | 1.1% | 1.46 | 0.28 | 0.7 | 1.5 | 100 |

Notes:

1. The flow depth does not include freeboard.
2. Minimum channel depth includes freeboard.

## REFERENCE

USACE (1991). Hydraulic Design of Flood Control Channels. United States Army Corps of Engineers, EM 1119-2-1601

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**APPENDIX 5**

Monitoring procedure for mining facilities, and management of tailings, waste rock and water (CRI), 2020

(enclosed in attachments)

# Procedure for the monitoring of mining facilities, and the management of tailings, waste rock and water

| | |
|---|---|
| **Reference Number** | PRO-NMIN-1505-01a-A |
| **Implementation date** | 2020-09-02 |
| **Responsible department** | Services Techniques |

| Approved by | Departement | Signature | Date |
|---|---|---|---|
| André Dumais | Direction site | | 2020-09-23 |
| Mern Vatcha | Mines | | 2020-09-23 |
| Stéphane Twigg | Environnement | | 2020-09-23 |
| Mathieu Roberge | Concentrateur | | 2020-09-23 |

**Ledger of revisions :**

| Version # | Reason for the new version | Who modified the document | Modification date |
|---|---|---|---|
| 1.0 | Original creation | Nicolas Kuzyk | 2017-06-27 |
| 1.1 | Additions | Stéphane Twigg | 2017-06-29 |
| 1.2 | Revision | Nicolas Kuzyk | 2017-07-02 |
| 2.0 | Revision | Mern Vatcha, Nicolas Kuzyk | 2019-12-02 |
| 3.0 | Number change | Judy-Fay Ferron | 2020-02-09 |

## 1. DEFINITIONS

- None

## 2. LEGAL REQUIREMENTS

- Metal and Diamond Mining Effluent Regulations (DORS/2002-222)
- The following certificates of authorization :
  - « Mining Nunavik Nickel Project (Expo et Mesamax), construction of a tailings park and a collection basin », MDDEP, July 20th, 2011, N° Ref. 7610-10-01-70080-53 400813693.
  - « Exploitation of Allammaq deposit », MDDELCC, February 12, 2015, 7610-10-01-70080-74 401201535.
  - « Exploitation of Méquillon deposit – Projet Nunavik Nickel », MELCC, December 19, 2018, N° Ref. 7610-10-01-70080-77 401764637.
- Attestation of sanitation in an industrial environment (RLRQ, chapitre Q-2, section IV.2), Attestation N° 201610003

## 3. PURPOSE

Monitoring programs involve inspections and surveillance of operations, structural integrity, safety and performance of facilities. The purpose of the monitoring procedure is to identify, evaluate, correct and report any deviations in facility performance (presenting a hazard or potential hazard). The programs consist of a qualitative and quantitative comparison between the actual and expected performance of the facilities. Frequent reviews of monitoring data can provide early indications of a performance trend that may require a more detailed assessment or corrective action. Therefore monitoring programs should be completed on a regular basis according to a defined schedule.

## 4. SCOPE

This monitoring procedure applies to the following facilities:

- The tailings and waste rock park at the EXPO site: two tailings cells and one waste rock cell;
- The Main Collection Basin (MCB), the Downstream Collection Basin (BCA), clean water frift ditches and contact water collection ditches at the EXPO site;
- The Expo thickener, direct displacement pumps and tailing transport and discharge system;
- The dam at the outlet of Bombardier Lake;
- The contact water (CW) collection basins and clean water drift ditches at the Mesamax, Allammaq and Méquillon sites;
- The main water treatment plant at the Expo site and the portable water treatment plants at the Mesamax and Méquillon sites.

## 5. SUPPORTING DOCUMENTS

- Tailings, Waste Rock and Water Management Facilities – Operation, Maintenance and Surveillance Manual (Manuel EES) (version 2013-2). Golder Associates, June 5, Report number : : 12-1118-0034 (2000) ;
- Tailings, Waste Rock and Water Management Facilities – Operation, Maintenance and Surveillance Manual (OMS Manual) (CRI version 2019 – in draft)
- FORM-ENV-00X[1] Mining Facility Inspection Summary ;
- FORM-ENV-00XA Field Inspection Worksheet A : Dykes and Dam ;
- FORM-ENV-00XB Field Inspection Worksheet B : Ditches, pipes and access roads ;
- FORM-ENV-00XC Daily Inspection Worksheet for mining facilities ;
- FORM-ENV-00XD Weekly Inspection Worksheet for Mining Facilities;
- Emergency Response Plan

## 6. RESPONSABILITIES

### 6.1 Site Director

- Ensure all aspects of facilities management ;
- Be responsible for all aspects of miling and concentration operations ;
- Ensure adherence to the dyke and dam safety assessment program, including continuous monitoring ;
- Ensure full and continuous monitoring ;
- Provide the necessary resources for appropriate emergency response.

### 6.2 Mine surintendant

- Ensure that dam and dyke safety assessment programs, including monitoring, safety inspections and dam reviews, are carried out according to specified requirements;
- Be responsible for scheduling all formal inspections (annual, quarterly) and filing all original inspection sheets and other documents;
- Carry out quarterly facility inspections with the Concentrator and Environmental Superintendents;
- Be responsible for updating the OES manual;
- Ensure that operations comply with the Tailings Management Plan ;
- Collect data from measuring instruments and provide reports in a timely manner;
- Analyze and track information in order to establish any necessary corrective measures.

- Manage the implementation of construction plans for dikes and dams ;

[1] Les formulaires FORM-ENV-00X, -00XA, -00XB et -00XC sont disponible en annexe à la fin de ce document.

- Be responsible for the day-to-day operations of the construction of the facilities;
- Ensure adequate preparation of mining operations to deal with any emergency at the facilities;
- Observe operations and report any unusual and/or defective conditions to the Environmental Superintendent;
- Be in charge of closure plans and their updates;
- Monitor and report any signs of exfiltration in the embankments and feet of the dikes/dams

**Environnemental Superintendant**

- Ensures that the operation of the facilities is in accordance with corporate objectives, as well as federal and provincial regulations and permits;
- Ensures overall direction of corrective measures for any environmental problems;
- Decide with the Engineering Superintendent if and when communication and/or support from external agencies is required (e.g. consulting firms, response agencies, etc.);
- Be in charge of environmental follow-up programs;
- Inform government agencies as prescribed in existing regulations.

### 6.3 Concentrator Superintendant

- - Complete regular reviews of operating and monitoring practices for dikes and dams;
- - Coordinate duties and responsibilities with the Environmental Superintendent;
- - Complete the necessary work to minimize environmental impacts under the direction of the Environmental Superintendent;
- - Complete all work required to repair/replace the tailings transport system and the tailings impoundment;
- - Complete mechanical and electrical maintenance and repairs;
- - Operate, inspect and maintain the pumps, pipes and instruments of the facilities;
- - Complete daily and weekly facility inspections;
- - Be in charge of the daily operations of the tailings cells, including deposition, landfill, tailings treatment, etc. ;
- - Ensure compliance with all aspects of tailings system operations;
- - Ensure quality control of all aspects of the tailings transportation system and its operations;
- - Be responsible for maintaining adequate pond levels in conjunction with the Environmental Superintendents and Technical Services.
- - Be responsible for the day-to-day operations of waste rock disposal.

### 6.4 Chef Ressources Humaines, sûreté et mesures d'urgences

- Update the emergency response plan ;
- Be responsible for the annual testing of the EMP

### 6.5 Employés

- Complete appropriate training for all employees working in the areas of the facilities listed in Section 4 ;
- Report deviations, trends, and anomalies to their supervisors;
- Supervisors are responsible for reporting employee observations to their superintendents ;
- Be involved in the monitoring of the facilities as part of their activities.

## 7. DESCRIPTION DU PROGRAMME DE SURVEILLANCE

### 7.1 Inspection requirements

- As a minimum, facility inspections should identify and address the following items:
  - Pool levels exceeding the maximum operational level ;
  - Pipes and culverts in a dike or dam (or in their foundation) ;
  - Transverse cracks in a dyke (sign of differential settlement) ;
  - Longitudinal cracks along a dyke (sign of subsidence or slope instability); Longitudinal cracks along a dyke (sign of subsidence or slope instability)
  - Horizontal cracks in a dike (sign of core settlement) ;
  - Cavities (Signs of internal scour and erosion by water from the dike or dam);
  - Compaction, particularly differential (serious consequences if freeboard is reduced);
  - Subsidence, flare or lateral bulge (Signs of slope instability); and
  - Wet and soft areas, craters and water resurgence at the bottom of the downstream slope (very serious - can lead to a break) ;
  - Sediment-laden exfiltration (scouring and internal erosion - can lead to failure);
  - Increased rate of exfiltration (sign of adverse change) ;
  - New areas of exfiltration (sign of adverse change);
  - Slope erosion (waves and runoff - deficient borehole) ;
  - Animal burrows (can create holes in a dam or dyke) ;
  - Vegetation (interferes with inspections, roots can cause exfiltration) ;
  - Congested drainage ditches (prevents drainage; must provide adequate drainage);
  - Condition of spillways (deterioration can lead to gullying and breakage);
  - Pump/barge condition ;
  - Deterioration of concrete elements.

Table 1 provides a list of structures, components, and instrumentation within facilities that require monitoring:

**Table 1. Structural Inspection Schedule**

| Structure | Daily inspection * | Weekly inspection * | Quaterly Inspection * | Annual inspection ** |
|---|---|---|---|---|
| Residue storage cells 1 and 2 | X | X | X | X |
| Sterile waste storage cell 3 | | X | X | X |
| BCP Expo et BCA Expo | X | X | X | X |
| Bombardier Lake Dam (during culvert discharge) | | X | X | X |
| BC Mesamax, Allammaq et Méquillon | | X | X | X |
| Geotechnical instruments *** | | | X | X |
| BCP and CB emergency spillways (when water is present) | | | X | X |
| BCA emergency spillway (when water is present) | | | X | X |
| Collection and drift ditches at Expo, Mesamax, Allammaq and Méquillon sites (when T° > 0°C) | | | X | X |
| Pumps, mechanical and electrical devices | X | X | X | X |
| Tailings and water pipelines | X | X | X | X |
| Access roads | X | X | X | X |

* Daily, weekly and quarterly inspections must be performed by properly trained personnel.
** All annual inspections must be performed by an experienced civil/geotechnical engineer.
*** Instrument readings must be collected monthly. The most recent data must be included in the quarterly inspection report.

- In addition to scheduled inspections, any abnormality deviating from normal conditions that is observed between scheduled inspections must be documented on an Environmental Incident Form and reported to the Environmental Superintendent within 24 hours of the observation of the abnormality.
- The environmental superintendent may obtain the assistance of the general services superintendent to correct the deficiency.

## 7.2 Daily and weekly inspections

- Daily inspections must be performed by CRI staff with, at a minimum, a general knowledge of the facility components;
- Forms FORM-ENV-00XC Daily Mining Facility Inspection Worksheet or FORM-ENV-00XD Weekly Mining Facility Inspection Worksheet must be completed during the inspection;
- If a deviation is observed, a detailed inspection sheet must be completed with a clear description of the initial observation:

FORM-ENV-00XA for dikes, dams and spillways ;
FORM-ENV-00XB for ditches, pipes and access roads.

### 7.3 Quarterly Inspections

- Quarterly inspections (4 times/year) should be performed by experienced CRI personnel who are familiar with the arrangement, functions, and normal operating conditions of the facility components;
- In addition to the structures in Table 1, special attention should be paid to the visual appearance of the effluent discharged from the downstream basin and the exfiltration rates of all dikes;
- FORM-ENV-00XA must be completed for each dyke and spillway inspected;
- FORM-ENV-00XB must be completed for each ditch, pipe, and access road;
- The Mining Facility Inspection Summary Form FORM-ENV-00X must also be completed and properly filed with the Field Inspection Worksheets A and B and the data obtained from the geotechnical instrument readings, which will constitute a complete quarterly inspection document;
- The entire document must be submitted to the Environmental Superintendent within one week of the inspection ;
- Any irregularities must be reported verbally at the time of submission to ensure that special attention will be paid to them.

### 7.1 Annual inspections

- A detailed engineering inspection must be completed on an annual basis by an experienced geotechnical engineer to inspect the condition and performance of the tailings, waste rock and water management facilities, including all of the above components subject to quarterly inspections;
- The inspecting engineer shall review the quarterly inspection reports as well as the annual inspection reports from previous years to compare the observed conditions with the data collected during the annual inspection;
- An inspection report shall be prepared by the Engineer following the inspection ;
- This inspection report must deal with conditions, analyses and suggestions for improvement and must be submitted to the environmental superintendent.

### 7.2 Event-driven inspections

- In the event of extreme events, such as a shower with a low probability of recurrence (i.e. above a 20-year return period) or an earthquake, a detailed engineering inspection must be completed immediately by an experienced geotechnical engineer following the same standards as an annual inspection.

### 7.3 Dike/Dam Safety Review

- The primary objective of a dam/digging safety review is to determine whether tailings or water management facilities, particularly storage structures, have adequate reserves of stability (i.e., a sufficient margin of safety) as determined by standard engineering practices and regulatory requirements;
- These reviews should include a comparison with the facility design assumptions and conditions ;
- They should be performed by an experienced geotechnical engineer who is familiar with the site;
- They must include a complete inspection of all other facility components subject to annual inspections;
- A survey of the crest elevation of the dyke/dam should be conducted to detect any potential settlement;
- The safety review may replace the annual inspection for the year in which it is performed.
- Dyke/Dam Safety Reviews must be conducted:
  - Once after the first filling of the basins, cells and dam ;
  - During the last year of operation (assuming 10 years of operation);
  - Once every 10 years thereafter.

### 7.4 Annual Survey of Tailings Surface

- An annual survey of the tailings surface (including submerged tailings slopes if applicable) must be conducted to provide an update on the conditions of the deposit (for future planning of the tailings repository), and to contribute to the environmental assessment of the tailings in place ;
- The results of the survey should be submitted to the Environmental Superintendent.

### 7.5 Surveillance Instruments

- Thermistor readings/measurements are measured monthly, at a minimum;
- Access to instrumentation must be maintained to facilitate monitoring.
- The database must be updated and checked for completeness;
- The geotechnical engineer should be informed immediately if instrument readings reach the alert levels shown in Table 2.

**Table 2. Alert levels- geothechnical instruments**

| Instrument | Structures | |
|---|---|---|

| | | |
|---|---|---|
| Thermistances | MCP Expo, MCP Allammaq, MCP Mesamax, MCP Méquillon et Fossé H | Temperatures measured above freezing at nodes located more than 2 m vertically or less than 2 m from the node closest to the base of the HDPE membrane. |
| | Cells 1 and 2 | Temperatures measured above the freezing point at nodes located more than 2 m vertically below the HDPE membrane |
| Packing plates | Cell 1, MCP Expo, MCP Mesamax and MCP Méquillon | Measured settlements of more than 100mm |

### 7.6 Documentation

- The documentation of monitoring activities is maintained by the Engineering and Utilities Department and includes the following documents:
  - Files of daily and weekly inspections (paper utilities);
  - Quarterly inspections and reports (Network Engineering);
  - Annual inspections and reports (Network Engineering);
  - Event Triggered Reports and Inspections (Network Engineering);
  - Instrument readings and graphs (Network Engineering).

# ANNEX

FORM-ENV-00X Résumé d'inspection des installations minières ;
FORM-ENV-00XA Fiche d'inspection de terrain A : Digues et barrage ;
FORM-ENV-00XB Fiche d'inspection de terrain B : Fossés, conduites et voies d'accès ;
FORM-ENV-00XC Fiche d'inspection quotidienne des installations minières

CANADIAN ROYALTIES INC.

NUNAVIK NICKEL

**FORM-ENV-00X**

**RÉSUMÉ D'INSPECTION DES INSTALLATIONS**

Toutes les sections de cette fiche d'inspection doivent être complétées. Toute anomalie doit être décrite en compagnie de la localisation. Toute information additionnelle et photo pertinente doit être jointe au rapport.

Nom de l'inspecteur : No. Rapport : Date de l'inspection :

**CONDITIONS MÉTÉOROLOGIQUES :**

Température : Description :

Autres commentaires :

| | Pendant l'inspection | 3 jours précédent |
|---|---|---|
| Sec | ☐ | ☐ |
| Gel | ☐ | ☐ |
| Pluie | ☐ | ☐ |
| Neige | ☐ | ☐ |

**INSTALLATIONS INSPECTÉES :**

(une fiche d'inspection séparée, fiche A ou B, doit être complétée pour chaque structure)

**Structure/installation :**

| | |
|---|---|
| Cellule 1 de stockage des résidus | ☐ |
| Cellule 2 de stockage des résidus | ☐ |
| Cellule 3 de stockage des résidus | ☐ |
| Bassin de collecte principal – EXPO | ☐ |
| Bassin de collecte aval – expo | ☐ |
| Déversoir du bassin de collecte principal expo | ☐ |
| Déversoir du bassin de collecte aval expo | ☐ |
| Barrage à l'exutoire du lac bombardier | ☐ |
| Bassin de collecte Mesamax | ☐ |
| Déversoir du bassin de collecte Mesamax | ☐ |
| Instruments géotechniques | ☐ |
| Fossés de collecte/de dérive : Expo-Mesamax-Allammaq-Méq | ☐ |
| Pompes, dispositifs mécaniques et électriques | ☐ |
| Pipelines et routes d'accès | ☐ |
| Bassin de collecte Allammaq | ☐ |
| Déversoir du bassin de collecte – Allammaq | ☐ |
| Bassin de collecte Méquillon | ☐ |
| Déversoir du bassin de collecte – Méquillon | ☐ |

Action requise : ☐ Aucune ☐

Nom du réviseur : Date de révision :

CANADIAN ROYALTIES INC.

NUNAVIKNICKEL

Toutes les sections de cette fiche d'inspection doivent être complétées. Toute anomalie doit être décrite en compagnie de la localisation. Toute information additionnelle et photo pertinente doit être jointe au rapport.

