# **Appendix 61**

# **Whale Tail Thermal Monitoring Plan Version 5**



# WHALE TAIL MINE

# **Thermal Monitoring Plan**

In Accordance with Project Certificate No. 008, T&C 14

Prepared by: Agnico Eagle Mines Limited – Meadowbank Division

> Version 5 February 2025

## **EXECUTIVE SUMMARY**

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) received a Project Certificate No.008 from the Nunavut Impact Review Board for the development of the Whale Tail Pit, a satellite deposit located on the Amaruq Exploration property. In 2020 the Whale Tail Pit – Expansion Project (Expansion Project) was approved, permitting Agnico Eagle to expand and extend the Whale Tail Pit operations to include a larger Whale Tail open pit, development of the IVR open pit, and underground operations while continuing to operate and process ore at the Meadowbank Mine. In 2021 a positive conformity determination application was issued by the Nunavut Planning Commission for pushbacks on the IVR and Whale Tail pits (Pushback Project).

The deposits will be mined as an open pit (i.e., Whale Tail Pit and IVR Pit) and underground, and ore will be hauled by truck to the approved infrastructure at Meadowbank Mine for milling. Ore will be mined from the open pit and underground and processed over a ten-year mine life. Ore will be crushed on site after which it will be transported to Meadowbank Mine for milling. The mill rate will be approximately 9,000 to 12,000 tonnes per day.

This document presents the Thermal Monitoring Plan for the Whale Tail Mine (Piquganiq) in accordance with Terms and Conditions No. 14 included in the Project Certificate.

# **DOCUMENT CONTROL**

Version	Date (YMD)	Section	Revision
1	2018-05-04	All	To address Project Certificate No. 008. T&C 14
2	2019-03-31	All	Comprehensive update of the plan
3	2020-03-31	All	Comprehensive update of the plan
4	2022-03-31	All	Comprehensive update of the plan; includes the IVR area, new thermistors installed since 2020, and updated with longer production timeline.
5	2025-02-26	Executive Summary, Section 1, Section 3	Updated with longer production timeline, mine name nomenclature, and new thermistors installed since 2022.

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# 1 INTRODUCTION

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is developing the Whale Tail Mine (Piquganiq) (Mine), a satellite deposit located on the Amaruq Property (geological property), to continue mine operations and milling at Meadowbank Mine.

The Amaruq Property is a 408 km² site located on Inuit Owned Land approximately 150 km north of the hamlet of Baker Lake and approximately 50 km northwest of Meadowbank Mine in the Kivalliq Region of Nunavut. The deposit will be mined as an open pit (i.e., Whale Tail Pit and IVR Pit) and underground, and ore will be hauled to the approved infrastructure at Meadowbank Mine for milling. The planned project involves: one year of construction, ten years of mine operation, seventeen years of closure-related activities, and the post-closure period.

This document presents a Thermal Monitoring Plan prepared for the following mine facilities and natural locations:

- Waste rock storage facilities (WRSFs)
- Water management facilities including Whale Tail Dike, Mammoth Dike, WRSF Dike, IVR Dike, and the Whale Tail and IVR Attenuation Ponds
- Whale Tail Pit
- IVR Pit
- Whale Tail Lake shore

The Thermal Monitoring Plan provides general descriptions of the different facilities, describes the anticipated impact of operation of the facilities on the permafrost, and presents general guidelines that are used to define instrumentation needs for each facility. This document is not intended to provide detailed specifications for the instrumentation program, which will be defined as mining progresses and infrastructures are built. The Thermal Monitoring Plan will be reviewed periodically to adjust to the dynamics of mine construction and operation and adapt the monitoring strategy defined for each facility as needed.

## 1.1 PROJECT PERMIT

Meadowbank Mine is an approved mining operation and Agnico Eagle is extending the life of the mine by constructing and operating the Mine. The Mine was subject to an environmental review established by Article 12, Part 5 of the Nunavut Agreement. In June 2016, Agnico Eagle submitted a Final Environmental Impact Statement (FEIS) seeking a reconsideration of the Meadowbank Mine Project Certificate (No. 004/File No. 03MN107) and Type A Water Licence Amendment (No. 2AM-MEA1526) from the NIRB.

