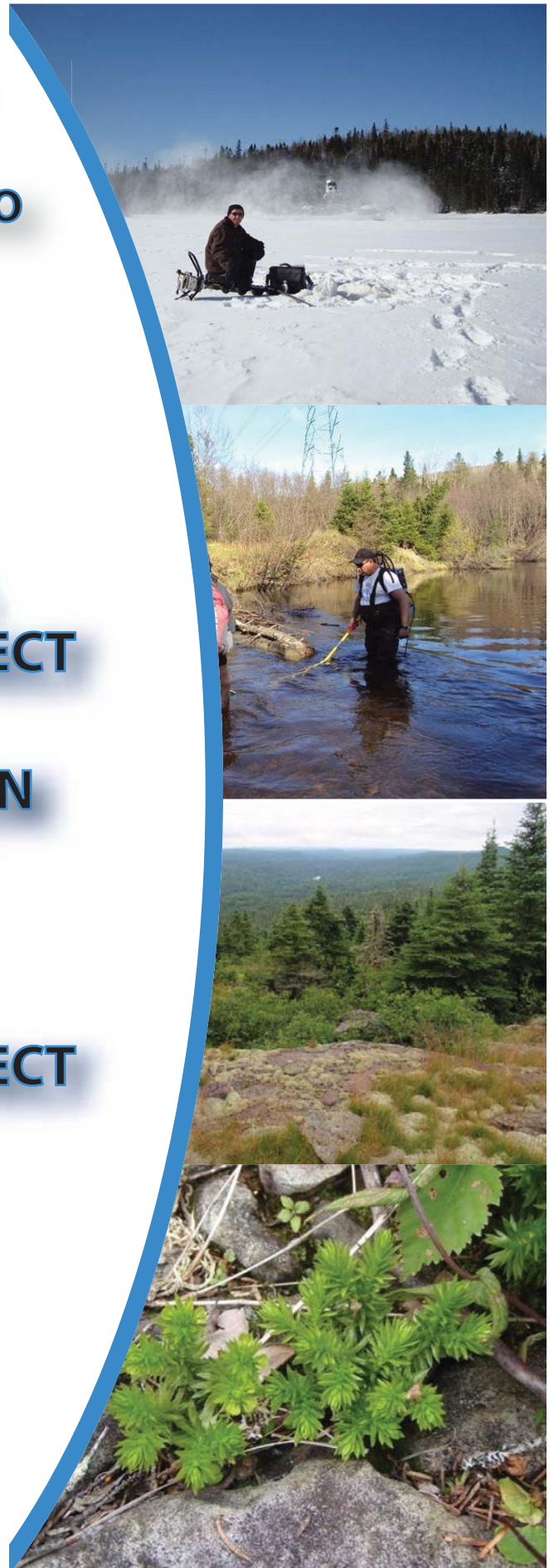


**ENVIRONMENTAL ASSESSMENT
FOR THE MARATHON PGM-Cu
PROJECT AT MARATHON, ONTARIO**

**STILLWATER CANADA INC.
MARATHON PGM-Cu PROJECT**

**SUPPORTING INFORMATION
DOCUMENT No. 15 -
IMPACT ASSESSMENT -
HYDROGEOLOGY -
MARATHON PGM-Cu PROJECT**

**Prepared by:
TRUE GRIT CONSULTING LTD.
1127 Barton Street
Thunder Bay, ON
P7B 5N3**





Stillwater Canada Inc.
Impact Assessment - Hydrogeology
Marathon Cu-PGM Project

Prepared by:

True Grit Consulting Ltd.

1127 Barton Street

Thunder Bay, ON P7B 5N3

T: 807.626.5640 Ext. 225

F: 807.623.5690

Project Number: 11-317-12

Contact: Leif Nelson, M.Sc., P.Geo.

July 5, 2012

Executive Summary

True Grit Consulting Ltd. (TGCL) was retained by Stillwater Canada Inc. (SCI) to complete a groundwater impact assessment of their proposed mine site located north of the Town of Marathon, Ontario. The purpose of the work is to assess the effects of the proposed mine and associated infrastructure on groundwater levels, flows and discharge at and around the site in support of the overall Environmental Assessment (EA) process under the Canadian Environmental Assessment Act (CEA Act).

Transient numerical groundwater modelling of the potential effects of mine infrastructure on groundwater levels, flow and discharge were carried out for the proposed Stillwater Marathon PGM-Cu project. The transient model consists of two sequential model runs representing the operational and closure periods of the mine and builds upon steady state modelling of baseline conditions previously reported.

The portion of the model that represents the eleven year operational life of the mine was primarily utilized to analyze the effects of the open pits, mine rock storage area (MRSA) and process solids management facility (PSMF) on groundwater levels with some analysis of the effects of those altered groundwater levels on groundwater flow. The progression of the open pits over the life of the mine will result in a drawdown of groundwater levels in the areas surrounding the pits however, due to the low hydraulic conductivity of the bedrock and steep topography of the area, the drawdown is not expected to extend beyond the local watershed and the flow in the Pic River will not be measurably affected.

The portion of the model that represents the closure period was primarily utilized to analyze groundwater flow pathways and discharge rates from beneath the MRSA and PSMF. The conceptual model for the site, which is based on field observations and other groundwater studies in the area and supported by the modelling completed for this project, predicts that water recharging the groundwater flow systems beneath the MRSA and PSMF will discharge to nearby surface water bodies. As a result, the primary water chemistry concern is surface water chemistry and the primary groundwater water chemistry concern is the chemistry of the groundwater discharging to surface water. A particle tracking application was applied to the groundwater flow model results to determine the flow paths of groundwater originating beneath the MRSA and PSMF. Based on the particle tracking results a water balance application was applied to calculate the discharge of groundwater from beneath both the MRSA and PSMF to individual watersheds.

Groundwater discharging from beneath the MRSA is predicted to either flow towards the main pit or the Pic River and its tributaries with the majority of the tracked particles ending up in surface water bodies. A sensitivity analysis was conducted where recharge was varied and the discharge rates are sensitive to recharge. However, the presence of the MRSA is not expected to increase recharge so the range of recharge values evaluated is expected to be representative.

Groundwater discharging from beneath the PSMF either flows north to the Stream 5 watershed which includes Hare Lake and eventually discharges to Lake Superior, west to the Stream 6 watershed which flows to Lake Superior or east to the Stream 1 watershed which flows to the Pic River. Sensitivity analyses that consisted of simulating grouting beneath the PSMF dams and assuming a uniform hydraulic conductivity in the top model layer across the site both showed substantial decreases in discharge to the Stream 1 and Streams 6 watersheds while the discharge to the Stream 5 watershed decreased for the grouting scenario and stayed the same for the uniform hydraulic conductivity scenario.

A spreadsheet based model was utilized in conjunction with data on volumetric pit refilling rates (precipitation, surface water and groundwater) and proposed pit topography to estimate the amount of time it will take to refill the open pits. The pits are predicted to fill 40 years after the completion of active pit dewatering.

Table of Contents

1.0	Introduction	1
1.1	Project Location	Error! Bookmark not defined.
1.2	Surrounding Land Uses	Error! Bookmark not defined.
1.3	Exploration History of the Site.....	Error! Bookmark not defined.
1.4	Project Overview	Error! Bookmark not defined.
2.0	Site Setting	8
2.1	Regional Setting.....	8
2.2	Site Investigations	8
2.3	Baseline Modelling.....	9
3.0	Methods	10
3.1	Open Pit Progression.....	10
3.2	Mine Rock Storage Area.....	11
3.3	Process Solids Management Facility	12
3.4	Pit Refilling	13
4.0	Results and Discussion.....	15
4.1	Change to Groundwater Heads and Flows.....	15
4.1.1	Open pits and Mine Rock Storage Area	15
4.1.2	Process Solids Management Facility.....	18
4.2	Particle Tracking	18
4.2.1	Mine Rock Storage Area.....	19
4.2.2	Process Solids Management Facility.....	19
4.3	Groundwater Discharge	20
4.3.1	Mine Rock Storage Area.....	20
4.3.2	Process Solids Management Facility.....	21
4.4	Groundwater Chemistry	22
4.5	Pit Refilling	22
4.5.1	Discussion.....	22
4.5.2	Summary.....	23
5.0	Groundwater Monitoring.....	24
5.1	Monitoring Wells.....	24
5.2	Annual Monitoring	24

6.0	Mitigation Strategies	26
7.0	Conclusions	27
8.0	Closure	28
9.0	References	29

Tables within Text

Table A:	Pit Inflows for Pit Refilling
Table B:	Groundwater Discharge to Pits
Table C:	Groundwater Discharge from the MRSA
Table D:	Sensitivity Analysis of Groundwater Discharge from the MRSA
Table E:	Groundwater Discharge from the PSMF
Table F:	Sensitivity Analysis of Groundwater Discharge from the PSMF
Table G:	Proposed Annual Monitoring Program Groups

Figure within Text

Figure A:	Location of the Proposed Marathon PGM-Cu Project Site near Marathon, Ontario
Figure B:	Existing Conditions at the Marathon PGM-Cu Project Site
Figure C:	Marathon PGM-Cu Project General Site Layout
Figure D:	Groundwater Discharge to Pits over Time
Figure E:	Water Elevation in Pits over Time

Figures

Figure 1:	Site Layout, Site Features and Monitoring Well Locations
Figure 2:	Modelled Steady State Groundwater Heads
Figure 3:	Distribution of Particles within MRSA and PSMF
Figure 4:	Particle Flow Paths
Figure 5:	Areas Contributing Groundwater Discharge
Figure 6:	Location of MRSA, PSMF, PSMF Dams and Open Pits in Model Domain
Figure 7:	Location of Higher Hydraulic Conductivity Zone and Length of Pic River Downgradient of MRSA in Model Domain
Figure 8:	Modelled Groundwater Heads at End of Mining
Figure 9:	Modelled Groundwater Heads after 100 Years of Closure
Figure 10:	Comparison of Modelled Groundwater Heads – Steady State and 100 Years of Closure
Figure 11:	Total Change in Modelled Groundwater Heads at End of Mining
Figure 12:	Cross Section at Model Row 70
Figure 13:	Comparison of Modelled Groundwater Heads – Steady State and 100 Years of Closure (Recharge of 79 mm/year at MRSA)
Figure 14:	Comparison of Modelled Groundwater Heads – Steady State and 100 Years of Closure (Recharge of 40 mm/year at MRSA)
Figure 15:	Comparison of Modelled Groundwater Heads – Steady State and 100 Years of Closure (Simulation of Impact of Grouting beneath PSMF Dams)
Figure 16:	Comparison of Modelled Groundwater Heads – Steady State and 100 Years of Closure (Simulation of a Uniform Hydraulic Conductivity in Model Layer 1)

- Figure 17: Sensitivity Analysis: Increased Recharge beneath the MRSA
Figure 18: Sensitivity Analysis: Decreased Recharge beneath the MRSA)
Figure 19: Sensitivity Analysis: Grouting Beneath PSMF Dams
Figure 20: Sensitivity Analysis: Uniform Hydraulic Conductivity
Figure 21: Proposed Monitoring Well Locations

Appendices

Appendix A: Change in Modelled Groundwater Heads over Life of Mine

1.0 Introduction

Stillwater Canada Inc. (SCI) proposes to develop a platinum group metals (PGMs), copper (Cu) and possibly iron (Fe) open-pit mine and milling operation near Marathon, Ontario. A Notice of Commencement (NoC) of an environmental assessment (EA) in relation to the proposed Marathon PGM-Cu Project (the “Project”) was filed by the Canadian Environmental Assessment Agency (CEA Agency) under Section 5 of the Canadian Environmental Assessment Act on April 29, 2010 (updated July 19, 2010).

The EA was referred to an independent Review Panel by the Minister of the Environment on October 7, 2010. On March 23, 2011 SCI entered into a Voluntary Agreement (VA) with the Province of Ontario to have the Project subject to the Ontario Environmental Assessment Act (OEA Act). This agreement was the instrument that permitted provincial government to issue a Harmonization Order (HO) under Section 18(2) of the Canada-Ontario Agreement on Environmental Assessment Cooperation to Establish a Joint Review Panel for the Project between the Minister of the Environment, Canada and the Minister of the Environment, Ontario.

The HO was issued on March 25, 2011. The Terms of Reference (ToR) for the Project Environmental Impact Statement (EIS) and the agreement establishing the Joint Review Panel (JRP) were issued on August 8, 2011.

The following provides an overview of the proposed development including its location, surrounding land uses, the exploration history of the site and the primary features of the mining and milling facilities. The information provided below, in the Environmental Impact Statement Report and supporting technical studies is based on the conceptual mine design for the Project. The conceptual design provides planning level information for the environmental assessment process. Detailed design will commence following EA approval in concordance with the concepts presented herein.

1.1 Project Location

The Project is located approximately 10 km north of the Town of Marathon, Ontario (Figure A). The town, with a population of 3,353 (2011 Census), is situated adjacent to the Trans-Canada Highway 17 (Hwy 17) on the northeast shore of Lake Superior, about 300 km east and 400 km northwest (by highway) of Thunder Bay and Sault Ste. Marie, respectively.

The centre of the Project footprint sits at approximately 48° 47' N latitude and 86° 19' W longitude. The Project site is in an area characterized by relatively dense vegetation, comprised largely of a birch and, to a lesser extent, spruce-dominated mixed wood forest. The terrain is moderate to steep, with frequent bedrock outcrops and prominent east to west oriented valleys. The climate of this area is typical of northern areas within the Canadian Shield, with long winters and short, warm summers.



Figure A: Location of the Proposed Marathon PGM-Cu Project Site near Marathon, Ontario

1.2 Surrounding Land Uses

The Project site lies partially within the municipal boundaries of the Town of Marathon, as well as partially within the unorganized townships of Pic, O'Neil and McCoy. The primary zoning designation within the Project Site is 'rural'.

In the immediate vicinity of the Project there are several authorized aggregate sites, including SCI's licensed aggregate site located to the northeast of Hwy 17 along the existing site access road (Camp 19 Road).

The Marathon Municipal Airport (CYSP), which operates as a Registered Airport (Aerodrome class) under the Canadian Aviation Regulations (CARs; Subsection 302), is adjacent to, and south of the Project site. The airport occupies a land area of approximately 219 hectares and is accessed from Hwy 17.

Several First Nations and Métis peoples claim the Project site as falling within their traditional land use boundaries. Based on Aboriginal accounts, prior to the construction of the forestry road, the land and water uses associated with (or close to) the site would have typically been limited to the Pic River corridor, the Bamooos Lake-Hare Lake-Lake Superior corridor and the Lake Superior shoreline and near-shore area, rather than the interior of the Project site. Traditional land and water uses (or rights conferred by Treaty) that can be ascribed to the site could include:

- Hunting;
- Trapping;
- Fishing; and,
- Plant harvesting for food, cultural and medicinal uses.

Primary industries supporting the Town of Marathon, as well as the region, have historically been forestry, pulp and paper, mining and tourism. The Project site is located within the Big Pic Forest Management Area. The Big Pic Forest includes Crown land east and north of Lake Superior and is generally north, south and west of the community of Manitouwadge and includes the communities of Marathon, Caramat and Hillsport.

Until July 2010 the forest was managed under the authority of a Sustainable Forest License (SFL), which was held by Marathon Pulp Inc. This SFL was revoked, with the forest reverting to the Crown as a Crown Forest. Until recently, Marathon Pulp Inc. (MPI) operated a kraft pulp mill in Marathon on the shore of Peninsula Harbour. The mill announced its indefinite shut down (effective at the end of February 2009) on February 11, 2009, and as a result there has been a significant downturn in the local economy. A second mill operated in Terrace Bay was temporarily closed in December 2011.

The Hemlo Mining Camp is located 30 km to the southeast. There are currently two mines in production at the Camp (David Bell Mine, Williams Mine), which are estimated to be in operations until 2025.

1.3 Exploration History of the Site

Exploration for copper and nickel deposits on the Project site started in the 1920s and continued until the 1940s with the discovery of titaniferous magnetite and disseminated chalcopyrite occurrences. During the past four decades, the site has undergone several phases of exploration and economic evaluation, including geophysical surveys, prospecting, trenching, diamond drill programs, geological studies, resource estimates, metallurgical studies, mining studies, and economic analyses. These studies have successively enhanced the knowledge base of the deposit.

In 1963, Anaconda acquired the Marathon property and carried out systematic exploration work including diamond drilling of 36,531 m in 173 drill holes. This culminated in the discovery of a large copper-PGM deposit. Anaconda discontinued further work on the project in the early 1980s due to low metal prices at the time.

In 1985, Fleck purchased a 100% interest in the Marathon PGM-Cu Project with the objective of improving the project economics by focusing on the platinum group element (PGE) values of the deposit. The Fleck drilling totaled 3,615 m in 37 diamond drill holes. In 1986, H.A. Symons carried out a feasibility study for Fleck based on a 9,000 tonnes per day conventional flotation plant with marketing of copper concentrate and Kilborn Limited carried out a prefeasibility review for Fleck that included preliminary results from the Lakefield pilot plant tests (Kilborn Limited, 1987). The feasibility study indicated a low internal rate of return which was confirmed by Teck Corporation who concluded the project was

uneconomic due to low metal prices at the time. On June 10, 1998, Fleck changed its name to PolyMet Mining Corp.

In 2000, Geomaque acquired certain rights to the Marathon PGM-Cu Project through an option agreement with Polymet. Geomaque and its consultants carried out a study of the economic potential of the Marathon PGM-Cu Project. The study included a review of the geology and drill hole database, interpretation of the mineralized zones, statistics and geostatistics, computerized block model, resource estimation, open pit design and optimization, metallurgy, process design, environmental aspects, capital and operating cost.

Marathon PGM Corp. acquired the Marathon PGM-Cu deposit from Polymet in December 2003. Marathon PGM Corp. funded programs of advanced exploration and diamond drilling on a continuous basis between June 2004 and 2009. Approximately 320 holes and 65,000 m were drilled from 2007 to 2009 to define and expand the resource and for condemnation holes outside of the pit area. A feasibility study was published in 2008 and updated in January 2010.

Stillwater Mining Company (SWC) and Marathon PGM entered into an agreement on September 7, 2010 pursuant to which SWC would acquire all of the outstanding shares of Marathon PGM. The acquisition agreement received ministerial approval under the Investment Canada Act on November 24, 2010 and the agreement closed on November 30, 2010. On December 31, 2010 Stillwater Mining Company formed a Canadian corporation, Stillwater Canada Inc. In March 2012, MC MINING LTD (MC) purchased 25% interest in Stillwater Canada Inc. who is the proponent of the Marathon PGM-Cu Project.

1.4 Project Overview

The Project is based on the development of an open pit mining and milling operation. The conceptual general layout of the components of the mine site, the transmission line corridor and access road is provided in Figure C below. One primary pit and a satellite pit complex to the south (currently envisaged to be comprised of four satellite pits) are proposed to be mined. Ore will be processed (crushed, ground, concentrated) at an on-site processing facility. Final concentrates containing copper and platinum group metals will be transported off-site via road and/or rail to a smelter and refinery for subsequent metal extraction and separation. The total mineral reserve (proven and probable) is estimated to be approximately 91.5 million tonnes. It is possible that an iron concentrate may also be produced, depending upon the results of further metallurgical testing and market conditions at that time.

During the operations phase of the Project, ore will be fed to the mill at an average rate of approximately 22,000 tonnes per day. The operating life of the mine is estimated to be approximately 11.5 years. The construction workforce will average approximately 400 people and will be required for between 18 and 24 months. During operations the work force will comprise an estimated 365 workers. The mine workforce will reside in local and surrounding communities, as well as in an Accommodations Complex that will be constructed in the Town of Marathon.

Approximately 288 million tonnes of mine rock¹ will be excavated. It is estimated that between eighty five to ninety percent of this material is non-acid generating (NAG) and will be permanently stored in a purposefully built Mine Rock Storage Area (MRSA) located east of the primary pit. The NAG or so-called Type 1 mine rock will also be used in the construction of access roads, dams and other site infrastructure as needed. Drainage from the MRSA will be collected, stored, treated and discharged as necessary to the Pic River. During mine operations, about 20 million tonnes of mine rock could have the potential to generate acid if left exposed for extended periods of time. This mine rock is referred to as Type 2 mine rock or potentially acid generating (PAG). The Type 2 mine rock will be managed on surface during mine

¹ Mine rock is rock that has been excavated from active mining areas but does not have sufficient ore grades to process for mineral extraction.

operations in temporary stock piles with drainage directed into the open pits. This material will be relocated to the bottom of the primary and satellite pits and covered with water to prevent potential acid generation and covered with Type 1 materials.

Process solids² will be managed in the Process Solids Management Facility (PSMF), as well as in the satellite pit complex. The PSMF will be designed to hold approximately 61 million m³ of material, and its creation will require the construction of dams. Two streams of process solids will be generated. An estimated 85 to 90% of the total amount of process solids produced will be non-acid generating, or so-called Type 1 process solids. The remaining ten to fifteen percent of the process solids could be potentially acid generating and referred to as Type 2 process solids. The Type 2 process solids will be stored below the water table in the PSMF or below water in the pits to mitigate potential acid generation and covered with Type 1 materials. Water collected within the PSMF, as well as water collected around the mine site other than from the MRSA will be managed in the PSMF for eventual reclamation in the milling process. Excess water not needed in the mill will be discharged, following treatment as is necessary, to Hare Lake.

Access to the Project site is currently provided by the Camp 19 Road, opposite Peninsula Road at Hwy 17. The existing road runs east towards the Pic River before turning north along the river to the Project site (approximately 8 km). The existing road will be upgraded and utilized from its junction with Hwy 17 for approximately 2.0 km. At this point a new road running north will be constructed to the future plant site. The primary rationale for developing the new road is to move traffic away from the Pic River. The new section of road will link two sections of forest access roads located on the site.