Nom de l'inspecteur : No. Rapport : Date de l'inspection :

**INFORMATION – DIGUE/BARRAGE:**

Identification : Élévation crête : Élévation bassin :

**7.7** INSPECTION DIGUE/BARRAGE:

**A) Crête :**

| | | |
|---|---|---|
| Fissures | ☐ Non | ☐ |
| Tassement | ☐ Non | ☐ |
| Érosion | ☐ Non | ☐ |
| Autre mouvement | ☐ Non | ☐ |
| Végétation sur la crête | ☐ Non | ☐ |

**b) Pente et pied de pente aval :**

| | | |
|---|---|---|
| Érosion | ☐ Non | ☐ |
| Tassement | ☐ Non | ☐ |
| Bombage | ☐ Non | ☐ |
| Écoulement de surface | ☐ Non | ☐ |
| Protection de pente | ☐ Non | ☐ |
| Végétation sur la pente | ☐ Non | ☐ |
| Terriers d'animaux | ☐ Non | ☐ |
| Suintement/Exfiltration | ☐ Non | ☐ **Localisation 1 :** |

**Débit :** ☐ Humidité ☐ Filet d'eau ☐ Soutenu

**Clarté :** ☐ Claire ☐ Boueuse

**Échantillon recueilli :** ☐Oui ☐ Non

☐ **Localisation 2 :**

**Débit :** ☐ Humidité ☐Filet d'eau ☐Soutenu

**Clarté :** ☐ Claire ☐ Boueuse

**Échantillon recueilli :** ☐ Oui ☐ Non

Végétation pied de pente ☐ Non ☐ Clairsemé ☐ Modéré ☐ Dense

Type :

Résurgences pied de pente ☐ Non ☐ Localisations :

# FORM-ENV-00XA
# PROJET NUNAVIK NICKEL
# INSTALLATION DE GESTION DES RÉSIDUS, DES STÉRILES ET DES EAUX
# FICHE A D'INSPECTION DE TERRAIN : RAPPORT D'INSPECTION DE DIGUE/BARRAGE

Identification de la digue /

**INSPECTION DIGUE/BARRAGE (SUITE) :**

**C) Pente amont et surface des résidus:**

| | | | | |
|---|---|---|---|---|
| Érosion | ☐ Non | ☐ Par l'action des vagues | ☐ Par ruissellement | |
| | | **Localisation :** | | |
| | | **Degré :** ☐ Mineur | ☐ Modéré | ☐ Sévère |
| Tassement | ☐ Non | ☐ | | |
| Bombage | ☐ Non | ☐ | | |
| Écoulement de surface | ☐ Non | ☐ | | |
| Protection de pente | ☐ Non | ☐ | | |
| Terriers d'animaux | ☐ Non | ☐ | | |
| Remous d'eau | ☐ Non | ☐ | | |
| Cratères | ☐ Non | ☐ | | |
| Eau accumulée à la surface des résidus | ☐ Non | ☐ | | |

**INSPECTION – DÉVERSOIR – STRUCTURE DE CONTRÔLE DE L'ÉCOULEMENT :**

**Type :**

| | | |
|---|---|---|
| ☐ Déversoir | ☐ Recycle d'eau | ☐ Autre : |
| ☐ Décantation | ☐ Seuil déversant | |

**Conditions observées :**

| | | | | |
|---|---|---|---|---|
| ☐ Bon état | ☐ Blocage entrée | ☐ Débris | Mesure corrective : | ☐ Complétée |
| | | ☐ Digue castor | | ☐ À compléter |
| | | ☐ Envasement | | |
| | ☐ Blocage exutoire | ☐ Débris | Mesure corrective : | ☐ Complétée |
| | | ☐ Digue castor | | ☐ À compléter |
| | | ☐ Envasement | | |
| | ☐ Érosion | ☐ Chenal | Mesure corrective : | ☐ Complétée |
| | | ☐ Pente | | ☐ À compléter |
| | | ☐ À la décharge | | |

**Commentaires :**

**FORM-ENV-00XA**

**PROJET NUNAVIK NICKEL**

**INSTALLATION DE GESTION DES RÉSIDUS, DES STÉRILES ET DES EAUX**

**FICHE A D'INSPECTION DE TERRAIN : RAPPORT D'INSPECTION DE DIGUE/BARRAGE**

Identification de la digue /

**INSTRUMENTATION - DIGUE BARRAGE :**

(Dessiner tout instrument nouvellement installé sur les plans et coupes pertinentes)

☐ Aucun

| | Opérationnel | Endommagé | Lecture recueillie |
|---|---|---|---|
| ☐ Thermistances | ☐ | ☐ | ☐ |
| ☐ Inclinomètres | ☐ | ☐ | ☐ |
| ☐ Plaques de tassement | ☐ | ☐ | ☐ |
| ☐ Autre : | ☐ | ☐ | ☐ |

**COMMENTAIRES ET RECOMMANDATIONS:**

Action requise : ☐ Aucune ☐ Suivi additionnel ☐ Entretien ☐ Mesure corrective immédiate

☐ Plan ou croquis joint :

☐ Photo jointes :

**COMMENTAIRES DU RÉVISEUR**

☐ AUCUNS

Nom du réviseur : Date :

CANADIAN ROYALTIES INC.

NUNAVIK NICKEL

# FORM-ENV-00XB
# PROJET NUNAVIK NICKEL
# INSTALLATION DE GESTION DES RÉSIDUS, DES STÉRILES ET DES EAUX
# FICHE B D'INSPECTION DE TERRAIN : FOSSÉS, CHENAUX ET ITEMS DIVERS

Toutes les sections de cette fiche d'inspection doivent être complétées. Toute anomalie doit être décrite en compagnie de la localisation. Toute information additionnelle et photo pertinente doit être jointe au rapport.

Nom de l'inspecteur : No. Rapport : Date de l'inspection :

**FOSSÉE ET CHENAUX :**

Identification : Élévation du radier au point d'origine :

Structure de contrôle du débit : ☐ Aucune ☐

**A) Conditions – Entrée / Point d'origine :**

☐ Bon état ☐ Affouillement et érosion
- ☐ Blocage : ☐ Débris
  - ☐ Digue de castor
  - ☐ Envasement
  - ☐ Végétation
- ☐ Pentes : ☐ Érosion
  - ☐ Instabilité / rupture

☐ Mesure corrective : ☐ Complétée
- ☐ À compléter

**B) Conditions – Exutoire :**

☐ Bon état ☐ Affouillement et érosion
- ☐ Blocage : ☐ Débris
  - ☐ Digue de castor
  - ☐ Envasement
  - ☐ Végétation
- ☐ Pentes : ☐ Érosion
  - ☐ Instabilité / rupture

☐ Mesure corrective : ☐ Complétée
- ☐ À compléter

**ROUTE D'ACCÈS :**

Localisation : ☐ Végétation ☐ Débris ☐ Érosion

Localisation : ☐ Végétation ☐ Débris ☐ Érosion

**FORM-ENV-00XB**

**PROJET NUNAVIK NICKEL**

**FICHE B D'INSPECTION DE TERRAIN : FOSSÉS, CHENAUX ET ITEMS DIVERS**

**PONCEAUX:**

Localisation : ☐ Bon état ☐ Bloqué ☐ Endommagé :

Localisation : ☐ Bon état ☐ Bloqué ☐ Endommagé :

Localisation : ☐ Bon état ☐ Bloqué ☐ Endommagé :

Localisation : ☐ Bon état ☐ Bloqué ☐ Endommagé :

Localisation : ☐ Bon état ☐ Bloqué ☐ Endommagé :

**PIPELINES:**

Pipeline: ☐ Bon état ☐ Endommagé :

Pipeline: ☐ Bon état ☐ Endommagé :

Pipeline: ☐ Bon état ☐ Endommagé :

Pipeline: ☐ Bon état ☐ Endommagé :

Pipeline: ☐ Bon état ☐ Endommagé :

Pipeline: ☐ Bon état ☐ Endommagé :

Pipeline: ☐ Bon état ☐ Endommagé :

**7.8** COMMENTAIRES ET RECOMMANDATIONS:

Action requise : ☐ Aucune ☐ Suivi additionnel ☐ Entretien ☐ Mesure corrective immédiate

☐ Plan ou croquis joint :

☐ Photo jointe :

**COMMENTAIRES DU RÉVISEUR:**

☐ AUCUNS

Nom du réviseur : Date :

CANADIAN ROYALTIES INC.

NUNAVIKNICKEL

# FORM-ENV-00XC INSPECTION JOURNALIÈRE

| Nom de l'inspecteur : | Date de l'inspection : |
|---|---|

| Activité | | État | | | Commentaires |
|---|---|---|---|---|---|
| | | Bon | Défect. | s/o | |
| Cellule 1 de stockage des résidus | Inspection route d'accès | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue nord | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue ouest | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue est | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue sud | ☐ | ☐ | ☐ | |
| | Inspection visuelle – Géomembrane | ☐ | ☐ | ☐ | |
| | Inspection visuelle – déversoir | ☐ | ☐ | ☐ | |
| Cellule 2 de stockage des résidus | Inspection route d'accès | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue nord | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue ouest | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue est | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue sud | ☐ | ☐ | ☐ | |
| | Inspection visuelle – Géomembrane | ☐ | ☐ | ☐ | |
| | Inspection visuelle – déversoir | ☐ | ☐ | ☐ | |
| Bassin de collecte principal | Inspection route d'accès | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue nord | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue ouest | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue est | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue sud | ☐ | ☐ | ☐ | |
| | Inspection visuelle – Géomembrane | ☐ | ☐ | ☐ | |
| | Inspection visuelle – déversoir | ☐ | ☐ | ☐ | |
| | Niveau d'eau (élévation max 522.0 m) | ☐ | ☐ | ☐ | |
| Bassin de collecte aval | Inspection route d'accès | ☐ | ☐ | ☐ | |
| | Inspection visuelle – bermes | ☐ | ☐ | ☐ | |
| | Inspection visuelle – déversoir | ☐ | ☐ | ☐ | |
| | Niveau d'eau | ☐ | ☐ | ☐ | |

| **Niveaux de conception** | BCP Expo | Bassin Mesamax | Bassin Allammaq | Barrage Bombardier | Bassin Méquillon |
|---|---|---|---|---|---|
| Crête | 524.0 m | 544.5 à 545.5 m | 560.8 à 560.6m | 550.0 m | 520.0m |
| Radier du réservoir | 522.5 m | 543.0 m | 559.0m | 548.1 m | 518.5m |
| Niveau d'eau maximal d'opération | 522.0 m | 542.5 m | 558.3m | -- | 518.0m |

# FORM-ENV-00XD INSPECTION HEBDOMADAIRE

| Nom de l'inspecteur : | Date de l'inspection : |
|---|---|

| Activité | | État | | | Commentaires |
|---|---|---|---|---|---|
| | | Bon | Défect. | s/o | |
| Cellule 3 de stockage des stériles | Inspection route d'accès | ☐ | ☐ | ☐ | |
| | Inspection visuelle – cellule de stockage | ☐ | ☐ | ☐ | |
| Barrage du lac bombardier | Inspection visuelle – barrage | ☐ | ☐ | ☐ | |
| | Inspection visuelle – déversoir opérationnel | ☐ | ☐ | ☐ | |
| | Inspection visuelle – ponceau/passes migratoires | ☐ | ☐ | ☐ | |
| | Inspection visuelle – bermes de protection des glaces | ☐ | ☐ | ☐ | |
| Bassin de collecte Mesamax | Inspection route d'accès | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue | ☐ | ☐ | ☐ | |
| | Inspection visuelle – déversoir | ☐ | ☐ | ☐ | |
| | Niveau d'eau | ☐ | ☐ | ☐ | |
| Bassin de collecte Allammaq | Inspection route d'accès | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue | ☐ | ☐ | ☐ | |
| | Inspection visuelle – déversoir | ☐ | ☐ | ☐ | |
| | Niveau d'eau | ☐ | ☐ | ☐ | |
| Bassin de collecte Méquillon | Inspection route d'accès | ☐ | ☐ | ☐ | |
| | Inspection visuelle – digue | ☐ | ☐ | ☐ | |
| | Inspection visuelle – déversoir | ☐ | ☐ | ☐ | |
| | Niveau d'eau | ☐ | ☐ | ☐ | |

| **Niveaux de conception** | BCP Expo | Bassin Mesamax | Bassin Allammaq | Barrage Bombardier | Bassin Méquillon |
|---|---|---|---|---|---|
| Crête | 524.0 m | 544.5 à 545.5 m | 560.8 à 560.6m | 550.0 m | 520.0m |
| Radier du réservoir | 522.5 m | 543.0 m | 559.0m | 548.1 m | 518.5m |
| Niveau d'eau maximal d'opération | 522.0 m | 542.5 m | 558.3m | -- | 518.0m |

**APPENDIX 6**

Environmental monitoring plan V.4 – 27th Monitoring (WSP), June 2015

(enclosed in attachments)

# 27. PARC À RÉSIDUS ET À STÉRILES

## 27.1 Objectif

Le suivi du comportement des résidus et des stériles dans le parc à Expo vise à évaluer leur comportement au cours de leur accumulation dans une cellule du parc. Il vise à confirmer si la génération d'acide s'installe ou non à l'intérieur des délais mesurés lors des essais en laboratoire et, advenant une réactivité plus rapide que prévu, à réagir en modifiant la stratégie d'accumulation des résidus et de la roche stérile dans le parc (p. ex. recouvrement plus hâtif d'une cellule).

## 27.2 Zone d'étude

La zone d'étude comprend le parc à résidus et à stériles situé à Expo (carte 27.1).

## 27.3 Méthode

Les roches stériles de la mine Expo ainsi que les résidus produits lors du traitement du minerai de toutes les mines satellites seront entreposés dans le parc à résidus et à stériles d'Expo, lequel est construit en cellules et par étapes. Le projet prévoit un empilement de roches stériles, deux cellules contenant des résidus épaissis, retenus par des bermes de roches stériles de la mine Expo, et un bassin de collecte des eaux. La construction par cellule et par étapes permet une fermeture progressive du parc à mesure que les cellules sont remplies. La crête et les pentes des digues de confinement des résidus sont recouvertes d'une géomembrane pour limiter l'infiltration d'air et d'eau. À sa fermeture, le parc sera recouvert d'une géomembrane qui empêchera l'infiltration d'eau et la circulation d'oxygène dans les résidus pour prévenir le développement de drainage minier acide.

Les digues du parc sont construites avec des matériaux qui ne sont pas susceptibles de se liquéfier. Elles sont érigées sur le socle rocheux ou sur du mort-terrain granulaire qui n'est pas susceptible de se liquéfier. Les facteurs de sécurité des digues face à la rupture sont élevés. Il existe un faible potentiel de tassement des fondations et la géomembrane choisie est en mesure de résister à des faibles tassements sans déchirure. Le tassement au pied des digues qui pourrait être occasionné par le transfert de chaleur des résidus chauds vers le pergélisol est étudié par l'installation de thermistances, des bornes de tassement et des piézomètres dans la digue et dans le roc sous les résidus. Ces instruments sont lus de façon périodique par le personnel de CRI.

Dans le but d'entreposer les résidus et les roches stériles de manière à générer le moins d'impacts possible, le suivi est axé sur la ségrégation en fonction de la taille des particules, de l'assèchement et de la vulnérabilité face à l'érosion éolienne et sur le comportement des résidus à la suite de la mise en place des stériles en couches de superposition en considérant les phénomènes de gel/dégel, de courants préférentiels et de formation de lentilles de glace.

Pour satisfaire les objectifs, le suivi du parc à résidus et à stériles d'Expo comprend quatre activités distinctes, soit :

- l'inspection visuelle et la stabilité physique des ouvrages;
- l'évaluation du comportement des résidus et des stériles lors de leur dépôt dans le parc;
- le potentiel de génération d'acide;
- l'inspection visuelle.

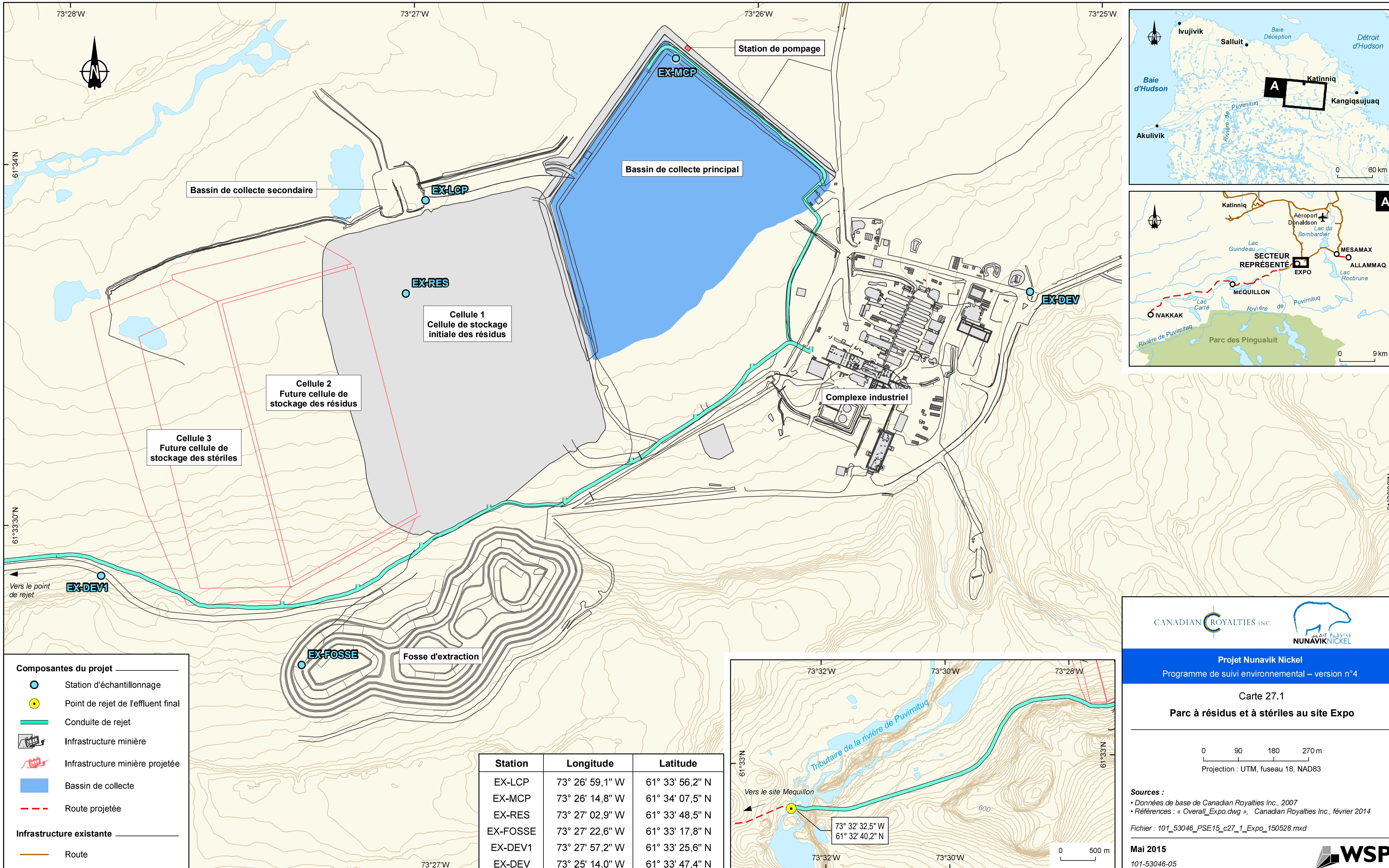
### 27.3.1 Inspection visuelle et stabilité physique des ouvrages

L'inspection visuelle et la stabilité physique des ouvrages visent à satisfaire l'une des exigences de la Directive 019 sur l'industrie minière (MDDEP, 2012).

