Appendix B1

Report: 2017 Annual Geotechnical Inspection

Letter: Implementation Plan for 2017 Annual Geotechnical Inspection Recommendations

February 2018

REPORT ON

2017 Annual Geotechnical Inspection Meadowbank Gold Mine, Nunavut

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REPORT

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Golder Associates

Executive Summary

Agnico-Eagle Mines Limited (AEM) mandated Golder Associates Ltd. (Golder) to conduct the 2017 geotechnical inspection of the Meadowbank Gold Mine Project to comply with the requirements of AEM's Water Licence Permit. The inspection was conducted from September 7 to September 14, 2017, and covered the geotechnical aspects and the review of the available instrumentation data for the dewatering dikes, the tailings storage facility (TSF) structures, the structures along the All-Weather Private Road (AWPR), located between the mine site and the town of Baker Lake, as well as the newly built Amaruq road, located between the mine site and the Amaruq site under development, the bulk fuel storage facility at the mine site and at Baker Lake, as well as other site facilities such as site roads, the landfill, the landfarm, the Stormwater Management Pond, the RSF till plug, the diffusers, the erosion and sediment protection structure and the airstrip.

At the time of the inspection, and based on the instrumentation data, the condition of the dewatering dikes appears stable. It is recommended to flag the piezometers that recorded data below 0°C in the past at East Dike and Bay-Goose Dike and be very careful when interpreting their data, as they might be broken. Once a piezometer has frozen, it cannot be relied upon even if it thaws.

It is recommended that the ultramafic waste rock stockpile continue to be kept at a distance from the downstream toe of South Camp Dike to allow for good visual observation of the downstream toe area. No geotechnical concern were identified on Vault Dike.

The settlement and tension cracks observed in 2013 and 2014 on the upstream side within the thermal cap of Bay-Goose Dike were still visible but seem no longer active. The water pond at the downstream toe and the seepage downstream of Bay-Goose Dike and into Bay-Goose Pit should continue to be monitored. North Channel, Channel 1, and Channel 3 should be carefully monitored as the instrumentation or field observations seem to indicate that seepage could be occurring at these locations but is directly reported to the Pits instead of the downstream toe of the dike. Monitoring of the impact of Portage Pit mining on the performance of Bay-Goose Dike is underway as the North Channel piezometers react to E5 mining activity. The seepage from Central Channel should continue to be monitored.

At the time of the inspection and based on the instrumentation data, the TSF structures were generally in good condition. The tailings beach was adequate against the whole length of the structures, except on the downstream side of Stormwater Dike, the divider dike between the two cells of the facility. Having direct ponding water within Storwater Dike foundation is geotechnically acceptable. For South Cell closure and environmental aspects, given that it is inferred that the SWD foundation presents some open windows of exposed fractured bedrock that may contribute to feeding the seepage at Central Dike, it is recommended that a beach be put in place along SWD downstream slope to seal the foundation. AEM is closely monitoring the formation of a tailings beach against the peripheral structure of the TSF. Water was observed on the downstream side of Saddle Dam 2 ponding within the rockfill embankment, as per the last three years, but the thermistor indicates that the foundation and upstream toe remain frozen.

Several tension cracks associated with movement were observed in an area of the Stormwater Dike crest. These movements appeared in July and August 2017 shortly after water from the South Cell started reaching this sector at the toe of the dike and stabilized after freshet. The movements observed are happening in a sector where the dike was built on frozen soft sediment and itis inferred that they are caused by the South Cell water that progressed

over the dike foundation and thawed the soft layer. The inferred mechanism is the same as for the movements observed in 2016 for which an investigation and instrumentations carried out demonstrated that is the most probable mechanism. Given the deep intrusion of rockfill particles into the soft sediment observed during the 2016 investigation, a foundation failure was demonstrated, by use of stability analysis, unlikely. In the meantime, it is recommended to continue monitoring potential movement on Stormwater Dike and follow the emergency response plan if the situation deteriorates.

A water pond is accumulated on the downstream side of the Central Dike. This pond is fed by an underground seepage that is connected to some extend to the South Cell. During the inspection, water was observed ponding at the downstream toe of the dike between approximately Sta. 0+300 and the southern access road at Sta. 0+830. The water was clear with no sign of turbidity, although AEM reported that an orange coloration along with high turbidity and rapid temperature variations was observed during most of the open water season in 2017. This event has been investigated by AEM and has been attributed to precipitation of iron oxide from bacterial processes. At the time of the inspection an average flow of approximately 540 m^3/hr was pumped back to the South Cell to maintain the downstream pond at El. 115 m. A complementary investigation was carried out early summer 2017 to close data gaps in the vicinity of the dike foundation to better assess the conditions and potential risks for Central Dike. The results of the complementary campaign concur with the seepage-stability models used in the winter 2017 dike performance assessment, where the investigation results indicate that the water transmissivity is more likely controlled by the fractured bedrock than by the till layer. Therefore, it is considered that there is no need to review the winter 2017 seepage-stability models nor use 3D numerical analysis to reassess the Central Dike performance. It is considered that the further numerical model would not help to better understand and anticipate the conditions, nor manage the risk. It is considered that the best mitigation measure to decrease the seepage rates and the stability risk is to focus on decreasing the hydraulic gradient of water beneath the dike foundation. It is recommended to decrease the hydraulic head by lowering the water elevation within the TSF South Cell, deposit tailings over the entire basin floor, and direct the pond's maximum head of water to an area providing better control above the bedrock surface, where the maximum anticipated lakebed sediment and till thickness are present. The design basis of Central Dike is thus modified: it does not serve to promote deposition of tailings in front of containment structure only anymore, but rather also to provide blankets over suspected seepage entry points such as exposed bedrock surface along shoreline or beneath Stormwater Dike foundation. During the fall of 2017, the water level of the reclaim pond was progressively lowered to reduce the hydraulic pressure on the seepage and tailings deposition occurring along Saddle 4 toward Saddle Dam 5. According to AEM, this reduced the average seepage flow to 330 m^3/hr.

No geotechnical issues were identified with the culverts along the AWPR. It is recommended to pay particular attention to culverts R-00A, 5+700, PC-14 and PC-16. If insufficient capacity to handle the flows is observed at freshet, then it is recommended to clear the obstructions or repair the culverts. It is also recommended to monitor the progression of the erosion of culverts at freshet at PC-17A, PC-11, R14, R18-B, R20, R23 and R24 as there are signs that water is flowing beneath the road at these locations. If the erosion condition continues to deteriorate at these culverts, it is recommended to repair them. The bridges along the AWPR were in good geotechnical condition. Signs of settlement were observed at Bridge 6, R15. The bridge was dipping toward the western side on both abutments. The bridge foundation did not show any signs of adverse conditions. No remediation work is recommended for the moment, but the situation should be monitored.

No geotechnical issues were identified with the culverts along the Amaruq Road. It is recommended to pay particular attention to culverts #47, #61, #70, #83, #86 and #278. If insufficient capacity to handle the flows is observed at freshet, then it is recommended to clear the obstructions or repair the culverts. It is also recommended to monitor the progression of the erosion of culverts at freshet at culvert #167 as there are signs that water is flowing beneath the road at this location. Culvert erosion should be monitored at freshet. The bridges along the Amaruq Road were in good geotechnical condition.

It has been observed that most quarries along the AWPR had been cleaned since the 2015 inspection, although some walls need scaling. Presence of unstable blocks and loose rocks along steep walls were still observed in Quarries 3, 7, 9, 10, 16 and 23. It is recommended that workers be cautious in these quarries and be made aware of the potential hazard.

At the time of the inspection, all of the quarries and eskers along the Amaruq Road were dry, except Esker #2 and Esker #5, where thaw water was flowing into the environment and must be checked for TSS. Unstable loose rocks along steep walls and unstable soil slopes were observed in all eskers and quarries, except Esker #5. It is recommended that workers be cautious in these locations and are aware of the potential rockfall hazard.

No geotechnical issues were observed with the Meadowbank Vault fuel tank and the Amaruq fuel tank farm. Water was observed ponding in several areas at the Baker Lake fuel tank farm and at the Meadowbank Main Camp fuel tank. Ongoing removal of fluids that accumulated within the secondary containment facilities should be managed to minimize the amount of water in contact with the tank bases. At the Baker Lake fuel tank farm, the granular fill protecting the geomembrane was eroded, thus exposing the geomembrane all along the south side of Tanks 3 and 4 and on the west side of Tank 1. The geotextile was torn and fallen down the slope. A 300 mm deep depression was also observed on the crest above the exposed geomembrane. A hole in the exposed geomembrane was also observed on the south side of Tank 3. A fold in the geomembrane was observed at the northwestern corner of Tank 2. It is recommended to cover the exposed area with geotextile and fill material to re-establish the liner protection. A hole in the exposed geomembrane was also observed at Baker Lake on the south southwestern corner of Tank 3 at the toe of the slope. The hole in the geomembrane should be repaired to ensure a good performance of the retention basin. The geomembrane remains uncovered around the tanks of the twenty Jet A fuel tanks at Baker Lake. The bituminous geomembrane is damaged by the Jet A fuel (melting). It is recommended to remain vigilant during the freshet and throughout the year to manage water accumulated within the bermed area. If the melting of bituminous continues to occur, the seepage barrier may be treaten in a way that contaminated water will seep into the environment. At the Meadowbank Main Camp fuel tank, a 3 m long tension crack was observed on top of the subexcavated area behind the fueling station and seems stable.

It is recommended to monitor at freshet the performance of the five culverts installed on Vault Road, as three of them are partially collapsed in the middle. One of them had an entirely obstructed inlet and one of them had a collapsed outlet.

It is important that the diversion ditch and its erosion protection structure and sediment barriers be inspected during the next freshet season.

The diffuser at Wally lake (Vault) was relocated in a deeper part of the lake and is functioning normally. No geotechnical concerns were identified with the diffusers, landfill, landfarm, Stormwater Management Pond, nor the airstrip.

Study Limitations

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1.0 INTRODUCTION

Agnico-Eagle Mines Limited's (AEM) Meadowbank Division mandated Golder Associés Ltée (Golder) to conduct the 2017 annual geotechnical inspection, pursuant to the requirement of Type A Water Licence Permit No. 2AM-MEA0815 for the Meadowbank Gold Project, Nunavut.

Under Part I, Item 12 (pages 23 and 24), AEM is required to undertake an annual geotechnical inspection of its facilities between the months of July and September. The following structures were covered by the inspection:

- Dewatering dikes (East Dike, South Camp Dike, Bay-Goose Dike and Vault Dike);
- Tailings storage facilities (Stormwater Dike, Saddle Dam 1, Saddle Dam 2, Saddle Dam 3, Saddle Dam 4, Saddle Dam 5 and Central Dike);
- South Cell pond (reclaim pond);
- Geotechnical instrumentation;
- All-Weather Private Access Road (AWPR), Amaruq Road and site roads (in particular culverts and bridges at water crossings);
- Quarries on site and along the AWPR and Amaruq Road;
- Landfill and contaminated soil storage and bioremedial landfarm facility;
- Bulk fuel storage facilities at the mine site and in Baker Lake;
- Shoreline protection and diffusers;
- Sediment and erosion control structures;
- Other structures: sumps, airstrip, RSF till plug, Stormwater pond, diversion ditch.

The 2017 geotechnical inspection was conducted from September 7 to September 14, 2017, by Yves Boulianne, a professional geotechnical engineer from Golder. During the inspection, the weather was overcast to sunny with daily temperatures varying between 5°C and 15°C. The inspection was scheduled at the time of year when the seasonal depth of thaw (active layer) is expected at, or near its maximum. Surface water flow is generally low to moderate at this time of year. Peak water flows typically occur during the spring thaw (mid-June through mid-July).

This report describes the geotechnical aspects of the areas inspected and presents general observations and recommendations.

Figure 1 shows the main mine site area. At the time of the inspection, the structures of the South Cell of the Tailings storage facility (Saddle Dams 3, 4 and 5 and a portion of Central Dike) were being raised to El. 145 m and tailings deposition was ongoing in the South Cell from the south side of Central Dike.

An external review board, the Meadowbank Dike Review Board (MDRB), periodically meets to review dike designs, construction activities, as-built information and other geotechnical aspects of the project. The MDRB members were present on site in September during the 2017 annual geotechnical inspection.

1.1 Scope Limitations

The scope of the inspection is limited to the geotechnical aspects of each of the facilities listed in Section 1.0 above. The inspection did not include other assessments such as structural, mechanical or environmental.

For additional information related to the limitations of this scope, reference should be made to the Study Limitations provided at the beginning of this report.

2.0 DEWATERING DIKES

The dewatering dikes at Meadowbank include: East Dike, South Camp Dike, Bay-Goose Dike and Vault Dike. East Dike has been in operation since the dewatering of the northwestern arm of Second Portage Lake was completed in 2009. Bay-Goose Dike and South Camp Dikes became operational in July 2012 when the dewatering of the Bay-Goose Basin was completed. Construction of Vault Dike was completed in March 2013 and phase 2 of the dewatering of Vault Lake was completed in 2014.

The most current versions of the Operation, Maintenance and Surveillance (OMS) Manual (AEM, 2017a), and of the overall Emergency Response Plan (ERP) for the mine (AEM, 2017b) are dated March 2017 and June 2017. The Emergency Preparedness Plan (EPP) is included within the OMS. It is good practice to review these documents each year to keep the information up to date, particularly the 24-hour contact name and phone number.

A detailed visual inspection of the dewatering dikes is performed by AEM at least once a month. The monthly inspection reports were reviewed as part of the annual inspection. Most of the instruments on East Dike and Bay-Goose Dike are connected to a system that automatically collects and transmits data every 3 hours. Data for all instruments can be visualized on the software (VDV) and are checked daily by the mine engineering team. A review of the instrumentation data for the dewatering dikes is presented in Section 4.0 of this report.

Figure A1 shows a plan view of East Dike, Figures A2-A3 show a plan view of South Camp Dike and Bay-Goose Dike, and Figure A4 shows a plan view of Vault Dike. These figures indicate the location of the photos taken and observations noted during the inspection.

2.1 East Dike

East Dike is located on the east side of Portage Pit, and isolates the northwestern arm of Second Portage Lake. Dewatering of the northwestern arm of Second Portage Lake allowed for the development of Portage Pit and the construction of the Tailings Storage Facility. At the time of the inspection, East Dike served as an access road to the northern portion of Bay-Goose Dike and had not been used as a haul road since 2011.

East Dike was constructed in the summer of 2008; grouting of the foundation and bedrock occurred in 2008 and during the first quarter of 2009. East Dike is approximately 800 m in length, and was constructed within Second Portage Lake prior to dewatering. It consists of a wide rockfill shell, with downstream filters and a soil-bentonite cut-off wall that extends to bedrock up to 8 m below lake level.

Instrumentation has been installed within East Dike and includes piezometers, thermistors, inclinometers, and flow meters. Survey monuments were removed from East Dike in the past as they have never been used. The location of the instrumentation is indicated in Appendix C1. The inclinometer at Sta. 60+195 was destroyed in the past and has not been replaced. Replacement of this instrument is not considered necessary; however, monitoring of East Dike should continue and, if anomalous conditions are observed, then replacing this inclinometer should be re-evaluated. Refer to Section 4.1 for the analysis of the available East Dike instrumentation data.

At the time of the 2017 inspection, no signs of cracking, sloughing or settlement were observed on the structure (including the vicinity of the 2009 sinkhole near Sta. 60+472).

Three seepage zones were identified in the past near the downstream toe of East Dike (at Sta.60+247, 60+498, and 60+575). The zones at about Sta. 60+247 and Sta. 60+498 each have a seepage collection sump with a pump connected to a year-round pumping system. At the time of the inspection, the seepage was being captured within these sumps. According to AEM, the zone at about Sta. 60+575 was practically dry all year, and only a little ponding water with no flow was observed during the inspection. No sign of new seepage on the ground surface or downstream was observed.

Seepage flow is measured by the flow meters installed in the two seepage collection sumps downstream of East Dike. The average flow measured during the year was around 550 m^3/day with peak activity averaging approximately 850 m^3/day in June 2017. The measured flow is slightly decreasing compared to values from the past years. During the year, the water quality in the sump was monitored by the environment department every week during freshet. According to the procedure in place, the water is pumped in Portage Pit instead of being sent to Second Portage Lake when the TSS criterion is exceeded. This was the case starting from May 9th to October 29th 2017.

During the geotechnical inspection, and based on the instrumentation data, the condition of East Dike generally appears stable, as:

- No visual signs of slope instability or erosion were observed on the upstream and downstream rockfill slopes.
- No visual signs of cracking or settlement were observed on the dike and along the cut-off wall alignment.
- Seepage rates, while higher than anticipated in the design, are stable and are controlled by the pumping system in place. The TSS criterion is low enough for the water to be released in Second Portage Lake, except during the freshet of 2017.
- Freeboard is adequate.
- Instrumentation data: piezometric, thermal, seepage, and inclinometer data do not show deteriorating conditions (refer to Section 4.1).

Appendix A1 contains a photographic log and the record of inspection form for East Dike.

2.2 South Camp Dike

South Camp Dike is located south of the plant site area and is used to connect the mainland to South Camp Island. South Camp Dike, in conjunction with Bay-Goose Dike, isolates a portion of Third Portage Lake (Bay-Goose Basin) that allowed the development of Goose Island Pit and the southern portion of Portage Pit. It covers a narrow channel, approximately 60 m wide, with shallow water depths ranging from 0.5 m to 1.0 m.

South Camp Dike was constructed between April and June of 2009. Additional thermal capping material and rockfill for the haul road was added to the dike in the winter of 2009-2010. South Camp Dike has a broad rockfill shell with a bituminous geomembrane liner installed on the upstream side. Compacted granular material mixed with bentonite was placed above the toe of the liner. The liner was installed on native frozen (permafrost) till material in a trench approximately 3 m to 5 m below the lakebed surface. At the time of the inspection, South Camp Dike was used as an access road to connect the southern part of Bay-Goose Dike, and the contractor's offices and equipment area with the mine facilities.

An ultramafic waste rock stockpile about 10 m high is located 20 m away from the downstream toe of the dike. The distance between South Camp dike and the waste rock dump is sufficient to allow a complete visual inspection of the downstream area of the dike. It is recommended to continue keeping the downstream toe of the dike clear to facilitate inspection. The downstream toe and slope area was in good condition.

Two thermistor strings are installed on the upstream side of the dike. The thermistor data indicate that the foundation of the dike remained frozen throughout the past summers (2009 to 2016). Refer to Section 4.2 for a detailed analysis of South Camp Dike instrumentation data.

No geotechnical issue or seepage was observed during the inspection.

Appendix A2 contains a photographic log and record of inspection form for South Camp Dike.

2.3 Bay-Goose Dike

Bay-Goose Dike is located within Third Portage Lake on the southern side of Portage Pit and encompasses the Goose Island Pit. Bay-Goose Dike, in conjunction with South Camp Dike, isolates a portion of Third Portage Lake (Bay-Goose Basin).

Construction of Bay-Goose Dike started in the summer of 2009. The earthworks component for the northern portion of the dike was mostly completed by early October 2009 and by October 2010 for the southern portion. Grouting of the foundation and bedrock occurred between March 2010 and July 2011. Jet grouting occurred in selected portions of the dike between October 2010 and May 2011. The first phase of dewatering Bay-Goose Basin was completed by mid-November 2011 and the second phase was completed in August 2012.

Bay-Goose Dike is approximately 2,200 m long and consists of a wide rockfill shell, with downstream filters and a cut-off wall. For the majority of the dike, the cut-off wall extends to bedrock and consists of soil-bentonite (SB) and/or cement-soil bentonite (CSB). For portions of the dike where the cut-off wall was not constructed to bedrock, jet grouting of the soil between the base of the cut-off wall and the bedrock was performed, thereby extending the low permeability element of the dike to the bedrock surface. The water depth beneath the dike is up to 9 m, with a maximum depth to bedrock below lake elevation upwards of 20 m.

Instruments to monitor and assess the dike's performance are installed on Bay-Goose Dike. The instrumentation includes piezometers, flow meters (water collection pipe and a plastic bucket), thermistor strings, and inclinometers. Every blast in the vicinity of the dike is monitored for blast vibration. Survey monuments were removed from Bay-Goose Dike as they have never been used. Appendix C1 shows the location of the instrumentation on Bay-Goose Dike.

The tension cracks observed in 2013 and 2014 on the upstream side within the thermal cap (between Sta. 32+100 to 31+750 approximately) were still visible during the 2017 inspection but did not show signs of progression and were not active anymore. Settlement within the thermal cap and on the upstream side of the crest (from Sta.

32+100 to 31+950 approximately), ranging from 0.1 m to >1.0 m, was observed but did not show any significant sign of movement since previous years. These areas should continue to be closely monitored to make sure no aggravating conditions are developing.

Seepage channels and water accumulation were observed at the toe of the dike during the inspection (North Channel, Central Channel, Central Shallows and Channel 3). There is currently no downstream seepage collection system at the downstream toe of the dike as the amount of seepage reporting downstream is currently too small to require such a system. Part of the seepage seems to be reported to the pits. Flow from these channels is monitored by various stations. At the time of the inspections, stations 6, 7, 8 and 9 were active and no turbidity was observed in the water at the downstream toe. From July to September 2017, the total average flow due to seepage from the toe of the dike was measured at 14.7 m^3/day compared to 24 m^3/day in 2016, 29 m^3/day in 2015, 132.2 m^3/day (1.5 L/s) in 2013, and 97.2 m^3/day (1.22 L/s) in 2012. The measured flow in 2017, 2016 and 2015 does not take into account the inflow of water from the pond at Central Channel as this value was not measured in 2017, 2016 and 2015 (61 m^3/day in 2013 and 2014).The overall seepage is stable and less than anticipated, and is thus currently not a concern. It is recommended to continue monitoring the evolution of the seepage at the toe of the dike and to continue measuring the inflow of water from the pond at Central Channel. Water was observed flowing in the North Channel during the inspection at Sta. 30+420 m. The flow was low and decreased since 2016. According to AEM, water was observed ponding at the toe during the year. Due to the topography, it is possible that water is ponding in this area from a nearby seepage channel (i.e., near the northern abutment). The flow is being monitored by station no. 8 (30+420) and no. 9 (30+380) and has an average flow of 4.9 m^3/day compared to 1.9 m^3/day in 2016, 17 m^3/day in 2015, 58 m^3/day in 2013 and 80.8 m^3/day in 2012. The sharp decrease of the flow recorded in 2016 could be caused by the seepage now reporting to Portage Pit E3/E4 instead of the downstream toe due to a connection between North Channel seepage and the nearby Pit E3/E4. The piezometers of the North Channel have shown response to the crest unloading that is part of the push back planned for extention of the pits E3 and E4 (see section 4.3.1 for more details). The North Channel is closely monitored to ensure that blast vibration from Pit E do not exceed the design limit of 50 mm/s. 6 new boreholes have been drilled for instruments between the toe of the dike and the pit. It is recommended to regularly inspect this area, monitor the flow of water, and be on the lookout for signs of seepage from the toe of the dike and in Pit E4.

Flow was observed into the Central Shallow seepage channel during the inspection at Sta. 30+625 and 30+655 The flow was low and decreased since 2016. The flow is being monitored by station no. 7 and had an average flow of 5.6 m^3/day in 2017 compared to 11.5 m^3/day in 2016, 12 m^3/day in 2015, 13.3 m^3/day in 2013 and 18.9 m^3/day in 2012. This is similar to historic trends.

A water pond formed by the Central Channel seepage was observed downstream at Sta. 31+125. The mine pumps this pond once a year after freshet. The inflow was not monitored in this area in 2017, 2016 and 2015. In 2013 and 2014, the inflow from this area was 61 m^3/day. It is recommended to keep measuring the water inflow when pumping the water pond formed at Central Channel.

Water flow was observed at Channel 3 during the inspection at about Sta. 31+500 m. The flow was low and decreased since 2016. A drainage channel is dug into the ring road nearby to allow water to flow freely in the pit. This area is monitored by station no. 6, which recorded an average of 4.2 m^3/day in 2017, compared to 9.3 m^3/day in 2016. According to AEM, water has been reported to the pit from this location during the year through a draining ditch.

A water pond was observed downstream at Sta. 31+750, between Channel 2 and Channel 1. This water pond is not considered seepage as its level never changes except at freshet and after rain events. It is recommended to visually inspect the pond periodically and, if the level changes, to monitor water flow.

Channels 1 and 2 were not active at the time of the inspection. An accumulation of water was observed further downstream against Goose Pit ring road. According to AEM, water is observed downstream in that area during freshet season and naturally drains to Goose Pit without reaching the dike toe. The instrumentation near Sta. 32+000 (Channel 1) indicates a potential seepage zone in that area. It is probable that seepage occurs at this location but reports directly to the pit. The instrumentation at this location needs to be closely monitored for changing trends.

During the inspection, it was observed that an inflow of water was still reported to Goose Pit and that some of the pit walls were wet. These observed water inflows were near Channel 1, Channel 2, and Channel 3 and are not being monitored anymore.

From the visual inspection and based on the instrumentation data, the performance of Bay-Goose Dike is satisfactory, as:

- No visual signs of slope instability or erosion were observed on the upstream and downstream rockfill slopes;
- The settlement and sloughing observed in the thermal cap and in the upstream side of the crest are stable and are no longer active;
- Freeboard is adequate;
- Instrumentation data: piezometric, thermal, seepage, and inclinometer data do not show deteriorating conditions (refer to Section 4.3).

Appendix A3 contains a photographic log and the record of inspection.

2.4 Vault Dike

Vault Dike is located across a shallow creek that connects Wally Lake and Vault Lake, at the Vault Pit area. Vault Dike was designed and constructed as a zoned rockfill dam with filter zones and an impervious upstream liner consisting of a bituminous membrane. The dike has an upstream key trench made of aggregate mixed with bentonite. The construction of Vault Dike was done in the winter of 2013 to keep its foundation frozen.