Power to the Project site will be provided via a new 115 kV transmission line that will be constructed from a junction point on the Terrace Bay-Manitouwadge transmission line (M2W Line) located to the northwest of the primary pit. The new transmission line will run approximately 4.1 km to a substation at the mill site. The width of the transmission corridor will be approximately 30 m.

Disturbed areas of the Project footprint will be reclaimed in a progressive manner during all Project phases. Natural drainage patterns will be restored as much as possible. The ultimate goal of mine decommissioning will be to reclaim land within the Project footprint to permit future use by resident biota and as determined through consultation with the public, Aboriginal peoples and government. A certified Closure Plan for the Project will be prepared as required by Ontario Regulation (O.Reg.) 240/00 as amended by O.Reg.194/06 "Mine Development and Closure under Part VII of the Mining Act" and "Mine Rehabilitation Code of Ontario".

Maps showing the existing features and topography of the site, as well as the proposed conceptual development of the site are provided in Figure B and C below.

² Process solids are solids generated during the ore milling process following extraction of the ore (minerals) from the host material.

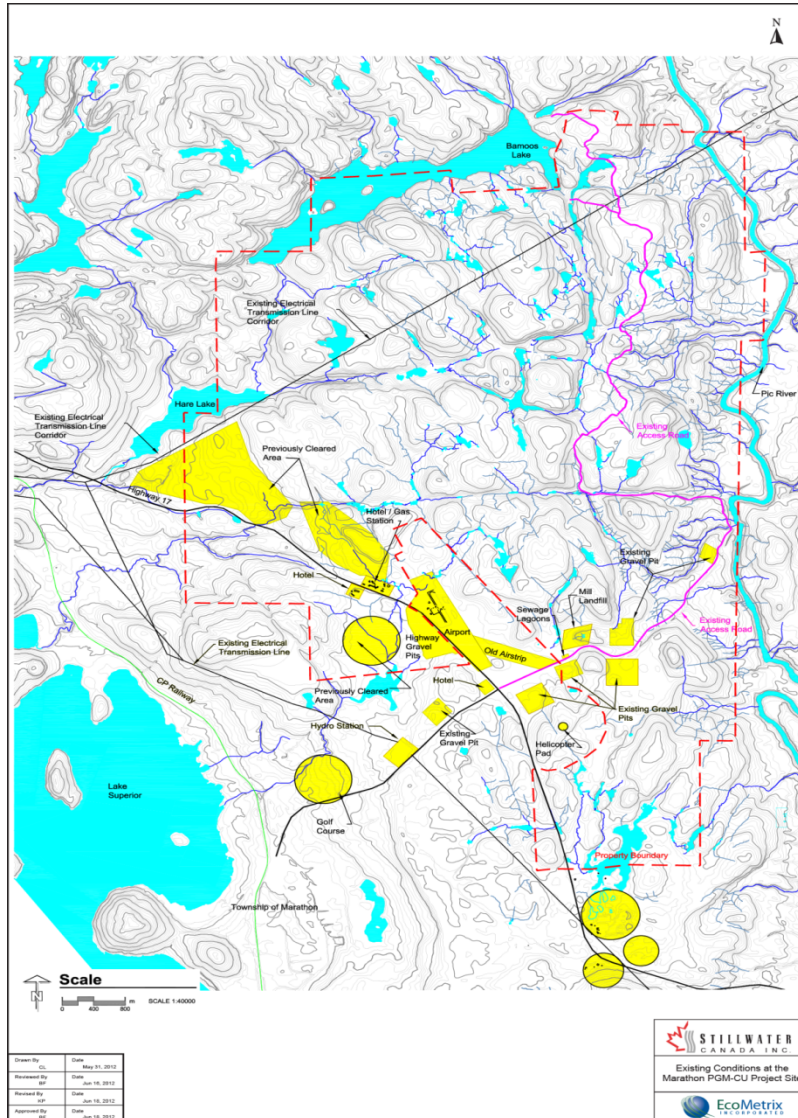


Figure B: Existing Conditions at the Marathon PGM-Cu Project Site

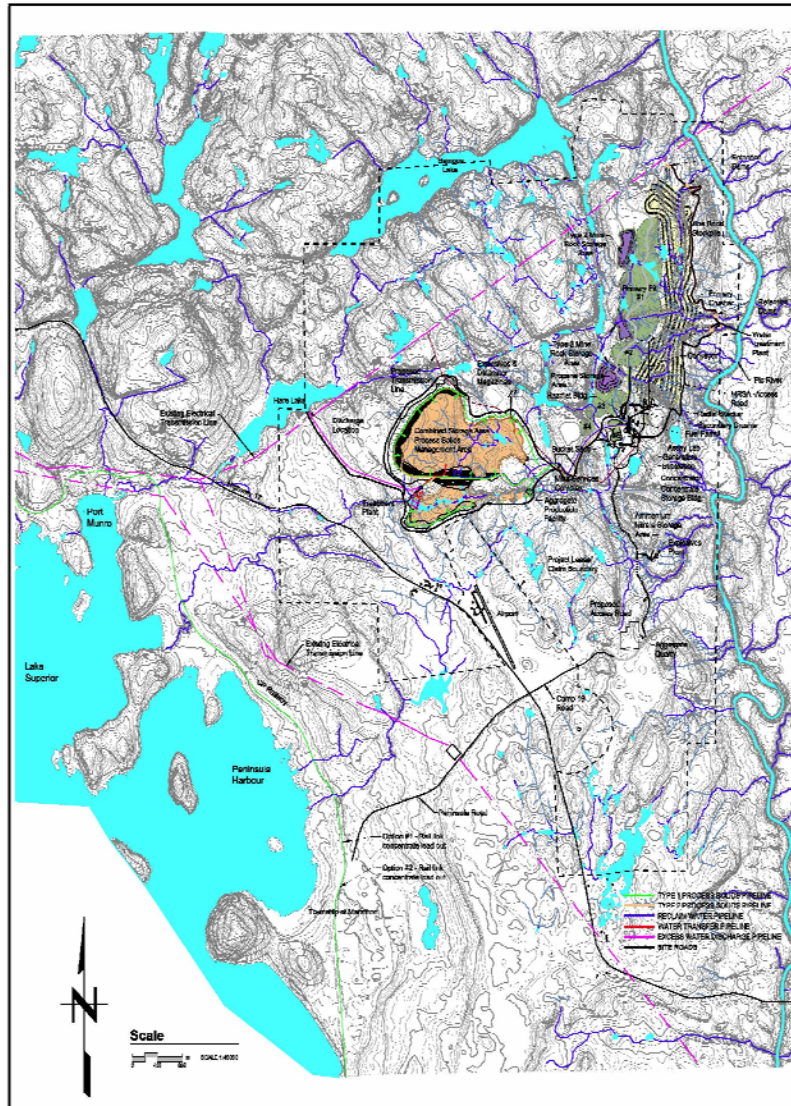


Figure C: Marathon PGM-Cu Project Conceptual General Site Layout

2.0 Site Setting

2.1 Regional Setting

The regional physiography of the area is strongly influenced by the massive and rugged bedrock hills which dominate the landscape through the area and the glacial activity that occurred during the Wisconsin Stage of the Pleistocene Epoch. Relief in excess of 150 metres (m) is common and the slopes of the sides of hills and valleys are complex and steep. Drainage is generally good, with localized areas of poor drainage.

Higher elevations consist almost entirely of rugged bedrock with a thin veneer of ground moraine. Within the valleys, in particular the Pic River valley, thick sequences of glaciolacustrine silt and clay have been deposited. These deposits were formed as the ice margin retreated northward and the ancestral Lake Superior inundated the valleys.

A significant feature of the site's bedrock geology that strongly influences the surficial drainage and likely influences the hydrogeology is the presence of an extensive network of radial and concentric lineaments that are clearly visible on air photos and topographic maps of the area. One of these lineaments contains the proposed location of cell #1 of the PSMF. The highest measured in situ hydraulic conductivity values are from wells in this area.

The surficial geology can be generally subdivided into two areas based primarily on elevation. Below an elevation of approximately 320 m, thick deposits of massive to varved glaciolacustrine silts and clays are present within the numerous valleys. These deposits were formed by deep water deposition when the surface of the ancestral Lake Superior was much higher than it is today. As the lake level receded, shallow water deposits of silty sand and fine sand formed. In general, the low permeability of these fine grained deposits will inhibit the movement of groundwater.

Above an elevation of approximately 320 m, the geology is dominated by the rugged bedrock topography. A thin veneer of ground moraine is generally present, as are localized areas of organics where drainage is poor, and/or thick accumulations of fine sediments in the deeper ravines and valleys. The ground moraine generally consists of silty sand till with abundant gravel, cobbles and boulders. As the ground moraine is thin, groundwater flow will be controlled by the underlying bedrock topography and the surface water drainage courses. Some groundwater flow into the underlying bedrock may occur where the bedrock is fractured and/or pervious structures are present.

The hydrology of the study area can be subdivided into three drainage areas. The majority of the study area drains east via a series of small creeks to the Pic River. This area includes the open pits, plant site, mine rock storage area (MRSA) and a small portion of cell #1 of the Process Solids Management Facility (PSMF). The northwest portion of the study area, including cell #2 of the PSMF, drains west to Hare Lake. The southwest portion of the study area including most of cell #1 of the PSMF drains southwest towards Lake Superior via two small streams. All drainage ultimately discharges to Lake Superior.

2.2 Site Investigations

Extensive hydrogeological investigations, monitoring and sampling have been undertaken at the Project site between 2007 and 2011 to characterize baseline conditions. The hydrostratigraphy of the site has been investigated through borehole drilling, drill core observation, grain size analysis and in situ hydraulic conductivity testing. Evaluation of this data and experience with sites in similar environments allowed the construction of a conceptual model of groundwater flow at the site. In this model groundwater flow is recharged at higher elevations and discharged at lower elevations generally within local sub-watersheds.

Active groundwater flow is concentrated in the shallow subsurface, in the overburden and upper (40 to 60 m) of fractured and weathered bedrock. The overburden is generally relatively shallow, less than 20 m, with the notable exception of the Pic River Valley where low hydraulic conductivity silt and clay extend beyond 20 m, the maximum depth investigated in the area.

A total of 36 monitoring wells have been installed at the Project site between 2008 and 2011 and they have been monitored for groundwater water elevations and sampled for chemical analysis on a regular basis. Groundwater quality is similar to that encountered at sites across northern Ontario with consistent exceedances of the Ontario Drinking Water Standards for parameters such as hardness, iron and manganese. At monitoring wells that have been sampled over several years trends in water quality are not apparent but there is natural variation in the concentrations of several parameters such as iron.

2.3 Baseline Modelling

The data collected during hydrogeologic investigations was also used to construct and calibrate a numerical groundwater flow model in MODFLOW (McDonald and Harbaugh, 1983) of the site to further understand hydrogeologic conditions at the Project site and provide a baseline for modelling the effects of site development on groundwater. The model was able to achieve a good calibration despite the size and topographic complexity of the site. The model validates the conceptual model developed for the site and provides a baseline for predictive modelling.

3.0 Methods

The progression of the open pits over time and the effect they have on groundwater levels, flow patterns and discharge rates in their vicinity were modelled in Visual MODFLOW using the MODFLOW-NWT formulation (Niswonger and Ibaraki, 2011) of MODFLOW. The NWT formulation was used because it is better able to handle large water table fluctuations and the drying and rewetting of model cells, both of which may occur in the vicinity of the modelled open pits. Previous modelling has been completed using earlier versions of MODFLOW and the results of that modelling have been provided to Stillwater and other members of the project team. We believe that the results of the modelling employing NWT are more representative than the results of earlier modelling and as a result this report will focus on the results of the NWT model. However, since the results of earlier models have been provided to others and may have been relied upon, those results are presented here as well.

The calibrated MODFLOW model of the site previously developed (TGCL, 2011) was used as the steady state baseline for pre-development groundwater elevations across the site (Figure 2).

Conceptual models of groundwater flow in the Canadian Shield of northern Ontario (Sykes and others, 2009), horizontal hydraulic gradients between groundwater and surface water at this site (TGCL, 2011), and geochemical characterization of groundwater at this site (TGCL, 2011) all indicate that groundwater flow systems at this site are short. Groundwater is recharged at higher elevations and discharges at nearby surface water bodies or low lands without developing extensive flow systems in the subsurface. As a result the primary concern related to groundwater at this site is the loadings of solutes that groundwater transports to nearby surface water bodies.

In order to estimate the discharge of groundwater originating at the MRSA or PSMF to the different water bodies downgradient of them, the particle tracking application MODPATH (Pollock, 1994) was used in conjunction with the water budget application ZoneBudget (Harbaugh, 1990) and the results of the MODFLOW simulations. First, particles were added within the outlines of the MRSA and PSMF and tracked forward in time for 100 years (Figure 14). Based on the pathlines produced by MODPATH (Figure 15) the areas within the MRSA and PSMF that contributed water towards the different water bodies were determined (Figure 16). The rate of groundwater exiting from each of these zones (in m³/day) was determined using ZoneBudget. This method conservatively assumes that all of the groundwater exiting each zone reaches the downgradient water body.

3.1 Open Pit Progression

The steady state model was modified to simulate the pits after three years of mining by changing the boundary between layers 1 and 2 to 272 m above sea level (ASL) within the boundaries of the main pit. In order for the boundary between layers 1 and 2 to be beneath the top of the model domain in all cells within the main pit the elevation of 272 m ASL was chosen which is lower than the elevation that the mine is expected to reach in the first three years (288 m ASL).

Within the boundaries of the satellite pits, the boundary between layers 1 and 2 was set at the approximate total depth of each pit. The pit boundaries and depths are conservatively based on the conceptual design of the mine at the time that the model was constructed and is subject to change as more detailed design of the mine is completed. It has been conservatively assumed that the satellite pits will be completely mined in the first three years.

Following adjustment of the boundary between the top two layers, model cells in layer 1 within the pit boundaries were then classified as inactive in the model (Figure 3). This resulted in the elimination of the drain cells representing streams in the area of the pit; in addition, all streams (represented as drain cells

in the model) within two cells of the pit were eliminated. The cells surrounding the newly inactive cells, which represent the walls of the mine pit, were then designated as drain cells by assigning the drain boundary condition to each. These wall cells were modelled as vertical seepage faces (wall drains) with the drain elevation set as the bottom of the cell and the conductance of the cell (m^2/day) defined as:

$$DY \times DZ \times KX \times 86,400 \times 5 \div DX$$

Where: DY is the length of the cell in the Y (horizontal) direction (m)

DZ is the length of the cell in the Z (vertical) direction (m)

KX is the hydraulic conductivity in the X (horizontal) direction (m/s)

DX is the length of the cell in the X (horizontal) direction (m)

86400 converts m/s to m/day (s/day)

5 is a constant that accounts for the increased hydraulic conductivity of the rock at the edge of the pit

The cells in layer 2 directly beneath the newly inactive cells in layer 1, which represent the floor of the pit, were also designated as drain cells by assigning the drain boundary condition to each. These cells were modelled with the drain elevation as the top of the cell (floor drains) and a conductance of $5 m^2/day$.

Next the Zone Budget module (Harbaugh, 1990) was used to assign all of the drain cells surrounding and beneath the inactive pit cells to a common Zone Budget zone (ZB zone). This allows Zone Budget to calculate the volume of water entering the pit. The cells representing the open pits in layer 1 of the model are shown in Figure 2.

The model was then run as a transient simulation for three years with the heads from the steady state simulation as the initial heads.

To simulate the mine after six years, the boundary between layers 2 and 3 was set at the expected depth within the expected footprint (and one cell around the edge of the footprint) at that point in the mine's life. The cells within the expected six year footprint were designated as inactive (these cells were previously part of the pit floor). The cells in layer 2 surrounding the newly inactivated cells were switched from floor drains to wall drains and the cells in layer 3 directly beneath the newly inactivated cells in layer 2 were assigned as floor drains using the formulas provided above. The floor drains in layer 3 were added to the ZB zone. The model was then run for three years (years four through six) with the heads from the previous transient simulation (which ended after year 3) as the initial heads.

To simulate the mine after eleven years, the procedure that was used after six years was repeated using the appropriate footprint, depth and layers. The model was then run for five years (years six through eleven) with the heads from the previous transient simulation (which ended after year six) as the initial heads.

3.2 Mine Rock Storage Area

The model assumes that the mine rock storage area (MRSA) will be sufficiently permeable due to the large grain size typical of waste rock that groundwater recharge will not be affected during the operational phase of the mine and that during closure the presence of a vegetative cover will reduce recharge. However, a sensitivity analysis was completed where recharge was first maintained at 79 mm and then reduced to 40 mm during closure and the results are presented in this report as well.

In order to determine groundwater migration pathways in the vicinity of the MRSA the particle tracking application MODPATH was used in conjunction with MODFLOW. Particles were placed along the outline of the MRSA with a grid spacing of approximately 50 m; within the outline of the MRSA particles were placed in east-west lines (which are generally parallel to groundwater flow and therefore better define the groundwater flow divide). The east-west lines are approximately 200 m apart and there is approximately 100 m between particles in the line (Figure 14). Particles were individually placed at the top of their cell to represent groundwater recharge. The particles were tracked forward in time, beginning at the end of mine life and running for 100 years.

The particle tracks determined by the model (Figure 15) were used to determine the location of the groundwater divide beneath the MRSA. Based on the interpreted location of the groundwater divide, two ZoneBudget zones were created in the MRSA in the model (Figure 16) and the amount of groundwater exiting each zone was determined.

During the transient simulations that represent the closure period, the main pit was modelled using the river boundary condition with its elevation equal to the final water elevation in the main pit. The transient simulation was run with two time steps, 40 years which is the time it has been calculated that it will take to fill the main pit and 100 years. The conductance of the river boundary was set high to promote flow into the open pit.

3.3 Process Solids Management Facility

The presence of the PSMF was modelled by assigning a river boundary condition to layer 1 over the areas covered by the PSMF (Figure 3). Head elevations of 327 m ASL and 373 m ASL were assigned to cell #1 and cell #2 of the PSMF respectively; the elevations were obtained from Knight Piésold (2012). Since the hydraulic conductivity of the process solids has been estimated to be similar to or greater than the native bedrock and overburden (Knight Piésold, 2012) the conductance of the river boundary was calculated based on the vertical conductivity of the cell in the top layer of the model. The depth of the river was set to the depth of the process solids at that location or 5 m if the top of the cell exceeded 327 m ASL in cell #1 or 373 m ASL in cell #2.

In order to determine groundwater migration pathways in the vicinity of the PSMF the particle tracking application MODPATH was used in conjunction with MODFLOW. Particles were placed in a grid across both cells of the PSMF with 50 m separating each particle from its neighbour (Figure 14). Particles were individually placed at the top of their cell to represent groundwater recharge. The particles were tracked forward in time, beginning at the end of mine life and running for 100 years.

The particle tracks determined by the model (Figure 15) were used to determine the location of the groundwater divides beneath the PSMF. Based on the interpreted locations of the groundwater divides, three ZoneBudget zones were created within the PSMF in the model (Figure 16) and the amount of groundwater exiting each zone was determined.

In order to determine the effect of the higher hydraulic conductivity zone interpreted to be present in the model beneath portions of cell #1 of the PSMF (Figure 4), a version of the model that does not contain the higher conductivity zone was run (the uniform K scenario) as part of a sensitivity analysis. During the construction, testing and calibration of the steady state model (TGCL, 2011) a variation of the model was constructed that did not contain the higher hydraulic conductivity zone. The model that contained the higher hydraulic conductivity zone produced a better calibration, especially in the vicinity of the PSMF and therefore the model that did not contain the higher conductivity zone was not presented. However, that variation of the model can be utilized here as the calibrated steady state basis for a transient model that can be compared to the transient model that is the same in all respects except for the initial heads and the presence of the higher conductivity zone.

In addition, as part of the sensitivity analysis, a variation of the model where the proposed locations of dams around the PSMF were assigned a hydraulic conductivity of 1×10^{-8} m/s to represent grouting of the bedrock (the grouted dam scenario) was run to evaluate the impact of grouting.

3.4 Pit Refilling

Future water levels in the pits are calculated using a void filling approach similar to those presented in Shevenel (2000), Surrano (1997) and Younger and others (2002) where the volume of the pits are defined and a water balance is calculated.

To allow calculation of the surface area of the water in the pits at each elevation given a vertical spacing of 1 m, linear interpolation was used between contours marking the top and bottom of each bench to a 1 m scale. Auto CAD was used to do the interpolation and to calculate the surface area of the water in the pit at each contour for each pit.

Then the volume of each pit was calculated using the water surface areas in the pit at a 1 m interval determined by linear interpolation and the equation:

$$\text{Volume (m}^3\text{)} = [(a_1 + a_2) \div 2] \times h$$

Where: h is the contour interval (m)

a_1 is the area of lower contour (m^2)

a_2 is the area of upper contour (m^2)

Two scenarios have been considered; in the first, the five pits are considered to be hydraulically connected and therefore the volumes of each pit have been added together. In the second scenario the main pit is isolated and considered by itself and the other four pits are considered together and considered to be hydraulically connected to one another. The total volume of the pits was calculated by summing the volume of each contour interval from the bottom up. The contour elevation, surface area, volume and accumulated volume were tabulated to create a look up table.

