The Oil Mining Company, Inc. (TomCo)

Construction Permit Application

Holliday Block

Submitted by:

The Oil Mining Company, Inc.
TomCo Energy plc
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To:
Utah Division of Water Quality
288 North 1460 West
Salt Lake City, UT 84114-4870

Prepared with the assistance of:
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Sandy, UT 84093

Date: November 24, 2014

LOWHAM WALSH LLC
Engineering & Environmental Services

November 24, 2014

Dan Hall, Manager
Ground Water Protection Section
Utah Division of Water Quality
Utah Department of Environmental Quality
195 North 1950 West
P.O. Box 144870
Salt Lake City, UT 84114-4870

RE: The Oil Mining Company, Inc. Ground Water Discharge Construction Permit Application

Dear Mr. Hall,

Enclosed is a Construction Permit Application for The Oil Mining Company, Inc. (TomCo). This application is submitted to the Utah Division of Water Quality (DWQ) and is part of a revision to TomCo's Ground Water Discharge Permit (GWDP) application, originally submitted to DWQ February 14, 2014. Additional revised pages for the GWDP application will be submitted under separate cover.

Please review the enclosed Construction Permit application, making note of the enclosed request for confidentiality. Feel free to call me at 801-561-1036 (o) or 307-349-3499 (c), or send me an email with any questions.

Sincerely,

Marit Sawyer

Marit Sawyer, Project Manager
LOWHAM WALSH, LLC

Encl: TomCo Construction Permit, with confidentiality letter from Ronald N. Vance Associates, P.C.
Xc: Paul Rankine – TomCo
Jason Moretz – Lowham Walsh Engineering and Environmental Services LLC
Fran Amendola – Option A Environmental Consultants

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November 13, 2014

Dan Hall, Manager
Ground Water Protection Section
Utah Division of Water Quality
Utah Department of Environmental Quality
195 North 1950 West
P.O. Box 144870
Salt Lake City, UT 84114-4870

Subject: The Oil Mining Company Inc., Ground Water Discharge Construction Permit Application - Proprietary and/or Business Confidential

Dear Mr. Hall:

The Oil Mining Company Inc. ("TomCo") is submitting the enclosed Construction Permit application for your review and approval as part of its Ground Water Discharge Permit ("GWDP") application, submitted to the Utah Division of Water Quality ("UDWQ") on February 14, 2014. A revised GWDP application will be submitted under separate cover.

The enclosed Construction Permit application includes specifications and drawings that contain proprietary and confidential information and data. TomCo submits this application with the understanding that this information shall be managed as proprietary and confidential by UDWQ. Drawings, information, and/or data considered to have proprietary or confidential information have been stamped with the words "confidential business information" in accordance with R317-8-3.3.

Further, this letter serves as a statement of reasons supporting TomCo's confidentiality claim. Utah's Government Record Access and Management Act ("GRAMA") provides that certain records including "trade secrets" as defined in Utah's Uniform Trade Secrets Act can be protected from public disclosure (Utah Code Section 63G-2-305). TomCo has followed the requirements under Utah Law to preserve the confidentiality of the EcoShale™ In-Capsule Technology and related processes to be used at the site in the attached application. The company's trade secrets and commercially-sensitive information are stamped "confidential" and TomCo requests that UDWQ preserve this confidence. *See* Utah Code Section 63G-2-309.

A "trade secret" is defined in Utah's Uniform Trade Secrets Act to include information such as formulae, patterns, techniques or processes where the owner or operator derives independent economic value from its secrecy and takes steps to protect the secret (Utah Code Section 13-24-2). The text marked as confidential in the application refers to such proprietary and confidential information. These trade secrets are independent from trademarks which have been filed by the originator of this technology, Red Leaf Resources, Inc. (Red Leaf), in the United States and internationally. TomCo has entered into a Licensing Agreement with Red Leaf, which subjects TomCo to keep confidential the EcoShale™ In-Capsule Technology and public disclosure of this technology would put TomCo in breach of its agreement with Red Leaf.

Commercial information is subject to protection if "disclosure of the information could reasonably be expected to result in unfair competitive injury to the person submitting the information" and the company's interest in protecting its information exceeds the public's interest in obtaining access to it (Utah Code Section 63G-2-305(2)). TomCo is subject to confidentiality agreements and has protected its processes under trademark and trade secret law. The UDWQ has been allowed to review the protected process under the terms of GRAMA. Therefore, this information should be protected from public disclosure, subject to restricted government review for environmental compliance.

Should you have any questions about this application or if additional information is required, please feel free to contact me directly.

Sincerely,

Ronald Vance

Encl: TomCo Construction Permit Application

cc: Paul Rankine – TomCo Energy plc
Marit Sawyer – Lowham Walsh LLC

Utah Ground Water Discharge Construction Permit Application for The Oil Mining Company, Inc. Holliday Block

Background

The Oil Mining Company, Inc. (TomCo) submitted a Ground Water Discharge Permit (GWDP) application on February 14, 2014 to the Utah Division of Water Quality (DWQ). DEQ prepared comments regarding this application dated April 29, 2014. This Construction Permit (CP) Application partially addresses DWQ's comments, while remaining comments will be submitted with a revised GWDP application under separate cover. It provides engineering design plans and specifications for the Early Production System (EPS) capsule. Some of the information in this CP application is confidential as it contains trade secrets relating to the Eco-Shale™ In-Capsule Technology as defined in Utah Code Section 13-24-2. In order to facilitate the public's understanding of the EPS design, generalized graphics and public-review versions of some of the specification documents are provided in **Section 1** of this CP application, while detailed specifications and design drawings containing trade secret information are contained in the confidential **Section 2** of this document.

This CP application closely follows Red Leaf Resources' (Red Leaf's) CP application, which owns the rights to the Eco-Shale™ In-Capsule Technology and from whom TomCo has acquired a licensing agreement. Below is a list of the drawings and technical specifications contained in this CP application, followed by a brief discussion of these items.

<u>**Section 1 (available for public review)**</u>

Technical Specifications, Design Documents (title, author, report number)

- Fill materials – Hatch – H335458-0310-15-123-0001 (with redactions to protect confidential information)
- Geomembrane Technical Specification – Hatch – H335458-0310-15-123-0002
- Technical Specification: Liquid Collection System-Floor Pan –Red Leaf Resources – RLSR_MCC_01_TSP_0003
- Geosynthetics Technical Specification – Hatch – H335458-0310-14-123-0004
- Field Scale Hydraulic Conductivity Evaluation of Compacted Bentonite Amended Soil by Sealed Double Ring Infiltration Testing – IGES – 01109-018 (with redactions to protect confidential information)

EPS Capsule Drawings

- Capsule Cross-section
- Bulkhead Cross-section
- Options Bulkhead Cross-section

<u>**Section 2 (confidential specifications and detailed design drawings)**</u>

EPS Capsule Drawings, Detailed (title, author, drawing number)

- EPS Project Containment System Overview – Red Leaf – RL-EPS-W-0001
- EPS Project Containment System Cross Sections – Red Leaf – RL-EPS-W-0002
- EPS Project Containment System Details – Red Leaf – Drawing Number: RL-EPS-W-0003

- EPS Project Containment System Monitoring Bulkhead & Sampling Overview – Red Leaf – RL-EPS-W-0004

Discussion

Design

Bentonite amended soil (BAS) is the primary barrier designed to prevent water from infiltrating into the capsule. A BAS layer envelops the capsule and is used in the roof, walls, and floor. Geotextile, geogrid, and geomembrane materials are included in the design to ensure geotechnical performance of the BAS during operation for purposes other than water protection. Gravel and earth fill materials are placed as thermal insulation to protect the BAS during operation. Other materials are used for capsule walls and cover (See EPS Capsule Drawings in Section 1).

EPS Monitoring

The following monitoring approaches are provided in the capsule to evaluate oil production, detect potential leaks, and evaluate EPS capsule performance. These are discussed briefly below:

- Collection Pan
- Lower Containment Layer
- Bedrock Under Capsule

Collection Pan: A drain used during operation to collect oil will be used following operations to monitor and evaluate any additional liquids that may reach the collection pan after the heating and cooling process is complete.

Lower Containment Layer: Piping will be placed below the lower containment layer to capture, convey and monitor any liquids that may reach the lower BAS liner. Any liquids encountered would flow to the bulkhead where they would be captured in pipes and evaluated.

Bedrock Under Capsule: A drain will be constructed between the bedrock foundation and the bottom of the capsule. Any liquids encountered would flow to the bulkhead where they would be captured and evaluated. This drain and the piping placed below the Lower Containment layer may be combined.

Drawings

General drawing of the EPS capsule are included in Section 1. Detailed construction drawings of the capsule, walls, oil collection pan, piping, and sampling points are confidential and provided in Section 2.

Specifications

The Standard Technical Specification for Fill Materials outlines standard tests, material descriptions, mixing and placement, and quality control standards related to fill materials for the capsule.

The Standard Technical Specifications for the Geomembrane Liner and Geosynthetics addresses materials to be used, site preparation, installation, cover material specifications, and repair methods, should repairs be needed, for geomembrane and geosynthetic materials used in capsule construction.

The Standard Technical Specification for the Liquid Collection System addresses the purpose of mechanical design limits, installation, and quality control standards associated with the floor pan that will be installed below the ore layer.

A report from IGES regarding BAS testing using a sealed double-ring infiltrometer is also included. Testing shows low hydraulic conductivity of BAS.

Technical Specifications and Reports

Standard Technical Specification

Fill Materials

H335458-0310-15-123-0001

PROFESSIONAL ENGINEER
No. 291095
DAN M.
ISOM
10/02/2014
ELECTRONIC SEAL
STATE OF UTAH

2014-09-23	0	Approved for Use	G. Qu	S. Hinchberger	D. Stanger	M. Emett
DATE	REV.	STATUS	PREPARED BY	CHECKED BY	APPROVED BY	APPROVED BY
				Discipline Lead	Engineering Manager	Client

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Disclaimer

This Specification has been prepared by Hatch Ltd. for the sole and exclusive use of Red Leaf Resources Inc. (the "Client") for the purpose of assisting the Client in making decisions with respect to the Seep Ridge EPS Project and shall not be (a) used for any other purpose, or (b) provided to, relied upon or used by any third party.

This Specification contains opinions, conclusions and recommendations made by Hatch Ltd. (Hatch), using its professional judgment and reasonable care. Any use of or reliance upon this report by the Client is subject to the following conditions:

- The Specification being read in the context of and subject to the terms of the agreement between Hatch and the Client dated June 2nd, 2014 (the "Agreement"), including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions that were specified or agreed therein;
- The Specification being read as a whole, with sections or parts hereof read or relied upon in context;
- The conditions of the site may change over time (or may have already changed) due to natural forces or human intervention, and Hatch takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this specification; and
- The Specification is based on information made available to Hatch by the Client or by certain third parties; and unless stated otherwise in the Agreement, Hatch has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith.

1. General

1.1 Introduction

1.1.1 Red Leaf Resources is planning on implementing the Seep Ridge early production stage (EPS) project located 75 miles south of Vernal, Utah, using its proprietary EcoShale technology. The EcoShale process uses large clay-lined capsules located near the mine for extracting the oil from rubblized shale.

1.2 Scope

1.2.1 The work to be done under this section consists of the minimum requirements for the supply of labour, plant, material, supervision and the performance of all Work necessary to :

(a) produce or supply, transport and stockpile fill materials and,

(b) load, transport, place, spread and compact fill materials as shown on the Drawings and as specified herein.

1.2.2 The fill materials do not include the pay zone materials, such as shale bed ore and pipe bed materials within the capsule, which are specified in Reference 2 as shown in Section 1.3.

1.2.3 Approvals, acceptability, and/or definitions related to this specification shall be made by the Owner's Engineer. The Owner's Engineer reserves the right to revise, update, or alternate these material specifications to comply with environmental and performance requirements. The Owner's Engineer may also specify similar, revised, or replacement methods/standards of those stated in this specification.

1.3 Standards and Reference

1.3.1 The Work covered under this section shall be done in accordance with the following standards:

Table 1: Summary of Test Standard

Test	Test Method	Title of Test
Standard Proctor Test	ASTM D-698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
Modified Proctor Test	ASTM D-1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
Moisture Content Test	ASTM D-2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
Density Test	ASTM D-7263	Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens

Test	Test Method	Title of Test
In-Situ Density and Water/Hydrant Content Test Note 1	ASTM D-6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods
Particle Size Test (Sieve Analysis)	ASTM D-6913	Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
Particle Size Distribution Test (Hydrometer Analyses)	ASTM D-422	Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants Or Standard Test Method for Particle-Size Analysis of Soils
Particle Size Distribution Test for Fill with Large Particles	ASTM D-5519	Standard Test Method for Particle Size Analysis of Natural and Man-made Rip Rap Materials.
Hydraulic Conductivity Test	ASTM D-5084	Hydraulic Conductivity of Saturated Porous Material Using a Flexible Wall Permeameter
Specific Gravity Test	ASTM D-854 (include all materials passing the 3/8" sieve), or Water Pycnometer Test	Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
Organic Matter Test	ASTM D-2974	Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
Water Replacement Test for Density	ASTM D-2167 (particle size < 1-1/2") or ASTM D-5030 (large particle size)	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method, or Standard Test Methods for Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit.
Sand-Cone Test for Density	ASTM D-1556	Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
Fine Material Test	ASTM D-1114	Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75-μm) Sieve
LL,PL, and PI Test	ASTM D-4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
CU Triaxial Test	ASTM D-4767	Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soil
Gas Permeability Test	JWBA Report (Ref.13)	Gas Permeability Test
MB Test Note 2	Alther, 1983 (Ref. 12)	Methylene Blue Test for Bentonite

Notes:
1. Calibration and correction shall be performed for all fills containing shale aggregate.
2. Calibration and correction may be required for all fills containing shale aggregate

1.3.2 The following references are used in this specification.

1. Early Production System (EPS) Quality Process Guideline, 408037-000-QA-REF-0001.
2. Hatch, 2014, H335458-0300-05-123-0001 Capsule Ore Bed and Margin – Fill Material Specifications – Process Requirements.
3. Hatch, 2014, H335458-0310-15-124-0005 Construction Quality Assurance Plan for Fill Materials.
4. Hatch, 2014, H335458-0000-50-123-003, Bulkhead Installation Specification.
5. Hatch, 2014, H335458-0000-50-123-0030 Oil Collection Pan Installation Specification.
6. Hatch, 2014, H335458-0000-60-123-0053 Cooling, Oil Collection and BAS Monitoring Pipes Installation and Welding Requirements.
7. Hatch, 2014, H335458-0000-60-123-0053 Double walled heat pipe and gas collection pipe installation specification.
8. Hatch, 2014, H335458-0000-60-123-0051 In-Capsule Gas collection pipe Fabrication and installation specification.
9. Hatch, 2014, H335458-0000-60-123-0056 In-Capsule Heating Pipe installation specification.
10. Hatch, 2014, H335458-0310-15-123-0002 Geomembrane Specification.
11. Hatch, 2014, H335458-0310-15-123-0004 Geosynthetics Specification.
12. G.R. Alther, 1983, The Methylene Blue Test for Bentonite Liner Quality Control, Geotechnical Testing Journal, Vol. 6, No.3, pp128-132._
13. JWBA Inc., March, 20, 2014, BAS Gas Permeability Testing –Final Report by Jim Bunger.

1.4 Definitions

1.4.1 **Owner**: Red Leaf Resources, Inc. (Red Leaf).

1.4.2 **Owner's Engineer**: Owner's engineer shall be appointed by Red Leaf. Identification of the Owner's Engineer shall be documented in writing.

1.4.3 **Contractor**: Refers to the company supplying labour, materials and equipment as well as performing the work necessary, as per this Section.

1.4.4 **Transport:** The work necessary to haul materials from the mine or quarries to stockpiles and then to site locations where such materials will be placed.

1.4.5 **Drawings:** The drawings issued for construction.

1.4.6 **Ore Grade:** For the purpose of this specification, ore grade refers to the gallons of oil per ton in the ore as determined from retort compression tests and Modified Fischer Assay tests.

1.4.7 **High Pay Material:** A native shale material with an average ore grade exceeding 10 gallons per ton.

1.4.8 **Low Pay Material:** A native shale material with an average ore grade below 10 gallons per ton.

1.4.9 **Testing Organization:** A qualified independent geotechnical testing company retained to perform field quality-control testing.

1.4.10 **Lot:** A portion of the material or section of the work that has been constructed or produced under essentially uniform conditions during the same shift or batch and contains material of essentially uniform quality and composition.

1.4.11 **Run of Mine:** Rock fill material produced from normal drill and blast mining operations.

1.4.12 **BAS (Bentonite Amended Soil):** An engineered soil mixture consisting of crushed and screened low grade shale, bentonite and water.

1.4.13 **GBAS (Glycerine and Bentonite Amended Soils):** An engineered soil mixture consisting of crushed and screened low grade shale, bentonite and a water-glycerine mixture.

1.4.14 **Matrix Soil:** Consists of the crushed screened low grade ore that is to be mixed with bentonite and water to create BAS or bentonite and water-glycerine to create GBAS.

1.4.15 **Choking Layers:** Layers of 3/8 inch minus (if required) and 1 inch minus aggregate materials that are used to fill the voids in large rock fill layers to create a smooth and uniform surface.

1.4.16 **Convective Barrier:** A zone of granular material with sufficient particle size and pore size distribution to retard convective heat flow within that material.

1.4.17 **SPMDD:** Standard Proctor Maximum Dry Density.

1.4.18 Well Graded: The fill has a good representation of particle sizes over a wide range, and its gradation curve is smooth and generally concave upward. The coefficient of uniformity shall be over than 4 and the coefficient of curvature shall be between 1 and 3, or as acceptance by the Owner's Engineer.

1.4.19 **Water (Hydrant) Content:** The ratio of water (hydrant) mass over the dry mass of aggregate.

1.4.20 **Natural Water Content:** The water content naturally in fill without any additional work including drying or adding water.

1.4.21 **W_{OPT}:** Optimum Water/Hydrant Content, obtained from Proctor tests, and defined as the ratio of water/hydrant mass over the dry mass of aggregate.

1.4.22 **Inert Material:** Material containing no kerogen and minimal organic in order to tolerate high temperatures without being retorted and/or broken down.

2. Materials

2.1 General

Proprietary - Confidential Business Information

Table 2: Fill Material Summary

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.2 Type 1 Fill

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

Figure 2: Illustration of Acceptable Zone for Compaction of Type 1 and 2 Fill

Note: The saturation line is dependent on the specific gravity of aggregate and hydrant. The shape of the acceptable zone may be different as per the specified limit in Table 5.

