CONSTRUCTION REPORT
TAILINGS STORAGE FACILITY
MEADOWBANK GOLD PROJECT
NUNAVUT

AGNICO-EAGLE MINES LIMITED

WITH COLABORATION OF GOLDER ASSOCIATES LTD.

June 15, 2013

Agnico Eagle Mines (AEM) representatives prepared the final construction report between 2012 and 2013, combining a draft report provided by Golder Associates Ltd. (Golder) and available information about the construction of the TSF. This report has been prepared by AEM representatives partially present on site or not present during construction, with their best knowledge of the TSF construction. The report contains information available during redaction and some details may have been omitted due to lack of information.

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LIST OF ACRONYMS AND ABBREVIATIONS

%	percent
^{o}C	degrees Celsius
AEM	Agnico-Eagle Mines Limited
El.	Elevation
GAL	Golder Associates Ltd.
IFC	Issued for Construction
km	kilometer
LLDPE	Linear Low Density Polyethylene
m	meter
m^3	cubic meter
mm	millimeter
NPAG	Non-potentially acid generating
PAG	Potentially acid generating
QA	Quality assurance
QC	Quality control
QN	Nth quarter of a year
QP	Qualified persons
SD1	Saddle Dam 1
SWD	Stormwater Dike
TSF	Tailings Storage Facility

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1.0 GENERAL

1.1 Objective and Scope

This report summarizes the construction activities from 2009 to 2011 for the Tailings Storage Facility (TSF) at Meadowbank Gold Project (Meadowbank), located approximately 80 km north of Baker Lake, Nunavut, to satisfy Meadowbank Water License 2AM-MEA0815 Part D, Item 26.

The major construction activities related to the Tailings Storage Facility works were carried out in the summer and early falls between 2009 and 2011. This report includes:

- Description and sequence of the major construction activities for each structure;
- Summary of the as-built construction quality assurance (QA) and construction quality control (QC) information;
- Summary of the as-built information (Including As-Built drawings).

Construction photos are available in Appendix A. QA and QC results and information available at the time of reporting are presented in Appendix B. As-Built drawings are presented in Appendix C.

As-built geometry information is based on surveys performed by the Owner, Agnico-Eagle Mines Ltd. (AEM), during the construction.

AEM representatives prepared the final construction report, combining a draft report provided by Golder Associates Ltd. (Golder). This report has been prepared by AEM representatives partially present or not present during construction, with their best knowledge of the construction. The report contains information available during redaction and some details may have been omitted.

During the construction, in general, quality control was the responsibility of AEM and quality assurance was the responsibility of Golder. Specifics roles and responsibilities are described further in this report.

1.2 Description of Tailings Storage Facility

Tailings generated from mining activities at the Meadowbank Gold Mine site will be stored in a portion of the basin formed by dewatering the northwest arm of Second Portage Lake. The dewatering of the Second Portage Arm started on March 17 2009 after the completion of East Dike. Two Godwin HL250 pumps have been use for an average of 12,346 m^3 pump per day during the dewatering. An approximate total of 22,000,000 m^3 have been pump to empty Second Portage Arm. Majority of the water have been treated in a water treatment plant (WTP). The dewatering has been completed on the October 21 2011.

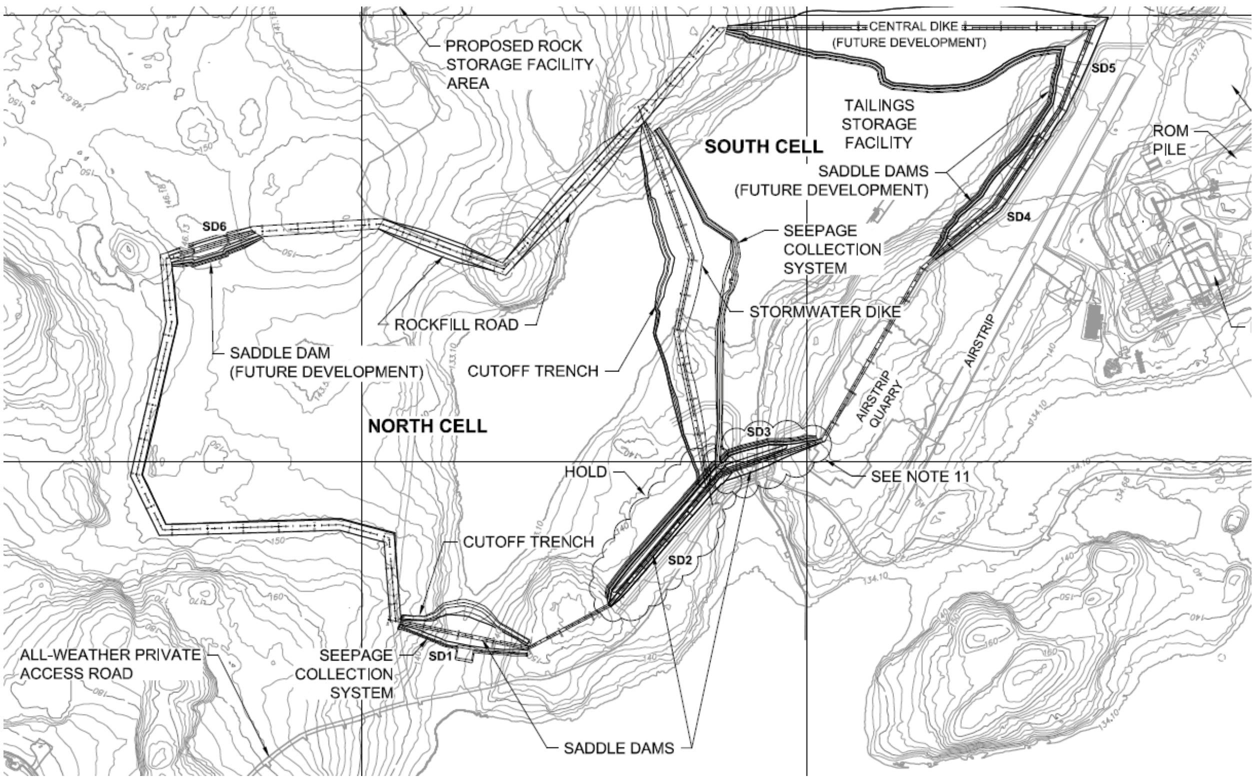

Figure 1: TSF Site Plan

Figure 1 presents the TSF site plan and the different structures included. The TSF construction is staged relative to tailings deposition and water management requirements.

Construction activities for the TSF included the construction of the Rockfill Road 1 and 2, the Stage 1 and 2 of Stormwater Dike, Saddle Dam 1, Saddle Dam 2 and the Connection between Stormwater Dike and Saddle Dam 2. These structures are presented in the section below. Detailed work activity and QA/QC activity for each structure are also described further in this report.

1.2.1 Rockfill Roads (RF1 and RF2)

The Rockfill Roads (RF), constructed in 2009 and 2010, are structures around the perimeter of the North basin (North Cell) providing access around TSF and to the Saddle Dams. Rockfill Road 1 (RF1) and Rockfill Road 2 (RF2) are located on the West side of the Waste dump. The RF are unlined rockfill structures with minimal foundation preparation.

1.2.2 Stormwater Dike

The Stormwater Dike (SWD) is a temporary rockfill structure inside the TSF. The construction of SWD occurred in 2009 and 2010. Is main purpose is to split the TSF in two cells; the North cell and the South cell. With the SWD, tailing deposition in the North cell is possible before the entire completion of the TSF. SWD allows to management of two separate cells for the first four years of production; after which time both basins will contain tailings.

1.2.3 Saddle Dams (SD)

The Saddle Dams are permanent structures designed to retain tailings and limit seepage to the environment. The SD are a series of lined rockfill structures connected by unlined rockfill roads around the perimeter of the TSF. Five different structures compose the SD; Saddle Dam 1, Saddle Dam 2, Saddle Dam 3, Saddle Dam 4 and Saddle Dam 5. Figure 1, shows the specific location for each of them. Saddle Dam 1 was started in 2009 and completed in 2010. Saddle Dam 2 was started in 2010 and completed in 2011. The others Saddle Dams will be constructed in the future during operation.

1.2.4 Stormwater Dike – Saddle Dam 2 Connection

SWD and SD2 connection is a temporary particular structure that link one permanent and one temporary structure. . The western end of the SWD was shifted toward the north by approximately 50 m to facilitate the tie-in with SD2 based on conditions encountered in the field. The purpose of the shift is to allow space for the connection with Saddle Dam 3 (SD3) during its construction. First stage of the connection has been built in 2010 and the second one in 2011. Basically, the design is the same as the SD exept for the type of liner that have been use.

1.3 Definitions

Definitions of terms used in this report are summarized in Table 1.

Table 1: Definitions

Term	Definition
Owner	Agnico-Eagle Mines Limited, Meadowbank Division (AEM)
Owner's Representative	Person(s) employed by the Owner in order to oversee the project works and the Owners interests. The primary point of contact for the Designer and the General Contractor.
Engineer	Golder Associates Ltd. (Golder)
Meadowbank	Meadowbank Gold Project site
Contractor	AEM, Operations
Approval	A written engineering or geotechnical opinion, related to the progress and completion of the Work.
Action Plan	A response to variance(s) by implementing a contingency and/or mitigation measures to better satisfy the design intent, construction drawings or the technical specification.
Work	The labour, materials and equipment required to excavate, place and compact fill, survey to layout the Work or to record the Work, to perform QC activities, and all other activities required to construct the West Channel Dike as detailed in the Specification and on the Drawings.
Ice-Poor Soils	Frozen soils that contain less than 10 percent visible ice and having a water content less than 20%. No visible ice lenses.
Ice-Rich Soils	Frozen soils that contain more than 10 percent visible ice and/or having a water content greater than 20%. Ice lenses may be present.
Quality Assurance (QA)	A planned system of inspection and testing that documents, to the satisfaction of the Owner, the Engineer, other stakeholders and regulators that the Work complies with the design, Drawings and Specifications. Quality Assurance forms a subset of the Quality Assurance program. Quality Assurance comprises inspections carried out during Quality Control and includes verifications, evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. Quality Assurance refers to the measures taken by the Quality Assurance organization, the Engineer, to assess if the Contractor is in compliance with the design, Drawings and Specifications.
Quality Control (QC)	A planned system of inspection, testing and documentation carried out by the Contractor during construction to ensure that the Work is being performed and completed in a manner that will comply with the

Term	Definition
	Drawings and Specifications. The Contractor is responsible for the Quality Control of all Work performed by him and all Work performed by any Subcontractor under contract with him.

1.4 Design, Technical Specifications and Construction Drawings

The detailed design for the SWD, SD1 and SD2 was prepared by Golder, including the construction drawings and technical specifications, issued on July 10th, 2009 and October 16th, 2009, respectively.

Table 2 presents a list of issued for construction (IFC) Revision 0 technical specifications dated October 16th, 2009, and Table 3 presents a summary of the IFC Revision 0 drawings dated July 10th, 2009.

Table 2: TSF Dike Construction IFC Technical Specification List

Specification Section No.	Title
S1	General
S2	Care of Water
S3	Foundation Preparation and Excavation
S4	Fill Placement
S5	Bituminous Geomembrane Liner
S6	Linear Low Density (LLDPE) Geomembrane Liner
S7	Geotextile
S8	Instrumentation
S9	QC and QA Requirements

Table 3: Tailings Storage Facility IFC Construction Drawing List

Drawing No.	Drawing Title
4100-00	Drawing and Specification Index
4100-01	Project Site Plan
4100-02	General Layout Plan
4100-03	Borehole Location Plan
4100-04	Staging Plan and Rockfill Quantities
4100-30	Stormwater Dike Staged Layout Plan

Drawing No.	Drawing Title
4100-31	Stormwater Dike Rockfill Plan and Profile (1 of 2)
4100-32	Stormwater Dike Rockfill Plan and Profile (2 of 2)
4100-33	Stormwater Dike Construction Sequence
4100-34	Stormwater Dike Cross-sections and Quantities
4100-36	Stormwater Dike Seepage Collection Ditch Plan and Profile (1 of 2)
4100-37	Stormwater Dike Seepage Collection Ditch Plan and Profile (2 of 2)
4100-38	Stormwater Dike Seepage Collection Ditch and Sump Details
4100-39	Stormwater Dike Coffer Dam Construction Sequence and Liner Details
4100-50	Saddle Dam Layout Plan and Quantities
4100-51	Saddle Dam Construction Sequence
4100-52	Saddle Dam Liner Details
4100-53	Saddle Dam Rockfill Plan and Profile (1 of 5)
4100-58	Saddle Dam Cross-sections
4100-59	Saddle Dam Instrumentation Plan and Section
4100-60	Saddle Dam 1 Seepage Collection System
4100-70	Rockfill Road Plan and Profile (1 of 2)
4100-71	Rockfill Road Plan and Profile (2 of 2)
4100-72	Rockfill Road Cross-sections and Quantities

Design modifications to the SWD and SD1 were completed to reflect field conditions during the initial construction phase. Design revisions to the construction drawings are summarized in Table 4.

Table 4: Tailings Storage Facility Drawing Revision

Design Figure	Figure Title	Issued Date	Supersedes and Replaces
Figure 1	Agnico-Eagle Mines Limited, Meadowbank Gold Project Nunavut, Stormwater Dike Staged Layout Plan	August 5, 2009	Drawing Nos. 4100-30 4100-31 4100-32
Figure 2	Tailings Storage Facility Typical Cross-Section and Details	August 5, 2009	Drawing Nos. 4100-33, Detail 3

Design Figure	Figure Title	Issued Date	Supersedes and Replaces
			4100-34
Figure 1	Tailings Storage Facility Saddle Dam 1 Rockfill Plan and Liner Details	August 17, 2009	Drawing Nos. 4100-51 4100-52 4100-53 4100-58

1.5 Construction Documentation

AEM was responsible for the collection, distribution and storage of TSF related construction documentation which included the following:

- Golder Tailings Storage Facility IFC Drawings and Technical Specifications;
- TSF construction QC/QA Documentation – Foundation Preparation;
- TSF construction QC/QA Documentation – Fill placement;
- Solution Optimum Construction Report (QC) – Bituminous and LLDPE liner;
- Layfield (QC) – Bituminous and LLDPE liner;
- Request for Information (RFI); and
- Site Memoranda and Technical Memoranda

2.0 ROCKFILL ROAD 1 CONSTRUCTION ACTIVITIES (2009)

2.1 Rockfill Road 1 and 2 - Construction Activity

Rockfill Road 1 was constructed in 2009 and Rockfill Road 2 in 2010, by AEM. As a perimeter structure, Rockfill Road 1 (RF1) was constructed with NPAG, directly on overburden, with minimal foundation preparation. Rockfill material was dumped and pushed to raise the embankment of RF1 and RF2.

Table 6 presents a summary of the main characteristics for the RF.

Table 6: RF1/RF2 As-Built Characteristics

Item	RF1	RF2	Unit
Crest elevation	150	150	masl
Maximum height at rockfill crest center line	12	9	m
Rockfill width at crest	25	25	m
Crest length	525	325	m

2.2 Rockfill Road 1 and 2 – QA/QC Activities

The construction of RF1 and RF2 was completed by AEM, under the direction of AEM representatives. Golder was not involved in the construction of RF1 and RF2. Visual observations and work planning was done by AEM during the construction.

3.0 STORMWATER DIKE CONSTRUCTION – STAGE 1 (2009)

3.1 Stormwater Dike Stage 1 - Construction Activities

Stormwater Dike construction started in July 2009 with the dewatering of the northwest arm of Second Portage Lake. Key work items completed as part of the SWD Stage 1 construction program included the following:

- Dewatering of the northwest arm of Second Portage Lake;
- Stage 1 footprint foundation preparation;
- Stage 1 rockfill shell placement;
- Liner toe trench excavation;
- Cofferdam construction;
- Liner bedding (coarse filter and fine filter) placement and compaction;

- Bituminous geomembrane liner placement;
- Liner cover placement; and
- Stage 2 foundation preparation and initial rockfill placement.

Survey was carried out at the start, during and completion of each activity, under the supervision of AEM.

Earthwork construction activities for the Stormwater Dike were completed by the contractor FGL, under the supervision of AEM representatives. Solution Optimum was contracted for the ES3 geomembrane bituminous liner installation. Construction activity details for SWD Stage 1 are summarized in Table 7 and are described in subsequent sections.

Table 8 presents a summary of the main characteristics for the SWD Stage 1construction of the SWD.

Table 7: Summary of Construction Activities for Stormwater Dike – Stage 1 (2009)

Activity	By	Start Date	Completion Date	Notes
Dewatering of the northwest arm of Second Portage Lake	AEM	March 17 2009	-October 21 2011	■ Golder QA field team arrived to site on July 21st, 2009.
Stage 1 footprint foundation preparation	AEM	July 24th, 2009	September 10th, 2009	
Stage 1 rockfill shell placement	AEM	August 1st, 2009	November 5th, 2009	■ 1st phase of Stage 1 completed on September 12th, 2009.
Liner toe trench excavation	AEM	July 31st, 2009	September 22nd, 2009	
Coffer Dam construction	AEM	August 15th, 2009	August 26th, 2009	
Liner bedding (coarse filter and	AEM	August 19th, 2009	November 8th, 2009	■ 1st phase of Stage 1 completed on

Activity	By	Start Date	Completion Date	Notes
fine filter) placement and compaction				September 27th, 2009.
ES3 bituminous liner placement	Solution Optimum	September 17th, 2009	November 26th, 2009	■ 1st phase of Stage 1 completed on October 4th, 2009. ■ 2nd phase of Stage 1 started on November 3rd, 2009.