Une inspection visuelle des ouvrages est effectuée deux fois par année, soit lors de la période de fonte des neiges et avant la première neige. Cette inspection se fait en marchant les fossés, les déversoirs, le pied aval puis la crête des digues. Toute irrégularité est notée lors de ces inspections, dont notamment la présence d'érosion, le blocage d'écoulement par des débris, les zones de déformation et les affaissements localisés. L'inspection visuelle est réalisée par l'ingénieur de CRI responsable du parc à résidus et à stériles. Au besoin, des photographies référencées sont prises pour suivre l'évolution d'un point d'observation donné. Le responsable du parc à résidus et à stériles doit, le cas échéant, prendre action pour corriger les situations qui le justifient, comme une dégradation découlant de l'érosion.

L'évaluation de la stabilité physique des ouvrages permet d'évaluer le régime thermique du site et l'ampleur du mouvement des digues qui pourrait découler du dégel partiel de la fondation. Pour ce faire, il est proposé de mettre en place des thermistances pour le suivi de la température et des bornes de tassement pour le suivi du mouvement des digues. Il est également prévu d'installer des puits d'observation au voisinage des fossés de drainage pour suivre la qualité de l'eau souterraine dans la couche active du sol. Les thermistances sont notamment installées dans les sols de fondations sous les digues et dans les résidus déposés. Elles sont lues à fréquence régulière par le personnel de CRI. Elles permettent de s'assurer que la température demeure sous le point de congélation à la base des ouvrages, ce qui permet d'assurer l'intégrité et l'étanchéité de ceux-ci.

Les bornes de tassement sont installées en crête des digues. Elles sont relevées par arpentage et leur élévation est rattachée à un repère fixe, ce qui permet d'en suivre l'évolution dans le temps. Comme les digues sont progressivement rehaussées dans le temps par mode de construction aval, de nouvelles bornes doivent être mises en place lors de chaque étape de rehaussement. De préférence, les bornes sont positionnées à l'extérieur des voies de circulation, idéalement à proximité des talus amont et à une certaine distance des coins de cellules. Les bornes sont lues périodiquement chaque année par le personnel d'arpentage de CRI et les résultats sont interprétés par le géotechnicien responsable de la conception de l'ouvrage.




| Station | Longitude | Latitude |
|---|---|---|
| EX-LCP | 73° 26' 59,1" W | 61° 33' 56,2" N |
| EX-MCP | 73° 26' 14,8" W | 61° 34' 07,5" N |
| EX-RES | 73° 27' 02,9" W | 61° 33' 48,5" N |
| EX-FOSSE | 73° 27' 22,6" W | 61° 33' 17,8" N |
| EX-DEV1 | 73° 27' 57,2" W | 61° 33' 25,6" N |
| EX-DEV | 73° 25' 14,0" W | 61° 33' 47,4" N |

CANADIAN ROYALTIES INC

NUNAVIKNICKEL

**Projet Nunavik Nickel**

Programme de suivi environnemental – version n°4

Carte 27.1

**Parc à résidus et à stériles au site Expo**

0 90 180 270 m

Projection : UTM, fuseau 18, NAD83

***Sources :***

*• Données de base de Canadian Royalties Inc., 2007*

*• Références : « Overall_Expo.dwg », Canadian Royalties Inc., février 2014*

*Fichier : 101_53046_PSE15_c27_1_Expo_150528.mxd*

**Mai 2015**

*101-53046-05*

WSP

Des puits d'observation sont aménagés dans la couche active du pergélisol, en amont hydraulique du site et en aval des fossés externes de drainage. Ceux-ci ne sont toutefois pas utilisables puisqu'ils sont gelés en permanence.

### 27.3.2 Évaluation du comportement des résidus lors de leur dépôt dans le parc

L'inspection visuelle et la stabilité physique des ouvrages seront couplées à l'évaluation du comportement des résidus lors de leur dépôt dans le parc, laquelle sera réalisée mensuellement et portera sur les éléments suivants :

- la mesure du niveau d'eau ou de glace à l'intérieur des diverses cellules;
- la mesure de la revanche relative à la déposition des solides;
- le relevé des canaux d'érosion à la surface des résidus (été seulement);
- la vérification de l'état de fonctionnement des pompes.

La mesure du niveau de glace et celui des résidus dans les diverses cellules se fera en plusieurs points le long de chacune des digues afin d'évaluer l'ensemble de la déposition à un moment donné et la capacité de stockage résiduelle d'une cellule. Pour ce faire, un système de repères sera établi afin de conserver la position de ces points d'observation. La pertinence de ces mesures deviendra plus grande lorsque le projet atteindra la pleine capacité d'une cellule donnée, tel qu'en 2016 dans le cas de la cellule 2 et en 2021 pour la cellule 3. Une augmentation de la fréquence d'observation pourrait être requise lors de ces périodes critiques. Les données accumulées lors du dégel permettront, entre autres, d'évaluer les gains d'espace résultant de la fonte des lentilles de glace au sein des résidus. L'ensemble de ces données sera utilisé en temps réel par l'ingénieur de CRI responsable du parc à résidus et à stériles afin de moduler la déposition des résidus dans le parc.

### 27.3.3 Potentiel de génération d'acide

Pour vérifier *in situ* la progression réelle du risque de drainage minier acide (DMA), CRI propose d'effectuer un suivi de la qualité de l'eau de ruissellement entre la fosse et le bassin de collecte à Expo. Ce suivi sera réalisé pendant la construction et l'exploitation, de manière à pouvoir mettre en place les mesures requises en cas de développement de DMA.

Pour ce faire, des échantillons d'eau de ruissellement seront prélevés à six endroits distincts, soit :

- au point de collecte des eaux dans la fosse;
- dans le fossé de drainage de la halde en amont du bassin de collecte (du drainage du parc);

- dans le bassin de collecte principal, à proximité du point de décharge;
- dans le bassin de collecte secondaire;
- à deux endroits dans le fossé de déviation d'eau non contaminée.

Selon l'endroit, les paramètres d'analyse et la fréquence peuvent varier (tableau 27.1). Les paramètres de la liste A s'appliquent à l'eau de déviation et tiennent compte des paramètres d'intérêt environnementaux typiquement issus du remaniement de matériel géologique propre.

Tableau 27.1 Paramètres et fréquence du suivi de la qualité de l'eau à Expo.

| Site d'échantillonnage | Nombre de stations par site | Paramètre de suivi[1] | Fréquence (lorsque présent) |
|---|---|---|---|
| Fosse | 1 | Liste B | Hebdomadaire |
| Bassin de collecte inférieur | 1 | Liste B | Hebdomadaire |
| Bassin de collecte principal | 1 | Liste C | Quotidien – période de rejet<br>Hebdomadaire – période sans rejet |
| Cellule de résidus | 1 | Liste C | Mensuel |
| Fossés de déviation | 2 | Liste A | Hebdomadaire |

1. Paramètres de suivi :
   Liste A : pH, conductivité, matières en suspension, turbidité.
   Liste B : pH, conductivité, matières en suspension, turbidité, alcalinité, azote ammoniacal, aluminium, arsenic, chlorure, chrome, cobalt, cuivre, fer, nickel, nitrate, plomb, sulfate, zinc.
   Liste C : pH, conductivité, matières en suspension, turbidité, alcalinité, azote ammoniacal, aluminium, arsenic, chlorure, chrome, cobalt, cuivre, fer, nickel, nitrate, plomb, sulfate, zinc, hydrocarbures, thiosels.

Les paramètres de la liste B s'appliquent à l'eau de ruissellement en contact avec les stériles, le minerai et la fosse, et tiennent compte des paramètres d'intérêt environnementaux définis lors de l'étude géochimique sur le stérile et le minerai (Golder Associés Ltée, 2009; 2010) ainsi que des paramètres indicateurs de DMA.

Les paramètres de la liste C s'appliquent à l'eau de ruissellement qui est en contact avec le minerai et les résidus. Ils tiennent compte des paramètres stipulés dans la liste B et des exigences au point de rejet des effluents stipulés dans la Directive 019 sur l'industrie minière (MDDEP, 2012) qui devront être satisfaits au point de rejet des eaux du bassin de collecte.

À la fin de la vie utile du PNNi, la qualité de l'eau de la fosse ennoyée fera l'objet d'un suivi mensuel pour un minimum de deux ans suivant la fermeture. Si une bonne qualité d'eau est observée pendant cette période (sans nécessité de traitement), le suivi de la qualité de l'eau sera effectué annuellement pour le reste de la période post fermeture, d'une durée de dix ans.

Par ailleurs, il est proposé de vérifier l'évolution du DMA directement dans le parc à résidus et à stériles par un suivi de la qualité de l'eau. Une inspection mensuelle de l'aspect visuel des résidus, en mettant une emphase sur la présence de taches d'oxydation et de sels minéraux sur la surface des résidus est aussi prévu.

Dans le cas où le suivi de la qualité de l'eau de ruissellement suggère une dégradation, telle qu'une augmentation soutenue des concentrations de sulfate et des métaux avec ou sans acidification, ou des concentrations de paramètres chimiques dans l'eau des bassins de collecte qui dépassent les critères d'effluent minier (Directive 019), l'eau du bassin de collecte sera traitée et les concentrations atténuées avant le rejet dans l'environnement. De plus, de la chaux pourra être ajoutée sur la roche ou dans l'eau du fossé collecteur pour tamponner le pH.

### 27.3.4 Inspection annuelle et rapport

Une inspection annuelle du parc à résidus et à stériles sera effectuée à la fin de chaque été par un ingénieur géotechnique. Préalablement à cette inspection, les données relatives à l'inspection visuelle et à la stabilité physique des ouvrages, à l'évaluation du dépôt des résidus ainsi que du potentiel de génération d'acide des stériles et des résidus devront être recueillies pour l'année en cours par le personnel de CRI et transmises à l'ingénieur en géotechnique qui en fera la revue.

L'ingénieur produira un rapport qui résumera le suivi des données de terrain et des observations notées lors de sa visite du site. Il pourra, au besoin, recommander certaines mesures correctives concernant la gestion du parc à résidus et à stériles.

Le rapport produit par Golder Associés Ltée à l'automne 2014 formule les recommandations suivantes qui seront appliquées en 2015 :

- Minimiser les quantités d'eau accumulées dans le bassin de collecte principal et la cellule 1 en optimisant le procédé de traitement des eaux minières.
- Augmenter les bermes au coin nord-est du bassin de collecte secondaire afin de prévenir l'entrée d'eau propre provenant de la toundra. L'entrée d'eau propre augmente le volume d'eau à traiter.
- Améliorer l'ensemble du réseau de fossés de déviation des eaux de contact afin de diminuer le volume d'eau propre à traiter.
- Niveler la halde à minerai afin de drainer les parties nord et est, afin de canaliser les eaux en contact de cette zone afin de les envoyer vers le bassin de collecte principal. Également, modifier la configuration de la halde à minerai pour la placer à l'intérieur du réseau de drainage, au nord de la route d'accès ou encore recouvrir complètement le minerai afin de minimiser les eaux de contact.
- Minimiser l'accumulation d'eau dans la fosse afin de réduire le relargage des métaux.

- Continuer à surveiller l'instrumentation selon un calendrier régulier;
- Déterminer les effets de la collecte d'un plus grand volume d'eau sur les capacités du bassin, les taux de pompage et le traitement de l'eau;
- Examiner les plans de gestion de l'eau du site et déterminer comment transférer toute l'eau au bassin de collecte principal sans accumulation;
- Nettoyer les débris du ponceau sous la principale route d'accès au nord de l'usine de traitement;
- Remplacer et calibrer certains thermistors;
- Finaliser la construction du fossé de déviation au nord de la cellule 2 pour permettre la circulation de l'eau de ruissellement au bassin de collecte secondaire;
- Réparer l'enrochement en amont du MCP où se situe le tuyau de vidange du bassin de collecte secondaire.

## 27.4 Calendrier

Le suivi du parc à résidus et à stériles d'Expo a été entrepris en 2012 et se poursuivra annuellement jusqu'à une dizaine d'années suivant sa restauration complète.

## 27.5 Sources de l'engagement

***Certificat d'autorisation global du MDDELCC***

Condition 1 (modification du 6 juin 2011) : Le promoteur devra présenter à l'Administrateur, six mois avant l'extraction des stériles de la première fosse exploitée, un programme d'échantillonnage représentatif des stériles conçu pour vérifier *in situ* la progression réelle du risque de drainage minier acide. Le programme devra inclure une description des mesures temporaires et permanentes de contrôle et d'atténuation qui seraient apportées si la génération d'acide s'avérait supérieure à ce qui a été prévu, dont des mesures supplémentaires de protection qui pourraient être appliquées aux haldes à stériles ainsi qu'aux cellules et aux digues du parc à résidus en attendant le recouvrement final.

Condition 2 (modification du 6 juin 2011) : Le promoteur devra déposer à l'Administrateur pour approbation, six mois avant l'aménagement du parc à résidus, un programme de suivi du comportement des résidus lors de leur déposition dans le parc. Ce programme sera axé sur la ségrégation en fonction de la taille des particules, l'assèchement et la vulnérabilité face à l'érosion éolienne et le comportement des résidus suite à la mise en place des stériles en couches de superposition. Il considérera aussi les phénomènes de gel/dégel, de courants préférentiels et de formation de lentilles de glace pouvant interférer dans leur comportement. Le promoteur tiendra compte des résultats de ce programme de suivi dans la poursuite de ses activités de dépôt des résidus.

Condition 4.5 : Avant d'utiliser la fosse Expo pour la gestion des résidus, le promoteur devra présenter à l'Administrateur, pour approbation, les modalités d'encadrement de cette utilisation, ainsi que le suivi de l'évolution du niveau d'eau dans la fosse permettant de s'assurer que l'ennoiement des résidus miniers sera une mesure efficace à court et à long terme pour contrer le drainage minier acide.

***Directive 019 sur l'industrie minière du MDDELCC***

La Directive 019 sur l'industrie minière du MDDELCC stipule qu'un « exploitant minier doit effectuer, au moins une fois par saison, des visites de surveillance périodiques de la stabilité physique des ouvrages de confinement et des structures attenantes. Ces visites doivent également être effectuées à la suite d'événements climatiques exceptionnels. L'exploitant doit tenir à jour, et rendre accessible en tout temps, un registre faisant état de ces visites ».

*Dernière mise à jour : 23 juin 2015*

**APPENDIX 7**

CCN committee meeting report (IBA), December 11th, 2020

(enclosed in attachments)

*ELECTRONIC COMMUNICATION ONLY*

**NUNAVIK NICKEL AGREEMENT**
**ANNUAL SIGNATORIES'S MEETING**
**December 11th 2020**
**9:30h -12:30h**

Greetings to you,

Please find below the proposed meeting agenda for the coming Nunavik Nickel Signatory meeting, scheduled **December 11th 2020 from 9:30h to 12:30h.**

**PROPOSED AGENDA:**

**1- Update on the Covid-19 situation at Nunavik Nickel mine;**

**2- Operations status:**

- **a) Environmental performance**
- **b) Operations**
- **c) Nunavik Nickel mine mining development / Long-term Vision Plan (2028)**
- **d) Profit sharing and Procurement**

**3- New Development Annex 7.1 – Puimajuq/Allamaq sites;**

**4- Human Resources / Inuit Employment & training**

**5- Nunavik Nickel Agreement section 12.3**

**6- Mine closure plan review & financial guarantees update;**

**7- Varia**

Participants are invited to join the meeting with Webex, by computer or by telephone. All relevant supporting documents will be shared prior to the meeting.

**When it's time, join your Webex meeting here.**

Meeting number (access code): **179 429 2519**

Meeting password: **fKvE7rQpG46**

Join meeting

**Tap to join from a mobile device (attendees only)**
**+1-415-655-0001,,1794292519##** Nunavik Toll
+1-438-797-4001,,1794292519## Canada Toll (Montreal)

**Join by phone**
**+1-415-655-0001** Nunavik Toll
+1-438-797-4001 Canada Toll (Montreal)
Global call-in numbers

**Join from a video system or application**
Dial 1794292519@makivik.webex.com
You can also dial 173.243.2.68 and enter your meeting number.

**Join using Microsoft Lync or Microsoft Skype for Business**

Dial 1794292519.makivik@lync.webex.com

CANADIAN ROYALTIES INC.