The water balance of the pits is calculated on an annual basis and defined as:

$$\text{Runoff}_{\text{Pit}} + \text{Runoff}_{\text{Land}} - \text{Evaporation}_{\text{Pit}} + \text{Groundwater Inflow} = \text{Volume Increment}$$

Where: $\text{Runoff}_{\text{Pit}}$ is the additional volume of water landing on the water in the pit

$\text{Runoff}_{\text{Land}}$ is the volume of water landing on the watershed that enters the pit

$\text{Evaporation}_{\text{Pit}}$ is the volume of water evaporating from the water in the pit

Groundwater Inflow is the volume of groundwater inflow

Volume Increment is the volume of water that accumulated in the pit that year.

All units are in cubic metres per year.

$\text{Runoff}_{\text{Pit}}$ is calculated using the equation:

$$\text{Runoff}_{\text{Pit}} = \text{Annual Precipitation Rate (mm/year)} / 1000 * \text{Surface Area of Water in Pit (m}^2\text{)} * 0.4$$

The annual precipitation rate is 826.5 mm/year as presented in Calder (2012). The surface area of water in the pit is equal to that determined for the previous year. The surface runoff volume was determined for mine operation (i.e. no water accumulating in the pit) and is not varied in the model, so at all times in the model the entire watershed area (including the area of the water in the pit) is contributing runoff, which has been calculated as 60% of the precipitation (Calder, 2012). To avoid overestimating the amount of water in the areas of the model occupied by the water in the pit, the precipitation rate has been multiplied by 0.4.

Evaporation is calculated using the equation:

$$\text{Evaporation}_{\text{Pit}} = \text{Annual Evaporation Rate (mm/year)} / 1000 * \text{Surface Area of Water in the Pit (m}^2\text{)}$$

The annual evaporation rate is 488.2 mm/year, the potential evapotranspiration rate presented in Golder (2007). The surface area of water in the pit is equal to that determined for the previous year.

The groundwater inflow volume was determined as described in Section 3.1 for both scenarios and the inflow after 11 years was used (Section 4.1). The surface runoff volume was determined by Calder Engineering and is presented in Calder (2012).

Table A: Pit Inflows for Pit Refilling		
	Groundwater Inflow (m³/year)	Runoff_{Land} (m³/year)
Connected Pits	253,675	2,439,683
Main Pit – Isolated	121,910	937,309
Other Pits – Isolated	131,765	1,502,375
Source	Section 4.1	Calder, 2012

The accumulated volume of water in the pit was calculated each year by adding the current year's volume increment to the previous year's accumulated volume. The accumulated volume after each year is used to determine the water elevation using the look up table. Then the newly determined water elevation is used to determine the next year's water surface area.

The outlet of the pits as they are currently configured is at an elevation of 258 m ASL and is located along the eastern edge of the main pit. Once the water level reaches 258 m ASL the pit filling prediction model terminates.

4.0 Results and Discussion

4.1 Change to Groundwater Heads and Flows

Figures 5 and 6 present the modelled groundwater heads at the end of mining and 100 years of closure respectively. In addition, Figure 7 presents the pre-development and post closure (100 years of closure) groundwater heads on the same figure to allow easy comparison of groundwater heads before operations begin and well after mining has ceased.

In general, once mining begins groundwater heads will increase and remain elevated within and around the PSMF due to its presence and design which keep most of the process solids saturated beneath the water table which is the standard design of such facilities.

During operations, groundwater elevations around the open pits will decrease as groundwater discharges to the pits and a zone of depression is formed centred on the pits. Since the pits are within the Pic River watershed a small amount of groundwater will be diverted out of the watershed while the pits are dewatered. However, no long-term changes to the amount of groundwater discharging to the Pic River are anticipated. During closure, water will accumulate within the main pit once dewatering operations cease and groundwater levels in the surrounding rock will increase as the surface of the water in the pit rises. The elevation of the water in the pit is expected to stabilize at an elevation that will result in it receiving groundwater and as a result the water table in the vicinity of the main pit is expected to stabilize at an elevation lower than its pre-development elevation.

4.1.1 Open pits and Mine Rock Storage Area

Figure 8 presents the modelled change in groundwater heads from pre-development conditions to year 11 around the open pits and MRSA.

As anticipated, the drawdown zone in layer 1 increases in areal extent throughout the mine life but a significant amount of the drawdown occurs within the first three to six years which is the time when mining is progressing through the fractured upper bedrock (Figure 5 and Appendix A).

Drawdown occurs on all sides of the pits, and despite the small scale complexities, the edge of the drawdown (defined here as 1 m of drawdown) is broadly similar on all sides. As a result of the relatively low hydraulic conductivity of the bedrock and steep topography in the area the drawdown does not extend more than a few hundred metres from the edges of the pits.

The presence of the MRSA to the east of the pits affects groundwater levels and the distribution of the drawdown beneath it. The MRSA will cover several small stream beds that lie within its footprint and as a result the drain cells representing those streams were removed from the model. Within the model removing drains would usually correspond to increasing heads but the presence of the pit counteracts that increase and the result is less drawdown to the east of the pit than would otherwise occur. In some areas beneath the MRSA (e.g. the south end of the pile) an increase in head is predicted in the model which represents a small degree of groundwater mounding below the pile.

A series of cross-sections through row 70 of the model (see Figure 2 for the location of row 70) is presented in Figure 9 depicting the water table during pre development, end of mining and 100 years after the end of mining. Head contours are displayed that indicate that the water table is a subdued expression of the topography often intersecting the ground surface in low lying areas. The drawdown around the main pit is localized relative to the depth of the pit due to the topography and hydraulic conductivity of the rock.

Drawdown around pits 3, 4 and 5 appears to approach steady state by year 6 implying that discharge to the pits is matched by recharge over the capture zone. The edge of the drawdown does not reach the Pic River and therefore will not result in withdrawing water from the river. However, the mine pits will intercept some groundwater that would otherwise have discharged to the river. The Zone Budget application approximated this reduction as a maximum of 6.8 m³/day after 11 years of mining, which when compared to the average flow in the Pic River of approximately 4.4 x 10⁶ m³/day represents a reduction of about 0.0001%.

This model represents the subsurface as an equivalent porous medium (EPM) which means that when applied to fractured rock, as it is at this site, it averages out some properties such as porosity and hydraulic conductivity. One implication of this is that the actual distribution of the drawdown will not precisely match the model results; the model results are best viewed as averages. For example, a monitoring well installed in a section of un-fractured rock would show less drawdown than predicted while a monitoring well installed in fractured rock, especially if the fractures are connected to the pit, would show more drawdown. This is a result of the un-fractured rock having less porosity and lower hydraulic conductivity than the EPM, while the fractured rock will have more porosity and higher hydraulic conductivity as a result of the fracture(s). Nonetheless, the model is appropriate when applied at this scale and the conclusions from the model results remain valid.

The drawdown caused by pit dewatering will decrease or eliminate baseflow to creeks and streams in the vicinity of the pits. The approximate extent of the drawdown is shown on Figure 8. Some of these areas will also be affected by other mine related activities such as the creation of the MRSA.

Almost all of the modelled drawdown is contained within the Pic River watershed with the exception of a small area a few hundred metres west of pits 3 and 4 where small amounts of drawdown may extend into the Lake Superior watershed. Based on the conceptual model of the site where local flow systems controlled by topography dominate with recharged water discharging at adjacent low lying areas, groundwater divides will generally coincide with surface watershed divides and therefore the drawdown in groundwater levels will not measurably influence the water balance or groundwater flows in adjacent watersheds.

Inflows to the pits were calculated during the same modelling exercise through the Zone Budget application and presented in Table A below.

Table B: Groundwater Discharge to Pits	
Year	Discharge (m³/day)
3	1,330
6	1,237
11	1,322

In addition, each transient simulation was modelled with 3 month time steps and the more detailed results with results every 3 months are presented below in Figure D.

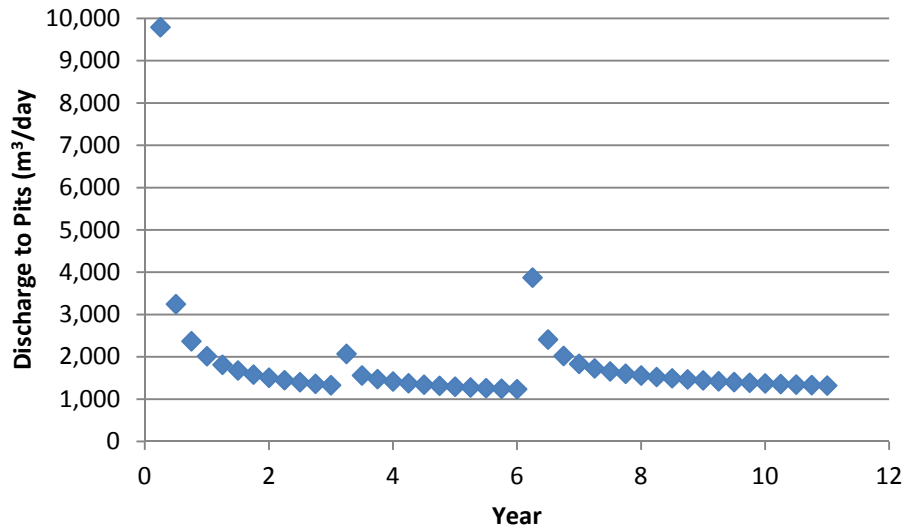


Figure D: Groundwater Discharge to Pits over Time

Figure D shows that in the first 3 months after the pit is enlarged in the model (years 0, 3, and 6) the discharge rate spikes upwards as a result of the water discharging to the newly created drain cells around and below the expanded pit. Discharge rates fall sharply after the spike and slowly decrease over time until the pit is enlarged again. This pattern of spikes and slow declines is an artifact of the way in which the model was created and the limitations of finite element models such as MODFLOW. Open pit mines expand in steps much smaller than those in the model so no spikes are anticipated and a more realistic pattern appears to be a fairly steady inflow of approximately 1,300 m³/day, once the mine has progressed below the water table.

When the model was rerun to 11 years with two ZoneBudget zones, one representing the main pit and the other representing the four satellite pits, the model predicted discharge rates of 625 and 697 m³/day respectively.

Previously a total groundwater discharge rate of 695 m³/day, including 334 m³/day to the main pit and 361 m³/day to the satellite pits, was reported to SCI and the project team. The updated values are considered to be more representative because of the improved formulation utilized in the modelling software.

The updated values do not represent a material change to expected dewatering rates because most of the water from the pits results from surface water runoff, not groundwater.

During closure the water level in the pits will rise after the dewatering system has been turned off. As a result the groundwater elevations adjacent to the pit will also rebound until the elevation of the water in the pit reaches its final elevation. The main pit will be a location of groundwater discharge, similar to other surface water bodies in the general area and consistent with the conceptual model of the site. Since the main pit is located in the Pic River watershed, the presence of the main pit is not anticipated to significantly alter regional groundwater flow or baseflow to the Pic River.

In the final year of the mine's life the plan is to fill satellite pits 2, 3 and 4 with process solids and mine rock (potentially acid generating material will be deposited below the water table and remain saturated). The model predicts heads above the modelled ground surface in the area of the satellite pits, indicating

that in this area the water table is predicted to return to its general predevelopment level near the ground surface and that streams will re-establish themselves (or will be reconstructed during closure).

4.1.1.1 Sensitivity Analysis

Varying the recharge beneath the MRSA does not have a significant effect on the groundwater heads around the MRSA (Figures 10 and 11) although in general increasing the recharge will increase heads and decreasing the recharge will result in lower heads in the ground beneath and adjacent to the MRSA.

4.1.2 Process Solids Management Facility

The presence of the PSMF will generally raise groundwater levels in its vicinity because of the elevated heads within the cells. However, the steep topography in which the PSMF is located will still play a strong role in constraining groundwater movement.

Knight Piesold (2012) conducted modelling of the seepage beneath the dams around the PSMF using the two dimensional model SEEP/W and estimated that the water would seep beneath the dams around cell #1 at a rate of 4.02 L/s (347 m³/day). Using the Zone Budget application it was determined that the MODFLOW model estimates that 417 m³/day will discharge from the cells beneath cell #1 of the PSMF to the cells beneath the dams around cell #1 of the PSMF. The relative percent difference between the two predictions is 18%, indicating good agreement between these two independent estimates.

As expected, the model predicts that groundwater levels will increase all around cell #1 and north and west of cell #2 (Figures 7 and 8) as a result of the presence of the PSMF. The only areas where significant increases (defined as changes greater than 10 m) are predicted by the model are west of cell #1 and southwest of cell #2.

4.1.2.1 Sensitivity Analysis

When the hydraulic conductivity of the cells in layer 1 beneath the PSMF dams is decreased to simulate the grouting of hydraulically active fractures in the upper bedrock, the model predicts that significant changes (greater than 10 m) will not occur outside the boundaries of the PSMF. Figure 12 presents the pre development and 100 year post mining groundwater head distributions at the site assuming that grouting is completed beneath the PSMF dams. When the higher hydraulic conductivity zone that passes beneath cell #1 is removed from the model and the cells assigned the same hydraulic conductivity as the rest of layer 1, the model predicts that no significant changes (greater than 10 m) will occur outside the boundaries of the PSMF. Figure 13 presents the pre development and 100 year post mining groundwater head distributions at the site when the hydraulic conductivity does not vary across the site in the upper layer of the model.

4.2 Particle Tracking

Particle tracking was utilized to determine groundwater flow paths from locations at the pre development ground surface within the MRSA and PSMF forward in time as water migrates through the subsurface. Each particle can be thought of as an individual water particle that can be tracked over time as it moves through the groundwater flow regime that has developed at either the MRSA or PSMF. In this way a visual representation of the movement of an individual particle can be displayed and when particles are placed across the area representing the MRSA and PSMF, a representation of all of the significant groundwater pathways beginning in these structures can be produced.

As further described in the sections to follow, the particle tracks correspond well to the conceptual model of groundwater flow previously developed for the site where groundwater discharges to surface water near where it entered the ground (in these cases the MRSA and PSMF).

4.2.1 Mine Rock Storage Area

Tracking the particles placed within the MRSA (Figure 14) shows that an east-west groundwater divide is expected to form beneath the mine rock with approximately half of the groundwater flowing in each direction. Almost all of the particles flowing west discharge to the main pit within the 100 year life of the model due to the pit's close proximity to the MRSA. A few particles originating in the southwest corner of the MRSA discharge to a drain boundary representing a stream south of the main pit and that stream is within the sub-watershed contributing water to the main pit during closure. Particles flowing west generally form longer pathways but end up discharging to the model's drain boundaries which represent the Pic River and its tributaries.

4.2.1.1 Sensitivity Analysis

Increasing the recharge beneath the MRSA by 19 mm to 79 mm does not visibly change the particle tracking results (Figure 17). The only location where some variation is noted is in the centre of the MRSA where the groundwater flow divide migrates east when recharge is increased. Similarly when recharge is decreased by 20 mm to 40 mm the flow divide migrates west (Figure 18).

With a few minor exceptions, varying the recharge beneath the MRSA does not visibly alter the particle tracks originating within the MRSA. As a result, the direction of groundwater movement is not significantly altered, it still migrates either towards the Pic River or the main pit (which eventually flows into the Pic).

4.2.2 Process Solids Management Facility

In general the particles placed near the edges of the PSMF are the most mobile and they migrate out from the PSMF; the particles in the interior remain fairly stationary or slowly migrate vertically. Particle movement from cell #1 of the PSMF only occurs towards the west and east. Higher elevations (i.e. hills) to the north and south and cell #2 to the north inhibit groundwater flow (and therefore the movement of particles) towards the north and south. At the west end of cell #1 groundwater migrates west from the cell and eventually discharges to the drain boundary representing Stream 6 within a few hundred metres of the edge of the PSMF. At the east end of cell #1 groundwater migrates east for a few hundred metres before discharging to a drain boundary representing a stream in the Stream 1 watershed directly east of the east end of the cell.

Particles migrate out from cell #2 of the PSMF in all directions and the particles that migrate generally discharge to drain boundaries representing streams or to cell #1. The majority of the particles placed within cell #2 do not migrate laterally but rather slowly migrate vertically from the location they were placed. The head within cell #2 remains constant at a specified elevation as a function of the boundary condition applied within cell #2 that represents a steady water table being maintained within the cell. Groundwater migrating out from the southern edge of cell #2 moves south and discharges to cell #1 which is at a lower elevation than cell #2 or the drain boundary that represents a stream west of cell #1. Portions of groundwater migrating out from the western most edge of cell #2 will eventually discharge into the both the Stream 5 and Stream 6 watersheds. Groundwater migrating out from the northwestern edge of cell #2 moves northwest or north before discharging to streams in the Streams 5 watershed. Portions of groundwater migrating out from the eastern edge of cell #2 generally migrate east, with some interpreted to eventually discharge in the Stream 5 watershed and the rest interpreted to discharge in the Stream 1 watershed.

4.2.2.1 Sensitivity Analysis

When the model is run with lower hydraulic conductivity values assigned to model cells in the top layer beneath the locations of proposed PSMF dams, particle tracks around both PSMF cells are modified (Figure 19). The particles placed at the eastern end of cell #1 no longer migrate east and fewer particles at the western end (only those placed near the bottom of the valley) migrate west. Changes to particles originating in cell #2 are less pronounced, in general fewer particles are migrating and the pathways are more direct from the cell to the drain boundaries.

When the zone of higher hydraulic conductivity in the top layer that extends beneath cell #1 is removed by decreasing hydraulic conductivity in the zone to the value used in the rest of the top layer, fewer particles migrate out from cell #1 (Figure 20). The reduction in the number of particles leaving cell #1 is most pronounced at the eastern end where particles do not migrate east from the cell but remain stationary. At the western end of the cell fewer particles migrate west and those that do take slightly different paths. The only locations where particle tracks originating in cell #2 are modified is where particles that originated at the southeast and southwest corners of the cell enter the model cells that formerly were assigned higher hydraulic conductivity.

4.3 Groundwater Discharge

4.3.1 Mine Rock Storage Area

Groundwater exiting the cells in the top layer of the model beneath the footprint of the MRSA either migrates horizontally into cells beside them and outside the footprint in layer 1 (this is considered to be shallow groundwater flow) or vertically into cells below them in layer 2 (considered to be deeper groundwater flow). According to the conceptual model for the site, the majority of the groundwater should enter the cells in layer 1 as opposed to the cells in layer 2 (i.e. stay within the shallow flow system). This is the case for groundwater discharging from the cells below the MRSA; 91% stays in layer 1 and 9% discharges to layer 2 based on the ZoneBudget analysis (Table C). Based on the visual observation of the particle tracks, it has been estimated that approximately half of the groundwater discharging from the MRSA will migrate towards the main pit and the other half will migrate towards the Pic River and its tributaries. The zone budget analysis predicts that 42% will migrate towards the main pit and 58% will migrate towards the Pic River and tributaries (Table C).

Table C: Groundwater Discharge from the MRSA		
	Towards Main Pit (m³/day)	Towards Pic River and tributaries (m³/day)
Horizontal (Layer 1)	136	185
Vertical (Layer 2)	14	19
Total	150	204

4.3.1.1 Sensitivity Analysis

Increasing the recharge to the model cells beneath the MRSA increases the discharge from those cells to the surrounding cells and therefore to the main pit and the Pic River and its tributaries as well (Table D).

Table D: Sensitivity Analysis of Groundwater Discharge from the MRSA

	Increased Recharge (79 mm)		Decreased Recharge (40 mm)	
	Towards Main Pit (m ³ /day)	Towards Pic River and tributaries (m ³ /day)	Towards Main Pit (m ³ /day)	Towards Pic River and tributaries (m ³ /day)
Horizontal (Layer 1)	180 (+32%)	224 (+21%)	92 (-33%)	145 (-22%)
Vertical (Layer 2)	16 (+18%)	23 (+18%)	11 (-20%)	16 (-20%)
Total	196 (+31%)	247 (+21%)	103 (-31%)	160 (-22%)

Note: percent change is based on precise model outputs

4.3.2 Process Solids Management Facility

Groundwater exiting the cells in the top layer of the model beneath the footprint of the PSMF either migrates horizontally into cells beside them and outside the footprint in layer 1 (shallow flow), vertically down into cells below them in layer 2 (deeper flow) or vertically up and is removed by the applied boundary condition. The volume discharging to the boundary is not presented or discussed in detail in this groundwater report. However, as a check on the overall validity of the net amount of water entering the top of the model within the footprint of the PSMF, the volume was calculated to be equivalent to 77 mm of recharge which is very similar to the recharge value to 79 mm applied across the rest of the site.

According to the conceptual model for the site, the majority of the groundwater should enter the cells in layer 1 as opposed to the cells in layer 2. This is the case for groundwater discharging from the cells below the PSMF; 96% stays in layer 1 and 4% moves into layer 2 based on the ZoneBudget analysis (Table E).

Table E: Groundwater Discharge from the PSMF

	Towards Stream 1 Watershed (m ³ /day)	Towards Stream 5 Watershed (m ³ /day)	Towards Stream 6 Watershed (m ³ /day)
Horizontal (Layer 1)	210	159	462
Vertical (Layer 2)	3	18	11
Total	213	177	473

4.3.2.1 Sensitivity Analysis

Decreasing the hydraulic conductivity of the model cells in layer 1 beneath the PSMF dams to simulate grouting of the hydraulically active fractures in the upper bedrock decreases the horizontal discharge towards all of the watersheds and increases the vertical discharge. However, the magnitude of the decrease in the horizontal discharge greatly exceeds the increase in vertical discharge resulting in a large net decrease. The magnitude of the decrease is greater for the Stream 1 and Stream 6 watersheds than for the Stream 5 watershed primarily because the preferential pathway for discharge to the Stream 1 and Stream 6 watersheds is the higher hydraulic conductivity zone at the bottom of the valley in which cell #1 of the PSMF sits and the relative decrease in hydraulic conductivity there is greater beneath the dams that intersect that zone than beneath the dams in the Stream 5 watershed.