Table 8: Stormwater Dike – Stage 1 (2009) As-Built Characteristics

Item	Stormwater Dike	Unit
Stage 1 Crest elevation	140	m a.s.l.
Maximum height at rockfill crest centreline	21	m
Rockfill width at crest	64	m
Crest length	1,200	m
Maximum rockfill base width	122	m
Upstream slope	3H : 1V	-
Dike Seepage Control	Coletanche ES3 bituminous geomembrane liner	-

3.1.1 Construction Materials and Quantities

The materials used in the construction are described in the technical specifications. Table 9 summarizes the earthwork quantities for the SWD Stage 1.

Table 9: Summary of Stormwater Dike- Stage 1 (2009) As-built Earthworks Construction Quantities

Item	As-built Quantity	Unit	Notes:
Foundation excavation quantity	79,000	m^3	Approx. quant.

Stage 1 rockfill shell	243,000	m^3	Approx. quant.
Upstream toe trench excavation of lakebed soils	19,500	m^3	Approx. quant.
Till backfill over bedrock along slope and toe trench	6,400	m^3	Approx. quant.
Liner Bedding: Coarse Filter (200 mm minus)	8,900	m^3	Approx. quant.
Liner Bedding: Fine Filter (20 mm minus)	8.700	m^3	Approx. quant.
ES3 Bituminous geomembrane Liner	24,000	m^2	Approx. quant.

3.1.2 Foundation Preparation

The foundation preparation was carried out westward from the east abutment following the footprint of Stage 1 of the SWD. The foundation conditions were investigated with test pits along the footprint of the SWD.

The foundation preparation consisted of excavation of organics, soft till and ice-rich materials. Unsuitable material was removed until suitable foundation was reached. Unsuitable material was disposed in the waste dump outside of the SWD area. Bedrock, firm till and/or ice poor materials suitable for foundation were encountered at shallow depths. On the east and west abutments bedrock was encountered under a 2 m layer of frozen and thawing till. On the low lying areas, a 1 m to 4 m thick layer of loose saturated till with occasional pockets of sand and gravel overlaid firm till.

Between the upstream toe and the centreline of the dike from Sta. 10+750 to Sta. 10+875 artesian inflows into the excavation was observed. 20 mm minus material was placed over artesian sources and packed with the shovel bucket prior to rockfill placement.

The work for the foundation preparation was completed by FGL and AEM, under the supervision of AEM representatives.

3.1.3 Rockfill Shell Placement

Stage 1 rockfill shell material comprised PAG and NPAG rockfill. Placement advanced westward from the east abutment. The rockfill shell was initially raised to a variable elevation, 4 m to 5 m above the lake surface, to allow the liner tie-in works to be completed before winter weather conditions. The rockfill shell was raised to El. 140 m with a minimum 10 m wide crest. The rockfill was hauled to the SWD primarily using 100 ton trucks and 60 ton trucks to the narrower sections at the crest of the Stormwater Dike. The dumped rockfill material was placed in lifts of 2 m in thickness using D8 and/or D9 dozers. Compaction of the rockfill material was achieved with trafficking of loaded haul trucks. Following placement CAT 385 and/or CAT 330 excavators re-sloped the upstream side slope to 3H:1V.

Rockfill materials for the SWD construction were geochemically classified as potentially and non-potentially acid generating (PAG and NPAG) by AEM. The material was placed by FGL and AEM, under the supervision of AEM representatives

3.1.4 Upstream Liner Toe Trench Excavation

The upstream toe excavation was carried out by AEM westward from the east abutment. The foundation preparation consisted of the excavation and removal of organics, soft till, ice rich materials and fractured bedrock. Unsuitable material was removed until suitable foundation was reached. Unsuitable material was disposed in the waste dump outside of the SWD area. Bedrock, firm till and/or ice poor materials suitable for the foundation were encountered at shallow depths. On the east and west abutments and submerged island bedrock was encountered under a layer of frozen and thawing till. On the low lying areas, a 1 m to 4 m thick layer of loose saturated till with occasional pockets of sand and gravel overlaid firm till.

At about Sta. 10+830 water inflow from an artesian source was observed. A culvert and pump were installed in the area prior backfilling the tie-in trench with till to El. 137.5 m to cap the artesian source. Once completed, a 1.8 m length of the culvert was buried below the final liner level in the trench. Fine filter material was used to backfill the culvert and a wire piezometer was installed. Finally till was placed to cap the culvert and provide a liner bedding surface. Work was completed by FGL and AEM, under the supervision of AEM representatives

3.1.5 Cofferdam

Two cofferdams were constructed to El. 129 m and El. 128.5 m on the upstream and downstream sides of the dike to prevent water inflow from the north and south basins, respectively. At the time, dewatering was being set up and both the north and south basin water level were rising.

After rockfill placement, a trench was excavated in the downstream cofferdam to bedrock surface. Similarly, the upstream cofferdam was excavated to ice-poor fine grained soil, 1 m deep in natural ground. The minimum trench base width is 1.3 m. Following the trenches were backfilled with till previously stockpiled north of east abutment of SWD. The cofferdams were capped with rockfill.

The cofferdams were constructed by FGL and AEM, under the supervision of AEM representatives

3.1.6 Liner Bedding Placement

Following re-sloping of the upstream side slope of the rockfill to 3H:1V, a two layer bedding system was placed. Initially the liner bedding layers were placed and compacted over the initial rockfill placed to variable elevation, 4 m to 5 m above the lake surface, to allow the liner tie-in works to be completed before winter weather conditions. Following, the rockfill shell was raised to crest El. 140 m and the liner bedding layers were placed and compacted to crest elevation. The coarse filter material (200 mm minus) and fine filter material (20 mm minus) were typically hauled in 100 tonne trucks and dumped on the crest and part way down the slope.

The coarse filter material (200 mm minus) was placed over the rockfill upstream side slope with a CAT 330 and/or CAT 345 excavators for a thickness of about 0.5 m. The 200 mm minus material was produced by AEM and contractor's crusher and hauled to the SWD by 100 ton trucks. The coarse filter layer was track packed with two passes of a D8 dozer or CAT 330 excavator.

The fine filter material (20 mm minus) was placed on the upstream side slope over the coarse filter layer with a CAT 330 and/or CAT 345 excavators to place a thickness of about 0.5 m. The 20 mm minus material was produced by FGL crusher near the north end of Portage Pit and hauled to the SWD by 100 ton trucks. The fine filter layer was compacted with a minimum of 4 passes of a 10 ton smooth drum roller travelling up and down the slope. Vibration was only used when moving up slope. No water was added to the fine filter during placement or compaction.

Crushed rockfill materials (coarse filter and fine filter) were produced at AEM and Other's crushers. Crushed rockfill material was produced from NPAG rockfill. The liner bedding material was placed by FGL and AEM, under the supervision of AEM representatives

3.1.7 Bituminous Geomembrane Liner Installation

The bituminous geomembrane liner installation was carried westward from the east abutment. The initial installation was to a variable elevation, 4 m to 5 m above the lake surface, to allow the liner tie-in works to be completed before winter weather conditions. Subsequent to this, the dike was raised to crest El. 140 m and the liner was installed to crest elevation. A bench was created at the crest of the initial dike elevation to allow a horizontal seam in the liner.

The ES3 bituminous geomembrane liner was stored in site north of the east abutment. Full intact liner rolls were used and damaged areas from transportation, loading and unloading were discarded. The liner bedding surface was manually cleaned by hand shovel, air compressor and snow blower prior to liner deployment.

The deployment of the liner was carried out with a CAT 345 excavator with a modified spreader bar to support the roll in the air over the crest and a combination of an ATV and manual support on the edges pulled the liner down the slope to the liner tie-in trench.

The bituminous geomembrane liner was cleaned by hand held wire brushes, bristle brooms and/or air compressor immediately prior to welding. Seam welding was completed using a bitumen welder. Calibration welds were performed twice daily.

The bituminous geomembrane liner installation was carried out by Solution Optimum under the supervision of AEM representatives.

3.1.8 Liner Cover

The liner at the tie-in trench was covered with 1.0 m of till placed in two 0.5 m thick layers, compacted with the bucket of the shovel of a CAT 330 or 345 excavator and variably compacted with a 10 ton smooth drum roller. The till layers were placed with a shovel CAT 330 and a shovel CAT 345 excavators. A minimum 1.0 m thick layer of 200 mm minus material was placed on top of the till. The 200 mm minus material was placed forward from the top of the already placed 200 mm minus cover. Trucks hauling liner cover materials were routed over the 200 mm minus cover to promote compaction of the liner cover materials in the tie-in trench. Work was completed by FGL and AEM, under the supervision of AEM representatives

A nominal 0.5 m thick layer off 20 mm minus material was placed over the bituminous geomembrane liner from the liner toe to about 2 m up the slope. The upper portion of the liner on the slope has been left uncovered.

Liner wrinkles at the toe of the slope formed during material placement were covered with 0.5 m thick patches of till.

3.1.9 Stage 2 Construction

Stage 2 foundation preparation was carried out in the dry and underwater in the low lying area between approximate Sta. 10+500 and Sta. 10+700 during winter conditions in fourth quarter (Q4) 2009. Ice was broken up along the downstream edge of Stage 2 with a CAT 345 excavator and minimal foundation preparation was completed from the top of the rockfill shell prior to rockfill placement through the water. On land, the surface was grubbed and minimal overburden over frozen till was excavated. Snow accumulated against the rockfill shell and on the lakebed surface was removed prior to rockfill placement. Stage 2 rockfill placement was in progress in 2009 and was continued during operations in 2010.

3.2 Stormwater Dike Stage 1 – QA/QC activities

Golder was represented on site by a QA Manager and a QA field team that carried out the QA inspection and testing and check QC activities. Golder's QA manager mobilized to site on July 14th 2009 and the QA field team on July 21st 2009. As requested by the owner, from October 12th 2009 Golder presence on site was limited to a single Golder staff member to inspect the construction activities. Due to Golder's limited presence on site after October 12th 2009, the QA activities completed during this period were limited to dayshift.

The QC program was managed and directed by AEM. QC testing was completed under the supervision of AEM. AEM supervised and monitored the construction activities.

For the purpose of this report, QA and QC program will be grouped. QA and QC activities and results are complementary and are discussed in the same subsequent sections, under the appellation QA/QC program or activity. Specific activities carried by Golder will be specified only under QA appellation and specific activities carried by AEM will be specified only under QC appellation.

A summary of Stormwater Dike Stage 1 QA testing and monitoring is presented in Table 10.

Table 10: Summary of Stormwater Dike Construction QA Testing and Monitoring- Stage 1

Construction Item	Work Description	Minimum QA Testing Requirement and Frequency	QA Tests Performed
General	Care of water	Visual observation	Continuous
	Borrow material Storage	Visual observation	Continuous
Foundation preparation	Location and extents	Survey review	Continuous and As Built following construction
	Subgrade inspection	Visual observation	Continuous
	Moisture content	1 in every 5 QC	14
Rockfill shell placement	Gradation	Visual observation	Continuous
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Coarse Filter	Gradation (stockpile and as placed)	1 in every 5 QC	0
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Fine Filter	Gradation (stockpile and as placed)	1 in every 5 QC	16
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Trench backfill (Till)	Placement technique	Visual observation	Continuous
Bituminous Geomembrane Liner	Seams	Visual inspection	Continuous
	Tensile shear strength of seams	Oversee 1 every 5 QC tests (9)	19 (oversee) 14 (3^{rd} party laboratory)
	Vacuum box testing	Oversee 1 every 10 QC tests	56
	Ultrasonic testing	Oversee 1 every 5 QC tests (0)	0
	Liner thickness	1 every 1000 m seam length	1
	Liner density	1 every 1000 m seam length	1
	Tensile shear strength of liner	1 every 2000 m seam length	0

Liner cover	Gradation as placed	1 in every 5 QC	0
	Compaction	Visual observation	Continuous

3.2.1 Foundation Preparation

All prepared foundation areas were inspected and accepted by AEM/Golder site staff prior to initiating any fill placement. QA/QC activities for the foundation preparation and inspection included:

- Visual observation during foundation excavation, including removal of organic soils, soft soils and ice rich soils;
- Visual observation of waste material removal and disposal; and
- Foundation approval of competent subgrade.

The foundation conditions were investigated with test pits along the footprint of the Stormwater Dike and a firm soil suitable for foundation was encountered at shallow depths (1 m to 3 m deep). The foundation preparation was carried out and unsuitable materials were hauled to portage pit waste dump.

Fourteen QA till samples were collected during foundation preparation within the footprint of Stage 1. All samples were tested for water content and grain size distribution. Two hydrometer tests were completed on selected QA till samples. Part of the results is available in Appendix B.

3.2.2 Initial Rockfill Shell Placement

QA/QC activities for the rockfill shell placement included:

- Visual observation of the rockfill gradation, lift thickness and segregation;
- Overview of the rockfill placement technique;
- Visual inspection of equipment routed to promote compaction;
- Upstream re-sloped rockfill surface approval.

The rockfill appeared well graded with occasional oversize boulders that were moved to the downstream side of the dike.

3.2.3 Upstream Toe Excavation

QA/QC activities for the upstream toe excavation included:

- Visual observation during upstream toe excavation including removal of organic soils, soft soils and ice rich soils;
- Foundation approval of competent subgrade;
- Visual observation of till placement and compaction;
- Till QA samples of *in situ* materials taken to assess particle size distribution and moisture content.

Organic soils, soft till, ice rich soils and fractured bedrock were excavated and hauled to portage pit waste dump.

A thin layer of till was placed and compacted over bedrock surface to provide a smooth liner bedding at the upstream toe.

Foundation approval by the QA team was given after visual inspection of the subgrade. Same approval was given also by the QC team.

Four QA till samples were collected during tie-in trench till placement. All samples were tested for grain size distribution and one moisture content test was completed. Additionally, water content testing of the fraction passing the #4 mesh were recorded while completing the grain size distribution tests. Part of the results is available in Appendix B.

The QA/QC results indicate that gradation of the samples of till material placed was within specification.

3.2.4 Cofferdam

QA/QC activities for the cofferdam construction included:

- Visual observation of the rockfill gradation and placement technique;

- Visual observation of trench excavation to competent subgrade;
- Visual observation of till placement and compaction;
- Golder QA observations were limited to dayshift. QC representatives were present on both shifts.

Both cofferdams are not permanent structures.

3.2.5 Liner Bedding Placement

QA/QC activities for the liner bedding placement included:

- Visual observation of the liner bedding material gradation, lift thickness and segregation;
- *Insitu* QA/QC samples taken to assess particle size distribution;
- Overview liner bedding material placement technique;
- Visual inspection of liner bedding compaction;
- Coarse filter and fine filter placement and compaction approval.

QA observations report that between Sta. 10+826 and Sta. 10+829 as well as Sta. 10+810 and Sta. 10+820 no coarse filter was placed on top of the rockfill slope. To mitigate the area additional fine filter was placed. Also, fine filter material in place was observed to have oversize particles. Similarly, oversize particles were noted under the liner between Sta. 10+150 and Sta. 10+210.

Sixteen (16) QA grain size distribution tests and five QA water content tests were completed. Part of the results is available in Appendix B. The results indicate that gradation of the samples of fine filter material placed was generally within specification. No coarse filter QA samples were tested during the construction.

The QA/QC results indicate that gradation of the samples of fiter material placed was within specification.

3.2.6 Bituminous Geomembrane Liner Installation

The geomembrane installer Solution Optimum was responsible of the QC program during the installation, under the supervision of AEM. Golder was responsible of the QA program.

QA activities for the ES3 bituminous liner installation included:

- Liner bedding surface visual inspection;
- Visual observation of liner deployment technique;
- Visual inspection of seams;
- Oversee QC tensile shear strength and vacuum box tests;
- Selection of bituminous geomembrane liner samples;
- Liner installation approval for liner cover placement.

The liner was generally deployed in a relaxed condition along the slope; however, some wrinkling was observed after placement and folds of the liner were created during liner cover placement. Wrinkles in the liner were covered with at least 0.5 m of till; however, this method was observed to be applied to unacceptable folds at Sta. 10+360, Sta. 10+380 and Sta. 10+570.

Water was observed to pond at the liner tie-in trench, under and over the liner from Sta. 10+150 to Sta. 10+240 and Sta. 10+280 to Sta. 10+300.

Oversized material was noted under the liner between Sta. 10+150 and Sta. 10+210.

Between Sta. 10+400 and Sta. 10+420 the liner was observed to be in tension at the inflection point of the slope; the liner does not rest on the underlying liner bedding material. The liner was covered without mitigation.

The welding machine experienced different break down periods during liner installation. Liner deployment continued in an attempt to protect the foundation surface. The deployed panels were ballasted in place with 20 mm minus material piles placed over geotextile patches or directly over the liner at the center of each panel and/or along the liner panels overlap. Large particles were observed within the 20 mm minus material.

The bituminous geomembrane liner was cleaned by hand held wire brushes, bristle brooms and/or air compressor immediately prior to welding. Seam welding was completed using a bitumen welder. Liner welds met or exceeded the minimum required specified values. Calibration welds were performed twice daily, at the start of the shift and in the afternoon.

Liner overlap was generally satisfactory during deployment although panel 243 was observed to be left in place with a 150 mm overlap and was deemed acceptable by the liner subcontractor.

The temperature during deployment and seaming of the ES3 bituminous liner during October and November ranged between -10° and -25° Celsius.

Golder oversaw nineteen (19) QC tensile shear strength and fifty six QC vacuum box tests. Tensile shear testing was performed in ambient air conditions. No QC ultrasonic tests were performed. Fourteen (14) in situ seam liner samples were tested at an independent laboratory for tensile shear strength. The sample DT 217/218 did not meet the specifications and it is recommended to patch this seam.