NUNAVIK NICKEL

# Nunavik Nickel Committee
# Signatory Meeting
# December 11, 2020

# Agenda

1. Update on the Covid-19 situation at Nunavik Nickel mine
2. Operations status:
    a) Environmental performance
    b) Operations
    c) Nunavik Nickel mine mining development / Long-term Vision Plan 2028)
    d) Profit sharing and Procurement
3. New Development Annex 7.1 – Puimajuq/Allamaq sites
4. Human Resources / Inuit Employment & training
5. Nunavik Nickel Agreement section 12.3
6. Mine closure plan review & financial guarantees update
7. Varia

# Covid-19

# History of events

- March 16, Montreal office shutdown and workers put in telework
- March 22, cancellation of inuit charter as Nunavik northern communities are put in lockdown
- March 23, official lockdown of Quebec businesses (PM). All mines to be put on C&M
- March 27, completed the demobilisation of all non essential personnel not needed for C&M
- March 28, official temporary layoff date
- April 2, Restarted finalization of Expo pit following special autorisation from gvt authorities
- April 13, received autorisation to restart full operations (southern employees only because of lockdown)
- Early May, all southern employees were back to work
- July 13, started testing employees at airports
- September 29, Inuit employees started returning to work
- December 11, all inuit employees are back to work

# List of measures on Site

- Introduced pre-boarding investigation (48 hours) by site nurses and a triage questionair at airports
- New plane restrictions: mandatory hand washing when boarding; reduced passengers configuration (71/112, 47/76, 37/60) until July; masks are mandatory from boarding to camp arrival; no food service on board; mandatory to wear long sleeves; assigned seats
- Imposed administrative quarantine to employees who have travelled outside Canada or who have Covid symptoms
- Organized on site testing with Glencore Raglan
- Increased Outland personnel needed (cafeteria personalised service, lunch room service, meals schedule, desinfection of public areas,…)
- Increased nurses (1) needed on site to help manage crisis
- Cafeteria reorganisation and configuration (food & drinks distribution, entrance surveillance with temperature monitoring, mandatory hand washing, social distanciation,…)
- Developped the on site Covid-19 contingency plan (isolation, equipment procurement, medevac organization, protocal definition,…)
- Closure of public areas (Salon CRI, cafeteria (outside meal hours), inuit kitchen, meeting rooms, corner store, gym …)
- Stopped all social activities on site
- Mandatory hand washing everywhere on site
- Cancelled all training given on site, as well as conferences and conventions
- Maximum grouping for work related purpose of 5 people/30 min.
- Cancelled all production none essential visits on site
- Deception Bay camp closed to all outsiders

# List of measures

- Working procedures in departments were revisited in orther to satisfy Covid hygiene measures
- Heavy equipment clean up procedures imposed when changing shift; manual tools clean up enforced between users
- Mandatory faceshield and mask to be worn if distanciation measures can't be respected
- Plastic curtains protections installed in pickups to separate passengers
- July 13, started testing all passengers at airport. Testing facilities moved to Quality Hotel.
  - New testing supplier starting Dec 9, from Mtl and VO. Test results received on plane arrival in Donaldson.
- July 27, introduction of mandatory mask everywhere on site
- Early August, developped food coupon for our inuit employees (100$/week for 6 weeks)
- Inuit employees started to receive regular pay on September 1, eventhough return to work started September 29
- Organized return to work process for inuit workers:
  - Pre-boarding investigation (48 hours) by site nurses and a triage questionair at airports
  - Mask wearing mandatory in plane
  - Tested on site when arriving and tested 2 days before departing

# Results

YTD, we have had 4 cases of southern employees who tested positive were Medevac down south immediately when found positive

# Environment

# Environment – Spill Statistics

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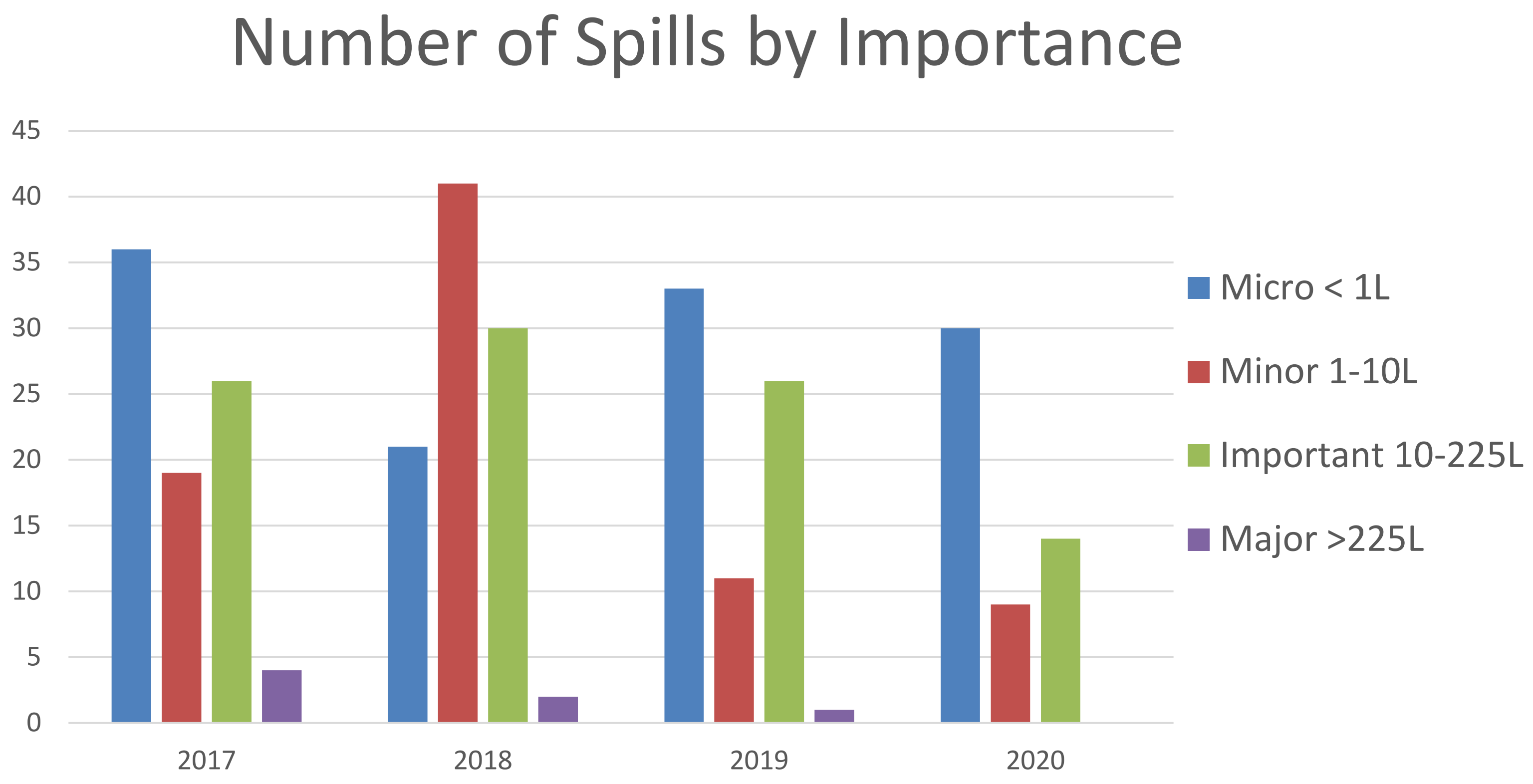
NUNAVIKNICKEL

| Spills Statistics 2017-2020 | | | | |
|---|---|---|---|---|
| | **2017** | **2018** | **2019** | **2020** |
| **Micro Spills**<br>(0-1 Liter) | 28 | 21 | 33 | 30 |
| **Minor Spills**<br>(From 1 to 10 Liter) | 8 | 16 | 11 | 9 |
| **Important Spills**<br>From 10 to 225 Liters) | 18 | 20 | 26 | 14 |
| **Major Spills**<br>(More than 225 Liters) | 6 | 1 | 1 | 0 |
| **Total** | 60 | 58 | 71 | 53 |
| **Mandatory reportable spills to authorities**<br>(›1 Liter or in water) | 32 | 37 | 38 | 23 |

# Spills by importance




*Data of 2020 include January to December 1st

# Environment monitoring report and inspections

### Monitoring Report (Annual 2019 report)

- Was transmitted in April 2020 – Distribution list updated annually
- Inuktitut version (translated from the English version by Sally Quppia Mark – CRI Environment technical assistant)

### Authorities inspection

- MELCC inspectors from August 3 to 6, 2020 – No non-compliance, we received congratulations for our housekeeping and for the progressive rehabilitation performed (Berbegamo camp and scrap metal recycling to southern facilities)
- Due to the Covid-19 situation, the KRG representative, Aglae Boucher-Telmosse – Environmental specialist, could not attend the inspection
- Members of the NNC will be invited for the 2021 Environmental inspection – Date will be submitted as soon as available to the NNC members

# Inuit Stakeholders Environmental communication

On January 22th 2020, two representatives of CRI Environmental department traveled to Puvirnituq to meet the mayor and the councilors.

- Discussions about environmental monitoring, rehabilitation following spills, and measures applied by CRI to limit its impacts and protect the environment.

- Presentation in English and Inuktitut
- We added environnemental monitoring to adress Puv's concerns about water quality of the Puvirnituq river
- Visits were planned for Kangisujuaq and Salluit as well, but were postponed due to the Covid19 situation

# Environmental monitoring and characterization – 2020 Highlights

- Complete fish community study performed by Aecom biologists
  - Non lethal capture to measure length, weight, general health etc. up and downstream of the effluent discharge (60 fish/area)
  - Some letal capture to measure metal in fish flesh (9 fish/area)
  - All results will be presented in the 2020 environnemental monitoring reports

- Environmental Characterization of our future planned operation (Puimajuq, Ivakkak, etc.), in a perspective to:
  - Acquire better knowledge of its land, wildlife, vegetation
  - Integrate and validate appropriate mitigation measures to limit our impact
  - Submit the regional C of A's

- 21 days of field work with 4 biologists

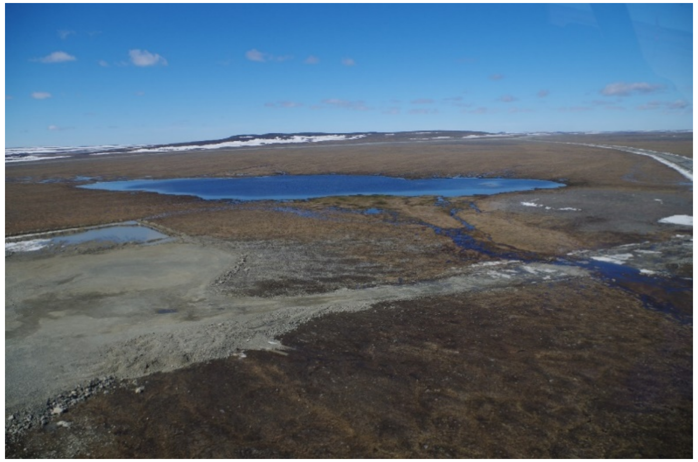
# Environment – Increased monitoring and improvement

- 3 supplementary water sampling stations implemented on the Puvirnituq river.
  - metal analysis (nickel, copper, etc.), concordingly with the discharge point of the mining effluent.
  - Results are very low; around or below the possible limite of detection
  - All results will be presented in the annual environmental monitoring report (2020)
- Systematic environmental inspection of all exploration drill sites to insure the absence of waste or hydrocarbon after completion.
- Several environmental awarness toolboxes provided to drillers by the Environment department – We make sure a spill kit is available at all drill sites and that any hydrocarbons liquid is adequately and safely used and stored
- Spill statistics and handling of incident

# Environment – Challenge and rehabilitation improvements

- Quick rehabilitation of the Mequillon esker (Borrow pit) after exploitation; the culvert was removed to let the waterstream flow like before. Road material removed as much as possible to facilitate vegetation regrowth
- Since 2019, water intake from lake Bombardier has decreased by 73% following the concentrator's efforts to reclaim process water

| 2017 | 2018 | 2019 |
|---|---|---|
| 750 747 000 L | 764 628 625 L | 314 533 650 L |



# Environment – Actual permitting status

- **Ivakkak road and exploitation :** Already included in the Global Certificate of Authorization – Regional C of A's under review by authorities

- **Puimajuq road and exploitation :** Global authorization (Art. 201 - CQEK) received. Regional authorization (Art. 22 and 32) have been submitted and under review. A new annex is required in the IBA process (Annex 7)

- **Expo Underground :** Global authorization (Art. 201 - CQEK) and Regional authorization received – (Ore not accessible by open pit - Same mining lease – No additional footprint)

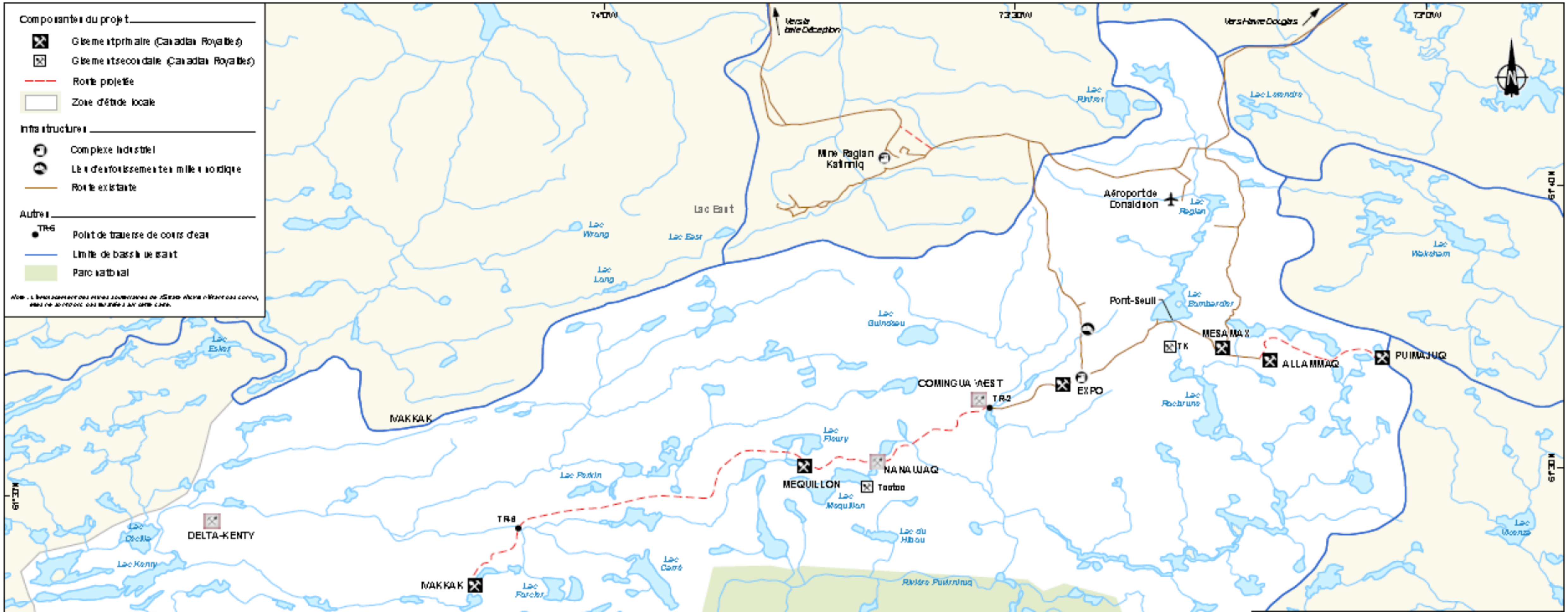
- **Tailing deposition in Expo pit :** Global authorization (Art. 201 - CQEK) will be submitted in 2021, Regional authorization submission will ensue

# Environmental review and permiting process for new development/project

- **New development/project** requires a Global modification (Art 201), issued by the KEQC – (Kativik Environmental Quality Commission). It's the first mandatory step for any further required permiting (Provincial authorities - MELCC)
- **Also**, in compliance with IBA Section 3.2 and 3.3, **New development/project** requires new annex in the IBA (In the form of **Annex 7)**
- **Annex 7** consist of a Mitigation measures summary on social and environmental aspects ; Described for a **New Development**, in a **New Development Annex** and, for a **New Project**, in a **New Project Annex** (IBA Section 4.2).
- A complete and mandatory Environmental and Social Impact Study (ESIS) had to be performed and submited to the KEQC **and** the IBA members for approval - Among all topics included, foreseen environmental, social impact and mitigation measures summary are presented in the ESIS.
- Therefore, as implemented for the Puimajuq/Allamaq Annex 7.1, a sub-committee should be put in place for **New development/project** upcoming.

# 2021-2028 Nunavik Nickel Life Of Mine

# Localisation 0f Ore bodies



# Ore Moved & Processed since 2012

| Deposit | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|
| **Expo OP** | 63 443 | 174 291 | 5 033 | 417 868 | 979 483 | 728 180 | 1 215 012 | 1 171 708 | 638 229 |
| **Allammaq UG** | | | 3km Road | Portal dev | 250 826 | 520 687 | 592 256 | 316 533 | 429 363 |
| **Méquillon OP** | | | | | | | | 17km Road | 583 146 |
| **Mesamax OP** | | 717 046 | 674 767 | 439 802 | 215 251 | | | | Pushback |
| **Puimajuq OP** | | | | | | | | | 8km Road |
| **Total** | **63 443** | **891 337** | **679 800** | **857 670** | **1 445 560** | **1 248 867** | **1 807 268** | **1 488 241** | **1 650 738** |

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|
| **Mill Feed (t)** | | **609 096** | **839 054** | **1 254 719** | **1 389 208** | **1 500 177** | **1 626 757** | **1 642 496** | **1 647 000** |
| **Ni %** | | 1,53 | 1,55 | 1,13 | 1,05 | 1,14 | 1,10 | 0,87 | 0,73 |
| **Cu %** | | 2,33 | 1,74 | 1,53 | 1,23 | 1,14 | 1,11 | 0,98 | 0,96 |
| **Co (%)** | | 0,08 | 0,08 | 0,05 | 0,05 | 0,05 | 0,05 | 0,04 | 0,04 |
| **Pd (gr/t)** | | 4,35 | 3,29 | 2,25 | 1,88 | 2,21 | 2,17 | 1,79 | 2,01 |
| **Ni eq(%)** | | 3,69 | 3,23 | 2,41 | 2,11 | 2,26 | 2,19 | 1,79 | 1,69 |
| **Ni eq (mt)** | | 22 485 | 27 124 | 30 262 | 29 360 | 33 895 | 35 619 | 29 356 | 27 836 |

# NEW STRATEGIC 2021 LOM

| Deposit | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Expo OP** | | | | | | | | | | | | |
| **Allammaq UG** | 280 000 | | | | | | | | | | | |
| **Méquillon OP** | 840 155 | 115 226 | 379 230 | | | | | | | | | |
| **Mesamax OP** | 31 000 | 240 000 | | | | | | | | | | |
| **Puimajuq OP** | 15 000 | 153 400 | | | | | | | | | | |
| **Expo UG** | Portal dev | 425 000 | 577 500 | | | | | | | | | |
| **Ivakkak OP** | 20km Road/MCP | 25 000 | 580 000 | | | | | | | | | |
| **Méquillon UG** | Portal dev | Ramp dev | 105 770 | 720 000 | 720 000 | 720 000 | 720 000 | 720 000 | 720 000 | 720 000 | 720 000 | 534 230 |
| **Ivakkak UG** | | | Ramp dev | 240 000 | | | | | | | | |
| **Mesmax UG** | | | | Ramp dev | 235 200 | | | | | | | |
| **Nanaujaq UG** | | | | MCP/Pad | Ramp dev | 75 000 | 400 000 | 600 000 | 350 000 | | | |
| **Delta OP** | | | | 20km Road | Road/MCP | 100 000 | 350 000 | 272 000 | | | | |
| **Cominga West UG** | | | Portal dev | 75 000 | 300 000 | 125 000 | | | | | | |
| | | | | | | | | | | | | |
| **Expo Marginal Ore** | 476 345 | 683 874 | | 193 189 | - | - | - | - | - | - | - | - |
| **Total** | **1 642 500** | **1 642 500** | **1 642 500** | **1 228 189** | **1 255 200** | **1 020 000** | **1 470 000** | **1 592 000** | **1 070 000** | **720 000** | **720 000** | **534 230** |
| **Ni %** | 0,61 | 0,68 | 0,85 | 0,73 | 0,88 | 0,98 | 1,36 | 1,24 | 0,79 | | | |
| **Cu %** | 0,90 | 0,88 | 1,19 | 0,99 | 0,99 | 1,03 | 1,13 | 1,08 | 0,93 | | | |
| **Co (%)** | 0,03 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | |

# What is the metal value, Where are the profit margin

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- To simplify, if we consider only Cu & Ni:

| Feed | CRI | Concentrate |
|---|---|---|
| 100 t | | 5 t |
| 0,75%Ni | 75% Ni Recovery | 11% |
| | | 1 368 US$/mt |
| 0,85%Cu | 85% Cu Recovery | 3 t |
| | Payable: 80% | 23% |
| | Sales | 1 176 US$/mt |
| | **107 US$/t of ore feed** | |

Small Profit Margin

| Feed | Raglan | Concentrate |
|---|---|---|
| 100 t | | 19 t |
| 2,75%Ni | 75% Ni Recovery | 11,00%Ni |
| | | 1 368 US$/mt |
| 0,80%Cu | 85% Cu Recovery | 3 t |
| | Payable: 80% | 23,00%Cu |
| | Sales | 1 176 US$/mt |
| | **291 US$/t of ore feed** | |

