

Manufacturing Quality Assurance Manual



GSE BentoLiner

Fabric Encased Geosynthetic Clay Liner Products





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1.0 INTRODUCTION

This manual provides an overview of the GSE Manufacturing Quality Assurance Program for GSE BentoLiner fabric encased geosynthetic clay liner (GCL) products. It is intended for use by GSE's customers to enhance their understanding of the quality system under which GSE BentoLiner fabric encased GCL products are manufactured.

2.0 COMMITMENT TO QUALITY

GSE is committed to meeting or exceeding customer's requirements and industry standards. This commitment to quality is established through a documented quality management system, continuous employee training, investment in technology and emphasis on process control. GSE has allocated resources to ensure that this commitment to quality translates into the best products and services for its customers.

3.0 MANUFACTURING QUALITY ASSURANCE

GSE has an on-site quality assurance laboratory at each manufacturing facility worldwide. Each facility has a fully equipped, well staffed, dedicated laboratory with strict guidelines to maintain a high level of quality and up-to-the-minute results on GSE's finished products.

GSE has a rigorous set of minimum standards and an effective test program to assure compliance has been established. These procedures and requirements are frequently reviewed and adjusted to assure compliance with current market demands and/or predetermined project specifications. Also raw materials and process parameters are controlled to provide products complying with GSE's minimum characteristics and regulatory standards.

4.0 MANUFACTURING QUALITY ASSURANCE ORGANIZATION

GSE quality assurance department assures that only products meeting GSE and/or the customer's requirements are released for shipment. The quality assurance personnel are directly responsible for monitoring, testing, and providing feedback to the manufacturing department ensuring the production of the specified product quality. Each member of the quality assurance team must participate in detailed training that includes factory exposure.

The GSE quality assurance team consists of the manufacturing quality assurance laboratories, engineering staff and manufacturing personnel. The combination of expertise and experience from these groups provide GSE with the proper tools to maintain the highest level of product quality and customer service in the industry.

5.0 STAFF & SCHEDULING

The quality assurance laboratories are staffed during any manufacturing run. A continuous communication link is maintained between the laboratory and manufacturing personnel, maximizing production efficiency and product quality.



6.0 PRODUCT IDENTIFICATION & DOCUMENTATION

As the sodium bentonite clay is the primary “active” ingredient for the GSE BentoLiner GCL products, the supplier assigns clay lot numbers based upon their processing and delivery constraints. Once the clay is received, GSE maintains the lot designation for tracking and identification purposes.

A. Roll Numbering

Each roll of finished product is assigned a unique roll number. The quality assurance laboratory maintains records documenting the raw materials and resulting product quality information that can be associated with any particular roll of geosynthetic clay liner.

B. Post Production Quality Assurance

A sample of finished GCL is obtained by cutting across the roll width, 2.0 ft (600 mm) by 15.5 ft (4.7 m). This sample is immediately sent to the quality assurance laboratory for finished product testing.

C. Evaluation of Results

Samples of finished GSE BentoLiner GCL are tested using the frequencies and procedures listed in Appendix A. All data is recorded and compared to established customer or project specifications. If the finished product does not meet the required average values, the manufacturing personnel are immediately notified to make the appropriate adjustments. Only products meeting GSE’s standard values and/or customer’s specifications will be approved for shipment to the corresponding project.

D. Reporting

All rolls supplied for a specific project or order will be provided a manufacturing quality assurance document. This report identifies the standards by which the GSE approval is based along with the actual test results demonstrated. Each report is reviewed and initiated by the GSE’s laboratory technician.

E. Packaging & Labeling

Each roll of GCL is packaged in a polyethylene sleeve capable of preventing undue moisture from contacting the enclosed GCL. Rips or tears in any packaging must be repaired or replaced, if in the judgement of the QC personnel, the damage is considered significant.

7.0 RECORDS RETENTION

GSE maintains all necessary reports and/or samples for products produced and sold. Records and/or samples are maintained according to GSE's standard retention policy as outlined below.

Geosynthetic Clay Liner

ITEMS	YEARS
Raw Test Data (in computer database)	5
Quality Control Certificates	5
Sample Retain [1.0 ft ² (300 m ²)]	5



8.0 TESTING CAPABILITIES

GSE maintains a modern, state-of-the-art, quality assurance laboratory capable of performing the analysis listed in Appendixes A-F in Spearfish, South Dakota. Calibration of all laboratory equipment is performed minimally on an annual cycle. The calibration certificates are maintained for review upon request.

A. Routine Testing

GSE has developed a strict quality assurance program, which exceeds all industry's standards and/or the customer's specifications. This testing program covers raw materials and finished goods and is adhered to by all GSE's quality assurance laboratories.