Two bituminous geomembrane liner rolls were sampled by Golder and one was tested to assess its thickness and density. The density testing results met the required specification. The average thickness testing result met the specification; however, some values were lower than specified. No tensile shear strength testing of the liner was performed.

Part of the QC test results are available in Appendix B.

3.2.7 Liner Cover

QA/QC activities for the liner cover placement included:

- Visual observation of the liner cover material gradation, lift thickness and segregation;
- Overview liner cover material placement technique;
- Visual inspections of liner cover compaction.

The liner at the tie-in trench was covered with 1.0 m of till placed in two 0.5 m thick layers and packed with the bucket of the shovel of a CAT 330 and/or CAT 345 excavators. Locally the till packed with the bucket of the shovel was highly fissured and insufficient compaction was achieved. A 10 ton smooth vibratory roller was inconsistently used to compact the till layers. No compaction of the till layers was carried out from Sta. 10+240 to 10+390 and Sta. 10+610 to 10+625. Trucks hauling liner cover materials were routed over the 200 mm minus cover to promote compaction of the liner cover materials.

A nominal 0.5 m 20 mm minus layer was placed over the ES3 liner from the liner toe to about 2 m up the slope. The upper portion of the liner on the slope has been left uncovered

No liner cover QA samples were tested during the 2009 SWD construction.

4.0 STORMWATER DIKE CONSTRUCTION - STAGE 2 (2010)

4.1 Stormwater Dike Stage 2 - Construction Activities

Stormwater Dike construction stage 2 started in July 2010. The Stormwater Dike - Saddle Dam 2 (SWD-SD2) Connection construction activities completed in 2010 have been included in the appropriate sections that follow to facilitate discussion. Key work items completed as part of the SWD Stage 2 construction program included the following:

- Footprint foundation preparation (east abutment and SWD-SD2 connection);
- Stage 2 rockfill shell placement;
- Liner toe trench excavation;
- Liner bedding (coarse filter and fine filter) placement and compaction;
- Bituminous geomembrane liner placement and tie-in with 2009 ES3 liner;
- Liner cover placement; and
- Cofferdam construction (SWD-SD2 connection);

Survey was carried out at the start, during and completion of each activity, under the supervision of AEM.

Earthwork construction activities for the Stormwater Dike were completed by the contractor FGL, under the supervision of AEM representatives. Layfield was contracted for the ES3 geomembrane bituminous liner installation. Construction activity details for SWD Stage 1 are summarized in Table 11 and are described in subsequent sections.

Table 12 and 13 presents respectively a summary of the main characteristics for the SWD Stage 2 construction and for the Connection between SD2/SWD .

Table 11: Summary of Construction Activities for Stormwater Dike

Activity	By	Start Date	Completion Date	Notes
Stage 2 Foundation Preparation	AEM	September 21st, 2009	October 23rd, 2010	• Foundation preparation commenced at the east abutment prior to Golder's arrival on-site July 21st, 2010 • Completion date includes SWD/SD2 connection.
Stage 2 Rockfill shell placement	AEM	September 21st, 2009	October 30, 2010	• Completion date includes rockfill placement for SWD/SD2 connection.
Liner toe trench excavation	AEM	Prior to July 21st, 2010	October 23rd, 2010	• Completion date includes SWD/SD2 connection.
Liner bedding (coarse filter and fine filter) placement and compaction	AEM	Prior July 21st, 2010	October 30th, 2010	• Upon initial site visit to SWD filter slope material was being compacted. • Completion date includes SWD/SD2 connection
ES2 bituminous	Layfield Group	August 30th, 2010	September 27th, 2010	• Completed up to Sta. 10+230. From

Activity	By	Start Date	Completion Date	Notes
liner placement and tie-in with 2009 liner				this station to upstream SD2 face still required.
Liner cut-off trench backfill	AEM	September 6th, 2010	End of October 2010	
Liner Cover	AEM	September12th, 2010	September 18th, 2010	• Completion date is for east abutment only. Liner has not yet been deployed west of about Sta. 10+230 and thus no liner cover placed yet.
Cofferdam	AEM	November 7th, 2010	Mid-November 2010	• Cofferdam was not completed when QA team demobilized off of site on November 9th, 2010

Table 12: Stormwater Dike – Stage 2 (2010) As-Built Characteristics

Item	Stormwater Dike	Unit
Stage 2 Crest elevation	148	m a.s.l.
Maximum height at rockfill crest centreline	29	m
Rockfill width at crest	24	m
Crest length	1,200	m
Maximum rockfill base width	152	m
Upstream slope	3H : 1V	-
Dike Seepage Control	Coletanche ES2 bituminous	-

Item	Stormwater Dike	Unit
	geomembrane liner	

Table 13: Connection SD2/SWD – Stage 2 (2010) As-Built Characteristics

Item	Stormwater Dike	Unit
Crest elevation	148	m a.s.l.
Maximum height at rockfill crest centreline	8	m
Rockfill width at crest	24	m
Crest length	126	m
Maximum rockfill base width	36	m
Upstream slope	3H : 1V	-
Dike Seepage Control	Coletanche ES3-2 bituminous geomembrane liner	To be installed in 2011

4.1.1 Construction Materials and Quantities

The materials used in the construction are described in the technical specifications Table 14 summarizes the earthwork quantities for the SWD, including the SWD-SD2 connection.

Table 14: Summary of SWD As-Built Earthworks Construction Quantities

Item	As-built Quantity	Unit	Notes:
Foundation excavation quantity	4,750	m^3	
Stage 2 rockfill shell	711,000	m^3	
Upstream toe trench excavation	15,000	m^3	
Till backfill over bedrock along slope and toe trench	5,000	m^3	
Liner Bedding: Coarse Filter (200 mm minus)	18,500	m^3	
Liner Bedding: Fine Filter (20 mm minus)	17,750	m^3	

ES2 Bituminous geomembrane Liner	19,000	m^2	
Liner cover	0	m^3	Reference DOC no. for limits/requirement of liner cover
Cofferdam	1,500	m^3	

4.1.2 Foundation Preparation

Foundation preparation was required to both the east and west of the Stage 1 abutments to accommodate the increased in height of the dike crest from El. 140 m to 150 m during Stage 2 construction. Foundation preparation was completed on both the west and east embankments prior to the arrival of the QA team onsite (July 21st, 2010). Although Stage 2 construction was planned to be raised to El. 150 m, the crest was only raised to El. 148 m as of the QA team demobilizing on November 9th, 2010.

The foundation preparation consisted of excavation of organics, glacial till and ice-rich materials to accommodate the Stage 2 construction. Bedrock suitable for foundation was encountered at shallow depths. The excavated waste material was hauled to portage pit waste dump and/or disposed outside the dike footprint. In general, on the east and west abutments bedrock was encountered under a 1.5 to 4 m layer of frozen and thawing till with limited blasting required on the east abutment.

The work for the foundation preparation was completed by FGL and AEM, under the supervision of AEM representatives.

4.1.3 Rockfill Shell Placement

Stage 2 rockfill shell for Stage 2 started September 21st, 2009 and was completed before July 2010. The rockfill shell had been raised to elevation El. 148 m. Following placement excavators re-sloped the upstream side slope to 3H:1V. Rockfill shell was placed following generally the same procedure as for Stage 1.

Rockfill materials for the SWD construction were geochemically classified as potentially and non-potentially acid generating (PAG and NPAG) by AEM and supplied from on site pits and quarries. The material was placed by FGL and AEM, under the supervision of AEM representatives

4.1.4 Upstream Toe Excavation

Upstream toe excavation to accommodate Stage 2 construction was carried out by AEM on both the west and East abutments. The foundation preparation consisted of the excavation and removal of organics, ice-rich materials and fractured bedrock. The excavated waste material was hauled to the waste dump and/or disposed outside the dike footprint. Work was completed by FGL and AEM, under the supervision of AEM representatives

4.1.5 Liner Bedding Placement

Following re-sloping of the upstream side slope of the rockfill to 3H:1V, a two layer bedding system was placed. Upon arrival of the QA team on July 21st, 2010 the coarse filter bedding material had been placed on the upstream rockfill face of the Stage 2 construction. For the SWD-SD2 connection the thickness of the coarse filter was also 0.5 m. The coarse filter material was produced by AEM and contractor’s crusher and hauled to the SWD by on-site haul trucks.

The coarse filter material (200 mm minus) was placed in layer of approximately 0.5m over the rockfill upstream side slope with the same methods as Stage 1. The 200 mm minus material was produced by AEM and contractor’s crusher and hauled to the SWD by 100 ton trucks. The coarse filter layer was track packed with two passes of a D8 dozer or CAT 330 excavator.

The fine filter material (20 mm minus) was placed on the upstream side slope over the coarse filter layer with one or two CAT 345 excavators that placed a thickness of 0.5 m from both the crest of the dam and the El. 140 m bench. The 20 mm minus material was produced by Other’s crusher near the north end of Portage Pit and hauled to the SWD by on site haul trucks. The fine filter layer was compacted with a minimum of three passes of a 10 ton vibrating smooth drum roller travelling up and down the slope with the third pass being an overlapping pass. No water was added to the fine filter during placement or compaction.

Crushed rockfill material was produced from NPAG rockfill. The liner bedding material was placed by FGL and AEM, under the supervision of AEM representatives

4.1.6 Bituminous Geomembrane Liner Installation

The bituminous geomembrane liner installation was carried out by the Layfield Group, under the surpervision of AEM, in three phases:

1. Initial installation commenced at STA. 11+050 and progressed westward to STA. 10+275;

2. From the east abutment westward to STA. 11+110; and

3. Westward from STA. 10+220 to STA. 10+275.

The ES2 bituminous geomembrane liner was stored on site adjacent to the downstream crest at the west abutment and west of the downstream face of Saddle Dam 2 (SD2). Full intact liner rolls were used and damaged areas from transportation, loading and unloading were discarded. The liner bedding surface was manually cleaned by hand shovel and bristle broom, where necessary, prior to liner deployment.

The deployment of the liner was carried out with a CAT 345 excavator with a modified spreader bar to support the roll in the air over or slightly behind the crest and manual support on the edges to allow the liner to be pulled down the slope to the liner tie-in trench or overlap with the 2009 liner.

The bituminous geomembrane liner was cleaned by hand held, bristle brooms and/or dry rags prior to welding. Seam welding was completed using a bitumen welder. Calibration welds were performed twice daily when welding was carried out all day, otherwise, only once prior to the commencement of welding. The liner extended approximately 4 m out along the dam crest and where it was not tied into the 2009 liner. Sequential panel numbers were written on the liner as per the specifications. Ballasting material was placed at the dam crest over the liner and if necessary along the panel edges as the work was completed or at the end of each shift. Where needed, patches were carried out by torching a piece of ES2 to the surrounding panel.

4.1.7 Liner Cover

Where the liner was not tied into the 2009 liner it was extended to the tie-in trench. This was limited to the east abutment as winter conditions prevented liner deployment on the west abutment (*i.e.* SWD-SD2 connection). The deployed liner was covered with about 1.0 m of till placed in two 0.75 m thick layers and compacted with the bucket of the shovel of a CAT 345 excavator, followed by compaction with a 10 ton smooth non-vibrating drum roller. The till layers were placed with a CAT 345 excavator from the upstream side of the liner tie-in trench. Work was completed by FGL and AEM, under the supervision of AEM representatives.

4.1.8 Cofferdam

A cofferdam was in the process of being constructed between STA. 10+75 and 10+220 to crest El. 142 masl on the west abutment upstream of the trench excavation for the till plug tie-in. The cofferdam was being constructed to provide tailings and supernatant pond containment within the TSF until the construction is completed for SD2 and the SWD. The cofferdam is a temporary structure.

The cofferdams were constructed by FGL and AEM, under the supervision of AEM representatives

4.2 Stormwater Dike Stage 2 - QA / QC activities

Golder was represented on site by a QA Manager and a QA field team that carried out the QA inspection and testing and check to QC activities. Golder's QA manager and QA field team mobilized to site on July 21st 2010 . From October 11th 2010 Golder presence on site was limited to a single Golder staff member (QA Manager) to inspect the construction activities. Due to Golder's limited presence on site after October 11th 2010, the QA activities completed during this period were limited to dayshift.

The QC program was managed and directed by AEM. QC testing was completed under the supervision of AEM. AEM supervised and monitored the construction activities.

A summary of Stormwater Dike Stage 2 and SWD-SD2 connection QA testing and monitoring is presented in Table 15.

Table 15: Summary of Stormwater Dike Construction QA Testing and Monitoring- Stage 2

Construction Item	Work Description	Minimum QA Testing	QA Tests Performed

		Requirement and Frequency	
General	Care of water	Visual observation	Continuous
	Borrow material Storage	Visual observation	Continuous
Foundation preparation	Location and extents	Survey review	As-Built following construction
	Subgrade inspection	Visual observation	Continuous
	Moisture content	1 in every 5 QC	0
Rockfill shell placement	Gradation	Visual observation	Occassionally
	Placement technique	Visual observation	Occassionally
	Compaction	Visual observation	Occassionally
Coarse Filter	Gradation (stockpile and as placed)	1 in every 5 QC	0
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Fine Filter	Gradation (stockpile and as placed)	1 in every 5 QC	1
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Trench backfill (Till)	Placement technique	Visual observation	Continuous
Bituminous Geomembrane Liner	Seams	Visual inspection	Continuous
	Tensile shear strength of seams	Oversee 1 every 5 QC tests (9)	54 (oversee)
	Vacuum box testing	Oversee 1 every 10 QC tests	20 (of 30)
	Ultrasonic testing	Oversee 1 every 5 QC tests	0
	Liner thickness	1 every 1000 m seam length	0
	Liner density	1 every 1000 m seam length	0
	Tensile shear strength of liner	1 every 2000 m seam length	0
Liner cover	Gradation as placed	1 in every 5 QC	6
Cofferdam	Compaction	Visual observation	Continuous

4.2.1 Foundation Preparation

QA/QC activities for the foundation preparation were limited to Stage 2 construction for a portion of the SWD-SD2 connection (*i.e.* west abutment) as foundation preparation for the east abutment was completed prior to the arrival of the QA team on site (July 21st, 2010). QA activities included:

- Visual observation during foundation excavation (includes a portion of cut-off excavation for SD2), including removal of organic soils, soft soils and ice-rich soils;

- Visual observation of waste material removal and disposal;

- Inspection of construction road immediately upstream and parallel to the SD2 till plug tie-in; and

- Foundation approval of competent subgrade.

Foundation approval by the QA team was given after visual inspection of the subgrade. Same approval was given also by the QC team.

As a portion of the west abutment foundation includes the SD2 upstream toe, ground and foundation conditions were investigated by air-track drilling and a firm soil suitable foundation was encountered at shallow depths (2 m to 4 m deep). The construction road immediately upstream and parallel to the SD2 till plug tie-in was considered suitably compacted that it was not removed prior to placement of the rockfill shell. During foundation preparation unsuitable materials were hauled to portage pit waste dump.

4.2.2 Base Filter Placement

QA/QC activities for the base filter placement included:

- Visual observation of the base filter material gradation, lift thickness and segregation;

- Overview base filter material placement technique;

- Visual inspection of base filter layers compaction;

- Fine filter and coarse filter placement and compaction approval.

An inverted filter system was placed over the portion of the SD2 till plug tie-in as part of the SWD-SD2 connection construction. The inverted filter system comprises a 0.5 m thick coarse filter layer over a 0.5 m thick fine filter layer which was placed prior to the rockfill shell placement. Base filter placement and compaction was performed as specified with compaction carried out by 10 ton non-vibrating smooth drum roller and track compaction by excavator CAT 345.

No invert filter placement was carried out at the location of the construction road that parallels the upstream face of SD2 and is located immediately upstream on the SD2 till plug tie-in.

4.2.3 Rockfill Shell Placement

QA activities for the rockfill shell placement were limited to the SWD-SD2 connection (i.e. west abutment) and included:

- Visual observation of the rockfill gradation, lift thickness and segregation;

- Overview of the rockfill placement technique;

- Visual inspection of equipment routed to promote compaction;

- Upstream re-sloped rockfill surface approval.

Overall the rockfill appeared well graded with occasional oversize boulders that were moved to the downstream side of the dike. However, tension cracks were observed on the downstream crest edge between about STA. 10+849 to 10+940. These tensions cracks are considered to be the settlement of the rockfill due to the oversteepend downstream slope.

Rockfill placement was largely completed for Stage 2 construction prior to the QA team arrival onsite and was in majority conducted under QC supervision from AEM.

4.2.4 Upstream Toe Excavation

QA/QC activities for the upstream toe excavation included:

- Visual observation during upstream toe excavation including removal of organic soils, soft soils, ice-rich soils, and rockfill;
- Foundation approval of competent subgrade;
- Visual observation of till placement and compaction;
- Till QA samples of *in situ* materials taken to assess particle size distribution and moisture content.

Upstream foundation preparation at the toe of both the west and east abutment included the excavation and removal of organic soils, ice-rich soils and fractured bedrock, which were hauled to the portage pit waste dump. Rockfill from construction during Stage 1 was removed locally on the west abutment.

Foundation approval by the QA team was given after visual inspection and bedrock mapping of the subgrade. Same approval was given also by the QC team.

A thin 50 to 100 mm layer of dry 20 mm crush with 8 percent by mass dry bentonite was placed over the fractured bedrock within the cut-off trench excavation on the east abutment prior to the placement of till. The till was placed and compacted over bedrock surface to provide a smooth liner and low-hydraulic bedding at the upstream toe.