A uniform hydraulic conductivity across layer 1 of the model results in decreased discharge towards the Stream 1 and Stream 6 watersheds and essentially no change to the discharge towards the Stream 5 watershed. The reduction in discharge is related to the reduction in hydraulic conductivity in the model

cells at the bottom of the valley in which cell #1 sits through which most of the discharge towards the Stream 1 and Stream 6 watersheds flows. Since discharge towards the Stream 5 watershed does not flow through any of the cells whose hydraulic conductivity was decreased there is essentially no change to the amount of discharge to the Stream 5 watershed.

Table F: Sensitivity Analysis of Groundwater Discharge from the PSMF

	Grouting Beneath Dams			Uniform Hydraulic Conductivity		
	Towards Stream 1 Watershed (m ³ /day)	Towards Stream 5 Watershed (m ³ /day)	Towards Stream 6 Watershed (m ³ /day)	Towards Stream 1 Watershed (m ³ /day)	Towards Stream 5 Watershed (m ³ /day)	Towards Stream 6 Watershed (m ³ /day)
Horizontal (Layer 1)	23 (-89%)	68 (-57%)	65 (-86%)	40 (-81%)	157 (-1%)	154 (-67%)
Vertical (Layer 2)	3 (+6%)	20 (+6%)	13 (+14%)	3 (-9%)	17 (-3%)	10 (-9%)
Total	26 (-88%)	88 (-50%)	78 (-84%)	43 (-80%)	175 (-1%)	164 (-65%)

Notes: percent change and totals are based on precise model outputs

4.4 Groundwater Chemistry

Groundwater chemistry downgradient of the MRSA and PSMF will be a function of background groundwater chemistry and the water chemistry within each structure. In general concentrations in downgradient groundwater are not expected to exceed source concentrations due to natural attenuation processes including dilution, dispersion, precipitation and sorption (e.g. Wilkin, 2007) and concentrations will decrease with distance from the structure. The distribution of groundwater whose chemistry has been affected by either the MRSA or PSMF can be approximated by the distribution of particle tracks (Figure 15) although dispersion is not accounted for in these tracks meaning that the potential extent of affected water chemistry will be somewhat greater.

As supported by the conceptual model for the site it has been determined that groundwater chemistry is not the primary concern here; the discharge of groundwater and solutes dissolved in groundwater to surface water bodies is the primary concern. As a result the discharge rates provided in this report for the watersheds in the area can be combined with the geochemical data being collected, analyzed and interpreted by others to calculate a conservative loading rate to the various streams and the Pic River in the vicinity of the MRSA and PSMF.

4.5 Pit Refilling

4.5.1 Discussion

The water level in the open pits is predicted to reach the outlet elevation of 258 m ASL 40 years after the cessation of active pit dewatering when all of the pits are modelled as hydraulically connected. When the main pit is considered by itself, the model predicts that it will require 99 years to fill because the majority of the rock removed will be from the main pit but the main pit only collects runoff and surface water flows from about half of the drainage area. When the four satellite pits are considered in isolation from the main pit but hydraulically connected between themselves, the model predicts that the satellite pits will fill in four years.

Results of the predictive pit filing model are shown on Figure E, below. As shown on Figure E, the rate of filling (in m/year) in the connected pits model decreases from approximately 56 m/year in the first year to approximately 3 m/year in years 30 through 40 as the water surface area increases.

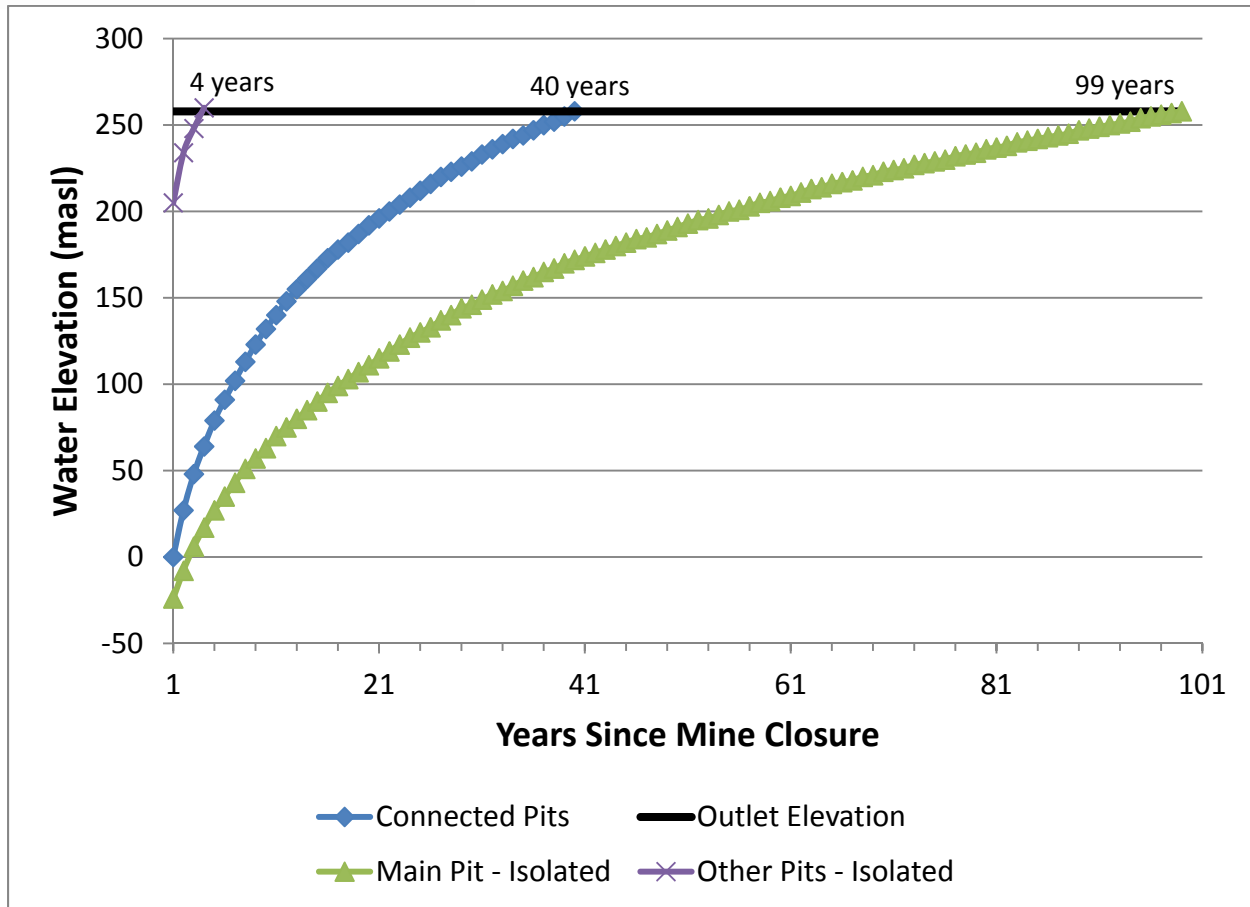


Figure E: Water Elevation in Pits over Time

The majority of the water refilling the pits will be surface water; for example at year 11 of mine life, 83% of the water entering the pit is expected to be surface water related and 17% groundwater related (Calder, 2012).

4.5.2 Summary

If not used for storage of process solids and mine rock, the pits will fill to their outlet at 258 m ASL in forty years (the satellite pits will have filled in approximately 4 years and the main pit would fill over the remaining 36 years). If, as currently planned, the pits (other than pit 5) are used for storage of process solids and mine rock, it will take less than 40 years for them to fill.

5.0 Groundwater Monitoring

Groundwater monitoring should continue at the site in the event that approval is received to progress with development of the mine. All of the existing monitoring wells should be included in the monitoring program and it is also recommended that additional monitoring wells be added to the program based on the results of the predictive modelling contained in this report.

5.1 Monitoring Wells

It is recommended that monitoring wells be installed at five additional locations (Figure 21). The locations are downgradient of the PSMF or MRSA and within predicted migration pathways; one location is between the MRSA and the Pic River (MW13-113) and four locations are downgradient of the PSMF (MW13-114, -115 -116 and -117). A single shallow well is recommended at MW13-113 and nested shallow and deep monitoring wells are recommended at the other four locations.

Additional wells may be required if this project proceeds to the permitting and approvals stage and would be located based on discussions between Stillwater's representatives and regulatory agencies such as the Ontario Ministry of the Environment.

Consideration should also be given to adding additional monitoring wells downgradient of other infrastructure that have not been sited at this time such as tank farms, septic systems, stockpiles and so on.

Some wells (BH08-1A/B, BH08-7A/B, BH09-9A and KP11-03A/B) are located in areas that are currently proposed to be mined or buried beneath process solids and will therefore eventually be removed from the monitoring program. However, they should be maintained as long as practical. Prior to their destruction, BH08-1A/B, BH09-9A and KP11-03A/B must be abandoned in accordance with Ontario Regulation 903 so that they do not act as preferential pathways for groundwater migration.

5.2 Annual Monitoring

For the purposes of an annual monitoring program, the monitoring wells should be divided into two groups. Wells directly downgradient of the PSMF, MRSA and other infrastructure should be placed in one group and monitored more frequently and the remaining wells should be monitored less frequently.

Wells in Group A are listed below in Table B and should be monitored and sampled three times per year for a list of field and analytical parameters consistent with the groundwater sampling done to date. Wells in Group B, should be monitored and sampled once per year for the same list of field and analytical parameters as Group A.

Table G: Proposed Annual Monitoring Program Groups			
Group A		Group B	
BH08-1A/B	MW11-103A	BH08-3A/B	MW11-104A/B
BH08-4	MW11-105B/C	BH08-5A/B	MW11-106A/B
BH09-8A/B	MW11-112A	BH08-7A/B	MW11-107A
BH09-9A	MW13-113A	BH09-6A	MW11-108A
BH10-01A/B	MW13-114A/B	MW11-101B	MW11-110A/B
BH10-26	MW13-115A/B	MW11-102B	MW11-111A/B
KP11-03A/B	MW13-116A/B	MW11-103B	

Table G: Proposed Annual Monitoring Program Groups

Group A		Group B	
MW11-101A	MW13-117A/B		
MW11-102A			

6.0 Mitigation Strategies

Mitigation strategies such as segregating potentially acid producing mine rock and process solids and maintaining them in saturated conditions have already been incorporated into the design of the mine and its infrastructure. In addition, a comprehensive groundwater monitoring network is in place and will be expanded based upon input from regulators and other stakeholders if the permitting and approvals process progresses.

7.0 Conclusions

The excavation of an open pit mine and the construction and filling of a mine rock storage area and process solids management facility are large scale engineering projects that will inevitably affect the chemistry and distribution of groundwater in their vicinity. However, due to the generally low hydraulic conductivity overburden and bedrock and local scale groundwater flow systems encountered at this site and characteristic of the Canadian Shield of northern Ontario (Sykes and others, 2009), the effects on groundwater chemistry and distribution will be limited.

Drawdown of groundwater levels around the open pits will not extend beyond the watershed or to the Pic River. Baseflow to streams in the vicinity of the pits will be reduced or eliminated, as expected, but the reduction in flow to the Pic River will not be measurable.

Groundwater migrating from beneath the MRSA is predicted to either flow towards the main pit (150 m³/day) or the Pic River and its tributaries (204 m³/day). A sensitivity analysis was conducted where recharge was varied and the discharge rates are sensitive to recharge. However, the presence of the MRSA is not expected to increase recharge so the range of recharge values evaluated is expected to be representative.

Groundwater discharging from beneath the PSMF is predicted to either flow north to the Stream 5 watershed (177 m³/day) which includes Hare Lake and eventually discharges to Lake Superior, west to the Stream 6 watershed (473 m³/day) which flows to Lake Superior or east to the Stream 1 watershed (213 m³/day) which flows to the Pic River. Sensitivity analyses that consisted of simulating grouting beneath the PSMF dams and assuming a uniform hydraulic conductivity in the upper model layer across the site both showed large decreases in discharge to the Stream 1 and Stream 6 watersheds while the discharge to the Stream 5 watershed decreased for the grouting scenario and stayed the same for the uniform hydraulic conductivity scenario.

The pits are predicted to fill 40 years after the completion of active pit dewatering (or sooner if the pits are used to store process solids and mine rock) through a combination of surface water and groundwater in flows.

8.0 Closure

Respectfully submitted by:

True Grit Consulting Ltd.



Leif Nelson, M.Sc., P.Geo.
Senior Hydrogeologist
lnelson@tgcl.ca



Jason Garatti, M.Sc.Eng., P.Geo.
Principal/Manager, Environmental Services
jgaratti@tgcl.ca

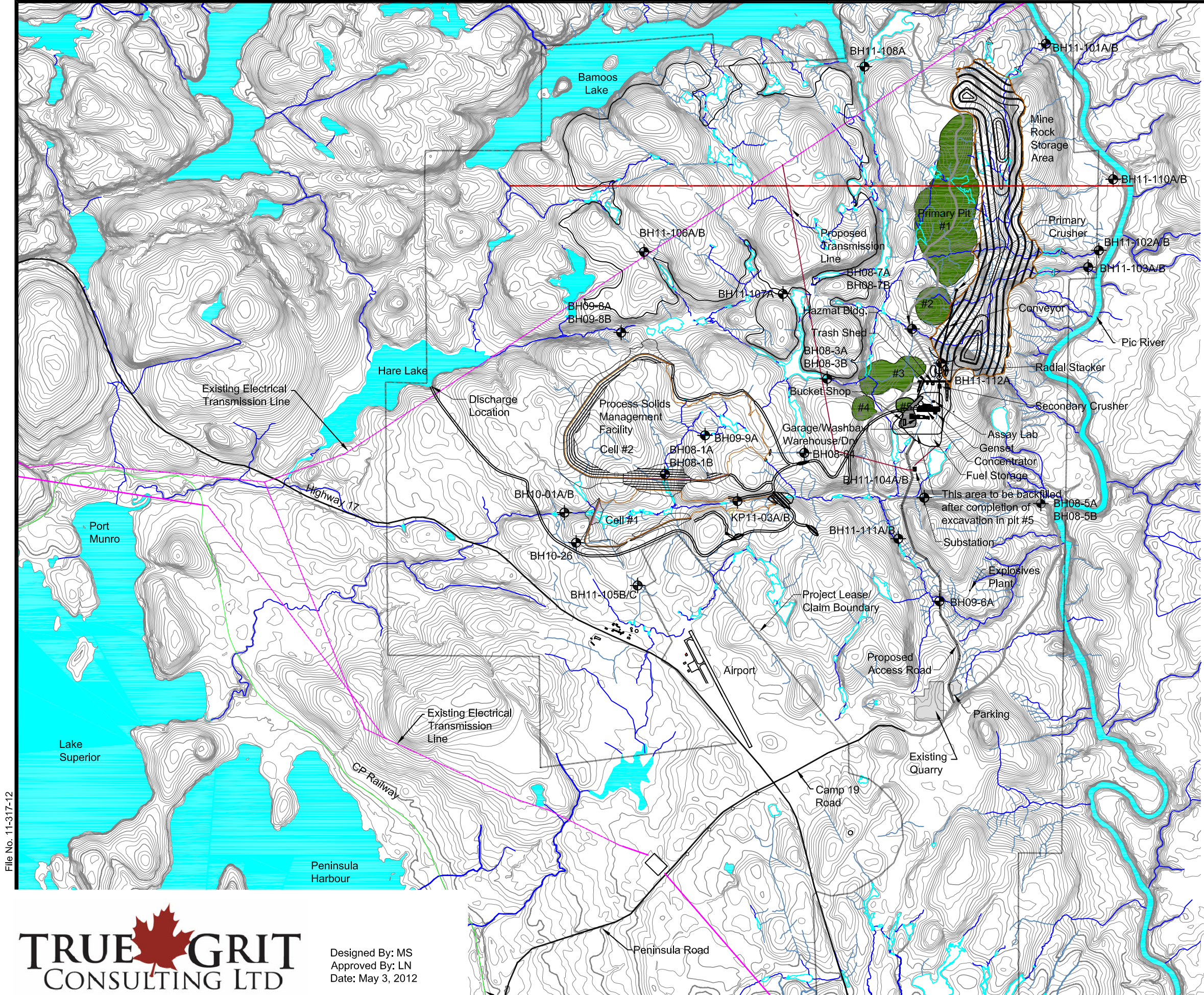
LN/JG/EZ:pn

9.0 References



- Calder Engineering, 2010. Marathon PGM-Cu Project Hydrology and Water Management (Draft). Marathon PGM Corporation. November, 2010.
- Calder Engineering, 2012. Technical Memorandum: East Waste Rock Stockpile & Pit Complex Water Balance, Marathon PGM-Cu Project, Stillwater Canada, Inc. January 2, 2012.
- Golder Associates, 2007. Technical Memorandum: Climactic Data for the Marathon PGM Project. March 7, 2007.
- Harbaugh, A.W. 1990. *A computer program for calculating subregional water budgets using results from the U.S. Geological Survey modular three-dimensional ground-water flow model*. U.S. Geological Survey Open-File Report 90-392, 46 p.
- Knight Piésold Ltd. 2012. *Combined Storage Area Seepage Analysis*. March 8, 2012.
- McDonald, M.G., and A.W. Harbaugh, 1983. *A modular three-dimensional finite-difference ground-water flow model*. Open-File Report 83-875. U.S. Geological Survey.
- Niswonger, R.G., S. Panday and M. Ibaraki, 2011, *MODFLOW-NWT, A Newton formulation for MODFLOW-2005*: U.S. Geological Survey Techniques and Methods 6-A37, 44 p.
- Pollock, D.W. 1994. *User's Guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model*: U.S. Geological Survey Open-File Report 94-464, 234 p.
- Shevenell, L. 2000. Analytical method for predicting filling rates of mining pit lakes: example from the Gretchell Mine, Nevada. *Mining Engineering*, 52(3), 53 – 60.
- Surrano, S.E. 1997. *Hydrology for engineers, geologists and environmental professionals: an integrated treatment of surface, subsurface and contaminant hydrology*. Hydrosience Inc. Lexington, Ky.
- Sykes, J.F., S.D. Normani, M.R. Jensen and E.A. Sudicky. 2009. *Regional-scale groundwater flow in a Canadian Shield setting*. *Canadian Geotechnical Journal*. v. 46, pp. 813-827.
- TGCL, 2011. Stillwater Canada Inc. Baseline Report – Hydrogeology Marathon PGM-Cu Project. DRAFT Report, December 7, 2011.
- Wilkin, R.T., 2007. *Metal Attenuation Processes at Mining Sites*. Ground Water Issue. United States Environmental Protection Agency, Cincinnati, Ohio.
- Younger, P.L., Banwart, S.A. and Hedin, R.S. 2002. *Mine Water Hydrology, Pollution, Remediation (Environmental Pollution Vol. 5 Edited by Alloway, B.J.)* The Netherlands: Kluwer Academic Publishers Dordrecht.



Figures




Legend

-  BH08-3A Existing Groundwater Monitoring Well
-  Model Row 70

Scale

0 400 800 m SCALE 1:40000



Note: Mine Pits and Process Areas derived from Knight Piesold Consultings "Proposed Site Investigation Plan Summer 2011" Figure 1. Mine Rock Storage and Process Solids Management Facility Areas derived from Knight Piesold Consultings "Combined Storage Area PSMF - Year 10" Figure 6.

Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

Site Layout, Site Features and Monitoring Well Locations

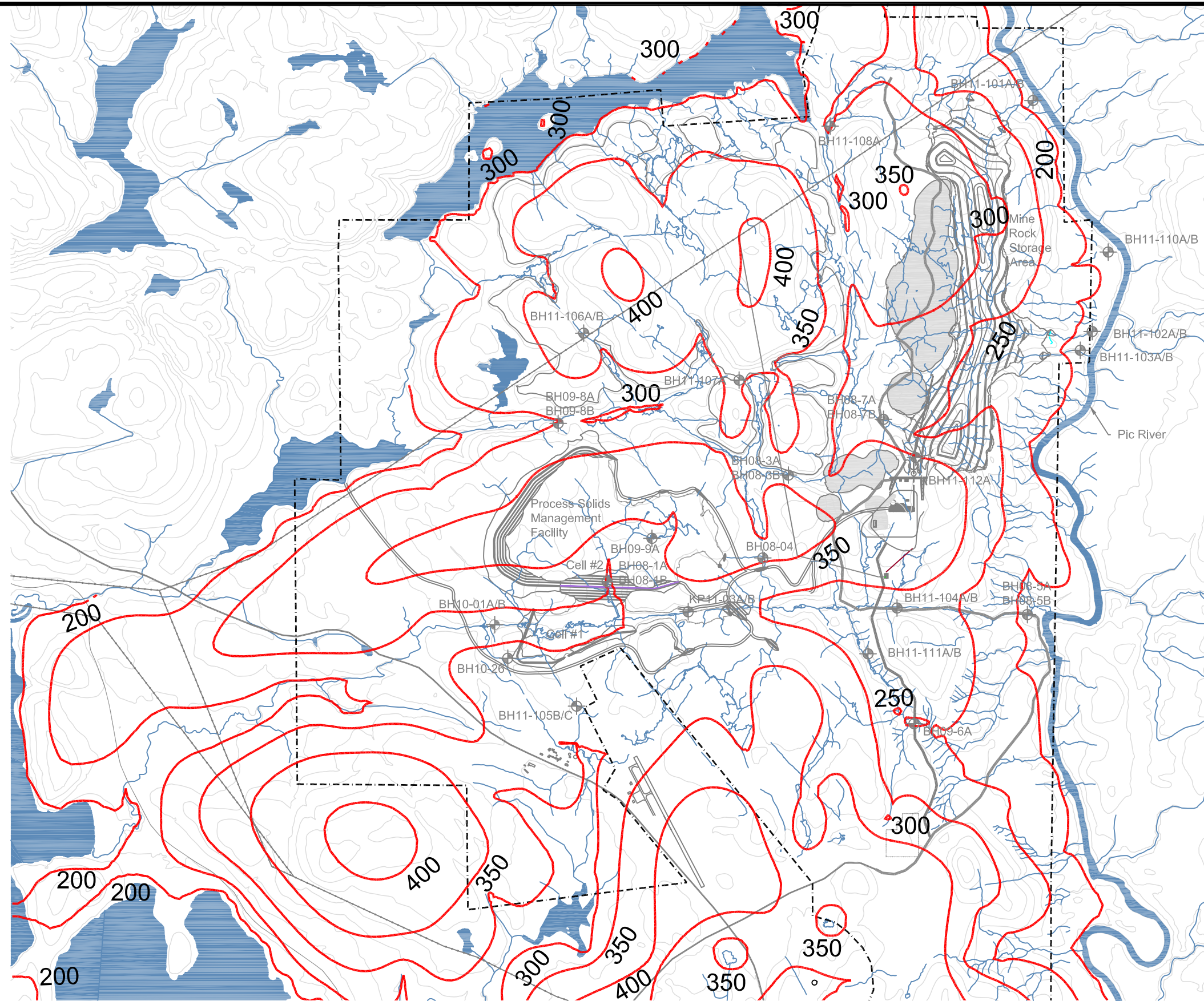
FIGURE 1

File No. 11-317-12

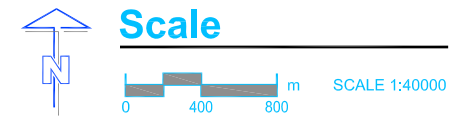


Designed By: MS
 Approved By: LN
 Date: May 3, 2012

File No. 11-317-12

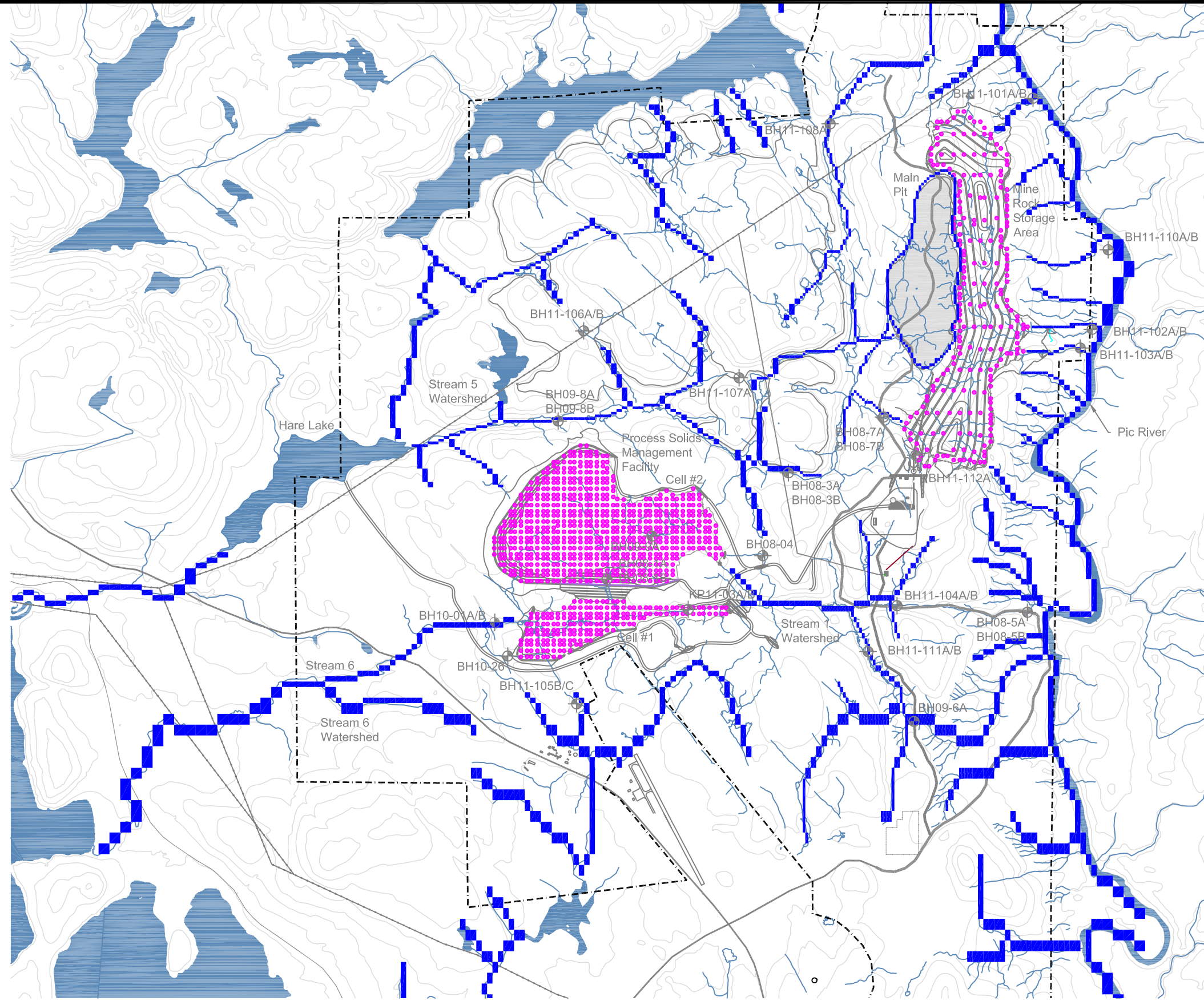


LEGEND
 — Modelled Groundwater Head
 200 Elevation (m ASL)



Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12

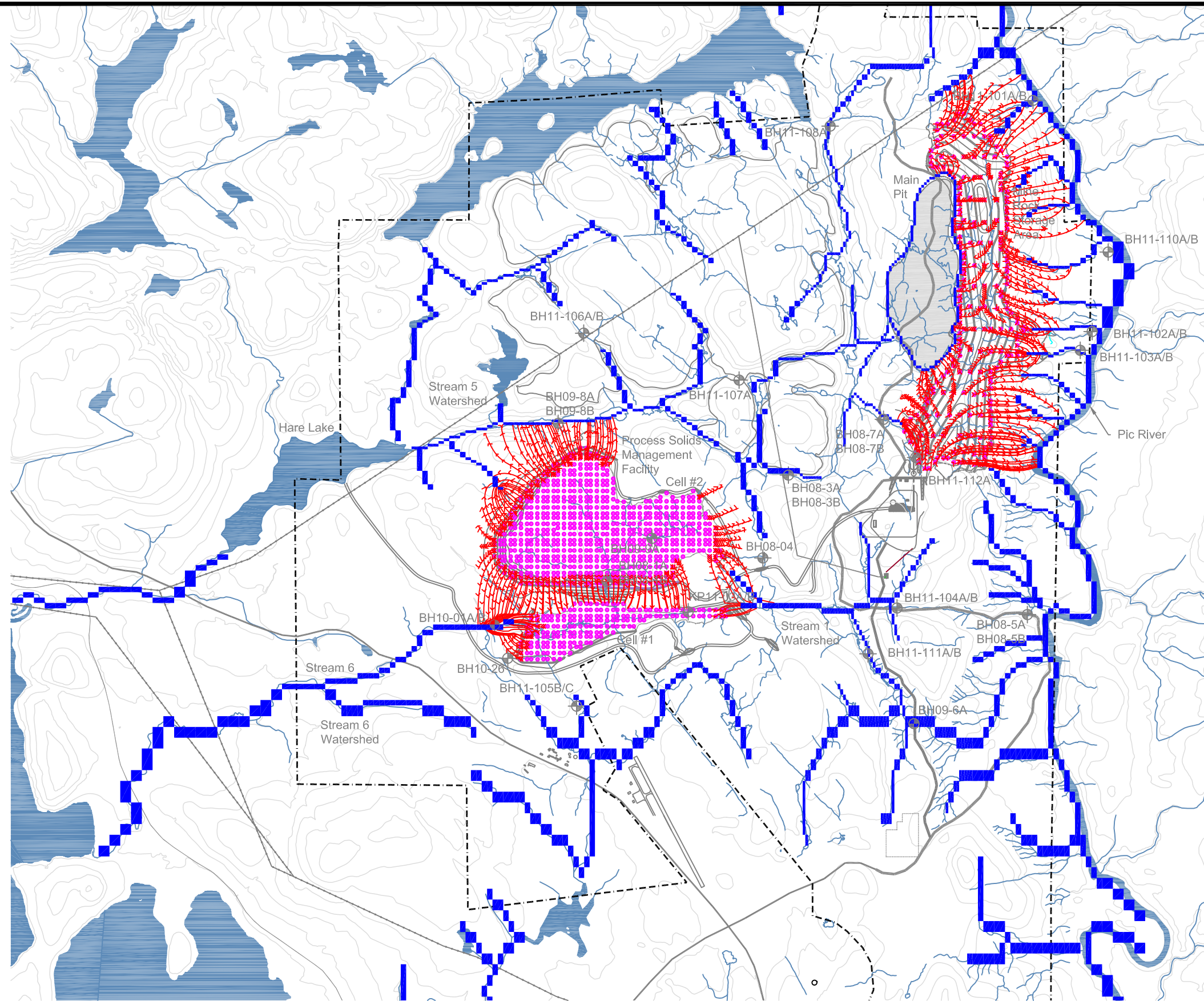


LEGEND
 • Particles
 — Modelled Drain Boundaries

Scale
 0 400 800 m SCALE 1:40000

Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12



LEGEND

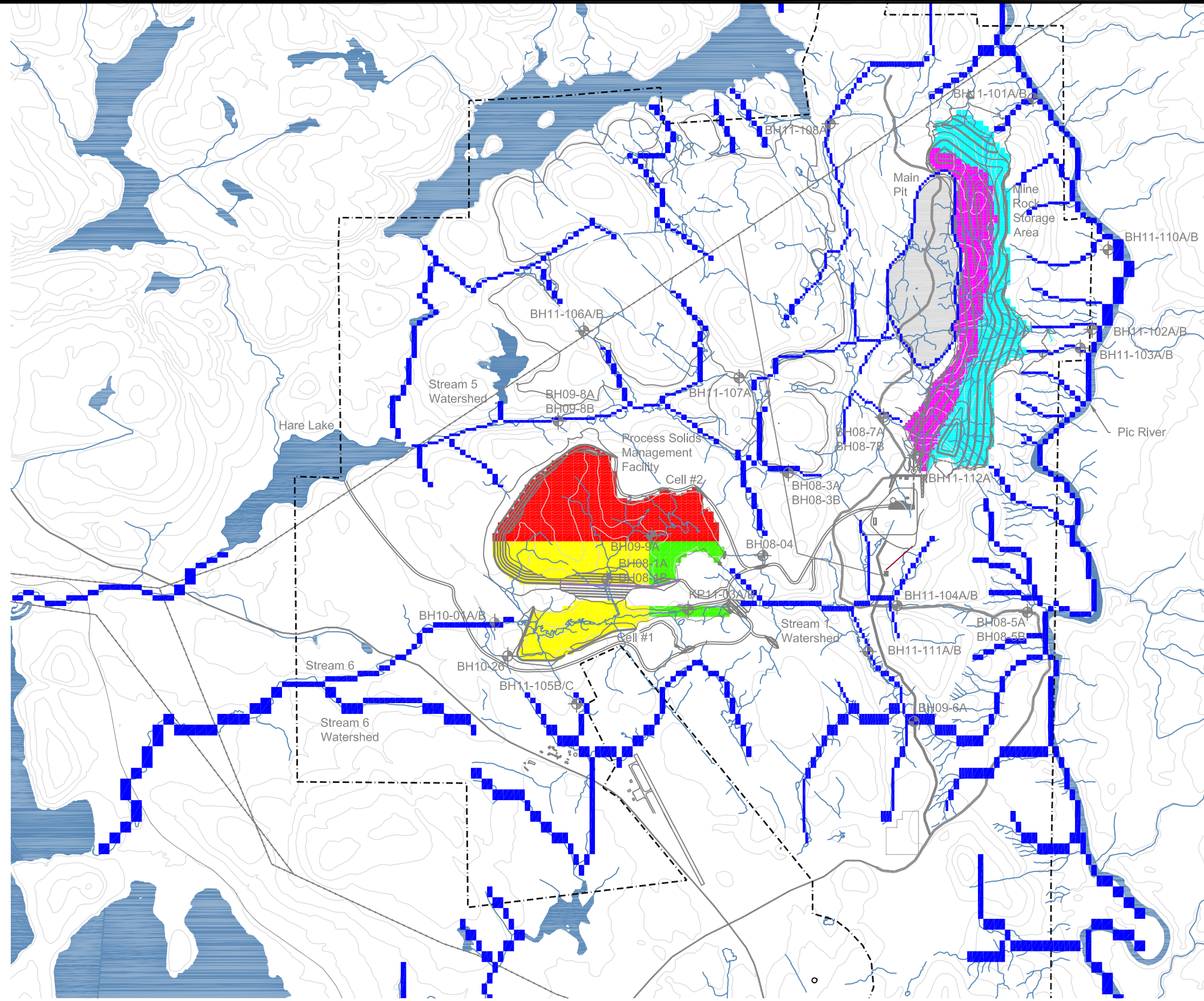
- Particles
- Flow Path (Each Arrow Represents 10 Years of Travel)
- - - Modelled Drain Boundaries

Scale

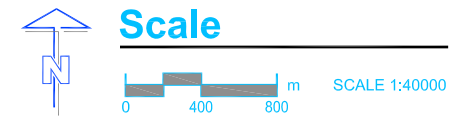
0 400 800 m SCALE 1:40000

Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12

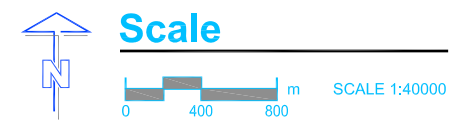
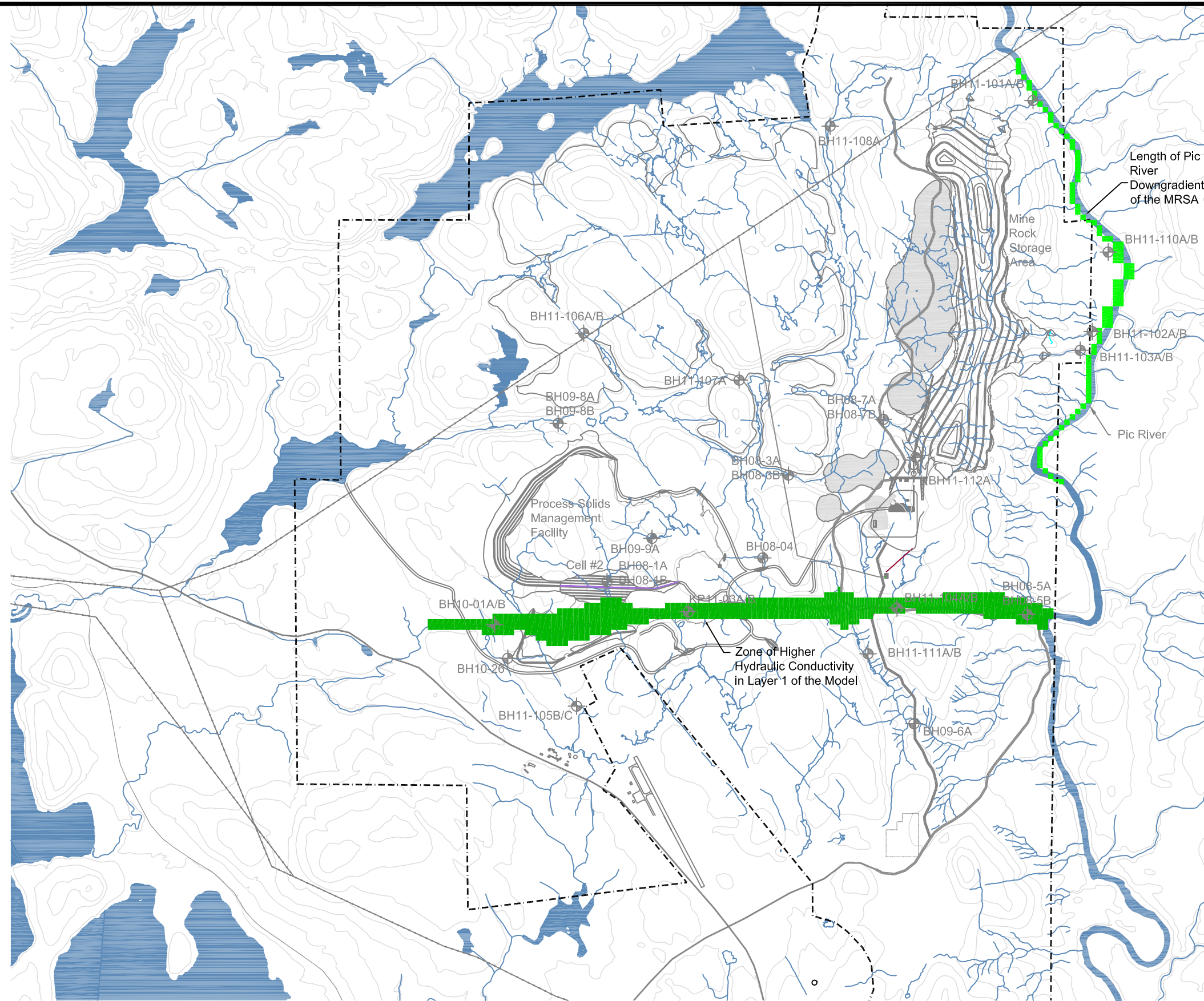


- LEGEND**
- Areas Discharging to Main Pit
 - Areas Discharging to Pic River and Tributaries
 - Areas Discharging to Stream 6 Watershed
 - Areas Discharging to Stream 5 Watershed
 - Modeled Drain Boundaries



Stillwater Canada Inc.
Impact Assessment Report - Hydrogeology
Marathon PGM-Cu Project

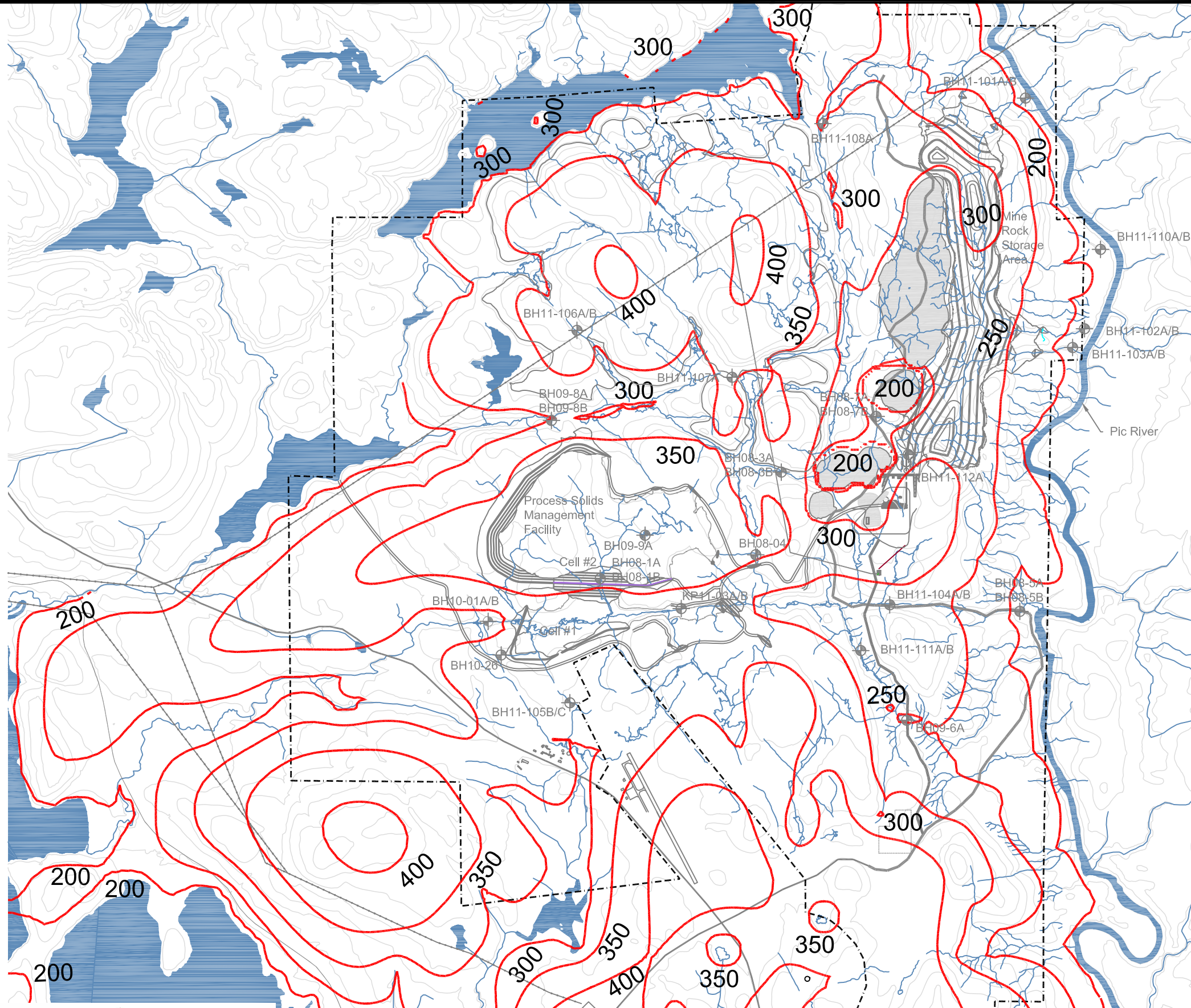
File No. 11-317-12



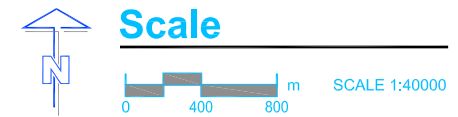
Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