2.3 Type 2 Fill *Confidential*

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.4 Type 3 Fill *Confidential*

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.5 Type 4A Fill *Confidential*

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.6 Type 4D and 4W Fill

Confidential

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.7 Type 5 Fill *Confidential*

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.8 Type 6 Fill *Confidential*

Proprietary - Confidential Business Information

2.9 Type 7 Fill

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.10 Type 8A and 8B Fill

Confidential

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.11 Type 8C Fill *Confidential*

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

2.12 Type 9 Fill

Confidential

Proprietary - Confidential Business Information

2.13 Silty Loam

Proprietary - Confidential Business Information

2.14 Bentonite

2.14.1 Bentonite will be required to produce Type 1 and 2 Fills. The Bentonite shall have high swelling and ultra-low permeability. Confidential Confidential

Proprietary - Confidential Business Information

2.15 Glycerine

Proprietary - Confidential Business Information

2.16 Water

Water for mixing with bentonite Confidential shall be clean and free from deleterious amounts of soil, and satisfy the requirement specified in Table 18, or as accepted by the Owner's Engineer.

Proprietary - Confidential Business Information

3. Execution

3.1 Storage

Proprietary - Confidential Business Information

3.2 Blending

Proprietary - Confidential Business Information

3.3 General Fill Placement

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

3.4 Types 1 and 2 Fills - Soil Mixing

Proprietary - Confidential Business Information

3.5 Type 1 and 2 Fills - Compaction

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

3.6 Type 4 Fill – Compaction

Proprietary - Confidential Business Information

3.7 Type 5 Fill – Placement

Proprietary - Confidential Business Information

3.8 Type 6 Fill – Compaction

Proprietary - Confidential Business Information

3.9 Type 7 Fill – Placement and Compaction

Proprietary - Confidential Business Information

3.10 Type 8A Fill –Compaction

Proprietary - Confidential Business Information

3.11 Type 8B – Soil Mix and Compaction

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

3.12 Type 8C– Placement

Proprietary - Confidential Business Information

3.13 Type 9 – Placement

Proprietary - Confidential Business Information

3.14 Choking Layers

Proprietary - Confidential Business Information

3.15 Site Tolerances

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

4. Quality Control

4.1 General

4.1.1 Reference 1 in Section 1.3 shall be used for direction on addressing quality processes and documentation of materials and equipments, from procurement through final installation.

4.1.2 The Owner's Engineer will establish direct and continuous quality control over fill materials throughout the period of construction and shall provide guidance on definitions, provide approvals, and make necessary determinations for completion of requirements outlined in this specification. The documentation requirement and sample custody shall follow Reference 3 in Section 1.3.

4.1.3 The Contractor shall provide a mobile testing facility to enable testing of the fill materials, including, but not limited to, grain size distribution and moist content. Other tests may be added and specified by the Owner's Engineer.

4.1.4 The Owner or the Owner's Engineer may delegate a Testing Organization to undertake third party testing to ensure conformance with these specifications.

4.1.5 If a third-party Testing Organization is used, the Contractor shall coordinate and cooperate with the Testing Organization to allow the sampling and testing of fill material as well as the use of the Contractor's mobile test facility.

4.1.6 The results of all testing shall be submitted to the Owner's Engineer and no lift shall be covered by a succeeding lift until it has been accepted by the Owner's Engineer.

4.1.7 The Contractor shall excavate test pits in Type 1 and/or Type 2 Fills as deemed necessary by the Owner's Engineer for inspection. The location of the test pits shall be designated by the Owner's Engineer and they shall be a minimum of 3 ft deep with side slopes not steeper than 1H: 1V. The total number of test pits required will not exceed 10. All test pit excavation shall be backfilled and compacted with materials as required by the Owner's Engineer.

4.1.8 Sampling/test location patterns shall be developed prior to conducting the test program. The grid pattern procedure is recommended to suit the construction plan and procedure. In addition, no sampling point is to be located within 5 ft of another sampling point.

4.2 *In Situ* Density and Moisture Content

4.2.1 In situ density and moisture content measurements shall be performed according to ASTM D-6938 with calibration and correction made to account for the shale aggregate (kerogen) and glycerine if applicable.

4.2.2 Within each lift, perform one density and moisture content test as per the requirement in Table 19, or as approved by the Owner's Engineer.

Table 19: Recommended Minimum *In-situ* Tests

Test	Recommended Test Method	Minimum Testing Frequency (Note 1) Type 1 and 2 Fills in Floor or Roof	Type 1 and 2 Fills in Side Walls	Type 4 Fill (if compaction required)	Type 5 Fill (Note 5)	Type 8A and 8B Fills	Type 8C Fill (Note 5)
Rapid In-situ Moisture and Density Test (Note 2)	ASTM D -6938 or equivalent	4 per 1000 yd^3 or 1 per 10,000 sq. ft/lift or 4 tests per material lot, whichever is greatest	8 per 1000 yd^3 or 5 per 1000 ft/lift, whichever is greater	2 per 1000 yd^3 in floor and roof. 4 per 1000 ft/lift in side wall.	1 per 2000 yd^3	2 per 1000 yd^3 or 4 per 1000 ft/lift, whichever is greater	1 per 2000 yd^3 or 10 tests, whichever is greater.
Laboratory Moisture Content Test (Note 3)	ASTM D-2216	One in every 10 rapid in-situ moist and density tests. (Not applicable for Type 2 Fill)	One in every 10 rapid in-situ moist and density tests. (Not applicable for Type 2 Fill)	One in every 10 rapid in-situ moist and density tests.	One in every 10 rapid in-situ moist and density tests or 1 test per source, whichever is greater.	One in every 10 rapid in-situ moist and density tests or 3 tests, whichever is greater.	One in every 10 rapid in-situ moist and density tests or 1 test per source, whichever is greater.
In-situ Density Test (Note 4)	ASTM D-2167 ASTM D-1556 ASTM D-5030	One in every 20 rapid in-situ moist and density tests	One in every 20 rapid in-situ moist and density tests	One in every 20 rapid in-situ moist and density tests	One in every 10 rapid in-situ density tests.	One in every 10 rapid in-situ moist and density tests or 3 tests, whichever is greater.	One in every 10 rapid in-situ density tests or 3 tests, whichever is greater.
Number of Passes	Observation	2 per 1000 yd^3	2 per 1000 yd^3	2 per 1000 yd^3	Not Applicable	2 per 1000 yd^3	Not Applicable
Construction Oversight	Observation	Continuous	Continuous	Continuous	Continuous	Continuous (including homogeneous mix for TY 8B)	Continuous

Notes:
1. Additional tests should be performed in the areas for which QA personnel have reason to suspect inadequate compaction
2. The test refers to a nuclear method. Any other equivalent shall be accepted by the Owner's Engineer. The depth of measurement shall be 6" and 12". In addition, at least one test should be performed each day the soil is compacted.
3. Every tenth sample tested with the rapid in-situ moisture test should be also tested by the laboratory test to aid in identifying any significant, systematic calibration errors.
4. This test shall be performed (as close as possible to the same location of the rapid in-situ test) with the sand cone or water replacement to aid in identifying any significant, systematic calibration errors.
5. For Type 5 and 8C Fills, the density shall be checked by tracking truck loads into capsule using ground scale and surveying the volume. Spot check shall be performed using a full truck load for minimum 3 tests.

4.3 Material Tests

4.3.1 Tests shall be performed at a rate that complies with Table 20, or as approved by the Owner's Engineer.

Table 20: Recommended Materials Tests

Parameter	Fill Materials	Test	Minimum Test Frequency
Percent of Fines	Type 1 and 2	ASTM D-1140	For the capsule floor and roof, 1 per 1000 yd^3 or 1 per 20,000 sq ft/lift or when fill conditions changes, whichever is greatest
			For the capsule side walls, 2 per 1000 ft/lift or when fill conditions changes, whichever is greatest
Percent of Bentonite	Type 1 and 2	Methylene Blue Test (Alther, 1983) or Equivalent*	For the capsule floor and roof, 1 per 1000 yd^3 or 1 per 20,000 sq ft/lift or when fill conditions changes, whichever is greatest
			For the capsule side walls, 2 per 1000 ft/lift or when fill conditions changes, whichever is greatest
Particle Size Distribution (PSD)‡	Type 1, 2, 3, 4, 8A, and 8B	ASTM D-6913 (or ASTM D-422 as required by the Owner's Engineer)	For the capsule floor and roof, 1 per 2000 yd^3 or 1 per 40,000 sq ft/lift, or 1 per source, whichever is greatest
			For the capsule side walls, 1 per 1000 ft/lift, or 1 per source, whichever is greatest
	Type 5 and 8C	ASTM D-6913 or Wipfrag** or equivalent*	1 per 5000 yd^3 or 1 per source, whichever is greater
	Type 7 and 9	Wipfrag** or equivalent*	3 per source
	Bentonite	ASTM D-422	1 per 10,000 yd^3 or 1 per source, whichever is greater
Specific Gravity	Type 3, 4 (4A,4W,4D), 5, 8 (8A, 8B†, 8C), Bentonite	ASTM D-854 (include all materials passing the 3/8" sieve), or Water Pycnometer Test	1 per PSD test or 1 per shipment, whichever is greater

Parameter	Fill Materials	Test	Minimum Test Frequency
Proctor Test	Type 1, 2, 4, 8A and 8B†	ASTM D-698 (or ASTM D-1557 as required by the Owner's Engineer)	1 per 10,000 yd^3 or 1 per source, whichever is greater
Liquid and Plastic Limit	Type 1 and 2, Bentonite	ASTM D-4318	1 per 10,000 yd^3 or 1 per source, whichever is greater
Oil Grade	Type 3, 4D, 4W, 5	Modified Fischer Assay	1 per 10,000 yd^3 or 3 per source, whichever is greater
Hydraulic Conductivity/ Gas Permeability/ CU Triaxial Test***	Type 1 and 2	ASTM D-5084 /Non-Standard /ASTM D4767	Sampling frequency: 1 per 1000 yd^3 or 1 per 20,000 sq ft / lift, whichever is greater

Notes:

*:Equivalent method(s) shall be accepted by the Owner's Engineer.

**: For wipfrag or equivalent image analysis software, minimum 10 qualified images shall be taken or as many as necessary for statistical accuracy for each analysis.

***:The Shelby tube sampling shall be performed as per specified frequency for potential testing. The actual test frequency shall be directed by the Owner's Engineer.

†: The specified test for Type 8B shall be performed on its aggregate (Type 8A) instead of the mix with cement.

‡: PSD shall be measured for samples taken after placement. To assess degradation, PSD may be measured on the samples right after production or as directed by the Owner's Engineer.

END OF SECTION

Appendix A
Mix Design Illustration for BAS and GBAS

(Remaining Text is Confidential)

Proprietary - Confidential Business Information

Proprietary - Confidential Business Information

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Standard Technical Specification

Geomembrane - Technical Specification

H335458-0310-15-123-0002

PROFESSIONAL ENGINEER
No. 291095
DAN M. ISOM
10/02/2014
ELECTRONIC SEAL
STATE OF UTAH

2014-09-23	0	Approved for Use	G. Qu	S. Hinchberger	D. Stanger	M. Emett
DATE	REV.	STATUS	PREPARED BY	CHECKED BY	APPROVED BY	APPROVED BY
				Discipline Lead	Engineering Manager	Client

Table of Contents

Disclaimer

This Specification has been prepared by Hatch Ltd. for the sole and exclusive use of Red Leaf Resources Inc. (the "Client") for the purpose of assisting the Client in making decisions with respect to the Seep Ridge EPS Project and shall not be (a) used for any other purpose, or (b) provided to, relied upon or used by any third party.

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1. General

1.1 Scope

1.1.1 This section covers the manufacturing, supply and installation of a geomembrane liner for the Red Leaf Experimental Oil Shale Capsule Project as shown on the Drawings and described herein.

1.1.2 Contractor shall furnish, install and test the geomembrane liner in accordance with this Specification and subject to the terms and conditions of the manufacturer's requirements.

1.1.3 The following sections cover Subgrade Preparation, Sheet Specifications, Liner Installation, Cover Material requirements, Inspection and Quality Control, and Manufacturer, Fabricator, Installation Qualification.

1.2 Qualifications

1.2.1 Manufacturer and Installer shall be competent and experienced in the production and installation of geomembrane and liners sector with at least five years continuous experience in the manufacturing and installation. These parties shall have at least ten million square feet of acceptable manufacturing and installation experience.

1.2.2 Installation Supervisors must have worked on similar capacity on projects including similar size and complexity to the project as described in the Contract Documents.

1.2.3 Installer shall provide a minimum of one Master Seamer for the Work with a minimum of ten million square feet of geomembrane installation experience and associated seaming work using the type of seaming apparatus proposed for this Project.

1.3 Reference and Standards

1.3.1 Fill Materials Specification, Hatch, Doc. H335458-0310-15-123-0001.

1.3.2 Geosynthetic Specification, Hatch, Doc. H335458-0310-15-123-0004.

1.3.3 Early Production System (EPS) Quality Process Guideline, 408037-000-QA-REF-0001.

1.3.4 Bulkhead Fabrication and Installation Specification, Hatch, H335458-0000-50-123-0029.

1.3.5 Pertinent provisions of the following American Society for Testing and Materials (ASTM) Standards shall apply to the Work:

- D 570-98 – Standard Test Method for Water Adsorption of Plastics.
- D 638-98 - Test Method for Tensile Properties of Plastics.

- D746-13 – Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
- D751-06 – Standard Test Methods for Coated Fabrics.
- D882-12 – Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
- D 1004-94a - Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
- D1044-13 – Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion.
- D1149-07 – Standard Test Methods for Rubber Deterioration-Cracking in an Ozone Controlled Environment.
- D1203-10 – Standard Test Methods for Volatile Loss from Plastics using Activated Carbon Methods.
- D 1204-94 - Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperatures.
- D 1238-98 - Test Methods for Flow Rates of Thermoplastics by Extrusion Plastometer.
- D 1505-98 - Test Method for Density of Plastics by the Density-Gradient Technique.
- D1693-13 – Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
- D2136-02 – Standard Test Method for Coated Fabrics – Low Temperature Bend Test.
- D 4218-96 - Test Method for Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
- D 4437-84 (1998) - Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
- D 4833-88 (1996) - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
- D4873-02 – Standard Guide for Identification, Storage and Handling of Geosynthetic Rolls and Samples.
- D 5199-98 - Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
- D 5514-94 - Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics.

- D 5596 – Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
- D 5617-94 - Test Method for Multi-Axial Tension test for Geosynthetics.
- D 5596-94 - Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
- D5641-94 – Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
- D6392-12 – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced using Thermo-Fusion Methods.
- D6693 – Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.
- D6747-12 – Standard Guide for Selection of Techniques for Electrical Detection of Leaks in Geomembranes.
- D7007-09 – Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials.
- D7240-06 – Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique.
- D7700-12 – Standard Guide for Selecting Test Methods for Geomembrane Seams.
- D7872-13 – Standard Practice for Use of an Electrically Conductive Geotextile for Leak Location Surveys.
- D7865-13 – Standard Guide for Identification, Packaging, Handling, Storage and Deployment of Fabricated Geomembrane Panels.

1.3.6 Pertinent provisions of the following Geosynthetic Research Institute (GRI) publications have been utilized:

- GRI GM 13 Test Methods, Test Properties, Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.

1.4 Definitions

1.4.1 **Owner**: Red Leaf Resources, Inc. (Red Leaf).

1.4.2 **Owner's Engineer:** Owner's engineer shall be appointed by Red Leaf. Identification of Owner's engineer shall be documented in writing.

1.4.3 **Contractor**: Refers to the company supplying labor, materials and equipment and performing the work necessary as per this Section.

1.4.4 **Liner Installer:** Refers to the subcontractor assigned to install the geomembrane liner.

1.4.5 **Quality Control and Assurance Plan for Geomembrane:** Document to be provided by Liner Installer that meet or exceed the specification in GRI GM 13 and this specification.

1.4.6 **Lot:** A quantity of resin used in the manufacture of geomembranes. Finished rolls will be identified by a roll number traceable to the resin lot used.

1.4.7 **Manufacturer:** The party responsible for manufacturing the geomembrane rolls.

1.4.8 **Panel:** Unit area of a geomembrane that will be seamed in the field and is larger than 100 ft^2 (9.3 m^2).

1.4.9 **Patch:** Unit area of geomembrane that will be seamed in the field and is smaller than 100 ft^2 (9.3 m^2).

1.4.10 **Subgrade Layer:** Soil layer which immediately underlies the geosynthetic material(s).

1.5 Submittals

1.5.1 Contractor shall provide a manufacturer's certificate warranting compliance with these Specifications. The certificate shall identify the liner material, quantity, batch number and date of manufacture.

1.5.2 Contractor shall submit samples of the proposed liner material to the Owner's Engineer with manufacturer's literature including minimum average roll values and expected average roll values of the physical properties of the geomembrane liner for information.

1.5.3 Manufacturer and Installer are required to provide a list of references detailing their relevant project experience.

1.5.4 Liner Installer shall submit to the Owner's Engineer the qualification of its welding personnel to perform the work and tested sample results from each welder and welding machine prior to commencement of the work.

1.5.5 Liner Installer shall submit to the Owner's Engineer his proposed work plan for installation of the liner including sizes for the factory assembled panels and an Installation Layout Drawing showing the sequence of installation including field seams, details and the quantity of membrane in square yards.

1.5.6 Liner Installer shall be responsible for providing Quality Control and Assurance. As such, submit to the Owner's Engineer a proposed Quality Control and Assurance Plan that meet or exceed the specification in GRI GM 13 (Section 1.3). The plan should include calibration of test equipment, mechanical tests on membrane materials, field and factory patches and seams, and undertaking leak detection tests on installed liner materials.

1.5.7 Liner Installer shall submit a construction completion report no later than 14 days after completion of the liner installation. The report shall include:

1. Daily weld property average reports containing: Date of weld; Location of Weld; Welding machine number; Welder's name; Test sample numbers and locations; Test sample results; Weld temperatures; Documentation and locations of repairs; and Air temperatures and weather conditions.
2. As built Drawings.

2. Materials

2.1 Sheets

2.1.1 No rework or scrap material shall be used in the manufacturing process of the geomembrane sheets.

2.1.2 The sheeting shall be free of die lines, gels, streaks, blisters, contaminants, agglomerates, poorly dispersed ingredients, pinholes or other manufacturing defects.