Large Profit Margin

| **Consensus Economics Inc. Long Term Price (Nov 2020)** | |
|---|---|
| 7,051 | US$/lb of Ni |
| 2,900 | US$/lb of Cu |
| 0,75 | CND$ per 1 US$ |

# NEW STRATEGIC 2021 LOM – Financial Challenge

| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 |
|---|---|---|---|---|---|---|---|---|---|
| **Mill Feed (t)** | **1 642 500** | **1 642 500** | **1 642 500** | **1 228 189** | **1 255 200** | **1 020 000** | **1 470 000** | **1 592 000** | **1 070 000** |
| **Ni %** | 0,61 | 0,68 | 0,85 | 0,73 | 0,88 | 0,98 | 1,36 | 1,24 | 0,79 |
| **Cu %** | 0,90 | 0,88 | 1,19 | 0,99 | 0,99 | 1,03 | 1,13 | 1,08 | 0,93 |
| **Co (%)** | 0,03 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 |
| **Pd (gr/t)** | 1,70 | 1,57 | 2,08 | 1,82 | 1,94 | 1,97 | 2,03 | 1,99 | 1,91 |
| **Ni eq(%)** | 1,46 | 1,50 | 1,92 | 1,65 | 1,84 | 1,96 | 2,40 | 2,25 | 1,71 |
| **Ni eq (mt)** | 23 959 | 24 602 | 31 536 | 20 298 | 23 038 | 20 020 | 35 313 | 35 815 | 18 248 |

| **Consensus Economics Inc.<br>Long Term Price (Nov 2020)** | |
|---|---|
| 7,051 | US$/lb of Ni |
| 2,900 | US$/lb of Cu |
| 20,710 | US$/lb of Co |
| 1083,000 | US$/troy oz Pd |
| 0,75 | CND$ per 1 US$ |

# FOSSES – 2019 a 2023

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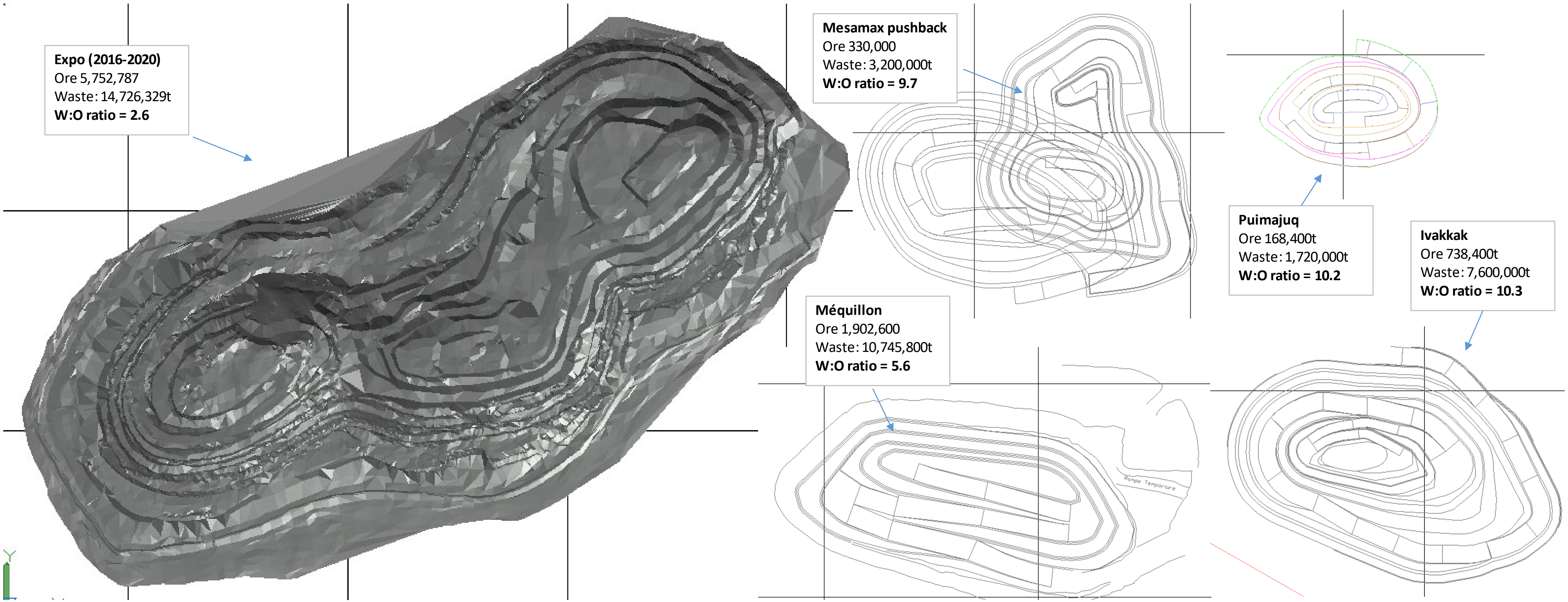
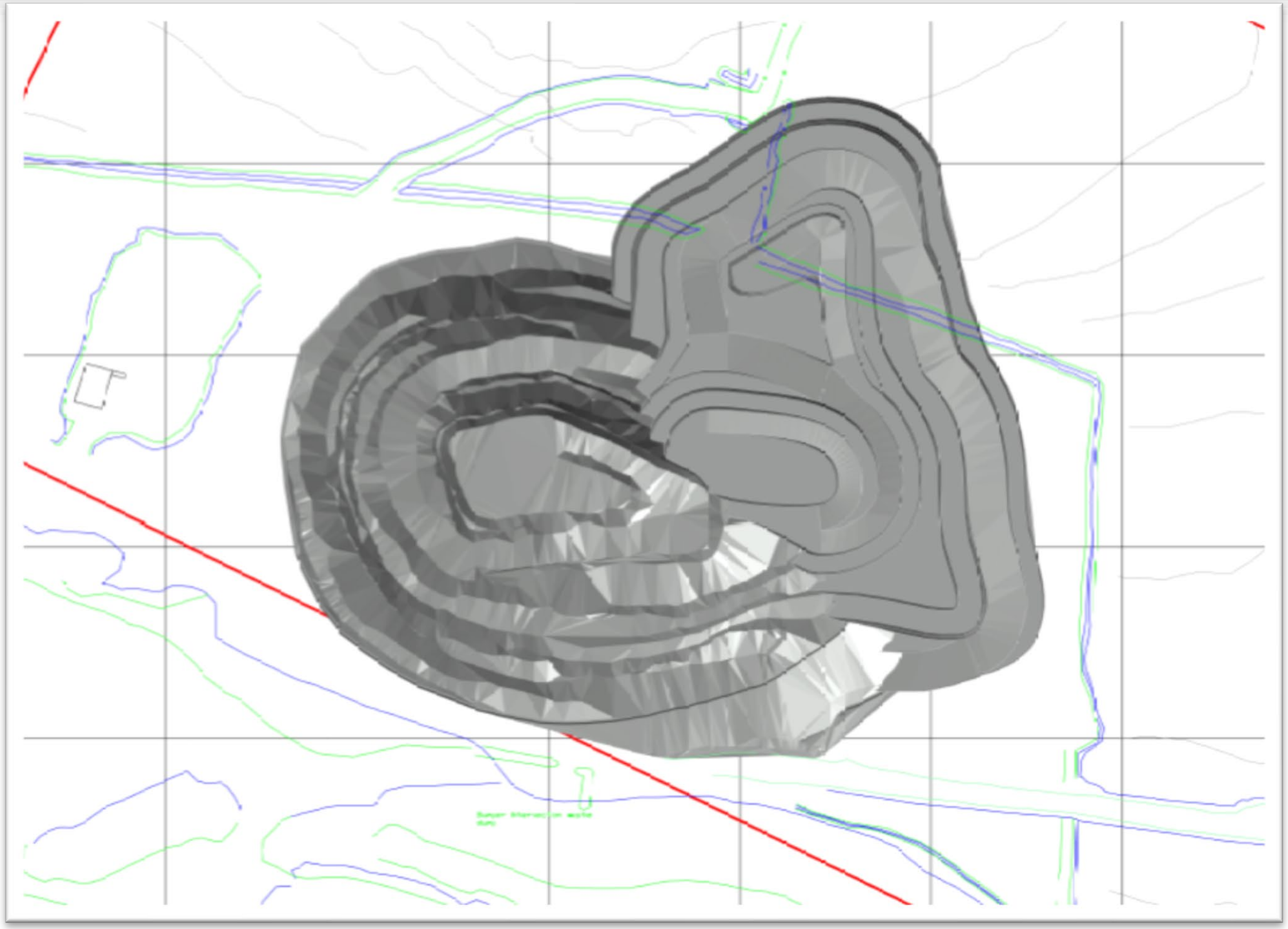
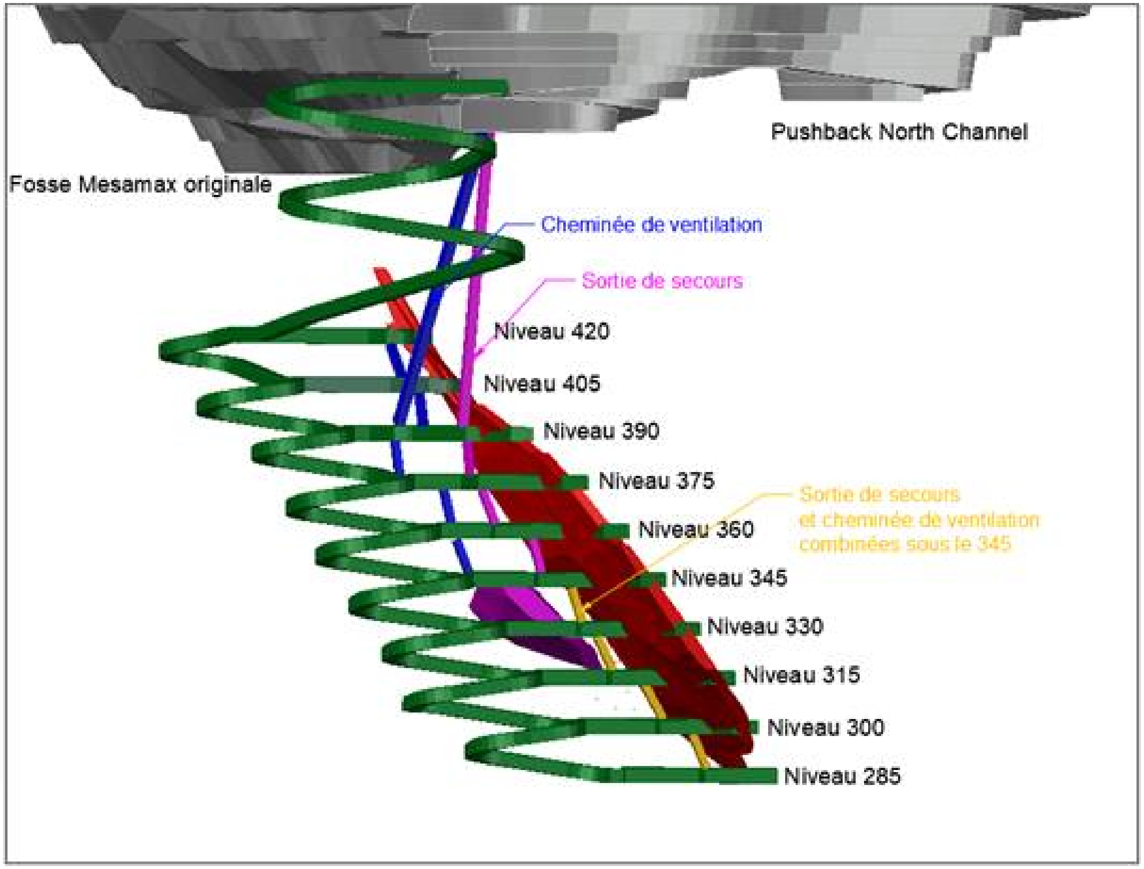


# MESAMAX – PUSHBACK et UG





# MESAMAX PUSHBACK - Economical Evaluation

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| Extraction de la fosse | Tonnage | Coût unitaire $/t | 6,40 $ | Coûts |
|---|---|---|---|---|
| Minerai | 406 637 | | | 2 602 477 $ |
| Stérile | 3 544 213 | | | 22 682 963 $ |
| Stripping ratio | 8,7 | | Coûts production | 25 285 440 $ |

| | $Unitaire<br>$/t | | Coûts<br>$ |
|---|---|---|---|
| Expédition (SHIPPING) | [redacted] | | [redacted] |
| Concentrateur (CONCENTRATOR) | | | |
| Services généraux (General services) | | | |
| Géologie (Géology) | | | |
| Services techniques (Technical sevices) | | | |
| RH + SS + Env + CC (HR + H&S) | | | |
| Logistique (Logistic) | | | |
| Transportation vers concentrateur | | | |
| | | Autres coûts | 49 503 988 $ |

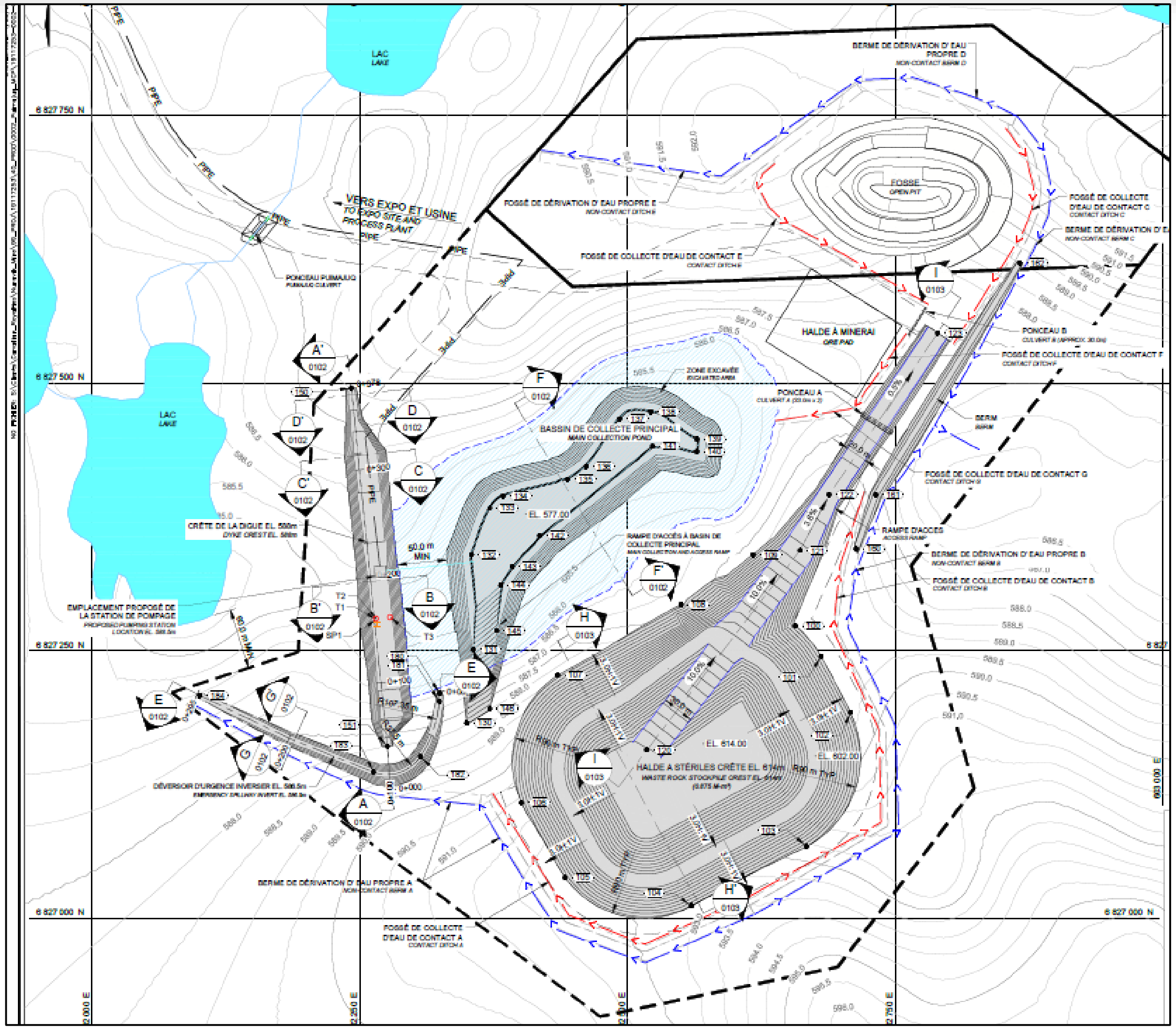
| Infrastructures | Quantité | Unités / modèle | Coût unitaire<br>$ | Coûts<br>$ |
|---|---|---|---|---|
| Route d'accès | | km de longueur | [redacted] | [redacted] |
| Ingénierie / Environnement | 1 | forfait | | |
| Pad infrastructures | | $m^2$ de surface | | |
| Complexe de roulotte | | $m^2$ de bâtiments | | |
| Garage + concrete slab | | $m^2$ de surface | | |
| Génératrice (450 kW) | | unités | | |
| MCP et fossés | 44 | heures équipements | | |
| UTE | | unités traitant 200 m3/h | | |
| Fuel farm | | unités | | |
| | | | Total Capex | 45 267 $ |

| | Minerai | | Taux de change | |
|---|---|---|---|---|
| | Mesamax Est | North Channel | $US for 1$CND | |
| Teneur coupeur: 90$ NSR | 78 281 | 328 356 | 0,75 | Dilution 6% inclut |

| | Teneurs | Teneurs | Prix (US $) - 2019 ST | | NSR usine ($) |
|---|---|---|---|---|---|
| Ni (%) | 1,460 | 0,372 | 7,42 $ | $/lb | NSR Mesamax Est |
| Cu (%) | 1,476 | 0,574 | 2,70 $ | $/lb | 434,25 $ |
| Co (%) | 0,058 | 0,019 | 17,70 $ | $/lb | |
| Pt (g/t) | 0,585 | 0,499 | 950,00 $ | $/oz | NSR North Channel |
| Pd (g/t) | 2,581 | 1,866 | 1 484,00 $ | $/oz | 162,96 $ |
| Au (g/t) | 0,091 | 0,247 | 1 500,00 $ | $/oz | |
| Ag (g/t) | 0 | 0 | 18,63 $ | $/oz | |

| | |
|---|---|
| Revenu total | 87 502 343 $ |
| Coûts d'opération | 74 789 428 $ |
| Coûts en capital | 45 267 $ |
| Coût total | 74 834 695 $ |
| **REVENUS - DÉPENSES** | **12 667 647 $** |

