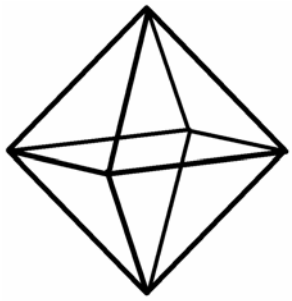
Plan



Kennecott
Eagle Minerals

Eagle Project

TDRSA Leak Detection System and Response Action Plan

Project I.D.: 04W018

Kennecott Eagle Minerals Company
Marquette, Michigan

December 2007

Eagle Project
TDRSA Leak Detection System and Response Action Plan

Contents

Tables

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Appendix

1. Introduction

1.1 Purpose

This TDRSA Leak Detection System and Response Action Plan ("the Plan") has been prepared for the Kennecott Eagle Minerals Company (KEMC) Eagle Project to describe how the collection of liquid in the Temporary Development Rock Storage Area (TDRSA) Leak Detection System (LDS) will be managed during construction and operations of the TDRSA. The LDS parameters assist in identifying the source of liquid collected and what action, if any, should be taken.

During construction and operation of the TDRSA, leak potential will likely originate from specific sources depending on the activities taking place. This plan evaluates the most likely leak sources over the TDRSA life to focus prevention, inspection, and action on the highest risk scenarios. Overall, the most likely opportunity for liner leaks stems from the construction process and during the placement of the first several feet of development rock on the TDRSA base. Recognizing this, a comprehensive construction and installation procedure overseen by assigned Construction Quality Assurance personnel is planned. Rigorous installation inspections are part of the program that minimizes leak risk from quality-control sources. Once the TDRSA liner system is installed and the bottom layer of development rock is placed, leak risk is reduced to a minimum as additional development rock is placed.

Water can enter or be present in the TDRSA from several sources: precipitation that leaks through the top cover, precipitation from the active face, infiltration through a liner breach, and water captured during the development rock placement. Water present in the LDS may originate from a liner breach, however, water can also be present from construction activities. This plan has been prepared to allow evaluation of liquid in the LDS and to assess its source. In addition, if the liquid is identified as a liner breach, actions are provided to mitigate the breach(es) and to protect groundwater.

2. Design and Construction

2.1 Design

The TDRSA is an engineered aboveground storage area used to temporarily store rock generated during mine development from the decline, drifts, levels, raises, and other underground workings needed to access the ore body. The rock, called development rock, will be transported from the development face by truck and placed on the lined TDRSA. The quantity of development rock that will be stored in the TDRSA is 247,900 yd^3. Once ore mining begins, all development rock stored in the TDRSA will be returned to backfill the mined areas.

The TDRSA will have a perimeter berm/access road, perimeter drainage ditch, contact water collection system sump and leak detection sump on the south end. A double liner system will be installed as shown in Figure 1. The TDRSA will first be filled over the entire floor area with a layer of development rock to protect the liner system.

The sump and LDS are shown in Figure 2. The LDS will consist of a 40 mil textured HDPE secondary liner and geocomposite drainage layer underlying the primary liner system. The leak detection liner and geocomposite drainage layer will allow collection and monitoring of liquid that may flow into the system as a result of construction water, a breach in the primary liner system, and/or surface or ground water infiltration. The LDS will be installed across the entire subbase and will be connected with the LDS sump.

2.2 Construction Quality Assurance

During construction of the TDRSA liner system, construction quality assurance (CQA) personnel will be on-site to observe that construction procedures and methods are performed in accordance with project and regulatory requirements. A TDRSA CQA Plan appears in Appendix A detailing the inspection and quality controls on liner installation. CQA personnel will follow specific observation protocol to document construction of the TDRSA liner system components including the subgrade, GCL, geomembrane liners (primary and LDS), geocomposite, contact water collection system, and drainage layer soil.

3. System Monitoring

3.1 Inspections and Monitoring of the Leak Detection Sump

Once development rock is being actively placed, the LDS sump will be monitored monthly for the presence of liquid. Inspections will be documented using the inspection forms provided in Appendix B. Liquid in the sump will be detected with a pressure transducer located in the LDS sump (Figure 2). If present, liquid in the sump will be pumped out and the volume recorded. If the volume exceeds 25 gallon per acre per day(gad), (USEPA, 1987), or in this case, 150 gallons for the approximate 6 acre TDRSA, the LDS sump will be checked for presence of liquid the following day. If present, the liquid will be pumped out, volume recorded, and analyzed for the parameters listed in Table 3-1:

Table 3-1
Leak Detection System Sump
Water Quality Parameters List

Parameter	Analytical Method	Threshold Limit	Units
Sulfate	EPA-375.4/9038	500	mg/L
pH	Field Measurement	--	standard pH units

Prepared by: MJP1
Checked by: JOS1

Sulfate levels of 500 milligrams/liter (mg/L) and greater than 25 gad (150 gal) indicates a breach of the TDRSA primary liner and the Response Action Plan will be implemented. Sulfate concentration less than 500 mg/L indicates the water present is from sources such as construction and no action is needed.

3.2 Response Action Plan

A Response Action Plan (RAP) is a site-specific plan that establishes procedures in the event that liquids are measured in the LDS sump exceeding 25 gad and a sulfate concentration of 500 mg/L or more in accordance with Special Permit Condition F.22 of the Nonferrous Metallic Mineral Mining Permit No. MP 01 2007 (MDEQ, 2007).

To implement the RAP, KEMC will proceed as follows:

- Notify MDEQ and MDNR in writing of the exceedance within 7 days of its discovery.
- Continue daily assessment of liquid quantity and sample testing. If the 25 gad rate continues to be exceeded, KEMC will install a permanent pump in the LDS sump for continuous liquid removal to minimize liquid head on the LDS liner.
- Within 30 days after notification of the exceedance, KEMC will submit to MDEQ and MDNR a report discussing the determination of the nature/source of the liquid and actions taken.

The best option to mitigate a leak will depend on a number of factors including the amount and rate of development rock placed, chemistry of the liquid in the LDS sump, and the effectiveness of the secondary liner system to contain the leakage. Therefore, no single action can be pre-selected. Continuing monitoring of the LDS sump will be key in determining RAP success. Potential actions to be evaluated include:

- Installation of an additional liner over the existing in-place development rock. This will prevent precipitation from infiltrating in-place development rock, thus eliminating the source of the liquid transmitted through a liner breach. A permanent pump can be installed in the LDS collection sump to collect the remaining liquid infiltrating through the in-place development rock. Installation of the additional liner could be staged such that development rock would be temporarily placed over the existing rock until the first stage of additional liner is completed. This rock could then be relocated to the additional lined area as the second stage of additional liner is completed. During these construction events, the area could be graded to direct runoff into a temporary, lined pond area created within the TDRSA and the runoff pumped to the CWBs.