On July 2016, the NIRB determined that the proposed Mine required a separate screening assessment under the Nunavut Agreement and the *Nunavut Planning and Project Assessment Act* (NuPPAA). A separate Project Certificate (NIRB Project Certificate No. 008) was issued for the Mine on March 15, 2018 by the NIRB. This Thermal Monitoring Plan reflects the commitments made with respect to submissions provided during the technical review of the FEIS, to comply with Terms and Condition No. 14 included in the Project Certificate.

In 2020 the Whale Tail Pit – Expansion Project (Expansion Project) was approved, permitting Agnico Eagle to expand and extend the Whale Tail Pit operations to include a larger Whale Tail open pit, development of the IVR open pit, and underground operations while continuing to operate and process ore at the Meadowbank Mine. In 2021 a positive conformity determination application was issued by the Nunavut Planning Commission for pushbacks on the IVR and Whale Tail pits (Pushback Project).

#### 1.2 OBJECTIVES

The primary objective of the Thermal Monitoring Plan is to document and monitor ground thermal conditions at site and identify impacts to the permafrost, if any, that could be associated with development, operation, and closure of the different mine facilities. This is done through the implementation of a monitoring program designed to assess variations in the ground thermal conditions and a data analysis program that will compare results obtained to baseline conditions prior to mine developments.

The monitoring program will allow for identification of affected permafrost zones and for the comparison between the anticipated and observed effects of the mine facilities on the permafrost. The results of the monitoring program will also be used to guide activities that might be required in the future to document the development and/or evolution of permafrost at site.

In certain areas, effects of mine operations on the permafrost are anticipated to be temporary and normal conditions are expected to be restored progressively upon closure of the mine. The monitoring plan will constitute a means to assess and validate this assumption, and monitoring results will be used to determine if mitigation actions are required and define what these will be at specific locations, as needed.

# 2 BACKGROUND

#### 2.1 CLIMATE ENVIRONMENT

The Mine site has the following mean climate characteristics (Agnico Eagle 2016):

- Mean annual air temperature of -11.3 °C
- In summer months from June through September, the mean monthly air temperature ranges from 4.9 to 11.6 °C. In winter months from October to May, the mean monthly air temperature ranges from -6.4 to -31.3 °C
- Mean annual total rainfall of 168 mm
- Mean annual total snowfall (water equivalent) of 160 mm

#### 2.2 REGIONAL PERMAFROST

The Mine is in the zone of continuous permafrost. Permafrost refers to subsurface soil or rock where temperatures remain at or below 0°C for at least two consecutive years. This is synonymous to perennially cryotic ground, which may be frozen, partially frozen, or non-frozen depending on the ice/water content of the ground, and the salinity of the groundwater. The base of the permafrost is expected to be an undulating surface and the actual depth to permafrost is variable.

The Mine footprint is underlain by permafrost except under portions of Whale Tail Lake where water is too deep to freeze to the bottom during winter. Taliks (areas of unfrozen ground) are expected beneath a water body where the water depth is greater than the ice thickness. Closed talik formations show a depression in the permafrost table below relatively shallow and small lakes. Open talik formations that penetrate through the permafrost and connect the lake waterbody with the sub-permafrost regime are to be expected for relatively deeper and larger lakes in the mine area.

#### 2.3 SITE SUBSURFACE GEOLOGY

The Whale Tail deposit is in the northern portion of the Whale Tail Lake. Based on previous site investigation data, soils in the mine area are typically medium to coarse grained glacial till and colluvium with high coarse fragment content overlying bedrock at shallow depths. Saturated soil layers overlying frozen layers have been observed on site. A review of the records of the thermistor boreholes indicates soil thicknesses varying from 6.1 to 12.4 m. Underlying the soil, bedrock in the area generally consists of a stratigraphic sequence of greywacke, iron formation and komatiite, with varying thicknesses.