Six QA till samples were collected during tie-in trench till placement with one of the in-situ samples collected frozen and one a class B till (*i.e.* higher moisture content). All samples were tested for both grain size distribution and moisture content. Two samples had hydrometer testing completed. Additionally, water content testing of the fraction passing the #4 mesh were recorded while completing the grain size distribution tests. Part of the results is available in Appendix B.

4.2.5 Liner Bedding Placement

QA/QC activities for the liner bedding placement included:

- Visual observation of the liner bedding material gradation, lift thickness and segregation;
- *In-situ* QA samples taken to assess particle size distribution;
- Overview liner bedding material placement technique;
- Visual inspection of liner bedding compaction;
- Coarse filter and fine filter placement and compaction approval.

QA laboratory results available are presented in Appendix B. Although limited samples were taken, visual QA observations of the placement of coarse and fine filter material for the SWD-SD2 connection indicated, in general, that it was placed in accordance to the specifications. No coarse filter QA was tested during the construction.

QC till samples were collected during filter material placement. Samples were tested for grain size distribution and one moisture content test was completed.

The QA/QC results indicate that gradation of the samples of filter material placed was generally within specification.

4.2.6 Bituminous Geomembrane Liner Installation

The geomembrane installer Layfield was responsible of the QC program during the installation, under the supervision of AEM. Golder was responsible of the QA program.

QA activities for the ES2 bituminous liner installation included:

- Liner bedding surface visual inspection;
- Visual observation of liner deployment technique;
- Visual inspection of seams;
- Oversee QC tensile shear strength and vacuum box tests;
- Selection of bituminous geomembrane liner samples;

- Liner installation approval for liner cover placement.

The liner was generally deployed in a relaxed condition along the slope.

Panel overlap was observed to be 0.25 m between about STA. 10+241 to 10+260, which is less than the minimum 0.30 m overlap specified. Panel seams 1 to 175 and 212 to 232 were checked for sufficient 'buttering', however, due to snow coverage inspection of the panel seams from Panel 175 to the west are still required.

The bituminous geomembrane liner was cleaned by hand held wire brushes and/or bristle brooms immediately prior to welding. Seam welding was completed using a bitumen welder. Liner welds met or exceeded the minimum required specified values. Calibration welds were performed twice daily, at the start of the shift and in the afternoon. If welding was only carried out for half a day, a calibration weld was performed immediately prior to commencing work.

The temperature during deployment and seaming of the ES2 bituminous liner during August and September ranged between 0° and 23° Celsius.

Golder oversaw 54 QC tensile shear strength and thirty QC vacuum box tests. Tensile shear testing was performed in ambient air conditions. There were two tensile shear strength tests carried out on Seam 167/168 that did not meet the specifications (91 and 94 percent) and the specifications only allow for one test to be up to 80 percent of the allowable shear value. As such, it is recommended to patch the seam. No QC ultrasonic tests were performed. In situ seam liner samples were tested at an independent laboratory for tensile shear strength

Part of the QC test results is available in Appendix B.

4.2.7 Liner Cover

QA/QC activities for the liner cover placement included:

- Visual observation of the liner cover material gradation, lift thickness and segregation;

- Overview liner cover material placement technique;

- Visual inspection of liner cover compaction.

As no liner was placed on the west abutment west from about STA. 10+230 no till, or otherwise, liner cover was placed.

4.2.8 Cofferdam

The purpose of the cofferdam is to provide tailings and supernatant pond containment within the TSF until construction is completed at the SWD-SD2 Connection toe and is a temporary structure. The cofferdam was done under the supervision of AEM.

5.0 SADDLE DAM 1 CONSTRUCTION – STAGE 1 (2009)

5.1 Saddle Dam 1 Stage 1 – Construction Activities

Saddle Dam 1 (SD1) construction started in July 2009 with the dewatering of the northwest arm of Second Portage Lake.

The general construction work sequence for Saddle Dam 1 consisted of:

- Dewatering of the northwest arm of Second Portage Lake;
- Foundation investigation for ice rich/ice poor soil determination;
- Foundation preparation;
- Fine filter base;
- Coarse filter base;
- Stage 1 rockfill shell placement for Stage 1 (crest at Elev. 141 m);
- Liner cut-off trench excavation;
- Liner bedding (coarse filter and fine filter) placement and compaction;
- Instrumentation installation (slope);
- Liner system placement to the Stage 1 crest;

- Liner cut-off trench backfill;
- Instrumentation installation (base and crest); and
- Liner cover

Survey was carried out at the start, during and completion of each activity, under the supervision of AEM.

Earthwork construction activities for the SD1 Stage 1 were completed by the contractor FGL and AEM, under the supervision of AEM representatives. Solution Optimum was contracted for the ES3 geomembrane bituminous liner installation. Construction activity details for SD1 Stage 1 are summarized in Table 16 and are described in subsequent sections.

Table 17 presents a summary of the main characteristics for the Stage 1construction of the SD1.

Table 16: Summary of Construction Activities for Saddle Dam 1 – Stage 1

Activity	By	Start Date	Completion Date	Notes
Foundation preparation	AEM	September 4th, 2009	October 18th, 2009	
Foundation investigation for ice rich/ice poor soil determination	AEM Golder	October 1st, 2009	October 7th, 2009	
Fine filter base	AEM	October 9th, 2009	October 20th, 2009	
Coarse filter base	AEM	October 9th, 2009	October 20th, 2009	
Stage 1 Rockfill shell placement	AEM	October 10th, 2009	October 21st, 2009	
Liner tie-in cut-off toe trench excavation	AEM	September 15th, 2009	October 19th, 2009	
Liner bedding (coarse and fine filter) placement	AEM	October 11th, 2009	October 21st, 2009	
Instrumentation installation (along upstream slope)	AEM	October 21st, 2009	October 21st, 2009	
Liner System Placement	Solution	October	November	

Activity	By	Start Date	Completion Date	Notes
	Optimum	24^{th}, 2009	1^{st}, 2009	
Liner cut-off trench backfill	AEM	October 10^{th}, 2009	November 3^{rd}, 2009	
Instrumentation installation (base and crest)	AEM	November 4^{th}, 2009	November 5^{th}, 2009	
Liner cover	AEM	October 28^{th}, 2009	November 9^{th}, 2009	■ Pending raising upstream buttress up to El. 136 m

Table 17: Saddle Dam 1– Stage 1 (2009) As-Built Characteristics

Item	Saddle Dam 1	Unit
Stage 1 Crest elevation	141	m a.s.l.
Rockfill width at crest	25	m
Maximum rockfill base width	Approx. 60	m
Upstream slope	3H : 1V	
Dike Seepage Control	LLDPE	-

5.1.1 Construction Materials and Quantities

The materials used in the construction are described in the specifications. Table 18 summarizes the estimated earthwork quantities for SD1.

Table 18: Summary of SD1 Estimated Earthworks Construction Quantities

Item	As-built Quantity	Unit
Foundation excavation quantity	26,600	m^3
Foundation Surface Preparation	14,400	m^2
Trench Excavation	7,300	
Fine Filter Base	5,900	m^3
Coarse Filter Base	5,300	m^3

Item	As-built Quantity	Unit
Rockfill shell	49,00	m^3
Till toe trench backfill	1,300	m^3
20 mm minus and assume 8% bentonite mix toe trench backfill	5,500	m^3
Geotextile	7,500	m^2
LLDPE Liner	7500	m^2

Notes: Quantities are not as-built

5.1.2 Foundation Preparation and Foundation Investigation for Ice-Rich / Ice-Poor Soils

The foundation preparation was carried out southward from the north abutment following the footprint of Stage 1 of SD1. The foundation conditions were investigated with boreholes along the footprint of SD1. The foundation preparation consisted of the excavation and removal of organics, soft till and ice-rich soils.

Trenches were excavated at the base of SD1 to promote drainage and thawing of the foundations soils prior to constrution. Organic soils and thawing soils were excavated with CAT 385 and/or CAT 345 excavators and hauled to a waste soil area upstream of SD1.

Ice-rich materials were removed by drilling and blasting to a depth of 5 m to 6 m beneath the projection of the geomembrane liner to be installed to the Stage 2 crest (El. 150 m). Confirmation boreholes were drilled in the upstream side of the SD1 footprint to verify the extent of ice-rich soils. Bedrock and ice-poor soils suitable for foundation were encountered at 0.3 m below the bottom of the blasted area. Sampling of blasted frozen ground indicated that ice-rich till comprised the upper 4 m to 5 m from the original ground surface. Samples from the subgrade were obtained and tested for water content; however, these are deemed unreliable due to contamination during debris cleaning after blasting.

The foundation preparation on the north abutment consisted of stripping organics and thawed surficial soils, followed by excavation of any frozen soil and fractured bedrock. The excavation works were performed with a CAT 385 excavator and a CAT 345 excavator cleaned up the foundation surface. A hydraulic hammer was used in selected areas to remove frozen soil and fractured bedrock. The bedrock surface was exposed along the entire upstream toe at the north abutment and was manually cleaned with brushes, shovels and an air compressor.

In the south abutment organics and thawed surficial soils were stripped and blasting to remove ice-rich soils was needed. A CAT 385 excavator was used to excavate blasted material and a CAT 345 excavator cleaned the area to expose the bedrock surface. The bedrock surface was manually cleaned with brushes, shovels and an air compressor.

Work was completed by FGL and AEM, under the supervision of AEM representatives

5.1.3 Base Filter Placement

An inverted two layer base filter system was placed over the upstream portion of the Stage 1 footprint prior to rockfill placement. The inverted filter system comprises a 0.5 m thick coarse filter layer over of a 0.5 m thick fine filter layer.

The fine filter material (20 mm minus) was placed at the base of the excavation sequentially as the foundation surface was approved. The fine filter material was produced by at Other's crusher and hauled by 100 ton trucks. The 20 mm material was placed with a D8 dozer for a thickness of about 0.5 m. The fine filter layer was compacted with a 10 ton vibratory smooth drum roller without moisture condititioning.

The coarse filter material (200 mm minus) was placed over the fine filter layer with a D8 dozer for a thickness of about 0.5 m. The 200 mm minus material was produced at AEM's crusher and hauled by 100 ton trucks. The coarse filter layer was compacted with a 10 ton vibratory smooth drum roller and no water was added.

Work was completed by FGL and AEM, under the supervision of AEM representatives

5.1.4 Initial Rockfill Shell Placement

The rockfill shell was constructed using NPAG rockfill from the Portage Pit. The rockfill shell placement was completed in about 11 days and involved a large quantity of equipment. The rockfill was hauled primarily using 100 ton trucks and placed with a D8 or D9 dozer in 1.5 m thick horizontal lifts to El. 141 m. Compaction of the rockfill material was performed using loaded haul trucks and placement equipment.

Following rockfill placement, CAT 385 and/or CAT 345 excavators re-sloped the upstream side slope to 3H:1V and larger rocks were removed prior to placement of bedding layers.

Work was completed by FGL and AEM, under the supervision of AEM representatives

5.1.5 Upstream Toe Trench Excavation

The upstream toe trench excavation was carried out to a depth of 2 m to 6 m, depending on the depth to bedrock, and removing organics, thawing soils, ice rich materials and fractured bedrock. Ice-rich materials were removed by drilling and blasting to a depth of 5 m to 6 m at the base of the trench. Confirmation boreholes were drilled to verify the extent of ice-rich soils. Bedrock and ice-poor materials suitable for foundation were encountered at 0.3 m below the bottom of the blasted area. Sampling of blasted frozen ground indicated ice rich till comprised the upper 4 m to 5 m from the original ground surface.

On the north abutment organics, thawed surficial soils, frozen soils and fractured bedrock were excavated with a CAT 385 excavator and a CAT 345 excavator cleaned up the foundation surface. A hydraulic hammer was used in selected areas to remove frozen soil and fractured bedrock. The bedrock surface was exposed along the entire upstream toe at the north abutment and was manually cleaned with brushes, shovels and an air compressor.

In the south abutment, ice rich soils were blasted and removed with a CAT 385 excavator and a CAT 345 excavator cleaned the area to expose the bedrock surface. The bedrock surface was manually cleaned with brushes, shovels and an air compressor.

The excavated waste material was hauled to a waste dump upstream of Saddle Dam 1.

Following subgrade approval, till was placed in 0.5 m thick loose lifts with a D8 dozer and compacted by track packing with a D8 dozer or CAT 345 excavator and 2 passes of a 10 ton smooth vibratory drum roller. The till material was sourced from a borrow area near Rockfill Road 2, adjacent to the water in the North Cell of the TSF.

The till layers were placed in the central portion of the dam in multiple lifts and progressing up the abutments where at least one lift was placed. Each lift surface was scarified or tracked with a D8 dozer prior to placement of subsequent lifts. The till plug at the central portion of the dam was raised to 1 m below the original ground surface.

Work was completed by FGL and AEM, under the supervision of AEM representatives

5.1.6 Coarse and Fine Filter Placement

A two layer bedding system was placed by AEM in horizontal lifts, 0.5 m thick, along the rockfill upstream side slope sequentially as the rockfill shell was raised. The bedding layers were initially placed in the central portion of the dam and then towards the abutments.

The coarse filter material (200 mm minus) was placed over the rockfill upstream side slope with a CAT 345 excavator or D8 dozer. The 200 mm minus material was produced by AEM crusher and hauled to the SD1 by 100 ton trucks. The coarse filter layer was compacted with a 10 ton vibratory smooth drum roller without moisture conditioning.

The fine filter material (20 mm minus) was placed on the upstream side slope over the coarse filter layer with a CAT 345 excavator. The 20 mm minus material was obtained from a stockpile near the former contractor location and then it was produced by the contractor's crusher near the north end of Portage Pit. The fine filter material was hauled to the SD1 by 100 ton trucks and dumped on top of the coarse filter material in the slope. The fine filter layer was compacted with a 10 ton vibratory smooth drum roller without moisture conditioning.

Crushed rockfill material (fine and coarse filter) was supplied by AEM and contractors crushers. Crushed rockfill was produced from NPAG rockfill.

Work was completed by FGL and AEM, under the supervision of AEM representatives

5.1.7 Linear Low-Density Polyethylene Liner Installation

The 500 g/m^2 geotextile and 1.5 mm thick double textured LLDPE liner installation was carried out by Optimum Solution southward from the north abutment. The LLDPE liner rolls were stored in site in a lay down area near Stormwater Dike and moved to the SD1 crest prior installation in October 23rd, 2009. Full intact liner rolls were used and damaged areas from transportation, loading and unloading were discarded. Liner installation began on October 24th and finished on November 1st, 2009. During this period the temperature ranged between -18° and -25° Celsius.

The liner bedding surface was manually cleaned by hand shovel, air compressor and snow blower prior to liner deployment. A thin layer of fine filter material mixed with bentonite powder (approx. 8% by mass) was spread along the toe trench till surface and roller compacted.

Panels of geotextile were deployed and fused together in advance of the deployment of LLDPE liner. The geotextile was extended 2 m from the toe of the slope and ballasted.

The deployment of the liner was carried out with a CAT 345 excavator with a modified spreader bar to support the roll in the air over the crest and a combination of an ATV and manual support on the edges pulled the liner down the slope to the liner tie-in trench. A rub sheet was placed between the liner and geotextile and was progressively moved along the slope.

Seaming using a double track fusion welder was performed as panels were deployed. The LLDPE liner was cleaned by hand held wire brushes, bristle brooms and/or air compressor immediately prior to welding. The fusion welder was set up to operate at a temperature of 850°F. Trial welds were performed twice daily. The liner extended approximately 4 m out along the dam crest and 6 m from the toe of the slope. Sequential panel numbers were written on the liner using spray paint. Ballasting material was placed at the end of each shift. Vacuum box, air channel and tensile shear strength testing of the extrusion welds were completed. Where needed, patches were carried out by tack welding a piece of liner to the panel and extrusion welding around the patches.

Work was completed by Solution Optimum, under the supervision of AEM representatives.

5.1.8 Upstream Toe Trench Backfill

The liner at the tie-in trench was covered with a 1 m thick layer of fine filter material mixed with bentonite powder (approx. 8% by mass) using a CAT 345 excavator. The mix was placed in two 0.5 m thick layers from the toe of the slope to 8 m upstream and compacted with 4 passes of a 10 ton smooth roller without vibration. A loader was used to provide the mix material to the excavator in the upstream toe trench.

The work was generally performed during nightshift to avoid bentonite dust blowing while installing the liner.

The fine filter bentonite mix was covered with a 1 m thick layer of 200 mm minus material. The 200 mm minus material was packed with the bucket of the excavator. Fine rockfill material was placed on the upstream side of the trench backfill.

Work was completed by FGL and AEM, under the supervision of AEM representatives

5.1.9 Instrumentation installation

A total of 5 thermistors were installed on Saddle Dam 1. Four thermistors are functional. Locations are indicated in the as-built drawings available in Appendix C.

5.1.10 Liner Cover

The LLDPE liner on the slope was covered with a 0.3 m thick layer of fine filter material. The fine filter material was placed on the slope using a CAT 385 excavator with a long stick and then spread over the liner. The excavator at the base of the dam placed the liner cover from the toe of the slope to mid-slope and then to 1 m below the crest of the dam from a windrow berm of 20 mm minus material placed along the crest of the dam to provide a liner anchor and level the work surface for the excavator. A buttress berm between the upstream toe plug cover and the liner cover to provide additional confinement to the liner at the toe of the slope was completed.

5.1.11 Stage 2 Construction Progress

An attempt to prepare the 2010 footprint at the south abutment was undertaken; however, the active layer was frozen to the permafrost layer. Foundation preparation of the Stage 2 footprint was postponed to 2010 summer construction season.

5.2 Saddle Dam 1 Stage 1 – QA/QC activities

The QC program was managed and directed by AEM. QC testing was completed under the supervision of AEM. AEM supervised and monitored the construction activities.