- Interim cover to prevent precipitation from infiltrating in-place development rock. The cover could be graded to direct runoff into a temporary, lined pond area created within the TDRSA and the runoff pumped to the CWBs.

- Establish a low threshold for pump activation in the contact water collection system sump such that minimal quantity of liquid and head would be maintained.

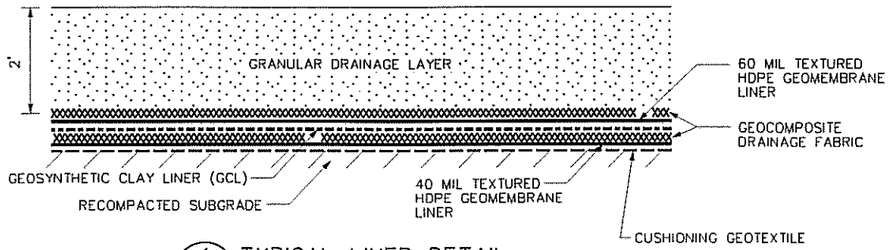
4. References

ASTM D 7007-03 *Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials*

Michigan Department of Environmental Quality. *General Permit Conditions Nonferrous Metallic Mineral Mining Permit No. MP 01 2007.* Anticipated Issuance Date of December 14, 2007.

USEPA. *Background Document of Bottom Liner Performance in Double-Lined Landfills and Surface Impoundments, EPA/530-SW-87-013* (1987).

Figures



1/1 TYPICAL LINER DETAIL

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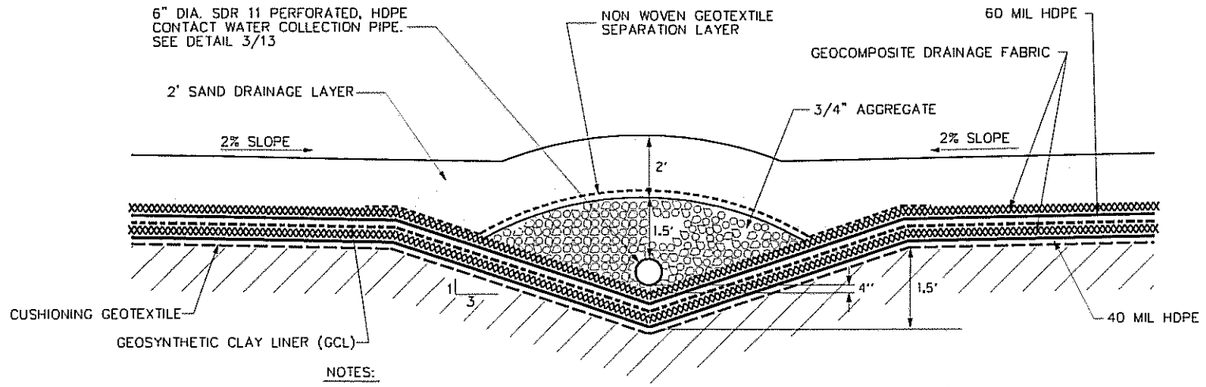

NOTES:

1. DRAINAGE LAYER WILL HAVE A MINIMUM HYDRAULIC CONDUCTIVITY OF 1 X 10^{-3} CM/SEC. (2' THICK).
2. GEOCOMPOSITE (GEONET) WILL HAVE A TRANSMISSIVITY OF NOT LESS THAN 1 X 10^{-3} M^2/SEC.
3. DRAINAGE AGGEGATE WILL BE WASHED, ROUNDED, NON-CARBONATE 3/4" COARSE AGGREGATE, HAVING A MINIMUM HYDRAULIC CONDUCTIVITY OF 1 X 10^{-1} CM/SEC.

2/1 TYPICAL CONTACT WATER COLLECTION TRENCH

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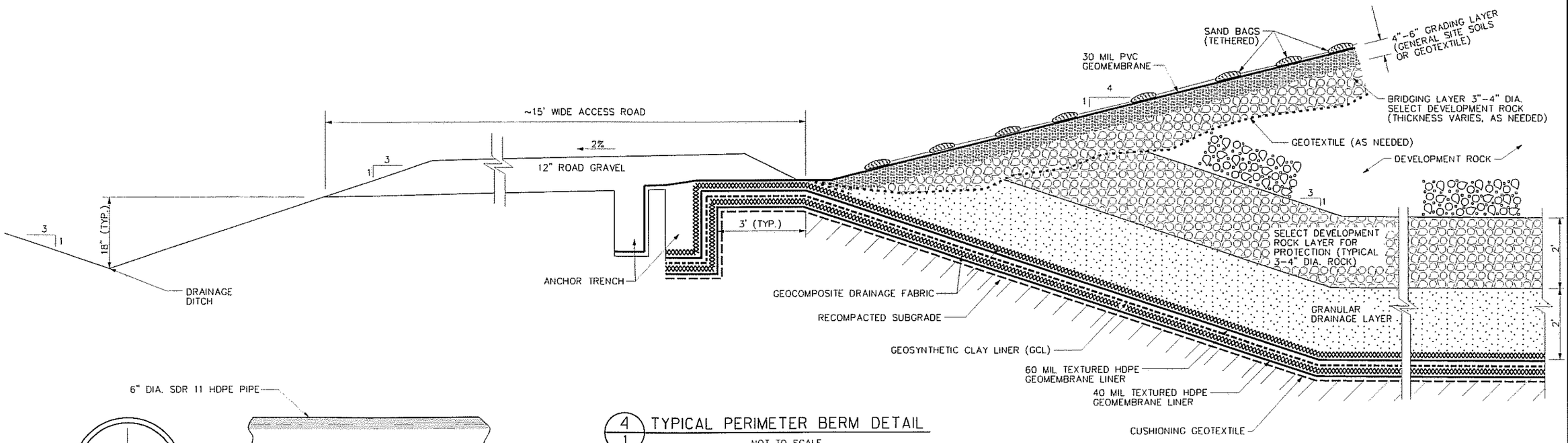

4/1 TYPICAL PERIMETER BERM DETAIL

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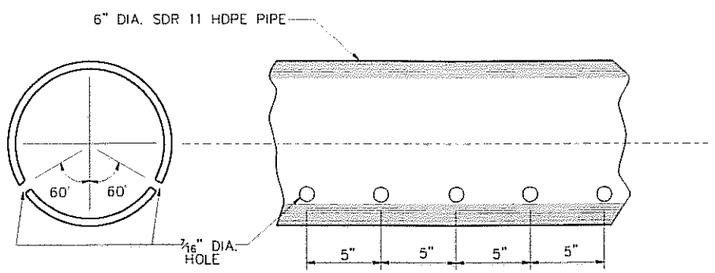

3/1 TYPICAL PIPE PERFORATION DETAIL

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REVISED	DATE	BY	DESCRIPTION
CHECKED BY: JOSI			DATE: DEC. '07
APPROVED BY: SVDI			DATE: DEC. '07
APPROVED BY:			DATE:

Kennecott Eagle Minerals

FIGURE 1

TDRSA LINER SYSTEM AND TEMPORARY COVER

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Prepared By: DAT	Project No. 04W018

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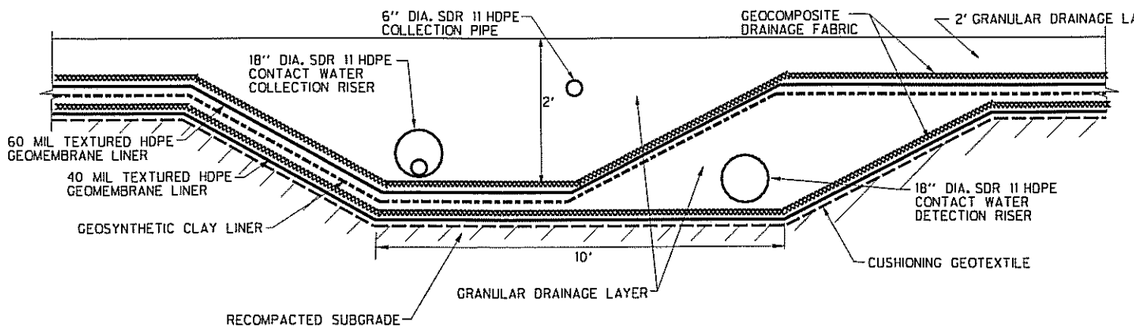

SECTION A-A

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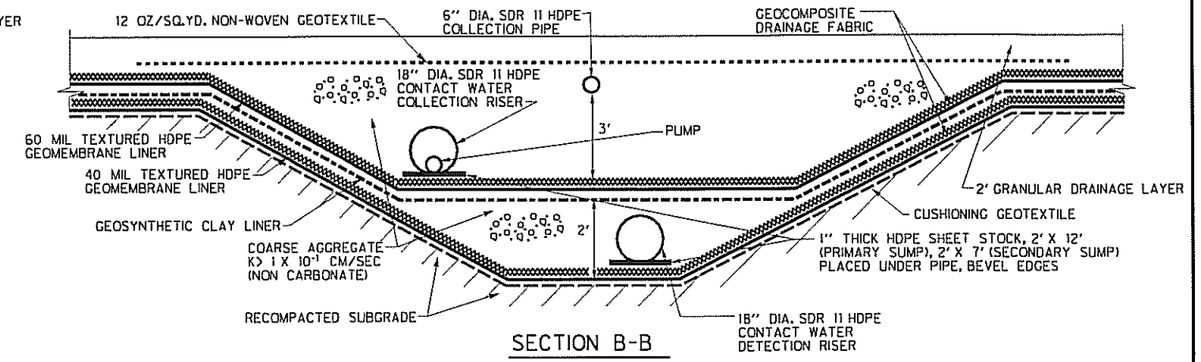

SECTION B-B

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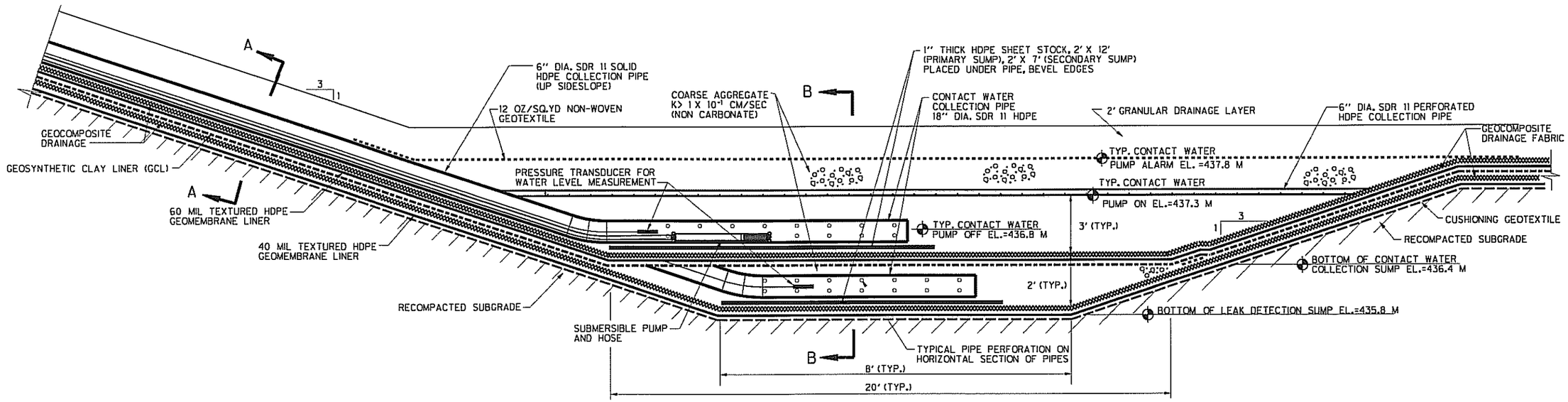

1/2 TYPICAL CONTACT WATER COLLECTION SUMP DETAIL

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REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:		JOS1		DATE: DEC. '07
APPROVED BY:		SVD1		DATE: DEC. '07
APPROVED BY:				DATE:

Kennecott Eagle Minerals

FIGURE 2

TDRSA CONTACT WATER COLLECTION SUMP AND LEAK DETECTION SYSTEM

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Prepared By:	JOW	Project No.	04W018

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Appendix A

TDRSA CQA Plan

Report

TDRSA CQA Plan

Eagle Project

Project I.D.: 04W018

Kennecott Eagle Minerals Company
Marquette, Michigan

February, 2006

(Revised July 2006)

(Revised December 2007)

Eagle Project

TDRSA CQA Plan

Project ID: 04W018

Prepared for

Kennecott Eagle Minerals Company

ISO 14001:2004 Registered System

Prepared by

Foth & Van Dyke and Associates, Inc.

February 2006

(Revised July 2006)

(Revised December 2007)

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Eagle Project
TDRSA CQA Plan

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1 Introduction

1.1 Purpose and Scope

The purpose of the Construction Quality Assurance (CQA) Plan is to provide minimum requirements for construction observation, testing, and documentation activities performed during construction. This plan is followed during construction to monitor and confirm that the construction features are constructed in accordance with the design and regulatory requirements.

The plan outlines the various sampling and testing programs to be carried out during the construction.

