AGNICO EAGLE

MEADOWBANK GOLD PROJECT

Groundwater Monitoring Plan

In Accordance with Water License 2AM-MEA1525

Prepared by:
Agnico Eagle Mines Limited – Meadowbank Division

Version 8
January 2018

EXECUTIVE SUMMARY

The Groundwater Monitoring Plan, version 8, presents three items: 1) the historic of groundwater monitoring at Meadowbank mine since 2003, 2) the extensive groundwater monitoring campaign achieved on site in 2017, and; 3) a groundwater monitoring program adapted for in-pit deposition operations planned to begin in April 2018. In addition, a review of methodologies and best practices under artic climate conditions is included for drilling, well installation and groundwater sampling.

The annual monitoring plan is a requirement for the Meadowbank Type A Water License No. 2AM-MEA1525 and is a continuation of previous Monitoring Plans. The following activities were fulfilled in 2017:

- The entire groundwater monitoring program was revisited in 2017 to improve the data collected for water quality model updates, as suggested by Environment and Climate Change Canada (ECCC). To achieved this, Agnico Eagle received technical advice and field services from a firm of professionals in the field of hydrogeology and geochemistry;
- The 2017 groundwater monitoring program included seventeen (17) monitoring stations, more specifically: two (2) groundwater observation wells (MW-08-02 and MW-16-01), two (2) lakes, seven (7) wall seepages, four (4) dike seepages, one (1) pit sump, and one (1) reclaim water;
- A total of twenty-nine (29) water samples were collected in the course of two sampling campaigns which includes twenty-one (21) groundwater samples and eight (8) surface water samples;
- The sampling program was repeated twice over the summer. Low-flow sampling techniques were applied. Duplicate and transport blanks were collected;
- Formation of thick ice bridges into the well challenged the sampling of MW-08-02 again this year.

Groundwater chemistry data is used to predict the quality of water accumulating in open pits, and to determine any effects of mining on groundwater quality, particularly with respect to tailings deposition.

Groundwater sampling is carried out twice annually. Analytical parameters will comply as per Schedule 1, Table 1, Group 2 of the Meadowbank Water License. Quality Assurance/Quality Control procedures will be implemented during each sampling event.

In 2018, the installation of three (3) new groundwater monitoring wells is proposed. Strategic locations for the new well are based on groundwater numerical simulation results aiming to reproduce in-pit deposition conditions. Moreover, to improve well designs and groundwater sample quality, best practices under arctic climate conditions continue to be investigated.

A groundwater monitoring report is submitted by Agnico Eagle Mines Limited to the Nunavut Water Board (NWB) with each Annual Report. The monitoring report includes yearly results, dates and methods of sampling. Also, an assessment of the data obtained in relation to salinity parameters and indicators of tailings reclaim water movement (total cyanide and dissolved copper) is included.

IMPLEMENTATION SCHEDULE

This Plan will be implemented immediately (2018) subject to any modifications proposed by the NWB as a result of the review and approval process.

DISTRIBUTION LIST

AGNICO EAGLE – Geology Superintendent

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DOCUMENT CONTROL

Version	Date (YMD)	Section	Revision
1	08/08/08		Comprehensive plan for Meadowbank Project
2	09/03/31	all	Comprehensive update of plan to include 2008 well installations
3	11/12/14		Update Executive Summary; insert Figure 1; update Table 1; addition of information on wells created in 2011; include well installation section;
4	14/01		Update Executive Summary; update Section 1.2 to reflect current wells; add Section 3.3 and 3.4 (seep and production drill hole sampling methods); update Section 5 (additional reporting on tailings-related parameters)
5	15/04	1.3 and 3.3 2.3	Sampling of pit wall seeps discontinued. Sampling of Goose Pit sump added. Updated with installation information for new well.
6	15/09	4.1 and 4.2	Updated list of analyse parameters. QAQC Section to include Trip and Field Blank Remove Goose Pit sump as monitoring station
7	17/03	Section 1.5, 3, 5 and 6	Add Section 5 and 6 and modify section 1.5 and 3
8	18/01/25	all	Comprehensive update of plan

Version 8

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1. INTRODUCTION

The annual monitoring plan is a requirement for Meadowbank Type A Water License No. 2AM-MEA1525.

This document is the 8th version of the Groundwater Monitoring Plan for Meadowbank Mine. This version presents an update of the groundwater monitoring program described in Version 7 (AEM, 2017).

This version relates the historic of groundwater monitoring at Meadowbank mine since 2003, presents the extensive groundwater monitoring campaign achieved on site in 2017, and proposed a groundwater monitoring program adapted for in-pit deposition that will begin in April 2018. Moreover, this document reviews methodology and best practices for drilling, well installation and groundwater sampling, especially under arctic climate conditions.

1.1 PURPOSE OF GROUNDWATER MONITORING

Groundwater data is used as a tool to predict the chemistry of water accumulating in open pits and to determine any effects of mining on groundwater quality, particularly with respect to tailings deposition activities. To this end, groundwater monitoring wells have been installed to sample groundwater in open talik areas, where unfrozen ground extends beneath large lakes. No groundwater monitoring wells is installed at the Vault Deposit, as the Vault Pit area is developed in permafrost.

Groundwater monitoring has traditionally been conducted using installed monitoring wells, but difficulties in obtaining representative samples by this method prompted the investigation of alternative methods from 2013 to 2016 based on technical advice from firms of experts. Nevertheless, groundwater samples are still collected in operable monitoring wells.

In 2017, the whole groundwater monitoring program was revisited, as suggested by Environment and Climate Change Canada (ECCC), to improve the quality of the data collected. Due to sustained difficulties in maintaining and sampling monitoring wells, Agnico Eagle received technical advices and field services from a firm of experts. Professionals in hydrogeology and geochemistry helped optimizing low-flow sampling techniques and opportunities for sampling groundwater from alternative methods. In 2017, an extensive monitoring field program took place and representative water samples were collected across the mine site. The principal goals were to understand the background geochemistry of groundwater and its potential interaction with surface water, especially in relation to tailing migration.

1.2 TAILING STORAGE FACILITY EXPANSION AT MEADOWBANK

Since 2015, Agnico Eagle is evaluating diverse technical options to accommodate additional tailing storage facilities at Meadowbank. After a Multi-Account Assessment (MAA), the In-Pit Tailings Deposition (IPD) was selected as the preferred option to store tailings waste produced from Whale Tail Mine in addition to its current tailings storage facilities (TSF). IDP demonstrated superior performance capacities in the following categories: health and safety, quality of life, water, air, capital cost, technology, natural hazards, and adaptability (SNC-Lavalin, 2016; 2017a).

To ensure the environment protection and evaluate potential risks for tailing migration into groundwater, a feasibility study was conducted by SNC-Lavalin professionals in 2016-2017 (SNC-Lavalin, 2017a). The feasibility study included a complementary characterization of the geological structures and permafrost extent on site and the development of a detailed hydrogeological numerical 3D model. The numerical simulations were designed to represent the worst-case scenarios in terms of contaminant transport within the aquifers. Therefore, a groundwater monitoring program was designed in relation to the groundwater flow and contaminant transport simulation results.

1.3 FUTURE GROUNDWATER MONITORING PROGRAM ADAPTED FOR IN-PIT DEPOSITION AT MEADOWBANK

Meadowbank groundwater monitoring program will be adapted to IDP. After Nunavut Water Board (NWB) approval, IPD could begin in April 2018. IPD would start in Goose Pit, already mined out, with the disposal of tailings produced from the Portage and Vault Pit processed ore, followed by an alternate filling of Portage Pit A and Pit E (SNC-Lavalin, 2017a) with the tailings produced from the Whale Tail Pit ore, if the project certificate and Water Licence A are issued as planned.

Future groundwater monitoring program will be adapted for IPD at Meadowbank. The installation of three (3) new groundwater monitoring wells is proposed. Strategic locations for these three wells were based on groundwater numerical simulation results and 2017 geotechnical borehole data. Moreover, methods to obtain representative groundwater samples and improve well designs under artic climate continue to be investigated. The groundwater monitoring program will be updated as the project progresses. New information from the hydrogeological numerical model and from hydrogeological field data will be integrated throughout.

2. GROUNDWATER MONITORING PROGRAM

2.1 GROUNDWATER MONITORING PROGRAM 2003-2016

Groundwater data is used as a tool to predict the chemistry of water accumulating in open pits, and to determine any effects of mining on groundwater quality particularly with respect to tailings deposition activities. Important components surveyed are chloride concentrations, salinity and Total Dissolved Solid (TDS) calculated via conductivity measurements. Copper and cyanide are also monitored to trace potential effects of mining operations on groundwater quality. To this end, groundwater monitoring wells have been installed to sample groundwater in open talik areas, where unfrozen ground extends beneath large lakes. No groundwater monitoring wells are installed at the Vault Deposit, as the Vault Pit is developed in an area of permafrost.

Groundwater samples have traditionally been collected in monitoring wells. From 2003 to 2016, fourteen (14) monitoring wells were installed at Meadowbank mine. Throughout these years, thirty-four (34) groundwater samples, twenty-one (21) duplicates were collected from these wells. Moreover, for quality insurance three (3) field blanks and 1 transport blank were also collected in the field.

Well installation and groundwater collection have been a major challenge under artic conditions in permafrost environment. Some of the challenges were:

- Well damaged by frost action;
- Heat traces malfunctioning, therefore ice bridges forming in well annulus;
- Well damaged during site operations;
- Well obstructed with development material, once again due to frost action.