A summary of Saddle Dam 1 - Stage 1 QA testing and monitoring is presented in Table 19.

Table 19: Summary of SD1 Construction QA Testing and Monitoring – Stage 1

Construction Item	Work Description	Minimum QA Testing Requirement and Frequency	QA Tests Performed
General	Care of water	Visual observation	Continuous
	Borrow material Storage	Visual observation	Continuous
Foundation	Location and extents	Survey review	Continuous and

Construction Item	Work Description	Minimum QA Testing Requirement and Frequency	QA Tests Performed
preparation			As Built following construction
	Subgrade inspection	Visual observation	Continuous
	Water content	1 in every 5 QC	53
Rockfill shell placement	Gradation	Visual observation	Continuous
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Coarse Filter	Gradation (stockpile and as placed)	1 in every 5 QC	2
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Fine Filter	Gradation (stockpile and as placed)	1 in every 5 QC	9
	Water content	1 in every 5 QC	0
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Trench backfill	Placement technique	Visual observation	Continuous
Geotextile	Seams and panels	Visual observation	Continuous
LLDPE geomembrane Liner	Liner sampling	Visual inspection	As Requested
	Liner rolls	Visual inspection	Each roll
	Seams	Visual inspection	Continuous
	Tensile shear strength of seams	Oversee 1 every 5 QC tests	14 10 (3rd Party shear and peel test of seams)
	Start-up and test seams	Oversee 1 every 5 QC	
	Vacuum box test	Oversee all QC tests	
	Air channel test	Oversee all QC tests	5
Liner cover	Gradation (stockpile and as placed)	1 in every 5 QC	1
	Compaction	Visual observation	Continuous
Instrumentation	Installation	Visual observation	

5.2.1 Foundation Preparation

QA/QC activities for the foundation preparation and foundation investigation included:

- Visual observation during foundation excavation, including removal of organic soils, thawing soils and ice rich soils;

- Visual observation during drilling, blasting and removal of ice-rich soils;

- *In situ* QA samples taken to assess ice content;

- Visual observation of waste material removal and disposal; and

- Foundation approval of competent subgrade.

Fifty-three QA samples were collected during foundation preparation within the upstream side footprint of Stage 1 and tested for ice and water contents of the foundation soils. Sampling of blasted frozen ground indicated that ice-rich till comprised the upper 4 m to 5 m from the original ground surface. Testing results from the samples from the subgrade were deemed unreliable due to contamination during debris cleaning after blasting.

Foundation approval by the QA team was given after visual inspection of the subgrade. Same approval was given also by the QC team.

5.2.2 Base Filter Placement

QA/QC activities for the base filter placement included:

- Visual observation of the base filter material gradation, lift thickness and segregation;

- Overview base filter material placement technique;

- Visual inspection of base filter layers compaction;

- Fine filter and coarse filter placement and compaction approval.

An inverted two layer base filter system was placed beneath the Stage 2 geomembrane liner projection prior to rockfill placement. The inverted filter system comprises a 0.5 m thick coarse filter layer over of a 0.5 m thick fine filter layer. Base filter placement and compaction was performed as specified. No in place QA base filter samples were tested during the construction program.

5.2.3 Initial Rockfill Shell Placement

QA/QC activities for the rockfill shell placement included:

- Visual observation of the rockfill gradation, lift thickness and segregation;
- Overview rockfill placement technique;
- Visual inspection of routed equipment to promote compaction;
- Upstream re-sloped rockfill surface approval.

The placement and compaction of the rockfill was observed and deemed to be satisfactory. Oversized material was removed from the upstream portion of the structure and placed in the downstream shell area.

5.2.4 Upstream Toe Trench Excavation

QA/QC activities for the upstream toe trench excavation included:

- Visual observation during foundation excavation, including removal of organic soils, thawing soils, ice rich soils and fractured bedrock;
- Foundation approval of competent subgrade;
- Visual observation of till placement and compaction;
- *In situ* till QA samples taken to assess particle size distribution and moisture content.

The excavation of the upstream toe trench was performed satisfactorily based on the observations made by the QA and QC team.

Four QA grain size distribution tests, two QA hydrometer tests and two QA water content tests were completed during the 2009 SD1 construction. Additionally, water content of the fraction passing the #4 mesh were recorded while completing the grain size distribution tests. Part of the laboratory results for till sample is presented in Appendix B.

5.2.5 Coarse and Fine Filter Placement

QA/QC activities for the liner bedding placement included:

- Visual observation of the liner bedding material gradation, lift thickness and segregation;
- *In situ* QA samples taken to assess particle size distribution;
- Overview liner bedding material placement technique;
- Visual inspection of liner bedding compaction;
- Coarse filter and fine filter placement and compaction approval.

The fine filter material was obtained from a stockpile near the former contractor location and then it was produced by the contractor’s crusher near the north end of Portage Pit. The grain size distribution tests showed that both sources satisfied the requirements of the specifications.

Two coarse filter and nine fine filter QA grain size distribution tests were completed during the 2009 SD1 construction. 1 every 5 QC gradation tests were required to satisfy the specifications. Part of the laboratory results for grain size distribution for sample are presented in Appendix B. The results indicate that gradation of the samples of coarse and fine filter materials placed were within the specification.

5.2.6 Linear Low-Density Polyethylene Liner Installation

The geomembrane installer Solution Optimum was responsible of the QC program during the installation, under the supervision of AEM. Golder was responsible of the QA program.

QA activities for the geotextile and LLDPE liner installation included:

- Liner bedding surface inspection;

- Visual observation of geotextile deployment and welding;
- Visual observation of liner deployment technique;
- Visual inspection of seams;
- Oversee QC tensile shear strength, vacuum box and air channel tests;
- Selection of in place LLDPE liner samples;
- Liner installation approval for liner cover placement;

The liner bedding surface was satisfactorily cleaned prior to geotextile and liner deployment. QA visually inspected all seams and all identified defects were repaired appropriately.

Panel 14 was blown down during deployment creating folds in the liner but no holes were identified. Solution Optimum placed beads of extrusion welding over scratches but no patching was performed. The full panel was used.

The LLDPE liner was satisfactorily cleaned prior to welding with a double track fusion welder however cleaning near the toe where bentonite powder was spread was not adequate. Liner welds met or exceeded the minimum required specified values. The speed, temperature, welding machine and date were not always recorded adjacent to each seam. Calibration welds were performed twice daily, at the start of the shift and in the afternoon.

Where needed, patches were carried out by tack welding a piece of liner to the panel and extrusion welding around the patches. Grinding was not always performed perpendicular to the seams.

QA oversaw 14 QC tensile shear strength and five QC air channel tests. QA reported the length of testing of air channel tests was observed to not always meet the requirements of the specifications. The seal for vacuum box testing was not always held for the specified length of time.

Ten *in situ* seam liner samples were tested at an independent laboratory for shear and peel test. The tested samples complied with the specifications.

QC test results available are presented in Appendix B.

5.2.7 Upstream Toe Trench Backfill

QA/QC activities for the upstream toe trench backfill included:

- Visual observation of the fine filter bentonite powder mix gradation, lift thickness and segregation;
- *In situ* QA samples taken to assess particle size distribution;
- Overview placement technique;
- Visual inspection of backfill compaction.

The work was generally performed during nightshift to avoid bentonite dust blowing while installing the liner. Golder observations were limited to dayshift.

A 50 ton truck hauling fine filter and bentonite powder mix was observed trafficking over the 1 m thick layer of fine filter and bentonite powder mix. No investigation was carried out to assess potential damage to the liner.

Four fine filter and bentonite powder mix QA grain size distribution tests were completed during the 2009 SD1 construction. The moisture content of the fraction under #4 mesh were recorded while completing the grain size distribution tests. Additionally, one standard Proctor and one permeability test were carried out on a combined sample. The permeability test was carried out at 95% of the standard Proctor maximum dry density.

QA testing by Golder for Saddle Dam 1 fine filter bentonite powder mix grain size distribution are presented in Appendix B.

5.2.8 Instrumentation Installation

AEM supervised every instrumentation installation for SD1 – Stage 1. As-built location and installation elevation were recorded by AEM and are presented in the as-built drawing in Appendix C.

5.2.9 Liner Cover

QA activities for the liner cover placement included:

- Visual observation of the liner cover material gradation, lift thickness and segregation;
- *In situ* QA samples taken to assess particle size distribution;
- Overview of liner cover material placement technique;

The LLDPE liner on the slope was covered with a 0.3 m to 0.6 m thick layer of fine filter material. The liner cover thickness was generally adequate.

Golder observed excavator tracks extending beyond the toe trench over the north extremity of the liner at the north abutment. An investigation of the liner in the area showed no damage.

A buttress berm between the upstream toe plug cover and the liner cover to provide additional confinement to the liner at the toe of the slope was completed.

One liner cover QA grain size distribution test was completed during the SD1 Stage 1 construction. Additionally, moisture content of the fraction under #4 mesh were recorded while completing the grain size distribution tests. Part of the laboratory result is presented in Appendix B.

6.0 SADDLE DAM 1 CONSTRUCTION – STAGE 2 (2010)

6.1 Saddle Dam 1 Stage 2 – Construction Activities

Saddle Dam 1 Stage 2 construction started in July of 2010.

The general Stage 2 construction work sequence for Saddle Dam 1 consisted of:

- Foundation preparation (north and south abutments);
- Fine filter base;
- Coarse filter base;

- Stage 2 rockfill shell placement (raise crest to El. 150 m);
- Liner bedding (coarse filter and fine filter) placement and compaction;
- Liner system placement to the Stage 2 crest El. 150 m;
- Liner cut-off trench backfill and tie-in with 2009 liner; and
- Liner cover (north and south abutments).
- Survey was carried out at the start, during and completion of each activity, under the supervision of AEM.

Earthwork construction activities for the SD1 Stage 2 were completed by the contractor FGL and AEM, under the supervision of AEM representatives. Layfield was contracted for the LLDPE liner installation. Construction activity details for SD1 Stage 2 are summarized in Table 20 and are described in subsequent sections.

Table 21 presents a summary of the main characteristics for the Stage 2construction of the SD1.

Table 20: Summary of Construction Activities for Saddle Dam 1-Stage 2

Activity	By	Start Date	Completion Date	Notes
Foundation preparation	AEM	Prior to August 6th, 2010	Mid-August 2010	• North and south abutments. Includes the use of fine filter mixed with bentonite used to cover discontinuities
Fine filter base	AEM	August 27th, 2010	September 5th, 2010	• North and south abutments
Coarse filter base	AEM	August 28th, 2010	September 5th, 2010	• North and south abutments
Stage 2 Rockfill shell placement	AEM	August 27th, 2010	September 17th, 2010	
Liner tie-in cut-off toe	AEM	Prior to	September	• North and south

Activity	By	Start Date	Completion Date	Notes
trench excavation		August 6th, 2010	27th, 2010	abutments completed Sept 27th, 2010 • No cover required between abutments as tie-in with 2009 liner
Liner bedding (coarse and fine filter) placement	AEM	September 6th, 2010	October 1st, 2010	• Completed north and south abutments Sept 17th, 2010 • Completed portion between north and south abutments Oct 1st, 2010
Liner System Placement	Layfield Group	September 20th, 2010	November 8th, 2010	• Completed north and south abutments Sept 22nd, 2010 • Central portion between north and south abutments completed Nov 8th, 2010
Liner cut-off trench backfill and tie-in with 2009 liner	AEM	September 6th, 2010	November 6th, 2010	• North and south abutments completed Sept 27th, 2010 • Tie-in with 2009 liner completed Nov 6th, 2010
Instrumentation Installation	AEM	Mid-October, 2010	End-October, 2010	
Liner Cover	AEM	September 24th, 2010	October, 2010	

Table 21 :Saddle Dam 1– Stage 2 (2010) As-Built Characteristics

Item	Saddle Dam 1	Unit
Stage 1 Crest elevation	150	m a.s.l.
Rockfill width at crest	15 (min)	m
Crest length	400	m
Maximum rockfill base width	Approx. 200	m
Upstream slope		3H : 1V
Dike Seepage Control	LLDPE	-

6.1.1 Construction Materials and Quantities

The materials used in the construction are described in the specifications. Table 22 summarizes the earthwork quantities for SD1 during Stage 2 construction.

Table 22: Summary of SD1 Estimated Earthworks Construction Quantities

Item	As-built Quantity	Unit
Foundation excavation quantity	3,100	m3
Foundation Surface Preparation	10,300	m2
Fine Filter Base	9,500	m3
Coarse Filter Base	8,800	m3
Rockfill shell	85,500	m3
Upstream toe trench excavation	2,500	m3
Till toe trench backfill	1100	m3
20 mm minus and assume 8% bentonite mix toe trench backfill	1,200	m3
Geotextile	11,000	m2
LLDPE Liner	11,000	m2

Notes : Quantities are not as-built.

6.1.2 Foundation Preparation Stage 2 Construction

Foundation preparation for Stage 2 was carried out on both the north and south abutments of SD1 between about El. 141 to 150 m following the footprint of Stage 2 for SD1. The foundation preparation consisted of the excavation and removal of organics, thawed surficial soils, frozen and ice-rich soils and fractured bedrock. Organic and thawing soils were excavated with a CAT 385 and/or CAT 345 excavators and hauled to a waste soil area upstream of SD1. No blasting was carried out during foundation preparations during 2010 construction works. The bedrock surface was exposed along the entire upstream and downstream footprints of the north and south abutments between about STA. 0+025 to 0+100 and STA. 0+345 to 0+461, respectively and was manually cleaned with brushes, shovels and an air compressor. The bedrock was considered suitable for foundation support of both the north and south abutments.

Work was completed by FGL and AEM, under the supervision of AEM representatives

6.1.3 Base Filter Placement

An inverted two layer base filter system was placed over the upstream portion between STA. 0+025 to 0+100 and STA. 0+320 to 0+460 of the north and south abutments, respectively of the Stage 2 footprint prior to rockfill placement. The inverted filter system consists of a 0.5 m thick coarse filter layer overlying a 0.5 m thick fine filter layer. Prior to placement of the initial lift of the inverted filter, crush (19 mm) mixed with dry bentonite was placed over larger bedrock aperture fractures and uneven surfaces. It was placed locally by excavator bucket and hand shovel and then surveyed by AEM.

The fine filter material (20 mm minus) was placed at the base of the excavation sequentially as the foundation surface was approved. The fine filter material hauled by 100 ton trucks. The 20 mm material was placed with a D9 dozer for a thickness of about 0.5 m. The fine filter layer was compacted with a 10 ton vibratory smooth drum roller without moisture conditioning.

The coarse filter material (200 mm minus) was placed over the fine filter layer with a D8 or D9 dozer for a thickness of about 0.5 m. The 200 mm minus material was produced at AEM's crusher and hauled by 100 ton trucks. The coarse filter layer was compacted, with no moisture conditioning, with a 10 ton vibratory smooth drum roller.

Crushed rockfill materials (coarse filter and fine filter) were supplied by AEM and contractor's crushers. Crushed rockfill material was produced from NPAG rockfill.

Work was completed by FGL and AEM, under the supervision of AEM representatives

6.1.4 Initial Rockfill Shell Placement

The rockfill shell was constructed using NPAG rockfill from the Portage Pit. The rockfill shell placement occurred in several phases, but was completed in about 30 days and involved a large quantity of equipment. The rockfill was hauled primarily using 100 and 150 ton trucks and placed with a D8 or D9 dozer in 1.5 m to 2 m thick horizontal lifts to El. 150 m. Placement of material and subsequent compaction of the rockfill material was performed to promote compaction using loaded haul trucks and placement equipment.

Following rockfill placement, CAT 385 and/or CAT 345 excavators re-sloped the upstream side slope to 3H:1V and larger rocks were removed prior to placement of bedding layers.

Work was completed by FGL and AEM, under the supervision of AEM representatives

6.1.5 Upstream Toe Trench Excavation

The upstream toe trench excavation on the north and south abutments between about El. 141 and 150 m was carried out to a depth of approximately 2 m to 3 m below the existing ground surface, depending on the depth to bedrock. Organics, thawing surficial soils, ice-rich and frozen materials and fractured bedrock were removed with an excavator and the foundation surface manually cleaned with shovels, bristle broom, rakes, water, and air-compressor. The bedrock surface was exposed along the entire upstream toe at the north and south abutments.

Following subgrade approval, a 25 mm to 50 mm thick layer of fine filter crush (19 mm) material mixed with bentonite powder (approx. 8% by mass) was spread where larger apertures and discontinuities occurred in the bedrock and the bedrock surface was uneven. Till was placed in 0.5 m thick loose lifts with a D8 or D9 dozer and compacted by track packing with a either dozer or CAT 345 excavator and two to three passes of a 10 ton smooth non-vibratory drum roller.

The till layers were placed in multiple lifts on either abutment commencing at around El. 150 m and progressing towards the existing liner cap placed during Stage 1 (2009) construction at STA. 0+100 and STA. 0+320 for the north and south abutments, respectively. Each lift surface was scarified or tracked with the dozer prior to placement of subsequent lifts.

Work was completed by FGL and AEM, under the supervision of AEM representatives

6.1.6 Coarse and Fine Filter Placement

A two layer bedding system was placed in horizontal lifts, 0.5 m thick, along the rockfill upstream side slope sequentially as the rockfill shell was raised. The bedding layers were placed starting at both of the furthest extents of the north and south abutments of the dam and then towards the centre.

The coarse filter material (200 mm minus) was placed over the rockfill upstream side slope with a CAT 345/350 excavator. The 200 mm minus material was produced by AEM crusher and hauled to the SD1 by 100 ton trucks. The coarse filter layer was compacted with a 10 ton vibratory smooth drum roller without moisture conditioning.