2.1.3 All sheets shall be free from holes, tears, scratches, cracks, creases or any handling damage. The edges of the sheeting are to be free of nicks and cuts visible to the unaided eye.

2.1.4 The maximum sheet temperature at roll wind-up shall be 95 degrees Fahrenheit (35 degrees Celsius). The minimum inside roll diameter shall be 6". Rolls should be wound up with less than 1" +/- telescoping.

2.1.5 Sheets shall lay flat when rolled out with a minimum amount of curl or waves on edge. Sheets shall be straight and not curve or wander.

2.2 Geomembrane Properties

2.2.1 High Density Polyethylene (HDPE)

2.2.1.1 Where specified on the Drawings, HDPE liners shall consist of high density polyethylene sheet, 60 mils (1.52mm) thick for the EPS Capsule.

2.2.2 The sheet surface can be smooth or textured as noted in the Drawings.

2.2.2.1 The HDPE liner shall conform to the following properties:

- Density (ASTM D1505): Greater than 0.94 gm/cc (9.42 lb/gal).

- Thickness (ASTM D1505): 60 mil; 1.52mm +/- 10%
- Carbon Black Content (ASTM D1603): 2-3% by weight.
- Carbon Black Dispersion (ASTM D5596): 9 of 10 views shall be Category 1 or 2; No more than 1 view from Category 3.
- Membrane Tensile Properties (ASTM D638):
  a. Minimum Tensile Yield Stress: 2100 psi average.
  b. Minimum Tensile Break Strength: 3800 psi average.
  c. Minimum Elongation at yield: 12%.
  d. Minimum Elongation at break: 100%.
- Minimum Tear Resistance (ASTM D1004): 42 lbs.
- Minimum Puncture Resistance (ASTM D 4833): 108 lbs.
- Low Temperature Brittleness (ASTM D746; Procedure B): Min.-40 degrees Fahrenheit (-40 degrees Celsius).
- Environmental Stress Crack Resistance (ASTM D1693; Condition C): Zero Failures in 2000 hrs.
- UV Resistance (ASTM 626): Less than 10% decrease in tensile properties at 10,000 hrs Xenon Arc.
- Dimensional Stability (ASTM D1204; 100°C, 1hr): ±1%.
- Water Adsorption (ASTM D570): 0.1% weight change.
- Maximum Volatile Loss of Resin (ASTM D 1203 Method A): 0.12.
- Ozone Resistance (ASTM D1149): No Cracks at 7x Magnification (7 days 1ppm 104 degrees F).
- Abrasion Resistance (ASTM D1044): 1-5mg/1000 Taber Rev.

2.2.3 All main seams shall be wedge welded to the following minimum properties:

- Shear Strength (ASTM D 882): 126 lbs/in.
- Elongation at Break (ASTM D822): 50%.
- Peel Strength (AE-PL2-85): 78 lbs/in.
- Peel separation (AE-PL2-85): 25% of fused interface width.

3. Execution

3.1 Material Labeling, Delivery, Storage, and Handling

3.1.1 Materials shall be delivered to the site only after the required submittals have been approved by Owner's Engineer.

3.1.2 During delivery and storage, protect geosynthetics from ultraviolet rays by covering it if stored outside greater than 60 days, excessive heat, mud, dirt, dust, debris, and rodents according to ASTM D4873 and D7865.

3.1.3 Deliver, store, handle and clean materials in accordance with the manufacturer's written instructions.

3.1.4 All materials delivered should be inspected for damage. Material damaged during handling and installation shall be disposed of offsite by the Liner Installer and replaced by the Liner Installer at no additional cost to the Owner.

3.1.5 Delivered panels and rolls shall be labelled or tagged to provide product identification sufficient for inventory and quality control purposes. As a minimum, packaging should be labelled with:

- Manufacturer's Name.
- Material type.
- Dimensions (thickness, length and width).
- Stock code or Product Identification Number.
- QC number.
- Panel number.
- Unfolding and deployment directions.

3.1.6 Cleaning solvents shall not be used unless product is approved by membrane manufacturer.

3.1.7 Panels shall be furnished skid mounted with suitable wrapping to protect against damage during shipping and extended ultraviolet light exposure by covering it if stored outside greater than 60 days prior to placement.

3.1.8 Schedule fabrication, delivery and installation such that rolls are unloaded directly onto their proper location on the site to minimize potential handling damage. Take caution to orient the rolls and panels correctly with respect to the liner layout.

3.1.9 Use water and rags for all cleaning. If soap is used for cleaning, rinse with clean water and dry before welding.

3.1.10 The on-site storage location for geomembrane material shall protect the geomembrane form punctures, abrasions, and excessive dirt, moisture and UV exposure should have the following characteristics:

- Level.
- Smooth.
- Dry.
- Protected from theft and vandalism.
- Adjacent to the area to be deployed.

3.1.11 Rolls shall be stored in a way that prevents sliding or rolling from stacks.

3.1.12 The above requirements for packaging and storage of the liner panels are minimum requirements.

3.2 Subgrade Layer Preparation

3.2.1 Ensure subgrade layer is acceptable for geomembrane installation in accordance with manufacturer's written instructions.

3.2.2 Subgrade layers may comprise Type 1, Type 3, Type 4, or Type 6 Fill placed in layers unless otherwise as noted in Drawings. If the subgrade layers are Type 3, Type 4 or Type 6 Fill, a non-woven geotextile (specification in Ref. 1.3.2) shall be placed over the subgrade as a cushion layer to protect geomembrane, unless otherwise as noted in Drawings.

3.2.3 Subgrade layers shall provide a firm, unyielding surface with no sharp changes or abrupt breaks in grade.

3.2.4 Subgrade fill shall be compacted to achieve stable earthworks that are not subject to slides, excessive settlement, or excessive erosion. The subgrade fill shall be prepared as per the fill material specification, in Section 1.3.1 for reference.

3.2.5 Subgrade layers shall be visually inspected (with the Owner's Engineer present) and if conditions are deemed unacceptable, corrective action must be taken.

3.2.6 Particular care should be taken to backfill and re-compact trenches or other excavations. Excavation may be slightly crowned to allow for a small degree of settlement.

3.2.7 Anchor liners at the top of fill lifts or fill stages in a V-shaped trench with a minimum depth of 18 inches located at least 18 inches from the edge of fill. Compact backfill material to 95% SPMDD.

3.2.8 Subgrade layers should be finish graded to provide a smooth bearing surface without windows or hummocks of loose soil.

3.2.9 For placement of membranes on steep slopes, create a smooth subgrade layer using hydraulic excavators equipped with vibratory plate tamper attachments or other method that produce equivalent effect.

3.2.10 Geomembrane subgrade layer and support layers shall be free of any wood, or other sharp projections that could puncture the membrane material.

3.3 Installation

3.3.1 Geomembrane

3.3.1.1 Maintain area of installation free of water, ice and snow accumulations.

3.3.1.2 Repair excessively soft supporting subgrade material as directed by the Owner's Engineer.

3.3.1.3 Do not proceed with panel placement and seaming when ambient temperatures are below 20° F or above 105° F, during any precipitation, in presence of excessive moisture (e.g., fog, dew), nor in presence of high winds.

3.3.1.4 Place and seam panels in accordance with manufacturer's recommendations on graded surface in orientation and locations indicated.

3.3.2 Install the liner tight with allowances for expansion and contraction having no folds or excess wrinkles present. The amount of slack will be limited to that recommended by the manufacturer to ensure the service life of the liner.

3.3.2.1 Do not permit passage of any vehicle directly on the membrane at any time. Vehicular traffic will be permitted on the liner only after the full fill materials are provided.

3.3.2.2 Ballast used to prevent uplift by wind must not damage the geomembrane. A continuous load is recommended along the edges of panels to eliminate the risk of wind uplift.

3.3.2.3 Provide sufficient thermal slack during placement to ensure that harmful stresses do not occur during service.

3.3.3 Where possible, place only as much liner as can be covered during a shift.

3.3.3.1 Under no circumstances should high ground pressure rolling equipment be allowed onto liner panels. Ensure personnel working on geomembrane do not use damaging footwear. When it is necessary for installers to walk on the panels, clean soft-soled shoes shall be worn.

3.3.4 Field Seaming

3.3.4.1 Keep seam area clean and free of moisture, dust, dirt, debris and foreign material.

3.3.4.2 Welding operations should not be carried out when precipitation is falling, unless the weld area can be kept dry by the use of shelters. Welding cannot be performed in cold weather below 32°F only if qualification weld tests indicate that the welding procedure used is producing peel test film tear bond quality welds.

3.3.4.3 To the maximum extent possible, orient seams down-slope and not across-slope.

3.3.4.4 All sheets welding is to be lapped and welded using the hot wedge method to produce two welds separated by an air channel. An average overlap of 6 inches should be used at all field seams between panels.

3.3.4.5 The panel edges to be joined should be thoroughly cleaned and dried using a clean cloth until the edges are free from foreign matter and water.

3.3.4.6 Extrusion Welding: Hot-air track adjacent pieces together using procedures that do not damage the geomembrane; prepare geomembrane surfaces by disc grinder or equivalent; and purge welding apparatus of heat-degraded extrudate before welding.

3.3.4.7 Where areas to be extrusion welded are roughened by grinding or equivalent, roughening marks shall be in the normal direction of the seam. All roughening debris will be blown or wiped off the surface prior to welding. The welding shall take place the same day the surface has been prepared or the surface will be re-prepared as specified above.

3.3.4.8 Hot Wedge Welding: Welding apparatus shall be a self-propelled device equipped with an electronic controller that displays applicable temperatures; clean seam area of dust, mud, moisture and debris immediately ahead of the hot wedge welder; and protect against moisture build-up between sheets.

3.3.4.9 No third party material will be allowed on main seams. Seams will be fused by the melt action of actual sheet to sheet under compression. No glues, tapes or other temporary holding techniques will be used in the area of seams.

3.3.4.10 Joints shall be continuous with no creases, inclusions or unbounded segments.

3.3.4.11 Punctures in the general liner should be repaired by covering the damaged area with a patch bonded to the liner using an extrusion fillet weld, see Section 3.4 for further details.

3.3.4.12 A seam where two liner sections which have seams in different direction have to be joined is referred to as a butt seam. Butt seams shall be run with the wedge welder. To ensure a good seal, the T-intersections between seams are extrusion welded.

3.3.5 Qualification Seams

3.3.5.1 A qualification seam will be run prior to any field seams.

3.3.5.2 A qualification seam is made with separate pieces of geomembrane using the same material and equipment that will be used for production welding and under the same surface (i.e., subgrade) and environmental (i.e. ambient temperature) conditions as the production welds.

3.3.5.3 Machine conditions, and operator used for welding must be the same as those used for the qualification weld.

3.3.5.4 Qualification seams must be tested in shear and peel, and meet the specified requirements for the material as stated in the materials section. Run a minimum of two qualification welds per day, per welding apparatus and operator; one made prior to the start of a shift and one completed at mid shift.

3.3.5.5 A qualification seam must be re-test whenever the operator is changed, the equipment adjusted, or at least every four (4) hours.

3.4 Repairs

3.4.1.1 Inspect seams and non-seam areas for defects, holes, blisters, and undispersed raw materials.

3.4.1.2 Identify any sign of foreign matter contamination.

3.4.1.3 Repair all through-thickness defects.

3.4.1.4 The liner installer shall provide written certification that the liner has been vacuum box tested at all panel thermal welded joint locations and all panel material has been visually inspected with deficiencies noted and corrected prior to purchasing. When a membrane liner is field seamed, spliced, modified or repaired, the part so fabricated shall be subject to the same performance test prescribed by the manufacturer and shall consist of visual inspection, vacuum and tensile testing. Repair areas shall be reported to the Owner's Engineer.

3.4.1.5 Repair minor tears and pinholes by patching until vacuum testing is successful. Patches to be round or oval in shape, made of the same geomembrane material, and extend to a minimum of 5" (100 mm) beyond the edge of the defect. Repaired areas shall be recorded on a field repair log and submitted to the Owner's Engineer.

3.4.1.6 Defective Seams: Cap strip or replace.

3.4.1.7 Small Holes or Tears: Patch and seal round holes or sharp ends of tears on slope or stressed area prior to patching.

3.4.1.8 Repair blisters, large cuts and undispersed raw materials with a patch.

3.4.1.9 Secure Patches by Adhesive Seam (Chemical Weld) or Hot Air Welding:

3.4.1.10 Hot Air Welding:

- Clean area to be patched.
- Hand weld the patch with a hot air gun and suitable roller.

3.4.1.11 Patches: Round or oval, of same geomembrane. See Section 3.4.1.5 for details.

3.4.1.12 Verification of Repairs: All repairs to be non-destructively tested using:

- Air Lance Test, ASTM D4437 Method 7.2.
- Vacuum Box Test ASTM D5641.

3.4.1.13 Keep records of all repairs and the results of repair testing.

3.5 Cover Material

3.5.1 Cover all liner materials with either Type 1, Type 2, Type 4, or other fill materials as approved by Owner's Engineer. For any cover material other than Type 1 and 2 fill, a non-woven geotextile (specification in Ref. 1.3.2) shall be placed below the cover material as a cushion layer to protect geomembrane.

3.5.2 Cover soil should be placed on the liner by dumping and spreading in a way to ensure that the tensile forces are not transmitted to the liner. Level dumped material with low ground pressure equipment.

3.5.3 Soil cover should be placed on slopes in an uphill direction.

3.5.4 Under no circumstance should equipment be allowed on the liner without sufficient cover material to ensure that no damage occurs to the liner. The depth of cover soil will depend on the type of cover material and the ground pressure of the equipment. Contactor shall perform compaction trials to ensure suitable methods and equipments are employed. Table 1 provides a preliminary estimation of covering lift thickness for construction equipment.

3.5.5 Equipment should not accelerate, decelerate, turn or perform manoeuvres which would transmit excessive stress to the liner. Placement operation should be planned out in a manner that minimizes activity of equipment on liner areas. Skid-steer equipment, if used, must not make any sharp skid turns on top of the liner or on top of a thin lift of backfill. Sharp turns with one tread locked can damage the liner. Skid-steer equipment must make long sweeping turns at all times.

3.5.6 The Liner Installer shall provide a Senior Project Supervisor or Foreman to supervise the work.

Table 1 Preliminary Assessment of Minimum Lift Thickness for Covering Material

Covering Material Thickness	Placement Equipment*
No Backfill*	Foot Traffic or a 4 Track ATV vehicle only
200-300 mm (8"-12")	D3-D4 LGP Cat, Rubber Tracked Skid-steer
300 mm (12")	Bobcat (Skid-Steer)
300 mm (12")	D4-D6 Style Cat
600 mm (24")	D7-D9 Style Cat
900 mm (36")	Loaded Scrapers, Motor Graders
900-1200 mm (36"-48")	Loaded Tandem Axle Trucks

Note: * Contractor may use heavier equipment provided field trials are performed showing no damage from the operation, as accepted by the Owner's Engineer.

3.6 Quality Control

Reference 1.3.3 in Section 1.3 shall be used for direction on addressing quality processes and documentation of materials and equipments, from procurement through final installation.

3.6.1 Liner Materials

3.6.1.1 Perform inspections of the subgrade layer that the liner is to be placed on jointly with the Liner Installer, Contractor and Owner's Engineer. Subgrade acceptance should be documented on a subgrade acceptance form that is signed by both the quality control and quality acceptance personnel.

3.6.1.2 Liner panels shall be installed on subgrade layers only after Owner's Engineer has inspected such layers and approved the base preparation.

3.6.1.3 Liner Manufacturer shall provide the Liner Installer and Owner with the mill run certificates and specified test results for each shift and batch.

3.6.1.4 Inspect all liner panels for shipping damage prior to installation. Repair materials that can be patched or discard irreparable materials.

3.6.1.5 The installation shall be inspected daily as placement progresses.

3.6.1.6 When placement and field welding is completed, Owner's Engineer and Contractor shall inspect the liner to ensure that materials, factory joints, field joints, repairs, and anchors are installed in accordance with these Specifications.

3.6.1.7 The following Quality Control data shall be provided by the manufacturer:

a. Resin Properties (Resin Number, Batch Number, see details in Section 2.2).

b. Sheet Properties (see details in Section 2.2).

c. Role Identification: Operator ID, Batch Number, Date Made, Roll Length, Roll Thickness.

3.6.1.8 Samples of liner that is delivered to the site shall be given for laboratory testing prior to installation of the liner to ensure the panel sheets and seams meet these Specifications. See Section 3.6.1.16 for test details. Any liner for which the tested sample fails to meet the required minimum physical properties of this specification may be rejected by Owner upon confirmation of the test results.

3.6.1.9 Rejected liner shall be replaced by Contractor prior to field installation at no additional cost to Owner. Any liner found to not meet these specifications as a result of further testing during installation may also be rejected by Owner and require replacement by Contractor at no additional cost to Owner.

3.6.1.10 At the start of each daily run, provide a qualification weld for each machine and operator. A record should be taken with the following data:

a. Ambient temperature.

b. Precipitation.

c. Wind.

d. Machine Speed.

e. Welder temperature.

3.6.1.11 A calibrated field peel test device should be on site at all times. Samples should be peel tested on every seam to ensure that the seam is being properly fused.

3.6.1.12 Provide a laboratory quality portable tensometer for field seam testing. Conduct periodic tensometer tests to ensure that field peel tests are valid.

3.6.1.13 The sampling of production welds for destructive testing shall be taken from the start or end of each seam. Tests shall be conducted according to the following test standards:

a. Tensile Test – 95% of yield strength of parent material (ASTM D882).

b. Peel Test – 80% of yield strength of parent material (ASTM D882).

3.6.1.14 All field seams shall be air pressure tested. The test pressure and duration parameters shall be submitted to the Owner's Engineer for acceptance. The test procedure shall comprise:

- Seal off both ends of the seam with heat and pressure.
- Attach a pressure gauge assembly.
- Pressurize the air channel with a compressor attached to a gauge assembly.
- Allow the pressure to stabilize in the air channel.
- Observe the pressure gauge. There should be no observable pressure drop for a time period of one minute per 65 foot (about 20 m) of seam length.
- If a rapid pressure drop occurs, perform a visual inspection of the seam. If a flaw is detected in the seam, pressure-test the seam on either side of the flaw. Repair the flaw using extrusion welding and test the extrusion weld using the vacuum test.
- Record the results of the test.