#### 2.4 BASELINE FIELD INVESTIGATIONS

The Mine site permafrost conditions were initially assessed by Knight Piésold (2015) between June and October of 2015 which included the installation of six thermistors in the vicinity of the proposed development of Whale Tail Lake to collect ground temperature data.

Golder Associates completed an additional thermal assessment for the Whale Tail Lake in 2017 (Golder 2017a) and installed four thermistors within the vicinity of Whale Tail Lake.

A Westbay well was installed on-site between March and April in 2016 where groundwater samples were collected from multiple intervals (Golder 2016). A first estimation of the thickness of the permanently frozen permafrost was made based on information collected from the Westbay well.

Additional investigations and thermistor installations were carried out by SNC-Lavalin in 2016 and 2017 for the purpose of dike design.

#### 2.4.1 Existing Instrumentation On Site

There are currently many active thermistors at the Whale Tail Mine area. Data from these thermistors have been used to estimate the site permafrost and talik conditions (Golder 2017a, 2018a).

The location and installation summary of the active and inactive thermistors within the Mine site are presented in the Whale Tail Thermal Monitoring Report. Data are collected from the thermistors by data loggers or using manual readout units.

Results of active thermistors are presented in the Whale Tail Thermal Monitoring Report.

#### 2.5 BASELINE THERMAL MODELLING

Thermal modelling has been conducted to predict variations in the thermal regime of the permafrost. Modelling results are presented in the following reports:

- 2015 Site Permafrost Characterization by Knight Piésold (2015).
- 2017 Whale Tail Lake Thermal Assessment by Golder (2017a).
- 2017 and 2018 Golder Waste Rock Storage Facility thermal analysis for cover design by Golder (2017b, 2018b).
- 2018 Pit Lake Post-Closure Thermal Assessment by Golder (2018a).
- 2018 Dike Thermal Assessment by SNC-Lavalin (2018).
- 2019 Landform Water Balance Modelling of Whale Tail and IVR WRSF under RCP8.5 by Okane (2019a).

General results obtained from these studies are used to define the permafrost baseline conditions summarized in Section 2.6.

#### 2.6 SUMMARY OF BASELINE PERMAFROST CONDITIONS

Baseline permafrost conditions on the Mine site were estimated as follows based on thermistor data up to October 2017 and previous works. This information describes the baseline permafrost condition at the site.

- The depth of permafrost in the mine site is estimated to be in the order of 427 to 495 m.
- The extrapolated mean annual ground surface temperature is estimated to be in the range of -3.4 to -9.9 °C.
- The estimated depths of zero amplitude from temperature profiles measured by the existing thermistors range from 18 m to 35 m.
- The temperatures at the depths of zero amplitude are in the range of -3.0 °C to -8.4 °C.
- The geothermal gradient is in the range of 0.005 °C/m to 0.025 °C/m.
- Based on the measured salinity concentration of 0.3% to 0.4% from groundwater samples
  collected on site, a freezing point depression of about 0.2 °C is estimated, which may reduce
  the frozen ground depth by approximately 20 m.

Ground thermal conditions under Whale Tail Lake were estimated by both thermal assessment and thermistor data. Results indicate the following:

- Under the northern portion of the lake including under the proposed pit location and along the proposed ramp area, there is likely a closed talik formation.
- An open talik is expected in the southern portion of the lake where it becomes wider and deeper.
- Data from the thermistor AMQ17-1265A installed within the lake (near southeast side of the Pit) suggests the talik depth at this location is about 112 m from the lake water level. Permafrost is present beneath the talik at that location to a depth of about 343 m.

# 3 THERMAL MONITORING PLAN

This section presents a general description of each facility, the expected thermal effects on the permafrost and planned thermal monitoring. The monitoring program will allow for evaluation of the actual impacts on the permafrost thermal regime during construction, operations, and closure of the facilities, and post-closure.