Despite multiple attempts to overcome these challenges, the collection of representative groundwater sampled was unsuccessful for most problematic wells. For example, saline solution was used to melt ice bridges formed in well annulus. The concentration of saline solution required to unplug the well could not be purged afterwards, the groundwater flow was not sufficient and the amount of water needed to be purged out of the well unrealistic under permafrost conditions.

Since well installation and groundwater collection have been a tremendous challenge at Meadowbank, alternative methods to obtain representative groundwater samples were investigated from 2013 to 2016 (see 2012 Groundwater Monitoring Report and recommendations by Golder Associates). Alternative groundwater monitoring stations investigated includes: pit wall seepages, production drill holes, pit sumps, horizontal wells installed into pit walls, and temporary wells for pit dewatering.

From 2013 to 2016, six (6) groundwater samples were collected from horizontal wells installed in Pit E southeastern wall, one (1) sample from a temporary well for pit dewatering, two (2) samples from pit sumps during exploitation and one (1) production borehole.

Although production and preshear drill holes with sufficient flow rates only occurred on occasion, when sufficient groundwater flow was encountered, sampling was achieved. Moreover, a sample was collected from a temporary dewatering well (6 inches in diameter, 65 meters depth), installed in Pit E from July to August 2016, to reduce water table and ensure pit slope stability. Prior 2016, seepage from pit walls, commonly occurring at different locations, has indicated surface water rather than groundwater flow.

In 2017, only two (2) wells remain operable for groundwater sampling. Aside from the two wells, none of the previous monitoring stations were available for sampling in 2017. Due to the difficulties encountered in maintaining and sampling monitoring wells, Agnico Eagle contracted experts to obtain technical advice on optimizing low-flow sampling techniques. Moreover, further sampling improvements and pursued opportunities for sampling groundwater from alternative sources as well as the existing wells were carried out. An extensive monitoring field program took place in 2017. The objectives were to: 1) collect representative samples across the mine site; 2) understand groundwater background geochemical conditions and its potential interaction with surface water, especially in relation to tailing migration.

In 2018, the next phase is to apply a groundwater program that will ensure groundwater monitoring in relation to tailing deposition inside the existing pits at Meadowbank.

The locations of each former and existing groundwater wells and other types of groundwater monitoring stations are provided in appendix A.

2.2 GROUNDWATER MONITORING PROGRAM ACHIEVED IN 2017

Two field visits were completed by a SNC-Lavalin professional in the course of summer 2017. A thorough investigation of the pit walls, mine infrastructures, dike seepages and groundwater monitoring stations network was achieved during the site visits. State of the art sampling techniques were performed and each sampling station, which were selected based on their contribution to the global understanding of groundwater quality. A photographic report is presented in Appendix B, showing the sampling procedures and the main water sampling stations. Twenty-nine (29) water samples were collected in the vicinity of Goose Pit, Portage Pit E and Pit A. The groundwater monitoring program 2017 aimed to:

- Improve the density and spatial distribution of groundwater monitoring stations and get representative samples;
- Investigate best practices to improve groundwater sampling methodologies;
- Achieve and repeat a complete groundwater sampling program as well as low-flow sampling techniques for licensing requirements;
- Collect groundwater chemical data required to understand the potential interaction between groundwater and surface water, especially in relation to tailing migration;
- Emit recommendations to improve the groundwater sampling program in the future.

Table 1 summarized the sample collected during the two site visits. In total, the stations sampled are represented by two (2) groundwater wells, two (2) lakes, seven (7) wall seepages, three (3) dike seepages, one (1) sump and one (1) reclaim water. A map illustrating the locations for each water sample is presented in Appendix A. The next section explains the context of each sampling station.

Table 1: Samples collected in 2017

Sample name	Location	Type	July 2017	August 2017
MW-16-01-100 m	Between Central Dump and Central Dike	Groundwater well	X	X
MW-16-01-20 m			X	X
MW-08-02 110 m	Southeast end of Central Dump		X	-
MW-08-02 150 m			X	X
SP-Lake	Second Portage Lake at 30 m depth (open talik)	Deep lake	X	-
Dog Leg Lake	Dog Leg Lake (close talik)		X	-
STS-5	Between Central Dike and MW-16-01	Dike seepage	X	X
ST8-North	Between Central Dump and East Dike		X	X
ST8-South			X	X
BG-Seepage-42 m	Goose Pit	Wall seepage	X	X
BG-Seepage-21 m			X	X
BG-seep-80 m			-	X
Pit A East Wall	Pit A		-	X
Pit A-Seepage			X	-
Pit E-seep-40 m	Pit E		-	X
Pit E-Seepage			X	X
Pit A- sump	Pit A	Pit Sump	-	X
BG Lagoon	West of Goose Pit	Sump/dyke seepage	X	X
ST-21 South	South Cell TSF	Reclaim water	-	X

2.3 MONITORING STATIONS AND SAMPLING METHODOLOGIES 2017

2.3.1 Monitoring well

Only two wells were operable in 2017. Installation details for operational monitoring wells (MW-16-01 and MW08-02) are provided in Appendix C. Details for all other decommissioned wells are presented in the Groundwater Monitoring Report related to the year of installation. Formation of thick ice bridges in the annular space challenged the sampling of wells MW-08-02 again this year. Therefore, sampling protocols were different for the two wells and methodologies are described below.

2.3.1.1 MW-16-01

A portable double valve sampling pump (DVP) was installed permanently at approximately 95 meters down for the well so that the pump is set in front of the screened interval. The well was purged to remove standing water inside the well and to induce a fresh groundwater flow from the rock formation by activating the DVP. The pump is activated by pushing compressed air into a ¼ inch Low Density Polyethylene (LDPE) tubing attached to the DVP. The in-situ physicochemical parameters were measured with a ®YSI multiparameter Probe that was calibrated prior usage. Purged water quality was monitored for pH, electrical conductivity, temperature, water clarity and colour (visual observation) during this operation. A minimum of 3 well volumes (volume of water between the in-well packer and bottom of screened interval) were removed prior sampling and until the monitored parameters stabilized (values remaining within 10% for three consecutive readings).

Groundwater sampling was carried out immediately after well purging with low-flow techniques. Groundwater samples were collected in clean, laboratory-supplied containers. Groundwater was sampled following quality control procedure on sampling and analysis described in section 2.5 and detailed in Appendix D.

2.3.1.2 MW-08-02

Well MW-08-02, installed 191 m below ground, has an ice bridge from 30 m to 150 m. The ice blocking the well annulus was melted using a steamer and clean lake water. It took about 4 hours to melt 120 m of ice from the well. Following this procedure, the well remains free of ice for a maximum of 24 hours. To not dammaged any expensive equipment, the well was purged using compressed air push through a tube lowered 150 m down the well for another 4 hours. Then, the well was allowed to recover for 12 hours to a static water level (30 m) before sampling. Afterwards, a 200 mL clean bailer was lowered 160 m below ground to retrieve a representative groundwater sample just above the screen interval. Groundwater sampling was carried out immediately after purging reading the in-situ parameters and sampling was carried out as mentioned in the previous section.

2.3.2 Dike seepage

The name "dike seepage" as a monitoring station applies to samples collected from dewatering wells (ST-8 North and ST-8 South), installed at the bedrock surface (6 m depth), to control East dike seepages. It also includes sumps created naturally by Central dike seepage (ST-S-5) or sump found between dikes near rock stockpiles (BG Lagoon). In most cases, samples are collected through a tap connected to a dewatering pump.

These sampling stations can be monitored though time, contribute to the understanding of groundwater quality at the mine and can be added to the long term groundwater monitoring program.

2.3.3 Wall seepage

The name "wall seepage" as a monitoring station applies to groundwater collected on pit walls where water comes directly through the bedrock and where a small ¼ diameter LDPE tubing can be inserted into small fracture to prevent the sample to be in contact with the atmosphere. The groundwater runs through the tubing by gravity and physicochemical parameters are recorded and standard sampling procedures are followed.

These sampling stations can be monitored though time, contribute to the understanding of groundwater quality at the mine and can be added to the long term groundwater monitoring program until the pit will be decommissioned.

2.3.4 Pit sump

The name "Pit sump" as a monitoring station applies to groundwater collected at the bottom of a pit when groundwater filled a cavity during exploitation. After interpreting the geochemical data, it can be stated that there is too much ambiguity of the provenance of some elements found in these analysis to pursue the sampling of this sampling station as is.

The interpretation of the results is difficult due to multiple source of contamination possible from mine operations taking place around the sumps such as drilling, blasting, and excavating. Moreover, the exact location of the sampling can never be reproduced year after year. Since an interesting groundwater sample could be collected from the pit bottoms, a good alternative would be to install a temporary well about 10 m from the sump that could be sample for groundwater with proper standard.

2.3.5 Deep Lake

The name "Deep Lake" as a monitoring station applies to water collected near lake bottom at its deepest point. Water was collected through a small ¼ inch diameter LDPE tubing, connected to a peristaltic pump. These samples were collected to verify the quality of groundwater at lake's bottom. Also, it aims to compare the different water geochemistry signatures originating from an open talik and a close talik, and to compare the data with the ones collected on site. These stations were monitored only once in 2017.