The fine filter material (20 mm minus) was placed on the upstream side slope over the coarse filter layer with a CAT 345/350 excavator. The 20 mm minus material was obtained from a stockpile near the former contractor location and then it was produced by the contractor’s crusher near the north end of Portage Pit. The fine filter material was hauled to SD1 by 100 ton trucks and dumped at the crest on top of the coarse filter material onto the slope. A CAT 345/350 excavator bucket moved material downslope prior to compaction. The fine filter layer was compacted with a 10 ton vibratory smooth drum roller with a minimum of three (3) passes and without moisture conditioning.

Crushed rockfill materials (coarse filter and fine filter) were supplied by AEM and contractor’s crushers. Crushed rockfill material was produced from NPAG rockfill.

Work was completed by FGL and AEM, under the supervision of AEM representatives

6.1.7 Linear Low-Density Polyethylene Liner Installation

The 500 g/m^2 geotextile and 1.5 mm thick double textured LLDPE liner installation was carried out by Layfield in two phases. The initial phase of liner deployment commenced from the north and south abutments and progressed towards the centre to about STA. 0+100 and 0+320, respectively. The second phase of liner deployment continued after the coarse and fine filter placement was completed on the upstream dam face between the above mentioned stations and then commenced at STA. 0+320 and progressed northwards towards STA. 0+100. The LLDPE liner rolls were stored on site near the north end of SD1 and/or immediately west of downstream face of SD2 and moved to the SD1 crest prior installation. Full intact liner rolls were used and damaged areas from transportation, loading and unloading were discarded. Liner installation began on September 1st, 2010 and finished on November 8th, 2010. During this period the temperature ranged between 10° and -20° Celsius.

The liner bedding surface was manually cleaned by hand and snow shovels, and bristle broom, prior to liner deployment. Between about STA. 0+100 and 0+320 latitudinal ridges formed in the fine filter during compaction of the upstream face. As the fine filter material was frozen during liner deployment panels (double if necessary) of geotextile were deployed in advance of the LLDPE liner to protect the LLDPE geomembrane. Adjacent panels of geotextile were fused together and the geotextile was extended about 1 to 2 m from the toe of the slope and ballasted where it did not tie-in with the 2009 liner. Where the 2009 liner existed the geotextile was cut short and the LLDPE geomembrane overlapped the 2009 liner by at least 1 m.

The deployment of the liner was carried out with a CAT 345 excavator with a modified spreader bar to support the roll in the air over or slightly behind the crest and manual support on the edges to allow the liner to be pulled down the slope to the liner tie-in trench or overlap with the 2009 liner. Seaming using a double track fusion welder was performed as panels were deployed. The LLDPE liner was cleaned by hand held dry rags and/or bristle brooms immediately prior to welding. The fusion welder was set up to operate at a temperature of 850°F or 400ºC and at a speed of 5 ft/min (1.5 m/min). Trial welds were performed twice daily when welding was carried out all day, otherwise, only once prior to the commencement of welding. The liner extended approximately 4 m out along the dam crest and where it was not tied into the 2009 liner. Sequential panel numbers were not written on the liner as per the specifications.

Ballasting material was placed at the dam crest over the liner and if necessary along the panel edges as the work was completed or at the end of each shift.

Vacuum box, air channel and tensile shear strength testing of the extrusion welds were completed. Where needed, patches were carried out by tack welding a piece of liner to the panel and extrusion welding around the patches, which was followed by vacuum box testing.

Work was completed by Layfield, under the supervision of AEM representatives

6.1.8 Upstream Toe Trench Backfill

The liner at the tie-in trench was covered with till materials using a CAT 345D excavator with material transported to the site by 50 and 100 ton trucks. Till was placed in 0.3 to 0.9 m thick loose layers from the toe of the slope on the north and south abutments to 8 m upstream and compacted initially with the bucket of the excavator, which was subsequently followed with four passes of a 10 ton smooth drum roller without vibration.

Work was completed by FGL and AEM, under the supervision of AEM representatives

6.1.9 Instrumentation Installation

AEM supervised every instrumentation installation for SD1 – Stage 1. As-built location and installation elevation were recorded by AEM and are presented in the as-built drawing in Appendix C.

6.1.10 Liner Cover

Till materials were placed with a CAT 345 over the liner in subsequent loose lifts of 0.3 to 0.5 m thick and compacted with the bucket of the excavator. Work was completed by FGL and AEM, under the supervision of AEM representatives

6.2 Saddle dam 1 Stage 2 – QA/QC activities

The QC program was managed and directed by AEM. QC testing was completed under the supervision of AEM. AEM supervised and monitored the construction activities.

A summary of Saddle Dam 1 QA testing and monitoring is presented in Table 23.

Table 23: Summary of SD1 Construction QA Testing and Monitoring

Construction Item	Work Description	Minimum QA Testing Requirement and Frequency	QA Tests Performed
General	Care of water	Visual observation	Continuous
	Borrow material Storage	Visual observation	Continuous
Foundation preparation	Location and extents	Survey review	Continuous and As Built following construction
	Subgrade inspection	Visual observation	Continuous
	Water content	1 in every 5 QC	0
Rockfill shell placement	Gradation	Visual observation	Continuous
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Coarse Filter	Gradation (stockpile and as placed)	1 in every 5 QC	2
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Fine Filter	Gradation (stockpile and as placed)	1 in every 5 QC	5
	Water content	1 in every 5 QC	5
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Trench backfill	Placement technique	Visual observation	Continuous
Geotextile	Seams and panels	Visual observation	Continuous
LLDPE geomembrane Liner	Liner sampling	Visual inspection	As Requested
	Liner rolls	Visual inspection	Each roll
	Seams	Visual inspection	Continuous
	Tensile shear strength of seams	Oversee 1 every 5 QC tests	30 (3rd Party shear and peel test of seams)
	Start-up and test seams	Oversee 1 every 5 QC	
	Vacuum box test	Oversee all QC tests	Periodic
	Air channel test	Oversee all QC tests	Periodic
Liner Cover	Gradation (stockpile and as placed)	1 in every 5 QC	0
	Compaction	Visual observation	Continuous

6.2.1 Foundation Preparation

QA/QC activities for the foundation preparation included:

- Visual observation following foundation excavation, including removal of organic soils, thawing soils and ice rich soils;
- Visual observation of waste material removal and disposal; and
- Foundation approval of competent subgrade.

QA activities began on August 6th, 2010 at SD1. Prior to the commencement of QA activities at this structure excavation/stripping of the overburden on both the north and south abutments between approximately El. 141 m and 150 m had largely been completed.

Foundation approval by the QA team was given after visual inspection of the clean bedrock subgrade on the upstream side of the dam crest. Same approval was also given by the QC team.

6.2.2 Base Filter Placement

QA/QC activities for the base filter placement included:

- Visual observation of the base filter material gradation, lift thickness and segregation;
- Overview base filter material placement technique;
- Visual inspection of base filter layers compaction; and
- Fine filter and coarse filter placement and compaction approval.

The inverted filter system comprises a 0.5 m thick coarse filter layer over of a 0.5 m thick fine filter layer. Base filter placement and compaction was performed as specified.

6.2.3 Initial Rockfill Shell Placement

QA/QC activities for the rockfill shell placement included:

- Visual observation of the rockfill gradation, lift thickness and segregation;
- Overview rockfill placement technique;
- Visual inspection of routed equipment to promote compaction; and
- Upstream re-sloped rockfill surface approval.

The placement and compaction of the rockfill was observed and deemed to be satisfactory. Oversized material was removed from the upstream portion of the structure and placed in the downstream shell area.

6.2.4 Upstream Toe Trench Excavation

QA/QC activities for the toe trench excavation included:

- Visual observation following foundation excavation, which included removal of organic soils, thawing soils, ice rich soils and fractured bedrock; and
- Foundation approval of competent subgrade.

The upstream toe trench excavation was largely completed when QA activities commenced at SD1 on August 6th, 2010. The excavation of the upstream toe trench was performed satisfactorily based on the observations made by QA.

6.2.5 Coarse and Fine Filter Placement

QA/QC activities for the liner bedding placement included:

- Visual observation of the liner bedding material gradation, lift thickness and segregation;
- *In situ* QA samples taken to assess particle size distribution;
- Overview liner bedding material placement technique;
- Visual inspection of liner bedding compaction; and

- Coarse filter and fine filter placement and compaction approval.

The fine and coarse filter material was obtained from a stockpile near the former contractor location and then it was produced by the AEM and contractor's crusher near the north end of Portage Pit. The grain size distribution tests showed that both sources satisfied the requirements of the specifications.

Two coarse filter and five fine filter QA grain size distribution tests were completed during the 2010 SD1 construction. 1 in every 5 QC gradation tests were required to satisfy the specifications.

QA testing by for coarse and fine filter grain size distribution including envelope limits as specified in the technical specifications are summarized and presented in Appendix B. Laboratory results for grain size distribution for each sample are also presented. The results show that gradation of the samples of coarse filters satisfied the specifications for one of the two samples tested. The results indicate that, in general, the fine filter material placed was within the gradation specifications.

6.2.6 Linear Low-Density Polyethylene Liner Installation

The geomembrane installer Layfield was responsible of the QC program during the installation, under the supervision of AEM. Golder was responsible of the QA program.

QA activities for the geotextile and LLDPE liner installation included:

- Liner bedding surface inspection;
- Visual observation of geotextile deployment and welding;
- Visual observation of liner deployment technique;
- Visual inspection of seams;
- Oversee majority of QC tensile shear strength, vacuum box and air channel tests;
- Selection of in place LLDPE liner samples; and

- Liner installation approval for liner cover with till.

The liner bedding surface was satisfactorily cleaned prior to geotextile and liner deployment between STA. 0+025 to 0+100 and 0+320 to 0+460; however, between STA. 0+100 and 0+460 the liner bedding surface had latitudinal ridges of frozen fine filter material. Although cleaning was carried out and removal of the ridges attempted, it was required to deploy additional geotextile in advance of the liner deployment. Golder visually inspected all seams and all identified defects were repaired appropriately.

Moderate winds were present during deployment of some of the panels between Panels 34 to 65 and Panels 17 to 19 that resulted in wrinkles. In particular, wrinkles adjacent to the 2009 liner tie-in were observed. Strong winds were present upon completion of all panels installed which caused uplift of the liner some 1 m to 2 m off of the liner bedding surface, which caused shifting of wrinkles and tension at both the crest and toe of the liner. Layfield placed beads of extrusion welding over scratches but no patching was performed or necessary. No visible damage or holes were identified; however, an additional inspection is recommended in 2011 as the liner was partially covered in snow. The LLDPE liner was satisfactorily cleaned prior to welding with a double track fusion welder. Liner welds met or exceeded the minimum required specified values. The speed, temperature, welding machine and date were always recorded adjacent to each seam. Calibration welds were performed twice daily when welding occurred all day (*i.e.*, at the start of the shift and in the afternoon) or once immediately prior to commencing seam welding.

Where needed, patches were carried out by tack welding a piece of liner to the panel and extrusion welding around the patches. Golder oversaw 30 QC tensile shear strength tests. No record of the number of QC vacuum box or air channel tests and start-up and test seams observed by Golder was maintained; however, the length of testing of air channel tests was observed to not always meet the requirements of the specifications and retesting was requested. Furthermore, air testing failed between Panel 34 and the 2009 liner at about El. 141 m which was subsequently covered by stockpile till. The seal for vacuum box testing was not always held for the specified length of time.

Part of the QC test results is available in Appendix B.

6.2.7 Upstream Toe Trench Backfill

QA/QC activities for the upstream toe trench backfill above the liner included:

- Visual observation of the till material, lift thickness and segregation;
- *In situ* and stockpile QA samples taken to assess particle size distribution;
- Overview placement technique; and
- Visual inspection of backfill compaction.

Four till QA grain size distribution tests were completed during 2010 by Golder for Saddle Dam 1 and the available results are summarized and presented in Appendix B with laboratory results. Natural moisture content determination was carried out on the fraction that passed the #4 mesh while completing the grain size distribution tests.

6.2.8 Instrumentation Installation

AEM supervised every instrumentation installation for SD1 – Stage 1. As-built location and installation elevation were recorded by AEM.

6.2.9 Liner Cover

QA/QC activities for the liner cover placement included:

- Visual observation of the liner cover material lift thickness; and
- Overview of liner cover material placement technique;

No QA samples were taken of the liner cover. 1 in every 5 QC samples was required.

7.0 SADDLE DAM 2 CONSTRUCTION –STAGE 1 (2010)

7.1 Saddle Dam 2 Stage 1- Construction Activities

Stage 1 Saddle Dam 2 (SD2) construction started in July 2010 it was fully completed to El. 146 m and only partially completed between El. 146 m to 150 m. Remaining works (Stage 2) include completion of the bedding surface, liner deployment and subsequent testing, and instrumentation installation.

The general construction work sequence for Saddle Dam 2 consisted of:

- Foundation investigation for ice-rich/ice-poor soil determination;
- Foundation preparation;
- Fine filter base;
- Coarse filter base;
- Rockfill shell placement;
- Liner cut-off trench excavation;
- Liner bedding (coarse filter and fine filter) placement and compaction;
- Liner system placement;
- Liner cut-off trench backfill;
- Liner cover;
- Instrumentation installation (slope); and
- Instrumentation installation (base and crest).

Earthwork construction activities for the SD2 Stage 1 were completed by the contractor FGL and AEM, under the supervision of AEM representatives. Layfield was contracted for the LLDPE liner installation. Construction activity details for SD1 Stage 2 are summarized in Table 24 and are described in subsequent sections.

Table 25 presents a summary of the main characteristics for the Stage 1 construction of the SD2.

Table 24: Summary of Construction Activities for Saddle Dam 2

Activity	By	Start Date	Completion Date	Notes
Foundation preparation	AEM	Prior to July 28th, 2010	Mid-September	• Golder Team arrived on-site July 21st, 2010
Foundation investigation for ice-rich/ice-poor soil determination	AEM Golder	August 1st, 2010	August 4th, 2010	• Air-track drilling
Fine filter base	AEM	September 1st, 2010	Mid-September	
Coarse filter base	AEM	September 2nd, 2010	Mid-September	
Rockfill shell placement	AEM	September 1st, 2010	October 27th, 2010	• Completed to El. 150 m
Liner tie-in cut-off toe trench excavation	AEM	Prior to July 28th, 2010		
Liner bedding (coarse and fine filter) placement	AEM	September 13th, 2010	October 20th, 2010	• Completed along the upstream of the dam face to El. 146 m • Completed along the upstream of the dam face between STA. 20+570 to 20+395 from El. 146 to 150 m • Completion still required from STA. 20+395 (El. 146 to 150

Activity	By	Start Date	Completion Date	Notes
				m) to northwest abutment. 2011
Liner System Placement	Layfield Group	September 23rd, 2010	October 25th, 2010	• Completion along upstream of dam face to El. 146 m on Oct 5th, 2010 • Completion along upstream of dam face between STA. 20+490 to 20+570 to El. 150 m on Oct 25th , 2010 • Completion still required from STA. 20+490 (El. 146 to 150 m) to northwest abutment. 2011
Liner cut-off trench backfill	AEM	September 13th, 2010	October 6th, 2010	• Completion of till plug
Liner cover	AEM	October 7th , 2010	October 24th, 2010	• Completion of geotextile deployment over LLDPE liner to El. 145 m on Oct 7th, 2010 • Surcharge lift completed to El. 145 m on Oct 22nd, 2010 • Bituminous geomebrane over LLDPE between STA. 20+490 to 20+570 on Oct

Activity	By	Start Date	Completion Date	Notes
				24th, 2010

Table 25: Saddle Dam 2– Stage 1 (2010) As-Built Characteristics

Item	Saddle Dam 2	Unit
Stage 1 Crest elevation	150	m a.s.l.
Rockfill width at crest	15 min.	M
Crest length	400	M
Maximum rockfill base width	Approx. 50	M
Upstream slope		3H : 1V
Dike Seepage Control	LLDPE	-

7.1.1 Construction Materials and Quantities

The estimated material quantities used in the construction are described in the specifications. Table 26 summarizes the earthwork quantities for SD2.

Table 26: Summary of SD2 estimated Earthworks Construction Quantities

Item	Estimated Quantity	Unit
Foundation excavation quantity	-	m^3
Fine Filter	33,200	m^3
Coarse Filter	20,800	m^3
Rockfill shell	176,200	m^3
Upstream toe trench excavation	-	m^3
20 mm minus and assume 8% bentonite mix toe trench backfill	7,400	m^3
Geotextile	30,800	m^2
LLDPE Liner	22,600	m^2

Notes: Quantities are not as-built.

7.1.2 Foundation Preparation and Foundation Investigation for Ice-Rich / Ice-Poor Soils

Upon arrival and initial inspection, stripping of the upper 1 to 1.5 m overburden beneath the upstream foundation footprint between about STA. 20+100 to 20+490 had been completed. The foundation conditions were investigated with air track test holes put down along the upstream footprint of SD2. The foundation preparation beneath the upstream side of SD2 consisted of stripping organics and thawed surficial soils, followed by ripping and excavation of any frozen soil and fractured bedrock. Localized blasting of large boulders was required near the southend of the dam within the upstream side footprint. The bedrock surface was exposed along the entire upstream toe of the dam and was manually cleaned with bristle brooms, rakes, and shovels.

Trenches (ditches) were excavated at the base and upstream of SD2 future upstream toe to promote drainage towards the TSF tailings basin of the thawing foundation surficial soils prior to construction. Organic and thawing soils were excavated with dozer and a CAT 345D excavator and hauled to a waste soil dump site off of the rock fill road on the east side of the TSF basin (i.e., near the landfill).