B. Other Testing Capabilities

Although the GSE quality assurance laboratories are fully equipped and capable to perform most tests routinely specified, there are a few analysis that are more economically performed by a dedicated testing facility. GSE believes requirements for such testing should be carefully considered, and if found to be necessary, specified in terms of a particular design requirements. Some tests that GSE recommends be performed via customer's arrangement with an outside testing facility are: Direct Shear Testing (ASTM D 5321, ASTM D 6243) and Permeability/Index Flux: (ASTM D 5887).

The interface friction characteristics of GCLs, geomembranes, and/or other geosynthetic products against adjoining site materials are specific to conditions of the installation. Friction characteristics critical to design parameters are best determined by independent testing incorporating site specific materials and conditions. GSE does not control and cannot warrant specific interface friction characteristics.

9.0 MATERIAL QUALITY ASSURANCE

GSE has established strict specifications for all raw materials and finished products. The results from every test performed must fall within the acceptable limits of these specifications.

A. Raw Materials

GSE utilizes four primary types of raw materials in the production of GSE BentoLiner products: sodium bentonite, carrier woven geotextiles, carrier scrim reinforced nonwoven geotextiles and cap nonwoven geotextiles. All geotextiles used in the production of GSE BentoLiner arrive in a finished roll form. Sodium bentonite arrives in bulk rail cars or bulk trucks. Upon receipt of raw materials, GSE begins the quality assurance process.

1. Sodium Bentonite

The granular sodium bentonite utilized in GSE BentoLiner GCLs is supplied by several different bentonite producers located in the Big Horn Basin and Black Hills regions of the U.S. The bentonite producers are responsible for all aspects of mineral processing including selective mining, processing to correct gradation, adherence to internal quality control procedures, and loading into bulk truck or bulk hopper railcars for shipment to the GSE BentoLiner manufacturing plant. The bentonite is typically not modified prior to its incorporation into GSE BentoLiner,



although minor changes in moisture content may occur during the shipping and manufacturing process.

GSE maintains rigid specifications for all of its bentonite suppliers and their products. Each supplier is required to certify and provide test data in the form of a Certificate of Analysis (COA) for each shipment to the GSE BentoLiner manufacturing plant. Data required on the COA includes the base clay parameters summarized on Table 1.

TABLE 1. BENTONITE SUPPLIER QUALITY REQUIREMENTS

Bentonite Property	Test Method	Specified Value
Swell Index	ASTM D 5890	24 ml/2g minimum
Fluid Loss	ASTM D 5891	18 ml maximum
Moisture Content	ASTM D 4643	12% maximum
Bentonite Particle Size	ASTM D 421	15% max + #20 mesh 10% max - #200 mesh

Railcar shipments of bentonite contain approximately 190,000 lb to 200,000 lb (86,000 kg to 91,000 kg), and bulk truck shipments contain approximately 60,000 lb (30,000 kg). In accordance with the guidelines specified in ASTM D 5889 "Standard Practice for the Quality Control of Geosynthetic Clay Liners", the bentonite clay is sampled for quality assurance testing at a rate of twice per railcar or at a minimum of once every 100,000 lb (45,400 kg). This sampling and testing frequency equates to an average of one test for every 100,000 ft² (9,300 m²), as there is approximately one pound of clay per square foot of GCL.

2. "Carrier" Woven Geotextile

The woven geotextile is the primary support for GSE BentoLiner EC & NSL GCL products and the woven plays a roll in providing dimensional stability to the GCL. A thorough trial of every woven geotextile contemplated for use is completed prior to its acceptance. Only those woven geotextiles that consistently meet or exceed the quality requirements are used.

a. Suppliers

The woven geotextile is manufactured elsewhere by either an alliance partner or approved supplier, and is delivered to the GSE BentoLiner manufacturing plants in rolls.

b. Supplier Certificates of Analysis

GSE receives and maintains on file geotextile manufacturer certifications, certifying that the products meet the engineering specifications.

c. Quality Inspection

GSE randomly samples the carrier woven geotextile upon receipt and analyzes to verify material properties. If GSE's test results indicate that the woven geotextile does not meet its quality criteria, the roll is further evaluated in accordance with GSE's standards. Geotextile products will not be tagged for acceptance until it is verified that the minimum average roll values have been achieved.



3. *Scrim Reinforced "Carrier" Nonwoven Geotextile*

The scrim reinforced "carrier" nonwoven geotextile is the primary support for the GSE BentoLiner NWL product series and the scrim may play a roll in providing dimensional stability of the GCL. A thorough trial of every scrim reinforced nonwoven geotextile contemplated for use in GSE BentoLiner GCL product manufacturer is completed prior to its acceptance. Only those scrim reinforced nonwoven products that consistently meet or exceed established quality requirements are used.

a. *Suppliers*

The scrim reinforced nonwoven geotextile is manufactured by others elsewhere and is delivered to the GSE BentoLiner manufacturing plants in rolls.

b. *Supplier Certificates of Analysis*

GSE receives and maintains on file the manufacturer certifications, stating that the geotextiles meet or exceed the engineering specifications.

c. *Quality Inspection*

GSE randomly samples the carrier scrim reinforced nonwoven geotextile upon receipt and analyzes it to verify material properties. If GSE's test results indicate that the scrim reinforced nonwoven geotextile does not meet established quality criteria, the roll is segregated and further evaluated. Geotextile products will not be tagged for acceptance until it is verified that the minimum average roll values have been achieved.