2.3.6 Geotechnical investigation holes

Field campaigns in summer 2017 at Meadowbank, included drilling of new boreholes susceptible to encounter groundwater. Attempt was made to collect a groundwater sample at borehole IPD-17-06. Although geotechnical holes are made under controlled conditions when compared to production holes, the inside diameter of metal casing are filled with grease, water is dirty and full of particles. After interpreting the physicochemical parameters for groundwater coming from geotechnical holes, and geochemical data from production holes and preshear holes, it can be stated that these holes are not a proper environment to retrieve representative groundwater samples.

2.4 PHYSICOCHEMICAL AND GEOCHEMICAL PARAMETERS

2.4.1 Groundwater parameters required by the water license

For each samples, field parameters are recorded (pH, turbidity, salinity and electrical conductivity). Analytical parameters included the following (per Schedule 1, Table 1, Group 2 of the Meadowbank Water License):

<u>Total and Dissolved Metals</u>: aluminum, antimony, arsenic, boron, barium, beryllium, cadmium, copper, chromium, iron, lithium, manganese, mercury, molybdenum, nickel, lead, selenium, tin, strontium, titanium, thallium, uranium, vanadium and zinc.

<u>Nutrients:</u> Ammonia-nitrogen, total kjeldahl nitrogen, nitrate nitrogen, nitrite-nitrogen, ortho-phosphate, total phosphorous, total organic carbon, total dissolved organic carbon and reactive silica.

<u>Conventional Parameters:</u> bicarbonate alkalinity, chloride, carbonate alkalinity, conductivity, hardness, calcium, potassium, magnesium, sodium, sulphate, pH, total alkalinity, TDS, and TSS, turbidity.

Total cyanide and Free cyanide. If total cyanide is detected above 0.05 mg/L at a monitoring station in receiving environment; further analysis of Weak Acid Dissociable Cyanide (CN WAD) will be triggered.

2.4.2 Additional parameters

Each groundwater sample has a distinctive signature on the basis of its dissolved concentrations of chemical constituents. Geochemical interpretation of groundwater data can be very useful to support a conceptual model by improving the understanding of groundwater movements and processes along pathways as water composition varies. It can also help identifies zones where surface water is continually interact groundwater or only during permafrost thawing.

The geochemical composition of groundwater is defined by its main anions (HCO_3^-, SO_4^{2-}, Cl^-) and its main cations (Ca^{2+}, Na^+, Mg^{2+} K^+). Mass balance calculations for main ions dissolved in groundwater are a mandatory reliability check for any geochemical analysis (Hounslow, 1995). Mass balance calculations are useful to gain a first insight into water chemistry. From these calculations, groundwater chemical composition can be represented in Piper and Stiff diagrams, which facilitate its interpretation.

For the reasons presented above, additional parameters were also analyses: dissolved calcium, dissolved potassium, dissolved magnesium, dissolved sodium, fluorides, bromides, and ammonium-nitrogen. The following physicochemical in-situ parameters were also recorded on site: Oxydo-reduction Potential (ORP) and Dissolved Oxygen (DO).

2.5 QUALITY CONTROL ON SAMPLING AND ANALYSIS

2.5.1 Handling

The following procedures will be followed to provide data quality control:

- Measurement of field parameters at selected intervals until stable readings (within 10% of each other);
- Minimization of the exposure of the sampled water to the atmosphere;
- Usage of compressed gas to evacuate water during sample collection;
- In-situ measurement of sensitive chemical parameters (pH, electrical conductivity, dissolved oxygen, alkalinity), where applicable; and
- Abiding by sample preservation methods (refrigeration and use of preservatives where needed), and specified holding times;
- Filtering for dissolved metal analysis with a 0.45 microns filter on site.

2.5.2 Duplicates, field and trip blank

A duplicate sample will be collected for one monitoring well per sampling event, and submitted as a blind duplicate to the analytical laboratory. When both results are higher than five times the method detection limit (MDL), the relative percent difference (RPD) will be calculated as:

RPD = absolute difference in concentration/average concentration x 100

USEPA (1994) indicates that an RPD of 20% or less is acceptable. Where one or both results are less than five times the MDL, a margin of +/- MDL is acceptable.

One field and one trip blank will also be collected at each sampling campaign.

3. ADAPTED GW MONITORING PROGRAM FOR IPD

Since 2015, Agnico Eagle is evaluating diverse technical options at Meadowbank to accommodate the storage from the mining of Amaruq ore deposit. After a Multi-Account Assessment (MAA), the In-Pit Tailings Deposition (IPD) was selected as the preferred option to store tailings waste produced from Whale Tail Mine in addition to its current TSF (SNC-Lavalin, 2016; 2017a). Meadowbank Dike Review Board (the "MDRB") supported the use of early in-pit tailings disposal as an attractive alternative in addition to current practices at Meadowbank. Specifically, in-pit disposal of tailings has advantages with respect to health and safety, quality of life, water, air, capital cost, technology, natural hazards and adaptability. The MDRB accepted that in-pit disposal would be recognized as the best available technology.

After regulators' approval, IPD could begin in Q2-2018 with a daily filling rate of 9,000 tons of dry tailings. IPD would start in Goose Pit, already mined out, and followed by an alternate filling of Portage Pit A and Pit E (SNC-Lavalin, 2017a).

To ensure the environment protection and evaluate potential risks for tailing migration into groundwater, a feasibility study was conducted by SNC-Lavalin professionals in 2016-2017 (SNC-Lavalin, 2017a). The feasibility study involved the development of a detailed 3D hydrogeological numerical model that includes the results from a complementary characterization in 2017 of the geological structures and permafrost extent. The groundwater numerical model aimed at representing the hydrogeological conditions found at the mine site, once the deposition of tailing will be finalized. The idea is to reproduce, in this context, realistic groundwater and contaminant transport within talik zones located throughout the permafrost environment. The numerical simulations were designed to represent the worst-case scenarios in terms of contaminant transport within the aquifers. This way, a groundwater monitoring program can be designed in relation to groundwater flow and contaminant transport simulation results.

Moreover, physical and chemical laboratory analyses were performed on Amaruq's tailings, intended to be deposited, to verify their properties and their potential for acid rock drainage (ARD) and release of chemicals (Golder, 2017). Finally, futur groundwater monitoring program will include the monitoring of groundwater quality in the vicinity of pit shells in relation to IPD operations and tailing leaching modelling results.

Future groundwater monitoring program will be adapted for in-pit deposition at Meadowbank. Three new groundwater monitoring wells will be installed at strategic locations based on groundwater numerical simulation results (see appendix A for MW location). Well screen interval will be defined based in 2017 borehole data. Screen depth intervals for each monitoring wells were selected accordingly to the last hydrogeological field investigation, conducted in summer 2017 especially for in-pit deposition prefeasibility study. It targets either the upper bedrock (25 to 50 m deep) which is generally more fractured and permeable than deeper bedrock, but also some deeper fractures that were locally more permeable than the host rock (>50 m deep). The groundwater monitoring program will be updated as the project progresses. New information from the hydrogeological numerical model and from hydrogeological field data will be integrated throughout.

Groundwater samples should be collected from the new wells preceding the first stages of in-pit deposition. The groundwater data will represent background geochemistry data prior to in-pit tailings deposition. Additionally, all monitoring stations sampled in the extensive 2017 program will be pursued when possible in the future. Finally, the groundwater sampling program will be performed twice annually using on-site monitoring wells and other monitoring stations. Low flow techniques will be applied where appropriate, best practice to obtain quality water samples from alternative monitoring stations and improve well design will continue to be investigated. Five percent of the total amount of sample collected will be taken in duplicate. One transport blank and field blank will also be collected during each sampling event (twice yearly). Specific details on sampling methodologies in monitoring wells are provided on appendix D.

4. DRILLING, WELLS INSTALLATION AND GW SAMPLING IN DEEP PERMAFROST ENVIRONMENT: CHALENGES AND SOLUTIONS FOR BEST PRACTICES

The first objective of this section is to review the challenges encounter in deep permafrost environment during drilling, wells installation and groundwater monitoring. Based on current knowledge, the second objective is to propose better practices to successfully install long-lasting monitoring wells and retrieve representative groundwater samples at the Meadowbank mine site. Two tables synthetizing the information from different sources are presented. Table 2 documents the challenges encounter while drilling and installing wells. Some tested methods to resolve the enumerated problems are listed and promising solutions that could be attempt in the future are presented. Table 3 documents the challenges encounter during groundwater sampling.