3.6.1.15 All patches shall be vacuum box tested to ensure no leakage will occur. Air vacuum test procedure shall comprise:

- Trim off any flaps from the wedge welder and coat the seam with a dilute soap solution.
- Place the vacuum chamber and depressurize with a vacuum pump to 3 PSI (about 20 kPa) vacuum.
- Observe the weld inside the vacuum chamber. Any leaks will allow atmospheric pressure air from beneath the liner to enter the vacuum chamber. Soap bubbles will form at the leak.
- Mark any leaks that are found, repair and retest.
- Record the results of the test.
- During this test the underside of the liner must be dry, the test will not work if water is present on the underside of the liner.

3.6.1.16 Use the following guidelines for Liner Installer to develop Quality Control and Assurance Plan:

Property	Test Method	Frequency
Thickness	ASTM D5199	Every Roll
Density	ASTM D1505	200,000 lb
Tensile Properties	ASTM D6693	20,000 lb
Tear Resistance	ASTM D1004	45,000 lb

Property	Test Method	Frequency
Puncture Resistance	ASTM D4833	45,000 lb
Stress Crack	ASTM D5397	200,000 lb
Carbon Black Content	ASTM D1603	20,000 lb
Carbon Black Dispersion	ASTM D5397	40,000 lb

3.6.2 Field Seams

3.6.2.1 Field seams will be sampled for testing in a way that does not compromise the installed liner.

3.6.2.2 One sample to be tested for every 500 ft of field seam.

3.6.2.3 Test samples are to be removed from the ends of seams, from the anchor trench, or other location that does not introduce a defect into the liner.

3.6.2.4 Samples to be approximately 4 in long to permit testing of one shear and two peel specimens (ASTM D6392).

3.6.2.5 Test samples immediately after seaming.

3.6.2.6 Record date, location and pass/fail description.

3.6.2.7 Vacuum testing shall be performed on all field seams in accordance with ASTM D 5641.

3.6.2.8 Conduct Air Pressure Testing in accordance with ASTM D 5820.

3.6.3 Leak Detection

3.6.3.1 Conduct leak detection testing on all sections of the geomembrane using a suitable electrical based leak detection method (i.e. ASTM D7007-09), or otherwise as noted in the drawings. Include leak detection plans and procedures in the Quality Control and Insurance Plan.

3.6.3.2 Conduct surveys after the geomembrane is covered, or otherwise as noted in the drawings. The expected minimum sensitivity is 3/50 inch (about 1.5 mm) diameter holes.

END OF SECTION

REDLEAF RESOURCES, INC.	**Seep Ridge EPS Project**	RLSR_MCC_01_TSP_0003
Technical Specification: Liquid Collection System – Floor Pan		**Issue Date:** 3/6/2014
		Revision : A

3/6/2014	A	Issued for Permit	K. Johns	S. Lethier	S. Packard
Date	**Rev**	**Status**	**Prepared by**	**Reviewed by**	**Approved by**

General

The work to be done under this specification consists of the supply of labor, plant, material, supervision and the performance of all work necessary for the supply and installation of the floor pan; including transportation, loading and unloading, handling, surface preparation in advance of installation, as shown on the drawings and as directed by the Owner's Engineer and as specified herein.

Approvals, acceptability, and/or definitions related to this specification shall be made by Owner's Engineer. Owner's Engineer reserves the right to revise, updated, or otherwise alternate these material specifications to comply with environmental and performance requirements. Owner's Engineer may also specify similar, revised, or replacement methods/standards for those in this specification.

Reference Standards

The Work covered under this section shall be done in accordance with the following standards:

- ASTM A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
- ASTM A749 - Standard Specification for Steel, Strip, Carbon and High-Strength, Low-Alloy, Hot-Rolled, General Requirements for

Definitions

Owner: Red Leaf Resources, Inc.

Owner's Engineer: Owner's Engineer shall be a Utah registered professional engineer, appointed by Red Leaf. Identification of Owner's Engineer shall be documented in writing.

Contractor: Refers to the company supplying all labor, materials and equipment and performing all the work necessary as per this Section.

Mechanical Design

The purpose of the floor pan is to collect the fluids (retort water and oil) that are produced during operation of the capsule. It will be located at the bottom of the capsule in an area that is lower than any material subjected to temperature conditions that will cause the shale to retort and release fluids.

The floor pan design shall specify the required slope of the substrate and the floor pan sheet layout, so fluids will flow to a collection area at the lowest point.

The floor pan is not designed to act as a structural member. The floor pan is to be installed on a designed substrate that will provide the required structural integrity.

The minimum thickness of the floor pan will be 22 gauge unless otherwise noted.

To assist with transport and installation, material shall be furnished with a suitable method for lifting and traveling members to avoid distortion of the material during handling.

Installation

The floor pan shall be installed on substrate that is installed per H335458-0310-15-123-001, Standard Technical Specification - Fill Materials.

The floor pan will be covered with backfill that is installed per H335458-0310-15-123-001, Standard Technical Specification - Fill Materials.

The floor pan shall be installed to the dimensions and within the tolerances specified.

If the floor pan is damaged prior to or during installation, the damaged area shall be discarded and not used or it shall be repaired prior to use.

Submittals

Submit to the Owner's Engineer manufacturer's instructions, printed product literature and data sheets received from the material supplier.

Material Certificates for each steel coil shall be submitted to the Owner's Engineer.

Quality Assurance

Contractor must follow the documented installation plan and work procedures approved by the Owner's Engineer.

All coils of steel shall be marked with the following information:

- Name of Manufacturer
- ASTM Designation
- Unique Material Identification Designator that is traceable to certification (such as heat or coil number)
- Grade

Quality Control

The Owner's Engineer, or designee, will establish and direct and quality control throughout the period of construction and shall provide guidance on definitions, provide approvals, and make necessary determinations for completion of requirements outlined in this specification.

The Owner or Owner's Engineer may delegate a Testing Organization to undertake third party testing to ensure conformance with the specifications.

If a third-party Testing Organization is used, the Contractor shall coordinate and cooperate with the Testing Organization to allow the sampling and testing.

Material Tests and Verifications

Tests shall be performed by the Owner's Engineer, or designee, as follows:

- Visual Inspection for damage and defects – each sheet
- Visual Inspection for required overlap of sheets – each sheet
- Visual Inspection for proper termination at edges – each sheet, both ends

END OF SECTION

Standard Technical Specification

Geosynthetics Technical Specification

H335458-0310-15-123-0004

PROFESSIONAL ENGINEER
No. 291095
DAN M. ISOM
10/02/2014
ELECTRONIC SEAL
STATE OF UTAH

2014-09-23	0	Approved for Use	G. Qu	S. Hinchberger	D. Stanger	M. Emett
DATE	REV.	STATUS	PREPARED BY	CHECKED BY	APPROVED BY	APPROVED BY
				Discipline Lead	Engineering Manager	Client

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Disclaimer

This Specification has been prepared by Hatch Ltd. for the sole and exclusive use of Red Leaf Resources Inc. (the "Client") for the purpose of assisting the Client in making decisions with respect to the Seep Ridge EPS Project and shall not be (a) used for any other purpose, or (b) provided to, relied upon or used by any third party.

This Specification contains opinions, conclusions and recommendations made by Hatch Ltd. (Hatch), using its professional judgment and reasonable care. Any use of or reliance upon this report by the Client is subject to the following conditions:

- The Specification being read in the context of and subject to the terms of the agreement between Hatch and the Client dated June 2nd, 2014 (the "Agreement"), including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions that were specified or agreed therein.
- The Specification being read as a whole, with sections or parts hereof read or relied upon in context.
- The conditions of the site may change over time (or may have already changed) due to natural forces or human intervention, and Hatch takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this specification; and
- The Specification is based on information made available to Hatch by the Client or by certain third parties; and unless stated otherwise in the Agreement, Hatch has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith.

1. General

1.1 Scope

1.1.1 This section covers the manufacturing, supply and installation of a geomembrane liner for the Red Leaf Experimental Oil Shale Capsule Project as shown on the Drawings and described herein.

1.1.2 Contractor shall install the geotextiles in accordance with this Specification and subject to the terms and conditions of the manufacturer's requirements.

1.2 References and Standard

1.2.1 Fill Material Specification, Hatch, Doc. H335458-0310-15-123-0001.

1.2.2 Geomembrane Specification, Hatch, Doc. H335458-0310-15-123-0002.

1.2.3 Early Production System (EPS) Quality Process Guideline, 408037-000-QA-REF-0001.

1.2.4 American Society for Testing and Materials International, (ASTM):

- ASTM D4355 – 07, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
- ASTM D4632 – 08, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
- ASTM D-4595-11, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
- ASTM D-4833 (1996), Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
- ASTM D4873 - 02 Standard Guides for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.

1.2.5 Geosynthetic Research Institute, (GRI).

- GRI-GG2 - Standard Test Method for Geogrid Junction Strength (ASTM D4873).

1.3 Definitions

1.3.1 **Owner**: Red Leaf Resources Inc.

1.3.2 **Owner's Engineer**: Owner's engineer shall be appointed by Red Leaf. Identification of Owner's engineer shall be documented in writing.

1.3.3 **Contractor**: Refers to the company supplying all labor, materials and equipment and performing all the work necessary as per this Section.

1.3.4 **Geosynthetics**: Geosynthetics are generally polymeric products including woven geotextiles, non-woven geotextiles and geogrids.

1.4 Submittals

1.4.1 Product Data: Submit to the Owner's Engineer manufacturer's instructions, printed product literature and data sheets for geotextiles and geogrids, and include product characteristics, performance criteria, physical size, finish and limitations.

1.4.2 Samples: Submit samples to the Owner's Engineer four weeks minimum before beginning work.

1.4.3 Certificates:

- Submit to the Owner's Engineer copies of manufacturer's mill test data and specification sheets at least two weeks prior to start of work.
- Submit to the Owner's Engineer certificates, including test results, at least two weeks prior to delivery to job site.

1.5 Quality Assurance

1.5.1 Reference 1.2.3 in Section 1.2 shall be used for direction on addressing quality processes and documentation of materials and equipments, from procurement through final installation.

1.5.2 Submit certified test reports showing compliance with specified performance characteristics and physical properties.

1.6 Delivery, Storage, Handling and Cleaning

1.6.1 During delivery and storage, protect geosynthetics from direct sunlight, ultraviolet rays, excessive heat, mud, dirt, dust, debris, and rodents (ASTM D4873).

1.6.2 Deliver, store, handle and clean materials in accordance with the manufacturer's written instructions.

1.6.3 Cleaning solvents shall not be used unless product is approved by manufacturer.

1.6.4 Delivery of materials to site should be in packaging labelled with;

- Material type
- Dimensions

- Stock code
- Sales order number
- QC number
- Roll number
- Unfolding and deployment directions.

1.6.5 All materials delivered should be inspected for damage. Any damaged or defective materials should be replaced with new materials.

1.6.6 Rolls shall be stored in a way that prevents sliding or rolling from stacks.

1.6.7 The extent to which geosynthetics are dragged on the ground shall be minimized.

2. Products

2.1 Materials

2.1.1 Geotextile (Non-Woven)

2.1.1.1 Geotextile to consist of a non-woven synthetic fibre fabric. The product shall be Layfield ® LP7, unless otherwise as noted in the Drawings, or equivalent accepted by Owner's Engineer.

2.1.1.2 Geotextile is to be a 100% continuous filament polypropylene non-woven needle punched engineering fabric which is resistant to freeze-thaw, soil chemicals and ultraviolet light. The geotextile shall equal or exceed the following minimum average roll values:

- Physical properties:
    - Trapezoidal Tear to ASTM D-4533: 75 lb (333 N).
    - Grab tensile strength and elongation (in any principal direction): to ASTM D-4632.
        - Grab tensile strength: 180 lbs (800 N).
        - Grab elongation: 50%.
    - Puncture Strength to ASTM D-4833: 105 lb (467 N).

2.1.2 Geotextile (Woven)

2.1.2.1 Woven geotextile shall be a double layer of polyesters to serve as a bond-breaker between BAS and underlying granular fill in the knuckle areas. The product shall be Mirafi® PET150, unless otherwise as noted in the Drawings, or equivalent accepted by Owner's Engineer.

2.1.2.2 Geotextiles shall be supplied in rolls. The geotextile shall equal or exceed the following minimum average roll values:

- Physical properties:
  - Wide width tensile strength to ASTM D-4595.
  - Strength @5% Strain (MD): 3600 lbs/ft (52.5kN/m).
  - Strength @Ultimate Strain (MD): 10000lbs/ft. (150kN).
  - Creep Reduced Strength (MD): 6170 lbs/ft (90kN/m).

2.1.3 Geogrids

2.1.3.1 This geogrids shall be used at roof covering the insulation layer to provide addition sliding resistance at the knuckle areas. Geogrids shall be made of sheets of an extruded polyolefin, preferably polypropylene. The product shall be Strata® SG550, Mirafi® 8XT, unless otherwise as noted in the Drawings, or equivalent accepted by Owner's engineer.

2.1.3.2 Geogrids shall be suitably formulated from first quality polymeric materials. The material shall be free of water soluble compounding ingredients and must be resistant to mildew and bacterial degradation. It shall also be resistant to chemical attack of diesel fuel and other corrosive matter.

2.1.3.3 The allowable design strength: 1060 lbs/ft (57 kN/m).

2.1.3.4 Aperture dimensions shall be greater than 1 in (about 25 mm).

3. Execution

3.1 Preparation

3.1.1 Geotextile and Geogrid

3.1.1.1 Prepare the surface on which the geotextile or geogrid is placed to a smooth surface and remove obstruction, debris, depressions, erosion features, or vegetation. Remove any irregularities to ensure continuous contact of the geotextile or geogrid with the entire surface. Remove any loose material, soft or low density pockets of material, and grade erosion features such as rills, gullies etc. out of the surface before geotextile or geogrid placement.

3.2 Installation

3.2.1 Geotextile (Non-woven and Woven)

3.2.1.1 Place geotextile material by unrolling onto graded surface in orientation, manner and locations indicated on the Drawings or as directed by the Owner's Engineer. Remove all snow and ice prior to placing material.

3.2.1.2 Geotextile will be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacturing, transportation, storage, handling or installation. Replace damaged geotextile to the approval of the Owner's Engineer.

3.2.1.3 Place geotextile material smooth and free of tension stress, folds, wrinkles and creases.

3.2.1.4 Place woven geotextile as double layers. Ensure the longitudinal direction (i.e., the machine direction with a lower friction) of the woven material parallel with the slope direction.

3.2.1.5 Overlap each successive strip of geotextile 20 in (about 500 mm) over previously laid strip.

3.2.1.6 Protect installed geotextile material from displacement, damage or deterioration before, during and after placement of fill material layers.

3.2.1.7 Place and compact soil layers over the geotextile in accordance with Section S31 12 12 – Placement of Fill.

3.2.1.8 Vehicular traffic not permitted directly on geotextile.

3.2.1.9 The non-woven geotextile may be also used as a filter cover material for the sub-drains.

3.2.2 Geogrid

3.2.2.1 Place geogrid material by unrolling onto graded surface in orientation, manner and locations indicated on the Drawings or as directed by the Owner's Engineer. Remove all snow and ice prior to placing material.

3.2.2.2 Geogrid will be rejected if it has defects, rips, flaws, deterioration or damage incurred during manufacturing, transportation, storage, handling or installation. Replace damaged geogrid to the approval of the Owner's Engineer.

3.2.2.3 Place geogrid material free of tension stress, folds, wrinkles and creases.

3.2.2.4 If geogrid does not have equal aperture dimensions, unroll geogrid in a way that the short axis of the roll is parallel with the slope direction (if applicable).

3.2.2.5 Place geogrid on sloping surfaces in one continuous length from toe of slope to upper extent (anchor trench if applicable).

3.2.2.6 Overlap each successive strip of Geogrid minimum 20 in (about 500 mm) over previously laid strip. Use plastic cable tie successive or adjacent strips together, or as directed by Owner's engineer.

3.2.2.7 Protect installed geogrid material from displacement, damage or deterioration before, during and after placement of fill material layers.

3.2.2.8 Fill placement shall proceed in such a manner that it minimized development of wrinkles in and/or movement of the geogrid.

3.2.2.9 Geogrid material could become brittle in cold climate. Vehicular traffic and excessive dynamic loads shall not be not permitted directly on geogrid. Placement of geogrid shall not be below 32°F unless accepted by the owner's engineer.

3.2.2.10 A minimum loose lift thickness of 6 in (150 mm) is required before operating tracked vehicles over the geogrid placement area. Under all circumstances, turning of tracked equipment shall be avoided while over the geogrid placement area.

3.3 Repairs

3.3.1 Geotextile and Geogrid

3.3.1.1 A damaged geotextile or geogrid can be repaired by placing an entirely new panel of the same material over the damaged panel. It is not necessary to remove the damaged panel.

3.3.1.2 The new geotextile or geogrid will need to be anchored in the same manner as the original damaged panel.

END OF SECTION

IGES®

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Field Scale Hydraulic Conductivity Evaluation of Compacted Bentonite Amended Soil by Sealed Double Ring Infiltration Testing

EcoShale™ Early Production System (EPS)
Seep Ridge, Uintah County, Utah

IGES Job No. 01109-018

March 3, 2014

Prepared for:

REDleaf Resources, Inc.
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Suite 200
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Field Scale Hydraulic Conductivity Evaluation of Compacted Bentonite Amended Soil by Sealed Double Ring Infiltrometer Testing

Uintah County, Utah

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EcoShale™ Early Production System (EPS)
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Submitted March 3, 2014
IGES, Inc.

Prepared by:

Mike Platt, P.E.I.
Staff Engineer
IGES, Inc.

PROFESSIONAL ENGINEER
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Senior Geotechnical Engineer
IGES, Inc.

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1.0 EXECUTIVE SUMMARY

This report presents the results of field scale hydraulic conductivity testing of compacted BAS using two Sealed Double Ring Infiltrometer tests for proposed EPS capsule. The purpose for the hydraulic conductivity testing of compacted BAS was to evaluate a prototype liner that could be used to provide a minimal flow barrier below the EPS capsule during and after operations.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of two Sealed Double Ring Infiltrometer (SDRI) tests (ASTM D5093 – Standard Test Method for Field Measurement of Infiltration Rate using Double-Ring Infiltrometer with Sealed Inner-Ring) performed on a test pad comprised of bentonite amended soil (BAS) at the REDleaf project operations site located in Uintah County, Utah. The scope of work performed by IGES Inc. included:

- The observation, documentation, monitoring, and testing of the SDRI test pad.
- Collect representative disturbed and undisturbed test specimens of the constructed fill for laboratory testing.
- Installation of SDRI test equipment.
- Initiation SDRI testing and monitor field performance over a minimum of 30-45 day period.
- Conduct laboratory testing for hydraulic conductivity as a means of comparison with the test pad performance.
- Reduce and interpret the field SDRI test data.
- Remove and dismantle SDRI equipment.
- Prepare a comprehensive report documenting test pad construction, performance, and testing all laboratory test data developed.