Location of Higher Hydraulic Conductivity Zone and Length of Pic River Downgradient of MRSA in Model Domain

File No. 11-317-12

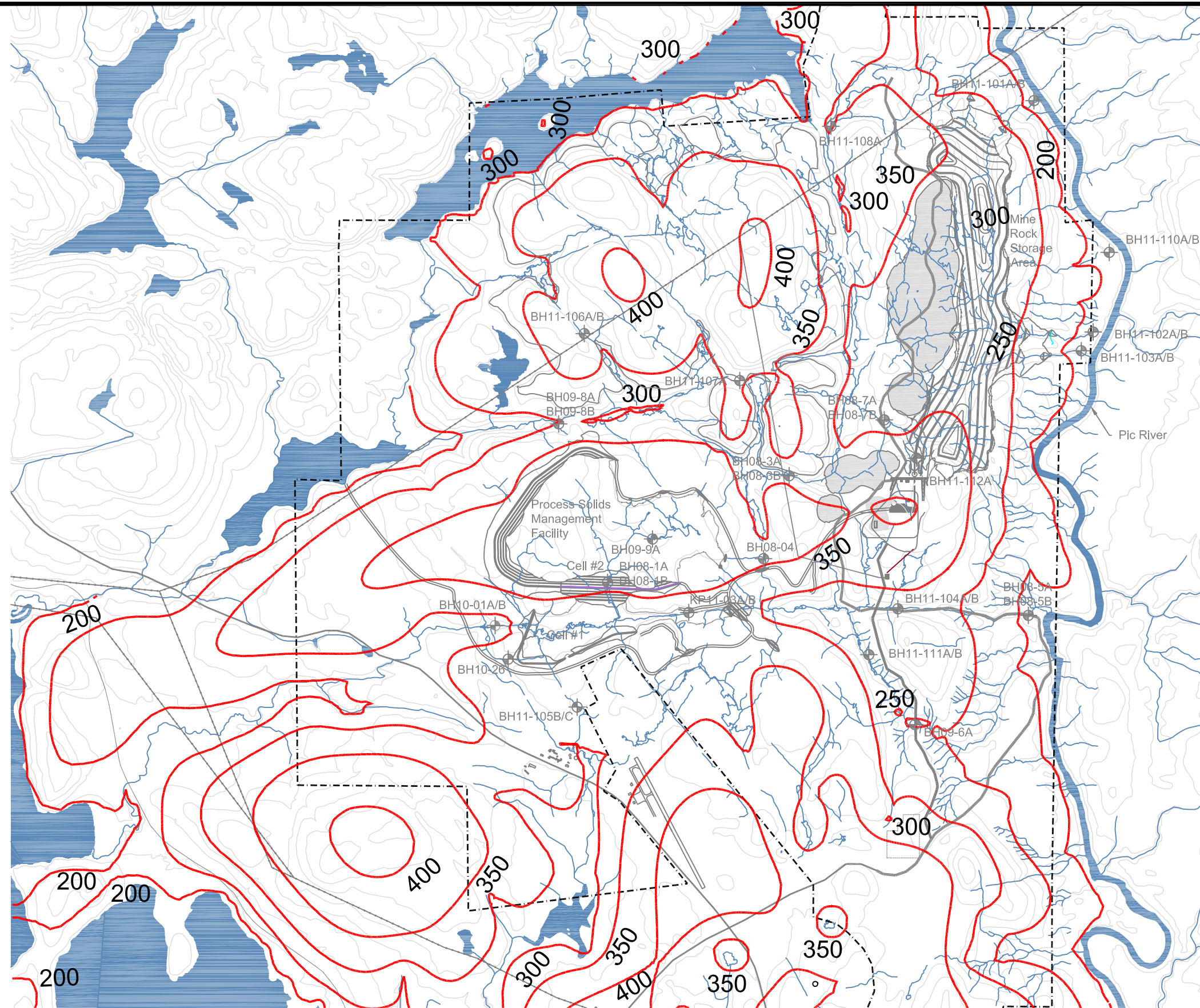


LEGEND
 — Modelled Groundwater Head
 200 Elevation (m ASL)

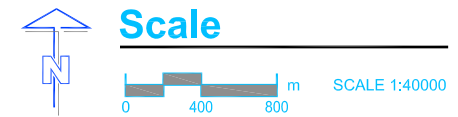


Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12

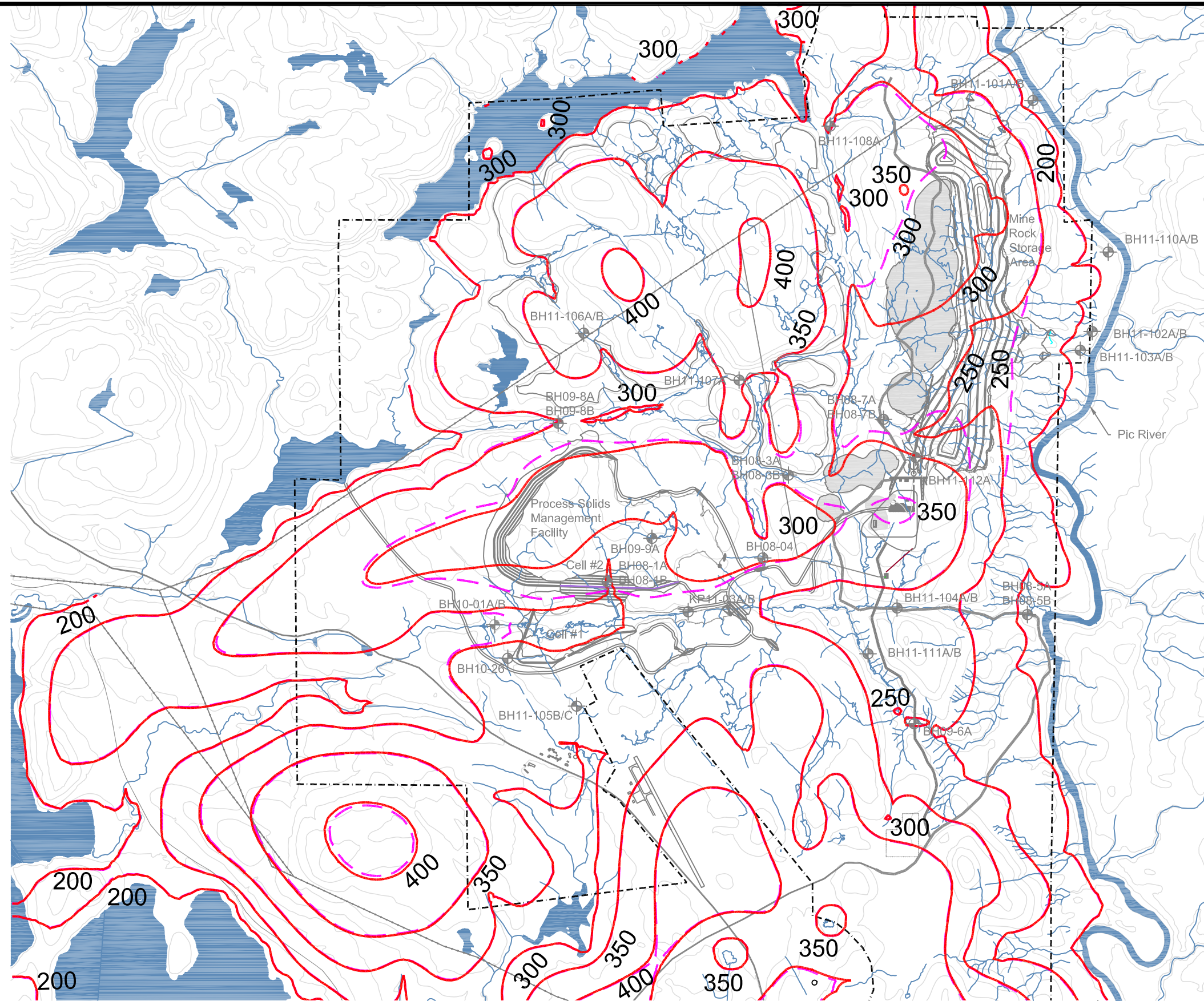


LEGEND
 — Modelled Groundwater Head
 200 Elevation (m ASL)

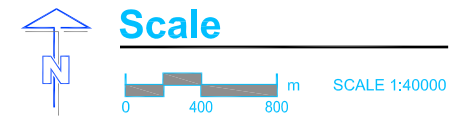


Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12

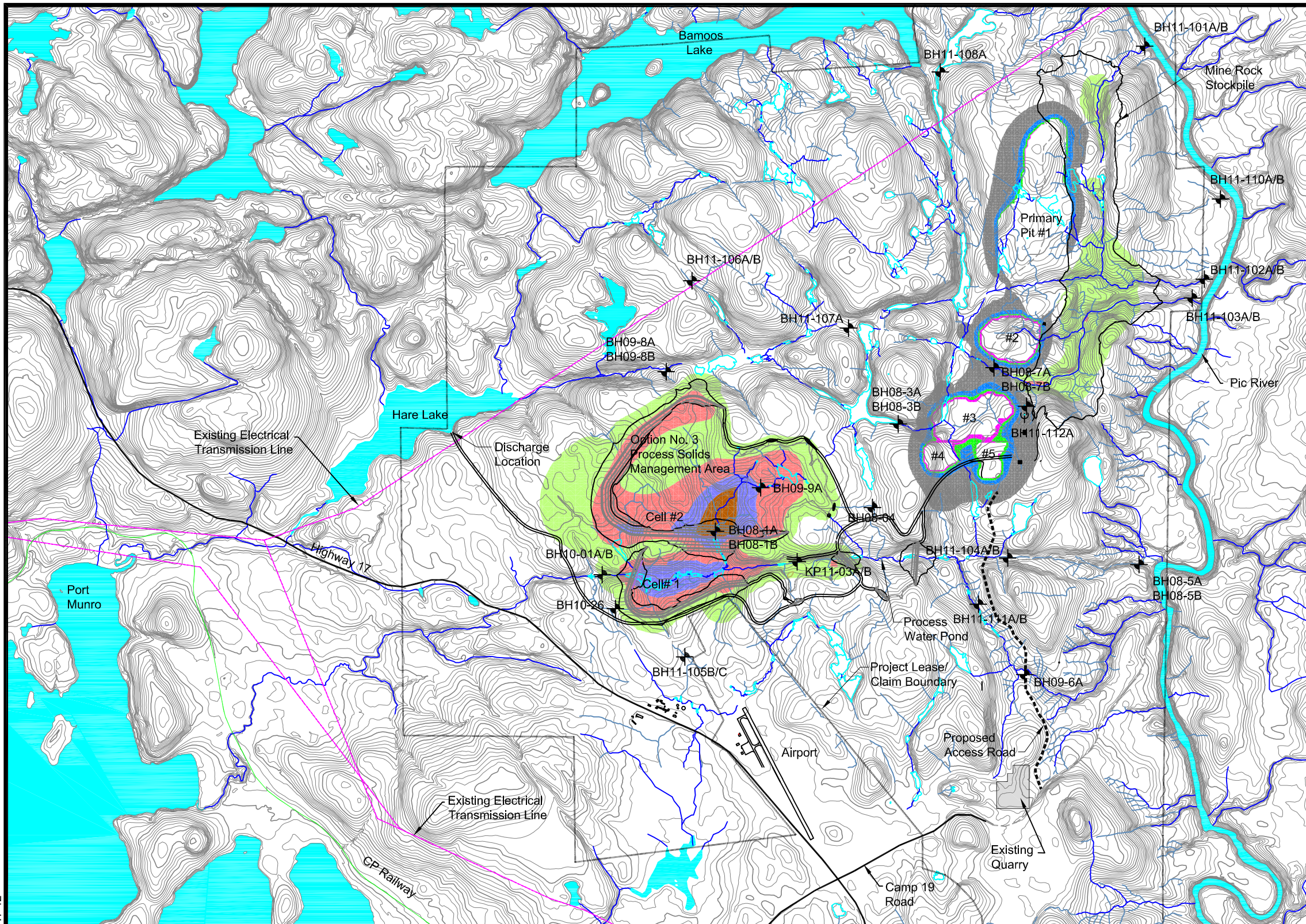


LEGEND
 — Steady State Modelled Groundwater Heads
 — Modelled Groundwater Heads after 100 Years of Closure
 200 Elevation (m ASL)

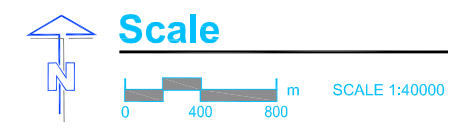


Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

Comparison of Modelled Groundwater Heads - Steady State and 100 Years of Closure



Change in Modelled Groundwater Head (m)			
Number	Minimum	Maximum	Color
1	-150.00	-50.00	Magenta
2	-50.00	-30.00	Green
3	-30.00	-10.00	Blue
4	-10.00	-1.00	Grey
5	1.00	10.00	Light Green
6	10.00	30.00	Red
7	30.00	50.00	Purple
8	50.00	100.00	Brown

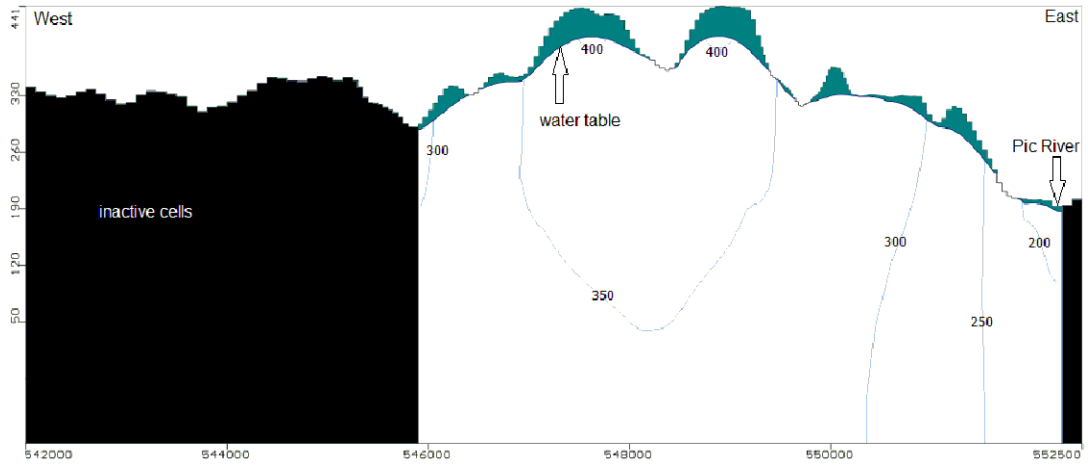


File No. 11-317-12

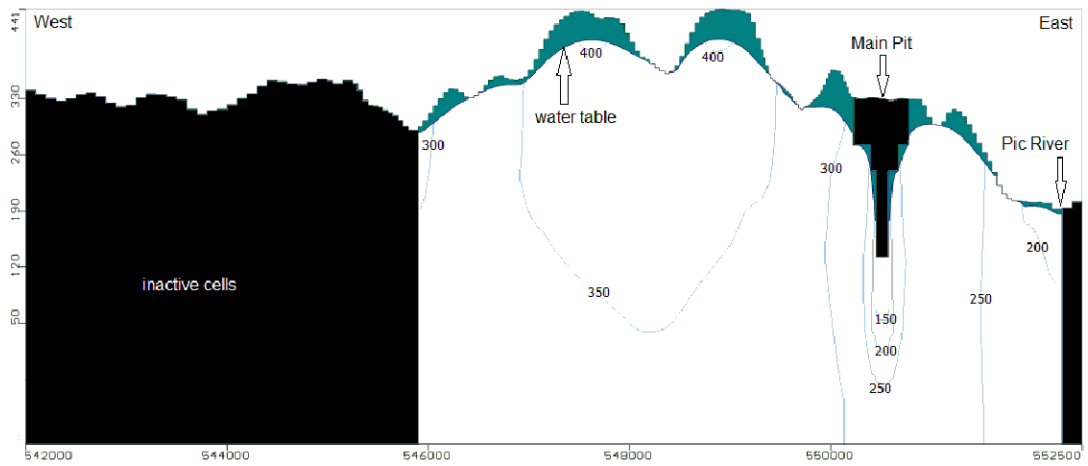
Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

Total Change in Modelled Groundwater Heads at end of Mining

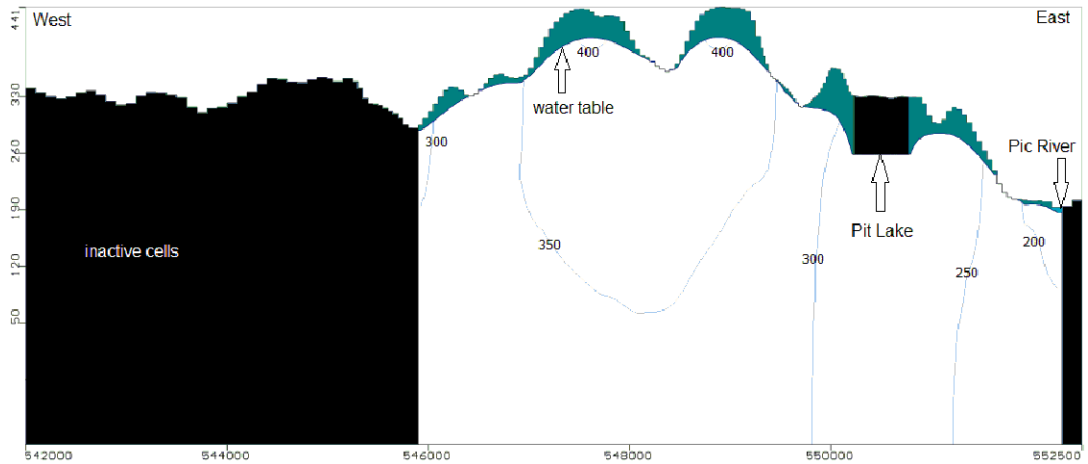
Steady State



End of Mining



100 Years of Closure



Note: Eight times vertical exaggeration.

File No. 11-317-12

Stillwater Canada Inc.
Impact Assessment Report - Hydrogeology
Marathon PGM-Cu Project

