APPENDIX 11.IV

Results of Flooded Open Pit Filling Scenario

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11.IV.1 INTRODUCTION

This appendix provides the results of analysis performed to assess the potential for the Open Pit at the proposed NICO Project to fill with water under natural climatic influences in the closure condition of the mine. The purpose of the assessment is to quantify the approximate timeline required to fill the Open Pit. The model includes the following elements:

- inputs to the pit include groundwater seepage, precipitation to the water surface and pit walls, runoff from the natural drainage, and runoff from the Co-Disposal Facility (CDF);
- losses from the pit include evaporation from the water surface and outflow which begins when the pit fills to the Full Supply Level (FSL) at elevation 260 meters above sea level (masl) which coincides with the ramp; and
- surface areas used in the assessment include an Open Pit area of 51 hectares (ha), the natural ground surface drainage reporting to the pit of 34 ha, and the drainage reporting from the CDF of approximately 80 ha.

11.IV.2 METHODOLOGY

This model has been assessed through several iterations due to changes in the site layout, geometric configuration of the CDF, geometric configuration of the Open Pit, and perceived closure scenarios which differed by operating circumstances. Significant changes through the development of the model included changes to the operating circumstances and configuration of the CDF (November 13, 2010 as per Technical Memorandum issued on 1 October 2010 regarding Site Water Management for NICO Project [Version 2] by Golder Associates Ltd.) and changes to the pit configuration (29 November 2010 as per the revised pit configuration issued in August, 2010 by P&E Consultants).

Two groundwater inflow contributions were considered in estimating seepage to the Open Pit. The first was groundwater inflow through the bottom of the Flooded Open Pit, which was calculated using analytical expressions by Marinelli and Niccoli (2000). The second was groundwater inflow through the sides of the Flooded Open Pit, which was calculated using the Theim solution for inflow to a well. These equations require estimates of the radius and depth of the Flooded Open Pit, the hydraulic conductivity of the surrounding bedrock, and the height of the water table away from the pit crest. The radius of the Flooded Open Pit was assumed to be 300 metres (m) to allow pit height to be the only variable. The radius of 300 m was based on the volume of the final pit, assuming the pit can be approximated as a right cylinder. The height of the water table away from the pit crest was assumed to be 260 m elevation, approximately 166 m above the base of the pit. Groundwater seepage above elevation 260 m is assumed to be negligible, and better estimated as part of precipitation and interflow. The radius of influence to the pit was assigned to 1000 m.

The following list details assumptions and calculations which were used in the assessment:

- Precipitation is based on the Undercatch Corrected data set available for the Yellowknife Airport from 1953 to 2007 (Annex G). Precipitation is used in the model as monthly average values where an average year is repeated throughout the model. Precipitation is assumed to fall and accumulate as snow from November to April inclusive. The average monthly precipitation values are presented in Table 11.IV.2-1.

Table 11.IV.2-1: Monthly Average Precipitation and Gross Evaporation

Month	Total Precipitation (mm)	Gross Evaporation (mm)
January	21.5	0.0
February	19.5	0.0
March	19.0	0.0
April	14.5	0.0
May	20.5	0.0
June	25.2	118.6
July	40.1	154.4
August	44.1	120.7
September	36.0	66.8
October	38.8	18.0
November	37.1	0.0
December	27.1	0.0
Total	**343.4**	**478.5**

mm = millimetres

- Runoff to the Open Pit is calculated using runoff coefficients for the natural ground surface and CDF (Table 11.IV.2-2). Both surfaces use the same runoff coefficients in anticipation that the CDF will be characteristically similar in regards to infiltration, evaporation, and runoff in the closure condition. Coefficients for the winter months incorporate sublimation and transportation losses from the snowpack.
- Seepage to the Open Pit is controlled by the water level in the pit whereby seepage to the pit is greatest when there is no water in the pit and smallest when the pit is at the FSL at 260 masl. The hydraulic conductivity of the bedrock is assumed to be 5E-9 m/s based on in-situ testing and subsequently shown to be a reasonable estimate by the 3-D hydrogeology numerical modelling and calibration work.