Table 2: Protocol review for drilling and well design in permafrost setting

Borehole drilling and well design challenges	Tested methodology	Innovative solution (What could be done)
Drilling operation in permafrost.	• Advance the boreholes with standard HQ (Golder 2008 a) • Use heated water for drilling fluid (Golder 2008 a) • The fluid remaining in the borehole should have a target temperature of 60°C as water near boiling may freeze more quickly (Statler et al. 2010) • Borehole instrumentation should be on site and ready for installation once drilling is complete (Statler et al. 2010) • Drilling should proceed more slowly, providing the rock surrounding the borehole to warm up and allow a maximum time for installation of bottom hole assembly (Statler et al. 2010) • A bottom hole assembly is 15 m long and is used to isolate the bottom of the hole to allow sampling and monitoring (Statler et al. 2010) (includes pneumatic packer inflated with N_2 head over propylene glycol, a	***Define permafrost and talik location prior or while drilling*** Temperature gauging should be conducted and logged during drilling operation. This information is key decision parameter for heat tracing cable length and elevation of purge and sampling pumps (Franz Environmental Inc. 2009) Pressure, salinity parameters should be taking in consideration to define talik/permafrost zones

	U tube sampling system with a sample reservoir and a temperature sensor line (Freifeld et al. 2008) • Vertical well have less chances of failure. Inclination must be defined accordingly. • When installing bottom hole assembly, the sampling lines and heat tape should be wrapped with insulation to help prevent freezing • Heat tape should be installed with a safety factor i.e. if the highest thermal conductivity expected is 4 W/mK, plan 10 W/mK (Statler et al. 2010) • Heating cables must be attached on the downward side of the well (Franz 2009).	
Breakage of well pipes. Freezing of the standing water exposed to permafrost in the well causing breakage of well pipes or obstruction within the pipes	Use stainless steel instead of PVC. PVC centralizers were used to keep the well centered with boring but PVC centralizer may fail. Using two inflatable packers; one with the borehole annulus and another with the well pipe, to prevent talik water to rise in the permafrost section (Golder 2008). Inflate packers according to their purpose, note status of packers year after year to follow the same procedure and minimize damage potential (Franz 2009).	Use centralizer made of another material than PVC, the objective is to keep the well riser in the center of the borehole and prevent that the riser pipe assembly bends (Franz 2009).
Packer failure. Water bypass packers due to cold temperature-induced contraction of packer, loss of inflation	Ensure enough fuel in the generator so it can run continuously during purging so that the heating cable work all the time and both inside and outside packers should be inflated.	
Material damage through shipping.	Material shipped to the site must be properly package and should arrived	

Stainless steel tubing damage during shipping, cause leakage through casing	and be inspected well ahead of the time the material is needed to be used (Franz 2009).	
<u>Well installation.</u> Well installed from 2003 through 2014 failed for various reasons	Install pre-pack bentonite wells (Meeting minute on lessons learned at Meadowbank 2016) 1-1/2'' screen is installed in the hole with a 1-1/2 pipe. Prepack bentonite is installed above the screen to create the bentonite plug. Heat trace is tightly taped around the 1-1/2'' pipe during to installation to avoid the heat trace to touch each other and create a shortcut. Metal casing is installed and anchored in the bedrock in order to protect the well from material movement. No more grouting is used to fill the space between the casing and the pipe as it didn't prevent the hole MW-11-01 from collapsing. Packer was used in the past to replace the bentonite Proper well inclination should be considered for well installation and in the case of an incline well, heating cables must be attached on the downward side of the well (Franz 2009).	Verify if using U-sampler methodology with borehole assembly would be better over this

Table 3: Protocol review for sampling representative groundwater in permafrost setting

GW sampling challenges	Tested methodology	Innovative solution (What should be done)
Unrepresentative groundwater sample because of cross contamination. Groundwater sample contaminated by borehole drilling or well operation Mixing between resident groundwater and brines/drill fluid used for drilling restricts a proper interpretation of groundwater chemistry Potential contamination through borehole operations (drill bit, drill cuttings, packers), sampling equipment, sampling environment or during sample transportation		Contamination of samples with drilling brine should be minimized Use a tracer and analyses salinity of drill fluid. Tracer such as sodium fluorescein (Henkemans 2016) or perfluorocarbon tracer (PFT) with drill fluid (Pfiffner et al. 2008) to define the amount of contamination from drilling fluid from sampled groundwater. At the end of the borehole, block the drill string and perform a "wet" pull following borehole drilling to remove as much drilling fluid as possible from the borehole before it froze to the rock surface. To further clean the hole use a bailer (Statler et al. 2010; Pfiffner et al. 2008). Use a sampling system such as: U-Tube (Freifeld 2009) or Thermos bottle concept (Sutphin et al. 2006). Minimize contamination with proper sampling equipment i.e. cleaned pump, sanitized equipment dedicated to borehole, test equipment for contamination, use blank sample and transport blank to verify a potential contamination. Field samples must be immediately preserved using appropriate methods to retain competency for subsequent geochemical analyses (Wilkins et al. 2014).
Ice bridge formation within wells.	Heat tracer cables penetrating the permafrost zone were attached to the outside of the well pipe and were	

Borehole ice formation freezing of the standing water exposed to permafrost in the well also preclude the collection of more than one set of fluid samples from a given borehole due to post drilling formation.	activated at the sample collection time. Ensure generator run continuously to energized heat cables. Use a downhole camera if necessary to inspect well damage before proceeding to groundwater sampling.	
<u>Difficulties encounter while well purging and sampling</u> Melted the nylon line of the DVP pump system used to remove water from the well annulus above the casing packers Inoperable pump in the borehole annulus, therefore packers are of no use. Heat cable (energized to keep the well from freezing)	Required activation of the heating cables to melt the ice in the well prior sampling Use stainless steel tubing connected to the DVD pump rather than nylon	Temperature gauging should be conducted and logged during drilling operation. This will allow defining depth of permafrost and talik water location. This information is key decision parameter for heat tracing cable length and elevation of purge and sampling pumps (Franz Environmental Inc. 2009) Pump should be located within unfrozen water at all times is a key factor in avoiding problems due to freezing groundwater during purging/sampling (Franz 2009)
Line of the U-tube sampling system froze	Use an insulated hose encompassing both the sampling lines and the heat trace cable would have prevented the freezing (Statler et al. 2010; Friefeld et al. 2008).	

5. KEY POINTS AND RECOMMANDATIONS

An extensive groundwater monitoring campaign was achieved on site in 2017

In total, twenty-nine (29) water samples were collected in the course of two sampling campaigns which included twenty-one (21) groundwater samples and eight (8) surface water samples. The groundwater monitoring program included the following seventeen (17) monitoring stations: two (2) groundwater observation wells (MW-08-02 and MW-16-01), two (2) lakes, seven (7) wall seepages, four (4) dike seepages, one (1) pit sump, and one (1) reclaim water;

Monitoring station need consistency (same stations need to be sample through time), and more wells are required. After a preliminary interpretation of groundwater geochemical results, no more attempts to retrieve a groundwater samples should not be done for the following types of monitoring stations:

- MW-08-02 until the well can remain unfrozen for more than 24 h;
- Pit sumps, preshear, production holes and geotechnical holes.

The groundwater monitoring plan for the in pit deposition will consist of the installation of three (3) new groundwater monitoring wells at strategic locations based on groundwater numerical simulation results and 2017. One of these new groundwater wells, installed at east dike, will replace well MW-08-02. Well screen intervals for the new wells will be defined on the basis of 2017 borehole data that indicate permeable fractures. Moreover, Agnico will continue to investigate methods to obtain representative groundwater samples and improve well designs under arctic climate. The groundwater monitoring program will be updated as the project progresses. New information from the hydrogeological numerical model and from hydrogeological field data will be integrated throughout.

Only a few studies are available on deep permafrost environment. In most study, permafrost is defined by the temperature isotherm zero. However, pressure and salinity will influence the actual freezing point of water and therefore the presence or the absence of ice (Stotler et al. 2010; van Everdigen 1976). Pressure, salinity and the visual absence of ice in cores should be considered in the search for talik zones instead of just relying on temperature data.

- Important to define properly talik zones not only based on temperature gradient. Pressure and salinity will influence freezing temperature and the definition of permafrost/talik zone.
- Drilling methodology is the basis to a proper setting form representative groundwater sampling (many procedures have to be followed).

- Groundwater sample contamination can come from many sources, it is important to minimize and prevent the effect of sample contamination as much as possible (avoid drill/brine fluid, purge well as much as possible, clean purging and sampling equipment before use, installed well properly to avoid leakage of cross-contamination of fluid).

There is always a percentage of drill fluid left in the rock formation, so it is relevant to use a tracer to define the percentage of contamination (Pfiffner et al. 2008). Brine and drill fluid get pushed into fractures and former drill fluid stays in the rock formation and risk to contaminate groundwater samples. This would lead to erroneous groundwater salinity and TDS concentrations. When possible, it is suggested to use fresh heated water during the drilling. Cross-contamination between layers can occur as brine water from drilling won't freeze as readily as fresh water, heated fresh water would form an icy zone around the borehole and could be removed during the melting and purging procedures of the monitoring well. Some suggestions include the use of tracer with drilling fluid to define the degree of contamination of a groundwater sample, the usage of a U-sampler known for high purity samples for real-time and laboratory analysis, and a rigorous assessment of sample contamination including subsampling of material in contact with the borehole, drilling lubricant, drill cuttings, tools used for groundwater sampling, etc. The collection of blank samples during well and sampling operation is recommended.

After the drilling operation, if a salt such as calcium chloride is used to prevent the borehole from freezing, it is suggested to measure the quantity of salt added to the borehole and that an extensive purge protocol related to the volume of salt added be done. Moreover, the conductivity of the groundwater remove from the well should be monitored during the purge to ensure removal of the salt added before sampling.

To improve the groundwater well installation and sampling program, Agnico Eagle will make additional efforts to apply the proposed innovative solutions and best practices when possible.

6. REPORTING

An annual groundwater monitoring report will be submitted by Agnico Eagle Mines Limited to the Nunavut Water Board (NWB) with the Meadowbank Annual Report of the following year. This report will include the following information:

- Installation logs for any new monitoring wells;
- Location in UTM coordinates of all groundwater monitoring locations;
- Description of the working condition of the existing wells;
- Date of groundwater sampling;
- Details of sampling methods;
- Analytical results including: field data, laboratory analytical data and QA/QC information;
- Comparative assessment of data obtained to date to input values used in the Water Quality Model for the site (relevant salinity parameters); and
- Comparative assessment of parameters indicative of mine impacts to groundwater, with particular regard to tailings (total cyanide and dissolved copper);
- Actions taken regarding recommendations for the groundwater sampling program.