The settlement and cracks observed in 2013 and 2014 were not noticeable anymore. No geotechnical concerns were identified and Vault Dike was in good condition.

Five thermistor strings are installed on Vault Dike and four are operational. One thermistor (TH-3) had been damaged by sloughing in previous year and stopped working in October 2015. Data are collected every 3 days and show that the foundation of the dike is mostly frozen all year long, except for a 3 m thick layer of bedrock around TH7. Refer to Section 4.4 for a more detailed analysis of the instrumentation data on Vault Dike.

Appendix A4 contains a photographic log and record of inspection form for Vault Dike.

3.0 TAILINGS STORAGE FACILITY

The tailings storage facility (TSF) is located within the dewatered portion of the northwestern arm of Second Portage Lake and consists of the North Cell and the South Cell. The North Cell is being progressively closed while the South Cell is operational and is being progressively constructed as additional capacity to store tailings is required. Stormwater Dike is an internal structure separating the North Cell from the South Cell. A plan view of the TSF is shown on Figure 1.

The TSF was commissioned in conjunction with the mill start-up in February 2010, with tailings being deposited within the North Cell of the facility. The North Cell and internal structures (Saddle Dam 1, Saddle Dam 2, Stormwater Dike) were constructed to El. 150 m in two Stages from 2009 to 2011. Tailings deposition was transferred from the North Cell to the South Cell at the end of 2014. Tailings deposition occurred during the summer of 2015 within the North Cell and resumed in the South Cell in October 2015. Progressive closure of the North Cell started in the winter of 2015 with the construction of a non-acid generating rockfill capping over the tailings and continued in the winter of 2016. Water is transferred as needed from the North Cell to the South Cell to control the water elevation of the North Cell.

The construction of the South Cell started in 2012 with Central Dike, thereby closing the eastern portion of the South Cell. The beginning of the tailings deposition in the South Cell started at the end of 2014. From 2012 to 2016, Central Dike was raised to El. 143 m in four stages. In 2017. The north abutment of Central Dike was raised to El. 145 m in preparation for the raise of the entire dike next year. To increase the capacity of the South Cell, additional peripheral structures (Saddle Dam 3, Saddle Dam 4 and Saddle Dam 5) were constructed to El. 145 m in three stages from 2015 to 2017. The South Cell is designed to be able to be raised to El. 150 m. The construction of subsequent portions of the South Cell will occur in the future if additional capacity is required.

A retention basin and a series of diversion ditches surround the catchment basin of the North Cell. These structures are designed to convey surface water runoff away from the TSF. Since 2014, the Western Diversion Ditch is collected within a retention basin prior to being pumped within the North Cell. This is due to a turbidity problematic from the erosion of the side slope and the crest of the ditches. Refer to Section 8.2 for the inspection of these diversion structures.

In the summer of 2014, the mine constructed an engineered tailings barrier along RF1 and RF2 to mitigate migration of tailings through RF1 and RF2. Refer to Section 8.3 for the inspection of these structures.

The most current versions of the Operation, Maintenance and Surveillance (OMS) Manual (AEM, 2017a), including the Emergency Preparedness Plan (EPP), and of the overall Emergency Response Plan (ERP) for the mine (AEM, 2017b) are dated March 2017 and June 2017. It is good practice to review these documents each year to keep the information up to date, particularly the 24-hour contact name and phone number.

An inspection of the TSF is performed once a month by AEM. The instruments were manually read twice a week during the summer and once a week during the winter, until dataloggers were installed in 2017. Readings are now automatically read every 3 hours. The monthly inspection reports were reviewed as part of the annual inspection. A summary of the instrumentation data obtained from the TSF is presented in Sections 4.5, 4.6 and 4.7 and in Appendices C2 and C3.

Figure B1 shows a plan view that indicates the location of the pictures and general observations related to the North Cell and South Cell. Figures B2, B3 and B5 contain a plan view that shows the location of the photos and observations noted on Saddle Dam 1, Saddle Dam 2 and Saddle Dam 3. Figure B4 contains a plan view that shows the location of the photos and observations noted on Stormwater Dike. Figures B6-B7 contains a plan view that shows the location of the photos and observations noted on Central Dike, Saddle Dam 5 and Saddle Dam 4.

3.1 General Observations of the Tailings Facility

Per the TSF design, a tailings beach must be present at all times against all peripheral structures.

At the time of the inspection, the pond of water in the North Cell was located towards the centre of the facility and there was a tailings beach against the peripheral structures to protect them from ice in the winter and to prevent the migration of water out of the TSF (see Figure 1 for an approximate location of the tailings beach). The tailings elevation in the North Cell was around El. 149.5 m and the pond elevation was at 147.7 m approximately. The tailings beaches against the structures of the North Cell were adequate.

At the time of the inspection, the pond elevation in the South Cell was at 136.76 m and the tailings elevation varied approximately between 139 and 127 m. Water in the South Cell was ponding against the entirety of the downstream toe of Stormwater Dike. A tailings beach was developed against the entire length of Central Dike and Saddle Dams 4 and 5. At the time of the inspection, tailings deposition was done from Saddle Dam 4. AEM is closely monitoring the formation of a tailings beach against the peripheral structures and is monitoring the compliance of the tailings deposition with the deposition plan.

During the inspection, a number of depressions with diameters up to 2 m approximately were observed in the tailings in the South Cell and seemed to form a straight line perpendicular to Central Dike. According to AEM, more depressions have been observed in the same area in the past and covered by more tailings. This area is suspected as the location where the seepage under Central Dikes originates, as depressions form as water penetrates the bedrock. These holes structures developed further during the summer of 2017. According to AEM, the tailings deposition from Saddle Dam 4 covered these depressions shorty after the time of the inspection. The use of tailings to plug the base of the South Cell in areas of potential open windows over exposed fractured bedrock is considered a good method to seal the cell and improve conditions beneath the Central Dike.

A rockfill berm was constructed in 2016 at the toe of Stormwater Dike in the South Cell (from Sta. 10+300 to Sta. 10+750) to mitigate the crest and downstream slope movement observed in this sector at the end of August 2016. Following an investigation and instrumentation program, the movements observed are inferred to be caused by the soft sediment foundation thawing due to the South Cell water pond reaching the dike foundation during the summer. Water ponding against Stormwater Dike is part of the tailings deposition plan and is acceptable as Stormwater Dike is not a peripheral structure. Having direct ponding water within Storwater Dike foundation is geotechnically acceptable. For South Cell closure and environmental aspects, given that it is inferred that the SWD foundation presents some open windows of exposed fractured bedrock that may contribute to feeding the seepage at Central Dike, it is recommended that a beach be put in place along SWD downstream slope to seal the foundation before the end of the deposition activities.

At the time of the inspection, Saddle Dam 3 was not operational as tailings were not deposited from this structure and the South Cell pond had not yet reached the upstream toe of this structure. Saddle Dam 4 and Saddle Dam 5 were operational and tailings deposition started from the junction between Saddle Dam 4 and Saddle Dam 5 during the construction to raise these structures to El. 145 m. Permanent sumps have not yet been installed on the downstream side of Saddle Dam 4 and Saddle Dam 5 and water accumulation is pumped as required. A permanent sump has been installed on the downstream side of Saddle Dam 3 in September 2017. It is important that the water level on the downstream side is not allowed to raise higher than the granular layer of the upstream toe liner tie-in to prevent uplifting of the geomembrane.

Appendix B1 contains a general photographic log of the TSF's North Cell and South Cell.

3.2 Saddle Dam 1 – North Cell

Saddle Dam 1 is located in the northwestern corner of the TSF and forms one of the perimeter structures of the North Cell intended to retain tailings and supernatant fluid during the operation and the closure of the TSF. Saddle Dam 1 crosses a depression between the northwestern arm of Second Portage Lake and Third Portage Lake.

Saddle Dam 1 is a rockfill embankment with an 3H:1V upstream slope and a 1.3H:1V downstream slope. This structure has inverted base filters, upstream graded filters, and a linear low density polyethylene (LLDPE) geomembrane liner on the upstream dike face. The geomembrane liner is placed between an upper and lower non-woven geotextile layer for protection, and is covered by approximately 0.3 m of granular material up to El. 140 m. No granular layer was placed above El. 140 m and the liner is exposed above that elevation. According to the design, a tailings beach has to be maintained on the face of the structure to reduce the potential for ice damage to the liner. The abutments are founded on bedrock, while the central portion of the dike is founded on ice-poor soil. Till and/or crushed aggregate mixed with dry bentonite powder have been placed above the toe of the liner.

Stage 1 of Saddle Dam 1 was constructed in the fall of 2009 to a height of 10 m (crest elevation of 141 m) and a length of 250 m. Stage 2 was constructed in 2010 to an overall height of 20 m (final crest elevation of 150 m) and length of about 400 m.

Four thermistor strings are installed on Saddle Dam 1 and are automatically read every 3 hours following the installation of dataloggers in 2017. Three thermistors (T1, T2, T3) are installed to monitor the thermal condition within the structure and its foundation, and were installed in 2009 and early 2010 as part of Stage 1. The fourth thermistor string (T4) was installed in 2009 and extended in 2010 along the upstream face of the dam to monitor the thermal condition of the tailings. The location of the instrumentation is shown in Appendix C3. Refer to Section 4.6.1 for the analysis of the instrumentation data.

During the inspection, it was observed that Saddle Dam 1 is performing well and does not show any geotechnical concern. An adequate tailings beach was observed along the upstream face of Saddle Dam 1. A stockpile of fine filter material has been present on the north parth of the dike since 2011.

A permanent dewatering pump is installed downstream within a sea-can container. Water was observed ponding near the sump. Pumping was done during freshet, and as necessary during summer. The environment department is monitoring the water quality during the year and this information is shared with the engineering department. The water quality results indicate that the water is not seepage from the North Cell. During the MDRB in 2016, the Board members suggested to remove this pumping system and to backfill the toe drain trench to allow natural drainage of the water toward Third Portage Lake. Their opinion is that the foundation of Saddle Dam 1 is now frozen and therefore the weight of tailings will preclude any liner heave. Golder agree with this recommendation and recommend that the monitoring of the instrumentation in this sector continue and to reassess the situation if needed. However, as this sump is a permanent feature, it is required that the water quality remains monitored and be reported, and thus the sump cannot be backfilled during operations to comply with legal requirements.

Appendix B2 contains a photographic log and the record of inspection form for Saddle Dam 1.

3.3 Saddle Dam 2 – North Cell

Saddle Dam 2 is located along the western side of the TSF and connects to the western corner of Stormwater Dike. Along with Saddle Dam 1, it forms one of the perimeter structures of the TSF's North Cell which retain tailings and supernatant fluid during the operation and closure of the TSF. Saddle Dam 2 crosses a depression between the northwestern arm of Second Portage Lake and Third Portage Lake. Its construction and design is similar to Saddle Dam 1. Saddle Dam 2 has a maximum height of about 10 m and a crest length of 460 m.

The upstream foundation of the dike and abutments are primarily founded on bedrock; however, some portions of the structure, underneath the inverted filter, are founded on ice-poor soil. During construction, a thin layer of low permeability till was placed and compacted along the toe liner tie-in connection with bedrock. A thin layer of crushed aggregate (0-22 mm) mixed with dry bentonite powder was also placed under the thin layer of low permeability till in areas where open factures were observed within the bedrock. The toe liner tie-in was then covered with till.

Four thermistor strings (T1, T2, T3, and T4) have been installed at Saddle Dam 2 to monitor the thermal condition within the structure and its foundation. The location of the instrumentation is shown in Appendix C3. Refer to Section 4.6.2 for the analysis of the instrumentation data.

During the inspection, it was observed that Saddle Dam 2 is performing well and does not show any geotechnical concern. An adequate tailings beach was observed against the upstream side of the structure.

During the inspection, water was observed ponding on the downstream side within the rockfill embankment (between Sta. 20+275 to Sta. 20+475 approximately). This water was also observed during the 2016 and 2015 annual inspections and the instrumentations indicate that the foundation remains frozen. According to AEM, water has been ponding at that location for a long time.

Appendix B3 contains a photographic log and the record of inspection form for Saddle Dam 2.

3.4 Stormwater Dike – Divider Dike

Stormwater Dike is an internal structure that subdivides the TSF into the North Cell and the South Cell within the dewatered northwestern arm of Second Portage Lake. Stormwater Dike can be considered as a temporary structure as it will no longer be operational at closure. In this document, the North Cell side is taken as upstream and the South Cell side as downstream.

Stormwater Dike is a rockfill embankment structure founded on lakebed soils. The upstream slope is approximately 3H:1V and the downstream slope is about 1.3H:1V. A bituminous geomembrane liner has been installed above the graded filters on the upstream face of the dike. Low permeability till was placed and compacted along the upstream toe of the dike, above the liner.

Stormwater Dike was progressively constructed. Stage 1 was constructed in 2009 to a height of 10 m (crest elevation of 140 m) and a length of 860 m. Stage 2 was primarily constructed in 2010 to an overall height of 18 m (crest elevation of 148 m) and length of about 1,060 m. A horizontal bench is present along the upstream face of the structure due to the connection of the 2009 and 2010 portions of the structure. The junction between the bituminous liner of Stormwater Dike and the LLDPE liner of Saddle Dam 2 was completed in 2011. The crest of Stormwater Dike was raised to 150 m in 2013.

The majority of the dike is seated on dense till from the former lakebed within the talik while the abutments are generally founded on bedrock. The foundation preparation of Stage 2 was completed in winter conditions. It was generally done above water except in an area where water ponding was present (between Sta.10+500 and 10+750 approximately). This pond was located where the topography suggests that the soft lakebed sediment thickness may be greater than at other locations along the dike. Due to the presence of water, the ice crust was cracked with the excavator and only minimal foundation preparation was possible. As a results, most of the lakebed sediment probably remained in place in this area.

At the end of August 2016, during a routine inspection, AEM noticed tension cracks and signs of settlements on the crest of Stormwater Dike between Sta. 10+500 to 10+750 approximatively. The crack system that suddenly developed in this area had a lateral and vertical component according to the monitoring equipment. To mitigate against a possible foundation failure, a rockfill buttress support was constructed at the downstream toe of Stormwater Dike in the South Cell (from Sta. 10+300 to Sta. 10+700 approximatively). After the completion of this buttress (following the annual inspection), the displacement at Stormwater Dike stabilized and then stopped. Cracks have since been filled with bentonite.

In July 2017, during a routine inspection, AEM noticed new tension cracks and signs of settlements on the crest of Stormwater Dike around Sta. 10+425, between St.a 10+550 and Sta. 10+650, between Sta. 10+800 and Sta. 10+950, and around Sta 11+050 approximatively. Settling of about 300 mm was observed between Sta. 10+800 and Sta. 10+950, approximately. AEM indicated that this depression was pre-existing but increased in depth and lateral extent in 2017. Cracks appear to be oblique tension fractures, extending over the entire width of the dike crest. Some cracks were up to 5 cm wide and most of them did not progress after they were first observed. The area affected by these cracks is consistent with the limits of the South Cell water ponding against Stormwater Dike, which probably thawed the frozen soft soil foundation. During the annual inspection, the downstream toe of the dike was not visible as it has been entirely covered by the South Cell pond since July 2016, and partially covered before that.

In 2016 and 2017, following these observations, movement monitoring instruments were installed on the crest of the dike (total of 4 extensometers and 19 prisms). No movement was observed by the extensometers in 2017 after their installation.

Following the 2016 sign of movement event, an investigation and instrumentation program was carried out. This campaign shows that the most problable mechanism of the movement was settlement due to the thawing of soft sediment caused by the rise of ponding water in the South Cell through Stormwater dike foundation. Additionnal stability analyses using an updated stratigraphy and geotechnical parameters indicated that the use of a rockfill buttress to stabilize the downstream toe against foundation failure was not required due to an obtained factor of safety above 1.5.

A single deep thermistor (T147-1) and a piezometer string (VWP 13265) were installed at the downstream toe of Stormwater Dike (within the South Cell). These instruments were broken in September 2016 during the construction of the buttress at the toe of Stormwater Dike within the South Cell. Three new thermistors (SWD-01-16, SWD-02-16 and SWD-03-13) and two new piezometers (PZ-SWD-02 and PZ-SWD-03 were installed since then. Refer to Section 4.7 for the analysis of the instrumentation data at Stormwater Dike including movement monitoring.

Appendix B4 contains a photographic log and the record of inspection form for Stormwater Dike.

3.5 Saddle Dam 3, Saddle Dam 4 and Saddle Dam 5 – South Cell

The South Cell of the TSF consists of four perimeter structures: Central Dike, Saddle Dam 3, Saddle Dam 4 and Saddle Dam 5. Saddle Dam 3 is located in the northwestern corner of the South Cell and merged into Saddle Dam 2 during construction to El. 145 m this year. Saddle Dam 4 is located in the southwestern corner of the South Cell and merged into Saddle Dam 5, which merges with the southern end of Central Dike, during construction to El. 145 m this year.

Saddle Dams 3, 4, and 5 are designed and constructed as zoned rockfill dams with filter zones, low permeability upstream liners, and upstream toe liner tie-in key trenches. The Saddle Dams 3, 4 and 5 cross-sections consist of a rockfill embankment, constructed from run-of-mine waste rock, placed in lifts and compacted. The upstream faces are designed at a 3H:1V slope and the downstream faces are designed at a 1.5H:1V slope. The upstream faces of Saddle Dams 3, 4 and 5 are comprised of two granular filter zones and a polyethylene liner (LLDPE) extending along the upstream foundation. The filter zones meant to keep the tailings inside the facility in a case of liner puncture but mainly act as appropriate bedding for the liner. An upstream liner tie-in key trench excavated to bedrock and filled with compacted till is located along the upstream area of the structures. The bulk part of Saddle Dams 3, 4 and 5 consists of coarse rockfill material.

Stage 1 of Saddle Dam 3, 4 and 5 was constructed in 2015. During Stage 1, Saddle Dam 3 and 4 were constructed to El. 140 m and Saddle Dam 5 to El. 137 m. Stage 2 of Saddle Dam 3, 4 and 5 was constructed to El. 143 m in 2016. Stage 3 of Saddle Dam 3, 4 and 5 was constructed to El. 145 m in 2017. These structures are designed to be able to be raised to El. 150 m and the final crest elevation of these structures is subject to review by AEM. At the end of Stage 3, the decision was made by AEM to close the abutments of these structures, as no further raise was planned at the moment. If these structures are to be raised higher, it will be necessary to re-open the abutments. The completed crest length is approximately 245 m for Saddle Dam 3 (with liner only installed up to El. 143 m in 2017), 365 m for Saddle Dam 4, and 255 m for Saddle Dam 5.

At the time of the inspection, the 2017 construction was winding down and Saddle Dam 4 and Saddle Dam 5 were operational, but not Saddle Dam 3. The water level of the South Cell had reached the upstream toe of Saddle Dam 4 and Saddle Dam 5 only. Saddle Dam 3 was not retaining tailings nor water. This structure will become operational in 2018 with the South Cell pond reaching its upstream toe. No geotechnical issues were observed with these structures.

Thermistors are installed at Saddle Dam 3 and Saddle Dam 4. Refer to Sections 4.5.2 and 4.5.3 for the interpretation of the instrumentation data.

During the inspection, water was observed ponding in some areas of the downstream side of Saddle Dam 3 and Saddle Dam 4. As the downstream toe is higher than the South Cell pond along Saddle Dam 4, this water does not come from the TSF. On the downstream side of, Saddle Dam 3, water is ponding at a level below the South Cell elevation, but no water is ponding on the usptrea side of the dike. It is important to maintain the water level on the downstream side lower than the level of the upstream toe liner tie-in granular material layer to prevent uplift of the geomembrane. As the elevation of the downstream side is lower than the elevation of the granular material, this should not be a problem if the downstream water level is managed.

Appendices B5 and B6 contain a photographic log and the record of inspection forms for Saddle Dams 3 and 4.

3.6 Central Dike – South Cell

Central Dike is located along the eastern side of the TSF and crosses a depression within Second Portage Lake. Along with Saddle Dam 4 and Saddle Dam 5, Central Dike forms one of the perimeter structures of the South Cell.

Central Dike design includes a compacted rockfill embankment with an upstream seepage barrier, granular filters and a key trench along the centreline of the dike transitioning on the upstream toe near both abutments. The foundation soils include lakebed sediments and till overlying bedrock. Soft and ice-rich soils were removed from the Central Dike footprint during construction.

Construction of Central Dike started in 2011. Central Dike was built to El. 143 m during the 2016 construction season (Stage 5), and its north abutment raised to El. 145 m during the 2017 construction season (Sta. 0+090 to 0+174 m). Central Dike is designed to be able to be raised to El. 150 m and the final crest elevation is subject to review by AEM. At the end of the 2017 construction season, the decision was made by AEM to leave the extremity of the north abutment unfinished. This decision was made to make it easier to raise the rest of the structure to El. 145 m next year by connecting to the existing layer. The completed crest length is approximately 900 m at El. 143 m.

Seepage into the basin at the downstream toe of Central Dike was observed when tailings deposition was transferred from the North Cell of the TSF to the South Cell in 2014. The rate of seepage started to increase proportionally to the rise of the pond level of the South Cell. Desktop studies were undertaken by Golder in 2015 to estimate the seepage flows and pore water pressures, verify the dike stability, and attempt to predict the eventual flow volume that would report to the downstream toe for higher pond elevation. The seepage pathway used in the Golder 2015 model was through a layer of fine material in the till layer of the foundation as it was deemed the most critical scenario for the structure stability. The main recommendation from this desktop study was to maintain beaches adjacent to Central Dike and to maintain a 'back pressure' on the downstream side of Central Dike in order to reduce the hydraulic gradient by holding the downstream pond at El. 115 m. Willowstick was also hired to carry out electromagnetic surveys to detect seepage paths. The geophysical campaign led to additional recommendations and identified possible seepage path locations. Following the geophysical campaign, an investigation was conducted by SNC Lavalin (SNC) and AEM in December 2015 at station CD-595, and between CD-810 and CD-850. Highly altered and fractured bedrock was encountered and high hydraulic conductivity was measured from Packer testing. Instrumentation of the four boreholes with piezometers and thermistances was done at the same time. A study has been completed in 2017 by Golder to update the seepage modelling with a seepage flow through the bedrock, and allowed for updating of the Emergency Preparedness Plan as well as the Operation, Maintenance, and Surveillance Manual. The summer 2017 investigation and instrumentation campaign shows that the seepage pathway was most probably mainly controlled by the bedrock. Review of coupled seepage-stability analysis indicates that the dyke is actually physically stable and that decrease of South Cell water level and use of tailings to seal the bottom of the cell would improve the seepage and piezometric pressure beneath Central Dike. Implementation of those measures during the fall of 2017 shows anticipated conditions improvement.

At the time of the inspection, there was a tailings beach against the entire length of the structure. AEM is planning on maintaining a proper tailings beach against the entire length of this structure during operation and closure as per the design requirements.

During the inspection, water was observed ponding at the downstream toe of the dike between approximately Sta. 0+300 and the southern access road at Sta. 0+830. The water was clear with no sign of turbidity, although

AEM reported that an orange coloration along with high turbidity and rapid temperature variations was observed during most of the open water season in 2017. This event has been investigated by AEM and has been attributed to precipitation of iron oxide from bacterial processes. At the time of the inspection an average flow of approximately 540 m^3/hr was pumped back to the South Cell to maintain the downstream pond at El. 115 m. No water inflow was reported to Portage Pit in 2017 from that location. AEM are working closely with the MDRB and the dike designer (Golder) to determine the seepage pathway and to establish measures to keep the situation under control. Golder recommends: 1) maintaining a tailings beach against Central Dike; 2) controlling the hydraulic gradient by proper management of South Cell water pond and dike downstream toe pond; 3) closely monitoring the water quality; and 4) inspecting the structure for changing conditions. During September and October 2017, the water level of the reclaim pond was progressively lowered as to reduce the hydraulic pressure on the seepage. This was done by transferring water from the South Cell to Goose Pit. According to AEM, the average flow had decreased to 330 m^3/hr by the beginning of November 2017.

In 2013, twenty boreholes were drilled on three different rows on Central Dike. The first row corresponds to the central key trench, the second row corresponds to the final downstream toe, and the third row corresponds to the Portage Pit limit. Piezometers and thermistor strings are installed in each of these boreholes (for a total of 69 piezometers and 20 thermistors). Two thermistors strings are installed on the upstream face to monitor the temperature within the tailings of the South Cell. All instruments are read automatically every 3 hours since the installation of dataloggers in the summer of 2017. An investigation campaign was conducted in 2017 and included the installation of additional instrumentation. The interpretation of the instrumentation data is provided in Section 4.5.1.

Appendix B7 contains a photographic log and the record of inspection form for Central Dike and Saddle Dam 5.

4.0 GEOTECHNICAL INSTRUMENTATION

As part of the 2017 geotechnical inspection, the dewatering dikes and TSF instrumentation data were reviewed. During the year, daily review of the instrumentation on the dewatering dikes is done by mine personnel and monthly reports summarizing their observations are issued internally. The compilation of the instrumentation data was not part of the scope of this study, and the figures showing the data were provided by AEM. The information provided by AEM is presented as received in Appendix C. The data were sent as figures for the dewatering dikes and as PowerPoint documents and Excel File for the TSF structures. Continued monitoring and review of instrumentation data is recommended.

4.1 East Dike

Instrumentation within East Dike was installed in the spring of 2009 to monitor the dike's performance following construction and during dewatering, operation, and into closure. Additional instrumentation was added in 2009 and 2010 to increase coverage across the dike. Since June 2012, all piezometers and thermistors on East Dike are connected to an automatic data collection and transmission system (VDV database). The following subsections present a summary of the data collected between 2016 and September 2017.