2 Construction Observation - Record Keeping

2.1 Construction Observation Report

The CQA monitor(s) are responsible to collect all samples and perform all Quality Control (QC) testing required by the CQA Plan. A daily report will be prepared by each inspector for each day of activity. The report will contain, at a minimum, the following information:

- Date
- Type of inspection
- Summary of weather conditions
- Summary of any meetings held and attendees
- Equipment and personnel on the project
- Summary of construction activities and locations
- Description of off-site materials received
- Calibration and recalibration of test equipment
- Description of procedures used
- Test locations, procedures, results and test data sheets
- Summary of samples collected
- Personnel involved in inspection and sampling activities
- Signature of the inspector
- Description of delays in construction activities
- Detailed description of any problems or non-conforming construction
- Progress of work in terms of approximate quantities

2.2 Daily Summary Report

The CQA officer or the CQA monitors, under the direct supervision of the CQA officer, will prepare a daily summary report containing, at a minimum, the following:

- Date
- Summary of weather conditions
- Summary of location where construction is occurring
- Contractors, equipment and personnel on the project
- Summary of any meetings held and attendees
- Description of all materials used and references or results of testing and documentation
- Calibration and recalibration of test equipment
- Daily inspection reports from each CQA monitor
- Description of any construction not meeting the project requirements and how it was corrected

2.3 Photographs

Photographs shall be obtained for all items of construction. A sufficient number of photographs shall be obtained to document the construction of each construction item (e.g., each manhole, each type of pipeline, each method of anchoring geomembranes, etc.). Each photograph shall be a 35 mm or digital photograph. A photo log containing the following information will be maintained:

- Date, time, location and orientation of photograph
- Name and signature of photographer
- Location and description of the work

Construction problems and non-conforming work shall be documented with photographs taken before and after the problem or when the non-conforming work has been corrected.

2.4 Test Data Sheets

CQA monitor will record all test data results on the test data sheets. Independent consultants engaged by the CQA shall submit their test results or data on forms acceptable to and approved by the CQA monitor.

2.5 Document Control and Record Storage

2.5.1 Daily Records

The daily records maintained during construction activities include, but are not limited to the following daily records:

- Daily inspection reports.
- Daily summary reports.
- Test data sheets from each CQA monitor.
- Test data or documentation data sheets from independent consultants (if any).
- Field book maintained by each CQA monitor.
- Field notes from all record surveys.

2.5.2 Storage of Records

All document originals listed in Section 2.5.1 above will be stored in 3-ring binders at the construction site. Copies of all documents will be on file at the CQA officer's office.

3 Construction Observation - Testing and Verification

This section outlines minimum requirements for the testing and verification of the components of construction.

3.1 Survey Verification

At a minimum, the record surveys shall document the following:

Composite Liner System

- Subbase of liner on 50-ft grid.
- Contact water collection system trench elevations every 25 ft (every 50 ft if a total station or laser is used).
- Geomembrane location information for panels, repairs, destructive tests, and anchor trench.

Contact Water Collection and Extraction System

- Collection pipe locations and invert elevations every 25 ft (every 50 ft if a total station or laser is used).
- Locations and pertinent elevations of manholes, cleanouts, leak detection sump, and collection sump.

3.1.1 Tolerances

Tolerances for each survey are listed in Table 3-1. Areas which do not meet the tolerances listed in Table 3-1 will be regraded or removed and replaced until the tolerances are met and resurveyed.

Table 3-1
Summary of Survey Tolerances

	Item	Frequency	Tolerance
1	Composite Liner		
	a) Subbase grade	50 ft grid	- 0.2 ft
2.	Contact Water Collection System		
	a) Collection piping	every 25 ft	± 0.05 ft/100 ft [(1)]
	b) Leak detection sump and collection sump	Bottom/top of sump. Grade breaks/corners	- 0.2 ft

[(1)]Positive drainage to be maintained at each location

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Checked by: JOS1

3.2 Thickness Verification

The CQA monitor shall verify the thickness of the gravel drainage layer as indicated in Table 3-2. The method of verification may include survey, hand augers, hand shoveling, or other approved method.

Table 3-2
Summary of Minimum Thicknesses

Item	Frequency	Minimum Thickness	Tolerance
1. Gravel Drainage Layer	200 ft grid	min. 1.0 ft	+0.1 ft

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Checked by: JOS1

4 Construction Observation - Soil Components

4.1 Scope, Sampling Requirements and Acceptance Criteria

The following elements of the design shall be constructed and sampled according to the CQA program in this section:

- Compacted subgrade
- Granular drainage layer

4.2 Compacted Subgrade

All fill materials placed for liner support construction (i.e., subgrade, berms, etc.) shall be tested in accordance with the following schedule:

Test	Minimum Frequency	Acceptable Test Values
Compaction characteristics: modified Proctor (ASTM D 1557) or standard Proctor (ASTM D 698)	Minimum of 1 test, then an additional 1 test/5,000 cy (in-place)/each soil type,	NA
In-Place Density and Percent Compaction: (ASTM D 2922 or ASTM D 1556)	100-ft grid/1-ft lift	90% of modified Proctor or 95% of standard Proctor maximum dry density

4.2.1 CQA Officer Inspection of Subgrade and Foundation

The CQA officer or CQA monitor(s) shall perform the following functions during subgrade preparation:

- Verify that all trees, stumps, roots, boulders and debris are removed.
- Verify that placement of frozen soil or soil onto frozen ground does not occur.
- Verify that the foundation is constructed and graded to provide a smooth, workable surface on which to construct the liner.

4.3 Granular Drainage Layer

All granular drainage layer construction for the contact water collection system shall be tested in accordance with the following schedule:

	Test Description	Test Method	Minimum Frequency	Specification
a.	Grain Size	ASTM D 422	1/1,000 cy	< 5% passing No 200 sieve, uniformity coefficient of less than 4 (gravel soils) or less than 6 (sandy soils)
b.	Hydraulic Conductivity	ASTM D 2434	1/2,500 cy	> 1 X 10^{-3} cm/sec

Prepared by: MJP1
Checked by: JOS

All gravel filter and coarse aggregate material for the leak detection sump and collection system shall be tested in accordance with the following schedule:

	Test Description	Test Method	Minimum Frequency
a.	Grain Size	ASTM D 422	1/1,000 lin ft of trench 1 per sump
b.	Hydraulic Conductivity	ASTM D 2434	Minimum of one sample

In addition, the CQA officer shall inspect the granular drainage layer, gravel filter, and coarse aggregate materials for undesirable objects.

5 Geotextile Cushioning Layer

5.1 On-Site Quality Assurance

5.1.1 Geotextile Cushioning Layer Rolls and Panels

Construction quality assurance monitoring for geotextile cushioning material rolls and panels includes:

1. Monitoring and documenting the unloading of trucks delivering geotextile rolls to the site.

2. Monitoring and documenting the handling and on-site storage procedures and location of the geotextile rolls.

3. Review of manufacturer's QA testing for conformance with project specifications.

5.1.2 Geotextile Cushioning Layer Panel Placement

Quality assurance monitoring for geotextile panel placement includes:

1. Monitoring and documenting sewing of adjacent geotextile panels for conformance to the project specifications.

6 Construction Observation – GCL

6.1 On-Site Quality Assurance

6.1.1 GCL Rolls and Panels

Construction quality assurance monitoring for the rolls and panels include:

1. Monitoring and documenting the unloading of trucks delivering GCL rolls to the site.

2. Monitoring and documenting the handling and on-site storage procedures and location of GCL rolls.

3. Recording the manufacturing roll and batch number of GCL rolls delivered to the site, date of fabrication and physical dimensions.