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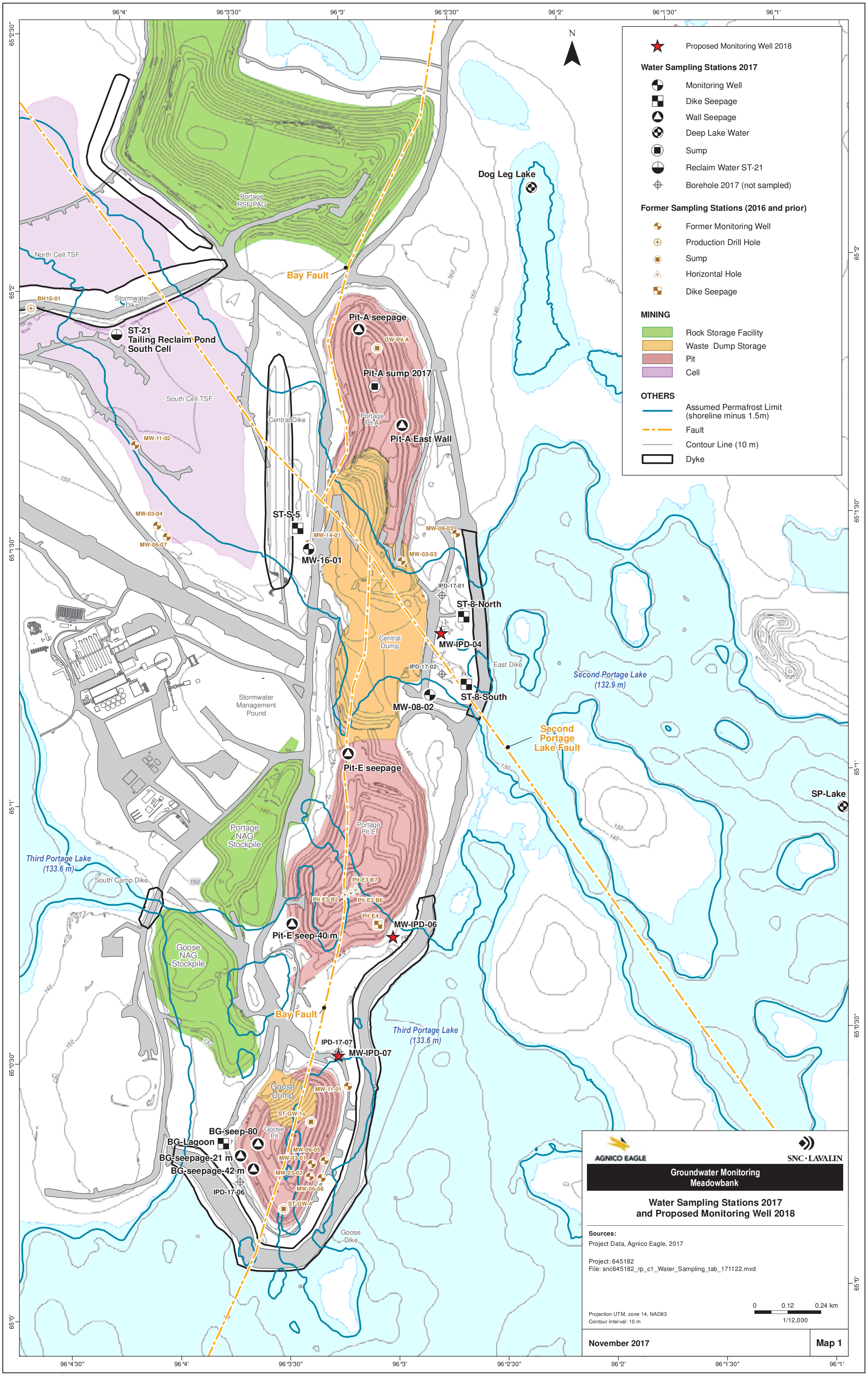
APPENDIX A

Map of former, current and proposed Groundwater Monitoring Stations at Meadowbank



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APPENDIX B

Photographic Report

P1: EQUIPMENT TESTING AND CLEANING

Equipment testing and cleaning prior field work:

Double valve pump (DVP) and control unit were tested. Two DVP pump were taken apart and cleaned with phosphate free soap Liquinox®.

Former control unit Model 466 is out of order and was replaced with a new control unit Solinst 464 250 psi version. https://www.solinst.com/products/groundwater-samplers/464-pneumatic-pump-control-units/electronic-control-unit-datasheet/

P2: SAMPLING GROUNDWATER WELL MW-16-01

Sampling groundwater well MW-16-01:

Groundwater well MW-16-01 was sample with low flow techniques using nitrogen gaz.

A double valve pump (DVP) was installed at around 95 m below ground. The DVP pump was installed at the screen interval level.

The pumps and the tubing were dedicated to the well.

P3-P5: STEAMING AND PURGING ICE IN WELL MW-08-02

Since the heat traces on well MW-08-02 are damaged, the well is blocked with 120 m of ice. He ice is melted with a steamer used with 500 feet of hoses.

Melting 120 m of ice in MW-08-02 takes about 2 hours. Some water comes back up the well since ice is obstructing the well.

MW-08-02 was purged with compress air to remove the melted ice and the water added through the steaming operations. All the operations to free the well from ice together take an entire day. Despite the extensive purging, it is impossible to remove all trace of the operation from the well. The hose have to be extended on the ground and dirt end up going into the well. It is impossible to keep all material clean.

P6-P8: SAMPLING GROUNDWATER WELL MW-08-02

The water level is measured. If the groundwater level is back to its static level of about 30 m for this well, a groundwater sample is collected. At this points ice already stated to form in water.

To retrieve a water sample closest to the screened interval, a rope and a metal rod are taped on the 200 mL clean bailer plastic bailer. The bailer is lowered down to the maximal depth of 160 m for this well where a water sample is collected. It takes twenty (20) full 200 mL bailer to fill the bottles for the required analysis.

Despite the fact that sample collected in July is similar in composition from the one collected in September, there are too much variability in major constituent. This is not a proper method to sample this well. The well would need to be purged with a DVP for multiple hours before collecting a sample.

P9: SAMPLING DIKE SEEPAGE ST-8-NORTH

A temporary well is installed at ST-8 North for dewatering. The well is 6 m deep. A sample through a tap connected to a dewatering pump

P10: SAMPLING DIKE SEEPAGE ST-8-SOUTH

A temporary well is installed at ST-8 South for dewatering. The well is 6 m deep. A sample is collected through a tap connected to a dewatering pump.

P11: SAMPLING DIKE SEEPAGE ST-S-5 (SURFACE WATER)

ST-S-5 is a dyke seepage that is continuously pumped. A sample is collected through a tap connected to a dewatering pump installed at the bottom.

P12-P16: SAMPLING DIKE SEEPAGE LAGOON BG (SURFACE WATER)

Water level higher in July

Water level in September (much dryer)

P17-P18: SAMPLING WALL SEEPAGE BG-21 m

The pit walls were carefully investigated to find seepages accessible that were: clearly coming from the rock (groundwater), and that had a flow sufficient to be sampled.

Clean LDPE ¼ diameter tubing is inserted into the bedrock cavity to capture groundwater and prevent it to come in contact with air.

The water runs by gravity into a flow through cell, one again to prevent water to come in contact with air, to measure representative multiple physicochemical parameters with a YSI Pro 556.

All wall seepages are sampled the same manner.

P19-P20: SAMPLING WALL SEEPAGE BG (42 m and 80 m)

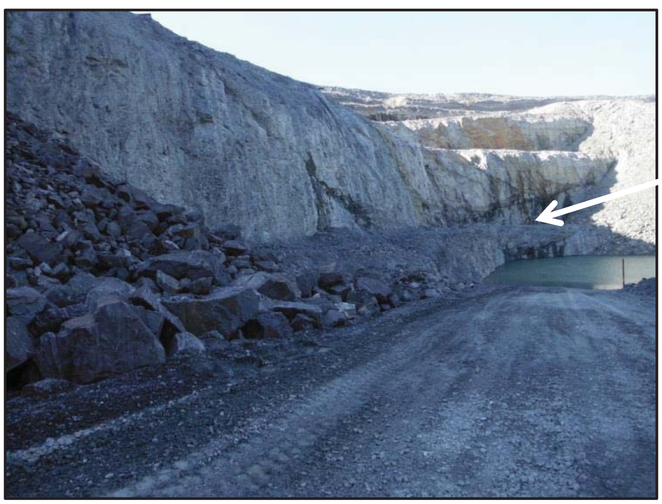
July - Sampling groundwater at Bay Goose Pit wall at approximatively two benches down the ground surface ~42 m.