Table 11.IV.2-2: Runoff Coefficients

Month	Coefficient
January	0.6
February	0.6
March	0.6
April	0.6
May	0.5
June	0.4
July	0.3
August	0.3
September	0.3
October	0.4
November	0.6
December	0.6

- Monthly gross evaporation from the water surface is presented in Table 11.IV.2-1. The monthly gross evaporation is calculated using the Meyer's formula (Annex G).
- The water balance for evaluating the volume reporting to the pit is based on a monthly time step where the following rules apply:
  - Precipitation as snowfall reports to surfaces and is accumulated through the winter months of November to April. Snowmelt runoff occurs in May along with precipitation for the month of May. Sublimation and other losses from the snowpack are assumed in the runoff coefficients. Infiltration and evapotranspiration from the ground and CDF surfaces are also assumed in the runoff coefficients. For the open season, precipitation (mostly rainfall) reports to the pit (or collection ponds) as runoff, which is calculated as a product of the volume of precipitation and the runoff coefficient for that month.
  - Evaporation occurs over the water surface as the Flooded Open Pit fills. The magnitude of evaporation from the pit changes as the surface water area increases or decreases based on the overall change in water volume within the pit. Evaporation is the only loss of water from the pit until the Flooded Open Pit fills and spills over; all other parameters identified in Table 11.IV.2-1 are inputs to the pit.
  - Seepage reporting to the pit is controlled by the water level in the pit.
  - In the Flooded Open Pit water balance, the volume at the start of the month controls the lake elevation and surface area that define the magnitudes of seepage, evaporation and volume of precipitation falling directly within the pond for that month. For evaluating the final volume for each month, the net change in the volume of the pit is calculated from the inputs and losses and applied to the volume at the beginning of the next month. The final volume for one month becomes the initial volume for the next month which controls the next surface area and lake elevations for the next calculations.
  - The pit fills until the lake elevation is 260 masl where outflow from the pit begins. The volume discharged from the pit is the excess water that must be discharged to maintain an elevation of 260 masl. The lake elevation of 260 masl corresponds to a lake depth of 166 m.

11.IV.3 RESULTS

The results of the model are presented on Figure 11.IV.3-1. The time required to fill for the Flooded Open Pit under natural climatic influence is approximately 120 years at which point the pit will overflow from the ramp.

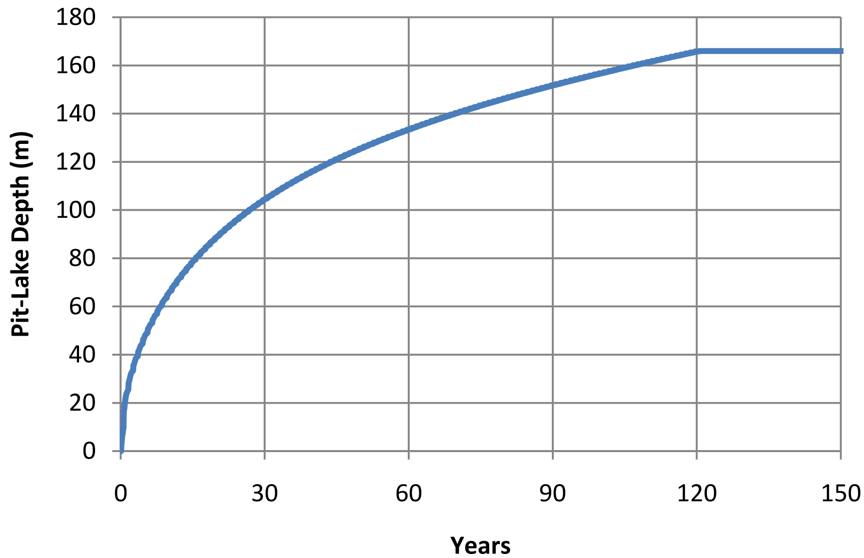

Figure 11.IV.3-1: Flooded Open Pit Filling Results

11.IV.4 CLOSURE

The methodology used to estimate the time to fill the Flooded Open Pit at the proposed NICO Project incorporates average climatic parameters, runoff coefficients, and a standard water balance approach. The model assumed an average annual climatic influence whereby the pit is filled by precipitation, runoff, and seepage and has losses to evaporation. The model predicted that the time to fill would be approximately 120 years.

11.IV.5 REFERENCES

Marinelli, F., and W. L. Niccoli. 2000. Simple analytical equations for estimating ground water inflow to a mine pit. Ground Water 38, no. 2: 311-314.