2.2 PROJECT DESCRIPTION

The EPS capsule will consist of a single cell containing processed run of mine oil shale rubble, for which a liner is needed to prevent infiltration of surface water and condensate and to minimize the potential for subsequent groundwater contamination. The SDRI test is used to evaluate both the BAS performance and construction method suitability for the proposed capsule liner.

2.2.1 Observation and Monitoring of Test Pad Construction

Construction of the BAS test pad was observed and monitored by representatives from IGES on November 1, 2012. The parameters observed by IGES included the loose height of BAS placement (loose lift thickness), compacted height of BAS after placement, method of compaction, unit weight of compacted BAS material, and water content of BAS material.

2.2.2 Testing and Documenting Test Fill Construction

In order to evaluate the compaction performance of the BAS Test Pad, the unit weight and water content measurements were obtained using a Nuclear Density Gage. Representative disturbed and undisturbed test specimens of the constructed fill were obtained for laboratory testing. Documentation of the test pad construction was accomplished by annotating the BAS as it was loosely placed, compacted, and tested and by recording the construction process by way of a video camera. Video recordings were broken down into three disks in DVD format providing documentation of construction of the BAS test pad. This documentation was sent to Woody Campbell with the Utah Department of Environmental Quality, Division of Water Quality on December 27, 2012 for his review.

3.0 BACKGROUND

3.1 SEALED DOUBLE RING INFILTROMETER

The purpose of the SDRI test is to evaluate the vertical, one-dimensional in-situ or field scale infiltration of water through a porous material. This apparatus allows for the measurement of low infiltration rates that are generally associated with fine-grained clayey soils. The SDRI test equipment consists of both an inner and outer ring. The outer ring is open to the atmosphere, whereas the inner ring is sealed and submerged during the measurement of flow. The SDRI test configuration prior to being filled with water is shown in Figure 1.

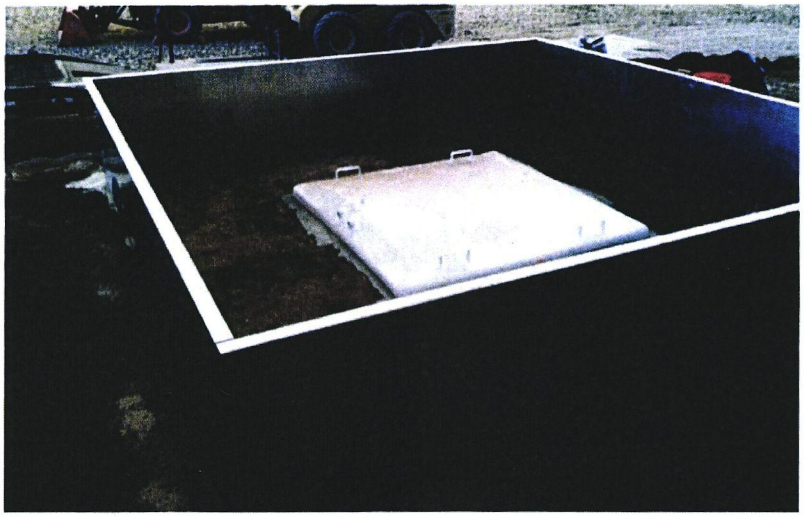

Figure 1 – SDRI test equipment installation prior to being filled with water

The sealed inner ring has three ports (see Figure 2). Two inlet ports are located on the side of the inner ring, while one port is located on top of the inner ring. Water is allowed to enter both side inlet ports while initially filling the apparatus with water. All air is allowed to exit via the top port, which is located at the highest point of the inner ring. However, during testing only one inlet port is used to allow water to enter the inner ring from flexible bags, which are connected via plastic tubing (see Figure 3). The other inlet port is plugged to prohibit any additional water to enter into the inner ring during testing. The port on top of the inner ring is used to occasionally vent and bleed air out of the inner ring.

Figure 2 – Inner ring with ports

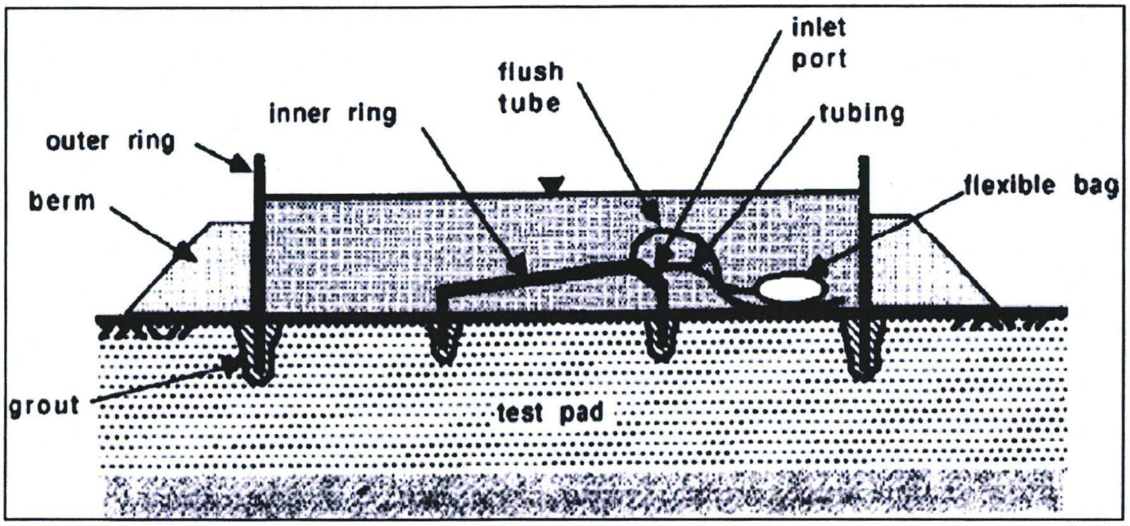

Figure 3 – Schematic of a Sealed Double Ring Infiltrometer (ASTM D5093)

During testing, two flexible bags are filled with water and connected to one of the side inlet ports of the inner ring using a tee connection and plastic tubing. The bags, and therefore the water in the inner ring, are under the same hydrostatic head as the surrounding water in the outer ring. As water begins to infiltrate the ground beneath the inner ring, an equal amount of volume of water is displaced out of the flexible bags and into the inner ring. While the ground becomes more saturated underneath the inner ring, the infiltration rate begins to decrease to a steady state condition over time. The bags are disconnected from the inner ring and weighed periodically throughout the infiltration process. The weight of each bag, the date and time the bags were disconnected and connected, and temperature of the water were recorded for each reading. When a great amount of water has been displaced out of the bags during the project, the bags were refilled for the continuation of testing.

3.2 TENSIOMETERS

Tensiometers are used to help estimate the position of the wetting front during the infiltration process. The tensiometers used on this project consisted of a sealed plastic tube with a porous tip on one end and a vacuum gage on the other. The saturated tensiometer is placed into a predrilled hole to a desired depth within the unsaturated soil. Initially when the tensiometer is placed into the soil, water will be drawn from the tube and the gage will begin to register suction (matric suction). As the wetting front passes the tip, the matric suction will decrease and water will reenter the tensiometer until the suction goes to zero at a high degree of saturation. Tensiometers were placed at depths of 6, 12, and 18 inches into the SDRI test pad.

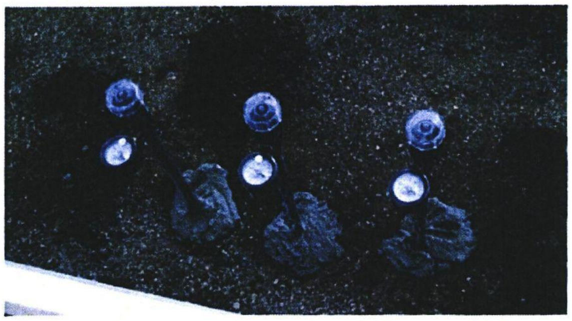

Figure 4 – Tensiometer nest at 6, 12, and 18 in. depth

3.3 SWELL GAUGES

Swell gauges are used to evaluate the magnitude of swell of the soil beneath the inner ring during infiltration. Metal fence posts were driven into BAS matrix diagonally from one another and outside of the influence of infiltration. A tensioned wire is located between the two fence posts spanning locations that are directly above the handles of the inner ring. Staff gauges are bolted to the handles of the inner ring and used to measure the change that is to occur during infiltration. The wire serves as an elevation reference point for any vertical movement of the inner ring. Swell gauges spanning a diagonal distance are shown in Figure 5.

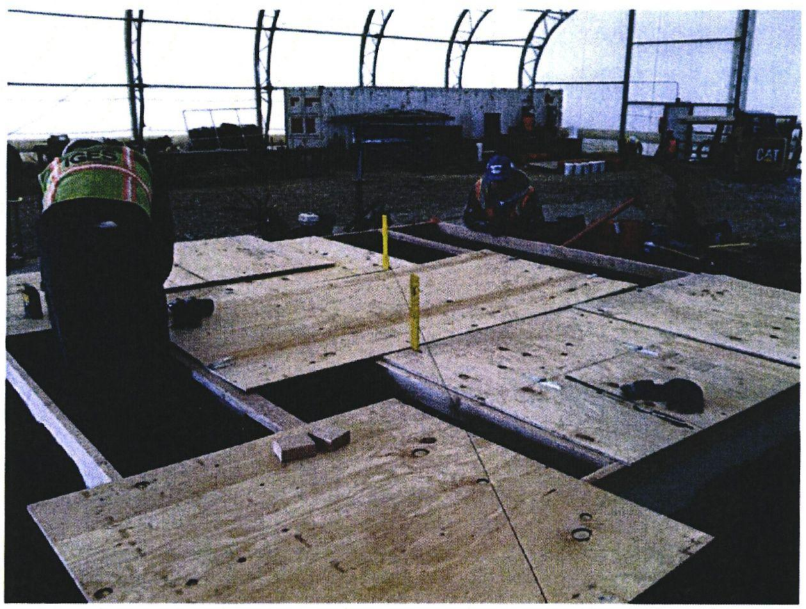

Figure 5 – Swell gauges being installed to monitor the potential vertical movement of the BAS.

4.0 METHODS OF STUDY

4.1 FIELD INVESTIGATION

The specific objectives of the field investigation performed at the REDleaf Resources project were as follows:

1. Monitoring, observing, testing, and documenting the construction a 25' x 30' BAS SDRI pad.
2. Installation two sealed double ring infiltrometer tests.
3. Monitoring, testing, and documenting the infiltration rate and hydraulic conductivity of the BAS SDRI pad using the sealed double ring infiltrometer tests.
4. Obtaining disturbed and undisturbed test specimens before and after SDRI testing for laboratory testing.

4.1.1 Construction of SDRI Pad

Construction of the test pad commenced on November 1, 2012. The first step in constructing the BAS liner for SDRI testing was to place Confidential business information Proprietary shale material (see Figure 6) on top of the existing surface and compact it using a vibratory smooth drum roller. To facilitate the quality of the SDRI testing program, the test pad was constructed inside the Kevlar structure located at the REDleaf project site.

Figure 6 – Confidential business information Proprietary material underlying the SDRI BAS test pad

The test pad consisted of an engineered soil containing Western Clay Sure Seal 80 bentonite and Confidential business information Proprietary crushed oil shale rubble meeting a target design gradation. The proportion of Western Clay Sure Seal 80 bentonite to Confidential business information Proprietary crushed oil shale rubble was Confidential business information Proprietary bentonite to Confidential business information Proprietary crushed oil shale rubble on a dry weight basis. The product of this engineered soil is denoted as a bentonite amended soil (BAS). The test pad consisting of BAS material was constructed to cover a 25' x 30' rectangular area. The area covered by BAS material supported two locations were SDRI tests could be performed. Two different methods of compaction were used to construct the BAS liner under the guidance and recommendations given to IGES from Norwest. These recommendations included the type of compaction equipment used for constructing the test pad, height of loosely and compacted BAS material during construction of the test pad, and number of passes per lift. The recommended compaction methods were observed and documented. A pass during the construction of the SDRI test pad was defined by Norwest as one complete cycle, back and forth, made by the type of compactor across the surface.

The two different compactors were used in order to observe, assess, and establish which type of compaction method would achieve the compaction specifications, while yielding the appropriate hydraulic conductivity value for the BAS during SDRI testing. A smooth drum CS74 vibratory soil compactor, which simulated the construction methods of the floor and roof of the capsule (SDRI 1) was used on the southern half of the pad as shown in Figure 7. A small Wacker Neuson RTSC2 Trench Roller, which simulated the construction methods of the walls of the capsule (SDRI 2), was used to prepare the north side of the test pad as shown in Figure 8.

Figure 7 – Smooth drum CS74 vibratory soil compactor used for compacting south side of BAS test pad

Figure 8 – Wacker Neuson RTSC2 Trench roller used for compacting north side of BAS test pad

Construction of the BAS test pad on the south side was accomplished in two lifts. Each lift consisted of loosely placing BAS material to a height of 18 inches and then compacting to a height of 12 inches using a smooth drum CS74 vibratory soil compactor (see Figure 9). Construction of the SDRI test pad on the north side was accomplished in three lifts. Each lift consisted of loosely placing the BAS material to a height of 12 inches and promptly compacting to a height of 8 inches using a Wacker Neuson RTSC2 Trench roller. The target 95% compaction of the BAS material was accomplished under a series of passes. The unit weight and water content for each test was obtained by nuclear density gauge. Construction of the test pad results for compaction type, number of passes, average total unit weight, average dry unit weight, average water content, and relative compaction are presented in Table 1. Complete compaction testing observations are provided in Appendix A.

Figure 9 – North side lift 1, 12 inch loose

Table 1 – Compaction type, number of passes, average total unit weight, average dry unit weight, average water content, and relative compaction for each test performed for each lift.

Lift No.	Test No.	Compaction Type	No. of Passes	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Water Content (%)	Relative Compaction (%)
1	1	CS74 vibratory soil compactor	2				
1	2	CS74 vibratory soil compactor	2				
1	3	CS74 vibratory soil compactor	2				
1	4	CS74 vibratory soil compactor	2				
1	5	RTSC2 Trench Roller	3				
1	6	CS74 vibratory soil compactor	2				
1	7	RTSC2 Trench Roller	3				
1	8	RTSC2 Trench Roller	3				
2	9	CS74 vibratory soil compactor	3				
2	10	CS74 vibratory soil compactor	3				
2	10A	CS74 vibratory soil compactor	3				
2	11	RTSC2 Trench Roller	3				
2	12	RTSC2 Trench Roller	3				
3	13	RTSC2 Trench Roller	3				
3	14	RTSC2 Trench Roller	3				
3	15	RTSC2 Trench Roller	3				

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The majority of the test pad was covered with a plastic tarp at the future locations of SDRI 1 and SDRI 2 to help maintain the water content at which the BAS material was originally placed and compacted, as shown in Figure 10. The plastic tarp partially covering the location of SDRI 1 was removed at the onset of installation of SDRI 1, whereas the plastic tarp partially covering the location of SDRI 2 was not removed until the installation of SDRI 2.

Figure 10 – Completed test pad covered with a plastic tarp in order to maintain the original water content at which the BAS was placed and compacted.

4.1.2 SDRI Intallation

The installation of SDRI 1 and SDRI 2 followed the procedure found in ASTM D5039. The installation process consists of assembling the outer rings, trenching and excavating, placement of the inner and outer ring in the trenches, covering the outer ring, and filling up the inner and outer rings with water.

The installation process begins with 4 aluminum panels, 12 feet in length and 3 feet in height, which were bolted together forming a 12' x 12' square outer ring. The outer ring was placed upon the SDRI test pad area, centered and squared. The ground was marked along the lower edge of the outer ring on all four sides. The square 5' x 5' fiberglass inner ring was centered within the outer ring area and marked on the ground along the four lower edges. Final markings of the inner and outer rings are shown in Figure 11.

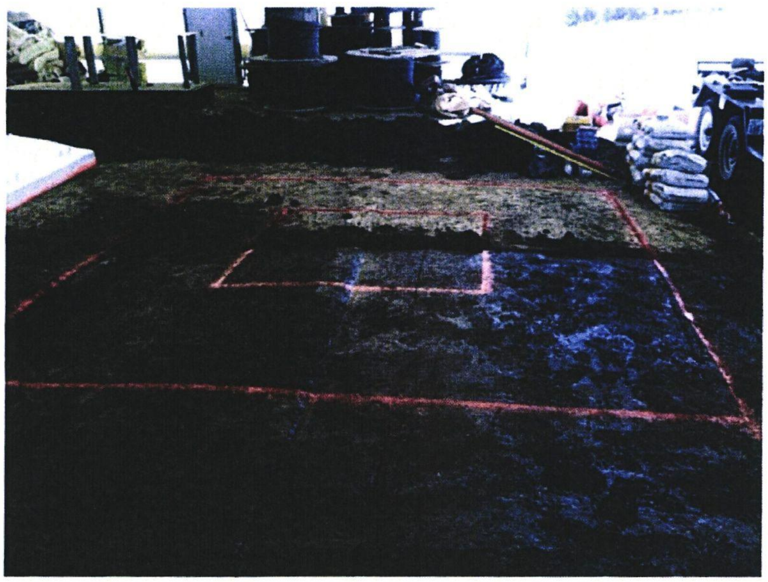

Figure 11 – Marked locations of inner and outer ring

After marking the locations of the rings, trenches for each ring were excavated using a trenching machine for the outer ring (see Figure 12) and a brick hammer for the inner ring. The trench for the outer ring was approximately 18 inches deep and 4 – 6 inches wide. The trench for the inner ring was approximately 6 inches deep and 2 inches wide. Both trenches were leveled on all four sides and at the corners of each side using a surveying level and Philadelphia rod.

Figure 12 – Excavation of the outer trench using a trenching machine

Before placing the outer and inner ring into their respective trenches, high solids powdered bentonite grout was mixed, prepared, and placed at the bottom of each side in the excavated inner ring trench. The inner ring was embedded, sealed, and leveled in the trench before placement of the outer ring, as shown in Figure 13.