# PUIMAJUQ



LAC
LAKE
VERS EXPO ET USINE
TO EXPO SITE AND PROCESS PLANT
BERME DE DÉRIVATION D' EAU PROPRE D
FOSSÉ DE DÉRIVATION D' EAU PROPRE E
FOSSÉ DE COLLECTE D'EAU DE CONTACT E
FOSSE
OPEN PIT
HALDE À MINERAI
ORE PAD
PONCEAU PUIMAJUQ
BASSIN DE COLLECTE PRINCIPAL
MAIN COLLECTION POND
EL. 577.00
CRÊTE DE LA DIGUE EL. 580m
EMPLACEMENT PROPOSÉ DE LA STATION DE POMPAGE
RAMPE D'ACCÈS À BASIN DE COLLECTE PRINCIPAL
FOSSÉ DE COLLECTE D'EAU DE CONTACT G
RAMPE D'ACCÈS
BERME DE DÉRIVATION D' EAU PROPRE B
FOSSÉ DE COLLECTE D'EAU DE CONTACT B
EL. 614.00
HALDE À STÉRILES CRÊTE EL. 614m
EL. 602.00
DÉVERSOIR D'URGENCE INVERSER EL. 580.5m
BERME DE DÉRIVATION D' EAU PROPRE A
FOSSÉ DE COLLECTE D'EAU DE CONTACT A
6 827 750 N
6 827 500 N
6 827 250 N
6 827 000 N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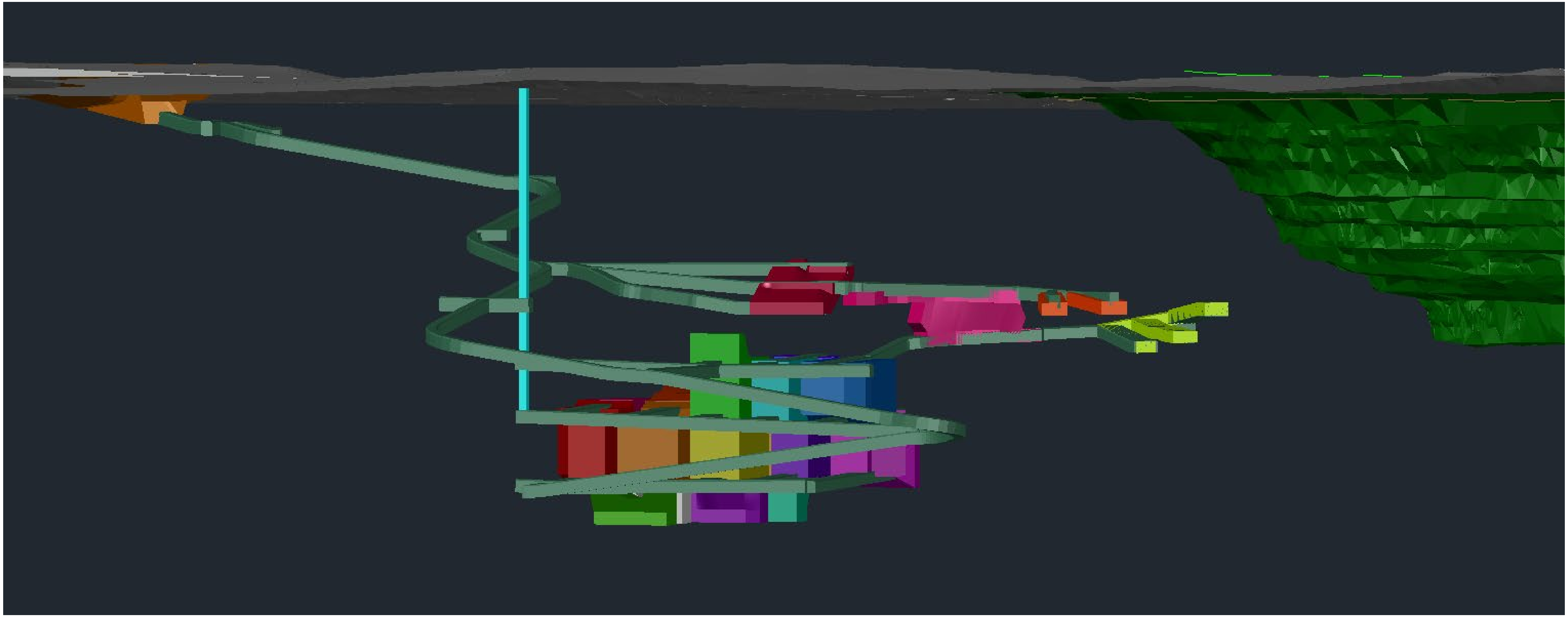
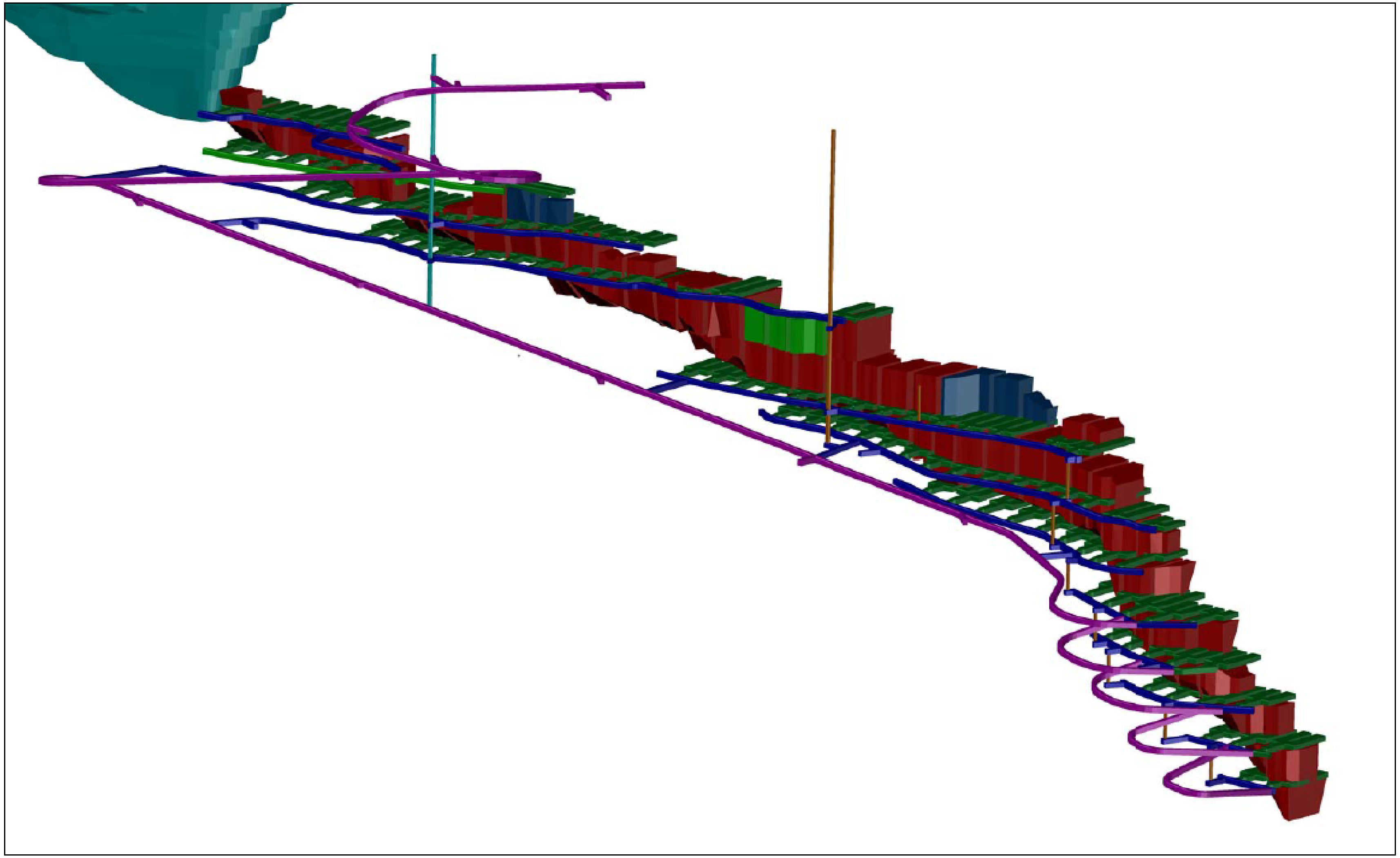
# EXPO UG OUEST



# Méquillon UG



Feasibility Study is ongoing

Cement backfill is evaluated

# IVAKKAK OP et UG

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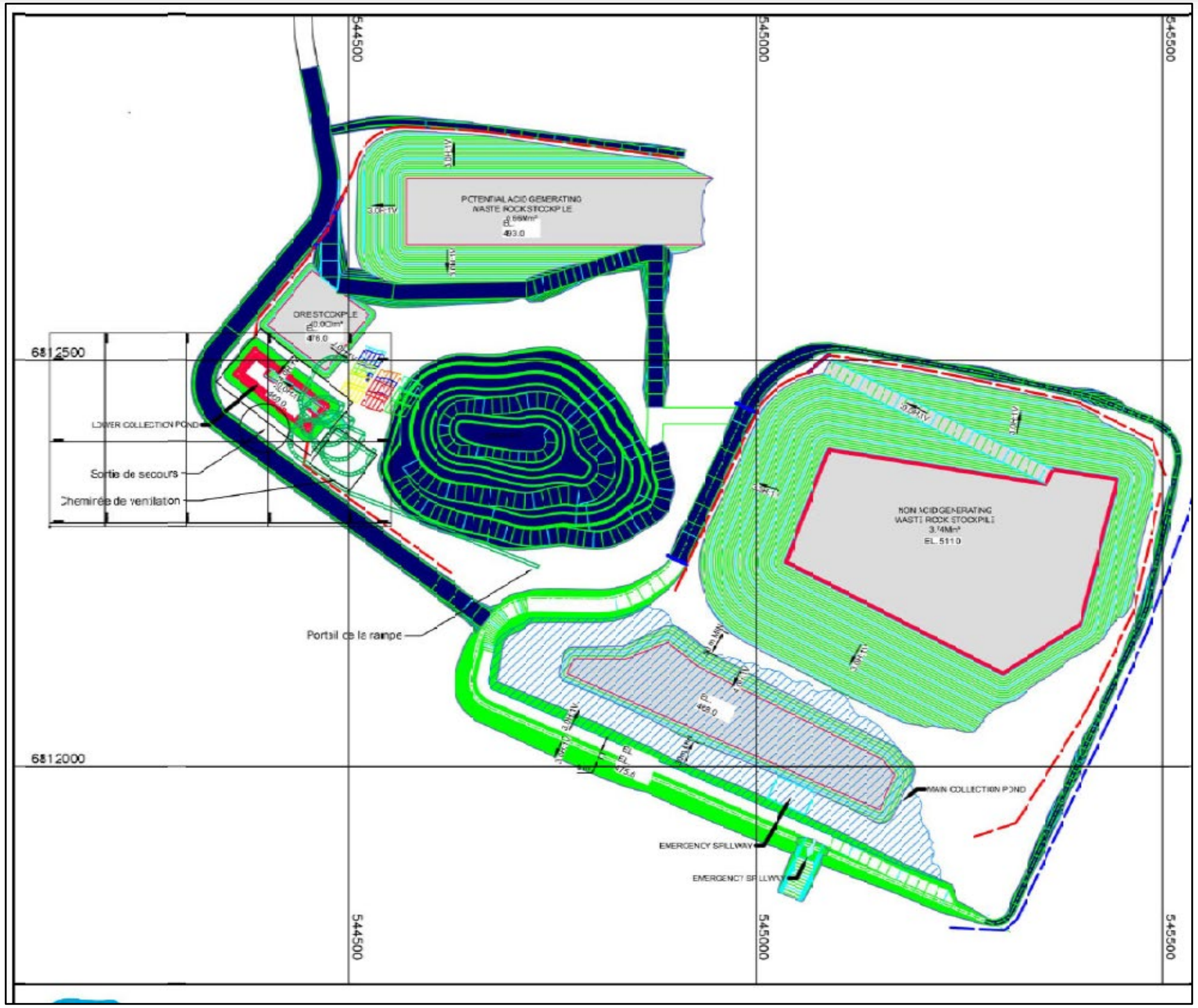
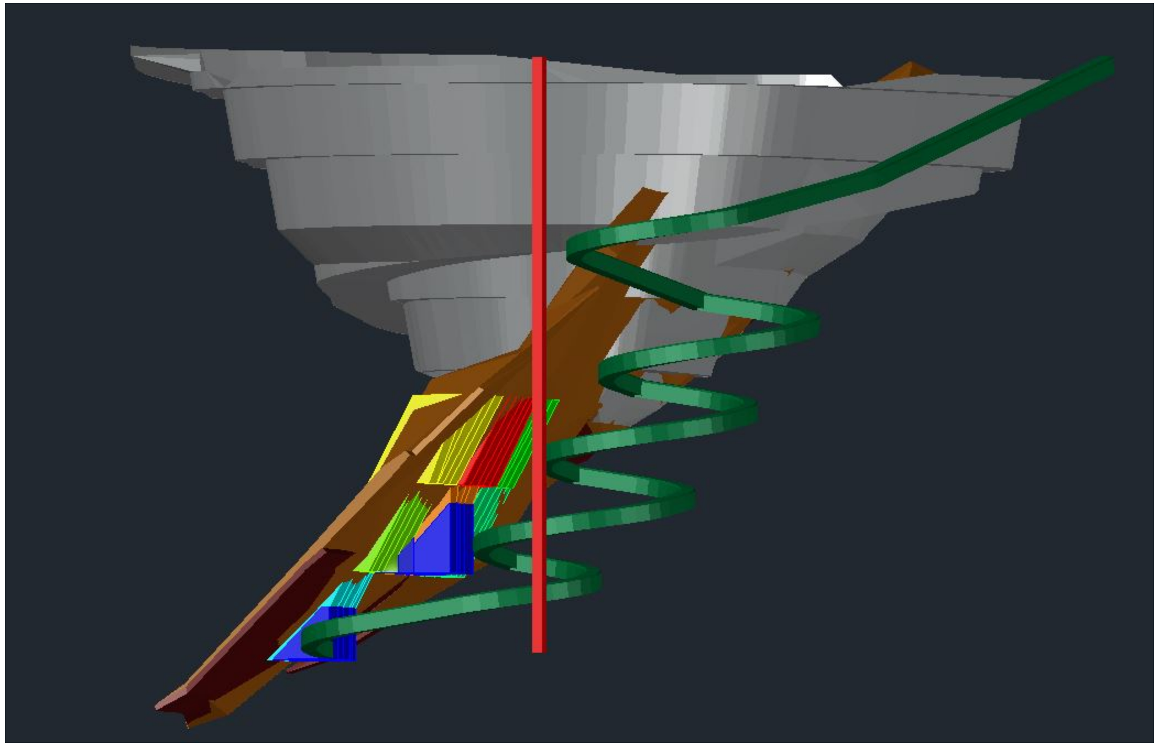
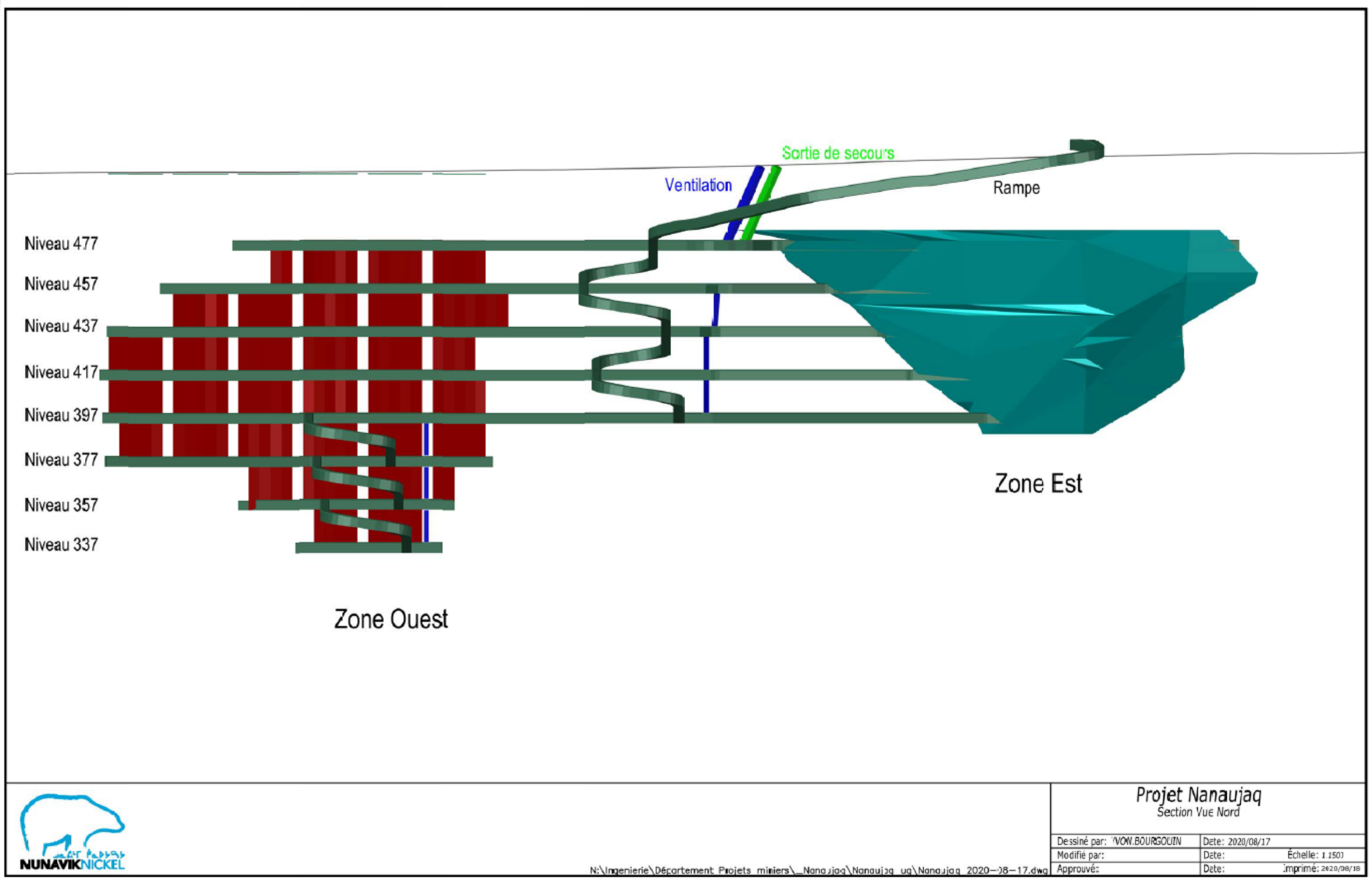
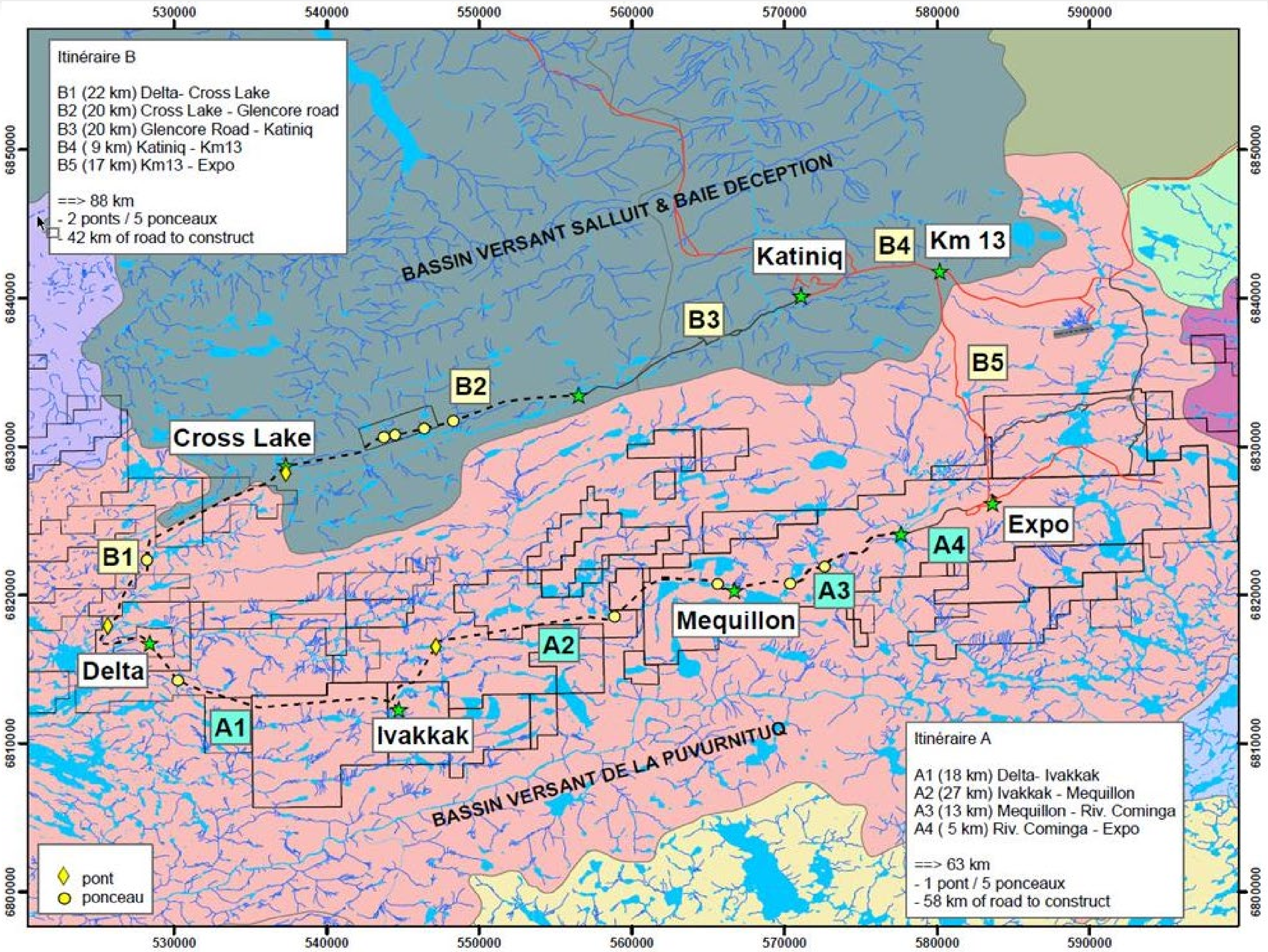