The information presented herein will be reviewed periodically during operations to reflect the actual site conditions.

Refer to the thermal monitoring report for analysis and presentation of the gathered data.

#### 3.1 WASTE ROCK STORAGE FACILITY

# 3.1.1 Facility Description

The Whale Tail WRSF is located north-west of the Whale Tail open pit. The IVR WRSF is located east of the IVR open pit. Waste rock and overburden will be trucked to the WRSFs throughout mine operations. Agnico Eagle plans to deposit a total of 211.0 million dry tonnes (Mt) of waste rock and overburden material between 2017 and 2028.

The final height of the Whale Tail WRSF is anticipated to be 100 m. The final height of the IVR WRSF is anticipated to be 80m. The construction process incorporates benches built in 5-m thick layers. Each bench toe will start at a setback distance of 20 m from the crest of the previous bench.

The diorite and south greywacke material, which are both non-potentially acid generating and non-metal leaching (NPAG/NML) are used as cover material for the Whale Tail and IVR WRSFs. Closure of the WRSFs will begin when practical as part of the progressive reclamation program. As part of the Whale Tail Pit – Waste Rock Management Plan (Agnico Eagle 2017), the Whale Tail and IVR WRSFs will be covered NPAG/NML waste rock to promote freezing of the pile as a control strategy to prevent acid generation and transport of contaminants.

### 3.1.2 Expected Thermal Effects on Permafrost

Construction of the WRSFs on permafrost is expected to result in aggradation of permafrost into the pile. The permafrost under the piles would remain, but temperatures in the upper permafrost zone are expected to evolve towards a thermal equilibrium established with the active layer and zero-amplitude zone moving upwards within the waste rock pile. Convective cooling is common in waste rock material and is expected to promote freeze-back within the pile.

The waste rock pile itself is expected to freeze back with time and have an active layer formed in the upper portion (O'Kane, 2021). Climate change in the long term is expected to extend the depth of the active layer in the pile, but the thick waste rock pile will constitute a protection to the underlying permafrost. If heat generation occurs from the oxidation of sulphide-bearing minerals within the pile, the freeze-back process would be delayed. Depending on the location of the heat generation source, the upper portion of the permafrost foundation could be impacted.

# 3.1.3 Thermal Monitoring Plan

There are currently vertical and horizontal thermistors installed in the Whale Tail and IVR WRSFs to monitor the thermal behaviour of the waste rock and underlying permafrost. Additional instruments will be installed during construction of the piles to monitor the evolution of temperature profiles with time and to evaluate if the process of permafrost aggradation and pile freeze-back is developing as anticipated. Thermistors installed during construction of the piles will be in completed benches, and additional thermistors will be installed on top of the piles upon end of operations and installation of the cover system for closure of the facilities. Thermistors installed after placement of the thermal cap on top of the facilities will be used to assess whether the defined cover thickness of 4.7m (Okane 2019b) is effective to maintain the top of the piles away from the active zone subject to seasonal freezing and thawing.

The thermistor strings are connected to data loggers for automatic data collection and storage. Data are reviewed periodically or as-needed, and results are summarized in the thermal monitoring reports on a yearly basis during operation and for five years after closure. The frequency of reporting will be reviewed after that and might be reduced.

#### 3.2 WATER MANAGEMENT FACILITIES

#### 3.2.1 Facility Description

Water management infrastructure includes contact water collection ponds, diversion channels, retention dikes, dams, culverts, water treatment plant for effluent, potable water treatment plant, sewage treatment plant, and discharge diffusers. Contact water on-site is directed to an Attenuation Pond (Whale Tail or IVR) where it is treated and then released to Kangislulik Lake or Whale Tail South through a discharge diffuser.

The Whale Tail Dike was constructed before operations to allow mining of the Whale Tail open pit. Once dewatering of the lake area downstream of the dike was completed the operational lake water level upstream of the dike was El. 155 masl, about 2.5 m higher than the original average lake level. The dike will be breached during closure to restore the lake and will form a permanent pit lake as the open pit is flooded.