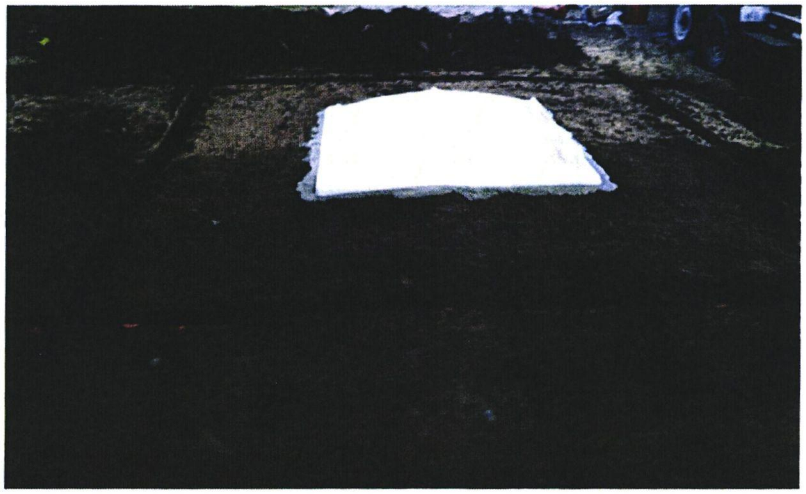

Figure 13 – Inner ring set in place with the excavated outer ring trench.

Additional amounts of grout were mixed, prepared, and placed at the bottom of the outer ring trench to an approximate depth of 8 inches. The outer ring was embedded and sealed in the trench. The remainder of the outer ring trench was filled with bentonite chips on both the inside and outside of the outer ring, as shown in Figure 14 and Figure 15. These chips were compacted and hydrated to provide a hydraulic barrier between the outer ring and the BAS test pad.


Figure 14 – Bentonite chips placed along the outside of the outer ring

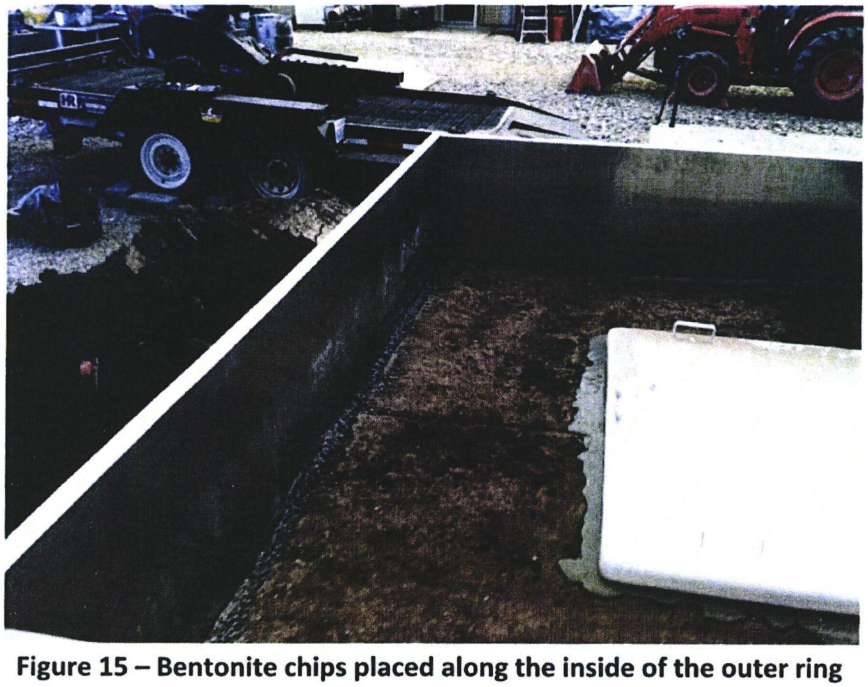

Figure 15 – Bentonite chips placed along the inside of the outer ring

To help mitigate the temperature change of water within the outer ring, polystyrene insulation was placed along the sides of the exposed outer ring. Once the insulation was in place, berms were built on the inside and outside of the outer ring upon completion of placing the bentonite chips in the outer ring trench. The purpose of the berms is to keep the outer ring from bowing, provide stability to the trench, keep the grout from being pushed out the trench once the outer ring is filled with water, to insulate, and to help prevent the leakage of water from occurring. Berms were built on all four sides of the outer ring as shown in Figure 16 and Figure 17.

Figure 16 - SDRI with berms built on the inside around the periphery of the outer ring

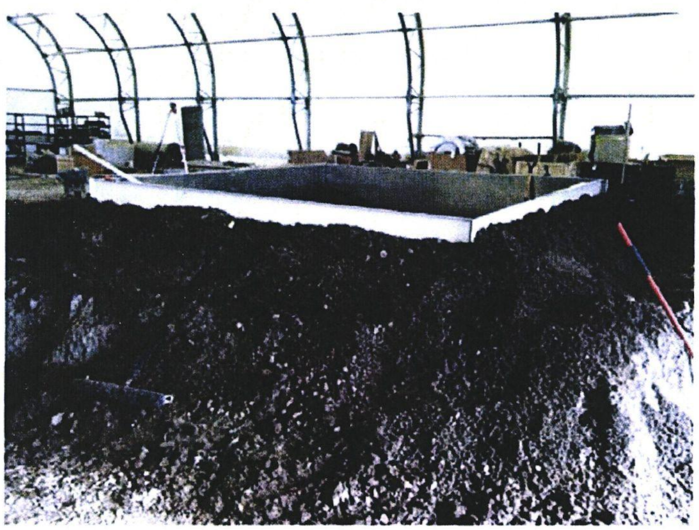

Figure 17 – SDRI with berms built on the outside around the periphery of the outer ring

Tensiometers were advanced into pre-drilled holes within the BAS between the inner and outer rings. A total of nine tensiometers were pushed at three different locations and positioned on each non-port side of the inner ring (see Figure 18). Tensiometers were pushed to depths of 6, 12, and 18 inches below the surface of the SDRI test pad at each location.

A 12 x 12 foot insulated cover was constructed and placed upon outer ring. The purpose for covering the outer ring was to minimize a drastic temperature change of the water and to help minimize evaporation that could occur during testing. The cover was made out of plywood, 2 x 4's, and insulation (see Figure 19).

Figure 18 – Locations of Tensiometers and initial construction of the outer cover

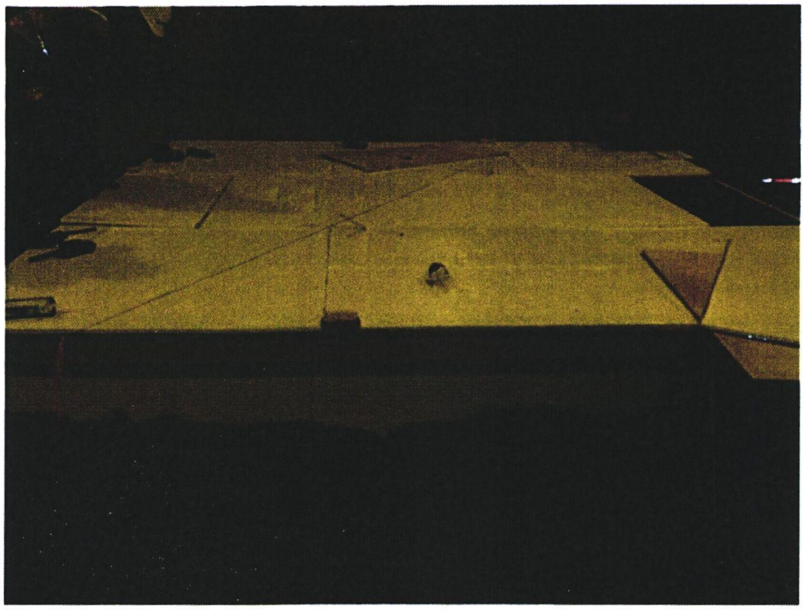

Figure 19 – Complete cover placed upon the outer ring

Water from the REDLeaf operations site was used to fill the inner and outer ring. To maintain the water at a constant temperature and keep from freezing during the periods of cold weather, an electric floating trough heater was placed in the water within the SDRI.

4.1.3 SDRI 1

Installation of SDRI 1 commenced on November 27, 2012 and was completed on November 29, 2012. SDRI 1 was located on the south corner of the SDRI test pad. Initial readings were obtained on November 29, 2012. Hydraulic conductivity testing the south side of the SDRI test pad occurred in the locations where the BAS material was compacted using a smooth drum CS74 vibratory roller. Infiltration testing for SDRI 1 continued until March 31, 2013. The disassembly and removal of SDRI 1 occurred on April 16, 2013, and subsequently moved to the SDRI 2 testing location.

4.1.4 SDRI 2

Upon completion of the SDRI 1 test, the outer ring and inner ring were uplifted from the BAS material and moved to the north side of the SDRI test pad. The installation of SDRI 2 commenced on April 16, 2013 and was completed on April 18, 2013. Initial readings for SDRI 2 began on April 18, 2013. Hydraulic conductivity testing for the north side of the SDRI test pad where the material was compacted using a Wacker Neuson RTSC2 Trench Roller. Infiltration testing for SDRI 2 continued until December 3, 2013. The disassembly and removal of SDRI 2 occurred on December 17, 2013.

4.1.5 Field Sampling

Undisturbed and disturbed soil samples were obtained at the SDRI test pad during placement and compaction of BAS material and upon completion of each SDRI test. Eight bag samples were obtained as BAS loads were brought from the pug mill mixing site to the location of the test pad. Nine undisturbed thin wall samples were obtained around the periphery of the test pad on BAS material after compaction of the BAS had occurred as shown in Table 2.

Table 2 – Sample ID, sample type, and depth of sample of samples obtained during construction of the test pad

Sample ID	Type	Depth (ft)
Load 3	Bag	NA
Load 4	Bag	NA
Load 5	Bag	NA
Load 6	Bag	NA
Load 7	Bag	NA
Load 8	Bag	NA
Western Clay 80 Mesh	Bag	NA
East Bulk	Bucket	NA
West Bulk	Bucket	NA
9	Tube	0-0.5
9A	Tube	0-0.5
10	Tube	0-0.5
10A	Tube	0-0.5
13	Tube	0-0.5
13A	Tube	0-0.5
14	Tube	0-0.5
15	Tube	0-0.5

Four undisturbed thin wall samples were obtained near each corner of the inner ring location upon completion of SDRI 1 as shown in Table 3.

Table 3 – Sample ID, type of sample, and depth of sample for samples obtained within the inner ring area of SDRI 1 upon completion of the SDRI 1 testing

Sample ID	Type	Depth (ft)
1 NW	Tube	0-0.5
2 NE	Tube	0-0.5
3 SE	Tube	0-0.5
4 SW	Tube	0-0.5

Six undisturbed thin wall samples were obtained around the periphery of the inner ring are upon completion of SDRI 2 as shown in Table 4.

Table 4 - Sample ID, type of sample, and depth of sample for samples obtained within the inner ring area of SDRI 2 upon completion of the SDRI 2 testing

Sample ID	Type	Depth (ft)
A	Tube	0-0.5
B	Tube	0-0.5
C	Tube	0-0.5
D	Tube	0-0.5
E	Tube	0-0.5
F	Tube	0-0.5

All thin wall samples collected during the field investigation for each location were obtained at a depth of 0 – 0.5 feet below the compacted BAS surface.

Field density tests were performed within the inner ring area to assess any potential density loss that may have occurred as a result of swelling. The in situ field densities of the BAS matrix within the inner ring area for SDRI 1 were obtained at the four corners using a nuclear density gauge and are provided Table 5.

Table 5 – Field density measurements within the inner ring area upon completion of SDRI 1 testing (4/16/2013)

ID	Total Unit Weight (pcf)	Dry Unit Weight (pcf)	Water Content (%)
NW Corner			
SW Corner		*Confidential business information Proprietary*	
SE Corner			
NE Corner			

The in situ field densities of the BAS matrix within the inner ring area of SDRI 2 were obtained using thin wall sampling kit, and were obtained around the periphery of the inner ring. Samples obtained by way of the thin wall sampling kit were brought back to the IGES laboratory and tested. Results for field densities obtained from thin wall samples will be presented in Section 4.2.

4.2 LABORATORY INVESITGATION

BAS samples collected by IGES occurred during construction of the SDRI BAS test pad and at the time of completion of SDRI 1 and SDRI 2. Samples obtained were taken back to the IGES laboratory for material indexing testing and hydraulic conductivity testing. Basic material index testing included:

- Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (ASTM D2216)
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM D4318)
- Particle Size Analysis of Soils by Mechanical Sieving and Sedimentation Processes (ASTM D422)
- Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698)

A total of 9 unit weight tests and 20 water contents tests on samples obtained during construction of the test pad and completion of SDRI 1 and SDRI 2 testing. Unit weight tests were not performed on Sample IDs Load 1 through West Blk because these samples were obtained as bag samples or bucket samples. The total unit weight and water content results for the samples tested are presented in Table 6.

Table 6 – Unit weight and water content results for samples obtained during construction of the test pad and upon completion of SDRI 1 and SDRI 2 testing

Sample ID	Unit Weight (pcf)	Water Content (%)
Load 1		
Load 2		
Load 3		
Load 4		
Load 5		
Load 6		
Load 7		
Load 8		
Western Clay 80 Mesh		
East Blk		
West Blk		
1 NW		
2 SW		
3 SE		
4 NE		
B		
C		
D		
E		
F		

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A total of 29 Atterberg limit tests were performed on samples obtained during construction or the test pad and completion of SDRI 1 and SDRI 2 testing. Results for the liquid limit, plastic limit, and plasticity index determinations are shown in Table 7. These samples classify as fat clays. Complete liquid limit, plastic limit, and plasticity index results for samples obtained during SDRI test pad construction and upon completion of SDRI 1 and SDRI 2 testing are provided in Appendix B, Appendix D, and Appendix E.

Table 7 – Liquid limit, plastic limit, and plastic index results for samples obtained during construction of the test pad and upon completion of SDRI 1 and SDRI 2 testing

Sample ID	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Sample Description
9				
9A				
10				
10A				
13				
13A				
14				
15				
Load 1				
Load 2				
Load 3				
Load 4				
Load 5				
Load 6				
Load 7				
Load 8				
Western Clay 80 Mesh				
East Bulk				
West Bulk				
1 NW				
2 SW				
3 SE				
4 NE				
B				
C				
D				
E				
F				

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A total of two laboratory compaction characteristic tests using a standard effort (ASTM D698) were performed on samples obtained during the construction of the test pad. The optimum water content (w_{opt}) and maximum dry unit weight (γ_{dmax}) for laboratory compaction tests are presented in Table 8. Complete laboratory compaction test results are provided in Appendix B.

Table 8 Laboratory compaction results for samples obtained during construction of the test pad

Sample ID	W_{opt} (%)	γ_{dmax} (pcf)
East Blk	15.2	101.5
West Blk	13.8	103.3

To evaluate the BAS proportion of Confidential business information Proprietary bentonite to Confidential business information Proprietary oil shale rubble mixture, 28 particle size analysis (ASTM D422) were performed. A combined plot with the particle size distribution results for samples previously mentioned Section 4.1.5 is shown in Figure 20. Complete particle size distribution results for samples obtained during SDRI test pad construction and upon completion of SDRI 1 and SDRI 2 testing are provided in Appendix B, Appendix D, and Appendix E.

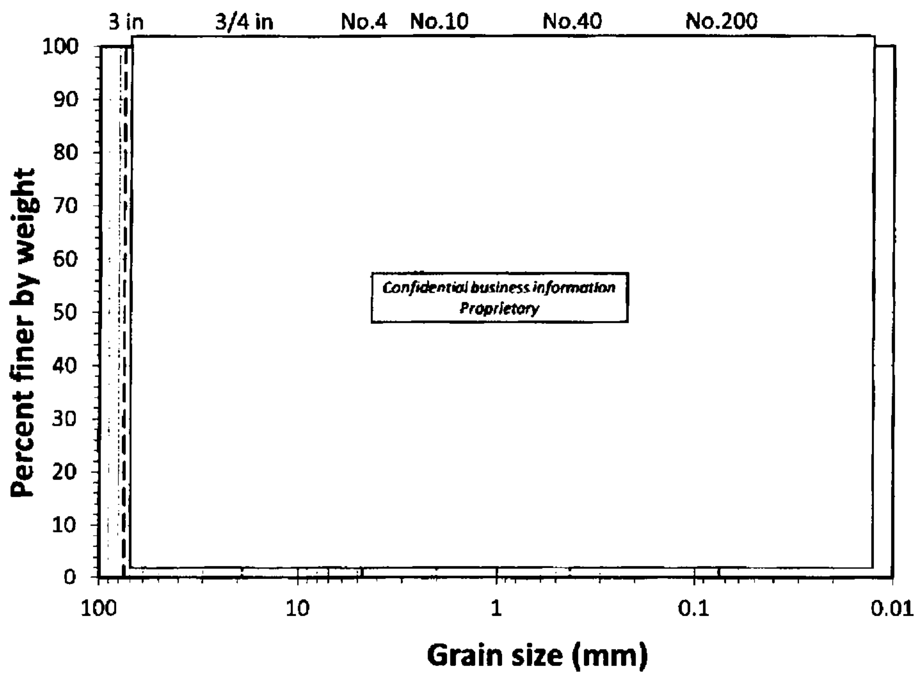

Figure 20 – Particle size distribution analysis for samples obtained during construction of the SDRI test pad and during SDRI testing

In order to evaluate the hydraulic flow characteristics of the BAS site soils for the estimation of the hydraulic conductivity following the Measurement of Hydraulic Conductivity of Saturated

Porous Materials Using a Flexible Wall Permeameter (ASTM D5084) was performed. The purpose of performing ASTM 5084 was to select BAS samples to supplement the data collected in the field. Hydraulic conductivity testing was performed on samples obtained during construction and upon completion of SDRI 1 and SDRI 2. Hydraulic conductivity results for samples obtained during the construction of the test pad are presented in Table 9.

Table 9 – Laboratory hydraulic conductivity results for samples obtained during construction of the BAS test pad

Sample ID	Depth (ft)	k (cm/sec)
9	0-0.5	4.0E-06
9A	0-0.5	8.2E-07
10	0-0.5	2.4E-07
10A	0-0.5	1.2E-06
13	0-0.5	8.2E-06
13A	0-0.5	4.7E-06
14	0-0.5	2.7E-07
15	0-0.5	5.1E-06

Suspected bypass flow along the sides of these samples resulting in the high hydraulic conductivity values shown above is discussed later in section 6.0 of this report.