Previous annual geotechnical inspection reports contain additional information regarding instrumentation data collected prior to September 2016. The 2017 instrumentation data for East Dike are presented in Appendix C1.

4.1.1 Piezometers

Three arrays of multilevel vibrating wire piezometers (VWP) were installed within East Dike in mid-March 2009 as follows:

- South Channel (Sta. 60+190)
- North Channel (Sta. 60+490)
- North Shallows (Sta. 60+700)

At each location, multilevel VWPs were installed:

- Upstream side of the cut-off wall, approximately 2 m from the centreline.
- Immediately downstream of the cut-off wall, approximately 2 m from the centreline.
- Further downstream of the cut-off wall, approximately 10 m from the centreline.

Single VWPs were also installed downstream of the cut-off wall near the contact area (base of cut-off wall and top of bedrock surface) at Sta. 60+150, Sta. 60+200, Sta. 60+240, Sta. 60+400, Sta.60+420, Sta.60+440, Sta. 60+450, Sta. 60+460, Sta.60+470 60+472, Sta. 60+480, Sta. 60+500, Sta. 60+510, Sta. 60+550, Sta. 60+600, Sta. 60+650, and Sta. 60+750.

Some of the installed piezometers on East Dike are broken or malfunctioning. Table 1 indicates the instruments flagged by AEM, the possible reason why it is malfunctioning, and the date when it started malfunctioning. The piezometers located at Sta. 60+150, 60+470 and 60+750 are broken and do not produce any pore water pressure data. The piezometers located at Sta. 60+550C, 60+650C, 60+700P1B and 60+700P2C are giving erratic data and reported as frozen by AEM. The data analysis indicates that these piezometers are in fact frozen. Piezometers 60+600C, 60+490P2C, 60+700P1A, 60+700P1C are also frozen and are giving widely fluctuating data. A piezometer that has frozen at some point cannot be relied upon. It is thus recommended to flag these piezometers and be very careful when interpreting their data.

Table 1: Malfunctioning Instruments on East Dike flagged by AEM

Name of Piezometer	Location	Possible Reasons for Malfunctioning	Malfunctioning Start Date
150-C	60+150	No reading, broken	November 2012
470-C	60+470	Pore water pressure reading broken, temperature still working	November 2009
550-C	60+550	Frozen, still shows head and temperature (erratic data)	November 2014
650-C	60+550	Frozen, still shows head and temperature	May 2016
700-P1B, 700-P2C	60+700	Frozen, still shows head and temperature	November 2014
750-C	60+750	Pore water pressure reading broken, temperature still working	April 2013

The piezometers data are showing that the pore water pressure is not increasing and is similar to the value recorded in the past with a long-term trend going towards a general decrease in the pore water pressure.

For the three piezometric arrays located at Sta. 60+190, Sta. 60+490, and Sta. 60+700, the following observations can be made.

- At Sta. 60+190, the observed levels are consistent with expectations for a functioning cut-off wall. There is a consistent drop in the hydraulic head across the cut-off wall and within the grouted bedrock in the downstream direction. Further downstream, the hydraulic head continues to decrease. There are spike increases in the hydraulic head in October 2016, April 2017, June 2017, and July 2017. These spikes are probably due to pumping interruption for maintenance. The spike in October 2016 was also observed in October 2015. As no data was available from June 2016 to September 2017, the later spikes could not be compared with the 2016 data. As observed in past years, no instrument froze in the winter and the temperature data indicates the presence of seepage. For example, the temperature reading at 190-P1-C increased to approximately 3.5°C in September 2016. Then, the temperature decreased between October 2016 and June 2017 to approximately 0.2°C despite extremely cold air temperatures. If the temperature fluctuations at 190-P1-C were caused by changes in air temperature at the ground surface, then thermal responses in both summer and winter would be expected. Since the latter is not the case, it is highly probable that seepage water from the upstream side of the dike is responsible for the thermal behaviour. The recorded piezometric pressure decreases towards the downstream side and with elevation, which seems to indicate that flow is occurring towards the pit. Given the hydraulic head response consistent with the expectations of a functioning cut-off wall, it is reasonable to assume that the seepage water is originating from a different part of the dike.
- At Sta. 60+490, flow through the dike is observed as the piezometric pressure is very similar before and after the cut-off wall (490-P3-B vs 490-P2-B in particular). There are spike increases in the hydraulic head in April 2017, June 2017 and July 2017. These spikes are probably due to pumping interruption for maintenance.Sign of seepage are also observed in the thermal instrumentation data associated with this piezometric array. None of the instruments are frozen and there is a correlation between the lake temperature and the temperature recorded by the piezometric array at this location and the temperature data follow the same trend with very little offset. The aforementioned piezometric and thermal trends correspond to the seepage zone observed at Sta.60+498. The recorded piezometric pressure decreases towards the downstream side and with elevation, which seems to indicate that flow is occurring towards the pit.
- At Sta. 60+700 the majority of the piezometers are frozen. The remaining instruments (upstream and downstream of the dike, close to the centreline) show that the observed levels are consistent with expectations for a functioning cut-off wall. An increase in hydraulic head is visible after June 2017. The temperature data are consistent with observations noted during the previous years and indicate mostly frozen conditions.

The following observations were also made for the single VWPs:

Sta. 60+200 to 60+510

The temperature variations recorded by these piezometers show the same trends as Sta. 60+490 and Sta. 60+190. These piezometers did not freeze during the year and are showing temperature trends that can be correlated with the lake temperature. These piezometers are probably recording the effect of the seepage observed at Sta. 60+498.

4.1.2 Thermistors

Five thermistor strings having 16 nodes at 1 m interval have been installed on East Dike (at Sta. 60+092, 60+185, 60+485, 60+695, and 60+842).

The instrumentation data for the August 2016 to August 2017 period are consistent with the historical trends.

These specific observations have been made for each instrument for the period analyzed:

Sta. 60+092 and Sta. 60+842

The thermistors installed at Sta. 60+092 and Sta. 60+842 are located on the southern and northern abutments. The upper 1 m of the dike of both abutments thawed in 2017 (active layer). From August 2016 to August 2017, there has been little to no change in the ground thermal regime. Below El. 134 m, the cut-off wall remained frozen for these two thermistors. The temperature within the dike varied from 5°C to -15.5°C within the active layer of the dike, from -1°C to -12.5°C in the till, and from -2.5°C to -11°C in the bedrock. Fewer temperature variations were generally observed with depth at each location.

Sta. 60+185

The thermistor string installed in the South Channel at Sta. 60+185 (bedrock about 6 m below water surface at El. 127 m) recorded the following temperature variations:

- The upper layer of the cap material (from El. 136 m to El. 131 m) was thawed in September 2016 and was frozen during the winter period (active layer). The active layer shows significant fluctuations in temperature, going from 3°C to -10°C.
- The cut-off wall above the lake level and in the till from El. 131 to 127 m remained frozen, but very slightly below 0°C. In the past, it was observed that the portion between El. 133 m and El. 127 m remained frozen during the year, however the bead at El. 132 shows thawing between September 2016 and the end of November 2016. Very little to no change in the ground thermal regime has been observed from the data. This result may seem surprising, as potential seepage is inferred from the thermal behaviour at 190-P1-C at Sta. 60+190. However, 190-P1-C is further downstream from the dike and the lag between maximum 190-P1-C and the data seem to suggest that the water is originating from a different part of the dike structure closer to Sta. 60+490.
- The bedrock portion of the dike (below El. 127 m) remained thawed. The bedrock had a temperature variation between 0.5°C and 2.8°C increasing with depth.

Sta. 60+485

The thermistor string at Sta. 60+485, installed within the North Channel (bedrock at approximately El. 126 m, 7 m below lake level), indicated the following temperature variations:

- The upper portion of the cut-off wall located in the lake (from El.136 m to El. 128 m) was in an active zone. Significant temperature fluctuations were recorded (11.5°C to -12.5°C).
- The cut-off wall below El. 128 m and the bedrock remained thawed during the year with significant variations in temperature (between 12°C and 0.5°C).

The thermal variation observed within the cut-off wall below El. 128 m and in the bedrock is significant with fluctuations between 11.5°C and slightly above 0°C. From August 2016 to August 2017, there is good correlation between recorded temperatures and the upstream lake temperatures, indicating advective flow through the dike (i.e., recorded temperature changes are primarily a result of temperature changes in water flowing through this area). The delay between changes in the recorded temperatures within the lake and within the cut-off wall is minimal. The temperature responses recorded in the piezometers at Sta. 60+490 P2 (A,B,C) and 60+490 P1 (A,B,C) are also significant, as are the responses recorded within the piezometers at Sta. 60+190-P1-C, Sta.60+450, Sta.60+460, Sta. 60+472, Sta. 60+480, Sta. 60+490, and Sta. 60+500. Seepage is being observed downstream and is collected in the sump and removed via the pumping system.

Sta. 60+695

The thermistor string installed in the North Shallow at Sta. 60+695 (bedrock at El. 128.5 m approximately, 4.5 m below upstream lake level) recorded the following temperature variations:

- The thermistor beads from El. 136 m to 130 m indicate that the upper portion of the cut-off wall was thawed in September 2016 and frozen during the winter (active layer). The recorded temperature variations are between 6°C and -17°C.
- The thermistor beads from El. 130 m to 128 m indicate that the cut-off wall and the till between these elevations remained frozen throughout the monitoring period, with temperature fluctuations between 0°C and -7°C.
- The temperature recorded in the bedrock varied between -0.5°C and 3.8°C increasing with depth. The temperature recorded at each node in the bedrock varied by approximately 1°C during the year.

4.1.3 Inclinometers

Two inclinometers are installed on East Dike at Sta. 60+495 and 60+705. An inclinometer was installed at Sta. 60+195, but was destroyed in July 2010 and has not been replaced. The inclinometer displacements are referenced along Axis A and Axis B; Axis A is perpendicular to the cut-off wall alignment (positive displacements are towards the Pit side), while Axis B is parallel to the cut-off wall (positive displacements are towards the increasing chainage), perpendicular to Axis A.

Recorded displacements are small. The maximum cumulative displacements at the crest was observed in the inclinometer installed at Sta. 60+705. The cumulative displacement is about 100 mm perpendicular to the cut-off wall (Axis A), and 55 mm aligned to the cut-off wall (Axis B). From 2016 to 2017, no significant movements were observed for all inclinometers; they have all been relatively stable since 2014. The recorded displacements are well within the tolerable displacements for the structure and are not a concern.

4.1.4 Seismograph

No PVS measurements were taken in 2017 for East Dike as no blast occurred in the vicinity of East Dike.

4.1.5 Flow Meters

The flow at the downstream toe in 2017 was measured by the flow meters installed in the two seepage collection sumps downstream of East Dike. The average flow measured during the year by the flow meters was around 500 m^3/day with peak activity having an average of approximately 850 m^3/day during the summer of 2017. The measured flow is slightly decreasing compared to values from the past years. During the past year, the turbidity of the water in the sump meet the TSS criteria set for direct discharge into the Second Portage Lake, except for peaks of TSS during freshet between April 2017 and July 2017 when water was discharged in the pits instead.

4.2 South Camp Dike

Two thermistor strings are installed on the upstream side of South Camp Dike. SD-10 is located near the liner toe. SD-09-A is located approximately 20 m further upstream within Third Portage Lake. South Camp Dike thermistor data for September 2016 to September 2017 are presented in Appendix C1. Based on the thermistors data, no signs of seepage are evident and the recorded value follows historical trends.

The following summarizes the observations regarding the thermal regime at these locations:

- The temperature profile at SD-09 on the upstream side of the dike shows that the soils located beneath the dike foundation and liner have remained frozen (permafrost) below El. 128 m. An active layer is present between El. 133 m and 128 m.
- The temperature profile at SD-10 shows that the foundation of the dike below the thermal cap stayed frozen all year long.

4.3 Bay-Goose Dike

Instruments were installed on Bay-Goose Dike in the summer of 2011 to monitor the dike's performance following construction, during dewatering, operation, and into closure. At the time of the inspection, all the piezometers and thermistors on Bay-Goose Dike had an automatic data collection and transmission system to the VDV database. The following subsections present a summary of the data collected between September 2016 and September 2017. Data plots for the instrumentation sent by AEM are presented in Appendix C1. Additional boreholes have been drilled in the North Channel sector in 2017 to install reflectometers in order to monitor the dike's reaction to nearby blasting in Pit E5.

4.3.1 Piezometers

Arrays of multilevel VWPs were installed within Bay-Goose Dike as follows:

- Sta. 30+158 (1P)
- Sta. 30+276.5 (2P)
- Sta. 30+378.5 (3P)
- Sta. 30+453.5 (4P)
- Sta. 30+645.5 (5P)
- Sta. 31+165 (23P)
- Sta. 31+600 (24P)
- Sta. 31+815 (25P)
- Sta. 31+885 (26P)
- Sta. 32+000 (27P)
- Sta. 32+065 (28P)
- Sta. 32+105 (29P)

At each location, multilevel VWPs were installed on the:

- Upstream side of the cut-off wall, approximately 2 m from the centreline;
- Immediately downstream of the cut-off wall, approximately 2 m from the centreline;
- Further downstream of the cut-off wall, approximately 10 m from the centreline.

In addition, single VWPs were installed immediately downstream of the cut-off wall near the contact area (base of cut-off wall and top of bedrock surface) at the following stations:

- Sta. 30+167 (6P2)
- Sta. 30+249.5 (7P2)
- Sta. 30+770 (12P2)
- Sta. 30+804.5 (13P2)
- Sta. 31+700 (18P2)
- Sta. 31+842 (22P2)

- Sta. 30+306.5 (8P2)
- Sta. 30+440 (9P2)
- Sta. 30+516.5 (10P2)
- Sta. 30+684.5 (11P2)
- Sta. 31+052 (14P2)
- Sta. 31+220 (15P2)
- Sta. 31+565 (16P2)
- Sta. 31+615 (17P2)
- Sta. 31+928 (19P2)
- Sta. 31+990 (20P2)
- Sta. 32+020 (21P2)

Some of the installed piezometers on Bay-Goose Dike are broken or malfunctioning. Table 2 indicates the list of malfunctioning instruments on Bay-Goose Dike as flagged by AEM, the possible reason why they are malfunctioning, and the date when they started malfunctioning.

Table 2: Malfunctioning Instruments on Bay-Goose Dike flagged by AEM

Name of Piezometer	Location	Possible Reasons for Malfunctioning	Malfunctioning Start Date
1P1-C	30+158	Rapid freezing, piezometric head went off limits and broke the instrument (temperature still works)	February 22, 2013
1P1A, 1P1-B	30+158	Frozen, still shows head and temperature	March 19, 2014
1P2-C	30+158	Frozen, still shows head and temperature	March 1, 2015
2P1-A, 2P1-B,	30+276.5	Frozen, still shows head and temperature	January 4, 2014
5P1-A, 5P1-B, 5P1-C, 5P2-C	30+645.5	Frozen, still shows head and temperature	February 8, 2014
6P2C	30+167	Frozen, still show head and temperature	March 1, 2015
10P2C	30+516.5	Frozen, still show head and temperature	February 17, 2015
11P2	30+684.5	Frozen, still shows head and temperature	February 27, 2015
12P2	30+770	Frozen, still shows head and temperature	January 17, 2013
13P2	30+804.5	Frozen, still shows head and temperature	December 20, 2012
14P2	31+052	Rapid freezing, piezometric head went off limits and broke the instrument (temperature still works)	February 21, 2012
15P2	31+220	Frozen, still shows head and temperature	February 4, 3013
16P2	31+565	Frozen, still shows head and temperature	January 15, 2013
17P2	31+615	Frozen, still shows head and temperature	February 2, 2014
18P2	31+700	Frozen, still shows head and temperature	February 2, 2014
29P1B2, 29P2B3,29P3B3,	32+105	Frozen, still shows head and temperature	March 6, 2014

Name of Piezometer	Location	Possible Reasons for Malfunctioning	Malfunctioning Start Date
29P2C			
29P1B3	32+105	Frozen, still shows head and temperature	March 4, 2014

An analysis of the piezometer data indicates that the piezometers identified as frozen by AEM show temperatures below 0°C. The thermal data analysis for the piezometers also shows that piezometers 2P1-C, 7P2, 8P2, 23P1-C, 25-P1-B1, 25P1-B2, 27P1-B2, 29P1-B1 and 29P3-A1 might have frozen as they recorded data below 0°C. The piezometric reading of these piezometers is fluctuating while remaining within probable data range. This could be because the thermal calibration is slightly off and the piezometer did not really freeze, or it could mean that the piezometer froze and is broken but that has not reflected in the data. A piezometer that has frozen once may not be relied upon even if it unfroze. It is recommended to flag these piezometers to be careful when interpreting their data while staying vigilant to any rapid piezometric variance. The first time a piezometric rapid increase associated to a frozen piezometers is observed, it is important to remain vigilant without overweighting the abnormal trend. For the instruments showing very high piezometric readings, it is recommended to compare the pressure recorded to the instrument limit in order to identify if the variance could be due to factors other than mechanical problems such as seepage.

The majority of the instrumentation was installed at Bay-Goose from May to June 2011. The pumping of Goose Bay was done from July to November 2011. The response of the pumping of Goose Bay can be observed in most of the piezometers, with sharp decreases in pore water pressure (pwp) from July to November 2011.

A cooling trend starting in July 2012 can be observed in all piezometers installed on Bay-Goose dike. The instruments located farther on the downstream side generally record lower temperature then the instrument closer to the dike and the lake. As a result, the instruments on the upstream side of the dike are generally the last ones to freeze and the ones farthest on the downstream side are the first to freeze. In some sectors, most of the piezometers are in frozen condition, while in some sectors almost none of the piezometers are in frozen conditions. There seems to be a correlation between the sector in which seepage have been observed historically and the number of frozen instruments.

From 2012 to 2017, a generalized trend can be observed in the pore water pressure measurements of most non-frozen piezometers located along the dikes (upstream and downstream side). An increase in pore water pressure is observed during winter (November to May approximately). The pore water pressure tends to stabilize or decrease during freshet (May to September approximately). Historically, the rising trend has been attributed to ice build up at the downstream toe of the dike and the decrease has been attributed to melting of this ice.

There is generally a drop in the hydraulic head across the cut-off wall and within the grouted bedrock in the downstream direction. In general, the data from the piezometers are similar to the historical trend.

In addition to the seasonal trend described above, specific observation trends can be observed for various areas of the dikes. These areas generally coincide with seepage channels as the majority of piezometers are frozen in non-seepage channel areas.

North Portion (Sta. 30+158 to 30+516.5)

The majority of the multilevel piezometers installed at 30+158 are in frozen conditions. The piezometer downstream of the dike froze in 2015 at the time Goose Pit reached its final elevation. The upstream piezometer froze in 2016.

More than half the multilevel piezometers installed near 30+276.5 are frozen. The recorded pore water pressure (pwp) in the unfrozen instruments increased from November 2014 to April 2015 by approximately 0.6-1 m. The piezometric level has since then been stable with cyclical variation but has not recovered to the level before 2015. The unfrozen piezometers on the downstream side near the cut off wall had a 0.6 to 0.8 m cyclical fluctuation from August 2016 to August 2017. Sharp increases and decreases in the recorded pore water pressure for all insturments are linked to drilling operations in Pit E5.

Large scale seasonal variation are seen in the pore water pressure recorded in all piezometers, with fluctuation more pronounded on the downstream side. Piezometers located near the North Channel from Sta. 20+378 to 30+453 have recorded an increasing trend in pwp from January 2017 to May 2017. In May 2016, a sudden drop of pwp was recorded in most instruments of the North Channel (up to 2 m). The furthest piezometer installed downstream at 30+453 recorded a huge pressure increase during the winter of 2017 (4.6 m increase), which had a similar drop during the summer. Sharp increases and decreases in the recorded pore water pressure for all instruments are linked to drilling operations in Pit E5.

These variation in pore water pressure are happening in the zone associated with the North Channel seepage and monitored by seepage station no. 8 and no. 9. The increase in magnitude of the pore water pressure until May 2017 and their sudden decrease might be caused by the mining activity and the depressurisation of the rock walls in Pit E5. From July 2017, an important decrease in flow reporting at the downstream toe of this sector was also observed in the monitoring stations, which supports this theory.

The temperature recorded by the piezometers from Sta. 30+158 to Sta. 30+276.5 shows a sharp increase in temperature the end of June 2016 for all instruments. The temperature spiked by 10°C in average shortly after blasting in Pit E5, and has remained stable until the time of the inspection. According to AEM, blasting operations have caused similar increases in the previous years, however the temperature usually decreases back to normal after the event. In 2017, the recorded temperatures have remained high and are monitored by AEM. All the beads of thermistor strings T1 (30+134) and T2 (30+185) also show negative spikes in temperature (0.5 to 2°C) at the end of June 2017, but also in January 2017, which is not reflected in the piezometers. What caused these quick temperature fluctuations at this location is not understood; there might be a problem with the instrumentation set-up at this location. The remaining thermistor beads in this sector show that the foundation of this sector is not frozen.

Central Shallows (Sta. 30+645.5 to 30+804)

The majority of the piezometers installed in this area are frozen and give erratic data. Seepage station no. 7, which was active during the summer of 2017, is near this area.

The unfrozen piezometer indicates an increasing trend in pwp of approximately 1.5 m from 2013 to 2015. The increase in pwp occured from January to May. In 2016 and 2017, the recorded pwp was stable.

Central Channel (Sta. 31+020 to 31+220)

There is a seepage zone with ponding water observed downstream associated with this channel. The majority of the piezometers in this area are not frozen.

From 2012 to 2017, the maximum and minimum recorded pwp for the piezometers downstream has been constant. There is generally a pressure build-up from January to June followed by several pressure drops and increases from June to September. In 2017, a minimum value around 130.6 m was recorded during freshet and a maximum value around 133.4 m was recorded during winter, similarly to the previous years. The pwp data tends to fluctuate more during freshet than during winter. This behaviour seems to be consistent with the explanation that the recorded pwp are influenced by the pumping of the water pond located downstream. In addition to the global trend, a small drop (up to 0.2 m) occurred in February 2017 at the same time as a peak in temperature observed at some of the piezometers. The peak may originated from a reading error (0°C). A temporary drop of about 0.8 m was recorded in September 2016 in the piezometers installed the furthest downstream only. These piezometers may be frozen.

Channel 3 (Sta. 31+565 to 31+700)

There is a seepage zone monitored by station no. 6 associated with this channel. There is a drainage channel dug into the ring road in the area to allow water to flow freely in the pit. The piezometric array in this area are frozen and a cooling can be observed in the recorded temperature since 2011.

A sharp increase in pwp was recorded for most piezometers during the winter of 2014 (except one piezometer on the upstream side that is stable). This increase was approximately 1 m higher than the increase recorded during the winter of 2013. From 2014 to 2017, the pwp was stable in the piezometer located directly downstream (general decrease of 0.2-0.6 m while following seasonal trends). The piezometers located farther downstream have recorded a decrease of approximately 1.6 m since 2014 (while following seasonal trends). An increase in pore water pressure was measured from December 2016 to June 2017 and is followed by a drop, as observed in previous years.

Channels 1 and 2 (Sta. 31+815 to 32+105)

No seepage has been observed at the toe of the dike in 2017, but there is a water pond in this location naturally draining to Goose Pit. The majority of the piezometers are not frozen in this area.

A drop in recorded pwp (2 to 4 m) has been observed in the piezometers located in Channels 1 and 2 in the freshet of 2013. After this event, the recorded pwp has generally been stable (0.2 to 0.6 m fluctuation from winter to freshet) from 2013 to 2017 for the piezometric arrays of Channels 1 and 2.

The thermal data at Sta. 31+815 might indicate some sign of seepage as the thermal cooling is less pronounced and there is a wider fluctuation of temperature recorded at this location than in the other thermistor nearby.

4.3.2 Thermistor

Thirty-three thermistors (from T1 to T30 and T3’ to T5’) have been installed on Bay-Goose Dike. From September 2016 to September 2017, the following observations have been made.

Sta. 30+134 (T1), Sta. 30+827 (T14) and 32+140 (T30)

The three thermistors installed at Sta. 30+134 (T1), Sta. 30+827 (T14), and Sta. 32+140 (T30) are located on the northern abutment, Goose Island, and the western abutments. The first node of these thermistors is installed about

1 m below the dike crest. For this period, the dike and its foundation were entirely frozen on the northern abutment (T1), Goose Island abutment (T14), and the western abutment (T30).

Sta. 30+185 (T2), Sta. 30+489.5 (T9), Sta. 30+553.25 (T10), Sta. 30+621.5 (T11), Sta. 30+650 (T12), Sta. 30+713 (T13), Sta. 31+080 (T15), Sta. 31+134.5 (T16), Sta. 31+170 (T17), Sta. 31+352 (T18), Sta. 31+752.5 (T21), Sta. 31+820 (T22)

Twelve thermistors were installed in the SB portion of the cut-off wall. All the thermistors with the exception of T15 and T18 show a similar trend:

- the rockfill is frozen all year below El. 134 m.
- there is generally an active layer in the till and the rockfill is thawed all year.
- the till foundation did not remain frozen for the entire year for any thermistor and the bedrock was always in an unfrozen state with temperatures ranging from 1°C to 3°C.

T18 (31+352) indicates that the till and the bedrock remained frozen, while T15 (31+080) indicated that the active layer included the till and the entire instrumented depth of the bedrock.