Ice-rich materials were removed by using a dozer equipped with a blade and ripper for an average depth of 2.5 m with a maximum depth of about 4 m beneath the ground surface for the projection of the geomembrane liner to be installed to the finished crest El. 150 m. Confirmation test holes were drilled in the upstream side of the SD2 footprint to verify the extent of ice-rich soils. A suitable bedrock foundation was found within 4 m of the surface, thus stripping of the overburden was carried out down to bedrock on the upstream side of the SD2 footprint. Sampling of frozen ground indicated that ice-rich till was observed within about 2 m from the original ground surface or up to 2 m above the bedrock.

Work was completed by FGL and AEM, under the supervision of AEM representatives

7.1.3 Base Filter Placement

An inverted two layer base filter system was placed over the upstream portion excluding the area of the till plug tie-in, of the footprint prior to rockfill placement. The inverted filter system comprises a 0.5 m thick coarse filter layer, which overlies a 0.5 m thick fine filter layer.

The fine filter material (20 mm minus) was placed at the base of the excavation sequentially as the foundation surface was approved. The fine filter material was produced with NPAG rockfill by at Other's crusher and hauled by 100 ton trucks. The 20 mm material was placed with a D6 dozer for a thickness of about 0.5 m. The fine filter layer was compacted with a 10 ton vibratory smooth drum roller with three passes without moisture conditioning.

The coarse filter material (200 mm minus) was placed over the fine filter layer with a D6 dozer for a thickness of about 0.5 m. The 200 mm minus material was produced at AEM's crusher and hauled by 100 ton trucks. The coarse filter layer was compacted with a 10 ton vibratory smooth drum roller 3 passes and no water was added.

Work was completed by FGL and AEM, under the supervision of AEM representatives

7.1.4 Rockfill Shell Placement

The rockfill shell was constructed using rockfill from the Portage Pit. The rockfill shell placement was completed in about 60 days and involved a large quantity of equipment. The rockfill was hauled primarily using 100 and 150 ton trucks and placed with a D9 dozer in multiple 1.5 m to 2 m thick horizontal lifts to El. 150 m. Placement of rockfill material was carried out to promote compaction using loaded haul trucks and placement equipment.

Following rockfill placement, CAT 345 excavators re-sloped the upstream side slope to 3H:1V and larger rocks were removed prior to placement of bedding layers.

Rockfill materials for Saddle Dam 2 construction were geochemically classified as NPAG by AEM and supplied from on-site quarries.

Work was completed by FGL and AEM, under the supervision of AEM representatives

7.1.5 Upstream Toe Trench Excavation

The upstream toe trench excavation was carried out to a depth of 2 m to 4 m, depending on the depth to bedrock, and removing organics, thawing soils, ice-rich materials and fractured bedrock. As mentioned above, ice-rich materials were removed by a dozer equipped with a ripper to a depth of up to 4 m at the base of the trench. Confirmation test holes were drilled to verify the extent of ice-rich soils. Sampling of frozen ground indicated that ice-rich till was observed within about 2 m from the original ground surface or up to 2 m above the bedrock. The bedrock surface was exposed along the entire upstream toe of SD2 and was manually cleaned with bristle brooms, shovels.

The excavated waste material was hauled to a waste dump site off of the rock fill road on the east side of the TSF basin, near the landfill.

Following subgrade approval, a layer 25 mm to 100 mm thick of fine filter (20 mm) crush mixed with dry bentonite (approximately 8% by mass) was placed locally over larger apertures in the bedrock; these locations were surveyed by AEM. Till was then placed in 0.5 m thick loose lifts with a D6 dozer and compacted by track packing with the dozer or CAT 345D excavator and up to 4 passes of a 10 ton smooth static drum roller. The till material was sourced from a borrow area off of the West Road adjacent to the Portage Pit.

Till layers were placed commencing just southeast from the central portion of the dam in multiple lifts and progressed towards the northwest abutment. Till placement to the southeast abutment occurred after till placement to the northwest abutment was completed. The majority of the lift surfaces were at least partially scarified or tracked with a D6 dozer or CAT 345D prior to placement of subsequent lifts. Due to ponding water on the surface of the till between approximately STA. 20+170 to 20+245 the upper soften till was removed by the smooth edge bucket of the CAT 345D and then immediately afterwards an approximately 25 mm layer of bentonite powder was spread. Furthermore, between about STA. 20+200 to 20+245 till premixed with bentonite was placed in two separate loose lifts of about 0.45 m thick each. To avoid ‘pumping’ of the till material compaction was limited to tracking by the CAT 345D. All other till at the plug tie-in was placed without bentonite.

Work was completed by FGL and AEM, under the supervision of AEM representatives

7.1.6 Coarse and Fine Filter Placement

A two layer bedding system was placed by AEM in horizontal lifts, 0.5 m thick, along the rockfill upstream side slope sequentially as the rockfill shell was raised to El. 146 m. Similarly, the two layer bedding system was placed from El. 146 m to 150 m between STA. 20+395 to 20+570 with completion required from STA. 20+395 towards the northwest abutment. The bedding layers were initially placed in the central portion of the dam and then towards the northwest abutment.

The coarse filter material (200 mm minus) was placed over the rockfill upstream side slope with a CAT 345 excavator. The 200 mm minus material was produced by AEM crusher and hauled to the SD2 by 100 ton trucks. The coarse filter layer was compacted with a minimum three passes of a 10 ton vibratory smooth drum roller without moisture conditioning.

The fine filter material (20 mm minus) was placed on the upstream side slope over the coarse filter layer with a CAT 345 excavator. The 20 mm minus material was obtained from a stockpile near the former contractor location and then it was produced by crusher near the north end of Portage Pit. The fine filter material was hauled to SD2 by 100 ton trucks and dumped on top of the coarse filter material on the slope. Compaction of the fine filter layer was completed with a 10 ton smooth drum roller.

Crushed rockfill materials (coarse filter and fine filter) were supplied by AEM and contractor's crushers. Crushed rockfill material was produced from NPAG rockfill.

Work was completed by FGL and AEM, under the supervision of AEM representatives

7.1.7 Linear Low-Density Polyethylene Liner Installation

The 500 g/m^2 geotextile and 1.5 mm thick double textured LLDPE liner installation was carried out by Layfield northwest ward from the southeast abutment. The LLDPE liner rolls were stored at the east end of the Stormwater Dike and/or immediately west of the downstream side of SD2 in a lay down area. Liner rolls were moved to the SD2 crest prior to installation, as required, commencing on September 23rd, 2010. Full intact liner rolls were used and damaged areas from transportation, loading and unloading were discarded. Liner installation began on September 23rd and continued in phases until October 25th, 2010. During this period the temperature ranged between -5° and 10° Celsius. As of October 25th, 2010, liner had been deployed on the upstream SD2 dam face between STA. 20+490 to 20+570 to El. 150 m; however, completion is still required from STA. 20+490 (El. 146 to 150 m) to northwest abutment (2011 construction season).

The liner bedding surface was manually cleaned by hand shovels, rakes, and bristle broom, if required, prior to liner deployment. Panels of geotextile were deployed and fused together in advance of the deployment of LLDPE liner between about STA. 20+320 to 20+355 and STA. 20+170 to 20+258. The geotextile was extended about 1 m from the toe of the slope and ballasted.

The deployment of the liner was carried out with a CAT 345D or 350 excavator with a modified spreader bar to support the roll in the air over or slightly behind the crest and manual support on the edges to allow the liner to be pulled down the slope to the liner tie-in trench. No rub sheet was placed between the liner and geotextile during deployment.

Seaming using a double track fusion welder was performed as panels were deployed. The LLDPE liner was cleaned by hand held dry rags and/or bristle brooms immediately prior to welding. The fusion welder was set up to operate at a temperature of 400ºC and at a speed of 1.5 m/min. Trial welds were performed twice daily when welding was carried out all day, otherwise, only once immediately prior to the commencement of welding. The liner extended approximately 4 m out along the dam crest and varied between 6 to 11 m from the toe of the slope. Sequential panel numbers were written on the liner as per the specifications. Ballasting material was placed at the dam crest over the liner and if necessary along the panel edges as the work was completed or at the end of each shift.

Vacuum box, air channel and tensile shear strength testing of the extrusion welds were completed. Where needed, patches were carried out by tack welding a piece of liner to the panel and extrusion welding around the patches, which was followed by vacuum box testing.

Work was completed Layfield, under the supervision of AEM representatives

7.1.8 Upstream Toe Trench Backfill

The liner at the tie-in trench was covered with till materials using a CAT 345D excavator with material transported to the site by 50 and 100 ton trucks. Till over the liner was placed in 0.5 to 0.9 m thick layers in several individual steps. The initial step commenced about 2 to 3 m upstream of the toe and extended about 6 to 12 m upstream from the toe. This resulted in an approximately 2 m wide ditch-line upstream of the end of the liner toe. The ditch was then backfilled as to contain and directed drainage from surface run-off towards the elevation low point upstream of the SD2 dam face at about STA. 20+180. From here ponding snow-melt and surface run-off was pumped up and over the construction road upstream (*i.e.* east). Finally, the 2 to 3 m immediately adjacent and upstream of the SD2 dam face toe was backfilled as the surcharge cover, discussed below, was placed. Lifts were compacted initially with the bucket of the excavator, which was subsequently followed with three to four passes of a 10 ton smooth roller without vibration. It was recorded that cobbles were locally placed against the liner.

Work was completed by FGL and AEM, under the supervision of AEM representatives

7.1.9 Instrumentation installation

AEM supervised instrumentation installation for SD2. As-built location and installation elevation were recorded by AEM and are presented in the as-built drawing in Appendix C.

7.1.10 Liner Cover

The LLDPE liner on the upstream face of the SD2 slope was covered with geotextile from the toe to about El. 145 m in preparation of applying a surcharge lift to the liner and till tie-in plug to mitigate uplift pressure effects from downstream surface run-off and near surface groundwater flow.

The till surcharge material was placed using a CAT 345D excavator in two loose 0.6 m lifts over the full width of the existing SD2 till plug material. This was followed by a 0.6 m lift of till material placed immediately over the geotextile that covered the upstream SD2 dam face slope to El. 145 m. This latter surcharge material was also placed with the excavator bucket, but aided with hand shovels and manual labour to protect the upstream liner. Surcharge material was compacted with the excavator bucket.

From about STA. 20+350 to the northwest abutment between about El. 143 to 145 m, placed surcharge materials are a mix of till and fractured bedrock that were sourced from the SWD-SD2 connection.

Work was completed by FGL and AEM, under the supervision of AEM representatives

7.2 Saddle Dam 2 Stage 1 – QA/QC activities

The QC program was managed and directed by AEM. QC testing was completed under the supervision of AEM. AEM supervised and monitored the construction activities.

A summary of Saddle Dam 2 QA testing and monitoring are presented in Table 27.

Table 27: Summary of SD2 Construction QA Testing and Monitoring

Construction Item	Work Description	Minimum QA Testing Requirement and Frequency	QA Tests Performed
General	Care of water	Visual observation	Continuous
	Borrow material Storage	Visual observation	Continuous
Foundation preparation	Location and extents	Survey review	Continuous and as-built following construction
	Subgrade inspection	Visual observation	Continuous
	Water content	1 in every 5 QC	45
Rockfill shell placement	Gradation	Visual observation	Continuous
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Coarse Filter	Gradation (stockpile and as placed)	1 in every 5 QC	1
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Fine Filter	Gradation (stockpile and as placed)	1 in every 5 QC	4
	Water content	1 in every 5 QC	4
	Placement technique	Visual observation	Continuous
	Compaction	Visual observation	Continuous
Trench backfill	Placement technique	Visual observation	Continuous
Geotextile	Seams and panels	Visual observation	Continuous
LLDPE geomembrane Liner	Liner sampling	Visual inspection	As Requested
	Liner rolls	Visual inspection	Each roll
	Seams	Visual inspection	Continuous
	Tensile shear strength of seams	Oversee 1 every 5 QC tests	60 (3rd Party shear and peel test of seams)
	Start-up and test seams	Oversee 1 every 5 QC	??
	Vacuum box test	Oversee all QC tests	Periodic
	Air channel test	Oversee all QC tests	Periodic

Construction Item	Work Description	Minimum QA Testing Requirement and Frequency	QA Tests Performed
Liner cover	Gradation (stockpile and as placed)	1 in every 5 QC	17
	Compaction	Visual observation	Continuous
Instrumentation	Installation	Visual observation	n/a

7.2.1 Foundation Preparation

QA/QC activities for the foundation preparation and foundation investigation included:

- Visual observation during foundation excavation, including removal of organic soils, thawing soils and ice-rich soils;
- Visual observation and recording of depth to bedrock during drilling investigation;
- *In situ* QA samples taken to assess ice content;
- Visual observation of ripping by dozer and excavation of ice-rich soils;
- Visual observation of blasting of boulders; and
- Visual observation of waste material removal and disposal.

Forty-five QA samples were collected during foundation preparation within the upstream side footprint and tested for ice and water contents of the foundation soils. Sampling of in-situ samples indicated that ice-rich till was observed within about 2 m from the original ground surface or up to 2 m above the bedrock.

Foundation approval by the QC team was given after visual inspection of the clean bedrock subgrade on the upstream side of the dam crest.

7.2.2 Base Filter Placement

QA/QC activities for the base filter placement included:

- Visual observation of the base filter material gradation, lift thickness and segregation;
- Overview base filter material placement technique;
- Visual inspection of base filter layers compaction; and
- Fine filter and coarse filter placement and compaction approval.

An inverted two layer base filter system was placed beneath the geomembrane liner projection prior to rockfill placement. The inverted filter system comprises a 0.5 m thick coarse filter layer which overlies a 0.5 m thick fine filter layer. Base filter placement and direction of truck haul traffic was directed to promote compaction. Overall, compaction and placement of the base filter was performed as specified.

No in situ QA base filter samples were tested during the construction program.

7.2.3 Rockfill Shell Placement

QA/QC activities for the rockfill shell placement included:

- Visual observation of the rockfill gradation, lift thickness and segregation;
- Overview rockfill placement technique;
- Visual inspection of routed equipment to promote compaction; and
- Upstream re-sloped rockfill surface approval.

The placement and compaction of the rockfill was observed and deemed to be satisfactory. Oversized material was removed from the upstream portion of the structure and placed in the downstream shell area.

7.2.4 Upstream Toe Trench Excavation

QA/QC activities for the upstream toe trench excavation included:

- Visual observation during foundation excavation, including removal of organic soils, thawing soils, ice-rich soils and fractured bedrock;

- Foundation approval of competent subgrade; and

- Mapping of major open apertures in the bedrock;

The excavation of the upstream toe trench was performed satisfactorily based on the observations made by QA and QC.

7.2.5 Coarse and Fine Filter Placement

QA activities for the liner bedding placement included:

- Visual observation of the liner bedding material gradation, lift thickness and segregation;

- *In situ* QA samples taken to assess particle size distribution;

- Overview liner bedding material placement technique;

- Visual inspection of liner bedding compaction; and

- Coarse filter and fine filter placement and compaction approval.

The fine filter material was obtained from a stockpile near the former contractor location and then it was produced by the contractor's crusher near the north end of Portage Pit. One (1) coarse filter and four (4) fine filter QA grain size distribution tests were completed during the Stage 1 of SD2 construction. The single coarse filter sample did not meet the specifications; whereas, all four fine filter samples tested satisfied the specifications.

QA testing for Saddle Dam 2 coarse and fine filter grain size distribution including envelope limits as specified in the technical specifications with laboratory results for grain size distribution are presented in Appendix B.

Additional bedding material needs to be placed from STA. 20+395 to the northwest abutment between El. 146 m to 150 m prior to deployment liner in 2011.

7.2.6 Linear Low-Density Polyethylene Liner Installation

The geomembrane installer Layfield was responsible of the QC program during the installation, under the supervision of AEM. Golder was responsible of the QA program.

QA activities for the geotextile and LLDPE liner installation included:

- Liner bedding surface inspection;
- Visual observation of geotextile deployment and welding;
- Visual observation of liner deployment technique;
- Visual inspection of seams;
- Oversee QC tensile shear strength, vacuum box and air channel tests; and
- Liner installation approval for liner cover placement;

No quality control certificates for the geotextile and liner were provided to Golder.

The liner bedding surface was satisfactorily cleaned prior to geotextile and liner deployment. Golder visually inspected all seams and all identified defects were repaired appropriately.

Moderate to very strong winds were present after the deployment of Panels 36 to 45 (STA. 20+329 to STA. 20+258) that resulted in the panels mobilizing; particularly at the toe. Wrinkles that formed due to shifting of the liner were removed and the liner inspected with no visible damage or holes identified. Moderate winds were also present during the deployment of Panels 46 and 47 which caused the panels to lift and twist resulting in local creases. Although no other visible damage was identified resin was applied to the creases. The liner was also observed to be in tension and not resting on the underlying liner bedding at the inflection point of the toe slope between STA. 20+450 to 20+500. The liner was subsequently covered with stockpile till.

The LLDPE liner was satisfactorily cleaned with a dry rag prior to welding with a double track fusion welder. Liner welds met or exceeded the minimum required specified values. The speed, temperature, welding machine and date were always recorded adjacent to each seam. Calibration welds were performed twice daily when welding occurred all day (*i.e.*, at the start of the shift and in the afternoon) or once immediately prior to commencing seam welding.

Where needed, patches were carried out by tack welding a piece of liner to the panel and extrusion welding around the patches. Grinding was not always performed perpendicular to the seams.

Golder oversaw 7 QC tensile shear strength tests all of which meet or exceeded the specifications. No record of the number of QC vacuum box and only a partial list of air channel tests observed by Golder was maintained; however, it was observed that the length the seal for vacuum box testing was not always held for the specified length of time. When air channel testing failed for a specific channel retesting was requested and carried out until the specifications were achieved.