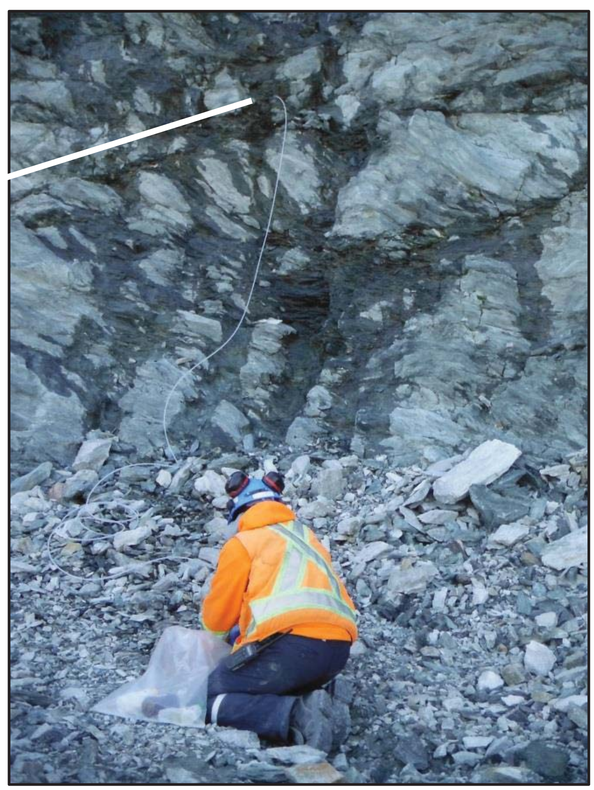
A tube is inserted into the wall to capture groundwater and prevent it to come in contact with air.

September - Sampling groundwater at Bay Goose Pit wall at approximatively two benches down the ground surface ~42 m.

A tube is inserted into the wall to capture groundwater and prevent it to come in contact with air.

The ice on the ramp had melted.





September - Sampling groundwater at Bay Goose Pit wall at approximatively four benches down the ground surface ~80 m.

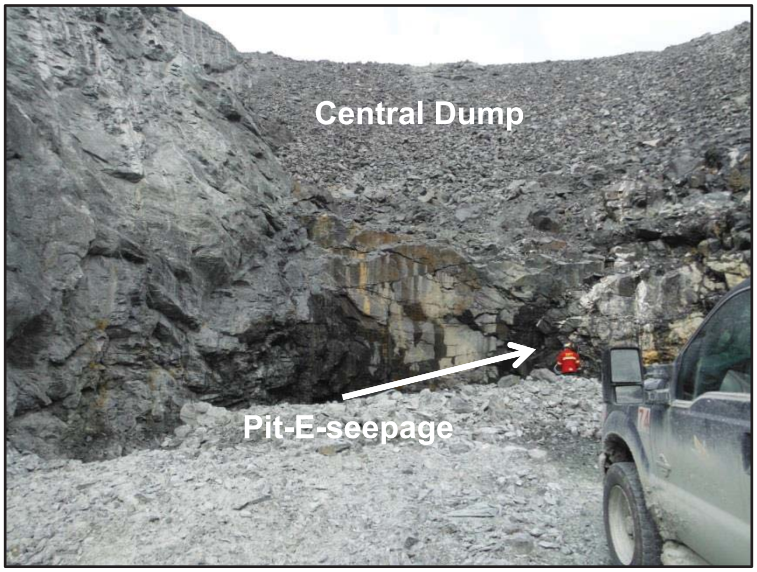
A tube is inserted into the wall to capture groundwater and prevent it to come in contact with air.

P21-P24: SAMPLING WALL SEEPAGE PIT A

July - Sampling groundwater on Pit A north wall, not enough water was flowing to sample this wall seepage in September

Septembre - Sampling groundwater on Pit A east wall.

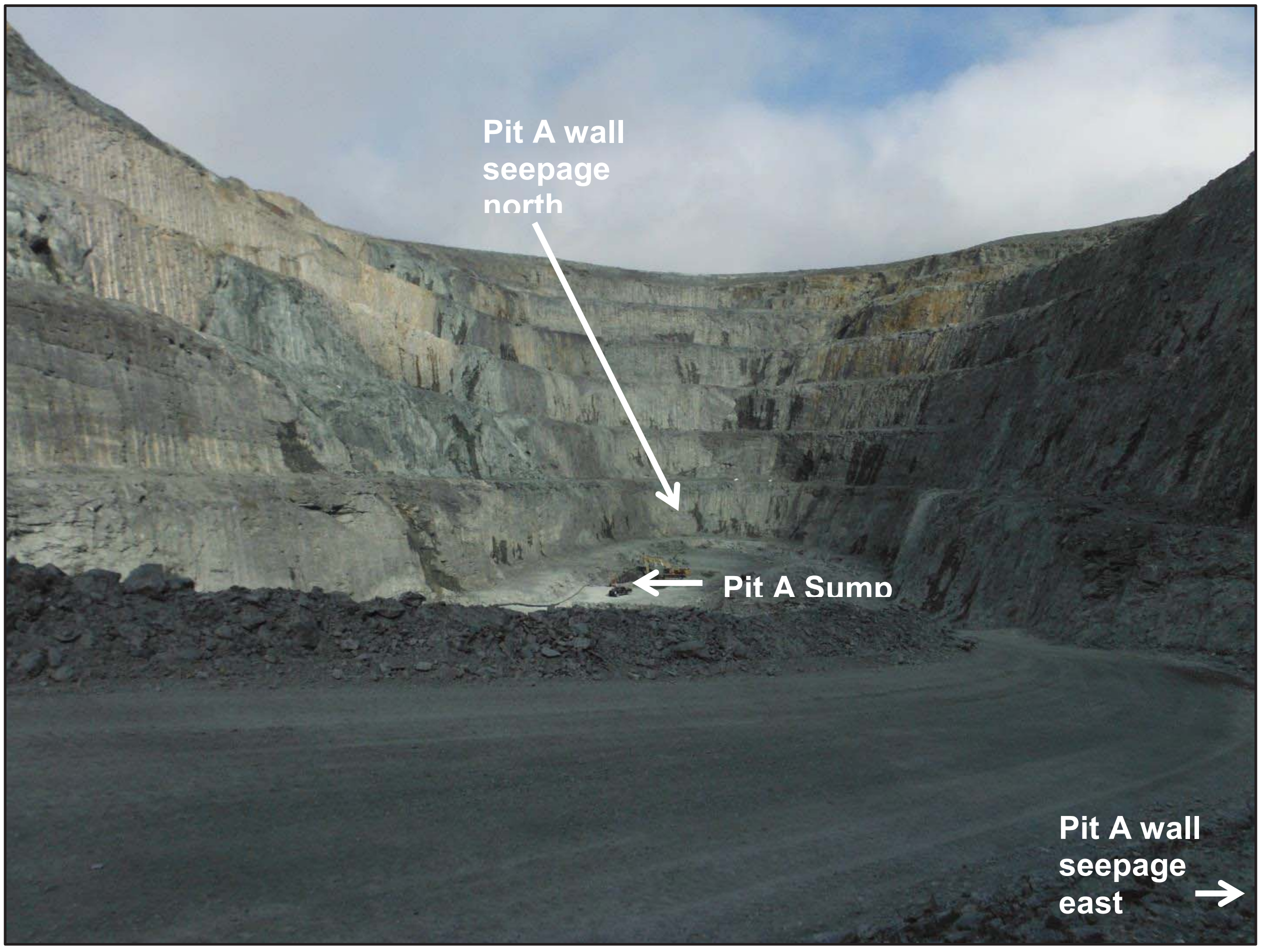
P25: SAMPLING WALL SEEPAGE PIT E



July and Septembre - Sampling groundwater on Pit E interface with Central dump

P26: SAMPLING WALL SEEPAGE PIT E WEST WALL

P27-P28: SAMPLING PIT A SUMP

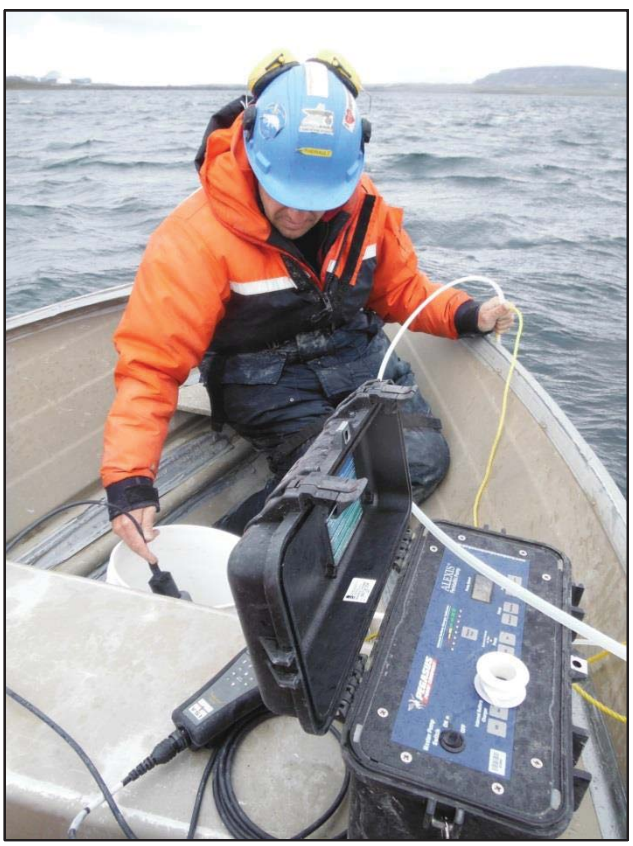


Septembre - Sampling groundwater on Pit A sump. Clean LDPE tubing was used with a peristaltic pump to sample the sump. However, the ground was too reworked and there was to much sediments in suspention for the sample to be representative of groundwater. When water comes up in pit bottom during exploitation, a temporary well could be installed to sample groundwater with standard methods.