Sta. 30+260 (T3), Sta. 30+261.5 (T3'), Sta. 30+272 (T4), Sta. 30+273.5 (T4'), Sta. 30+288.5 (T5), Sta. 30+290 (T5'), Sta. 30+330.5 (T6)

This portion of the dike contains a cut-off wall where settlement could occur due to CSB, a rigid material, sitting on top of SB, a soft material. The designed thermistor nodes configuration for T3 (Sta. 30+260), T4 (Sta. 30+272), and T5 (Sta. 30+288.5) were modified to have nodes located very close together and were to be installed to monitor the interface between the CSB and SB materials as noted below. Thermistors T3, T4, and T5 were not installed to the designed depths, but instead have been installed below the interface and monitor the bedrock contact. These thermistors are recording temperatures above 0°C.

Thermistor T6 indicates that the ground is completely unfrozen below an elevation of 130 m. Therefore the till foundation was unfrozen from September 2016 to September 2017. From 130-133 m, the ground fluctuates above and below 0°C and from 133-135 m, and the dike remained frozen.

In 2011, AEM installed three additional thermistors at Sta. 30+261.5 (T3'), Sta. 30+273.5 (T4'), and Sta. 30+290 (T5') that provide readings across the CSB/SB interface. The spacing between each node does not meet the design. No seepage directly downstream of this portion of the dike was observed; however, based on the topography, it is anticipated that seepage from this area could report to a lower point within the North Channel (i.e., 30+360). These thermistors show that the till and bedrock were completely unfrozen from September 2016 to September 2017.

Sta. 30+386 (T7), Sta. 30+417.5 (T8), Sta. 31+595 (T19), Sta. 31+605 (T20), Sta. 31+850 (T23), Sta. 31+880 (T24), Sta. 31+960 (T25), Sta. 31+995+ (T26), Sta. 32+030 (T27), Sta. 32+060 (T28), Sta. 32+100 (T29)

Eleven thermistors were installed in areas where the bottom of the cut-off wall was jet grouted. These thermistors show that the maximum active layer depth was above 135 m between September 2016 and September 2017. The majority of the rockfill stayed frozen all year and the till and bedrock were unfrozen all year with an exception at T29.

At T29, a part of the till foundation outside of the jet grouted area remained frozen for the entire September 2016 to September 2017 period. The jet grouted area, however, did not remain frozen at T29. The temperature of the jet grouted area varied between 0°C and 2°C.

4.3.3 Inclinometers

Six inclinometers are installed at Bay-Goose Dike: Sta. 30+282, Sta. 30+390, Sta. 31+590, Sta. 31+815, Sta. 31+885, and Sta. 32+065. The inclinometer displacements are referenced along Axis A and Axis B; Axis A is perpendicular to the cut-off wall alignment (positive displacement towards the Pit side) while Axis B is perpendicular to Axis A, parallel to the cut-off wall (positive displacements towards the increasing chainage). The use of a new reel has slightly offset the measurements from the ones taken before. The cumulative displacement in Axis A varied from 0.1 mm to 27 mm. Cumulative displacement values for Axis B varied from 0.1 mm to about 25 mm. It should be noted that some cumulative displacement curves received from AEM do not show the largest values that are outside the limits of the graphs. The larger settlement happened in the upper portion of the dike and in the thermal cap. Recorded displacements are mainly small and are within the tolerable displacements for the structure. From 2016 to 2017, no significant movement was observed for all inclinometers, which measurements have remained relatively stable since 2014.

4.3.4 Seismograph

For every blast at Goose-Pit and Pit E4/E5, seismograph monitoring of blast vibrations on the crest of Bay-Goose Dike has occurred. AEM analyse the monitored blast vibrations after each event. The maximum allowable PVS for all dikes is set at 50 mm/s per the designer recommendation. The highest recorded PVS for Bay-Goose from September 2016 to September 2017 was 33.6 mm/s at station DL1 near pit E5. No estimated tensile and shear strains were calculated during the annual geotechnical inspection. The recorded PVSs were compared to the PPV values used in the previous Meadowbank Pit Blasting Effect Study, which considered the tensile and shear strains, indicating that the blast vibrations recorded are not a concern for the integrity of the dike.

The reflectometers confirm that a response can be observed in the dike after the blasts.

4.3.5 Flow Meters

The flow was estimated from 4 seepage monitoring stations located at the downstream toe of the dike using a water collection pipe and a plastic bucket. From July to September 2017, the total average flow at the toe of the dike was measured at 14.7 m^3/day compared to 24 m^3/day in 2016, 29 m^3/day in 2015, 132.2 m^3/day in 2013, and 97.2 m^3/day in 2012. The measured flow in 2017, 2016 and 2015 does not take into account the inflow of water from the pond at Central Channel as this value was not measured in 2016 and 2015 (61 m^3/day in 2013 and 2014).

It is recommended to continue monitoring the evolution of the seepage at the toe and continue measuring the inflow of water from the pond at Central Channel.

4.4 Vault Dike

Five thermistor strings were installed on Vault Dike following its construction in the winter of 2013. T3 is installed in the deepest channel downstream, T5 is installed under the liner, T6 is installed upstream of the liner, T7 is installed east of the deepest channel, and T8 is installed upstream in the deepest channel outside of the key trench. The Vault Dike thermistor data are presented in Appendix C1. The instrumentation is indicating that the structure is behaving as expected with data following historical trends.

The following thermal regime observation were made :

- All beads of thermistor TH-3 stopped working in October 2015;
- The instrumentation shows that the entire foundation of Vault Dike (till and bedrock) is frozen;
- The active layer in the rockfill was up to 4 m thick in the summer of 2017.

4.5 TSF South Cell

4.5.1 Central Dike

Instruments were installed on Central Dike to monitor the dike's performance during its construction, operation, and closure. Nine boreholes were drilled on three rows corresponding to the central key trench (545-P1, 580-P1, 650-P1 and 750-P1), the final downstream toe (545-P2 and 650-P2) and the Portage Pit limit (465-P3, 650-P3, 875-P3 and WR-P3). Four additional boreholes were drilled and instrumented in 2016 during the seepage field investigation in the key trench alignment (595-P1, 810-P1, 825-P1 and 850-P1). Two thermistor strings were also installed on the upstream face to monitor the temperature within the tailings of the South Cell.

Seven additional boreholes were drilled and instrumented in 2017 (700-P1, 745-P3, 800-P2, 800-P3, 875-P2, 975-P3 and 1050-P3). The instrumentation on Central Dike consists in 2017 in a total of 69 piezometers and 20 thermistor strings installed in 20 boreholes.

The following presents a summary of the data collected until September 2017 for the piezometers and the thermistors. Data plots for the instrumentation sent by AEM are presented in Appendix C2.

4.5.1.1 Thermistors

The thermistors installed in 2013 are showing similar trends as in the past. The instruments installed in 2016 are showing similar trends as the instruments installed in 2013 in similar areas. The instruments installed in 2017 have not yet stabilized but already showing similar trends as the instruments installed in the previous years in similar areas

The following observations of the thermistor data can be made:

- The instruments installed along the central key trench (545-P1, 580-P1,595-P1,650-P1,750-P1, 810-P1, 825-P1) show thawed conditions (between 0.5°C and 5°C) within the till, the bedrock and the rockfill (from El. 110 m to 65 m). Thermistor 810-P1 shows higher temperatures but may be starting to malfunction according to AEM.
- Thermistor 825-P1 shows warmer readings in 2016-2017 than in 2015-2016, with temperature variation over the year in the bedrock and till higher than last year. This trend is not observed in thermistor 850-P1 nearby.
- The instruments installed along the downstream toe of the Central Dike footprint for a final crest elevation of 150 m indicate that the till unit at 545-P2 stayed frozen in 2016 but not at 650-P2, while the majority of the bedrock foundation did not freeze (between 0°C and 0.6°C degree below El. 92 m at 545-P2, and between 0.4°C and 1.5°C degree below El. 102.5 m at 650-P2).
- Throughout the year, temperature variations up to 1°C can be observed for each bead, except in rockfill near the surface (up to 10 m deep) where the amplitude is larger. The bedrock temperature from El. 105 to 55 m varies from -6.2°C to -3.5°C at 465-P3, from -6.7°C to -0.7°C at 650-P3 and from -0.3°C to 1.3°C at 875-P3. This seems to indicate that a permafrost condition is developed in part of the Portage Pit Wall while the part aligned with the south abutment of Central Dike did not freeze during the year.

- The thermistor installed in the West Road (745-P3) indicated that the rockfill stayed in frozen conditions below El. 124 m and that the dense till stayed frozen all year. It marks the limit of the frozen section observed on the downstream toe of Central Dike.
- Thermistors 875-P3 and 975-P3 installed near portage Pit show that the bedrock remained unfrozen below El. 105 m approximately, with temperatures ranging from 0 to 1.3°C.

These observations tend to confirm the visual observation of seepage downstream as the foundation of the dike (till and bedrock) on the downstream side are unfrozen all year. Till and bedrock temperature tend to decrease further from the downstream side and the piezometer near Portage Pit show permafrost condition.

4.5.1.2 Piezometers

The general piezometric trend is stable. Most instruments are correlated with the downstream pond elevation.

Piezometers in borehole 580-P1 broke in 2016 and were replaced in 2017 (580-P1R).

It can be observed that the piezometers located in boreholes between Sta. 595 and Sta. 875 are strongly reacting to the level of the water pond located downstream of Central Dike. In those boreholes, the 23 piezometers that are non-frozen and that are not in suction are recording piezometric elevation around El. 115 m and have strongly reacted to the pumping of the downstream pond in 2015. The piezometers between Sta. 595 and Sta. 875 located in the rockfill, till and bedrock are reacting similarly, which seems to indicate an hydraulic connection between the downstream pond, the till and the bedrock. The piezometric elevation recorded in the till and the bedrock between Sta. 595 and Sta. 875 is generally slightly higher than the elevation of the downstream pond, indicating excess pore water pressure. Piezometer 650-P2 and 875-P3 are very interesting, as they are the only instruments that seem to react to the South Cell level instead of the downstream pond level. Piezometer 650-P2-A has been on the rise since December 2015 and the measured piezometric elevation has now exceeded the South Cell pond elevation. Piezometer 875-P3-A fluctuates with the South Cell head, while although piezometer 875-P3-B follows the downstream pond level, it seems to be slowly rising as the South Cell pond elevation increases.

With the exception of 545-P1-D, the piezometers located between Sta. 465 and Sta. 580 are not reacting to the downstream pond water level or the elevation of the South Cell, and indicate much lower piezometric elevations. The exception to this observation is piezometer 545-P1-D, located in the till, that recorded a drastic increase in piezometric elevation when deposition started in the South Cell in 2014. This piezometer recorded another significant increase in piezometric elevation in the summer of 2015, which at the time was higher than the South Cell water level. Since October 2015, the piezometric elevation in this piezometer has stabilized to El. 125 m.

Generally, a downward hydraulic gradient in part of the bedrock and of the till can be interpreted in piezometers located in the same boreholes. Small upward gradients in the till or the upper bedrock can also be observed in some boreholes, such as 580-P1R, 650-P1, 700-P1, 750-P1 and 810 P-1. Significant upward pressure gradients in the bedrock can be observed in holes 545-P1, 545-P2, 825-P1 and 850-P1. It is not possible to observe a generalized upward hydraulic gradient trend that would indicate that pressurised bedrock is transmitting pore water pressure to the till. The piezometric elevation in the bedrock is often similar or smaller than recorded in some parts of the till layer. However, due to the topography, it is possible that water is reporting from bedrock located higher and induces excess pore water pressure on the foundation soil located lower below.

Like in previous years, it can be observed that some piezometers are recording negative pressure (suction). Negative pressure for unfrozen conditions was recorded in seven piezometers. Piezometers in suction are recording very few variations in measured pore water while the other instruments are reacting to the downstream pond elevation. These instruments are generally located in the bedrock. Based on the available information, it is not possible to determine the exact cause of this suction. This could be due to a problem with the instruments or to a non-continuous geological environment in which the water table is locally below the installation depth of some of the instruments. Table 3 indicates the instruments measuring suction. The results of these instruments must be interpreted with caution.

By comparing the piezometers' installation elevation to the thermistor readings, it is possible to observe that ten piezometers have experienced temperatures below 0°C until the time of the inspection. Four of these piezometers also recorded suctions. The piezometers that were frozen generally showed piezometric readings that were stable except for 465-P3-A, 545-P2-A and 650-P3-A. A piezometer that has frozen once cannot be relied upon even if it thawed, as freezing generally breaks the piezometer or shifts its calibration curve. It is recommended to flag these piezometers and be careful when interpreting their data even if they seem to make sense. For example, 650-P3-A closely follows the water level fluctuations of the South Cell until 2015, but since it is frozen, the decrease in pore water pressure recorded might not be representative of actual field conditions. Table 3 indicates the instruments that could have frozen in the past.

Table 3: Observations on the Piezometer Readings of Central Dike

Name of Piezometer	Installation Unit	Observation
545-P1-A	Bedrock	Suction.
545-P1-D	Till	Starting in September 2014, the piezometric elevation started to increase rapidly and equilibrate with the South Cell water level. Another rapid increase in 2015. Stable since.
580-P1-(A to E)	Bedrock	Instruments stopped working in July 2016. Replaced in 2017 by 580-P1R.
580-P1R-A	Sand	Data available since June 2017. Piezometric elevation fluctuates with downstream pond level.
580-P1R-B	Bedrock	Data available since June 2017. Suction.
595-P1-(A to E)	Till, bedrock, rockfill	Piezometric elevation similar to downstream pond. Casing stuck in the bedrock (piezometers C to E installed in the casing).
650-P1-A	Bedrock	Suction. No reading since February 2017.
650-P1-B	Bedrock	Piezometric elevation fluctuates with downstream pond level. No reading since February 2017.
650-P1-(C,D)	Till	Piezometric elevation fluctuates with downstream pond level . No reading since February 2017.
750-P1-(A,B,C)	Bedrock	Suction.
750-P1-D	Till	Piezometric elevation fluctuates with downstream pond .
750-P1-E	Rockfill	Piezometric elevation fluctuates with downstream pond .
545-P2 B	Bedrock	Suction .
545-P2-C	Bedrock	Frozen, suction.
545-P2-D	Till	Frozen, suction.
650-P1 (B,D)	Bedrock and till	Broken since August 2016.
650-P2-A	Bedrock	Piezometric elevation exceeds the South Cell pond level.

Name of Piezometer	Installation Unit	Observation
650-P2-B	Bedrock	Piezometric elevation fluctuates with downstream pond level.
650-P2-C	Bedrock	Piezometric elevation fluctuates with downstream pond level, frozen.
650-P2-D	Till	Suction. Frozen.
465-P3-A	Bedrock	Frozen.
465-P3-B	Bedrock	Frozen.
650-P3-A	Bedrock	Piezometric elevation fluctuates with downstream pond. Frozen.
650-P3-B	Bedrock	Suction. Frozen.
700-P1-(A,C)	Bedrock	Piezometric elevation fluctuates with downstream pond .
700-P1-D	Rockfill	Piezometric elevation fluctuates with downstream pond .
800-P2-(A,B,C)	Bedrock	Readings available since June 2017. Piezometric elevation fluctuates with downstream pond .
800-P3-(A,B)	Bedrock	Readings available since June 2017. Piezometric elevation fluctuates with downstream pond. Instruments may be frozen.
810-P1-A	Bedrock	Piezometric elevation fluctuates with downstream pond .
810-P1-B	Bedrock	Broken since January 2017.
810-P1-(C,D)	Till	Piezometric elevation fluctuates with downstream pond .
825-P1-(A,B)	Bedrock	Piezometric elevation fluctuates with downstream pond .
825-P1-E	Till	Sharp increase in april 2017 and has followed the trend of the South Cell pond since then.
875-P2	Bedrock, till	Data available since June 2017. Piezometric elevation fluctuates with South Cell pond. Small glitch in the data when readings were automatized.
875-P3-A	Bedrock	Piezometric elevation fluctuates with South Cell pond .
875-P3-B	Bedrock	Piezometric elevation fluctuates with downstream pond but is impacted by the raise in the South cell pond level.

4.5.1.3 Seismograph

For every blast at Portage Pit, seismograph monitoring of blast vibrations on the crest of Central Dike has occurred at four locations along the dike. AEM looks at the monitored blast vibrations after each event. The maximum allowable PVS for all dikes is set at 50 mm/s per the designer recommendation. The highest recorded PVS for Central Dike from September 2016 to September 2017 was 10.00 mm/s.

4.5.1.4 Turbidity and Water Quality

The turbidity of the downstream water pond was monitored in 2015, 2016 and 2017. The turbidity of the downstream pond increased with the pump speed. It can also be observed that the turbidity decreased in the freshet then increased stongly during the summer, with a peak at 38 NTU. The turbidity levels are generally lower than 15 NTU and the water is usually clear in the downstream pond.

However, between July and August 2017, a change in the water coloration was observed in the downstream pond. The water turned orange and back to normal several times in cycles. An orange sludge was observed on the surfaces below the water level. No change in pH was measured but turbidity increased during the summer. Chemical analyses were performed to identify the source of the coloration. The available results indicate that no tailings are present in the downstream pond and that the coloration is linked to natural bacterial processes.

4.5.2 Saddle Dam 3

Four thermistors are installed at Saddle Dam 3. Three of these thermistors are located along the axis of the faulted zone that was encountered during the construction of Saddle Dam 3 (around 20+650). Along this axis, one thermistor is installed downstream, one is installed on the crest, and the other is installed on the upstream toe liner tie-in. Another thermistor is installed at 20+720 within the upstream toe liner tie-in. These thermistors are mostly in permafrost condition, with the bedrock frozen all year long except at SD3-T3, where the upper 3 m of bedrock are part of the active layer. It will be important to follow the performance of the structure once Saddle Dam 3 becomes operational for containement of supernatant water.

4.5.3 Saddle Dam 4

Two thermistors are installed at Saddle Dam 4 near Sta. 40+300. One thermistor is installed on the crest while the other is installed on the upstream toe liner tie-in. These thermistors are mostly in permafrost condition. It will be important to continue follow the performance of the structure as Saddle Dam 4 is now operational and retaining tailings and water.

4.6 TSF North Cell

4.6.1 Saddle Dam 1

Thermistor data from within the structure indicate that the dike foundation remained frozen from September 2016 to September 2017. The foundation soil and bedrock remained in a frozen state with temperatures ranging from about -1.3°C to -5.4°C. At the upstream toe, below El. 132 m, the compacted till base material below the liner remained frozen. The majority of the rockfill shell remained frozen during the reported year as the active layer was 2 m. The instrumentation indicates that the structure is behaving as expected with data following historical trends.

No sign of seepage or thawing of the foundation soil can be observed from the instrumentation data. The structure is performing as expected.

Plots of the Saddle Dam 1 thermistor data are presented in Appendix C3.

The SD1-T1 thermistor string is installed in the centre of the upstream face of the dike immediately beneath the geomembrane liner to monitor temperatures within the deposited tailings. A thin layer of protective granular material exists above the geomembrane liner at this location. This thermistor indicates that the tailings are frozen below El. 146.5 m approximately with temperatures ranging from -2°C to 0°C, and that there is an active zone in the tailings above El. 146.5 m.

The SD1-T2 thermistor string is installed vertically through the upstream Stage 1 crest in the centre of the dike at El. 140 m. The data show that the dike foundation remained frozen during the past year with temperatures fluctuating between -1.3 C and -4.2°C, which is consistent with historical data. Temperatures between 0°C and -1.3°C were recorded in the rockfill of the dike, which remained frozen all year long below El. 140 m. No active layer has been observed below El. 140 m since 2015.

The SD1-T3 thermistor string is installed vertically through the upstream Stage 2 crest in the centre of the dike at El. 150 m. It can be observed that the dike foundation and dike rockfill remained frozen during the past year with temperatures between -4.2 C and -5.4°C. An active layer in the rockfill can be observed above El. 146 m. The remaining of the rockfill stayed in frozen conditions. The trends observed are consistent with the data from the past years.

The SD1-T4 thermistor string is installed vertically through the upstream toe of the dike near the centre of the dike. It indicates that the dike foundation on the upstream toe, including the liner tie-in till plug, remained totally frozen since 2011, with temperatures ranging from -7.2°C to -0.8°C from September 2016 to September 2017.

4.6.2 Saddle Dam 2

Thermistor data from within the structure indicates that the dike foundation remained frozen from September 2016 to September 2017 with temperatures ranging from -4°C to -7.2°C. At the upstream toe of the dike, the semi-pervious backfill remained frozen during the year. The rockfill mostly stayed in frozen condition with an active layer above El. 148 m. The instrumentation indicates that the structure is behaving as expected with data following historical trends.

No signs of seepage or thawing of the foundation soil were observed. The structure is performing as expected.

Plots of the Saddle Dam 2 thermistors data are presented in Appendix C3.

The SD2-T1 thermistor string is installed in the centre of the upstream face of the dike immediately on top of the geomembrane liner to monitor the thermal regime of the tailings in contact with the structure. This thermistor indicates that the tailings are frozen all year below El. 147.2 m approximatively (temperature between 0°C and -3.5°C) and that there is an active layer above that elevation.

The SD2-T2 thermistor string is installed vertically through the upstream crest in the centre of the dike at El. 140 m. It shows that the dike foundation remained frozen for the past year (temperature varying from -4.3°C to -7.2°C).

The SD2-T3 thermistor string is installed vertically through the upstream liner tie-in trench near the centre of the dike at about El. 144 m. It shows that the dike foundation and the semi-pervious backfill placed on top of the compacted till remained frozen during the past year (temperature between -4°C and -6.5°C).

The SD2-T4 thermistor string is installed vertically through the upstream toe about mid-way between the centre of the dike and the northwestern abutment. It shows that the dike foundation remained frozen during the past year along with the compacted till base material below the geomembrane liner in this area. The semi-pervious backfill placed on top of the compacted till also remained frozen during the summer of 2017. The temperature varied between -3.7°C and -6.4°C.

4.6.3 RF1-RF2

Four thermistors were installed in 2012 to monitor the temperature of RF1 and RF2 (which delineates the northeastern side of the TSF's North Cell). Plots of these thermistors' data are presented in Appendix C3.

Three thermistors are installed on RF1 (T121-1, T73-6, and RF1-3). Thermistor T121-1 shows frozen conditions all year long with temperatures varying from -0.8°C to -5.2°C. Thermistor T73-6 shows temperatures between -1.5°C and -3°C below El. 145 m and the presence of an active layer above that elevation. RF1-3 shows frozen conditions all year long below El. 147 m with temperatures varying between 0°C and -2°C. Above that elevation, there is the presence of an active layer within the upper elevation of the deposited tailings.

One thermistor is installed on RF2 (T122-1) and shows temperatures that vary from -1.6°C to -6.5°C, indicating that the RF2 foundation is in a permafrost state.

4.6.4 North Cell Tailings

Five thermistors are installed in the tailings of the North Cell of the TSF (SWD-1, SD2-1, 90-1, NC-TH-1 and NC-TH-2). These thermistors were installed from 2012 to 2016. Nine additional thermistors were installed in 2017 (SWD-01, NC17-01, NC-17-02, NC-17-03, NC-17-04, NC-17-05, NC-17-06, NC-17-07, NC-17-08). Plots of these thermistors' data are presented in Appendix C3. They indicate that the tailings in the North Cell are not entirely frozen, including in the talik area where the reclaim pond was kept during operation.

Thermistors SD2-1 and SWD-1 were installed in April 2014 in the tailings of the North Cell near SD2 and SWD. Data for these instrument were available only from April 2014 to October 2014.

Thermistor 90-1 was installed in 2012 in the tailings of the North Cell near Saddle Dam 1. From September 2016 to September 2017, the tailings at that location from El. 143 m to El. 130 m were frozen all year.

Thermistor NC-TH1 and NC-TH2 were installed in April 2016 in the tailings of the North Cell in the location of the former reclaim pond. NC-T1 show tailings temperature between 0°C and 3.5°C below El. 144 m and frozen tailings above that elevation. NC-T2 data area vailable until December 2016 and show tailings temperature between 0°C and 2°C below El. 124 m and frozen tailings above that elevation.

Thermistor NC-17-01 to NC-17-08 were installed in February 2017 in the tailings of the North Cell.

NC-17-01 shows in 2017 an active layer in the tailing and the upper bedrock between El. 130 and 135 m, frozen tailings above that El. 135 m, and frozen bedrock below El. 130 m with temperatures ranging between 0°C and -2°C.

NC-17-02 shows that the tailings and the bedrock did not freeze in 2017 below El. 140 m with temperatures ranging between 0°C and 2.3°C. The unfrozen conditions are attributed to the presence of the supernatant water pond near the Saddle Dams close to the instrument.

NC-17-03 shows that the tailings and the bedrock did not freeze in 2017 below El. 140 m with temperatures ranging between 0°C and 3.5°C. The unfrozen conditions are attributed to the presence of the supernatant water pond between RF1 and RF2 close to the instrument.

NC-17-04 shows that the tailings and the bedrock remained in 2017 below El. 135 m with temperatures ranging between 0°C and -3.5°C. Another zone located in the tailings between El. 142 and 147 m did remained frozen with temperatures ranging between 0°C and -5.5°C. Between El. 135 and 142 m, the tailings did not freeze and indicate the presence of a talik, consistent with the observations made when the reclaim water pond was present at this location during operations. An active layer is observed in the tailings above El. 147 m.

NC-17-05 shows that the tailings remained frozen in 2017 above El. 138 m. An active layer is observed in the tailings and the bedrock below El. 138 m. According to AEM, capacitance effects are seen on this instruments' readings, similarly to those observed on some Central Dike piezometers when automatic readings are collected. No instrument in the vicinity of RF1 or Stormwater dike seems to show the same thermal regime.

NC-17-06 shows that the tailings and the bedrock remained frozen in 2017 below El. 145 m with temperatures ranging between -9°C and 0°C. An active layer is observed in the tailings above El. 145 m.