4. Review of manufacturer's QA testing for conformance with specifications, including:

   a. Name of the manufacturer and fabricator

   b. Copies of quality control certificates that are issued by the producer of the GCL materials.

5. Selecting samples from GCL rolls delivered to the site for off-site conformance testing. Conformance testing will be performed as outlined below. Samples shall be sent to a geosynthetics testing laboratory for the following material properties:

Test Description	Test Method	Minimum Frequency	Specification
Mass of GCL/unit area	ASTM D 5993	40,000 sf	0.82 lb/ft^2
Tensile strength	ASTM D 6768	100, 000 sf	23 lb/in
Peel strength	ASTM D 6496	100,000 sf	2.1 lb/in
Free swell of bentonite	ASTM D 5890	100,000 sf	24 ml/2g
Cap Fabric mass/unit area	ASTM D 5261	100,000 sf	5.8 oz/yd^2

6. Fixing a code number to samples and recording the manufacturing numbers of the rolls from which samples are taken.

7. Labeling, packaging and shipping samples to an off-site laboratory for conformance testing.

8. Interpreting laboratory test results in accordance with the specifications and accepting or rejecting delivered rolls based on results of off-site testing.

9. Visual review and marking of GCL as it is unrolled and deployed at the job site for uniformity, damage, and imperfections, including holes, thin spots, tears, punctures, and foreign matter.

6.1.2 Panel Placement

Quality assurance monitoring for panel placement includes:

1. Obtaining a written acceptance of the subgrade by the GCL installer.

2. Evaluating and documenting weather conditions (e.g., temperature, wind) for GCL placement and informing the construction manager if requirements for weather conditions are not met, so the construction manager can decide to stop GCL placement.

3. Monitoring and documenting GCL placement as well as conditions of panels as placed.

    a. Noting panel defects, tears or other deformities.
    b. Measuring in-place panel dimensions.
    c. Recording panel numbers.

4. Documenting that the panels have been installed in accordance with the project and manufacturer's specifications.

6.2 Documentation and Reporting

Documenting and reporting methods will be implemented to systematically record results of on-site monitoring. Reporting forms will be used for roll and panel placement.

A GCL installer's certificate of acceptance of the subgrade will be obtained prior to placement of GCL panels.

A photo log will be created containing photos of all phases of the GCL installation.

Copies of test results for all off-site laboratory testing will be forwarded to the on-site supervisor and will be made available to the construction manager. The laboratory test result documents will be maintained in a job file and submitted with the final documentation report.

7 Construction Observation - Geomembrane

The following section summarizes the quality assurance plan for testing and monitoring of the geomembrane liner installation.

7.1 On-Site Quality Assurance

7.1.1 HDPE Geomembrane

7.1.1.1 Geomembrane Rolls and Panels

Construction quality assurance monitoring for the rolls and panels include:

1. Monitoring and documenting the unloading of trucks delivering geomembrane rolls to the site.

2. Monitoring and documenting the handling and on-site storage procedures and location of geomembrane rolls.

3. Recording the manufacturing roll and batch number of geomembrane rolls delivered to the site, date of fabrication and physical dimensions.

4. Review of manufacturer's QA testing for conformance with specifications, including:

    a. Name of the manufacturer and fabricator

    b. Name and type of liner

    c. Thickness of liner

    d. Origin and identification of the raw materials

    e. Copies of quality control certificates that are issued by the producer of the raw materials.

    f. Reports of tests that are conducted to verify the quality of the raw materials, such as specific gravity, melt flow index, and percent carbon black.

5. Selecting samples from geomembrane rolls delivered to the site for off-site conformance testing. Conformance testing will be performed as outlined in Table 7-1. Samples shall be sent to a geosynthetics testing laboratory for material properties.

6. Fixing a code number to samples and recording the manufacturing numbers of the rolls from which samples are taken.

7. Labeling, packaging and shipping samples to an off-site laboratory for conformance testing.

8. Interpreting laboratory test results in accordance with the specifications and accepting or rejecting delivered rolls based on results of off-site testing.

9. Visual review and marking of the geomembrane as it is unrolled and deployed at the job site for uniformity, damage, and imperfections, including holes, cracks, thin spots, tears, punctures, blisters, and foreign matter.

Table 7-1
Material Properties, Textured HDPE Geomembrane

Property	Test Method	Units	Minimum Frequency	40 mil Acceptance Criteria	60 mil Acceptance Criteria
A. Sheet Properties					
1. Thickness (min. avg.)	ASTM D5199/ ASTM D5994	Mil	5 places per roll	38	57
a. Lowest Ind. for 8 Out of 10 Values		Mil		36	54
b. Lowest Ind. for Any of 10 Values		Mil		34	51
2. Asperity Height (min. avg.)	GRI Procedure GM12	Mil	1/100,000 ft^2 min. 1 per resin batch	15	15
3. Tensile Properties (each direction)	ASTM D638 Type IV				
a. Yield Strength		lb/in.	1/100,000 ft^2 min. 1 per resin batch	63 min.	126 min.
b. Break Strength		lb/in.	1/100,000 ft^2 min. 1 per resin batch	45 min.	90 min.
c. Elongation at Yield		%	1/100,000 ft^2 min. 1 per resin batch.	12 min.	12 min.
d. Elongation at Break		%	1/100,000 ft^2 min. 1 per resin batch	100 min.	100 min.
B. Resin Properties					
1. Melt Flow Index	ASTM D1238	g/10 min.	1/100,000 ft^2 min. 1 per resin batch	1.0 max.	1.0 max.
2. Resin Density	ASTM D1505	g/cm^3	1/100,000 ft^2 min. 1 per resin batch	0.93 min.	0.93 min.
C. Seam Properties					
1. Peel Strength (fusion)	ASTM D6392	lb/in.	1 per 500 lin ft	50 min.	90 min.
2. Peel Strength (extrusion)	ASTM D6392	lb/in.	1 per 500 lin ft	44 min.	78 min.
3. Shear Strength	ASTM D6392	lb/in.	1 per 500 lin ft	60 min.	120 min.

Property	Test Method	Units	Minimum Frequency	40 mil Acceptance Criteria	60 mil Acceptance Criteria
4. Peel Strength	ASTM D6392	%	1 per 500 lin ft	< 25%	< 25%
D. Environmental Properties					
1. Stress Cracking	ASTM D5397	hrs.	1 per each resin batch	200	200

Prepared by: MJP1
Checked by: JOS1

7.1.1.2 Panel Placement

Quality assurance monitoring for panel placement includes:

1. Obtaining a written acceptance of the subgrade by the geomembrane installer.

2. Evaluating and documenting weather conditions (e.g., temperature, wind) for geomembrane placement and informing the construction manager when weather conditions do not meet specifications, so the construction manager can decide to stop geomembrane placement.