Seam liner samples were tested at an independent laboratory for shear and peel test. The tested samples complied with the specifications. Available QC test results are presented in Appendix B.

Liner deployment was incomplete for the upstream face of SD2, due to adverse winter conditions, with the remaining liner to be deployed from STA. 20+395 to the northwest abutment between El. 146 m to 150 m in 2011.

7.2.7 Upstream Toe Trench Backfill

QA/QC activities for the upstream toe trench backfill included:

- Visual observation of till lift thickness and segregation;
- *In situ* QA samples taken to assess particle size distribution;
- Overview placement technique;
- Visual inspection of backfill compaction.

Bedrock fractures with apertures >10 mm were mapped by Golder during foundation excavation between STA. 20+560 and 20+565. Although it was recommended that 20 mm crush stone enriched with dry bentonite be placed over these fractures, this was not carried out prior to the placement of till.

During till placement two issues with ponding water were present at the toe of the dike. The first pond was at STA. 20+200, between the upstream toe slope and the till toe plug and the second at around STA. 20+180, just beyond the end of the liner at the toe of the dike. Ponding occurred above (0.3m) and below (0.1 m) the liner at the first pond (STA. 20+200), whereas the second pond (STA. 20+180) was the location where the perforated drainage pipe discharged into. Both ponds were dewatered and the pond at STA. 20+180 was cleaned by a 345 excavator bucket to remove wet/muddy till and accumulated ice prior to placement of till.

Poor quality till was observed by QA to be placed between about STA. 20+150 to STA. 20+250 at toe of the till plug tie-in, which is not in conformance with the specifications. This till was not excavated or replaced.

Seventeen QA grain size distribution tests, seven QA hydrometer tests, and seventeen QA water content tests were completed during the 2010 SD2 construction. Water content determination was recorded from the fraction passing the #4 mesh while completing the grain size distribution tests. Available laboratory results for each till sample are presented in Appendix B

7.2.8 Instrumentation Installation

AEM supervised every instrumentation installation for SD2. As-built location and installation elevation were recorded by AEM and are presented in the as-built drawing in Appendix C.

7.2.9 Liner Cover

QA/QC activities for the liner cover placement included:

- Visual observation of the liner cover material gradation, lift thickness and segregation;
- *In situ* QA samples taken to assess particle size distribution;
- Overview of liner cover material placement technique;

In addition to the liner till plug tie-in a surcharge lift of till was also added to mitigate uplift pressure effects from downstream surface run-off and near surface groundwater flow. No design modifications for the till plug tie-in were provided to Golder prior to construction. The till surcharge material was placed in two 0.6 m lifts over the full width of the existing SD2 till plug tie-in. This was followed by a 0.6 m lift of till material placed immediately over the geotextile that covered the upstream SD2 dam face slope to El. 145 m.

Three liner cover QA grain size distribution test was completed during the 2010 SD2 construction. Additionally, water content of the fraction passing the #4 mesh were recorded while completing the grain size distribution tests. QA testing by Golder for Saddle Dam 2 liner surcharge cover grain size distribution is presented in Appendix B with laboratory result.

8.0 SADDLE DAM 2 AND CONNECTION SADDLE DAM 2 / STORMWATER DIKE CONSTRUCTION- STAGE 2 (2011)

8.1 Saddle Dam 2 and Connection Saddle Dam 2 / Stormwater Dike Stage 2 - Construction Activities

Saddle Dam 2 (SD2) and the Connection between Saddle Dam 2 and Stormwater dike (Connection) construction where completed in the late summer 2011. Low-density polyethylene 60 mil textured (LLDPE) geomembrane was installed on the upstream face of SD2 and Coletanche bituminous geomembrane ES2 (BGM) on the upstream face of the Connection between SD2 and SWD. The subgrade on the upstream face of both structures was prepared, inspected and approved prior to deployment of the geomembrane. Repairs on the LLDPE geomembrane on Saddle Dam 1 (SD1) were also completed.

Installation of LLDPE geomembrane on SD2, BGM geomembrane on the Connection and repairs on SD1 were completed between September 8 and 25. The geomembrane was installed and repaired by Layfield, with the help of labours from Moreau, under the supervision of Agnico Eagle – Dikes Engineering Team (AEM). The QC program was managed by Layfield and was required to complete the specified QC testing. AEM assisted and revised the work and test results. QC tests and results for the geomembrane are discussed below.

All geotextile and geomembrane products were already on site at Meadowbank and the installer only supplied welding tools and apparatus.

Till liner cover on the upstream toe of SD2 and of the Connection was completed by AEM after completion of the geomembrane installation, in October. A till blanket was also placed on the overlap between the BGM geomembrane and the LLDPE geomembrane on SD2.

Selected construction photos are available in Appendix A.

8.1.1 Coarse and Fine Filter Placement

Completion of coarse and fine filter placement was required from STA. 20+395 towards the northwest abutment for SD2. The coarse filter material (200 mm minus) was placed in a 0.5m layer over the rockfill upstream side slope with a CAT 345 excavator. The 200 mm minus material was produced by the crusher on site and hauled to the SD2 by 100 ton trucks. The coarse filter layer of 0.5 m was compacted with a minimum three passes of a 10 ton vibratory smooth drum roller without moisture conditioning. The fine filter material (20 mm minus) was placed on the upstream side slope over the coarse filter layer with a CAT 345 excavator. The 20 mm minus material was also produced by the crusher. The fine filter material was hauled to SD2 by 100 ton trucks and dumped on top of the coarse filter material on the slope. Compaction of the fine filter layer was completed with a 10 ton smooth drum roller. Coarse and fine filter placement and grade adjustment was also done at the Connection, with the same procedure.

Crushed rockfill materials (coarse filter and fine filter) were supplied by AEM and contractor's crushers. Crushed rockfill material was produced from NPAG rockfill.

Work was completed by FGL and AEM, under the supervision of AEM representatives

8.1.2 Liner Low-Density Polyethylene SD2 Stage 2 - Installation and Repairs Procedure

The geotextile and LLDPE geomembrane was installed on the subgrade prepared and approved by Layfield and AEM, on the upstream face of Saddle Dam 2, between El. 146 m and El. 150 m. Installation of LLDPE geomembrane on SD2 occurred mainly between September 8 and 17. Installation was conducted using a manual dispenser roll mounted on a 330Cat excavator to unroll the geotextile and geomembrane from the crest of SD2. Geotextile panels were first installed on subgrade and ballasted, followed by the geomembrane. Each geotextile and geomembrane panel were hold by labours during the deployment to ensure proper placement and sufficient overlap between panels. The rolls were oriented parallel to the upstream slope direction to reduce stress on the seams. Each panel was temporarily ballasted in the anchor trench on the crest and on the slope with sand bags before welding.

Fusion seams between panels were welded using a hand held wedge welder. Detailed extrusion welding was carried out using a plastic extrusion welding gun, on the tie in weld between the LLDPE geomembrane installed in 2010 and 2011 (approximately El. 146m), on repairs and where required. During installation of the geomembrane and prior to welding, all field seams were cleaned and dried.

The geotextile and LLDPE geomembrane were placed and ballasted in an anchor trench on the crest of SD2 after deployment. Following welding of the tie in, the anchor trench was backfilled with fine rockfill material.

Approximately 6,675 m2 of geotextile and 6,853 m3 of LLDPE geomembrane were installed on SD2 in September 2011, as reported by the installer Layfield.

8.1.3 Bituminous Geomembrane Connection– Installation and Repairs Procedure

The Coletanche bitumous geomembrane was installed on the subgrade prepared and approved by Layfield and AEM on the upstream face of the Connection between SD2 and SWD, between approximately El. 140 m and El. 148 m. Installation of BGM geomembrane on the Connection occurred mainly between September 17 and 25. Installation was conducted using a hydraulic and a manual dispenser roll mounted on a 345Cat excavator to unroll the geomembrane from the top of the slope. Each panel were hold by labours during the deployment to ensure proper placement and sufficient overlap between panels. Panels were cut and installed in order to fit properly the contours of the connection. Each panel was temporarily ballasted in the anchor trench on the crest and on the slope with sand bags before welding.

Seams were welded using a hand held torch and roller between panels and on the tie in weld between the BGM geomembrane installed in 2009 and 2011 (approximately El. 140m). Detailed welding for repairs was carried out using a hand held torch and a small trowel. During installation of the geomembrane and prior to welding, all field seams were cleaned and dried. No bubbling, over running or over heated bitumen and “fish mouths” were allowed in the welds.

The BGM geomembrane was placed in an anchor trench on the crest of the Connection after deployment. A minimum of 3.0 m length on each panel was placed horizontally in front of the upstream toe of the slope, in order to provide a good length of geomembrane underneath the till blanket. On the east end of the Connection, the BGM geomembrane was welded (tie-in weld) on the existing bituminous geomembrane installed in 2009, approximately at El. 141m. Following the welding of the tie in and placement of the till blanket, the anchor trench on the crest was backfilled with fine rockfill material.

Approximately 6,933 m3 of BGM geomembrane were installed on the Connection in September 2011, as reported by the installer Layfield.

Overlap between the LLDPE geomembrane and the BGM geomembrane was placed on SD2, in order to have proper seal and transition between both structures and geomembrane type. The BGM geomembrane was placed over two and half panels of LLDPE geomembrane on SD2. A till capping was placed on top of the overlap in order to place weight and additional impervious protection.

8.1.4 Saddle Dam 2 and Connection – Liner Cover

The till blanket placement, started in 2010 on the upstream toe of SD2 was completed after the LLDPE geomembrane installation. The till blanket was extended from the liner below the tie in weld (approximately El. 145m), towards the outside excavation limit in order to provide good protection for the geomembrane and additional impervious protection.

The till blanket placement on the upstream toe of the Connection was completed after the bituminous geomembrane installation. To anchor the geomembrane panels, the till blanket was placed over the horizontal panel length in front of the upstream toe. The blanket was extended towards the outside excavation limit and along the tie in weld, in order to provide good protection for the geomembrane and additional impervious protection.

The material was sorted with an excavator to removed oversized rocks, hauled with 100 tons truck and placed with dozers. The material was compacted with dozer tracks and traffic.

Work was completed by FGL and AEM, under the supervision of AEM representatives.

8.1.5 Saddle Dam 1

Repairs were completed by Layfield on SD1 to remove excessive wrinkles on the geomembrane. One wrinkle was located on the North side of SD1, parallel to the slope. Another wrinkle was located on the tie in between the geomembrane installed in 2009 and 2010, at approximately El. 142 m. Repair of the LLDPE geomembrane occurred between September 24 and 25. The excessive wrinkles were cut and repairs were completed with extrusion weld.

8.2 Saddle Dam 2 and Connection Saddle Dam 2 / Stormwater Dike Stage 2 - QC Activity

The geomembrane installer Layfield was responsible of the QC program during the installation, under the supervision of AEM. AEM reviewed work and testing procedures of Layfield .

8.2.1 QC Documentation

The QC documentation was produces and provided to AEM by the installer Layfield. QC documentation provided to AEM includes the following items:

- Certificate of Acceptance of Soil Subgrade Surface (LLDPE-SD2 and BGM-Connection) - All subgrade areas were inspected and approved prior to the placement of geotextile and geomembrane by Layfield and AEM representatives. Inspections by Layfield and AEM concentrated on ensuring there were no sharp edges, ruts, soft material, irregular surface or important segregation in the support material layer prior to deployment of the geotextile and/or geomembrane.

- Geomembrane Deployment Log (LLDPE-SD2 and BGM-Connection) – The form records details of each geomembrane panel deployed including the panel number, general condition, approximate area, weather during deployment and overlap with next panel.

- Geomembrane Seam Log (LLDPE-SD2 and BGM-Connection) - The form records details of each seam including seam number, section, time and condition of welding, operator and length welded. The form also includes for LLDPE the passing trial seams, machine conditions, destructive and non destructive tests.

- Geomembrane Trial Seam Log (LLDPE-SD2) – The log was completed before welding of deployed geomembrane. Trial test were conducted to calibrate properly the machine, accordingly to daily specific conditions, as recorded on the log.

- Geomembrane Vacuum / Air Lance Test Log (LLDPE-SD2 and BGM-Connection) – Seams sections and some repairs were tested with the vacuum box to ensure that adequate welding of the seams was achieved. Seam number and section tested are provided on the log.

- Geomembrane Seam Pressure Test Log (LLDPE-SD2) – Air pressure test was performed on each fusion seams welded with the wedge welder to detect unbounded area using air pressure. Seam number and section tested, air pressure and time are provided on the log.

- Geomembrane Destructive Test Log (LLDPE-SD2 and BGM-Connection) – Sections of approximately 500 mm were cut directly into the weld for destructive testing. The LLDPE was tested for shear strength and peel adhesion and the BGM was tested for shear strength. A section of the weld sample was tested on site and a section was given to AEM for future third party testing. Results of field tests are provided on the log.

- Geomembrane Defect / Repair Log (LLDPE-SD2 and BGM-Connection) – Repairs completed by Layfield were recorded on the log. Defect type, location, seam and repair type are included in the log.

- Panel Layout (LLDPE-SD2 and BGM-Connection) – General panel layout was provided for the work completed in 2011, showing the panel numbers and location.

Certificate of Final Inspection and Acceptance (LLDPE-SD2 and BGM-Connection) – The work completed in 2011 on SD2 and on the Connection was inspected and approved by Layfield and AEM, based on the above QC requirements and the project specifications.

Copies of the QC documentation provided by the geomembrane installer Layfield are included for the LLDPE on SD2 and for the BGM geomembrane on the Connection in Appendix B. The field QC testing procedure for the geomembrane is described below.

8.2.2 QC Testing

8.2.2.1 Prequalification Trial Weld

For the LLDPE geomembrane on SD2 and SD1, trial welds were prepared and tested by the installer to verify that seaming parameters (speed, temperature and pressure of welding equipment) were adequate, prior to welding. Trial weld were conducted for fusion welds and extrusion welds.

The results of the trail welds for the LLDPE geomembrane on SD2 and SD1 were recorded on the QC documentation and are available in Appendix B.

8.2.2.2 Continuity Testing

Continuity testing are non-destructive quality control test methods for determining the integrity of seams. General testing procedures are presented below for the LLDPE on SD2 and for the BGM geomembrane on the Connection.

- **Saddle Dam 2**

Seam pressure testing was conducted on all complete wedge fusion seams on the LLDPE geomembrane. Vacuum box test was performed on all extrusion weld sections on the tie-in and on repairs. Any seams that failed to the continuity testing, or in doubt of possible failure, were repaired and retested.

The results of the continuity testing for the LLDPE geomembrane on SD2 were recorded on the QC documentation and are available in Appendix B.

- **Connection Saddle Dam 2 – Stormwater Dike**

Geomembrane vacuum test was performed on selected seams and on tie-in seams. Approximately 30% of the seams were tested with the vacuum box.

The results of the continuity testing for the BGM geomembrane on the Connection were recorded on the QC documentation and are available in Appendix B.

8.2.2.3 Destructive testing

Sections of approximately 500 mm were cut into the seam for destructive test. One destructive test sample was taken per 150 m linear of seam length at location randomly specified by AEM for the LLDPE geomembrane on SD2. A total of 6 tests were taken on the fusion welds and 2 tests on the extrusion welds from the LLDPE geomembrane on SD2. Two destructive tests were taken from BGM geomembrane on the Connection. One destructive test was taken from the extrusion weld for repair on the LLDPE geomembrane on SD1.

The LLDPE seams (fusion and extrusion) were tested for shear strength and peel adhesion and the BGM geomembrane was tested for shear strength. A section of the weld sample was tested on site and a section was given to AEM for future third party testing.

The results of the destructive testing for the LLDPE geomembrane on SD2 / SD1 and the BGM gemembrane on the Connection were recorded on the QC documentation and are available respectively in Appendix B.

8.2.2.4 Visual Observations during installation

AEM regularly conducted visual observation of the geomembrane installation both during and after installation. The seams and geomembrane panels were inspected for holes and defects. Defects were marked and repaired by the installer as requested by AEM. Installation procedures and QC testing were also observed.

9.0 CONCLUSION

This report has been prepared to present a summary of the Tailings Storage Facility as-built construction information during 2009, 2010 and 2011 including QC and QA records available and the as-built drawings.

In general, the construction performed at the TSF during the 2009, 2010 and 2011 construction season complied with the drawings and specifications.

APPENDIX A – CONSTRUCTIONS PHOTOS

APPENDIX A

AGNICO EAGLE

SD1 2009 CONSTRUCTION PHOTOS

AGNICO EAGLE

SD1 – Initial Conditions, Prior to Construction

From north abutment looking south

SD1 –Drainage Ditches

SD1 – Foundation Preparation


Stripping Thawed Soils


Drilling for blasting of ice-rich materials


Preparing to blast ice-rich material and excavating blasted material

SD1 – Ice-Rich Foundation Material

Samples of ice-rich material from foundation that was excavated

SD1 – Foundation Preparation


Excavating blasted ice-rich material

SD1 – Filter Placement on Base of the Foundation

Fine filter placement and compaction

Coarse filter placement above fine filter

SD1 – Preparing Upstream Toe Foundation for Till Placement

AGNICO EAGLE

SD1 – Upstream Toe: Till Placement and Compaction

SD1 – Upstream Fine Filter Placement and Compaction

AGNICO EAGLE

SD1 – Bedrock Surface Cleaning on Abutments

SD1 – Rockfill Placement

SD1 – Construction Progress

SD1 – Construction Progress

AGNICO EAGLE

SD1 – Construction Progress