NC-17-07 shows that the tailings and the bedrock remained frozen in 2017 below El. 145 m with temperatures ranging between -8.5°C and 0°C. An active layer is observed in the tailings above El. 145 m.

NC-17-08 shows that the tailings and the bedrock did not freeze in 2017 below El. 140 m with temperatures ranging between 0°C and 4°C. The unfrozen conditions are attributed to the location of the instrument directly within the supernatant water pond.

The temperature profile measured in thermistor SWD-01 is discussed in the next section.

4.7 Stormwater Dike

On August 25, 2016, 2 extensometers, 4 crack monitoring stations and 3 prisms were installed on the crest of SWD in the area showing movements (between Sta. 10+500 and 10+750 approximately). Following the MDRB recommendations, AEM installed additional instruments in 2017 to monitor the response of Stormwater Dike during tailings deposition in the South Cell, leading to a total of 2 piezometers, 3 thermistors, 4 extensometers and 19 prisms installed on Stormwater Dike.

From May 2017 to August 2017, the prisms measured movement mainly in the vertical direction (up to 49 cm cumulative displacement). Limited lateral displacement (millimeters) was measured towards the South Cell (downstream side). Most of the movement happened during freshet, when cracks appeared on the crest, then it slowed down towards stabilization. The maximum cumulative displacement recorded for the summer period is around 5 cm. The 3D velocity measured decreased from 5 mm/day on average during freshet to 1.5 mm/day in summer.

A single deep thermistor (T147-1) and piezometer string (VWP 13265) were installed at the downstream toe of Stormwater Dike (within the South Cell). These instruments were broken in September 2016 during the construction of the buttress at the toe of Stormwater Dike within the South Cell. It is important to note that the ground surface at the location of this thermistor was around El. 125 m with the first thermal node at El. 120 m. It was not possible to obtain information about the lakebed sediment layer from this instrument. Thermistor T147-1 showed the existence of a frozen crust of material from El. 120 m to El. 112 m. Piezometer VWP 13265 was responding to the water level of the South Cell before it was broken.

In 2017, three new thermistors (SWD-01, SWD-02 and SWD-03) and two new piezometers were installed in investigation boreholes (PZ-SWD-02, and PZ-SWD-03).

SWD-01 is installed on the upstream side of Stormwater Dike within the North Cell tailings. This thermistor shows that the tailings and the bedrock did not freeze between January 2017 and August 2017 below El. 132 m with temperatures ranging between 0°C and 6°C. The unfrozen conditions are attributed to the presence of the supernatant water pond close to the instrument. The temperature readings are available for only eight months, but seem to indicate that the tailings above El. 132 m freeze and thaw over the year.

SWD-02 is installed on the downstream side of Stormwater Dike (approx. Sta. 10+650 m) within the stabilization buttress and is covered by the South Cell reclaim pond. This thermistor shows that the till and the bedrock did not freeze between March 2017 and August 2017 below El. 115 m with temperatures ranging between 0°C and 1°C. The unfrozen conditions are attributed to the location of the instrument within the water pond. The till remained frozen between El. 115 and 123 m, with temperatures ranging between -0.7°C and 0°C. Above El. 123 m, the mesurements show that the overlaying till, lakebed sediments and rockfill did not freeze.

SWD-03 is installed on the downstream side of Stormwater Dike (approx. Sta. 10+690 m) within the stabilization buttress and is covered by the South Cell reclaim pond. This thermistor shows that the till and the bedrock remained frozen between March 2017 and August 2017 below El. 121.5 m with temperatures ranging between -0.8°C and 0°C. Above El. 121.5 m, the mesurements show that the overlaying till, lakebed sediments and rockfill did not freeze.

The piezometers installed in 2017 show a trend in pore water pressure that follows the evoluation of the water level in the South Cell reclaim pond. PZ-SWD-03-B installed in the till shows that the hydraulic head overlaps exactly with the measured water level in the South Cell. PZ-SWD-02-A and PZ-SWD-03-A are installed within the bedrock and follow a similar trend, with an offset. PZ-SWD-02-A appears to be in continuity with the last measurements of the broken VWP 13265 instrument.

Plots of Stormwater Dike thermistor and piezometer data are presented in Appendix C3. The movement monitoring data can also be found at the end of this appendix.

5.0 ALL-WEATHER PRIVATE ROAD

The All-Weather Private Road (AWPR), formerly referred to as the All-Weather Private Access Road (AWPAR), was built in 2007-2008 to connect the hamlet of Baker Lake to the Meadowbank Mine site (Figures 2A, 2B, and 2C). The road is approximately 107 km long with nine bridge crossings and culverts installed at a total of thirty-eight locations. Table 4 at the end of Section 5.2 lists each structure along the AWPR, their designated name, their approximate location and the observations noted during the inspection.

The road design is based on a general rockfill sub-base and crushed granular rockfill surfacing with a combined minimum thickness of 1 m over thawed stable soil and 1.2 m over thawed susceptible soil.

No sign of thermal degradation of the permafrost was observed on the road during the inspection. It should be noted that sign of thermal degradation may not necessarily be observed due to the regular road maintenance performed by AEM. During the inspection, water levels and flow velocities at the crossings were normal for the time of year.

Fill material that comprises the majority of the road provides no significant barrier to low gradient water flow due to its coarse nature. During higher flow and runoff periods, water may flow through portions of the road fill. Water was observed flowing through the rockfill near three culverts during the inspection, and signs that water flowed beneath the road were observed at some other locations during the inspection. This could also be due to the inlet or the outlet of some culverts having been installed too high or too low, which did not promote the flow of water through the culvert until a certain water level had been reached.

During the year, AEM conducts regular and event-based visual inspections of the fish-bearing water crossing locations along the access road. This data should continue to be compiled by AEM to confirm the hydraulic function of the crossings, the adequacy of the crossing locations with respect to the watercourses, and minimal impact to fish habitat.

It is understood that AEM's monitoring program includes an assessment of sedimentation and potential erosion issues at the major bridge crossings. Consideration should be given to expanding AEM's monitoring program to include all culverts and bridges along the road to assess whether they are providing adequate capacity during the freshet and following large precipitation events.

5.1 Culverts

The culverts were generally in good condition at the time of the inspection. No significant degradation of culvert conditions has been observed when compared to the 2016 inspection. Most culverts were unobstructed with no signs of erosion and no signs of damage to the culverts.

A photographic log of the inspected culverts is provided in Appendix D1. Culverts in the following discussion, and in the photographic log, have been identified by name (e.g. R-24) to be consistent with those indicated on the as-built drawings provided by AEM and as shown on Figures 2A to 2C. Some of the additional culverts installed in 2010 and 2011 are not shown on these figures. Each culvert is also identified by its approximate kilometre location (e.g., km 98+250) along the road alignment.

Signs indicating that minor erosion has occurred were observed at the inlet of PC-17A (8+830), and the outlet of R14 (km 67+840) and R24 (km 98+100). No action is recommended for the culverts showing sign of erosion as the situation seems stable. Culvert erosion progression should be monitored at freshet.

During the inspection, signs of water flowing beneath the road were observed at some locations. This is generally due to the inlet or the outlet of the culvert having been installed too high or too low, which did not promote the flow of water through the culvert until a certain water level had been reached. This condition can promote erosion and risk of washout beneath the road and should be monitored. This situation has been observed in the past and seem to be stable as no signs of deteriorating conditions were observed. This condition was observed at PC-17A (8+830), PC-11 (39+552), R-18B (80+950), R-20 (85+490), and R-23 (93+600). PC-11, R-20 and R-23 showed a flow of water during the inspection. The progression of the situation should be monitored at freshet.

Obstructed and damaged culverts were observed at some locations during the inspection. In many cases, the obstructions are related to inlets and/or outlets becoming partially or completely obstructed by accumulated rockfill and road material. There was no substantial increase in the number of significantly damaged culverts observed during the 2017 inspection when compared to last year. The following culverts were too damaged and obstructed to function properly: R-00A (2+550), unnamed culvert at 5+700, PC-14 (4+260) and PC-16 (54+950). If insufficient capacity to handle the flow is observed at locations where culverts are obstructed or damaged, it is recommended to clear the obstructions or repair the culvert.

Table 4, found at the end of Section 5.2, describes the observations for each culvert at the time of the inspection as well as recommendations. For example, for some culverts it is recommended to monitor the water level upstream and the flow through the culverts during high flow events (e.g. freshet season).

5.2 Bridges

Nine bridges are located along the AWPR: four Acrow Panel bridges and five Rapid Span bridges. A structural and/or mechanical assessment of the bridges was not conducted and is beyond the scope of this geotechnical inspection. A description of the observations of the bridges made during the inspection is presented in Table 4. A photographic log of the bridges is included in Appendix D2.

The bridges have been identified in sequence, increasing in number along the road from Baker Lake to Meadowbank (e.g. from Bridge 1 to Bridge 9). The name of each bridge (e.g. R02) is consistent with the as-built drawings of the AWPR provided by AEM. Each bridge is also identified by its approximate kilometre location (e.g. km 8+750).

Due to the low-lying terrain between Baker Lake and Meadowbank, water flow typically occurs in broad areas and not in well-defined channels. The majority of water crossings spanned by bridges have increased channelization of flow due to the embankment fill at the crossing location. No significant signs of embankment erosion were observed at the time of the inspection as they are generally constructed with coarse rockfill.

The bridges and their embankments were in good geotechnical condition at the time of the inspection. Signs of settlement were observed at Bridge R-15 and this condition should continue to be monitored. The following observations were made for each bridge during the inspection:

- **Bridge 1, R02 at about km 8+750**: Normal flow was observed at the time of the inspection. No signs of erosion or turbidity were noted. In 2011, two additional culverts of 1,800 mm in diameter were installed nearby to increase the drainage capacity during high flow events and prevent the road and the bridge from washing out. It is understood that AEM removes snow and ice at this location and other bridges before the freshet and will continue this practice in the future.
- **Bridge 2, R05 at about km 17+600**: Minor damage to the bin wall of both abutments was observed, and is likely a result of past snow removal activities. No evidence of erosion was observed and the foundation was in good condition. The streambed consists primarily of cobbles, gravel and a few boulders towards the perimeter of the channel.
- **Bridge 3, R06 at about km 23+100**: Construction of the bridge has concentrated flow in this area. No signs of erosion or turbidity were observed and the bridge was in good condition at the time of the inspection.
- **Bridge 4, R09 at approximately km 48+500**: Construction of the bridge has concentrated flow in this area. No signs of turbidity or erosion were observed at the time of the inspection and the bridge was in good condition.
- **Bridge 5, R13 at about km 62+060**: At the time of the inspection, the bridge was in good condition. No signs of turbidity or erosion were observed.
- **Bridge 6, R15 at about km 69+200**: Signs of settlement were observed as the bridge was dipping toward the western side on both abutments. The bridge foundation did not show any signs of adverse conditions but is slowly settling. No remediation work is recommemmended for the moment, but the situation should be monitored. Minor damage to the bin wall of both abutments was also observed, and is likely a result of past snow removal activities. No evidence of erosion or turbidity was observed.
- **Bridge 7, R16 at about km 73+800**: No signs of erosion or turbidity noted. Construction of the bridge has concentrated the flow in this area.
- **Bridge 8, R18 at about km 79+500**: The bridge was in good condition. A boulder field is located beneath the bridge and no flow was observed at the time of the inspection.
- **Bridge 9, R19 at about km 83+150**: Steel plates with pipe anchors are installed along both embankments of the bridge. Some damage (bending) to the steel containment plates was observed, which may be associated with snow removal activities. The damage is minor and does not impact the geotechnical integrity of the bridge or of the embankment as the surrounding pipes seem to hold the metal sheet in place (protecting the abutment backfill). No turbidity or erosion was observed at the time of the inspection.

Table 3: Inspection of the Facilities along the All-Weather Private Road

Station	Name	Structure Description	Comments
0+430	PRC1	1x600 mm CSP	Culvert owned by the town and not AEM. Minor damage to outlet. Minor obstruction of the outlet. Still in good condition. No action required
0+470	PRC2	2x600 mm CSP	Culvert owned by the town and not AEM. Good condition
1+380	PRC3	1x600 mm CSP	Culvert owned by the town and not AEM. Good condition
2+550	R-00A	1x600 mm CSP	No sign of any flow. Inlet partially collapsed, outlet entirely collapsed with signs of obstruction from road material, one hole in the culvert visible from the crest of the road.
4+260	PC-14	2x600 mm CSP	These 2 culverts are too damaged to function any longer. If needed, new culvert should be installed further north.
5+200	Quarry 1		Slope remediation in progress. Rocks walls are generally clean and stable.
~5+700	unnamed	1x600 mm CSP	The inlet is partially buried in gravel.
8+750	R02 Centre Bridge	30 m Acrow Panel Bridge	In good condition
8+830	PC-17A	2x1800 mm CSP	Sign of erosion beneath the inlet and flow of water occuring beneath the culvert. The 1800 CSP were installed too high. While conditions are not perfect, they have proven stable over the past years. No sign of degradation from last year on both the inlet and outlet sides.
8+850	PC-17	2x1200 mm CSP	In good condition
9+952	PC-1	1x600 mm CSP	In good condition
10+580	R-03	1x600 mm CSP	In good condition
12+050	R-04	1x1200 mm CSP	In good condition
12+745	PC-13	1x600 mm CSP	In good condition

Station	Name	Structure Description	Comments
13+250	Quarry 2		Slope remediation in progress.
13+405	PC-2	1x600 mm CSP	In good condition
13+685	PC-3	1x600 mm CSP	In good condition
13+950	unnamed	1x600 mm CSP	In good condition
14+910	PC-4	1x600 mm CSP	In good condition
15+745	R-05A	1x1200 mm CSP	In good condition
17+600	R05 Center Bridge	30 m Acrow Panel Bridge	In good condition. Minor damage to the bin wall of both abutments as a result of past snow removal activites.
18+280	PC-5	1x600 mm CSP	In good condition
18+900	PC-6	1x600 mm CSP	In good condition
20+240	PC-7A	2x600 mm CSP	In general good condition. The outlet of the northern culvert is damaged.
20+250	PC-7	1x600 mm CSP	In good condition
23+100	R06 Center Bridge	30 m Acrow Panel Bridge	In good condition
23+700	Quarry 3		A crusher is installed in this quarry. The west wall is in good and stable condition, but would need additional cleaning. AEM did not clean it due to the presence of a falcon nest.
25+900	R-07	1x1200 mm CSP	In good condition
29+420	PC-8	1x600 mm CSP	In good condition
31+300	Quarry 4		Quarry flooded. In good condition.
34+650	Quarry 5		Slope remediation in progress. Rock walls are in good and stable condition, except for a small portion on the east side.
35+690	PC-9	1x600 mm CSP	In good condition.

Station	Name	Structure Description	Comments
36+470	Quarry 6		Slope remediation in progress. The remaining rock walls are clean and stable.
36+865	PC-10	1x600 mm CSP	In good condition. The outlet is partially buried.
39+552	PC-11	1x600 mm CSP	In good condition, but almost submerged by water. The inlet is too high and water is flowing underneath it.
39+800	Quarry 7		The quarry walls are in unstable condition. Scaling is recommended before resuming activities.
41+300	PC-12	1x600 mm CSP	In good condition, almost submerged.
42+950	Quarry 8		Crushing activities occurred in 2017.
44+600	Quarry 9		Presence of unstable loose rocks and boulders along the steepest and highest wall section. Slope remediation in progress.
48+500	R09 Center Bridge	12 m Rapid Span Bridge	In good condition
48+900	Quarry 10		Slope remediation in progress. The steep west rock wall is unstable.
53+500	Quarry 11		Slope remediation in progress. Rock walls are clean and stable.
54+950	PC-16	1x600 mm CSP	Outlet is buried and needs to be cleared.
58+300	Quarry 12		Slope remediation in progress. In general good condition.
62+060	R13 Center Bridge	12 m Rapid Span Bridge	In good condition
62+350	Quarry 13		Slope remediation is in progress. Loose blocks were observed in some portions the the rock wall.
65+700	Quarry 14		Quarry flooded, slope remediation in progress. Loose blocks were observed in some portions the the rock wall.
67+600	Quarry 15		Slope remediation in progress. Steep rock wall in relatively stable condition
67+840	R-14	3x1200 mm CSP	Middle and northern culverts show small sign of erosion at the outlet and have been damaged (collapsed) inside, below the road, but it is anticipated that they will continue to perform well. All of them were installed too high but function well. No action required.

Station	Name	Structure Description	Comments
69+200	R15 Centre Bridge	30 m Acrow Panel Bridge	Bin wall of both abutments were observed to be damaged but they are holding well. The bridge is dipping toward the west side on both north and south abutments. The foundation does not show signs of failure but is slowly settling. Its condition should be monitored.
70+400	Quarry 16		Slope remediation in progress. Presence of unstable loose rocks and boulders. A good safety berm was placed along the top of the pit crest.
72+800	Quarry 17		Slope remediation in progress. Steep rock wall in stable conditions.
73+800	R16 Centre Bridge	12 m Rapid Span Bridge	In good condition
77+440	R-17	1x1200 mm CSP	In good condition
79+500	R18 Centre Bridge	12 m Rapid Span Bridge	In good condition
80+200	Quarry 18		Slope remediation in progress. Steep walls are in good condition.
80+950	R-18A	3x1200 mm CSP	In good condition. The southern culvert inlet is partially buried.
	R-18B	1X600 mm CSP	In good condition, installed above ground surface (water can flow below culvert).
83-150	R19 Centre	12 m Rapid Span Bridge	Some damage to the steel containment plates and to one pile was observed, which may be associated with snow removal activity. The damage is minor and does not affect the geotechnical integrity of the bridge.
84+300	Quarry 19		Slope remediation has begun. Remaining walls are in good condition.
85+490	R-20	1x1200 mm CSP	Outlet of the culvert is slighly twisted. The middle of the culvert is slightly collapsed. The inlet is installed above the ground surface and water is able to flow beneath the culvert. No follow-up required, in stable conditions.
87+300	R-21	2x1200 mm CSP	Both culverts are slightly collapsed in the middle. Should have been installed lower to avoid erosion issue. In stable condition.
89+550	Quarry 20		Slope remediation in progress. Quarry walls are in good condition

Station	Name	Structure Description	Comments
93+400	Quarry 21		Slope remediation in progress. Quarry walls are in good condition.
93+600	R-23	1x1200 mm CSP	Minor damage near the top, but still in good condition. The culvert is installed too high and as a result there is a low flow of water through the road rockfill. The situation has been under control over the past years.
98+100	R-24	2x1200 mm CSP	Both outlet are installed too high. The outlet of the southern culvert still shows small signs of erosion, but this has been under control over the past years. Both culvert show deformation in the upper part.
99+200	Quarry 22		Slope remediation in progress. The walls are steep but in good condition.
101+950	R-25	2x600 mm CSP	One culvert is angling up toward the downstream end and natural drainage by gravity does not occur. A second culvert alongside is well installed and should drain water for the remainder of the season. No sign of erosion observed during the inspection.
104+400	R-26	3x1200 mm CSP	The boulder which was obstructing the inlet seems to have been moved. The culvert is on good condition, no follow-up required.
	Quarry 23		Presence of loose rocks on top of steep wall.

6.0 AMARUQ ROAD

The Amaruq Road, was built in 2016-2017 to connect the Meadowbank Mine site to the Amaruq site under development. The road is 64 km long with eight bridge crossings and culverts installed at a total of 290 locations. Table 5 at the end of Section 6.2 lists each structure along the Amaruq Road, their designated name, their approximate location and the observations noted during the inspection.

The road design is based on a general rockfill sub-base and crushed granular rockfill surfacing with a combined minimum thickness of 1 m over thawed stable soil and 1.2 m over thawed susceptible soil.

No sign of thermal degradation of the permafrost was observed on the road during the inspection. It should be noted that as with the AWPR, sign of thermal degradation may not necessarily be observed in the future due to the regular road maintenance performed by AEM. During the inspection, water levels and flow velocities at the crossings were normal for the time of year.

Fill material that comprises the majority of the road provides no significant barrier to low gradient water flow due to its coarse nature. During higher flow and runoff periods, water may flow through portions of the road fill. Water was observed flowing through the rockfill near one culvert during the inspection, but signs that water flowed beneath the road were observed at some locations during the inspection. This could also be due to the inlet or the outlet of some culverts having been installed too high or too low, which did not promote the flow of water through the culvert until a certain water level had been reached.

At the time of the inspection, the construction of Amaruq Road was being completed. As with the AWPR, AEM plans on conducting during the year regular and event-based visual inspections of the fish-bearing water crossing locations along the access road. This data will be compiled by AEM to confirm the hydraulic function of the crossings, the adequacy of the crossing locations with respect to the watercourses, and minimal impact to fish habitat.

It is understood that AEM's monitoring program includes an assessment of sedimentation and potential erosion issues at the major bridge crossings. Consideration should be given to expanding AEM's monitoring program to include all culverts and bridges along the road to assess whether they are providing adequate capacity during the freshet and following large precipitation events.

It is recommended to be on the watch for signs of erosion along the high sandy side slopes along the road and to backfill potential erosion at the toe of bridges as soon as it is noticed.

6.1 Culverts

All culverts with a diameter larger than 900 mm were thoroughly inspected. Smaller diameters culverts were checked from the road surface. Culverts not observed should be considered possibly buried.

The observation of ongoing culvert installation shows a good construction method, involving a sand bedding, the use of a vibrating plate for compaction and the installation of geotextile to envelop the corrugated steep pipes.

The culverts were generally in good condition at the time of the inspection. Most culverts were unobstructed with no signs of erosion and no signs of damage to the culverts.

Many culverts seem to have been installed rather high, depending on the permeability of the road to by freshet flow, thus possibly posing a risk of road washout. The worst condition would be a continuous boulder field under the sand and gravel road foundation without a rockfill layer at the base of the road.

A photographic log of the inspected culverts is provided in Appendix E1. Given that culverts are newly installed and almost all in good condition, only locations where important observations were made are documented in the photographic log. Culverts in the following discussion, and in the photographic log, have been identified by their identification number to be consistent with those indicated on the list provided by AEM. Each culvert is also identified by its approximate kilometre location (e.g., km 16+324) along the road alignment, starting at Vault Pit.

No signs of erosion were observed during the inspection. It must be noted that he culverts are newly installed and location where erosion could occur may not be identified yet. At culvert #194, the lack of rockfill layer may pose a risk of washout in the future. Culvert erosion progression should be monitored at freshet.

During the inspection, signs of water flowing beneath the road were observed at one location, culvert #167 (41+843). This is generally due to the inlet and the outlet of the culvert having been installed too high, which does not promote the flow of water through the culvert until a certain water level had been reached. This condition can promote erosion and risk of washout beneath the road and should be monitored. The progression of the situation should be monitored at freshet.

Obstructed and damaged culverts were observed at some locations during the inspection. In many cases, the obstructions are related to inlets and/or outlets becoming partially or completely obstructed by accumulated rockfill and road material or blocks. The following culverts were completely obstructed at a least one of the extremities: two outlets of the set of culverts #47 (11+101 to 11+107), #61 (1+050), #70 (17+837), #83 (20+300), #86 (20+740), #278 (278). If insufficient capacity to handle the flow is observed at locations where culverts are obstructed or damaged, it is recommended to clear the obstructions or repair the culvert.

Table 5, found at the end of Section 6.2, describes the observations for each culvert at the time of the inspection as well as recommendations. For example, for some culverts it is recommended to monitor the water level upstream and the flow through the culverts during high flow events (e.g. freshet season).

6.2 Bridges

Eight bridges are located along the Amaruq Road. A structural and/or mechanical assessment of the bridges was not conducted and is beyond the scope of this geotechnical inspection. A description of the observations of the bridges made during the inspection is presented in Table 4. A photographic log of the bridges is included in Appendix E2.

The bridges have been identified by their approximate kilometre location (e.g., km 16+000) along the road alignment, starting at Vault Pit.

Due to the low-lying terrain between Meadowbank and the Amaruq site, water flow typically occurs in broad areas and not in well-defined channels. The majority of water crossings spanned by bridges have increased channelization of flow due to the embankment fill at the crossing location. No significant signs of embankment erosion were observed at the time of the inspection as they are generally constructed with coarse rockfill.

The bridges and their embankments were in good geotechnical condition at the time of the inspection. No signs of erosion or turbidity were observed.