3. Monitoring and documenting geomembrane placement as well as conditions of panels as placed.

    a. Noting panel defects, tears or other deformities.

    b. Measuring panel thicknesses at a minimum of five locations along the length of each roll.

    c. Measuring in-place panel dimensions.

    d. Recording panel numbers.

4. Recording the locations of installed panels and checking that the panels have been installed in accordance with the design plan.

    a. Assigning each panel a unique panel number and identifying that panel with the manufacturer's roll number.

    b. Recording panel numbers and locations on a panel layout diagram.

7.1.1.3 Trial Seam Testing

Items included in quality assurance monitoring of field seams include the following:

1. Monitoring trial fusion welded seams constructed prior to each seaming sequence to evaluate the seaming crew and equipment.

a. Record machine temperature, ambient temperature, machine speed, seamer identification, machine number, date and time for all trial seams.

b. Trial seams will be made at the beginning of each seaming period and at least once every four hours, for each seaming apparatus used that day. Each seamer will make at least one (1) trial seam each day. Two specimens, 1 inch wide, will be cut from each end of the trial seam (i.e., four samples total). These samples are to be field-tested for shear and peel. Two (2) peel tests will be performed on the inside and outside tracks of the weld and two (2) shear tests will be performed. Alternate shear and peel tests so both tests are performed for each end of the trial seam.

2. Evaluating and documenting trial seam test results in accordance with the specifications and accepting or rejecting seaming crews and/or equipment.

3. Evaluating and documenting the suitability of weather conditions (e.g., temperature, wind, humidity) for seaming and informing the construction manager when weather conditions do not meet the specifications so the construction manager can decide to stop geomembrane seaming.

4. Observing and documenting seaming procedures and progress.

5. Assigning a seam number to each seam and recording seam construction data, including seaming crew identification, date and time of seam construction, ambient temperature.

   a. Record the location of all seams on a seam layout diagram.

6. Confirming that the installer's field tensiometer has current calibration documentation. At a minimum, the field tensiometer shall have been calibrated within 3 months prior to start of project.

7.1.1.4 Seam Testing and Repair

Items included in the quality assurance for monitoring seam testing and repair include the following:

1. Monitoring and documenting non-destructive testing done to evaluate continuity of all field and factory-fabricated seams.

   a. Observe seam pressure tests and vacuum box tests.
   b. Mark apparent failed seams for repair.
   c. Document seam repair and retesting.

2. Selecting locations where geomembrane samples will be taken to conduct destructive testing.

   a. A minimum of one destructive test sample will be collected for every 500 lineal feet of field seam.

b. Locations of destructive test samples will be noted on a repair and sample location diagram.

3. Monitoring the cutting of samples by the geomembrane installer.

4. Assigning a unique number to each sample and recording sample locations and other pertinent observations made during sampling.

5. Monitoring the cutting of the sample in three parts: one for the geomembrane installer, one for archiving, and one for testing by the off-site laboratory.

6. Monitoring and documenting the field seam destructive tests performed by the geomembrane installer.

7. Labeling, packaging and shipping samples to the independent laboratory for destructive testing.

8. Interpreting test results and accepting or rejecting seams based on off-site laboratory testing results. Five (5) of five (5) tests per sample shall pass the minimum peel and shear requirements.

9. Monitoring and documenting patching of holes caused by sampling.

10. Monitoring and documenting the non-destructive testing of the seams associated with seam repair.

11. Monitoring and documenting the repair of the rejected seams and the non-destructive testing of the seam repairs.

    a. Document passing seam tests between all destructive test locations.
    b. Record all seam repair locations.

12. Monitoring and documenting destructive testing related to seam repair.

    a. Monitoring and documenting one destructive seam sample for every 500 lineal feet of repaired seam as described above.

7.1.1.5 Defect Repairs

The following quality assurance monitoring and testing will be implemented to monitor defect repairs:

1. Performing systematic visual observation of the entire surface of the geomembrane to locate and document defects and indicate for each defect the type of repair that is required.

2. Monitoring and recording the repair of defects and the non-destructive testing of all repairs.

3. Recording the location and the nature of all defect repairs.

7.1.1.6 Anchorage Testing

Quality assurance associated with monitoring and testing of anchor trenches shall include the following:

1. Anchor trench excavation shall be monitored for proper depth and location.

2. Geomembrane panels extending into the anchor trench shall be monitored for complete seaming within the anchor trench.

3. Anchor trench backfill operations will be observed and documented.

    a. The length of the open trench shall not exceed the amount of liner to be placed in one day.

    b. The depth of a typical anchor trench shall be documented to conform to approved project drawings.

    c. Backfill shall be placed in lifts not to exceed one foot in loose thickness.

4. Trench backfill shall consist of the soil excavated from the trench and compaction shall meet or exceed the density of the adjacent material.

7.1.2 PVC Geomembrane

7.1.2.1 PVC Panels

Construction quality assurance monitoring for the 30-mil PVC (or other approved thicknesses) for temporary cover includes:

1. Monitoring and documenting the unloading of trucks delivering geomembrane panels to the site. Factory fabricated PVC panels are typically packaged accordion folded on a sturdy wooden pallet designed for fork lift access.

2. Monitoring and documenting the handling and on-site storage procedures and location of geomembrane panels.

3. Recording the manufacturing data of geomembrane panels delivered to the site, date of fabrication and physical dimensions.

4. Review of manufacturer's QA testing for conformance with specifications, including:

    a. Name of the manufacturer and fabricator

b. Name and type of liner

c. Thickness of liner

d. Origin and identification of the raw materials

e. Copies of quality control certificates that are issued by the producer of the raw materials.

f. Reports of tests that are conducted to verify the quality of the raw materials, such as surface uniformity, nominal gauge thickness, and minimum tensile properties.

5. Selecting samples from geomembrane panels delivered to the site for off-site conformance testing. Conformance testing will be performed as outlined in Table 7-2. Samples shall be sent to a geosynthetics testing laboratory for material properties.

6. Fixing a code number to samples and recording the manufacturing (serial) numbers of the panels from which samples are taken.

7. Labeling, packaging and shipping samples to an off-site laboratory for conformance testing.

8. Interpreting laboratory test results in accordance with the specifications and accepting or rejecting delivered panels based on results of off-site testing.

9. Visual review and marking of the geomembrane as it is unrolled and deployed at the job site for uniformity, damage, and imperfections, including holes, cracks, thin spots, tears, punctures, blisters, and foreign matter.