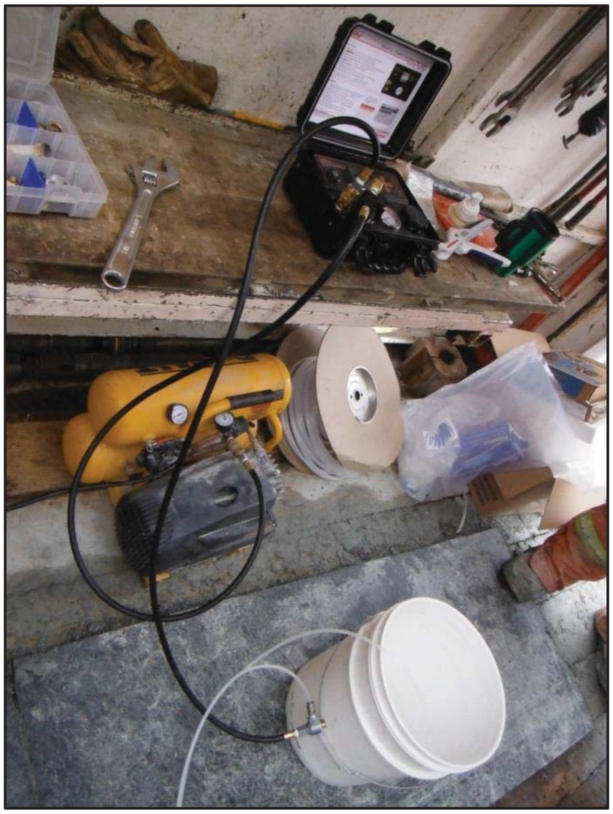
P29-P31: SAMPLING DEEP LAKE (SURFACE WATER)

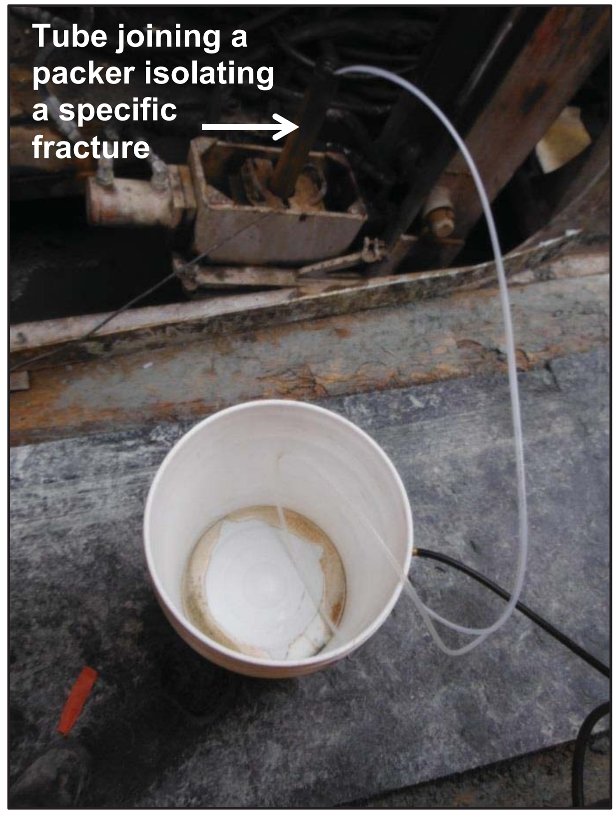
July – Two lake samples were collected. A metal rod was attached to clean LDPE ¼ diameter tubing. The rod and tubing were lowered down into the lake where bathymetry was known to be at its deepest for the area.

Water was pump via a peristaltic pump and physicochemical parameters were recorded via the flow through cell before taking a sample. Water was dirty at first because the rod inserted to Lake Bottom, but became clear soon after the beginning of pumping.



P32-P34: SAMPLING GEOTECHNICAL BOREHOLES

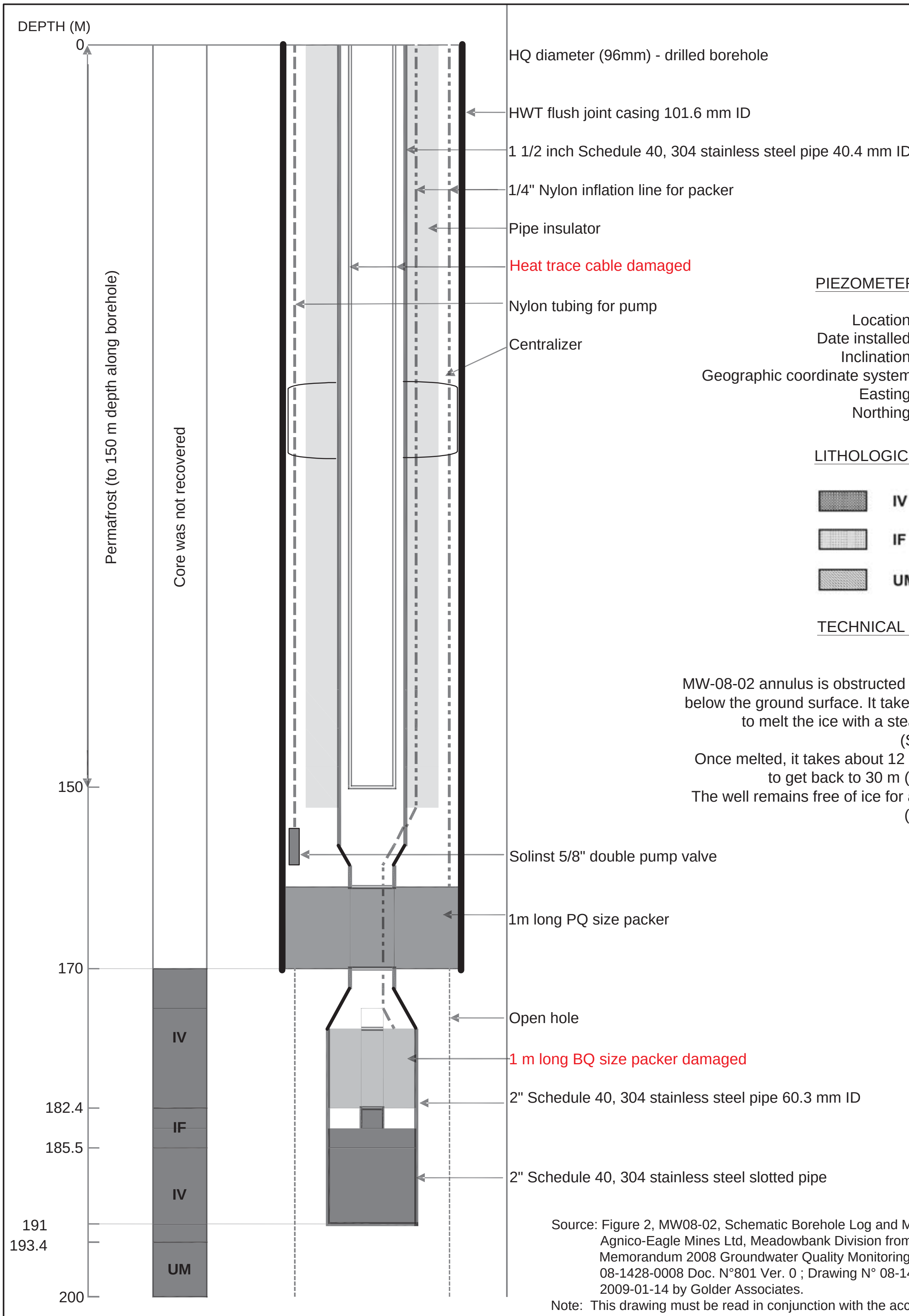




An attempt was made to sample IPD-17-06 Geotechnical hole at interval 140,6-146 m – A double valve pump was lowered down as closed as possible to the open screened interval (7,7 m above). The pump was operated with compress air instead of nitrogen. However, it was soon realized that the water coming out was too dirty to be sampled and that it would be impossible with the equipment in place to get cleaned water since the pump was too far from the screened interval. The inside of the casing were full of grease.

APPENDIX C

Well MW-16-01 and MW-08-02 construction



PIEZOMETER COMPLETION DETAIL

Location:	Meadowbank
Date installed:	November 2016
Inclination:	70°
Geographic coordinate system:	UTM NAD83 ZONE 14
Easting:	638750.9
Northing:	7214427.3

LITHOLOGIC UNIT LEGEND

- **IV** Intermediate Volcanics
- **IF** Iron Formation
- **UM** Ultramafic

TECHNICAL NOTE

Heat traces are damaged.
MW-08-02 annulus is obstructed by ice from 30 m to 150 m below the ground surface. It takes a minimum of four hours to melt the ice with a steamer and 500 feet of hose (SNC-Lavalin: 2017-07-17).
Once melted, it takes about 12 hours for static water level to get back to 30 m (SNC-Lavalin:2017-07-18).
The well remains free of ice for a period of about 24 hours (SNC-Lavalin:2017-07-18).

Source: Figure 2, MW08-02, Schematic Borehole Log and Monitoring Well Instrumentation, Agnico-Eagle Mines Ltd, Meadowbank Division from Appendix C4 Technical, Memorandum 2008 Groundwater Quality Monitoring Program, Meadowbank Mine, 08-1428-0008 Doc. N°801 Ver. 0 ; Drawing N° 08-1428-0008/7000 realized the 2009-01-14 by Golder Associates.

Note: This drawing must be read in conjunction with the accompanying report.