Table 4: Inspection of the Facilities along the Amaruq Road

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
0+449	#1	450 mm	Not observed.
0+675	#2	300 mm	Not observed.
1+133	#3	900 mm	In good condition.
1+137	#3-2	900 mm	
1+325	#4	800 mm	Not observed.
1+525	#5	600 mm	In good condition.
1+799	#6	600 mm	Not observed.
2+013	#7	900 mm	Inlet and outlet obstructed by blocks.
2+016	#7-2	900 mm	
2+125	#8	900 mm	In good condition.
2+127	#8-2	900 mm	
2+659	#9	600 mm	In good condition.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
3+400	Bridge 3.4		In good condition.
3+264	#10	600 mm	In good condition.
3+850	#11	300 mm	In good condition.
4+183	#12	900 mm	In good condition.
4+181	#12-2	900 mm	
4+179	#12-3	900 mm	
4+184	#12-4	900 mm	
4+186	#12-5	900 mm	
4+615	#13	300 mm	Not observed.
4+756	#14	600 mm	In good condition.
4+850	#15	900 mm	In good condition.
5+050	#16	300 mm	Not observed.
5+161	#17	800 mm	In good condition.
5+330	#18	700 mm	In good condition.
5+574	#19	900 mm	In good condition.
5+931	#20	900 mm	In good condition.
5+929	#20-2	900 mm	
6+310	#21	300 mm	Not observed.
6+423	#22	600 mm	Not observed.
6+442	#23	600 mm	In good condition.
6+493	#24	600 mm	In good condition.
6+530	#25	600 mm	In good condition.
7+216	#26	800 mm	In good condition.
7+218	#26-2	800 mm	
7+275	#27	600 mm	In good condition.
7+300	#27-2	600 mm	
7+325	#27-3	600 mm	Not observed.
7+349	#28	600 mm	Not observed.
7+375	#28-2	600 mm	In good condition.
7+779	#29	900 mm	Not observed.
7+781	#29-2	900 mm	Not observed.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
7+968	#30	900 mm	In good condition.
7+970	#30-2	900 mm	
8+005	#31	900 mm	In good condition.
8+383	#32	900 mm	In good condition.
8+405	#33	900 mm	In good condition.
8+426	#34	900 mm	In good condition.
8+428	#34-2	900 mm	
8+581	#35	700 mm	Not observed.
9+000	#36	700 mm	Not observed.
9+035	#37	900 mm	In good condition.
9+049	#38	900 mm	In good condition.
9+193	#39	900 mm	Damaged in the middle.
9+195	#39-2	900 mm	
9+291	#40	900 mm	In good condition.
9+388	#41	600 mm	In good condition.
9+416	#42	600 mm	Not observed.
9+460	#43	600 mm	In good condition.
9+490	#44	300 mm	In good condition.
9+710	#45	600 mm	Not observed.
10+700	Bridge 10.7	600 mm	In good condition.
11+020	#46	900 mm	In good condition.
11+101	#47	900 mm	2 of the 5 outlets are completely buried.
11+103	#47-2	900 mm	
11+105	#47-3	900 mm	
11+107	#47-4	900 mm	
11+203	#48	900 mm	The inlet is half buried.
11+411	#49	450 mm	Not observed.
11+748	#50	600 mm	In good condition.
11+905	#51	300 mm	Not observed.
12+195	#52	700 mm	In good condition.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
12+240	#53	700 mm	In good condition.
12+388	#54	600 mm	In good condition.
12+440	#55	600 mm	In good condition.
12+485	#56	600 mm	In good condition.
12+635	#57	450 mm	Not observed.
12+740	#58	900 mm	In good condition.
12+760	#59	900 mm	In good condition. Presence of fish.
12+775	#60	900 mm	In good condition.
13+050	#61	600 mm	Inlet in good condition but outlet completely buried.
13+265	#62	600 mm	In good condition.
13+390	#63	300 mm	In good condition.
13+920	#64	600 mm	In good condition but inlet half buried.
14+624	#65	800 mm	In good condition.
16+000	Bridge 16		In good condition.
16+324	#66	600 mm	Not observed.
16+689	#67	600 mm	In good condition.
16+750	#68	600 mm	In good condition.
17+000	Esker #1		Active (gravel and rock). Presence of loose rock on the steep wall, risk of sloughing.
17+250	#68-A	600 mm	In good condition.
17+500	#68-B	600 mm	In good condition.
17+784	#69	600 mm	In good condition.
17+837	#70	600 mm	Inlet totally buried.
18+580	#73	1200 mm	In good condition.
18+559	#74	900 mm	In good condition. Presence of fish.
18+61	#74-2	900 mm	
18+861	#75	600 mm	In good condition.
18+916	#76	450 mm	In good condition.
18+998	#77	450 mm	In good condition.
19+092	#78	300 mm	In good condition.
19+092	#78-2	300 mm	

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
19+495	#79	700 mm	In good condition.
19+659	#80	450 mm	In good condition.
19+841	#81	600 mm	In good condition.
20+000	Bridge 20		In good condition.
20+143	#82	300 mm	Not observed.
20+300	#83	600 mm	Inlet totally buried.
20+527	#84	700 mm	Not observed.
20+671	#85	600 mm	In good condition.
20+740	#86	600 mm	In good condition but outlet buried.
20+810	#87	600 mm	In good condition.
20+881	#88	300 mm	In good condition.
21+180	#89	450 mm	In good condition.
21+295	#90	800 mm	In good condition.
21+297	#90-2	800 mm	
21+770	#91	600 mm	In good condition.
22+040	#92	600 mm	In good condition.
22+100	#93	450 mm	Not observed.
22+147	#94	900 mm	In good condition.
22+149	#94-2	900 mm	Installed below the ground. Water is flowing well, presence of fish.
22+150	#94-3	900 mm	In good condition.
22+161	#95	900 mm	In good condition.
22+162	#95-2	900 mm	In good condition.
22+353	#96	600 mm	Not observed.
22+436	#97	600 mm	In good condition.
22+482	#98	600 mm	In good condition.
22+830	#99	600 mm	In good condition.
22+936	#100	600 mm	In good condition.
23+025	#101	600 mm	In good condition.
23+265	#102	600 mm	In good condition.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
23+562	#103	600 mm	In good condition.
23+595	#104	600 mm	In good condition.
23+900	Bridge 23.9		In good condition.
24+555	#105	600 mm	In good condition.
24+700	#106	600 mm	In good condition but outlet slightly damaged.
24+961	#107	900 mm	In good condition.
24+982	#107-2	900 mm	
24+984	#107-3	900 mm	
25+000	Esker #2		Active. In general good condition, but the small walls are steep and in loose conditions. Risk of rockfalls near the walls.
25+551	#108	600 mm	In good condition.
25+905	#109	800 mm	In good condition.
26+100	Bridge 26.1		In good condition.
26+350	#110	450 mm	In good condition.
26+461	#111	300 mm	In good condition.
26+630	#112	300 mm	In good condition.
26+736	#113	450 mm	In good condition.
26+810	#114	450 mm	In good condition.
26+865	#115	300 mm	In good condition, but outlet half buried.
26+940	#116	450 mm	In good condition.
27+173	#117	700 mm	In good condition.
27+433	#118	450 mm	In good condition.
27+777	#119	300 mm	In good condition.
28+125	#120	300 mm	In good condition.
28+300	#121	900 mm	The middle culvert is half buried in the ground and slightly damaged. Presence of fish.
28+302	#121-2	900 mm	
28+304	#121-3	900 mm	
28+414	#122	900 mm	In good condition.
28+416	#122-2	900 mm	

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
28+418	#122-3	900 mm	
28+575	#123	800 mm	In good condition.
28+710	#124	300 mm	In good condition.
29+040	#125	800 mm	In good condition.
29+240	#126	800 mm	Installed oblique to the road, but in good condition.
30+409	#129	1200 mm	Installed above ground level.
30+812	#130	600 mm	In good condition.
31+041	#131	600 mm	In good condition.
31+540	#132	600 mm	In good condition.
32+141	#133	300 mm	In good condition.
23+300	Bridge 32.3		In good condition.
32+389	#134	300 mm	In good condition. The inlet is installed under ground level and water is flowing.
32+567	#135	300 mm	In good condition.
32+905	#136	300 mm	In good condition.
32+940	#137	300 mm	In good condition.
33+000	#138	300 mm	In good condition.
33+214	#139	900 mm	In good condition.
33+216	#139-2	900 mm	
33+218	#139-3	900 mm	
33+256	#140	900 mm	In good condition.
33+258	#140-2	900 mm	
33+260	#140-3	900 mm	
33+727	#141	900 mm	In good condition.
33+728	#141-2	900 mm	
33+730	#141-3	900 mm	
33+732	#141-4	900 mm	
33+734	#141-5	900 mm	
34+160	#142	450 mm	In good condition.
34+291	#143	600 mm	In good condition.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
34+319	#144	1000 mm	In good condition.
34+395	#145	300 mm	Not observed.
34+660	#146	1200 mm	Well installed below the ground surface.
34+855	#147	600 mm	In good condition.
35+173	#148	600 mm	In good condition.
35+000	Rock quarry 35		Active. Unstable walls, risk of rockfalls.
35+670	#149	900 mm	In good condition.
36+171	#150	900 mm	In good condition.
36+173	#150-2	900 mm	
36+175	#150-3	900 mm	
36+177	#150-4	900 mm	
36+179	#150-5	900 mm	
36+562	#151	600 mm	In good condition.
36+933	#152	900 mm	In good condition.
37+027	#153	600 mm	In good condition.
37+028	#153-2	600 mm	
37+030	#153-3	600 mm	
37+032	#153-4	600 mm	
37+033	#153-5	600 mm	
37+261	#154	450 mm	In good condition.
37+470	#155	600 mm	In good condition.
37+506	#156	450 mm	In good condition.
38+028	#157	600 mm	In good condition.
38+490	#158	900 mm	In good condition.
38+491	#158-2	900 mm	
38+493	#158-3	900 mm	
39+768	#159	700 mm	Not observed.
39+966	#160	600 mm	In good condition.
40+051	#161	600 mm	In good condition.
40+238	#162	600 mm	In good condition.
40+474	#163	300 mm	In good condition.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
40+790	#164	300 mm	In good condition.
40+964	#165	600 mm	In good condition.
41+610	#166	900 mm	In good condition.
41+843	#167	900 mm	Water is flowing under the corrugated steel pipe.
42+342	#168	600 mm	Not observed.
42+765	#169	300 mm	In good condition.
43+340	#170	800 mm	In good condition. The inlet is installed below ground level and water is flowing.
43+500	Bridge 43.5		In good condition. The side slopes of both abutments are well protected with rockfill rip rap close to the bridge, but not further where the sand and gravel fill is exposed.
43+568	#170-A	900 mm	In good condition.
43+577	#170-B	900 mm	
43+587	#170-C	900 mm	
43+815	#171	600 mm	In good condition.
44+431	#173	1000 mm	In good condition. The 2 southern culverts are installed below ground surface and water is flowing.
44+433	#173-2	1000 mm	
44+435	#173-3	1000 mm	
44+470	#174	600 mm	In good condition.
44+640	#175	450 mm	In good condition.
44+800	Bridge 44.8		In good condition.
45+055	#176	600 mm	Not observed.
45+065	#177	600 mm	Not observed.
45+170	#178	600 mm	Not observed.
45+485	#179	700 mm	In good condition.
45+803	#180	600 mm	In good condition.
45+935	#181	600 mm	Not observed.
46+000	Esker #3		Active (gravel). In general good condition, except for the 2 m high unstable steep soil slope.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
46+126	#182	800 mm	In good condition.
46+185	#183	800 mm	In good condition.
46+187	#183-2	800 mm	In good condition.
46+230	#184	600 mm	In good condition.
46+404	#185	300 mm	In good condition.
46+541	#186	450 mm	In good condition.
46+570	#187	600 mm	In good condition.
46+595	#188	600 mm	In good condition.
46+870	#189	700 mm	In good condition.
46+985	#190	900 mm	In good condition.
47+046	#191	300 mm	Not observed.
47+190	#192	600 mm	In good condition. Lower overground on the inlet than on the outlet.
47+360	#193	600 mm	In good condition. May be installed too high, as no rockfill layer was observed.
47+660	#194	600 mm	In good condition but the inlet seems high. As there is no sign of a rockfill layer, there may be a risk of washout.
47+808	#195	700 mm	In good condition.
47+961	#196	300 mm	In good condition.
48+120	#197	600 mm	In good condition.
48+222	#198	450 mm	In good condition.
48+383	#199	900 mm	In good condition. Inlet installed at ground level.
48+385	#199-2	900 mm	
48+387	#199-3	900 mm	
48+389	#199-4	900 mm	
48+457	#201	900 mm	Installed below the ground level.
48+800	#203	600 mm	In good condition, outlet half buried.
48+840	#204	600 mm	In good condition.
49+108	#206	450 mm	In good condition.
49+310	#207	600 mm	In good condition.
49+431	#208	900 mm	Installed below ground surface.
49+433	#209	900 mm	In good condition.
49+435	#210	900 mm	In good condition.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
49+550	#211	450 mm	In good condition.
49+640	#212	600 mm	In good condition.
49+795	#213	300 mm	In good condition.
49+915	#214	800 mm	In good condition, but the inlet is high over the ground.
50+135	#215	300 mm	In good condition.
50+510	#216	600 mm	Not observed.
50+790	#217	450 mm	In good condition.
51+233	#218	900 mm	In good condition although the outlet seems high.
51+235	#218-2	900 mm	
51+237	#218-3	900 mm	
51+239	#218-4	900 mm	
51+460	#219	300 mm	In good condition.
51+883	#221	900 mm	In good condition.
51+885	#221-2	900 mm	
51+887	#221-3	900 mm	
52+000	Rock quarry 52		Active. In good and clean condition. The northern wall may pose a rockfall hazard (loose blocks).
52+315	#222	600 mm	In good condition.
52+650	#223	600 mm	In good condition.
52+705	#224	600 mm	In good condition.
52+715	#225	450 mm	In good condition.
52+935	#226	700 mm	In good condition.
52+937	#226-2	450 mm	
52+970	#227	600 mm	In good condition.
52+995	#228	700 mm	In good condition.
53+245	#229	300 mm	Not observed.
53+363	#230	700 mm	In good condition.
53+659	#231	300 mm	In good condition.
53+928	#232	300 mm	In good condition.
54+240	#233	450 mm	In good condition.
54+385	#234	450 mm	In good condition.
54+500	#235	600 mm	In good condition but inlet partially buried.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
54+625	#236	450 mm	In good condition.
54+655	#237	600 mm	In good condition.
54+850	#238	600 mm	In good condition.
55+060	#239	600 mm	In good condition.
55+164	#240	600 mm	In good condition.
55+235	#241	600 mm	In good condition.
55+329	#242	600 mm	In good condition.
55+593	#243	600 mm	Not observed.
55+625	#244	450 mm	In good condition. Installed above ground level.
55+735	#245	600 mm	In good condition. Water flows out into the ground.
56+005	#246	600 mm	In good condition.
56+065	#247	700 mm	Culvert in construction.
65+220	#248	700 mm	Culvert in construction.
56+435	#249	600 mm	Culvert in construction.
56+610	#250	800 mm	Culvert in construction.
56+745	#251	300 mm	Culvert in construction.
56+900	#252	900 mm	Culvert in construction.
56+965	#253	900 mm	Culvert in construction.
56+967	#253-2	900 mm	Culvert in construction.
56+969	#253-3	900 mm	Culvert in construction.
57+125	#254	600 mm	Culvert in construction.
57+195	#255	600 mm	Culvert in construction.
57+350	#256	600 mm	Culvert in construction.
57+525	#257	600 mm	Culvert in construction.
57+875	#258	600 mm	Culvert in construction.
57+985	#259	900 mm	Culvert in construction.
58+185	#260	300 mm	Culvert in construction.
58+350	#261	450 mm	Culvert in construction.
58+410	#262	450 mm	Culvert in construction.
58+885	#263	450 mm	Culvert in construction. Outlet is damaged.
58+922	#264	600 mm	Culvert in construction. In good condition.
58+967	#265	450 mm	Culvert in construction. Not observed.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
59+024	#266	300 mm	Culvert in construction. In good condition.
59+720	Esker #5		Active (gravel). In good condition. The soil was stripped to the limit of permafrost. The surface is thawing and water is flowing into the environment (to be checked for turbidity).
59+720	#267	900 mm	Installed above ground level.
59+774	#268	600 mm	In good condition. Installed in the ground.
59+860	#269	600 mm	In good condition.
60+000	#270	600 mm	Installed above ground level. Water flows through the culvert.
60+050	#271	600 mm	Installed below ground level. Water flows through the culvert.
60+087	#272	600 mm	Installed above ground level. Water flows through the culvert.
60+649	#273	300 mm	In good condition.
60+815	#274	600 mm	In good condition.
61+022	#275	600 mm	Culvert in construction.
61+282	#276	600 mm	Culvert in construction.
61+622	#277	450 mm	Culvert in construction.
61+870	#278	1200 mm	Inlet below ground level and outlet obstructed. Should be cleaned before spring.
62+307	#279	300 mm	In good condition.
62+416	#280	900 mm	In good condition.
62+350	#281	600 mm	In good condition.
62+500	Esker #6		In good condition, except for the north borrow pit: 2 m high steep slope with potential instability.
62+965	#283	450 mm	In good condition.
63+070	#284	900 mm	The middle culvert is punched and the northern culvert is bent.
63+072	#284-2	900 mm	
63+074	#284-3	900 mm	
63+429	#287	600 mm	In good condition.
63+530	#288	600 mm	In good condition.
63+733	#289	600 mm	In good condition.

STATION	NAME	STRUCTURE DESCRIPTION	COMMENTS (2017)
63+900	unnamed		Set of 4 culverts, 2 are heated by hot water. All are installed below ground level for fish. Water is flowing in the 2 middle culverts.
63+975	#290	600 mm	Culvert is deformed and bent.

7.0 QUARRIES AND ESKERS

7.1 Quarries along the AWPR

Twenty-two quarries were developed in the past along the AWPR to provide material for its construction. An additional quarry was developed near the airstrip at Meadowbank to provide further construction materials. All quarries were inspected as part of the geotechnical inspection and a photographic log is presented in Appendix F1. Table 4 above presents a summary of the observations and recommendations made during the 2017 inspection for the structures along the AWPR road including the quarries. In accordance with the as-built drawings, the quarries have been numbered sequentially from 1 to 22 starting near Baker Lake and increasing towards Meadowbank. The airstrip quarry is referred to as Quarry 23 and is used to store miscellaneous items such as drill core on racks, diamond drill contractor drill rigs, sea-can containers, pipes, and culverts.

The closure and reclamation plan requires that all quarries and borrow sources developed during the construction of the AWPR be reclaimed following their use. The closure plan further requires that all quarry slopes be left at an angle of 45 to 50 degrees. During the inspection, it was observed that slope remediation was in progress but none of them were totally reclaimed. Most quarries are clean although some walls need scaling. Loose blocks and granular material were also removed from most quarry walls. Loose blocks and granular material had been placed at the toe of the walls. At the time of the inspection, the majority of the quarries were dry.

During the inspection, it was observed that Quarries 4 and 14 were flooded. These quarries have been flooded for a couple of years and it is understood that AEM is evaluating how to eliminate the ponding of water within these quarries. Quarries 5 and 15 contained minor accumulations of water. Quarries that contain significant amount of ponded water should be monitored to assess if ponding persists and, if necessary, whether ditches should be developed to facilitate the drainage of water.

Unstable blocks and loose rocks along steep walls remain in Quarries 3, 7, 9, 10, 16 and 23. The west wall of Quarry 3 also contains a falcon nest that prevents its maintenance. It is recommended that workers be cautious in these quarries and are aware of the potential hazard.

7.2 Eskers and quarries along the Amaruq Road

Six eskers and two rock quarries were developed in the past along the Amaruq Road to provide material for its construction. All of them except Eskers #2D, #4 (A to D) and #5A are still active. All eskers and quarries were inspected as part of the geotechnical inspection and a photographic log is presented in Appendix F2. Table 5 above presents a summary of the observations and recommendations made during the 2017 inspection for the structures along the Amaruq Road including the eskers and quarries. In accordance with the as-built drawings, the eskers have been numbered sequentially from 1 to 6 starting at Meadowbank and increasing towards the Amaruq site. The quarries are not numbered and were identified for the inspection by their approximate location along the Amaruq Road.

The closure and reclamation plan requires that all quarries and borrow sources developed during the construction of the Amaruq Road be reclaimed following their use. The closure plan further requires that all quarry slopes be left at an angle of 45 to 50 degrees. At the time of the inspection, all of the quarries and eskers were dry, except Esker #2 which contained a small accumulation of water.

In Esker #5, the soil was stripped to the limit of the permafrost. The soil surface was thawing at the time of the inspection and water was flowing into the environment. This water must be checked for TSS.

Unstable loose rocks along steep walls and unstable soil slopes were observed in all eskers and quarries, except Esker #5. It is recommended that workers be cautious in these locations and are aware of the potential rockfall hazard.

8.0 BULK FUEL STORAGE FACILITIES

This section contains the observations made during the 2017 annual inspection of the Baker Lake, Meadowbank and Amaruq tank farm facilities (Main Camp and Vault).

8.1 Baker Lake Tank Farm

The Baker Lake tank farm consists of six large-capacity tanks (10 million litres each) and twenty Jet A fuel tanks (100,000 litres each) that have been constructed within four bermed areas (containment cells). Tanks 1 and 2 are located within the first containment area, which is located on the western side of the fuelling area. Tanks 3 and 4 are located within a second containment area adjacent to the first. A central berm is located between the two containment areas. Tanks 5 and 6 are within the third containment area located north and upslope of Tanks 3 and 4. Tanks 5 and 6 are situated within an entirely separate containment cell subexcavated into the hill slope above the initial tank farm area. Twenty Jet A Fuel tanks were installed in 2013 in a containment area located northwest of Tanks 5 and 6 lying over a 0.5 m-thick granular base fill material.

Each containment area has been lined with a 1.5-mm high density polyethylene (HDPE) geomembrane to provide secondary containment.

Visual inspection of the majority of the liner in the containment areas for Tanks 1 to 6 was not possible as it is covered with granular fill material to provide protection. The granular fill material protecting the geomembrane was eroded due to wave actions in some areas, exposing the geomembrane. This condition was observed all along the south side of Tanks 3 and 4 and on the west side of Tank 1. A section of exposed geomembrane with a fold was observed at the northwestern corner of Tank 2. A hole in the exposed geomembrane (300 mm diameter hole) was observed on the south southwestern corner of Tank 3 at the toe of the slope. The hole in the geomembrane should be repaired to ensure a good performance of the retention bassin. It is also recommended to cover the exposed area with geotextile and fill material to re-establish the liner protection.

Ponded water was observed on the southern side of the second and third containment areas. Presence of water on the southern side of the containment areas was reported in the 2011 to 2016 geotechnical inspections. No sump or pump was visible during the site visit. It is recommended to keep the water accumulation at a minimum near the tank foundation.

The geomembrane of the containment cell of the twenty Jet A fuel tanks remains uncovered around the tanks. The bituminous geomembrane is damaged by the Jet A fuel (melting). Water was observed ponding within the eastern and southern side of that containment cell. It is recommended to removed that accumulation of water before it freezes to avoid damaging the geomembrane of the containment cell by ice accumulation. If melting of the bitumen continues, then the liner may be treated in such a way that contaminated water would seep into the environment. It is recommended that AEM be on the watch for deterioration of the liner and take appropriate measures to protect the environment.

The embankments around the first and second tank farm containment areas were stable. Tension cracks observed in the past on the upper bench north of Tanks 3 and 4 and south of Tanks 5 and 6 are disappearing. The northern slope of the containment area of Tanks 5 and 6 are steep and the sand and gravel cover may be prone to erosion. Tension cracks were observed on the crest. Sloughing of the granular cover material occurred and exposed the geomembrane. The geotextile was torn and fallen down the slope. A 300 mm deep depression was also observed on the crest above the exposed geomembrane. There were signs of water flow in this area. Several holes of approximately 10 cm x 10 cm were present near the top of the slope. It is recommended that this area be reworked so that the degradation does not worsen.

The fuelling station on the western side of the tank farm consists of two containers and a pumping system. The fuelling area is covered by granular road base material. The fuelling station was in good geotechnical condition.

A photographic log of the Baker Lake tank farm and a plan view that shows the location of the photos and observations is included in Appendix G1.

8.2 Meadowbank Tank Farm (Main Camp)

The Meadowbank Main Camp tank farm consists of a single large-capacity tank (5.6 million litres) constructed within an area that has been subexcavated to provide secondary containment. The area has been lined with a 1.5-mm HDPE geomembrane.

At the time of the inspection, the tank backfill foundation pad was in good condition. The liner was well covered with granular fill material for protection. The two small channels of erosion observed in the past within the tank platform had been repaired.

Water (approximately 50 mm) was observed ponding within the eastern corner. The area covered by water was larger than in 2016. Signs of high water levels being present in this area in the past were noted during the inspection. Pumping of ponded water is considered a good practice and should resume.

A fuelling station is located on the northern side of the tank farm. The fuelling area is covered by granular road base material and a geomembrane liner is installed below the refuelling area. Small 3 m long tension cracks were observed during the inspection on top of the subexcavated area behind the fueling station. These cracks were present in 2016 and do not seem to have deteriorated The situation should continue to be monitored.

As the tank farm area has been subexcavated, runoff from the tank farm is not anticipated to occur. The side slopes in the tank area are shallow and appear stable.

Appendix G2 contains a photographic log and a plan view that shows the location of the photos and observations noted at the Meadowbank tank farm.

8.3 Meadowbank Tank Farm (Vault Pit Area)

The Vault tank farm consists of five tanks and was built in 2014. The retention basin is installed below the rockfill pad and is made of a geosynthetic clay liner. No geotechnical issues were noted with this structure.

Appendix G3 contains a photographic log and a plan view that shows the location of the photos and observations.

8.4 Amaruq Tank Farm

At the time of the inspection, the tank backfill foundation pad was in good condition. No geotechnical issues were noted with this structure.

Appendix G4 contains a photographic log.

9.0 OTHER MEADOWBANK FACILITIES

This section contains the observations made for the other Meadowbank facilities visited during the 2017 geotechnical inspection such as the site roads, the diversion ditch and erosion protection structure, the RSF till plug, the diffusers, the landfill, the contaminated soil storage and bioremedial landfarm facility, the Stormwater Management Pond, and the airstrip. Figure H1 shows the location of the photos taken during the inspection for the other Meadowbank facilities.

9.1 Site Roads

The following roads were inspected:

- East Road – Former haul road between North Portage Pit and East Dike;
- West Road – Haul road between North Portage Pit and the plant;
- Vault Road – Haul road between North Portage Pit and the Vault deposit;
- RF1 – Starts near the northern abutment of Stormwater Dike and follows the eastern perimeter of the TSF's North Cell and the southwestern side of the Portage Rock Storage Facility;
- RF2 – Starts at the end of RF1 and follows the western side of the Portage Rock Storage Facility.