The hydraulic conductivity of the thin wall samples obtained at the four corners of the inner ring area for SDRI 1 and inside the inner ring area of SDRI 2 was tested following the procedures outlined in ASTM D5084 with a slight sample preparation modification. To prevent water bypass during hydraulic conductivity testing, bentonite slurry was prepared and placed along the circumference of each sample. Effective confining stresses used to consolidate the test specimens obtained from SDRI 1 were 1, 5, and 10 ksf, with purpose of providing a baseline and upper limit hydraulic conductivity value. Laboratory hydraulic conductivity results for SDRI 1 at each effective confining stress and location are presented in Table 10.

Table 10 – Laboratory hydraulic conductivity results for samples obtained at the four corners of the inner ring area upon completion of SDRI 1

Sample ID	Depth (ft)	$k_{@1\,ksf}$ (cm/sec)	$k_{@5\,ksf}$ (cm/sec)	$k_{@10\,ksf}$ (cm/sec)
1 NW	0-0.5	1.8E-08	5.3E-09	2.8E-09
2 NE	0-0.5	9.5E-09	4.0E-09	2.0E-09
3 SE	0-0.5	1.1E-08	4.6E-09	2.5E-09
4 SW	0-0.5	2.1E-06	9.2E-09	7.7E-09

The effective confining stresses used to consolidate the test specimens were 1.44, 2.88, and 5.76 ksf. Hydraulic conductivity results for each effective confining stress inside the inner ring area of SDRI 2 are presented in Table 11. Laboratory results for hydraulic conductivity for samples obtained during construction of the test fill pad and upon completion of SDRI 1 and SDRI 2 testing are provided in Appendix B, Appendix D, and Appendix E.

Table 11 - Laboratory hydraulic conductivity results for samples obtained inside the inner ring area upon completion of SDRI 2

Sample ID	Depth (ft)	$k_{@1.44\,ksf}$ (cm/sec)	$k_{@2.88\,ksf}$ (cm/sec)	$k_{@5.76\,ksf}$ (cm/sec)
B	0-0.5	1.1E-08	9.4E-09	4.6E-09
C	0-0.5	3.2E-08	2.1E-08	9.5E-09
D	0-0.5	8.0E-09	6.3E-09	4.7E-09
E	0-0.5	1.7E-08	1.1E-08	6.7E-09
F	0-0.5	1.7E-08	1.4E-08	8.9E-09

5.0 DATA REDUCTION

5.1 SDRI DATA

Data obtained during the SDRI testing included date and time of reading, mass of bag 1 and mass of bag 2, temperature of water, the depth of water inside the outer ring, matric suction, and swell of the inner ring. Data was collected by personnel provided by REDLeaf Resources under the supervision of IGES. Data collection began on November 29, 2012 and ended on April 8, 2013 for SDRI 1 whereas, data collection for SDRI 2 began on April 18, 2013 and ended on December 6, 2013.

Data reduction involved obtaining the weight of each bag at each time and date. The weight loss between readings was converted into a quantifiable volume of water that was discharged between readings due to infiltration below the inner ring.

The infiltration rate (*I*) for each reading was determined by recording the total flow from the bags (Q_t) and dividing by the area of the inner ring (*A*) and the change in time between each readings (ΔT). The infiltration rate is denoted using the following equation:

$$I = \frac{Q_t}{A(\Delta T)}$$

The total flow from underneath the inner ring into the BAS matrix soil is a summation of the loss of water for each individual bag at each time and date the bags were weighed:

$$Q_t = \frac{(M_{1,j} - M_{1,j-1}) + (M_{2,j} - M_{2,j-1})}{\rho}$$

where:

M_1 = Mass of bag 1 in grams

M_2 = Mass of bag 2 in grams

ρ = density of water (1 gm/mL)

T_i = Time of reading at time j

T_{i-1} = Time of reading at the previous time step $j-1$

A = 25 ft^2 (2.3226 m^2).

$\Delta t = T_i - T_{i-1}$

The depth of water inside the outer ring was recorded for each time step in order to properly maintain a constant head above the inner ring and the flexible bags filled with water.

Hydraulic conductivity (k) can be calculated from the infiltration rate by evaluating the gradient (i) during the infiltration process. The gradient is defined as follows:

$$i = \frac{\Delta H}{L}$$

where:

ΔH = Height of water above compacted BAS material

L = Depth to the wetting front

The hydraulic conductivity can be evaluated as follows:

$$k = \frac{I}{i} = \frac{Q_t}{i(A)\Delta t}$$

The hydraulic conductivity data is normalized to a hydraulic conductivity at a standard water temperature of 20°C, k_{20}:

$$k_{20} = kR_T$$

$$R_T = \frac{2.2902(0.9842^T)}{T^{0.1702}}$$

where:

R_T = Ratio of the viscosity of water at the test temperature to the viscosity of water at 20°C

T = the average temperature over the incremental test interval

5.2 TENSIOMETER DATA

The location of the wetting front due to water infiltrating through test pad needs to be estimated during the infiltration process. Tensiometers were installed in an effort to help estimate the location of the wetting front within the test pad. Readings from the tensiometers were obtained during the hydraulic conductivity testing phase of SDRI 1 and SDRI 2 and are presented in 6.1and 6.2.

5.3 SWELL GAUGE DATA

As water infiltrated the SDRI test pad, the possibility of swelling of the test pad could occur. In order to properly monitor this movement, swell gauge readings were obtained during the SDRI 1 testing time period. Swell within the inner ring area of the test pad for SDRI 1 did not occur, thus swell gauges were not installed for SDRI 2.

6.0 RESULTS AND CONCLUSIONS

Results and conclusions for determining the steady state hydraulic conductivity of the BAS using a sealed double ring infiltrometer are presented in this section. The temperature, water depth, water tension, infiltration rate, and hydraulic conductivity, for data obtained from SDRI 1 are presented in Section 6.1. The temperature, water depth, water tension, infiltration rate, and hydraulic conductivity for data obtained from SDRI 2 are presented in Section 6.2.

The data from the tensiometers indicated that the location of the wetting front never reached the shallowest tensiometers at 6 inches. The laboratory density data were used to determine the complete phase relationships and to arrive at the porosity, *n*, of the compacted BAS at 31.7% and 32% for SDRI 1 and SDRI 2 respectively. The depth of the wetting front was then calculated at follows:

$$L = \frac{S + \int_0^t I(t)\,dt}{n}$$

where *I(t)* in the infiltration rate as a function of time.

The location of the wetting front at the end of testing was observed in the field upon dismantling the testing equipment and closely correspond to the calculated location of the wetting front using the formula as shown above.

6.1 SDRI 1

Infiltration testing for SDRI 1 lasted a total of 116 days. Water tension results for the test pad are presented in Figure 23. The hydraulic conductivity was determined to have a reached a steady state condition of 1.98E-9 cm/sec, as shown in Figure 25.

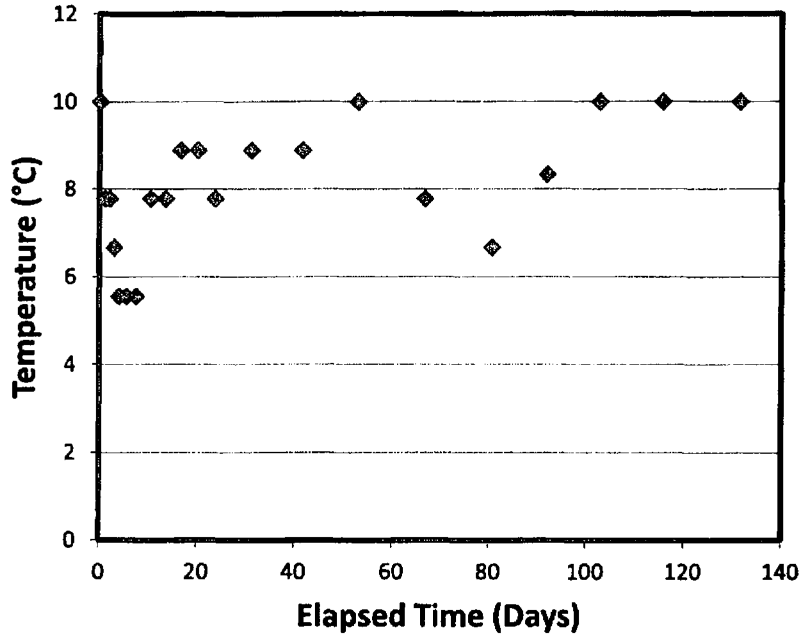

Figure 21 - Variation of temperature with elapsed time for SDRI 1

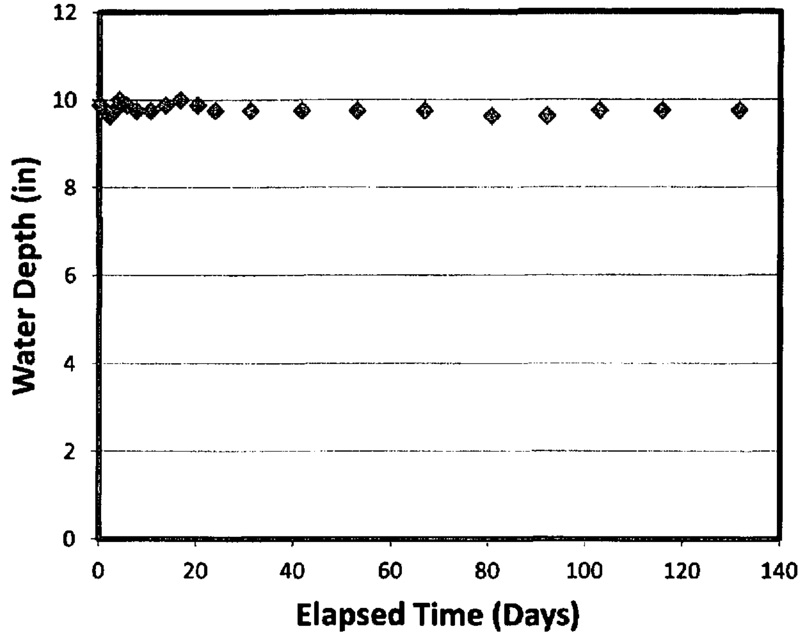

Figure 22 - Water depth with elapsed time for SDRI 1

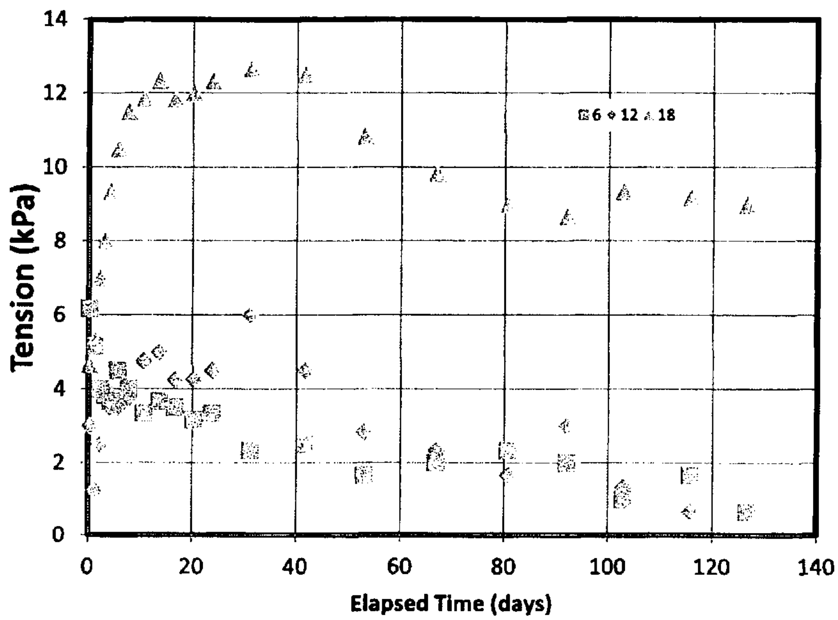

Figure 23 – Water tension with time at SDRI 2 for depths of 6, 12, and 18 inches into the SDRI test pad.

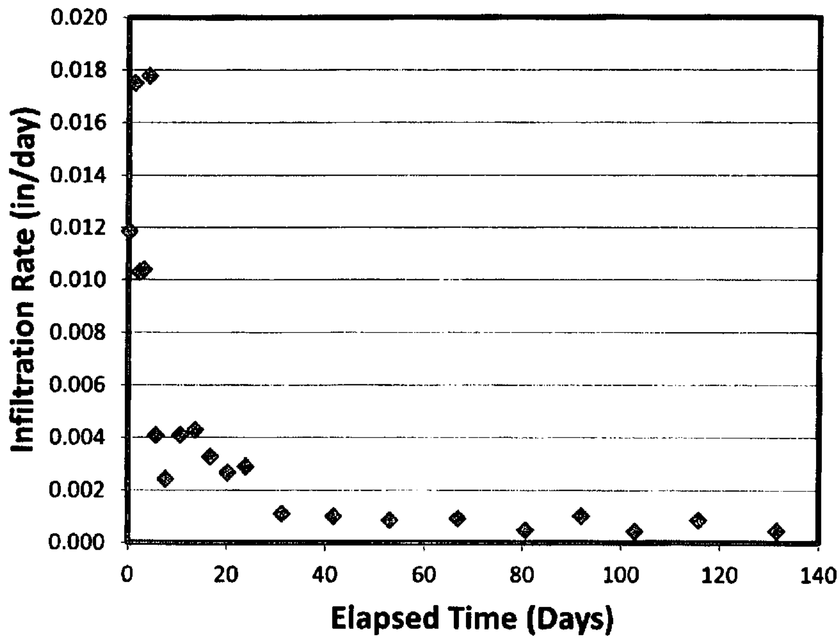

Figure 24 – Infiltration rate with time for SDRI 1

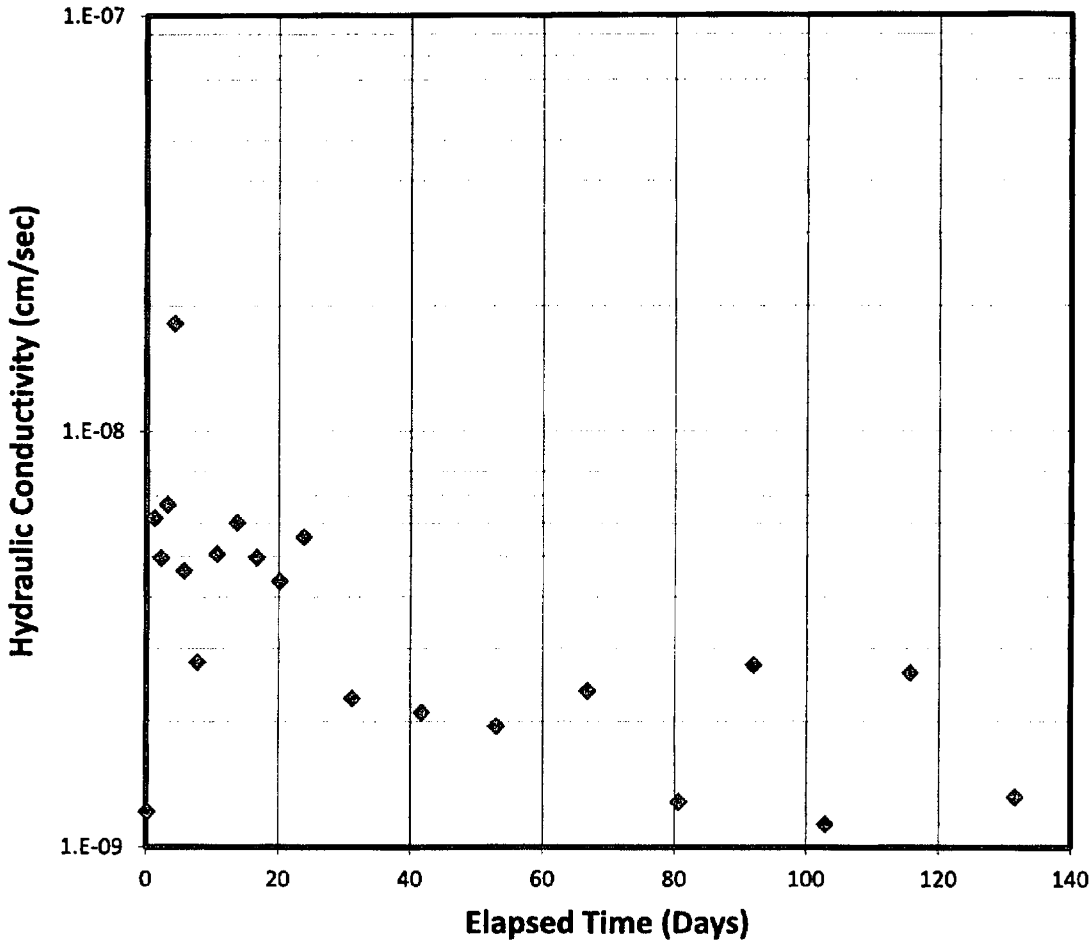

Figure 25 – Hydraulic conductivity with time for SDRI 1

6.2 SDRI 2

Hydraulic conductivity testing for SDRI 2 lasted a total of 230 days. Water tension results for the test pad for SDRI 2 are presented in Figure 28. The hydraulic conductivity was determined to have a reached a steady state condition of 3.38E-8 cm/sec as shown in Figure 30.