The Mammoth Dike is a dewatering structure constructed at the west side of the Whale Tail Pit, and on the east side of Kangislulik Lake to limit flow from Kangislulik Lake into the pit. Similarly, the North East Dike was constructed to limit inflow from lakes A46, A47 and AP68. Following the fish out and dewatering of surrounding lakes (A46 & A47) in 2020, the North East Dike was dismantled as part of the IVR Pit development.

The Whale Tail Attenuation Pond is located between the Whale Tail Dike and the Whale Tail Pit to collect mine water, runoff and seepage from the dike. The IVR Attenuation Pond is located between IVR Dike D-1 and the IVR Pit to collect mine water and runoff.

The WRSF Dike is a water retaining structure to manage contact water from the Whale Tail WRSF. Water is pumped to the Attenuation Ponds.

The IVR Dike D-1 is a contact water retaining infrastructure built to contain the IVR Attenuation Pond. It is located East of the Whale Tail Pit. The structure includes an emergency spillway to release the water to the Whale Tail Attenuation Pond.

## 3.2.2 Expected Thermal Effects on Permafrost

The Whale Tail Dike is constructed within a lake, overlaying an open talik. The construction of the Whale Tail Dike is expected to have a cooling effect on the underlying ground due to exposure to lower temperature than lake water. Minimal effects to the permafrost at the abutment areas are expected.

Following lake dewatering and the beginning of operations, natural ground in the downstream of the Whale Tail Dike is expected to freeze back progressively. Upstream of the dike, the lakebed and underlying talk is expected to remain unfrozen.

After the dike is breached in the final stages of closure, the Whale Tail Lake will be restored, causing frozen zones located downstream of the dike to thaw, progressively restoring the original lake talik.

The other dewatering dike areas are expected to have similar thermal impacts on the permafrost associated with construction, operation, and closure of the dikes.

The WRSF Dike will periodically contain a pond formed from runoff water flowing at the toe of the Whale Tail WRSF facility. Depending on pond conditions (volume, temperature, duration before pumping) there would be possible thawing of a shallow upper permafrost zone underlying the pond. However, due to the small pond size and the low operational level, this issue is unlikely.

The talik zone under the Whale Tail Attenuation Pond would remain. The areas surrounding the pond are expected to freeze back progressively after dewatering but would restore to talik conditions after breaching of the dewatering dikes and flooding of the area.

As for the IVR Attenuation Pond, with the maximum water elevation of the pond above the former lake elevation, some minor localized thawing of the permafrost is expected to occur outside of the original lake footprint.

#### 3.2.3 Thermal Monitoring Plan

There are thermistors currently installed in the Whale Tail Dike, WRSF Dike, Mammoth Dike, and IVR D-1 areas for geotechnical monitoring. Additional thermistors might be installed on these structures based on geotechnical monitoring need.

Thermistors have not been installed within the footprint of the Attenuation Ponds. The Attenuation Ponds are not anticipated to have any negative effects on permafrost due to their planned locations within an existing talik area.

Most thermistor strings are connected to data loggers for automatic data collection and storage. Thermistors that are not connected to a logger are read manually on at least a monthly basis or as needed. Data are reviewed periodically or as needed.

#### 3.3 OPEN PIT

#### 3.3.1 Facility Description

The Whale Tail Pit extends across the northern edge of Whale Tail Lake. The IVR Pit is located northeast of the Whale Tail Pit. Ore will be mined from the Whale Tail Pit and IVR Pit and processed over a ten-year mine life. Construction of the Whale Tail Pit site started in 2018. Construction of the IVR Pit site started in 2020. The operational phase of the mine site will span

from Year 1 (2019) to Year 10 (2028). Pit flooding is anticipated to commence in 2028 marking the beginning of the closure period and is expected to be complete in 2046.