# NANAUJAQ


Sortie de secours
Ventilation
Rampe
Niveau 477
Niveau 457
Niveau 437
Niveau 417
Niveau 397
Niveau 377
Niveau 357
Niveau 337
Zone Est
Zone Ouest
Projet Nanaujaq
Section Vue Nord
Dessiné par: YVON.BOURGOUIN
Date: 2020/08/17
Modifié par:
Date:
Échelle: 1:1500
Approuvé:
Date:
Imprimé: 2020/08/18
N:\Ingenierie\Département Projets miniers_Nanaujaq\Nanaujaq ug\Nanaujaq 2020-08-17.dwg

# Delta




- 3% Ni and 1,8% Cu
- +60km West to Expo
- Drilling completed
- Block model will be updated by Q1 2021

# Profit Sharing & Procurement

# Payment History

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| Somme de Document Amount | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Étiquettes de lignes | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Total général |
| **Makivik Corporation Société** | | | | | | | | |
| Invoice | 1 000 000 $ | 1 333 333 $ | 2 000 000 $ | 2 000 000 $ | 4 666 667 $ | 2 000 000 $ | 4 000 000 $ | 17 000 000 $ |
| Payment | 1 000 000 $ | 1 333 333 $ | 2 000 000 $ | 2 000 000 $ | 4 000 000 $ | 2 666 667 $ | 4 000 000 $ | 17 000 000 $ |

+/- $10M will be paid in early January as soon as we have the whole 2020 revenue numbers

# Inuit enterprises Contract Data Summary

NUNAVIKNICKEL

| NN_NIE Suppliers | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 Q3 | Total since 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| Air Inuit Ltd. | $575 | $15 991 495 | $13 720 473 | $11 966 200 | $9 007 974 | $9 237 082 | $10 413 427 | $8 932 296 | $6 938 400 | $86 207 922 |
| IGLU Construction Inc. | $17 534 | $60 633 | | | | | | | | $78 167 |
| Kiewit-Nuvumiut | | | | $634 823 | | | $107 951 | $170 969 | $70 900 | $984 644 |
| Laval Fortin Adams | $53 176 | $16 650 | $193 397 | | | | | | | $263 222 |
| Nunavik Construction | $1 039 219 | $5 648 622 | $5 109 675 | $6 097 268 | $5 077 467 | $3 110 918 | $2 721 066 | $2 576 658 | $2 009 389 | $33 390 281 |
| Nunavik Eastern Arctic shipping inc | | $8 410 176 | $4 595 818 | $2 389 570 | $1 991 852 | $1 003 452 | $2 964 337 | $2 998 375 | $2 634 841 | $26 988 422 |
| Nunavik Rotors Inc | $15 004 | $105 213 | $113 338 | $25 157 | $50 984 | $366 463 | $126 790 | $150 353 | $144 664 | $1 097 966 |
| Qaqqalik Landholding Corporation | | $6 000 | $749 860 | $347 569 | $359 858 | $483 223 | $250 004 | $324 362 | $324 730 | $2 845 606 |
| Redpath Nuvummiut | | | | $12 198 599 | $34 857 932 | $29 427 993 | $24 141 665 | $23 190 977 | $15 043 965 | $138 861 131 |
| Taqramut Transport Inc | $4 369 | | | $2 093 395 | $1 158 603 | $1 807 862 | $1 529 667 | $1 962 543 | $1 329 036 | $9 885 475 |
| Transport Padlayat | $616 297 | $3 760 371 | $6 340 986 | $5 703 912 | $5 999 402 | $6 205 825 | $7 322 525 | $6 470 069 | $4 933 771 | $47 353 157 |
| Avataani Environmental Services Inc. | | | | | | $265 141 | $274 319 | $407 382 | $189 637 | $1 136 479 |
| Nuna Ressources | | | | | | | | $79 568 | $113 904 | $193 471 |
| **Grand Total** | **$1 746 173** | **$33 999 162** | **$30 823 546** | **$41 456 493** | **$58 504 070** | **$51 907 959** | **$49 851 751** | **$47 263 552** | **$33 733 237** | **$349 285 944** |
| | | | | | | | | | | |
| **Non listed NN_NIE Suppliers** | | | | | | | | | | |
| CMAC Avataa | | | | $321 | $782 083 | $1 784 145 | $2 992 177 | $2 011 709 | $1 363 539 | $8 933 974 |
| Orbit Promec Nunavik | | $926 210 | $1 610 | $2 413 798 | $1 820 093 | $3 442 275 | $7 476 122 | $10 304 970 | $3 413 432 | $29 798 510 |
| Outland Camps FCNQ | | $5 248 998 | $5 969 749 | $6 552 984 | $8 218 329 | $7 960 806 | $7 943 335 | $9 138 580 | $6 454 523 | $57 487 303 |
| **Grand Total** | **$0** | **$6 175 207** | **$5 971 358** | **$8 967 102** | **$10 820 505** | **$13 187 227** | **$18 411 634** | **$21 455 260** | **$11 231 494** | **$96 219 787** |

# Procurement & Logistics

Q: How can we improve the Procurement process & communications channels?

- CRI has been providing a yearly list of our planned capital projects to Makivik. We welcome any questions from NIE companies that would like more information on any of these projects.

- We also provide a listing of all our goods and services contracts, with details on the types of goods and services as well as the duration and expiry dates of these contracts.

- CRI believes that more business can be awarded to NIE enterprises by improving the NIE enterprise list.

1. Frequently updated NIE list, preferably housed on Makivik website
2. Expanded description of goods and services offered
3. Case studies and projects completed by suppliers
4. Valid contact information and rapid response to inquiries

# Procurement & Logistics

Q: Has the “black-out window” in Deception Bay been respected;

A: We breached in March 2020 as per our tri-partite agreement between Glencore, CRI and Qaqqalik Landholding. We had an agreement in place to breach in March 2019, but did not end up using the extended time.

Q: Can CRI acknowledge and report that marine shipping is conducted in a balanced manner as provided in the NNA section 6.4.3 (Taqramut / NEAS : 50/50 split)?

A: Yes, for Northbound shipping the split since 2017 has been nearly 50/50, although individual years have higher variance.

Northbound cubic meters 2017-2020:

| | | |
|---|---|---|
| NEAS | 40 665,86 | 50,5% |
| Taqramut | 39 936,68 | 49,5% |

# Procurement & Logistics

Q: Are all conditions applied in regards of the NNA when shipping deadlines are exceeded? Can CRI provide a table with marine shipment missed scheduled events during the last year? What is the sufficient time for usage of MV Arctic and authorization process requests?

A: The process is as follows:

March-April: Plan and place purchase orders for summer sealift in 3 waves:

| Wave | HazMat | To be packed | Ready to ship | Expected at Site |
|---|---|---|---|---|
| 1st | 2020-06-01 | 2020-06-05 | 2020-06-15 | 2020-07-20 |
| 2nd | 2020-07-10 | 2020-07-15 | 2020-07-20 | 2020-08-25 |
| 3rd | 2020-09-05 | 2020-09-10 | 2020-09-15 | 2020-10-15 |

While most orders are placed weeks in advance, we do continue to receive requisitions up until the week of sailing, which we typically can load if the product is available and there is still room on the ship.

If the product lead time is too long or if the requisition is too late to make the 3rd wave, when then apply the following decision process:

1. Can we delay to the following summer sealift? If no, then;
2. We contact Glencore to enquire if space is available;
3. If so, we request permission from Makivik to ship the cargo;
4. After we give Glencore proof of agreement from Makivik and insurance coverage, we send the cargo to Quebec City for loading.

As to cargo that missed the deadline, the only event in 2020 is an emulsion pump truck that was transported by MV Arctic.

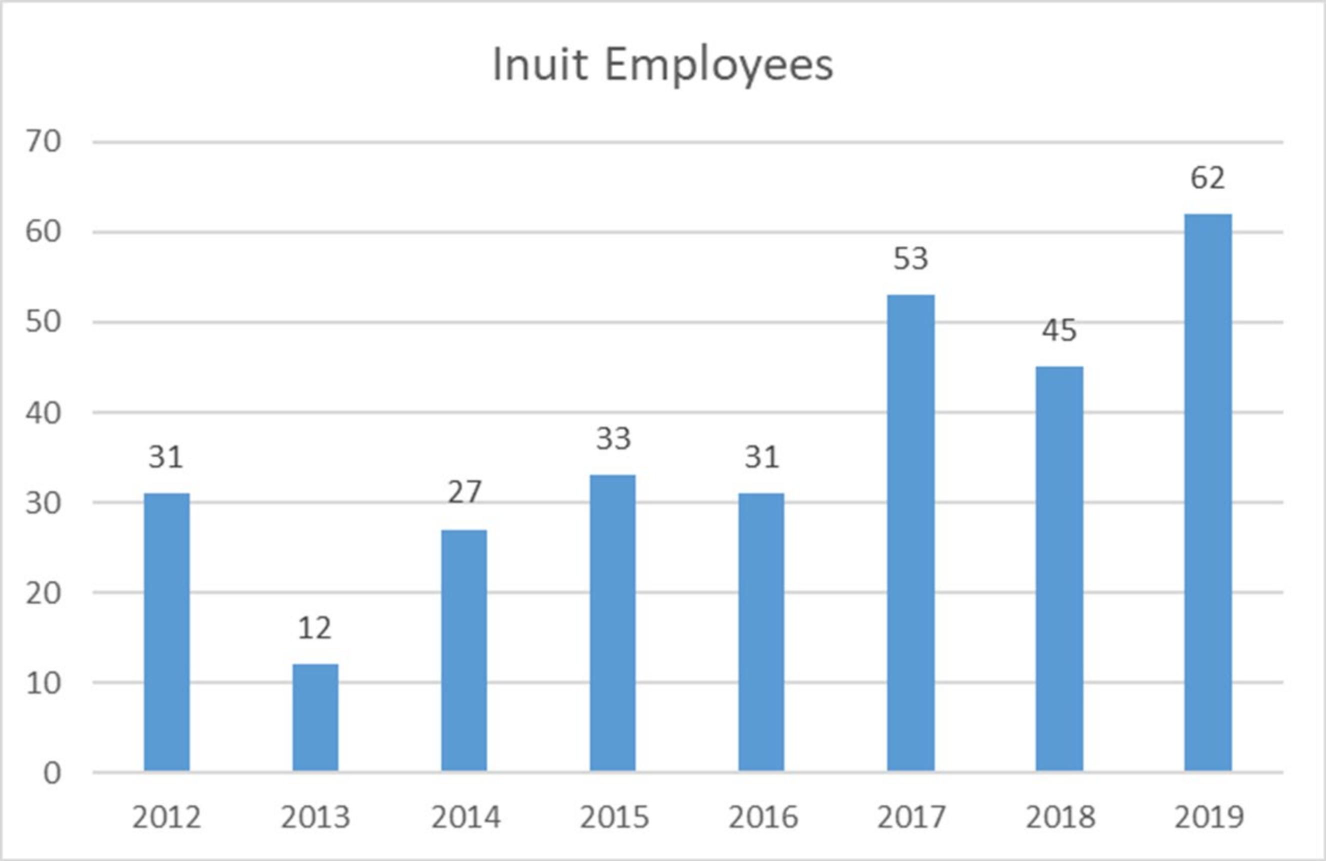
This is a recent event and the process was not followed, a letter will be sent to Makivik to regularize the situation.

# New Development Annex 7.1 Signatures

# Human Resources

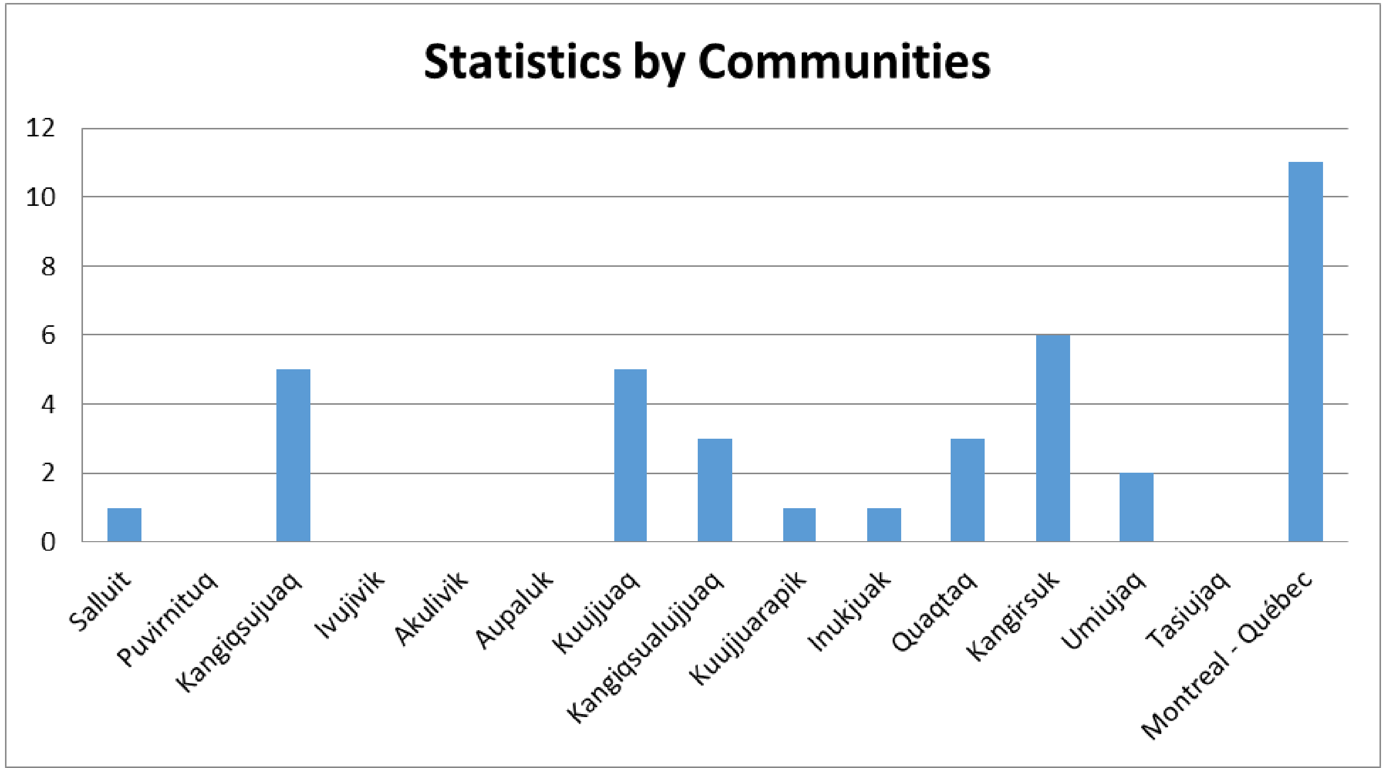
# Inuit employees 2020

- 2020 YTD 38 Inuit employees (represents 7% of our total site workforce of 557)
- Forecast for 2021 of 68 Inuit employees