Table 7-2
Material Properties, 30 mil PVC Geomembrane

Property	Test Method	Minimum Frequency	Specification
A. Sheet Properties			
1. Thickness (gauge, nominal)	ASTM D1593 (micrometer)	5 places per panel	30 mils min
2. Tensile Properties (each direction)	ASTM D 882		
a. Breaking Factor (lbs/inch width)		1/100,000 ft^2 min. 1 per resin batch	73 lbs/in min
b. Elongation at Break (percent)		1/100,000 ft^2 min. 1 per resin batch	380% min
c. Modulus (force) at 100% Elongation (lbs/inch width)		1/100,000 ft^2 min. 1 per resin batch.	32 lbs/in min

Property	Test Method	Minimum Frequency	Specification
B. Seam Properties			
1. PVC Peel Adhesion	ASTM D 413	1 per 3,000 lin ft (factory seams)	15 lbs/in min
		1 per 500 lin ft (field seams)	15 lbs/in min
2. PVC Bonded Seam Strength	ASTM D 882 (as modified by PGI)	1 per 3,000 lin ft (factory seams)	78 lbs/in min
		1 per 500 lin ft (field seams)	78 lbs/in min

Prepared by: MJP1
Checked by: JOS1

7.1.2.2 Panel Placement

Quality assurance monitoring for panel placement includes:

1. Obtaining a written acceptance of the subgrade (grading layer) by the geomembrane installer.

2. Evaluating and documenting weather conditions (e.g., temperature, wind) for geomembrane placement and informing the construction manager when weather conditions do not meet specifications, so the construction manager can decide to stop geomembrane placement.

3. Monitoring and documenting geomembrane placement as well as conditions of panels as placed.

    a. Noting panel defects, tears or other deformities.

    b. Measuring panel thicknesses at a minimum of five locations along the length of each panel.

    c. Measuring in-place panel dimensions.

    d. Recording panel numbers.

4. Recording the locations of installed panels and checking that the panels have been installed in accordance with the design plan.

    a. Assigning each panel a unique panel number and identifying that panel with the manufacturer's identification number.

    b. Recording panel numbers and locations on a panel layout diagram.

7.1.2.3 Trial Seam Testing (Thermal Welded Seams)

Items included in quality assurance monitoring of thermal welded field seams include the following:

1. Monitoring trial thermal welded seams constructed prior to each seaming sequence to evaluate the seaming crew and equipment.

    a. Record machine temperature, ambient temperature, machine speed, seamer identification, machine number, date and time for all trial seams.

    b. Trial seams will be made at the beginning of each seaming period and at least once every four hours, for each seaming apparatus used that day. Each seamer will make at least one (1) trial seam each day. Two specimens, 1 inch wide, will be cut from each end of the trial seam (i.e., four samples total). These samples are to be field-tested for shear and peel. Two (2) peel tests will be performed on the inside and outside tracks of the weld and two (2) shear tests will be performed. Alternate shear and peel tests so both tests are performed for each end of the trial seam.

2. Evaluating and documenting trial seam test results in accordance with the specifications and accepting or rejecting seaming crews and/or equipment.

3. Evaluating and documenting the suitability of weather conditions (e.g., temperature, wind, humidity) for seaming and informing the construction manager when weather conditions do not meet the specifications so the construction manager can decide to stop geomembrane seaming.

4. Observing and documenting seaming procedures and progress.

5. Assigning a seam number to each seam and recording seam construction data, including seaming crew identification, date and time of seam construction, ambient temperature.

    a. Record the location of all seams on a seam layout diagram.

6. Confirming that the installer's field tensiometer has current calibration documentation. At a minimum, the field tensiometer shall have been calibrated within 3 months prior to start of project.

7.1.2.4 Seam Testing and Repair

Items included in the quality assurance for monitoring seam testing and repairs include the following:

1. Monitoring and documenting non-destructive testing done to evaluate continuity of all field and factory-fabricated seams.

    a. Observe seam air channel tests and air lance tests.

b. Mark apparent failed seams for repair.
c. Document seam repair and retesting.

2. Selecting locations where geomembrane samples will be taken to conduct destructive testing.

   a. A minimum of one destructive test sample will be collected for every 500 lineal feet of field seam.

   b. Locations of destructive test samples will be noted on a repair and sample location diagram.

3. Monitoring the cutting of samples by the geomembrane installer.

4. Assigning a unique number to each sample and recording sample locations and other pertinent observations made during sampling.

5. Monitoring the cutting of the sample in three parts: one for the geomembrane installer, one for archiving, and one for testing by the off-site laboratory.

6. Monitoring and documenting the field seam destructive tests performed by the geomembrane installer.

7. Labeling, packaging and shipping samples to the independent laboratory for destructive testing.

8. Interpreting test results and accepting or rejecting seams based on off-site laboratory testing results. Four (4) of five (5) tests per sample shall pass the minimum peel and shear requirements and the average of the five tests per sample must meet the minimum requirements.

9. Monitoring and documenting patching of holes caused by sampling.

10. Monitoring and documenting the non-destructive testing of the seams associated with seam repair.

11. Monitoring and documenting the repair of the rejected seams and the non-destructive testing of the seam repairs.

    a. Document passing seam tests between all destructive test locations.
    b. Record all seam repair locations.

12. Monitoring and documenting destructive testing related to seam repair.

    a. Monitoring and documenting one destructive seam sample for every 500 lineal feet of repaired seam as described above.

7.1.2.5 Defect Repairs

The following quality assurance monitoring and testing will be implemented to monitor defect repairs:

1. Performing systematic visual observation of the entire surface of the geomembrane to locate and document defects and indicate for each defect the type of repair that is required.

2. Monitoring and recording the repair of defects and the non-destructive testing of all repairs.

3. Recording the location and the nature of all defect repairs.

7.1.2.6 Anchorage Testing

Quality assurance associated with monitoring and testing of anchor trenches shall include the following:

1. Anchor trench excavation shall be monitored for proper depth and location.

2. Geomembrane panels extending into the anchor trench shall be monitored for complete seaming within the anchor trench.

3. Anchor trench backfill operations will be observed and documented.

    a. The length of the open trench shall not exceed the amount of geomembrane to be placed in one day.

    b. The depth of a typical anchor trench shall be documented to conform to approved project drawings.

    c. Backfill shall be placed in lifts not to exceed one foot in loose thickness.

a. Trench backfill shall consist of the soil excavated from the trench and compaction shall meet or exceed the density of the adjacent material.

7.2 Documentation and Reporting

Documenting and reporting methods will be implemented to systematically record results of on-site monitoring and on-site testing. Reporting forms will be used for roll and panel placement, trial seam testing, panel seaming, non-destructive seam testing and destructive seam testing. Unique identifying numbers will be assigned to each panel and seam and used to reference the panel and seam location and test results.

A geomembrane installer's certificate of acceptance of the subgrade will be obtained prior to placement of geomembrane panels.