These roads were of adequate width and had appropriate berms at the time of the inspection. The haul road from Goose Pit to the plant was not inspected during this investigation. No geotechnical concerns were identified with East Road, West Road, RF1 and RF2.

Three culverts are installed beneath Vault Road at coordinates 640 964 E / 7 217 466 N. These three culverts were slightly collapsed in the middle and showed signs of erosion at the inlet. This condition was observed from 2012 to 2015. No action is required as their condition is stable. These culverts need to be monitored during freshet to ensure that they provide sufficient capacity and that erosion is not occurring. Two other culverts are located at 639 214 E / 7 216 189 N on Vault Road. It was observed that one of these culverts was entirely partially by rockfill, while the other culvert was collapsed on the NP2 side. It is recommended to observe this area at freshet and to clear the obstructions if insufficient capacity to handle the flow is observed.

Temporary roads developed for construction purposes were not inspected.

Appendix H1 contains photographs of the Vault Road culvert.

9.2 Diversion Ditches and Sediment and Erosion Protection Structure

A retention basin and a series of diversion ditches (Western and Eastern) surround the catchment basin of the North Cell. These structures are designed to convey surface water runoff away from the TSF.

Since 2014, the Western Diversion Ditch directs the water to a retention basin, which is then pumped to the North Cell due to a turbidity problematic caused by the erosion of the ditches. Rehabilitation work was done in 2016 to address the situation. The Eastern Diversion Ditch discharges to lake NP-2, then lake NP-1 and then to Dog Leg Lake. Sediment barriers and erosion protection structures are installed at the outlet of the diversion ditch in Lake NP-1, Lake NP-2 and Third Portage Lake (Dog Leg Lake).

During the inspection, it was observed that the diversion ditches around the TSF's western and eastern extensions were in good condition. The erosion protection structure and sediment barriers were also in good condition at the time of the inspection. It is important that they be inspected prior to the freshet season.

Appendix H2 contains photographs of the diversion ditch and its sediment and erosion protection structure.

9.3 RSF Till Plug

The RSF till plug (till plug) is located on the upstream side of the Diversion ditches access road between the Waste Rock Storage Facility (RSF) and lake NP2. The till plug is a zoned low permeability earth fill structure intended to prevent seepage from the RSF to reach lake NP2 and to facilitate seepage collection on the upstream side.

The till plug was constructed in the summer of 2013. Its construction consisted in profiling the upstream slope and placing a 0.5-m-thick layer of compacted crusher reject, and then installing a geotextile membrane covered by 0.5 m of fine ultramafic rockfill and material reject from till sieving. Both granular layers were compacted with an excavator bucket.

No sign of erosion or geotechnical issues were identified with this structure during the inspection. A pump equipped with an automatic switch was installed within the pond contained by the plug to redirect the water to the North Cell. As the chemical monitoring in NP2 has not shown any signs of contamination for the last two years, the performance of the till plug is considered adequate.

Appendix H3 contains photographs of the till plug.

9.4 Diffusers

The objective of the diffuser is to return the water to the environment without eroding the shoreline. There is a diffuser at Vault (within Wally Lake), and there is no longer a diffuser at Portage Lake since 2015.

During the inspection, it was observed that the diffuser at Vault was relocated in a deeper part of the lake and is functioning normally.

Appendix H4 contains photographs of the diffuser.

9.5 Landfill

The Meadowbank landfill is located on the northeastern side of the TSF, within the Portage RSF area. It is progressively being constructed and filled. Waste material is being dumped within a bermed area on a pad built using waste rock from the open pit. The waste is then covered with a thin layer of rockfill to reduce windblown debris. No geotechnical concerns were identified with the landfill. Appendix H5 contains photographs of the landfill.

9.6 Contaminated Soil Storage and Bioremedial Landfarm Facility

The Meadowbank Contaminated Soil Storage and Bioremedial Landfarm Facility was initially located on the downstream side of Stormwater Dike within the TSF's South Cell close to the Water Treatment Plant (WTP). During the summer of 2016, this structure has been relocated north of Central Dike, within the South Cell to prevent it from being flooded by the South Cell water pond. A 1 m thick till pad has been placed for the landfarm foundation. A berm surrounds the landfarm to contain the fluid/runoff and stops it from moving laterally. Contaminated soils are stored within this cell to promote biodegradation until the soil meets environmental criteria before being disposed within the Portage Rock Storage Facility.

No geotechnical concerns were identified with these structures. Appendix H6 contains photographs of the Contaminated Soil Storage and Bioremedial Landfarm Facility.

9.7 Stormwater Management Pond

The Stormwater Management Pond is located near the main camp and is being used to store various site waters and sewage. No runoff from the pond was observed at the time of the inspection. No geotechnical concerns were identified with Stormwater Management Pond and the nearby crusher ramp. Due to the proximity of the crusher ramp to the pond, it is recommended that regular geotechnical inspections of the crusher ramp be conducted.

No geotechnical concerns were identified with this structure. Appendix H7 contains a photographic log of Stormwater Management Pond.

9.8 Airstrip

There are several small channels dug adjacent to the airstrip to divert water into small excavations or "ponds." The channels and ponds are unlined, and the ponds have no designed outlet structure. In general, these ponds serve to collect water and allow suspended sediments to settle out before the water overflows into other vegetated areas and/or infiltrates them, depending on the thermal state of the soils.

The runway was extended in the winter of 2013 at both ends to allow a Boeing 737-200 to land at the Meadowbank site. The northwestern boundary of the airstrip extends approximately 20 m within the lake and was constructed in two phases. Rockfill was placed 1.0 m above water during Phase 1 and the rockfill was constructed to its final elevation during Phase 2. The rockfill slopes for Phase 2 have a side slope of 1.5H:1.0V. The rockfill of Phase 2 is surrounded by a 17.0-m-wide bench going from the toe of Phase 2 to the edge of the crest of Phase 1. The Phase 1 rockfill surface and visible side slope were built with coarse boulders to protect the embankment against waves and ice action. The airstrip construction within the lake is considered appropriate.

The slopes were re-profiled along a portion of the airstrip in 2017 to a 3H:1V slope to prevent settlement.

No geotechnical concerns were identified with this structure during the inspection. Appendix H8 contains a photographic log of the airstrip.

10.0 SUMMARY AND RECOMMENDATIONS

The following presents a summary of the key findings and recommendations of the 2017 geotechnical inspection.

10.1 Dewatering Dikes

- The current versions of the Operation, Maintenance and Surveillance (OMS) Manual (AEM, 2017a), including the Emergency Preparedness Plan (EPP), and of the overall Emergency Response Plan (ERP) for the mine (AEM, 2017b) are dated March 2017 and June 2017. It is a good practice to keep these documents up to date.
- The condition of the dewatering dikes is regularly inspected by the mine and this practice should continue.

East Dike

- Regular monitoring and assessment of the monitoring data (piezometric, thermal, inclinometer, flow meter and seismograph) should continue. It is recommended to flag the piezometers that recorded data below 0°C in the past and be very careful when interpreting their data as they might be broken.
- No signs of slope instability, erosion and tension cracks were observed on the structure. Based on visual inspection and the instrumentation data, the condition of East Dike appears stable.

South Camp Dike

- South Camp Dike was in good condition and no geotechnical concerns were identified.
- It is recommended to continue keeping the downstream toe of the dike clear to facilitate inspection. The nearby ultramafic rock dump should not obstruct the toe of the dike.

Bay-Goose Dike

- The tension cracks observed in 2013 and 2014 on the upstream side within the thermal cap were still visible but are no longer active. The settlement within the thermal cap was observed but did not show significant sign of movement since 2013. The area should continue to be monitored to make sure there are no aggravating conditions developing.
- Regular monitoring and assessment of the monitoring data (piezometric, flow, thermal, inclinometer, and seismograph) should continue. It is recommended to flag the piezometers that recorded data below 0°C in the past and be very careful when interpreting their data as they might be broken. Once a piezometer has frozen, it cannot be relied upon even if it thaws.
- Water ponds were observed at the downstream toe during the inspection as per the previous inspection. It is recommended to pump them periodically to allow for good visual inspection of the downstream toe. The pond flow formed by seepage should be monitored and recorded.

- Overall seepage is less than anticipated and is not a concern for now. The inflow of water from the pond at Central Channel should be monitored.
- North Channel, Channel 1 and Channel 3 should be carefully monitored and inspected. Limited evidence of seepage is observed at the downstream toe of these channels. The instrumentation data and field observations seem to indicate that seepage occurs at these locations but reports directly to the Pits instead of the downstream toe area. The seepage being reported to the Pits should be included in the Bay-Goose Dike seepage statistics.
- Close monitoring of the North Channel is done by AEM to control the reaction to blasting in the nearby Pit E5.
- At the time of the site inspection, and based on the instrumentation data collected up to that time, the condition of Bay-Goose Dike seems stable.

Vault Dike

- Vault Dike was in good condition at the time of the inspection. The settlement and cracks observed in 2013 and 2014 were not noticeable anymore. No new issues were observed.
- Regular monitoring and assessment of the thermistor data should continue.

10.2 Tailings Storage Facility

- The most current versions of the Operation, Maintenance and Surveillance (OMS) Manual (AEM, 2017a), including the Emergency Preparedness Plan (EPP), and of the overall Emergency Response Plan (ERP) for the mine (AEM, 2017b) are dated March 2017 and June 2017. It is a good practice to keep these documents up to date.
- At the time of the inspection, the peripheral structures of the TSF North Cell had an adequate tailings beach against them. An adequate tailings beach was observed against the entire length of Central Dike.
- Regular visual inspection as well as collection and regular review of instrument data should continue for all structures within the TSF.
- As concluded in the Central Dike 2017 coupled seepage stability assessment, the design basis of Central Dike and the South Cell is modified: it does not serve to promote deposition of tailings in front of containment structure only anymore, but rather also to provide blankets over suspected seepage entry points such as exposed bedrock surface along the shoreline or beneath Stormwater Dike foundation.

Saddle Dam 1

- No visual signs of slope instability, erosion or tension cracks were observed.
- The environmental department should continue monitoring the water quality and share this information with the engineering department.

Saddle Dam 2

- Water was observed on the downstream side ponding within the rockfill embankment between Sta. 20+275 and Sta. 20+475.

- No visual signs of slope instability, erosion or tension cracks were observed.

Stormwater Dike

- Several tension cracks associated with movement were observed on the crest Sta. 10+425, between Sta. 10+550 and Sta. 10+650, between Sta. 10+800 and Sta. 10+950, and around Sta 11+050 approximatively. These movements appeared in July 2017 shortly after water from the South Cell reached this sector and stabilized. The observed movements are happening in a sector where the dike was built on frozen soft sediment and were probably caused by the water thawing this soft layer. In 2016 and 2017 following these observations, movement monitoring instruments were installed on the crest of the dike (total of 4 extensometers and 19 prisms). The winter 2017 investigation at SWD confirmed that the most probable mechanism was the the thawing of the soft sediment upon ingress of water within SWD foundation. The stability assessment using updated stratigraphy and geotechnical parameters indicated that use of rockfill stabilization buttress for a foundation failure is not required as the obtained factor of safety is above 1.5.

Central Dike

- This structure was in good geotechnical condition. An adequate tailings beach was observed against the entire length of Central Dike.

- Seepage from the South Cell is ponding on the downstream side of Central Dike. At the time of the inspection, the water was clear although AEM reported that an orange coloration along with high turbidity and rapid temperature variations was observed in during most of the open water season of 2017. An average flow of approximately 540 m^3/hr was pumped back to the South Cell to maintain the downstream pond at El. 115 m.

  A complementary investigation was carried out early summer 2017 to close data gaps in the vicinity of the dike foundation to better assess the conditions and potential risk for Central Dike. The results of the complementary campaign concur with the seepage-stability models used in the winter 2017 dike performance assessment, where the investigation results indicate that the water transmissivity is more likely controlled by the fractured bedrock than by the till layer.

  Therefore, it is considered that there is no need to review the winter 2017 seepage-stability models nor use 3D numerical analysis to reassess the Central Dike performance. It is considered that the further numerical model would not help to better understand and anticipate the conditions, nor manage the risk. It is considered that the best mitigation measure to decrease the seepage rates and the stability risk is to focus on decreasing the hydraulic gradient of water beneath the dike foundation. It is recommended to decrease the hydraulic head by lowering the water elevation within the TSF South Cell, deposit tailings over the entire basin floor, and direct the pond’s maximum head of water to an area providing better control above the bedrock surface, where the maximum anticipated lakebed sediment and till thickness are present. The design basis of Central Dike is thus modified: it does not serve to promote deposition of tailings in front of the containment structure only anymore, but rather also to provide blankets over suspected seepage entry points such as exposed bedrock surface along the shoreline or beneath Stormwater Dike foundation.

  The water level of the reclaim pond was progressively lowered along automn 2017 as to reduce the hydraulic pressure on the seepage and talings deposition was amended to better cover the area between Saddle Dams 4 and 5. The mitigation measures resulted in decreasing the average flow to 330 m^3/hr in November 2017.

Saddle Dams 3, 4 and 5

- These structures are in good geotechnical condition. SD3 was not operational at the time of the inspection as it was not retaining tailings and water.
- During the inspection, water was observed ponding on the downstream side of Saddle Dam 3 and Saddle Dam 4. As the downstream toe is higher than the South Cell pond, this water does not come from the TSF. It is important to maintain the water level on the downstream side lower than the granular layer of the upstream toe liner tie-in granular material to prevent uplift of the geomembrane. As the elevation of the downstream side is lower than the elevation of the granular material, this should not be a problem if the downstream water level is managed. The management of this water could be simplified by the construction of a sump, as indicated in the construction drawings, to direct the water in a low point. This was done for SD3.

10.3 All-Weather Private Road

- No geotechnical issues were identified with the AWPR at the time of the inspection that were related to thermal degradation of the permafrost, thaw settlement, erosion of the road materials, or sediment migration from the road into adjacent watercourses.
- Regular inspections and maintenance of the road by AEM should continue. Consideration should be given to expand AEM's monitoring program to include all culverts and bridges along the road in order to assess whether they are providing adequate capacity during the freshet and following large precipitation events.
- AEM has been conducting regular and event-based inspections of the fish-bearing water crossing locations along the road and these should continue in order to confirm the hydraulic function of the crossings, adequacy of crossing locations with respect to the watercourses, and minimal impact to fish habitat.
- The erosion of the culverts is stable. The progression of the erosion of culverts PC-17A (8+830), PC-11 (39+552), R14 (67+840), R18-B, R-20 (85+490), R-23 (93+600) and R24 (98+100) should be monitored at freshet for any signs of progression or washout, as signs of water flowing beneath the road were observed at these locations.
- For some culvert locations, monitoring is recomended to see if flow occurs through the culvert (i.e. during the freshet). If insufficient capacity to handle the flows is observed, or water circulates under the road, then it is recommended to clear the obstructions or repair the culverts. Particular attention should be paid to R-00A (km 2+550), the unnamed culvert at 5+700, PC-14 (km 4+260), and PC-16 (km 54+950).
- The inspected bridges and their embankments were in good geotechnical condition. Signs of settlement were observed at Bridge 6, R15. The bridge was dipping toward the western side on both abutment. The bridge foundation did not show signs of adverse conditions. It is recommemmended to monitor the situation.

10.4 Amaruq Road

- The culverts were generally in good condition at the time of the inspection. Most culverts were unobstructed with no signs of erosion and no signs of damage to the culverts. Many culverts seem to have been installed rather high.

- No signs of erosion were observed during the inspection. It must be noted that he culverts are newly installed and location where erosion could occur may not be identified yet. At culvert #194, the lack of rockfill layer may pose a risk of washout in the future. Signs of water flowing beneath the road were observed at culvert #167 (41+843). The progression of culvert erosion should be monitored at freshet.
- Obstructed and damaged culverts were observed at some locations: two outlets of the set of culverts #47 (11+101 to 11+107), #61 (1+050), #70 (17+837), #83 (20+300), #86 (20+740), #278 (278). If insufficient capacity to handle the flow is observed at locations where culverts are obstructed or damaged, it is recommended to clear the obstructions or repair the culvert.
- The inspected bridges and their embankments were in good geotechnical condition.
- The next freshet period will be the first for the majority of the culvert newly installed in 2017. It is recommended to be on the watch for potential damage due to high flow during this first event.

10.5 Quarries and eskers

- Most quarries have been cleaned since the 2015 inspection. Loose blocks and granular material have also been removed from the quarry walls. Slope remediation is in progress, but none of them were totally reclaimed. It is understood that AEM is developing a plan to progressively close some of the quarries along the AWPR while maintaining others to produce and store material supplies for ongoing road maintenance.
- Presence of unstable blocks and loose rocks along steep walls was observed in Quarries 3,7, 9, 10, 12, 16, and 23. It is recommended that workers be cautious in these quarries and are aware of the potential hazard.
- Quarries 4 and 14 are flooded. It is understood that AEM is evaluating how best to eliminate the ponding of water within these quarries.

10.6 Bulk Fuel Storage Facilities

- Ponded water within the secondary containment cell was observed at the Baker Lake and Meadowbank main camp fuel tank farm. Memoval of water should be managed to keep the water accumulation at a minimum near the tank foundation.
- The granular fill material protecting the geomembrane was eroded at Baker Lake due to wave actions in some areas, exposing the geomembrane. This condition was observed all along the south side of Tanks 3 and 4 and on the west side of Tank 1. A section of exposed geomembrane with a fold was observed at the northwestern corner of Tank 2.It is recommended to cover the exposed area with geotextile and fill material to re-establish the liner protection.
- A hole in the exposed geomembrane (300 mm diameter hole) was observed at Baker Lake on the south southwestern corner of Tank 3 at the toe of the slope. The hole in the geomembrane should be repaired to ensure a good performance of the retention basin.
- The embankments around the Baker Lake tank farm containment areas were stable. Tension cracks observed in the past on the upper bench north of Tanks 3 and 4 and south of Tanks 5 and 6 are disappearing. Tension cracks were observed on the crest of the northern slope of the containment area of Tanks 5 and 6. Sloughing of the granular cover material occurred and exposed the geomembrane. The geotextile was torn and fallen down the slope. A 300 mm deep depression was also observed on the crest above the exposed geomembrane. There were signs of water flow in this area. Several holes of approximately 10 cm x 10 cm

were present near the top of the slope. It is recommended that this area be reworked so that the degradation does not worsen.

- The geomembrane remains uncovered around the tanks of the twenty Jet A fuel tanks at Baker Lake. The bituminous geomembrane is damaged by the Jet A fuel (melting). It is recommended to remain vigilant during the freshet and throughout the year to manage water accumulated within the bermed area. If melting of the bitumen continues, then the liner may be treated in a way that contaminated water would seep into the environment. It is recommended that AEM be on the watch for deterioration of the liner and take appropriates measures to protect the environment.
- A 3 m long tension crack was observed at the Meadowbank Main Camp tank farm on top of the subexcavated area behind the fueling station and has been stable since 2016. It is recommended to monitor this area for changing conditions.
- No geotechnical issues were noted with the Meadowbank Vault tank farm.
- No geotechnical issues were noted with the Amaruq tank farm.

10.7 Other Meadowbank Facilities

Meadowbank Site Roads

- Haul roads currently in operation are of adequate width and have appropriate berms.
- Three culverts were installed on Vault Road (coordinates 640 964 E / 7 217 466 N). As previously observed in past annual inspections, these three culverts were partially collapsed in the middle and showed signs of erosion at the inlet. This is currently not a significant issue, but it is recommended to monitor these culverts at freshet to ensure that they provide sufficient capacity and that erosion is not occurring.
- Two culverts are installed on Vault Road (coordinates 639 214 E / 7 216 189 N). It was observed that one of these culverts was entirely obstructed by rockfill, while the other culvert was collapsed on the NP2 side. It is recommended to observe this area at freshet and to clear the obstructions if insufficient capacity to handle the flow is observed.

Diversion Ditch and Sediment and Erosion Protection Structure

- No geotechnical concerns were observed with this structure.
- It is important that the erosion protection structure and sediment barriers be inspected during freshet season.

RSF Till Plug

- No geotechnical issues were observed with the RSF till plug.

Diffuser

- The diffuser at Wally lake (Vault) was relocated in a deeper part of the lake and is functioning normally.

Landfill and Contaminated Soil Storage and Bioremedial Landfarm Facility

- Another Landfarm Facility is now located north of Central Dike, within the South Cell. This structure was developed in 2017.

- No geotechnical concerns related to the landfill or the landfarms were identified at the time of the inspection.

Stormwater Management Pond

- No geotechnical concerns were identified regarding the Stormwater Management Pond, or the crusher ramp located nearby. The geotechnical stability of the crusher ramp should be regularly inspected by AEM due to its proximity with Stormwater management pond.

Airstrip

- No geotechnical concerns were identified with the airstrip.

11.0 CLOSURE

This report was prepared to summarize the findings from the 2017 geotechnical inspection conducted by Golder between September 7 and September 14, 2017, to comply with the requirements of AEM's Type A Water Licence Permit No. 2AM-MEA0815, Part I, Item 12. An inspection of the pit walls is reported under separate cover.

We trust the above information is sufficient for your current needs. Should you require additional information or further clarification, please contact us.

GOLDER ASSOCIÉS LTÉE

ORIGINAL SIGNED **ORIGINAL SIGNED AND SEALED**

Marion Habersetzer
Junior Geotechnical Specialist

Yves Boulianne, P.Eng.
Geotechnical Engineer, Associate

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature ORIGINAL SIGNED
Date
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

MH/YB/jlm

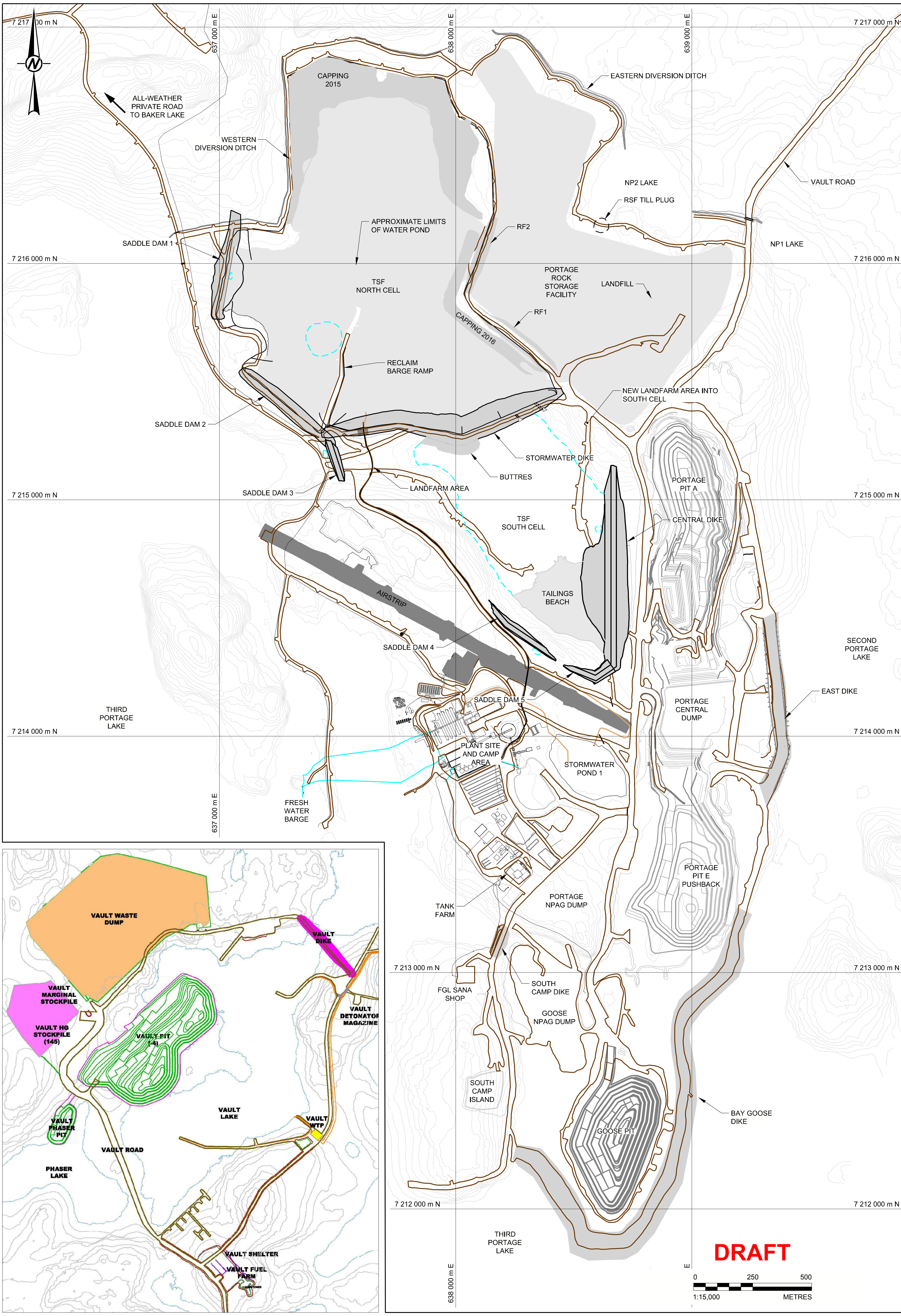
https://golderassociates.sharepoint.com/sites/16104g/preparation of deliverables/rev0/1784282-1574-rpt-rev0 2017 geotechnical inspection.docx

12.0 REFERENCES

Agnico-Eagle Mines Ltd., Meadowbank Division, 2017a. "Dewatering Dikes Operation, Maintenance And Surveillance Manual". Version 5. March 2017.

Agnico-Eagle Mines Ltd., Meadowbank Division, 2017b. "Emergency Response Plan, Meadowbank Gold Project". Version 10. June 2017.