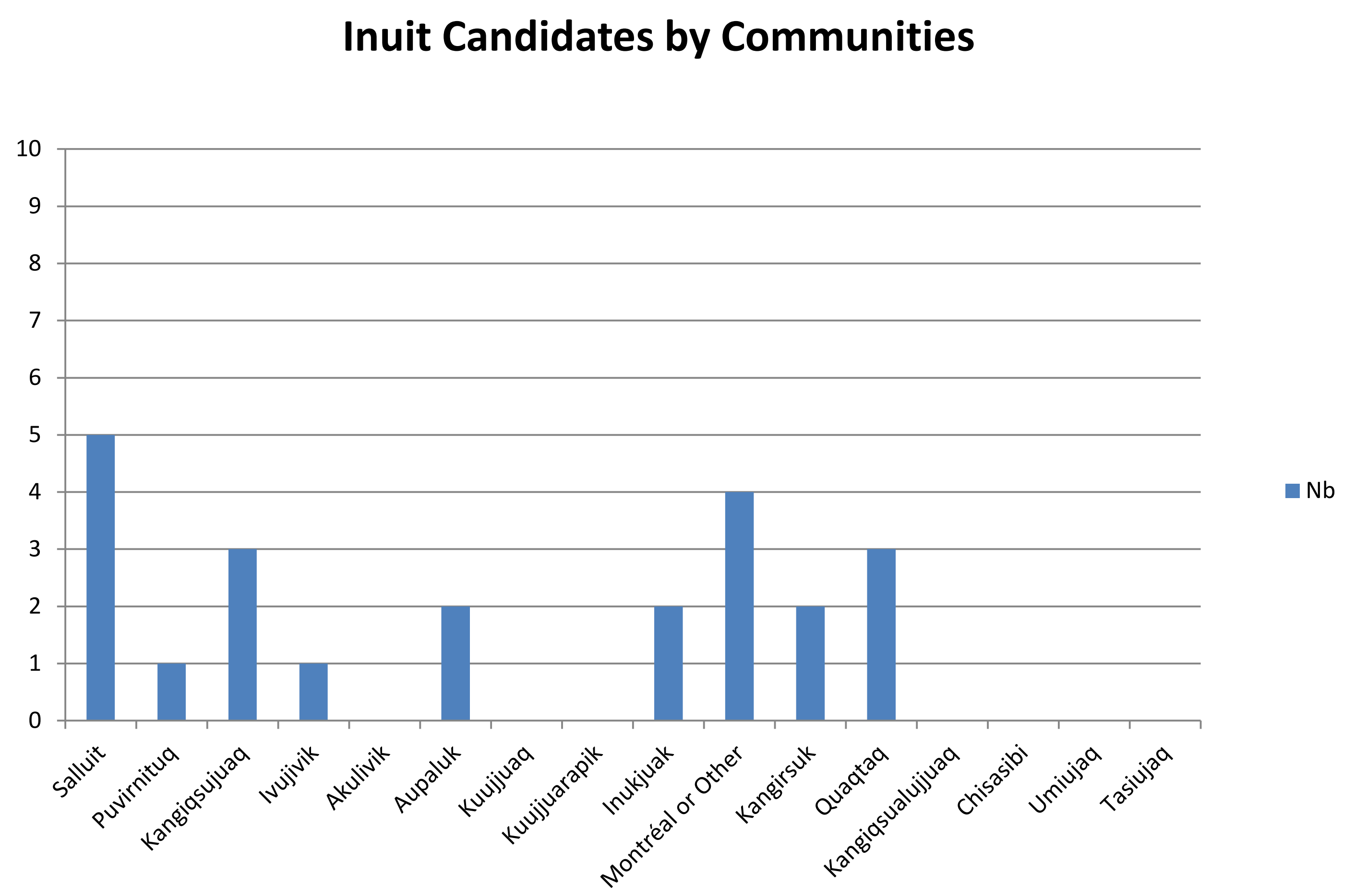


# CRI Inuit employees 2020

| CRI | September | October | November |
|---|---|---|---|
| Workers number | 543 | 542 | 557 |
| Inuit workers | 40 | 38 | 38 |
| % Inuit | 7.4% | 7.0% | 6,8% |



# Inuit applicants by communities



# Inuit Recruitment 2021

- Site Services:
  - Apprentice Electrician (1 position)
  - Apprentice pump operator (1 position)
  - HEO class 3 (2 positions)
  - Labourer (2 positions)
- Concentrator:
  - Assay lab clerk (2 positions)
  - Apprentice Millwright (2 position)
  - Labours (3 positions)
- Mining:
  - Apprentice Driller Blaster (4 positions)
- Mobile Maintenance
  - Labourer (1 position)
  - Apprentice Welder (1position)
- Human Resources
  - Security agent (2 positions)
- Utility
  - Apprentice carpenter (1 positions)

# Contractors Inuit Recruitment 2020

| September | Outland | Padlayat | Nunavik construction | Logistec | Redpath | CMAC / Avataa |
|---|---|---|---|---|---|---|
| Workers number | 72 | 40 | 18 | 17 | 85 | 8 |
| Inuit workers | 10 | 1 | 0 | 1 | 1 | 1 |
| % Inuit | 14% | 2% | 0% | 6% | 1% | 13% |

| October | Sodexo | Padlayat | Nunavik construction | Logistec | Redpath | CMAC / Avataa |
|---|---|---|---|---|---|---|
| Workers number | 71 | 40 | 19 | 17 | 86 | 8 |
| Inuit workers | 11 | 1 | 0 | 2 | 1 | 2 |
| % Inuit | 15% | 2% | 0% | 12% | 1% | 25% |

| November | Sodexo | Padlayat | Nunavik construction | Logistec | Redpath | CMAC / Avataa |
|---|---|---|---|---|---|---|
| Workers number | 84 | 40 | 18 | 27 | 88 | 8 |
| Inuit workers | 6 | 1 | 0 | 2 | 1 | 2 |
| % Inuit | 7% | 2% | 0% | 7% | 1% | 25% |

# New Labours Team Structure

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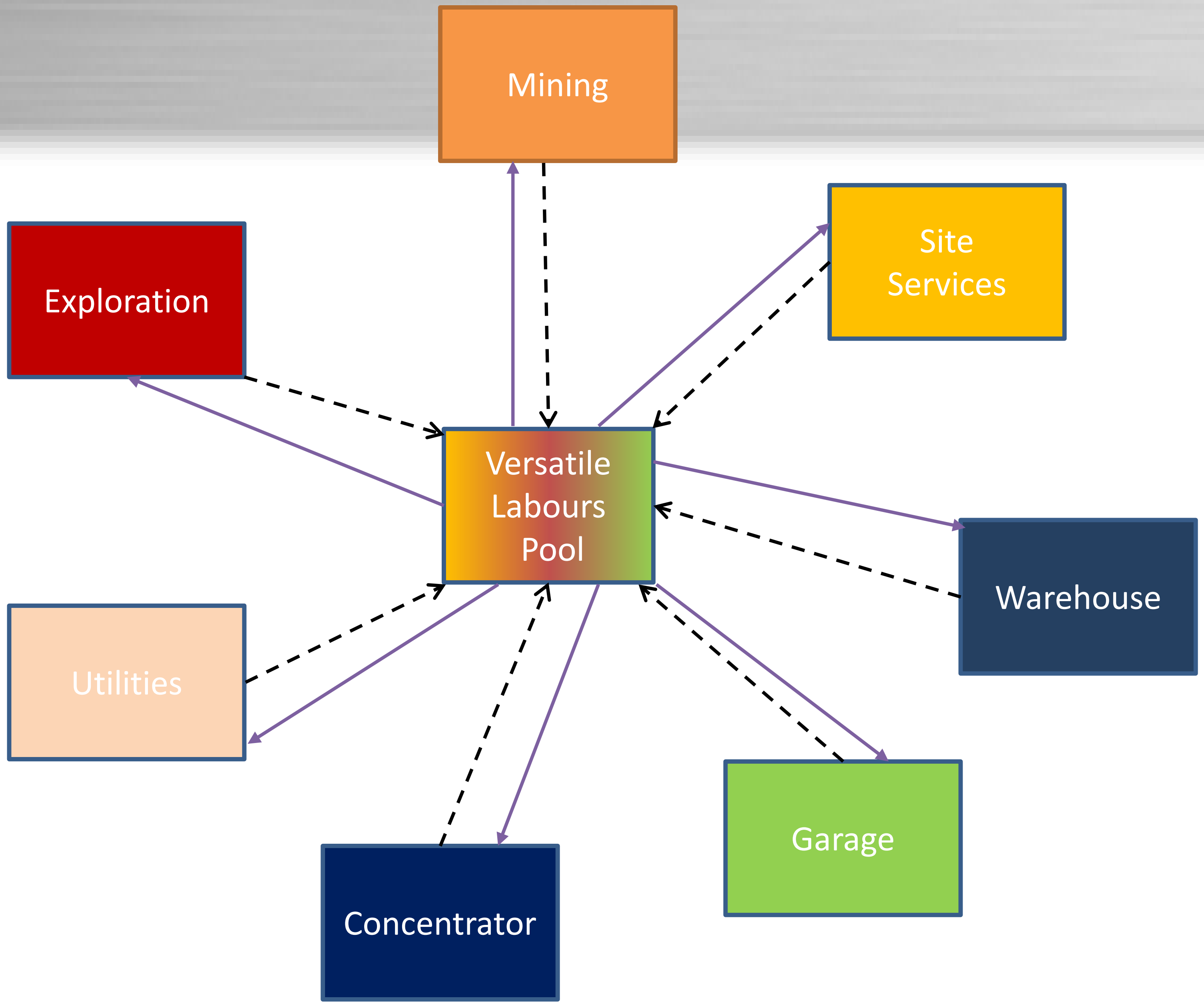
## Versatile labours (polyvalent)

- They will receive a **special training** with every Inuit instructors to be able to complete any task in any participating department
- They are able to **transfer and change tasks** according to the needs from one department to another
- If necessary, supervisors can ask for versatile laborers to **fill a need**


Mining
Exploration
Site Services
Versatile Labours Pool
Warehouse
Utilities
Garage
Concentrator

# Benefits for the workers

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| |
|---|
| 1. Task diversification |
| 2. Career development |
| 3. Increase the motivation |
| 4. Development of their skills according to their strengths |
| 5. Opportunities to be trained and promoted to more specialised jobs |

# Examples of success

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- Two Inuit workers that started as labours: William Arreak and Matthew Niviaxie
  - After training and following the program, Matthiew now upgraded to **Class 2** and is on his way to **Class 1**
  - William is still learning and is already helping his department on Operator jobs
- Charlie Annahatak upgraded to **Team Leader** for Site Services and **provides great support** to the supervisors
- The intention of this new program is to expend this program all over the company

# Nunavik Nickel Agreement section 12.3

# Mine closure plan review & financial guarantees update

# Restauration plan and financial guarantees

- The Project was permitted, developed and is operated taking progressive mine closure and site reclamation into consideration.
- The mine restoration plan (RP) aims at leaving sites in a physically and chemically stable condition, and restoring the land to make it suitable for local land uses.
- **An approved RP** by the MERN and the MELCC had to be obtain in order to get new mining lease (MERN) and all required  C of A's (MELCC)
- At this time, the RP is divided in four sub plans:
    1. Expo-Mesamax
    2. Allammaq
    3. Méquillon
    4. Puimajuq

# 1. Expo-Mesamax (including Deception bay facilities)

The Expo-Mesamax RP was initially submitted in 2011. It was first reviewed in 2014 to exclude the Méquillon and Ivakkak deposits that were not yet in production. The second review was completed in 2019. Outlines of these plans are:

- **All buildings** and fixed equipment installations will be **dismantled**;
- **All road** surfaces will be scarified / **returned to reflect natural conditions**;
- The Bombardier lake fresh water reservoir dam will be decommissioned;
- The **reactive waste rock and tailings cells will be capped with geomembranes and protective materials**;
- The non-hazardous waste management landfill will be sand capped and protected against erosion;
- Hazardous materials and economic recyclable materials will be shipped South for proper disposal/recycling;
- The **open pits will be flooded**.
- CRI would like to cede the Deception Bay wharf to the local government. If an agreement is not possible, the barge will be detached and returned south using a tow boat.
- The **concentrate warehouse at Deception Bay will be dismantled**. Soils will be cleaned if required and transported by truck to the Expo site tailings pond.

# 2. Allammaq

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Since the Allammaq deposit was subjected to a permit amendment in 2011, the related closure plan was submitted separately in 2014 and reviewed in 2019. Outlines of the plan are:

- **No stack of materials will remain on the Allammaq mine site**: all the ore will be sent and processed to the Expo Industrial Complex and all waste rock returned underground for backfilling;
- **All buildings and infrastructure** that will not be useful for post-closure monitoring **will be dismantled**. The rejects of dismantling will be buried at the Expo site or sent to an authorized disposal site. However, special attention will be given to the maximum recovery of non-metal ferrous and scrap metal to return to authorized recycling centers;
- Support infrastructure, i.e., pipes and tanks, will be removed. The places where these infrastructures were used for storage or transport of hazardous materials will be characterized and decontaminated if necessary;
- No hazardous material will be left on the mine site after the cessation of mining activities;
- All transport infrastructure that will not be useful for the post-closure monitoring or for local communities will be restored adequately according to the environmental standards in force;
- All equipment and surface heavy equipment will be sold, recovered or sent to an authorized disposal site;
- **An assessment of soil quality for all potentially contaminated sites will be carried out** and corrective actions will be applied according to the requirements in force;
- **Environmental monitoring of drainage water will continue over a period of 5 years after the cessation of mining activities;**
- The stability of the structures left behind will be monitored over a period five years after the cessation of mining activities.

# 3. Méquillon

The Méquillon specific closure plan was submitted in 2018. Outlines of the plan are:

- **All buildings and infrastructure** that will not be useful for post-closure monitoring **will be dismantled** and returned to the south;
- Support infrastructure, i.e. pipes and tanks, will be removed;
- **The reactive waste rock pile will be leveled and covered with a geomembrane to ensure long-term physical and chemical stability;**
- **The pit will be flooded;**
- The non-hazardous waste will be buried in the Expo northern landfill. However, special attention will be given to the maximum recovery of non-ferrous metal and scrap to return to authorized recycling centers;
- No hazardous material will be left on the Méquillon mine site after the cessation of mining activities;
- **An assessment of soil quality for all potentially contaminated sites will be carried out** and corrective actions will be applied according to the requirements in force;
- All transport infrastructure that will not be useful for post-closure monitoring or for communities will be properly restored according to environmental standards;
- **Environmental monitoring of runoff waters will continue over a period of 10 years after the cessation of mining activities** to verify the proper operation of the waste rock remediation method.

# 4. Puimajuq

The specific closure plan for the Puimajuq site was submitted in 2018. The main lines of the plan are:

- **All buildings and infrastructure** that will not be useful for post-closure monitoring **will be dismantled** and reused as a priority in the context of the NNiP. Dismantling waste will be managed at the Expo site landfill or sent to an authorized disposal site. Particular attention will be given to the maximum recovery of non ferrous metal and scrap to return to recycling centers approved;
- All ore will be sent and processed at the Expo complex; the area of the dump will be leveled;
- **Leachable waste rock (approximately 12%) will be returned to the pit and the non-leachable waste rock pile will be stabilized and profiled to control erosion and blend in with the environment.** It is possible that some of this waste rock was also returned to the pit;
- **The pit will be gradually flooded**, thus covering the leachable waste rock. In the event that the quality of the water accumulated in the pit does not comply with the regulations in force, lime could be poured into it for the purpose of metal precipitation;
- No hazardous material will be left on the Puimajuq mining site after mining activities cease;
- The equipment and heavy equipment will be sold, recovered or sent to an authorized disposal site;
- **A soil quality assessment of all potentially contaminated sites will be carried out** and corrective actions will be applied according to the requirements in force;
- **A monitoring program, with a minimum duration of 5 years, will be put in place when operations cease and extended as necessary.** It will include visual inspections of the integrity of the structures and monitoring of the quality of the runoff water, the pit and the water collection basin;
- During the monitoring period, the water diversion berms upstream of the site, the ditches and the collection basin will be kept in place. The water from the basin will be pumped to the Mesamax treatment plant. At the end of the monitoring period, and **only when it has been demonstrated that the water quality complies with the regulations in force, the water will be pumped to the pit**. **The basin will be dismantled and filled with non-leachable waste rock,** which will allow the solids deposited there to be isolated from the ambient environment. **The basin, berms and ditches will be leveled so as to integrate with the natural environment** and allow good water drainage;
- The main access road leading to Puimajuq, located on public land, may remain in place at the request of the local communities. The secondary roads will be scarified.

# Cost and financial guarantee

- The estimated total cost of closing the mine is:
  - Expo-Mesamax : $ 41M (2019 Canadian dollars)
  - Allammaq : $ 420,000 (2019 Canadian dollars)
  - Méquillon : $ 26M (2018 Canadian dollars)
  - Puimajuq : $ 1.9M ( 2019 Canadian dollars )
  - Total for all RP: 69 320 000 $
- Payment of the financial guarantee (In trust) was made in compliance with the regulation (MERN).
- The Restoration Plan for **New development/project** will be elaborated, and their specific restauration costs will be added to the financial guarantee.
- Since our extraction sites are still active, the progressive reclamation is currently taking place in the form of the cleaning and dismantling of the Berbegamo Exploration camp, and the shipping for recycling of all scrap metal accumulated in the landfill area.
- A sub-committee with Inuit stakeholders could be formed for the upcoming progressive reclamation that should start in 2022 (Allammaq, Expo tailing cells) as per section 12.6 (IBA).

## APPENDIX 8

Summary of the closure plan projected for the Expo pit

(enclosed in attachments)

## Summary of the closure plan projected for the Expo pit

Once tailings deposition in the pit is completed, tailings water in the pit will be removed and treated prior to its discharge in accordance with current environmental standards. Accelerated flooding of the pit will then take place. A water quality model was developed in the deisgn report to assist with the evaluation of anticipated water quality during the operation, closure and post-closure phases of the project. The measures projected for the Expo pit closure and the schedule that will be presented to the MERN are as follows:

| Schedule | Step | Details |
|---|---|---|
| July 2023 to September 2030 | Expo pit tailings water drainage and treatment | Tailings water at the bottom of the pit will contain contaminants such as metals and process reagents. Before flooding the pit with clean water, all of the tailings water will be pumped to be treated by the industrial wastewater treatment process at the Expo site prior to its releases to the environment. The water will be discharged to the environment in accordance with applicable standards at a rate of 180,000 m3 per month, from July to September of each year. |
| October 2030 à April 2035 | Accelerated flooding of the pit | Once tailings water in the pit has been completely removed and treated, the pit will be gradually flooded with clean water from Lac Bombardier over approximatively 4 to 5 years, at a rate of 1.3 $Mm^3$/yr.<br>Active flooding of the pit will end once the water level reaches an elevation of 535.4 m, corresponding to the lowest elevation along the pit rim.<br>An outlet spillway channel will be constructed on the northeast corner of the pit. Once accelerated flowing of the pit is completed around 2035, the channel will convey the pit overflow to the Puvirnituq river tributary. |
| October 2030 to December 2056 | Maintaining water quality | Pit water quality hardness will be maintained at 400 mg/l $CaCO_3$ equivalent trough a treatment consisting of adding Calcium Chloride during the closure and post-closure phases. |