## 3.3.2 Expected Thermal Effects on Permafrost

Whale Tail Pit will be excavated through an upper closed talik zone and underlying permafrost. During operations of the pit the talik zone is expected to freeze back progressively and the lower permafrost zone surrounding the pit walls will, in general, experience reduction in temperature other than at a shallow active zone adjacent to the pit walls subjected to seasonal thawing during summer.

Upon closure and subsequent flooding of the Whale Tail Pit, permafrost areas underneath the pit lake are expected to gradually thaw. Thermal assessments have indicated this process would take hundreds of years (Golder 2018a). The pit lake would eventually reduce the permafrost depth in the pit surrounding ground, but this process could take significantly longer time (in the order of 10,000 years) to complete.

IVR Pit is excavated through permafrost and as a result the mining activities are not expected to impact the thermal regime of that area.

# 3.3.3 Thermal Monitoring

Previously, thermistors were installed in the Whale Tail Pit and IVR Pit areas for geotechnical monitoring. One thermistor is currently active in the area near the IVR Pit and three thermistors are currently active in Whale Tail Pit. The other thermistors installed were destroyed as part of mining activity. Additional thermal investigations around the pit at shallow depth may be undertaken; the need for this will be defined during mining.

For/if any thermistors remain active or are installed in this area, they may be connected to data loggers for automatic data collection and data storage. Data will be reviewed periodically or asneeded, and results will be summarized in annual monitoring reports during operation and for five years after closure. The frequency of reporting may be modified in time as the thermal regime of the area stabilizes.

#### 3.4 WHALE TAIL LAKE SHORE

The shore of the Whale Tail Lake south basin will be affected by increased water levels upstream of the Whale Tail Dike, while the shores of the Whale Tail Lake north basin will be affected by lake dewatering downstream of the dikes, the mining of the open pits, and re-flooding after breaching of dewatering dikes during closure of the facilities.

The operational lake level of El. 155 m upstream of the Whale Tail Dike is about 2.5 m higher than the original average lake water level. This will result in flooding of part of the lake shore and shallow thawing of the upper portion of the permafrost during operations. Given the short mine operation period, the impact is anticipated to be small. Deeper portions of the permafrost in newly flooded areas upstream of the dikes are not expected to be affected significantly. After the dewatering dikes are breached, the original lake level will be restored, and permafrost conditions will recover gradually as the lake water level lowers.

There are two thermistors installed on the lake shore of Whale Tail North Basin, north of the Whale Tail Dike downstream road.

There are no thermistors installed on the lake shore of Whale Tail South Basin upstream of the dike. Given the short period of time during which the lake shore in the South Basin will be flooded, the effects on the permafrost will be temporary and limited to the shallow upper portion of the ground. It is not considered necessary to install additional thermistors in that area.

# 4 CLOSURE

The Thermal Monitoring Plan presented in this document is intended to constitute a guide for instrumentation and monitoring of the Mine facilities to evaluate the effects of mine developments on the thermal regime of the natural ground and relevant site infrastructures.

The instrumentation program at the different facilities will consist primarily of thermistor strings installed horizontally, vertically and at angles as needed. Data obtained from the thermistor strings will constitute the primary source of information for evaluation of changes in the thermal regime of the permafrost basin associated with construction, operations, and closure of the mine facilities.

The actual schedule of instrumentation and quantity, type of instrument, location, depth, and length of the thermistor strings to be installed will be defined specifically for each facility based on the mining plan, construction schedule, and accessibility to be defined during mine operation. The activities listed in this Plan will be periodically reviewed to reflect the dynamics of site development and operation. Decisions on thermistor installation will be based on the results of the monitoring program, as deemed required for a given area to assess effects on the thermal regime of the ground or facility.

Installation of different types of instrumentation such as vibrating-wire piezometers, monitoring wells, and oxygen probes may be considered in the future in areas such as the WRSFs if there is a need to better understand the process of water percolation, air-flow convection, and heat generation within the piles.

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