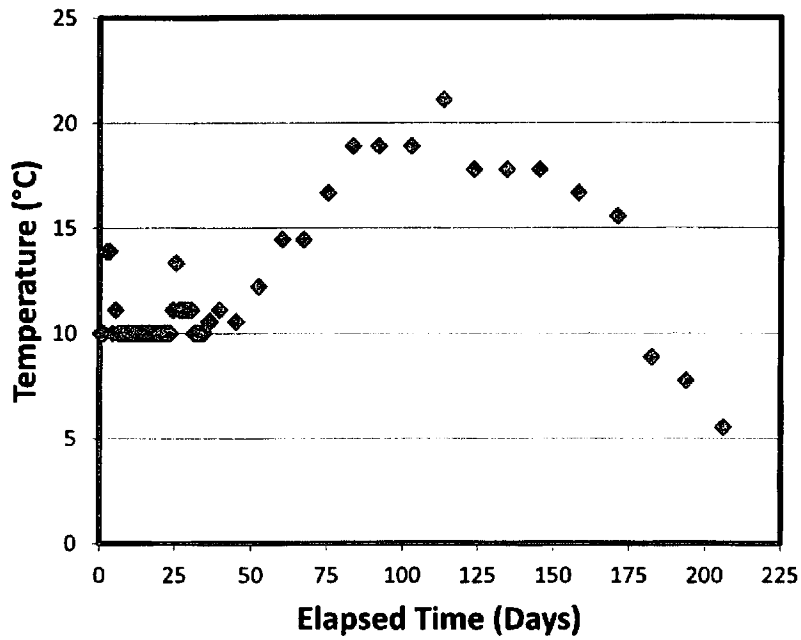

Figure 26 - Variation of temperature with elapsed time for SDRI 2

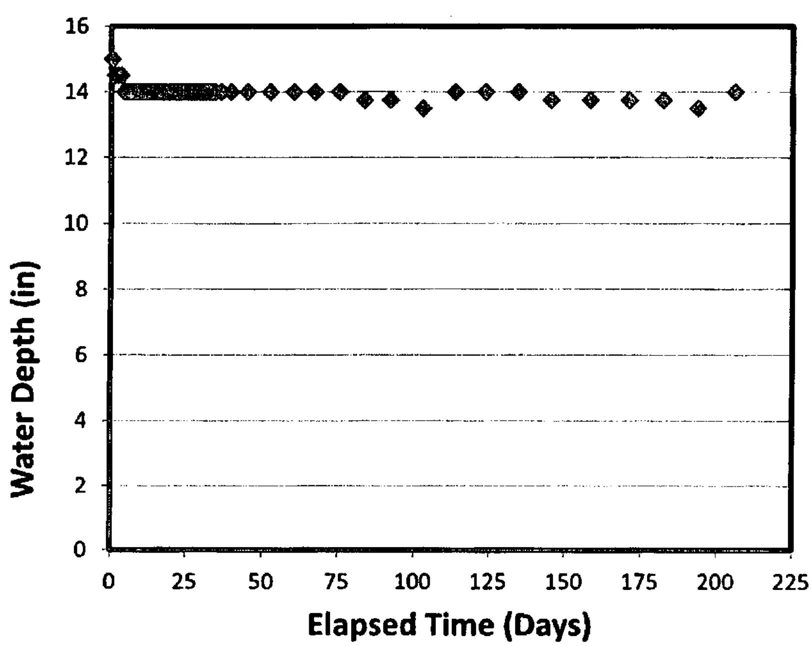

Figure 27 - Water depth with elapsed time for SDRI 2

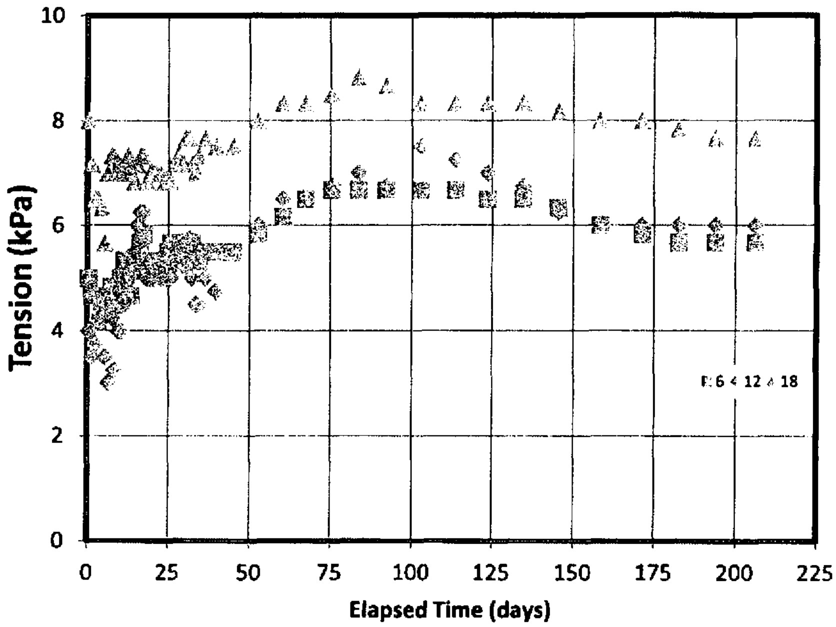

Figure 28 - Water tension with time at SDRI 2 for depths of 6, 12, and 18 inches into the SDRI test pad.

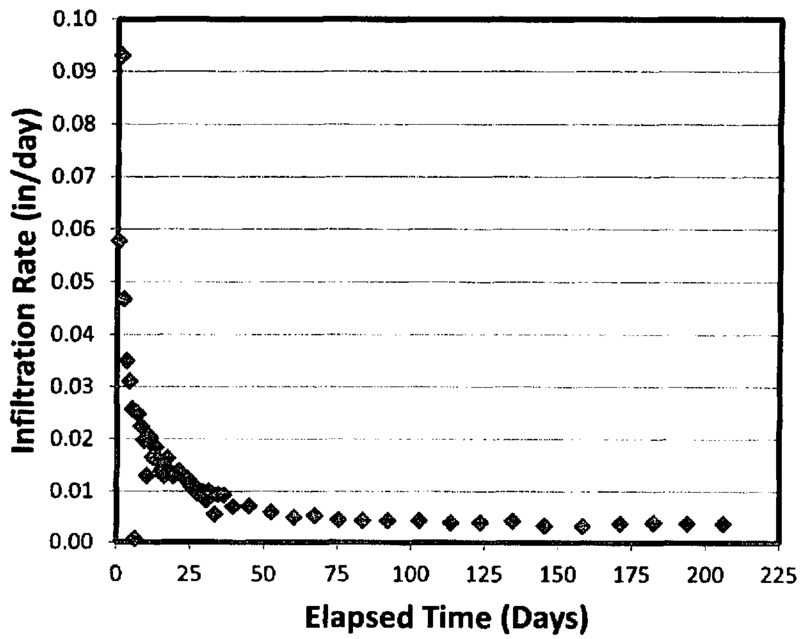

Figure 29 – Infiltration rate with time for SDRI 2

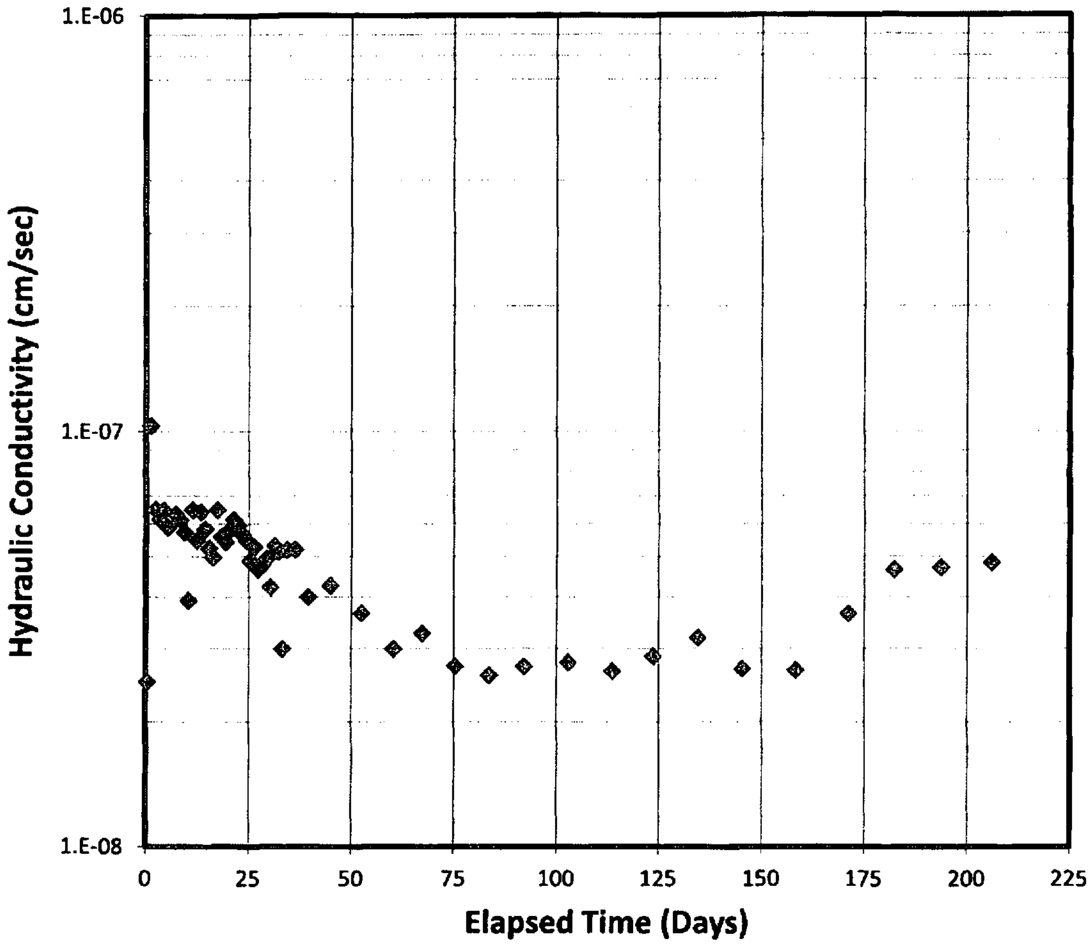

Figure 30 – Hydraulic conductivity with time for SDRI 2

6.3 CONCLUSIONS

The laboratory hydraulic conductivity tests which were initially performed and summarized in Table 9, indicated a potential of bypass flow between the membrane and the test specimen because of the coarse granular nature of the BAS material and the pathways that most likely developed attributed to the drive tube method of sampling. Bypass flow can occur with test specimens exhibiting relatively rough circumference surfaces. The in-situ samples exhibited this texture. In subsequent testing, an effort was made to mitigate this bypass flow potential by skim coating the circumference of the test specimens with a layer of hydrated bentonite prior to membrane encapsulation and testing. This sidewall treatment proved to be quite successful in mitigating this bypass flow and revealed that initial testing yielded erroneously high hydraulic conductivity values.

The results presented in Section 6.2 indicate that the SDRI field test yielded similar results with the laboratory tests. The results also indicate that the BAS produced during the fall of 2012 and corresponding construction methods yield a liner with a range of hydraulic conductivity of 2.0E-9 cm/sec (for SDRI 1, floor and roof construction methods) to 3.5E-8 cm/sec (for SDRI 2, vertical wall construction method). Companion laboratory test data also show that the increase in effective stress that the capsule base liner will be subjected to, will also result in a further decrease in hydraulic conductivity relative to that observed in SDRI 1.

Methods of BAS production and placement that would increase the hydraulic conductivity and should be avoided include:

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- Decreasing the amount of bentonite (less than ☐ by weight)
- BAS matrix material gradation changes with less fines and tend towards more poorly grading.
- Lower compaction effort.
- Lower compacted water content.
- Lower compacted degree of saturation.

Conversely, methods of BAS production and placement that would decrease the hydraulic conductivity and may be acceptable (upon laboratory testing verification) include:

- Increasing amounts of bentonite by weight (greater than ☐ by weight)
- Producing a more well graded BAS matrix material.

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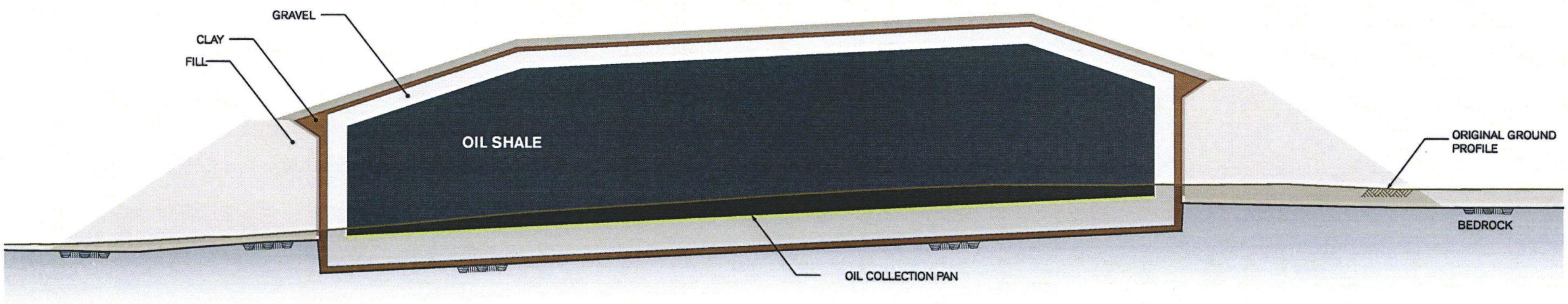
- Higher compaction effort.
- Higher compacted water content.
- Higher compacted degree of saturation.

Any change made to the BAS material should undergo additional laboratory hydraulic conductivity testing for verification. It is highly recommended that a sidewall treatment be applied as described in this report for all additional verification testing in the laboratory.

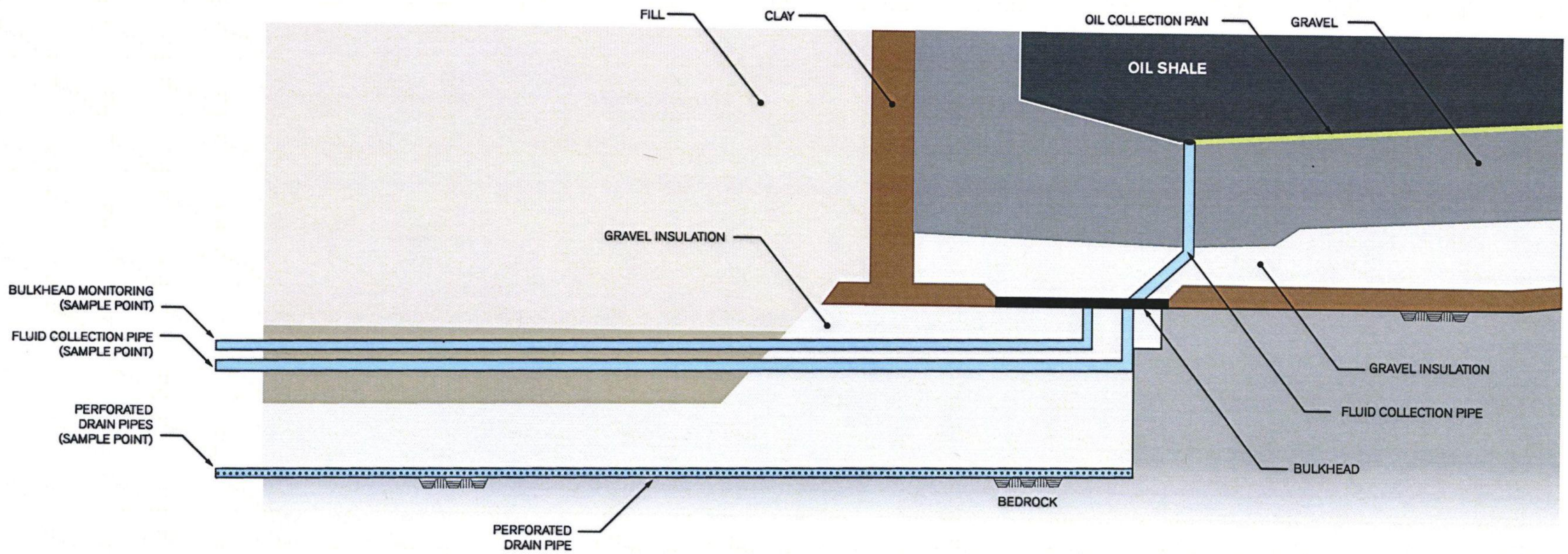
EPS Capsule Drawings



CLAY
OIL SHALE
GRAVEL
BEDROCK
FILL
ORIGINAL GROUND

CAPSULE CROSS SECTION

REDLEAF RESOURCES, INC.



CLAY
OIL SHALE
GRAVEL
BEDROCK
FILL
ORIGINAL GROUND

BULKHEAD CROSS SECTION

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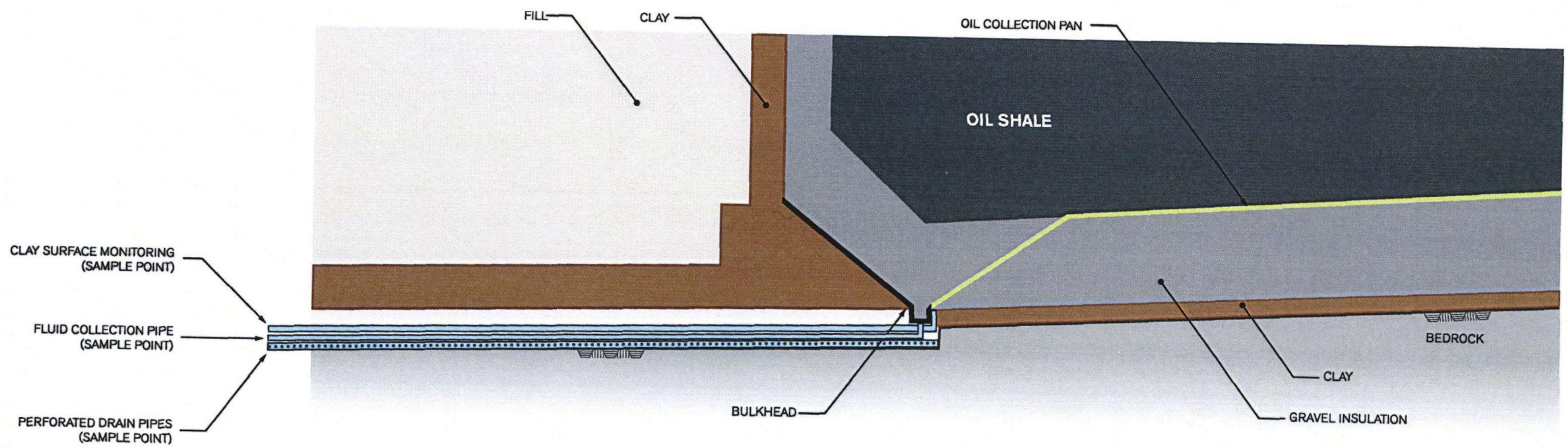

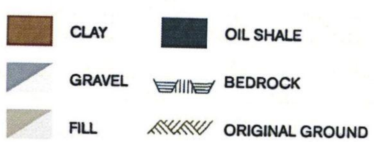

OPTIONAL BULKHEAD CROSS SECTION

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SECTION 2

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