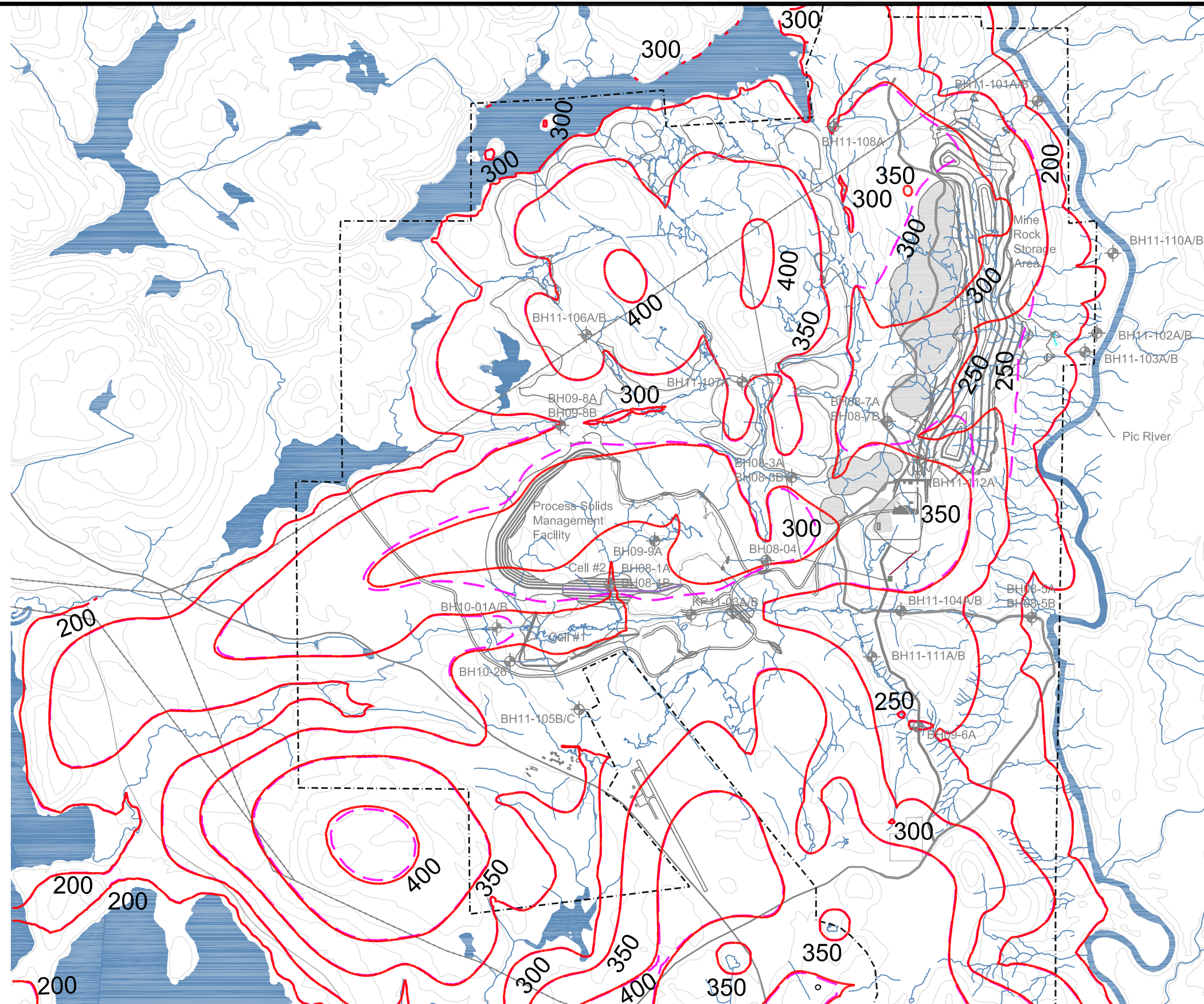


Designed By: MS
Approved By: LN
Date: May 1, 2012

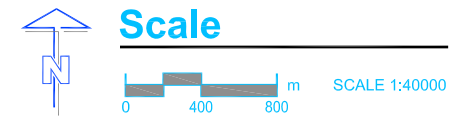
Cross Section at Model Row 70

FIGURE 12

File No. 11-317-12



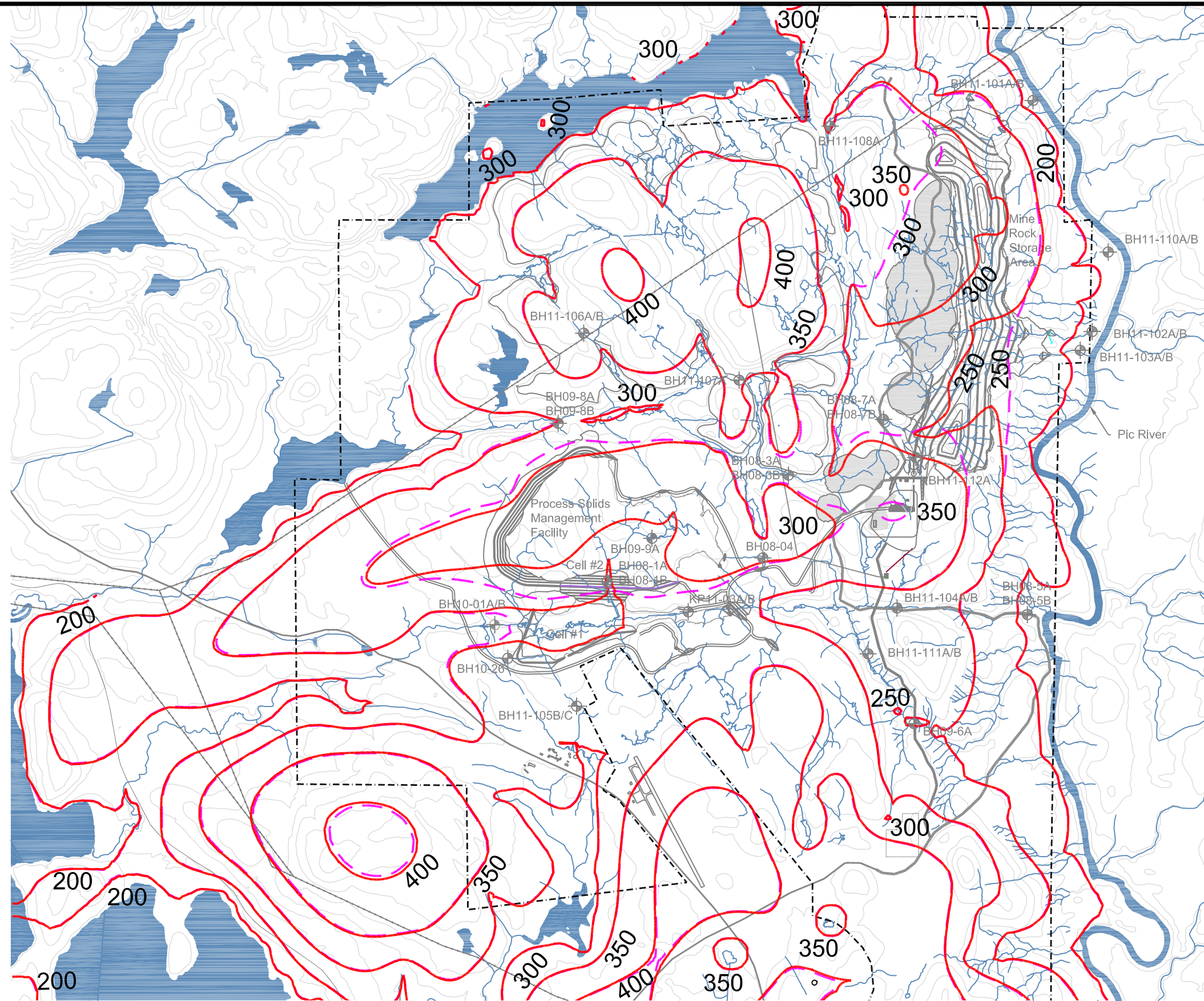
LEGEND
 - - - Steady State Modelled Groundwater Heads
 - - - Modelled Groundwater Heads after 100 Years of Closure
 200 Elevation (m ASL)



Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

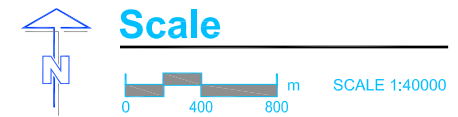
Comparison of Modelled Groundwater Heads - Steady State and 100 Years of Closure (Recharge of 79 mm/year at MRSA)

File No. 11-317-12



LEGEND

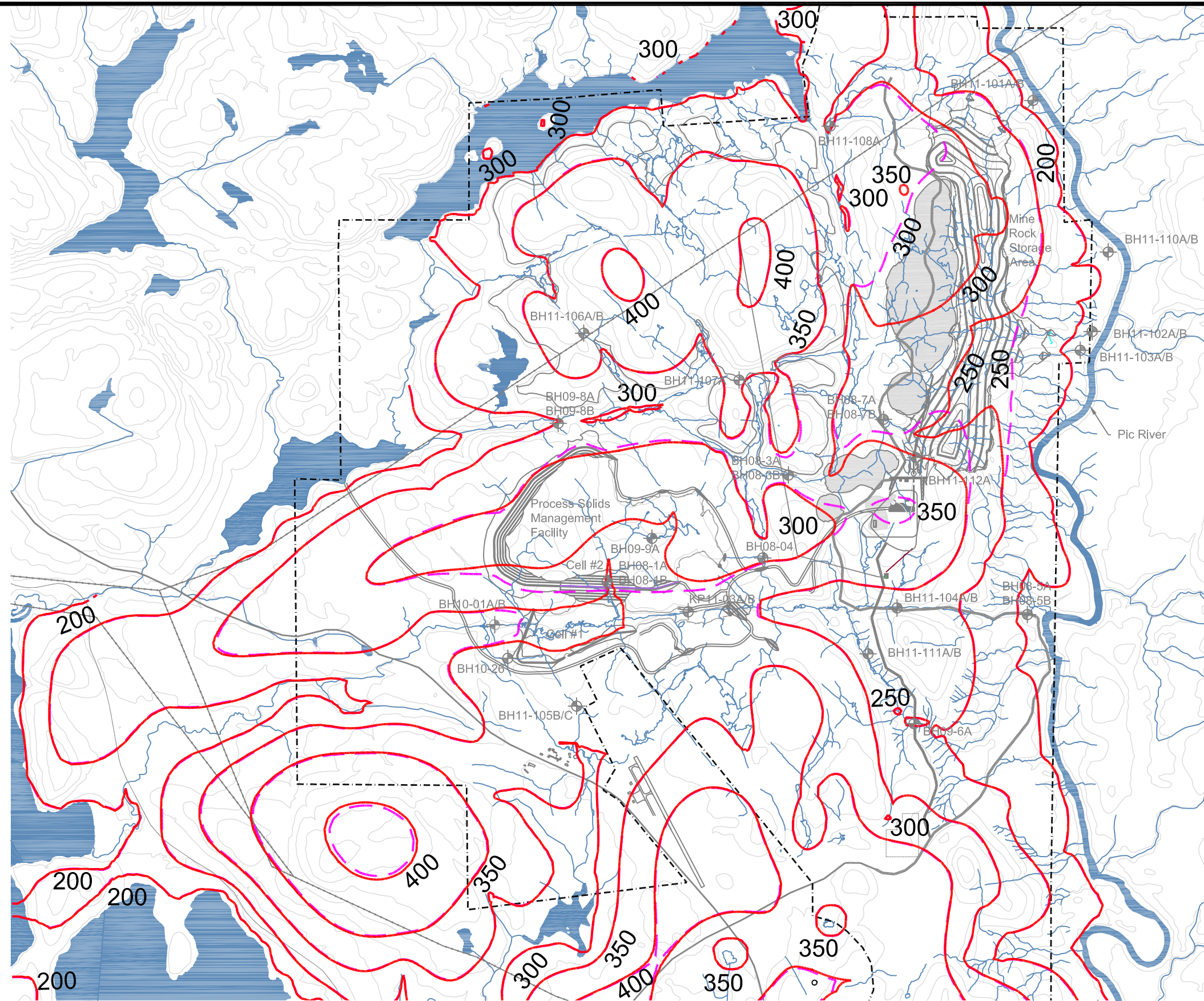
- Steady State Modelled Groundwater Heads
- Modelled Groundwater Heads after 100 Years of Closure
- 200 Elevation (m ASL)



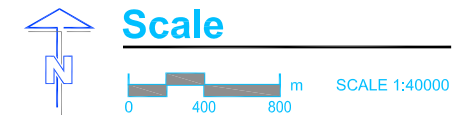
Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

Comparison of Modelled Groundwater Heads - Steady State and 100 Years of Closure (Recharge of 40 mm/year at MRSA)

File No. 11-317-12



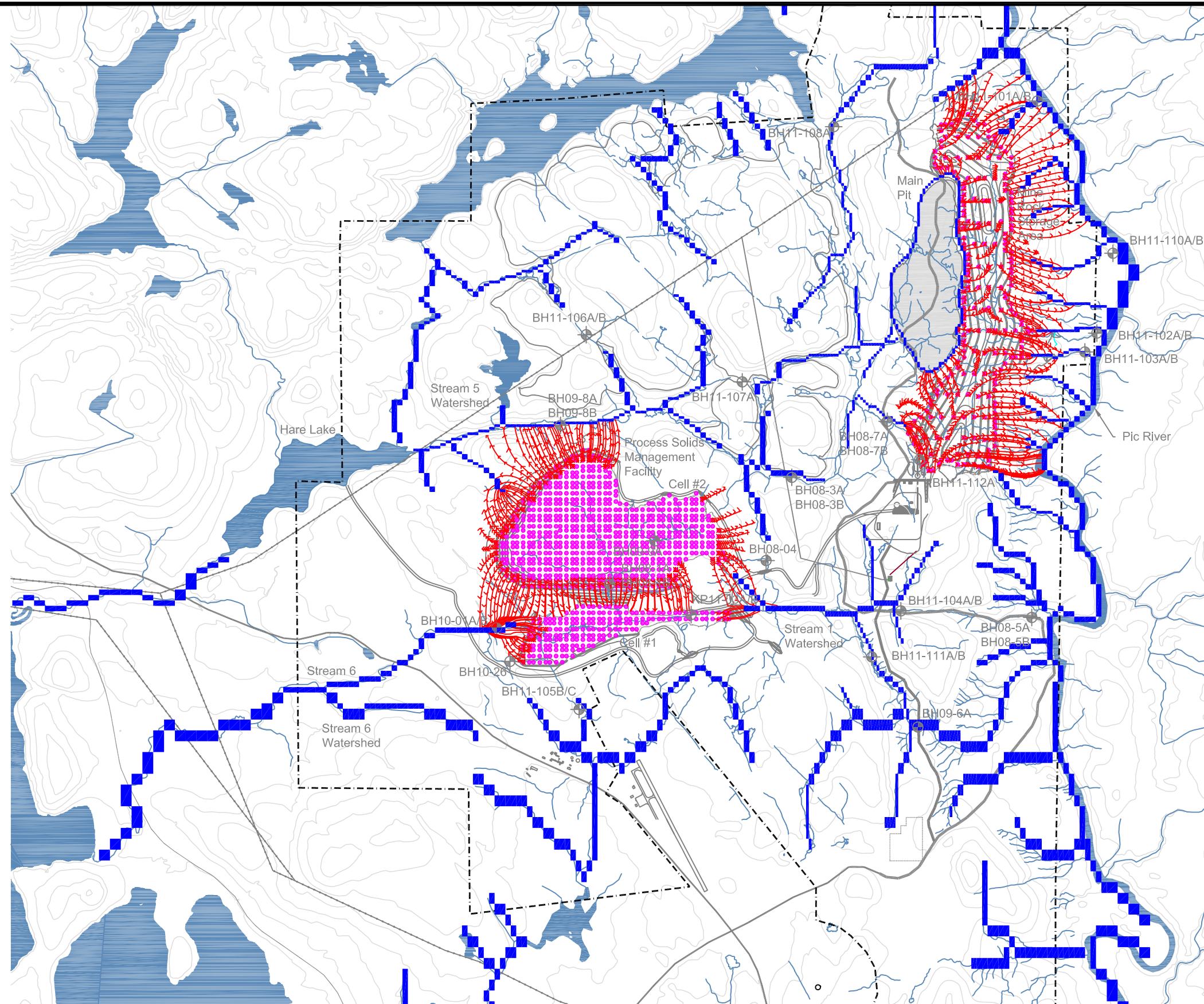
LEGEND
 — Steady State Modelled Groundwater Heads
 — Modelled Groundwater Heads after 100 Years of Closure
 200 Elevation (m ASL)



Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

Comparison of Modelled Groundwater Heads - Steady State and 100 Years of Closure (Simulation of Impact of Grouting beneath PSMF Dams)

File No. 11-317-12

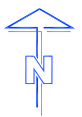


LEGEND

- Particles
- Flow Path (Each Arrow Represents 10 Years of Travel)
- Modelled Drain Boundaries

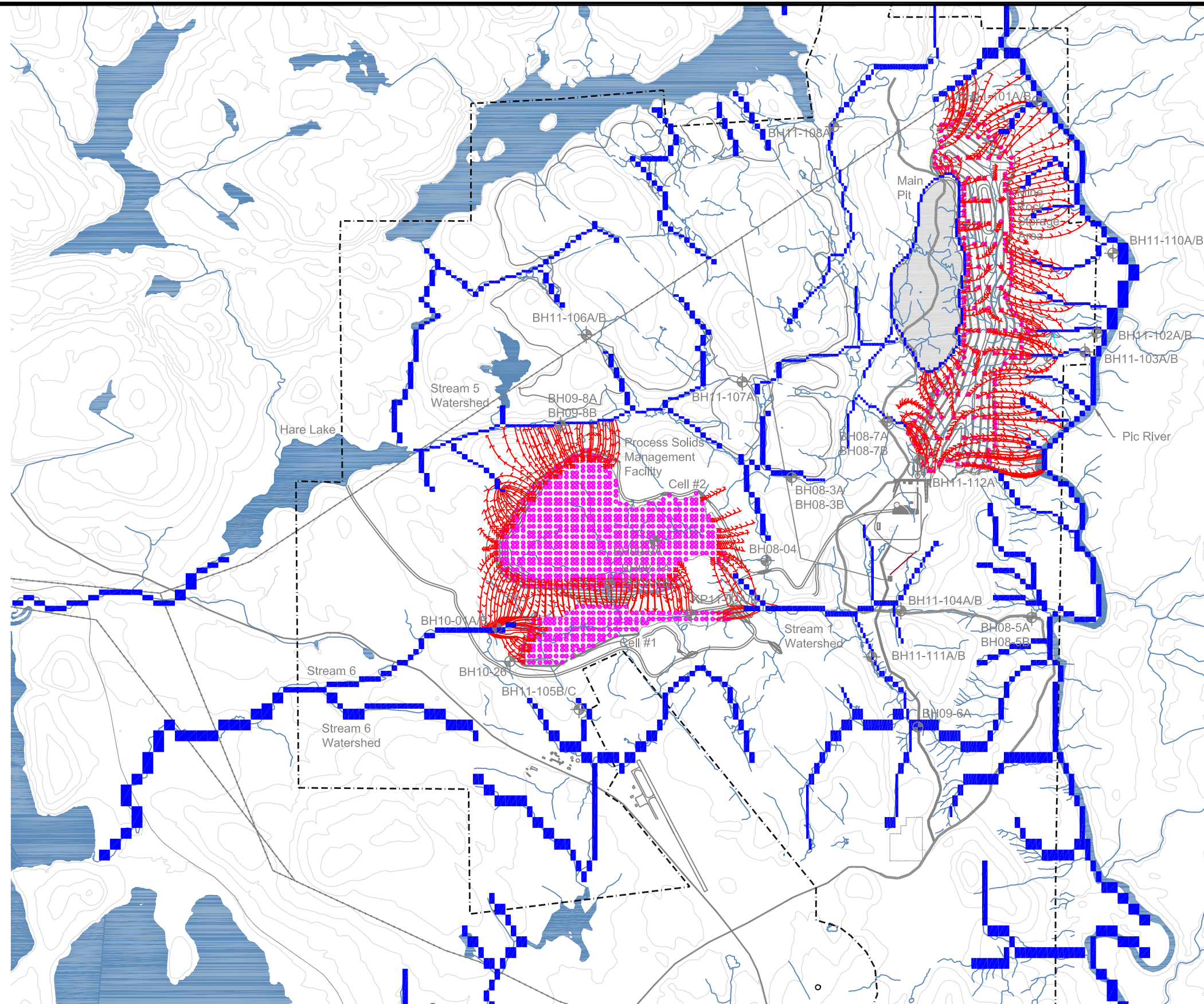
Scale

0 400 800 m SCALE 1:40000



Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12



LEGEND

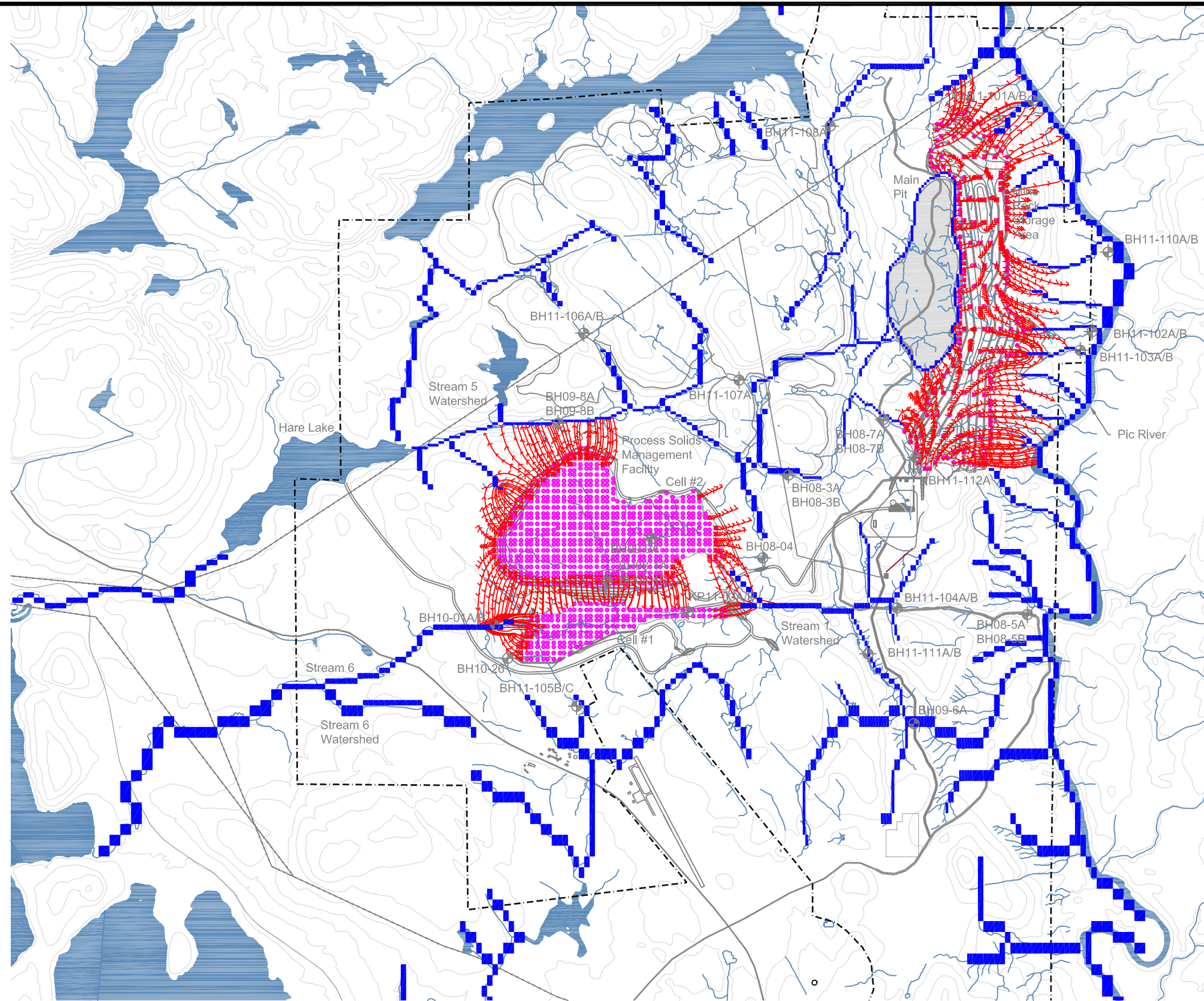
- Particles
- Flow Path (Each Arrow Represents 10 Years of Travel)
- - - Modelled Drain Boundaries