Panel location and seam location diagrams will be kept showing the location of all panels and seams, repairs and destructive sample test locations. These location diagrams will be updated on a daily basis and will be available for review by the construction manager.

A photo log will be created containing photos of all phases of the geomembrane liner installation, including deployment, seaming, testing, and anchor trench construction.

Copies of test results for all off-site laboratory testing will be forwarded to the on-site supervisor and will be made available to the construction manager. The laboratory test result documents will be maintained in a job file and submitted with the final documentation report.

8 Construction Observation - Miscellaneous Items

8.1 Geocomposite Drainage Layer

8.1.1 Geocomposite Rolls and Panels

Construction quality assurance monitoring for the rolls and panels include:

1. Monitoring and documenting the unloading of trucks delivering geocomposite rolls to the site.

2. Monitoring and documenting the handling and on-site storage procedures and location of geocomposite rolls.

3. Review of manufacturer's QA testing for conformance with specifications. The geocomposite and its components shall meet the property requirements stated below:

Property	Test Method	Minimum Frequency	Specifications
GEONET			
Thickness, minimum average	ASTM D 5199	15,000 lbs	200 mil
Polymer Density, minimum	ASTM D 1505	200,000 lbs	0.940 g/cc
Carbon Black Content	ASTM D 4218	15,000 lbs	2 percent
Carbon Black Disperson	ASTM D 5596	45,000 lbs	See note[1]
GEOTEXTILE			
Mass/Unit Area, minimum	ASTM D 5261	20,000 sq. yards	10 oz/sq yards
Grab Strength, minimum	ASTM D 4632	20,000 sq yards	260 lbs
Permittivity, minimum	ASTM D 4491	1.0/sec	100,000 sq. yd
AOS (095), maximum	ASTM D 4751	80 sieve	100,000 sq. yd.
GEOCOMPOSITE			
Transmissivity, minimum, including attached geotextiles[2]	ASTM D 4716	100,000 sq. yards	1×10^{-3} m^2/sec
Geonet/Geotextile adhesion[3]	ASTM D 413	100,000 sq. yards	1.0 lbs/inch

[1] Carbon black dispersion for 10 different views: 8 of 10 in Category 1 or 2; and all 10 in Category 1, 2, or 3.
[2] Manufacturing quality control transmissivity tests shall be measured using water at 20 degrees C with a gradiant of 0.1 under a normal pressure of 10,000 psf. A minimum seating period of 15 minutes shall be used.
[3] Average of five equally spaced tests across the roll width.

4. Visual review and marking of the geocomposite as it is unrolled and deployed at the job site for uniformity, damage, and imperfections, including holes, tears, punctures, and foreign matter.

8.1.2 Panel Placement

Quality assurance monitoring for panel placement includes:

1. Monitoring and documenting geocomposite placement as well as conditions of panels as placed, including the following:

a. Noting panel defects, tears or other deformities.
b. Orientation of panels as placed
c. Anchorage procedures
d. Documentation that cover materials are placed in a manner that prevents damage to the geocomposite
e. Documentation that each component of the geocomposite is secured to like components of adjacent panels

8.2 Contact Water Collection and Extraction System

Survey documentation of the contact water collection and extraction system and other pipeline systems shall be completed as described in Section 3. Any aggregate material used as gravel drainage layer, and backfill or bedding in the trench or sumps shall be sampled and tested as described in Section 4.3

All materials and equipment shall be inspected prior to construction for conformance with the specifications and for any defects and/or flaws.

All non-perforated pipe sections shall be air pressure tested following construction and backfilling. Pumps and controls shall be fully tested to assure all operational functions are working properly.

8.2.1 Installation

The CQA officer shall inspect all prefabricated structures for conformity with design specifications and for conformity with design specifications and for defective manufacturing. Additionally, the following CQA activities will be performed during contact water collection and extraction system installation:

1. Full-time observation to ensure that the underlying liner components are not damaged by collection system installation
2. Documentation that the collection pipe location and invert elevations are in accordance with project specifications
3. Documentation that pipe joining procedures are in accordance with project specifications
4. Documentation that fill materials placed around the collection piping are in accordance with project specifications
5. Documentation that the collection sump and the underlying leak detection sump are constructed in accordance with project specifications
6. Documentation that the collection and leak detection sumps' sideslope risers, associated extraction pumping equipment, and controls are installed in accordance with project specifications
7. Documentation and testing of backfilling procedures during installation of the double encased forcemain to the contact water basin.
8. Documentation that the piping is not damaged during cover material placement
9. Documentation of extraction systems, field test demonstrating system, operational readiness, including pumps, pressure meter control, values, etc.

9 Construction Observation Report

9.1 Documentation

Upon completion of the construction of each major phase and prior to placing in service, the CQA officer shall submit a documentation report to the MDEQ. This report contains, at a minimum, the following information:

- Certification by a professional engineer, registered in the State of Michigan, that, based on his/her knowledge and review of the construction records, the construction has been performed in substantial conformance with the engineering plans and specifications.
- Detailed narrative describing the construction events in chronological order and results of the quality assurance testing.
- Daily field reports prepared by the on-site CQA technician.
- Field and laboratory test data relevant to subgrade preparation.
- Field and laboratory test data relevant to installation of geosynthetic components of the liner (GCL, geomembrane, geotextile)
- Field and laboratory test data relevant to installation of the contact water collection and extraction system
- Discussion of any construction material or equipment which deviated from the engineering plans and specifications, reasons for deviation, methods to bring the deviation into compliance, and approval of deviations by the MDEQ.
- Photographs documenting all aspects of construction.
- Record drawings, sealed by a licensed professional engineer, documenting the "as constructed" elevations of the various components of the construction (± 0.5 feet), locations of field testing performed, geomembrane panel layout, and cross sections of the construction.
- Information required by Part 115, Administrative Rule 299.4921.

Appendix B

Leak Detection System
Inspection and Monitoring Forms

Leak Detection System Inspection and Monitoring Form
Kennecott Eagle Minerals Company

Inspector: _____

Date: _____

Inspection Results

Liquid in LDS Sump: _____ yes _____ no

Gallons Pumped from LDS Sump: _____

Liquid Sampled: _____ yes _____ no

Date Sampled: _____

Field pH: _____

Laboratory Sulfate Result: _____

Is the volume pumped greater than 150 gallons and the sulfate result greater than 500 mg/L? If yes, this is a reportable condition: Yes _____ No _____

Recommended Actions

Follow-up of Previously Recommended Actions

Date of Next Inspection: _____

Archive Inspection Form Until: (5 yrs from date of inspection)

Leak Detection System Inspection and Monitoring Log

Kennecott Eagle Minerals Company

Date	Liquid Present in Sump (y/n)	Field pH	Laboratory Sulfate (mg/L)	Gallons of Liquid Pumped from LDS Sump	Recommended/Implemented Actions	Initials