SNC·LAVALIN

PROJECT : AE Meadowbank Groundwater Monitoring

CLIENT : AGNICO EAGLE

TITLE : MW08-02 Schematic Borehole Log and Monitoring Well Instrumentation

N°	DESCRIPTION	DATE
00	For consultation	2017-11-02

DRAWN :	VERIFIED :
É. Cazeneuve	L. Tremblay

SCALE:	DATE :	FILE:	NO:
-	2017-11-02	645182	02

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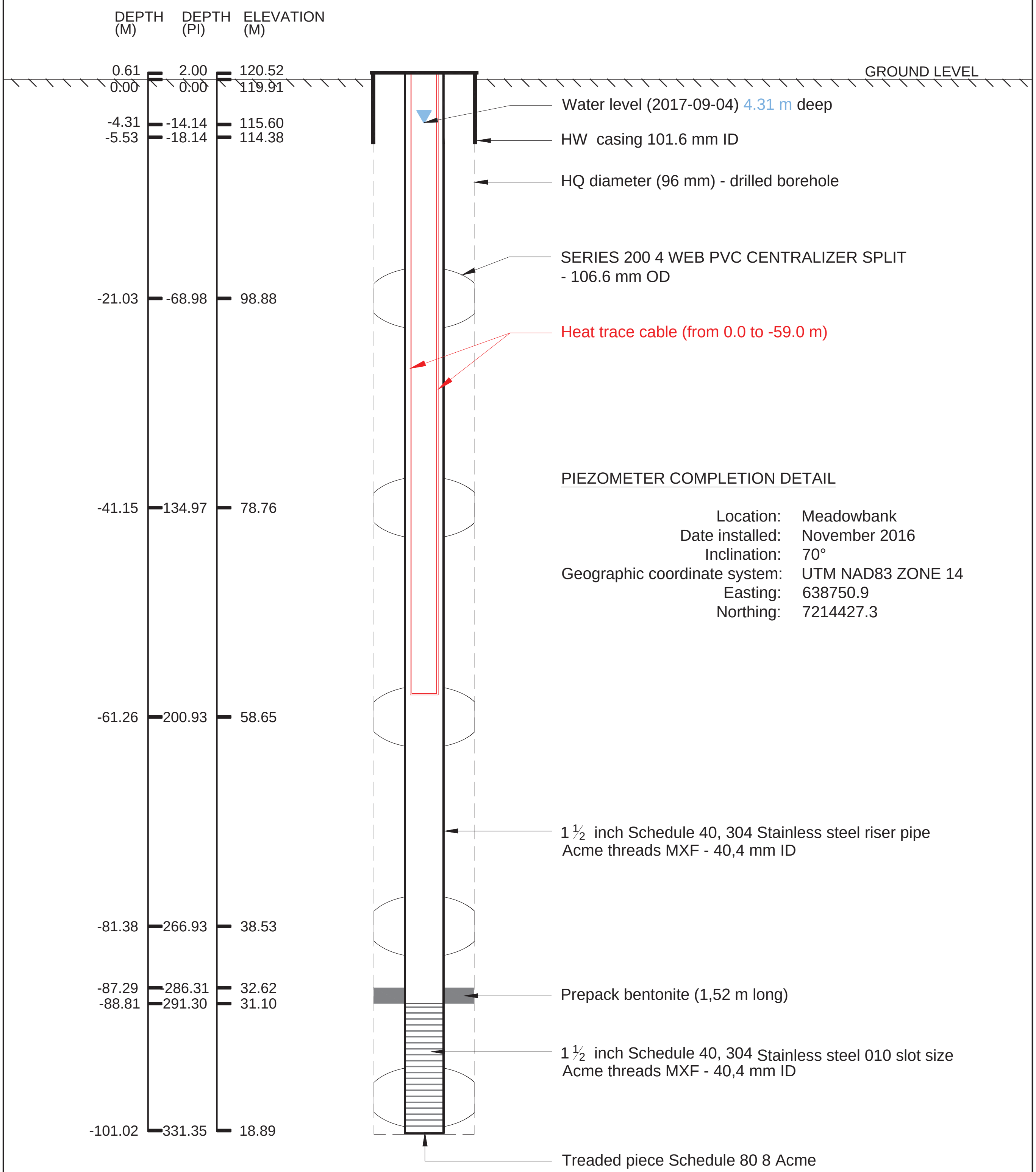
FORMAT 8,5x11



Note : This drawing must be read in conjunction with the accompanying report.

SNC·LAVALIN

PROJECT : AE Meadowbank Groundwater Monitoring

CLIENT : AGNICO EAGLE

TITLE : MW-16-01 Schematic Monitoring Well Instrumentation

DRAWN : É. Cazeneuve

VERIFIED : L. Tremblay

N°	DESCRIPTION	DATE
00	For consultation	2017-11-02

SCALE:	DATE :	FILE:	NO:
1Y : 10X	2017-11-02	645182	01

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APPENDIX D

Standard Operating Procedure for Sampling of Groundwater Monitoring Wells

WORK INSTRUCTION

Purpose:

- Conduct a groundwater monitoring program to investigate mining impacts on local GW. This is in accordance with both our NWB and NIRB permits.
- Standardize methodologies

Groundwater Sampling SOP:

GW sampling consists of measuring field parameters and collecting GW samples within the designated bottles.

Material needed:

- 3 Nitrogen tanks (JDE number 134720)
- Nitrogen regulator
- Solinst double valve pump
- Control unit 464 ECU 250 psi
- Black drive line and supply line
- Dual bonded tubing 500ft coil for the DVP
- Clean pails
- Calibrated Cond./pH/Temperature probe (PCStestr 35 or multi-parameter probe)
- Water level probe
- Adaptor, Fitting, Ring, Tools
- 2 pairs of Vise-grip
- Sampling bottle
- Syringe and adapted 0,45 micron filters
- Nitrile gloves
- Permanent marker

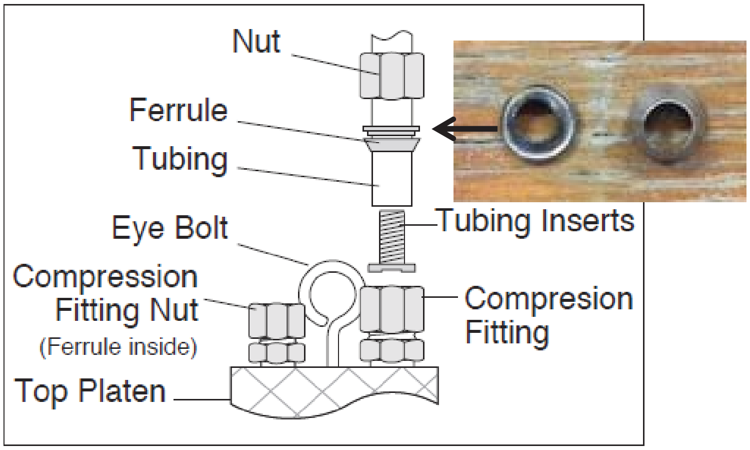
Procedures to be done in 2018 for existing GW Wells

MW-16-01

Heat traces are working permanently; therefore this well is free of ice. The DVP pump is already installed into the well at a depth of 95 m below ground surface. Measure the water level first. Then connect black drive and supply line with the nut on the tubing coming out of the well and to the nitrogen tank. See details below

Sample the water in the well

1- Place the ¼ inch double waterra line on the Solinst double valve pump. Already done, but here a schematic



https://www.solinst.com/products/groundwater-samplers/464-pneumatic-pump-control-units/electronic-control-unit-datasheet/

2- The ¼ inch line is double. One line will bring the water to the pail to be sampled and the other one will send nitrogen to the pump located at the bottom of the well. Make sure to identify which line is the one for nitrogen and which line is for water (longest metal tale on the pump is for nitrogen) (see Solinst instruction).
3- Connect the black hose to the Nitrogen control box (AIR OUT)
4- Connect the black hose (AIR IN) to the connector on the waterra line.
5- Connect the regulator to the nitrogen tank and slowly open the Nitrogen tank the pressure calculated for the water head into the well to be sample. **NEVER EXCEED 250 psi**. Test the Nitrogen tank before connecting to the control unit.

6- On the control box press RUN than put the menu on AUTO mode (fast).
7- See instruction to set up personalised drive and vent ranges.
8- This should take 1 minute before there is a water inflow.
9- Let it run for 30 minutes, measure parameters + record multi-parameter with the PCSTestr 35 or probe and sample the water. Record all field parameters results.
10- For filtering sample, fill the syringe directly with the water coming out of the ¼ diameter LDPH tubing and filter directly into dissolved metal bottles.

Optimizing Pressure

The key to a representative sample, especially when monitoring for volatiles, is to not allow drive gas to enter the pump and aerate the sample water during a drive period. This means you need to carefully calculate the appropriate amount of pressure to be applied. Always calculate pressure based on depth to static water level (measure the water level). In the case of MW-16-01 it is 5 m = 15 feet) (plus 10 psi for line loss), increasing only incrementally to improve performance so 25 feet.

The pressure needed is calculated based on the fact that it takes about 1 psi of pressure to raise 2.3 ft. of water. To calculate pressure needed in psi, take depth to static level in feet, and multiply by 0.43 psi/ft. (1 psi / 2.3 feet = 0.43 psi/ft.). E.g., if depth to static water level is 50 ft., the pressure needed is calculated by the following:

50 ft. to static level x 0.43 psi/ft. + 10 psi = 32 psi needed.

Refer to Solinst Website for more instruction: https://www.solinst.com/products/groundwater-samplers/408-double-valve-pumps/technical-bulletins/getting-best-quality-samples-double-valve-pump.php