Scale

0 400 800 m SCALE 1:40000

Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12



LEGEND

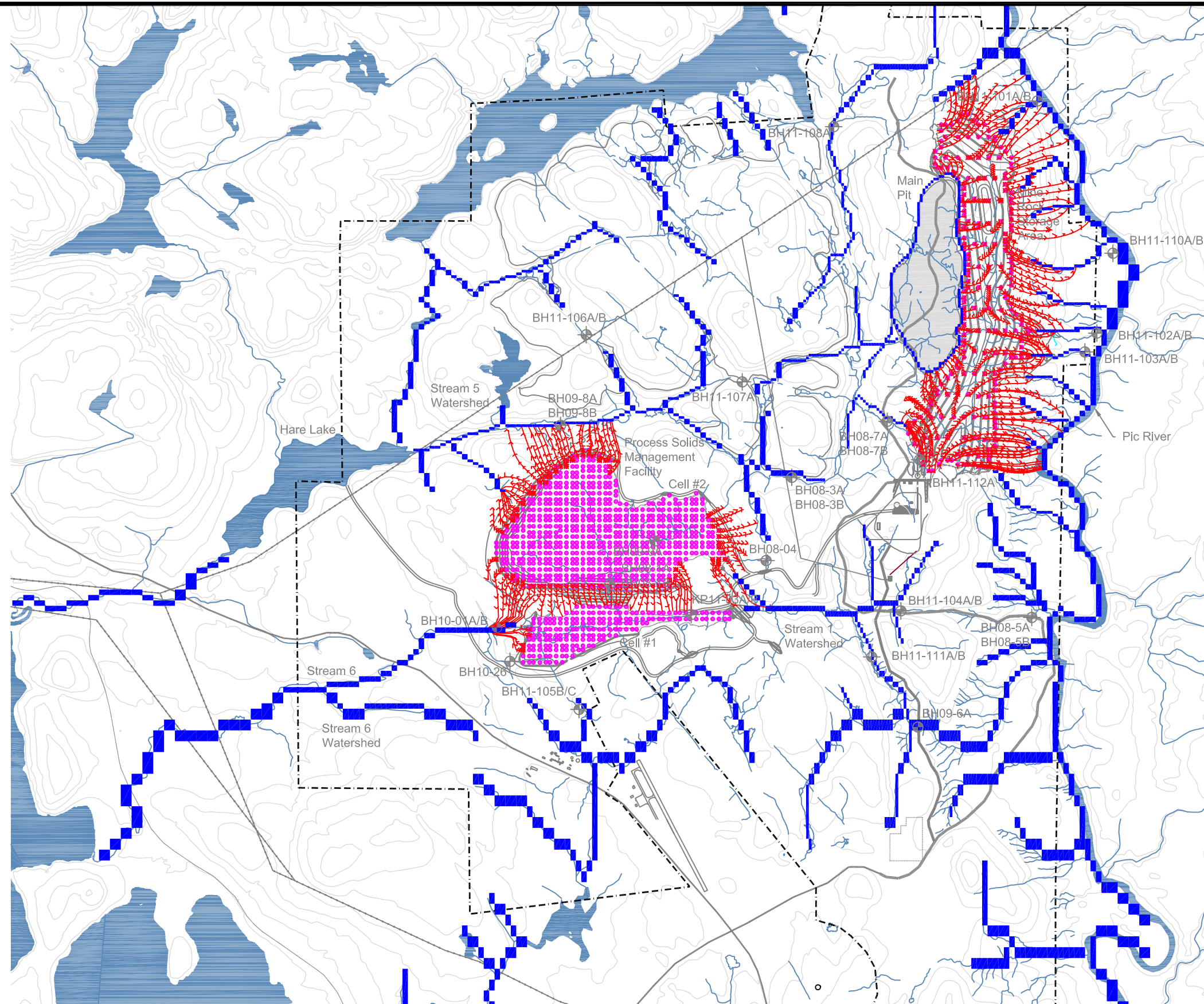
- Particles
- Flow Path (Each Arrow Represents 10 Years of Travel)
- Modelled Drain Boundaries

Scale

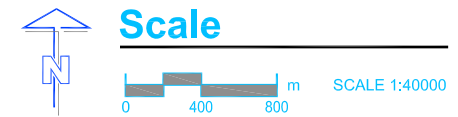
SCALE 1:40000

Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12

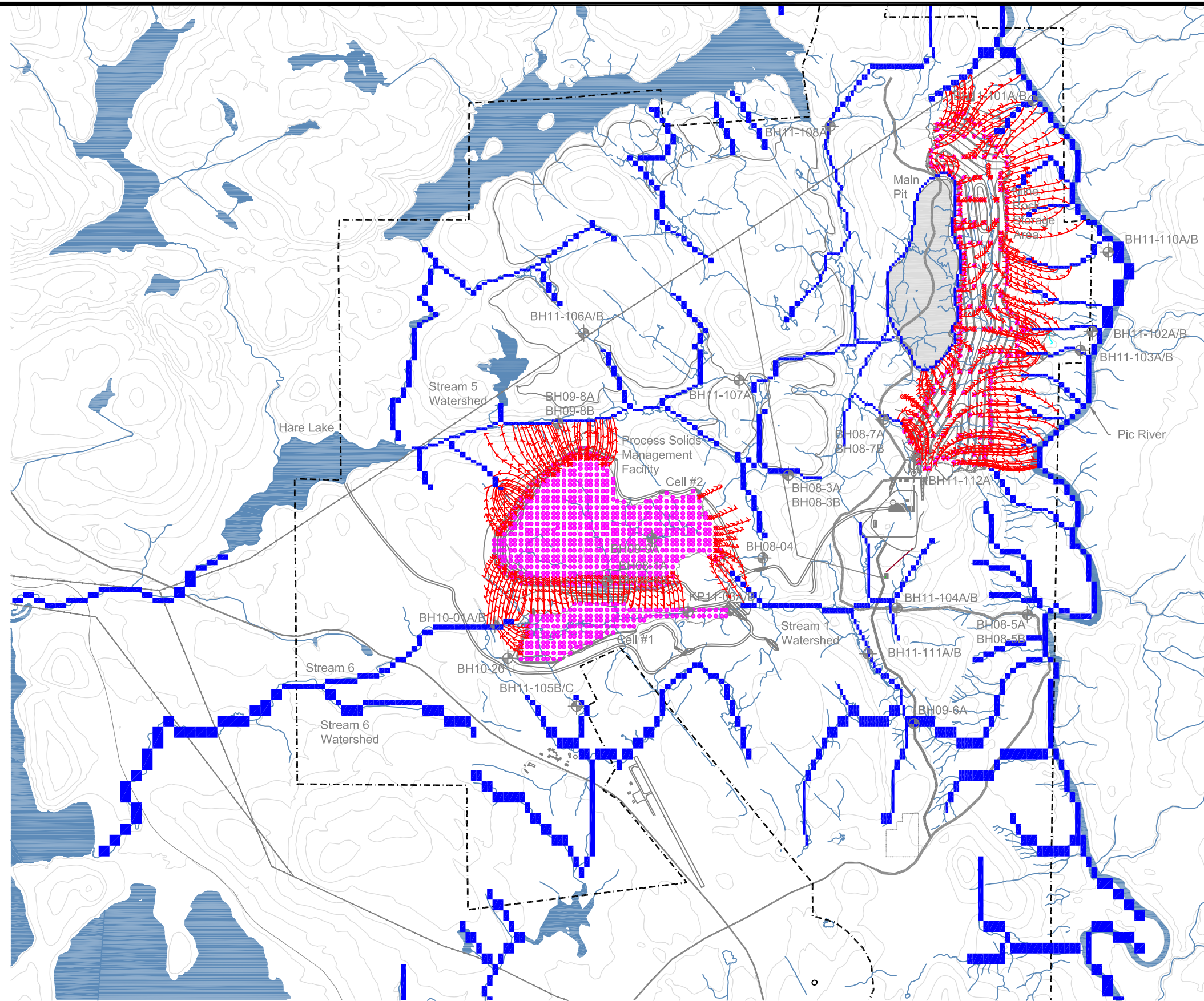


- LEGEND**
- Particles
 - Flow Path (Each Arrow Represents 10 Years of Travel)
 - Modelled Drain Boundaries



Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project

File No. 11-317-12



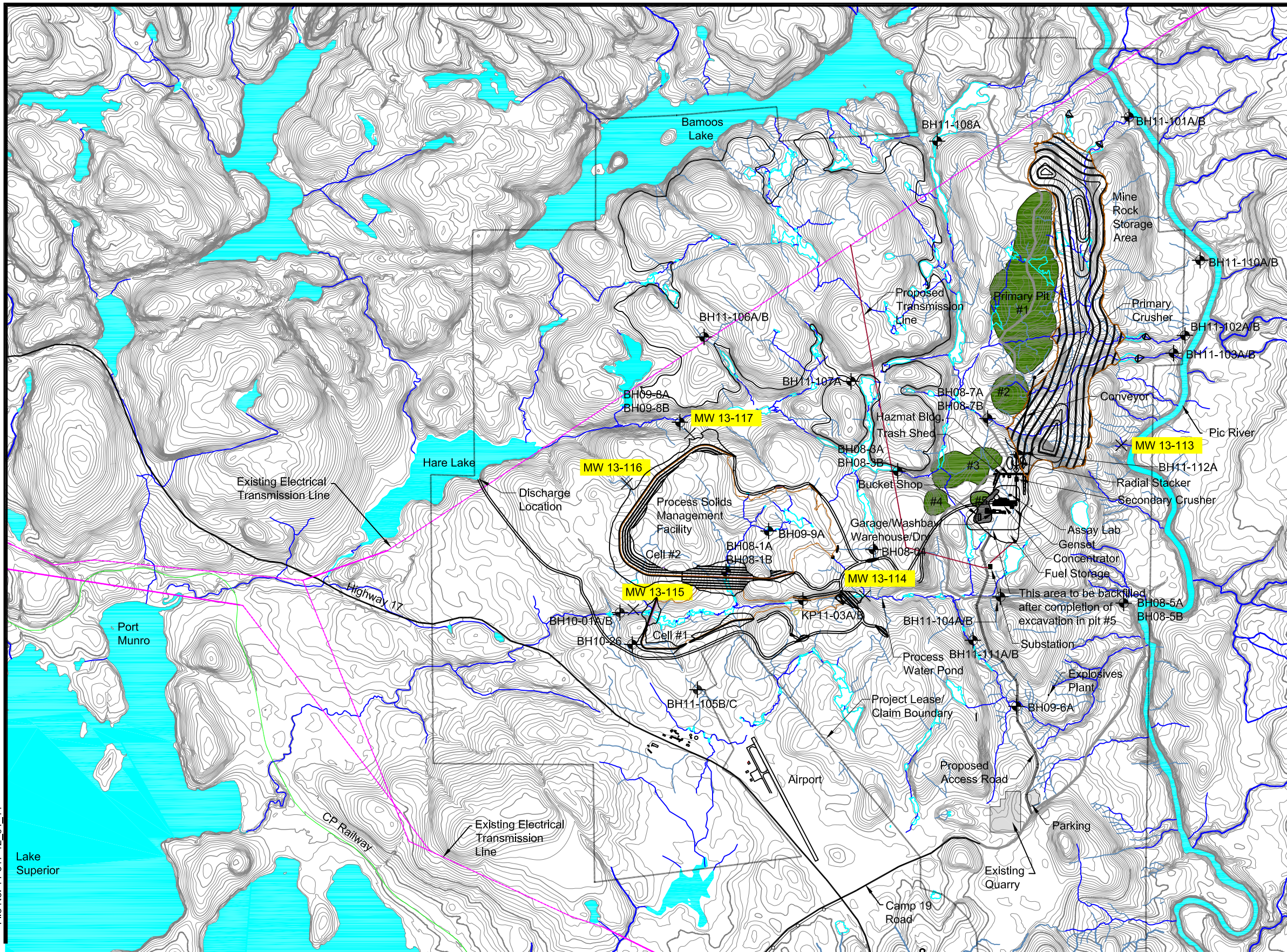
LEGEND

- Particles
- Flow Path (Each Arrow Represents 10 Years of Travel)
- Modelled Drain Boundaries

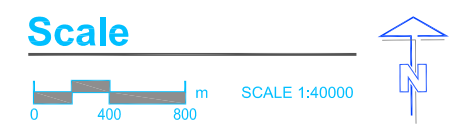
Scale

0 400 800 m SCALE 1:40000

Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project



- Legend
- BH08-3A Existing Groundwater Monitoring Well
 - MW 13-113 Proposed Groundwater Monitoring Well

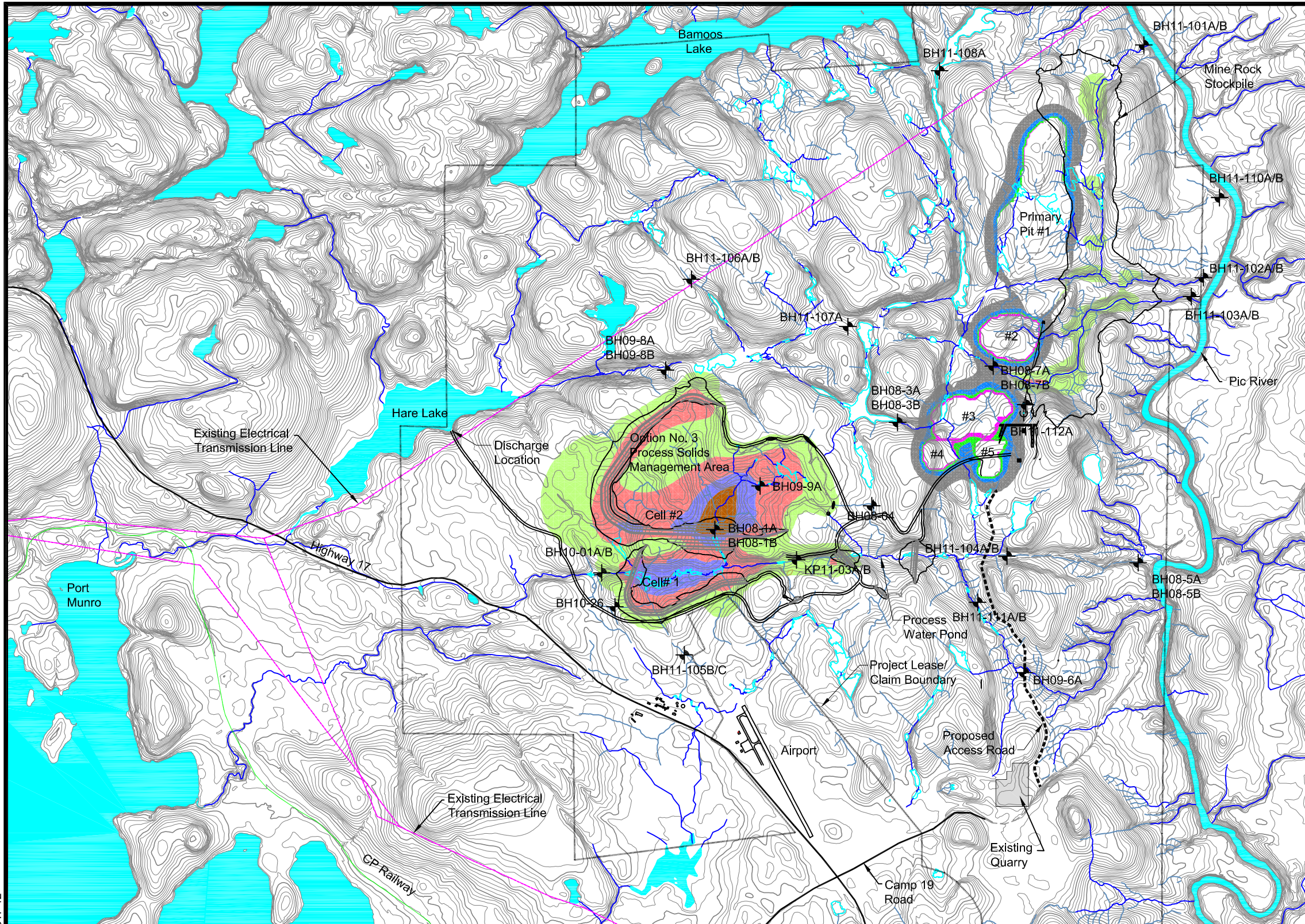


File No. 11-317-12_01_11

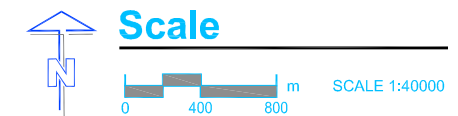
Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project



**Appendix A:
Change in Modelled Groundwater Heads over Life of Mine**



Change in Modeled Groundwater Head (m)			
Number	Minimum	Maximum	Color
1	-150.00	-50.00	Blue
2	-50.00	-30.00	Green
3	-30.00	-10.00	Yellow
4	-10.00	-1.00	Orange
5	1.00	10.00	Red
6	10.00	30.00	Orange
7	30.00	50.00	Yellow
8	50.00	150.00	Green



File No. 11-317-12

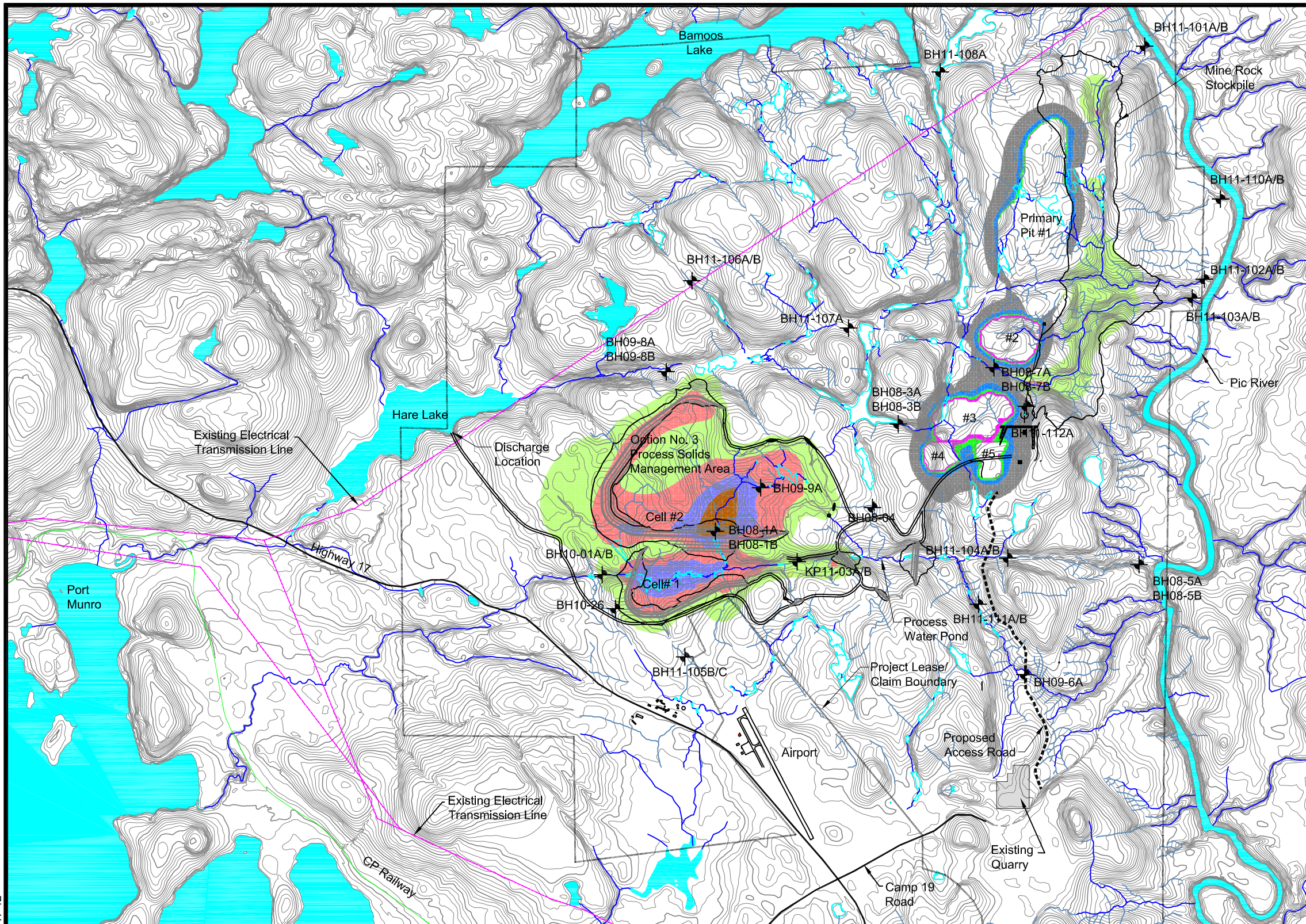
Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project



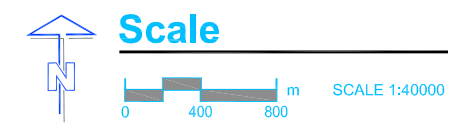
Designed By: CL
 Approved By: LN
 Date: May 3, 2012

Total Change in Modeled Groundwater Heads after 3 Years of Mining

FIGURE A1



Change in Modeled Groundwater Head (m)			
Number	Minimum	Maximum	Color
1	-150.00	-50.00	Magenta
2	-50.00	-30.00	Green
3	-30.00	-10.00	Blue
4	-10.00	-1.00	Grey
5	1.00	10.00	Light Green
6	10.00	30.00	Red
7	30.00	50.00	Blue-Red
8	50.00	100.00	Brown



File No. 11-317-12

Stillwater Canada Inc.
 Impact Assessment Report - Hydrogeology
 Marathon PGM-Cu Project



Designed By: CL
 Approved By: LN
 Date: May 3, 2012

Total Change in Modeled Groundwater Heads after 6 Years of Mining

FIGURE A2