Path: \\golder.gds\gal\Montreal\SIG\CAD\PROJETS\AGNICO-EAGLE\MEADOWBANK\PRODUCTION\1784282\5000\ | File Name: 1784282-5000-01.dwg



LEGEND

——— TOPOGRAPHIC CONTOUR

NOTE

GRID REFERENCE: NAD 83, UTM ZONE 14.

REFERENCE

DRAWING BASE PROVIDED BY AEM LTD., MEADOWBANK DIVISION IN "MBK Site map updated JULY 2014.dwg" DATED JULY 8, 2014.

CLIENT

AGNICO EAGLE

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-12-14
PREPARED	M. Habersetzer
DESIGN	S. Betnesky
REVIEW	M. Habersetzer
APPROVED	Y. Boulianne

PROJECT

2017 ANNUAL GEOTECHNICAL INSPECTION
MEADOWBANK GOLD MINE, NUNAVUT

TITLE

MEADOWBANK MINE SITE

PROJECT No.	PHASE	Rev.	FIGURE
1784282	5000	0	1

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

25 mm

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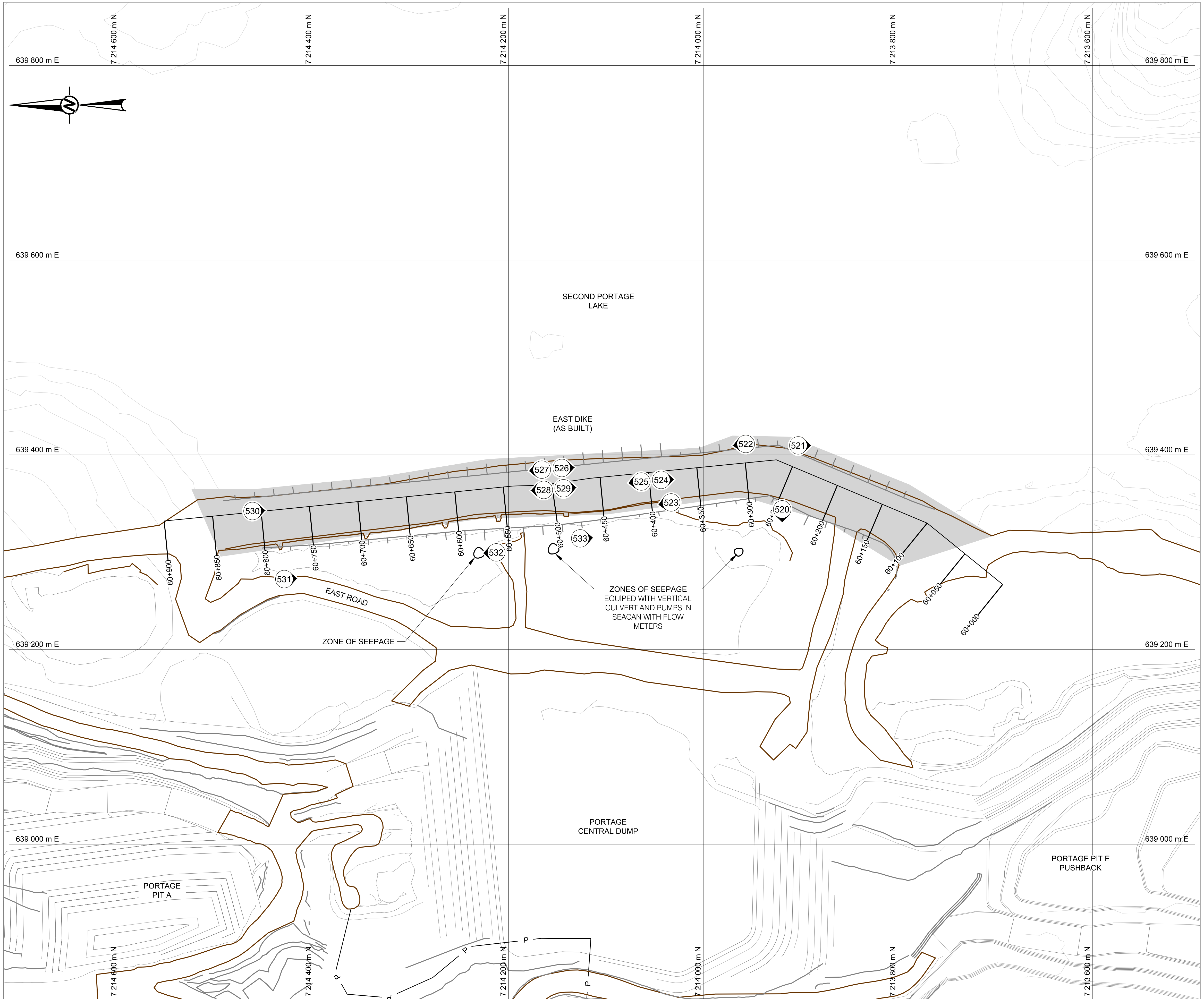
APPENDIX A

Dewatering Dikes

APPENDIX A1

East Dike Photographic Log and Record of Inspection



LEGEND

TOPOGRAPHIC CONTOUR

IDENTIFICATION AND DIRECTION OF PHOTOGRAPHY TAKEN DURING THE ANNUAL INSPECTION OF 2017

NOTE

GRID REFERENCE: NAD 83, UTM ZONE 14.

REFERENCE

DRAWING BASE PROVIDED BY AEM LTD., MEADOWBANK DIVISION IN "MBK Site map updated JULY 2014.dwg" DATED JULY 8, 2014.

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1:4 000 METRES

CLIENT

AGNICO EAGLE

PROJECT

2017 ANNUAL GEOTECHNICAL INSPECTION
MEADOWBANK GOLD MINE, NUNAVUT

TITLE

EAST DIKE

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-12-14
PREPARED	M. Habersetzer
DESIGN	S. Betnesky
REVIEW	M. Habersetzer
APPROVED	Y. Boulianne

PROJECT No.	PHASE	Rev.	FIGURE
1784282	5000	0	A1

Client:	AEM	**By:**	Yves Boulianne
Project:	Meadowbank	**Date:**	September 12, 2017
Location:	East Dike	**Reviewed:**	Yves Boulianne

GENERAL INFORMATION

Dam Type:	Rockfill embankment with a soil bentonite cut-off wall and downstream filters		
Weather Conditions:	Sunny	**Temperature:**	5°C

INSPECTION ITEM	OBSERVATIONS DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		521, 522, 524, 525, 526, 527, 528, 529, 530	
1.1 Crest elevation	136.5 m Cut-off 136.1m		Design thermal cap crest revised in 2011 to El. 136.5 m (Golder 2011a)
1.2 Reservoir level	132.91 m U/S		
Current freeboard	3.6 m		Design 2 m.
1.3 Distance to tailings pond (if applicable)	Not applicable		
1.4 Surface cracking	None at time of inspection		
1.5 Unexpected settlement	None		
1.6 Lateral movement	Not apparent		
1.7 Other unusual conditions	None		
2. UPSTREAM SLOPE		521, 522, 526, 527	
2.1 Slope angle	Approx. 1.6H:1V		
2.2 Signs of erosion	Stable		
2.3 Signs of movement (deformation)	None observed		
2.4 Cracks	None observed		
2.5 Face liner condition (if applicable)	Not applicable		
2.6 Other unusual conditions	None		

INSPECTION ITEM	OBSERVATIONS DATA	PHOTO	COMMENTS & OTHER DATA
3. DOWNSTREAM SLOPE		520, 523, 531, 532, 533	
3.1 Slope angle	Approx.1.6H:1V		
3.2 Signs of erosion	None observed		
3.3 Signs of movement (deformation)	None observed		
3.4 Cracks	None observed		
3.5 Seepage or wet areas	Not apparent		
3.6 Vegetation growth	None observed		
3.7 Other unusual conditions	None		
4. DOWNSTREAM TOE AREA		520, 523, 531, 532, 533	
4.1 Seepage from dam	Yes, presence of 3 zones		Zone of seepage downstream near Sta. 60+247. A sump is installed (pumping system located in container on the photo). No additional seepage observed at the surface of the ground. Pumping collection system started on April 4, 2012. Flow is being monitored since July 2013.
			Zone of seepage downstream near Sta. 60+498. A sump is installed (pumping system located in container on the photo). Ponded water nearby. No additional seepage observed at the surface of the ground during the inspection. Pumping collection system started on April 4, 2012. Flow is being monitored since July 2013.
			Seepage zone near Sta. 60+575. According to AEM, this zone was practically dry all year. Water ponding was observed during inspection but no flow was noticed.
4.2 Signs of erosion	Not observed		
4.3 Signs of turbidity in seepage water	Not observed		Based on AEM's monthly report: TSS criteria were not exceeded in 2017.
4.4 Discoloration/staining	No		
4.5 Outlet operating problem (if applicable)	Not applicable		
4.6 Other unusual conditions	None		

INSPECTION ITEM	OBSERVATIONS DATA	PHOTO	COMMENTS & OTHER DATA
5. ABUTMENTS			
5.1 Seepage at contact zone (abutment/embankment)	None observed		
5.2 Signs of erosion	None observed		
5.3 Excessive vegetation	No		
5.4 Presence of rodent burrows	None observed		
5.5 Other unusual conditions	None		
6. RESERVOIR			
6.1 Stability of slopes	Stable		Low relief region, stable upstream and downstream of dike. Portage Pit is on the downstream side of the dike.
6.2 Distance to nearest slide (if applicable)	None observed		
6.3 Estimate of slide volume (if applicable)	Not applicable		
6.4 Floating debris	None observed		
6.5 Other unusual conditions	None		
7. EMERGENCY SPILLWAY/ OUTLET STRUCTURE			
7.1 Surface condition	No spillway or outlet structure exists, only dewatering pump		
7.2 Signs of erosion			
7.3 Signs of movement (deformation)			
7.4 Cracks			
7.5 Settlement			
7.6 Presence of debris or blockage			
7.7 Closure mechanism operational			
7.8 Slope protection			
7.9 Instability of side slopes			
7.10 Other unusual conditions	No		

INSPECTION ITEM	OBSERVATIONS DATA	PHOTO	COMMENTS & OTHER DATA
8. Instrumentation			
8.1 Piezometers	Yes		See Section 4.0 of the report.
8.2 Settlement cells	No		
8.3 Thermistors	Yes		No data after June 2016. See Section 4.0 of the report.
8.4 Settlement monuments	Not anymore		They have been removed in the past.
8.5 Seismograph	Periodic		See Section 4.0 of the report.
8.6 Inclinometer	Yes		See Section 4.0 of the report
8.7 Weirs and flow monitors	Yes		Flow meters are installed for the two pumping systems downstream. The flow of the seepage zone at Sta. 60+575 is measured using a pipe.
8.8 Data logger(s)	Yes		The piezometers and thermistors on East Dike have automatic data collection since June 2012 (data transmitted every 3 hours).
8.9 Other			
9. DOCUMENTATION			
9.1 Operation, Maintenance and Surveillance (OMS) Plan			
9.1.1 OMS Plan exists	Yes		
9.1.2 OMS Plan reflects current dam conditions	Yes		
9.1.3 Date of last revision	March 2017		
9.2 Emergency Preparedness Plan (EPP)			
9.2.1 EPP exists	Yes		Included within OMS and ERP plan
9.2.2 EPP reflects current conditions	Yes		
9.2.3 Date of last revision	June 2017		

10. NOTES

Inspector's Signature		**Date:**	September 12, 2017

https://golderassociates.sharepoint.com/sites/16104g/preparation of deliverables/rev0/annexes inspection 2017/appendix a - dewatering dikes/a1 east dike/a1 - east dike inspection 2017.docx

Photograph A1-1 East Dike

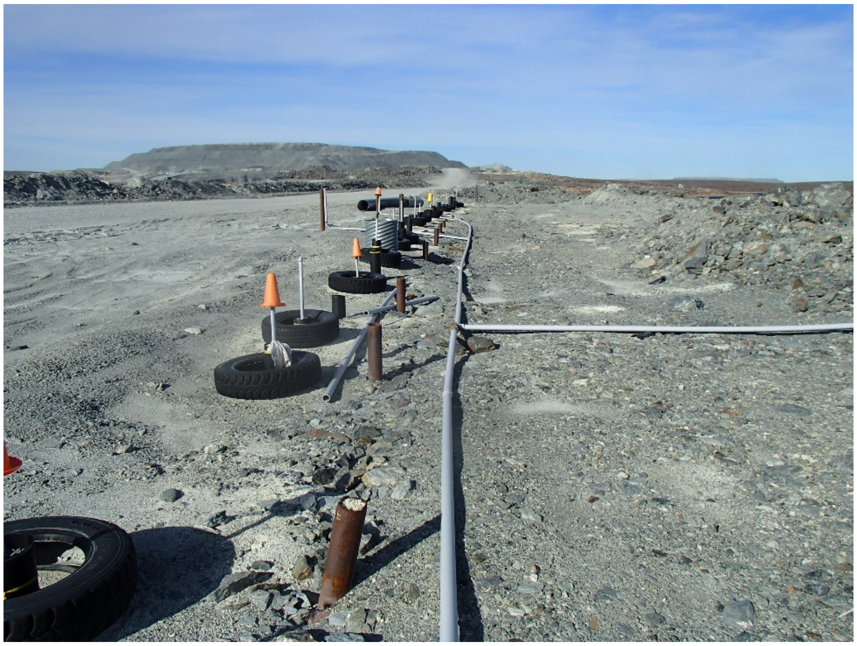
Date: September 12, 2017 **Photo Number**: 524

Description: From approximately Sta. 60+375, looking south at the crest.

Photograph A1-2 East Dike

Date: September 12, 2017 **Photo Number**: 525

Description: From approximately Sta. 60+410, looking north at the crest.



Photograph A1-3 East Dike

Date: September 12, 2017 **Photo Number**: 528

Description: From approximately Sta. 60+560, looking north at the crest.

Photograph A1-4 East Dike

Date: September 12, 2017 **Photo Number**: 529

Description: From approximately Sta. 60+540, looking south at the crest.

Photograph A1-5 East Dike

Date: September 12, 2017 **Photo Number**: 526

Description: From approximately Sta. 60+540 upstream, looking south at the crest and the upstream slope.

Photograph A1-6 East Dike

Date: September 12, 2017 **Photo Number**: 527

Description: From approximately Sta. 60+560 upstream, looking north at the crest and the upstream slope.

Photograph A1-7 East Dike

Date: September 12, 2017 **Photo Number**: 530

Description: From approximately Sta. 60+810, looking south at the crest.

Photograph A1-8 East Dike

Date: September 12, 2017 **Photo Number**: 522

Description: From Sta. 60+300 upstream, looking north along the upstream slope.

Photograph A1-9 East Dike

Date: September 12, 2017 **Photo Number**: 521

Description: From approximately Sta. 60+250 upstream, looking south at the crest and the upstream slope.

Photograph A1-10 East Dike

Date: September 12, 2017 **Photo Number**: 520

Description: From approximately Sta. 60+250, looking west at the downstream side and toe.

Photograph A1-11 East Dike

Date: September 12, 2017 **Photo Number**: 523

Description: From approximately Sta. 60+380, looking north at the downstream side.

Photograph A1-12 East Dike

Date: September 12, 2017 **Photo Number**: 531

Description: From approximately Sta. 60+770, looking south at the downstream toe.

Photograph A1-13 East Dike

Date: September 12, 2017 **Photo Number**: 532

Description: From approximately Sta. 60+570 downstream, looking north at the downstream toe.

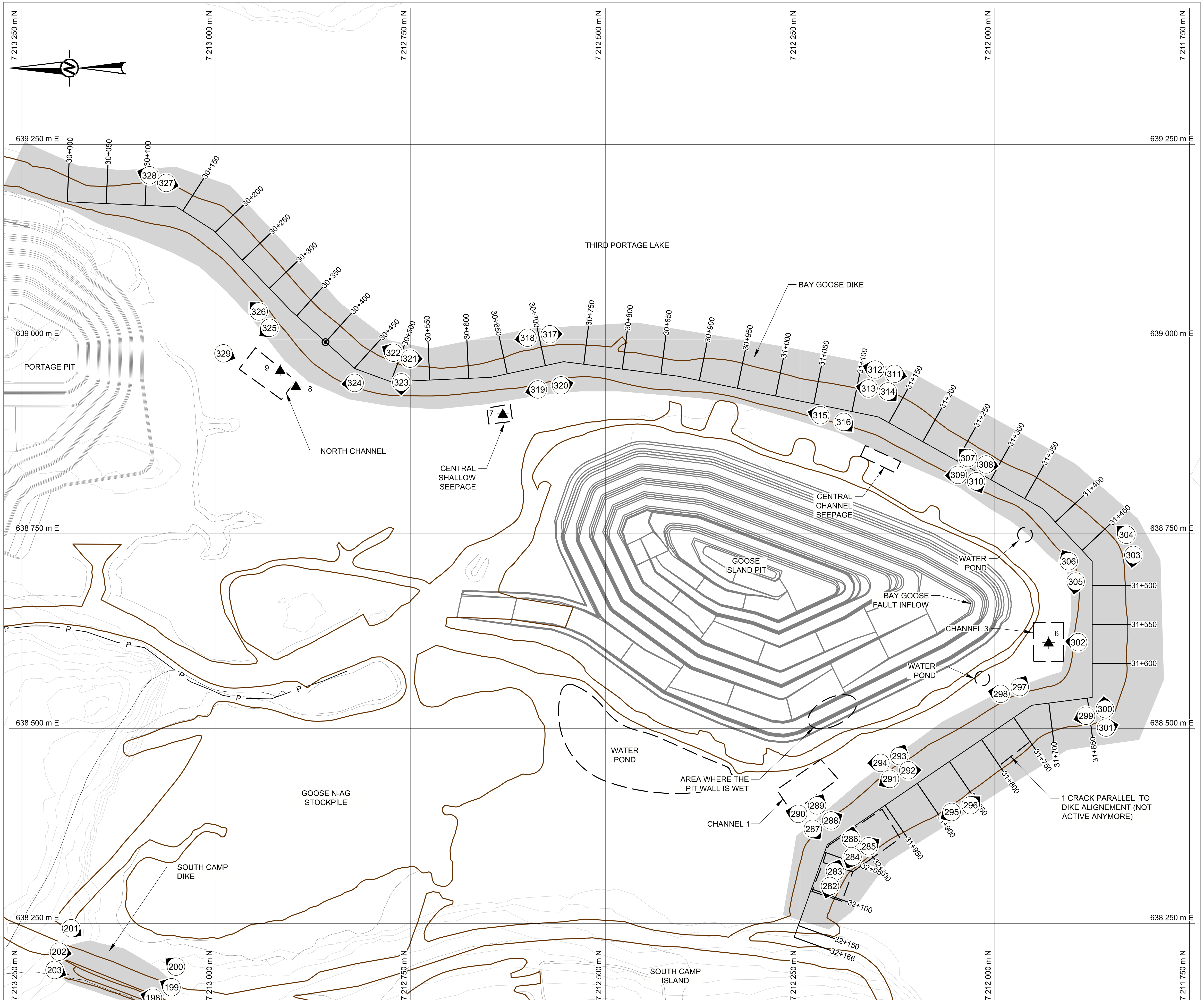
Photograph A1-14 East Dike

Date: September 12, 2017 **Photo Number**: 533

Description: From approximately Sta. 60+475 downstream, looking south at the downstream toe.

APPENDIX A2

South Camp Dike Photographic Log and Record of Inspection



LEGEND

TOPOGRAPHIC CONTOUR

IDENTIFICATION AND DIRECTION OF PHOTOGRAPHY TAKEN DURING THE ANNUAL INSPECTION OF 2017

MANUAL MONITORING FLOW STATION

NOTE

GRID REFERENCE: NAD 83, UTM ZONE 14.

REFERENCE

DRAWING BASE PROVIDED BY AEM LTD., MEADOWBANK DIVISION IN "MBK Site map updated JULY 2014.dwg" DATED JULY 8, 2014.

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CLIENT

AGNICO EAGLE

PROJECT

2017 ANNUAL GEOTECHNICAL INSPECTION
MEADOWBANK GOLD MINE, NUNAVUT

TITLE

BAY-GOOSE DIKE AND SOUTH CAMP DIKE

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-12-14
PREPARED	M. Habersetzer
DESIGN	S. Betnesky
REVIEW	M. Habersetzer
APPROVED	Y. Boulianne

PROJECT No.	PHASE	Rev.	FIGURE
1784282	5000	0	A2

Client:	AEM	**By:**	Yves Boulianne
Project:	Meadowbank	**Date:**	September 8, 2017
Location:	South Camp Dike	**Reviewed:**	Yves Boulianne

GENERAL INFORMATION

Dam Type:	Rockfill shell with upstream filter, a bituminous geomembrane liner and protective cover.		
Weather Conditions:	Sunny	**Temperature:**	15°C

INSPECTION ITEM	OBSERVATIONS DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		198, 199, 202	
1.1 Crest elevation	El. 136.6 m (rockfill) El. 134.7 m (liner)		
1.2 Reservoir level	U/S El.133.6 m D/S		No water observed at downstream toe since 2011.
Current freeboard	3 m (rockfill crest) 1.1 m (liner crest)		
1.3 Distance to tailings pond (if applicable)	Not applicable		
1.4 Surface cracking	None at the time of inspection		
1.5 Unexpected settlement	None at the time of inspection		
1.6 Lateral movement	Not apparent		
1.7 Other unusual conditions	None		
2. UPSTREAM SLOPE		198, 203	
2.1 Slope angle	Approx. 1.3V: 1H		Adequate
2.2 Signs of erosion	None observed		
2.3 Signs of movement (deformation)	None observed		
2.4 Cracks	None observed		
2.5 Face liner condition (if applicable)	Liner not visible at the time of the inspection		Bituminous geomembrane liner. Compacted granular material mixed with bentonite was placed above the liner, followed by a thermal cap layer covering the entire liner face.

INSPECTION ITEM	OBSERVATIONS DATA	PHOTO	COMMENTS & OTHER DATA
2.6 Other unusual conditions	None		
3. DOWNSTREAM SLOPE		200, 201	
3.1 Slope angle	Approx. 1.4V:1H		Adequate
3.2 Signs of erosion	None observed		
3.3 Signs of movement (deformation)	None observed		
3.4 Cracks	None observed		
3.5 Seepage or wet areas	Not apparent		
3.6 Vegetation growth	No		
3.7 Other unusual conditions	None		
4. DOWNSTREAM TOE AREA		200, 201	
4.1 Seepage from dam	None observed		
4.2 Signs of erosion	None observed		
4.3 Signs of turbidity in seepage water	None		
4.4 Discoloration/staining	No		
4.5 Outlet operating problem (if applicable)	Not applicable		
4.6 Other unusual conditions	None		
5. ABUTMENTS			
5.1 Seepage at contact zone (abutment/embankment)	None observed		
5.2 Signs of erosion	None observed		
5.3 Excessive vegetation	No		
5.4 Presence of rodent burrows	None observed		
5.5 Other unusual conditions	None		
6. RESERVOIR			
6.1 Stability of slopes	Stable		
6.2 Distance to nearest slide (if applicable)	Not applicable		
6.3 Estimate of slide volume (if applicable)	None observed		
6.4 Floating debris	None		
6.5 Other unusual conditions	None		

INSPECTION ITEM	OBSERVATIONS DATA	PHOTO	COMMENTS & OTHER DATA
7. EMERGENCY SPILLWAY/ OUTLET STRUCTURE			
7.1 Surface condition	No spillway or outlet structure exists		
7.2 Signs of erosion			
7.3 Signs of movement (deformation)			
7.4 Cracks			
7.5 Settlement			
7.6 Presence of debris or blockage			
7.7 Closure mechanism operational			
7.8 Slope protection			
7.9 Instability of side slopes			
7.10 Other unusual conditions			
8. INSTRUMENTATION			
8.1 Piezometers	No		
8.2 Settlement cells	No		
8.3 Thermistors	Yes		Section 4.0 of the report describes the thermal condition.
8.4 Settlement monuments	No		
8.5 Seismograph	No		
8.6 Inclinometer	No		
8.7 Weirs and flow monitors	No		
8.8 Data logger(s)	No		
8.9 Other	No		
9. DOCUMENTATION			
9.1 Operation, Maintenance and Surveillance (OMS) Plan			
9.1.1 OMS Plan exists	Yes		
9.1.2 OMS Plan reflects current dam conditions	Yes		
9.1.3 Date of last revision	March 2017		
9.2 Emergency Preparedness Plan (EPP)			

INSPECTION ITEM	OBSERVATIONS DATA	PHOTO	COMMENTS & OTHER DATA
9.2.1 EPP exists	Yes		Included within the OMS and ERP
9.2.2 EPP reflects current conditions	Yes		
9.2.3 Date of last revision	June 2017		

10. NOTES

Inspector's Signature		**Date:**	September 8, 2017

https://golderassociates.sharepoint.com/sites/16104g/preparation of deliverables/rev0/annexes inspection 2017/appendix a - dewatering dikes/a2 south camp dike/a2 - south camp dike inspection 2017.docx

Photograph A2-1 South Camp Dike

Date: September 8, 2017 **Photo Number**: 198

Description: From the south abutment, looking north at the upstream slope and the thermistors instrumentation set-up.

Photograph A2-2 South Camp Dike

Date: September 8, 2017 **Photo Number**: 203

Description: From the north abutment, looking south at the upstream slope and thermistors instrumentation set-up.

Photograph A2-3 South Camp Dike

Date: September 8, 2017 **Photo Number**: 199

Description: From the south abutment, looking north at the crest.

Photograph A2-4 South Camp Dike

Date: September 8, 2017 **Photo Number**: 202

Description: From the north abutment, looking south at the crest.