4. *"Cap" Nonwoven Geotextile*

The "cap" nonwoven geotextile is used in the manufacturer of all GSE BentoLiner product series. A thorough trial of every nonwoven geotextile contemplated for use is completed prior to its acceptance for the GSE BentoLiner GCL products. Only those nonwoven products that consistently meet or exceed the quality requirements are used.

a. *Suppliers*

The nonwoven geotextiles are manufactured by GSE or alliance partners whom are approved suppliers, and are delivered to the GSE BentoLiner manufacturing plants in rolls.

b. *Supplier Certificates of Analysis*

GSE receives and maintains on file manufacturer certifications, stating that the products meet or exceed engineering specifications.

c. *Quality Inspection*

Upon receipt, GSE randomly samples the nonwoven geotextile and analyzes to verify material properties. If GSE's test results indicate that the nonwoven geotextile does not meet its quality criteria, the roll is segregated and further analyzed. Geotextile products will not be tagged for acceptance until it is verified that the minimum average roll values have been achieved.

B. *Finished GCL Products*

GSE has implemented a strict and thorough manufacturing quality assurance process for all GCL products. GSE BentoLiner material properties and test frequencies are listed in Appendixes B-F.



1. *On-Line Manufacturing Quality Assurance*

The quality assurance program for the finished GCL products begin during the manufacturing process.

2. *Application Measurement*

As each roll is being produced, application rate readings are taken throughout the production of the roll. These readings are utilized to establish the average bentonite application values for each roll and are verified by roll weight testing upon completion of the finished goods.

3. *Statistical Process Control*

Variables such as line rate and bentonite application have established process parameters, which vary with the particular grade of material being produced. Finished roll weight, length and width are measured and used to assure conformance to finished product specification. Process variables are adjusted in response to the minimum average roll data.

C. *Post Production Quality Assurance*

The finished GCL is sampled across the roll width within each lot. This sample is immediately sent to the quality assurance laboratory for finished product testing.

1. *Sampling*

A 2.0 ft (600 mm) by roll width [15.5 ft (4.7 m)] sample is cut for quality assurance testing at the specified frequencies listed in Appendixes B-F. The laboratory sample is labeled with the roll number, and production date. Test specimens are taken from positions across the width of the roll. The five specimen positions are defined as a constantly repeating set of locations determined by the roll number. A 1.0 ft by 1.0 ft (300 mm by 300 mm) is labeled and retained for 5 years for future reference or testing.

2. *Evaluation of Results*

Samples are tested using the frequencies and procedures listed in Appendixes B-F. All data are recorded and compared to established order specifications. If materials do not meet the required GSE's minimum average values and/or the customer specifications, the manufacturing personnel are immediately notified to make the appropriate adjustments. Only products meeting GSE's minimum average values and customer's specifications will be approved for shipment to the corresponding project.

3. *Reporting*

All rolls supplied for a specific project or order will be provided a manufacturing quality assurance document. This document identifies the standards on which the GSE's approval is based along with the actual test results demonstrated by the material. Each report is reviewed by quality assurance personnel, stamped, and initiated by the GSE's laboratory technician.

D. *Product Shipping*

It is the GSE's policy to ship only products that have been tested and approved. All shipments are packaged according to industry's standard practices and/or customer's specifications. Only approved handling methods are used to move rolls into and out of shipping containers, please see the GSE Installation Quality Assurance Manual for more details.



Appendix A: Panel & Roll Specifications

STANDARD PANEL AREA MEASUREMENTS:

Panel Dimensions:	15.50 ft wide x 150 ft long (4.72 m x 45.7m) [Excluding an estimated 1.5 in (38 mm) sacrificial textile on both edge]
Total Panel Area:	2,325 sq ft (216 sq m) [Based on 15.5 ft (4.7 m) x 150 ft rolls]
Total Effective Area:	2,235 sq ft (207.6 sq m) [6 in (150 mm) longitudinal overlap, 12 in (300 mm) transverse overlap]

STANDARD ROLL SHIPPING DIMENSIONS:

Nominal Shipping Dimensions:	15.75 ft long (4.73 m) x 2 ft diameter (600 mm)
Nominal Weight (Product Specific):	2,100 - 3,000 lb (952 - 1315 kg), includes core & packaging
Core Size:	4.75 in (120 mm) I.D.
Packaging:	4 mil (0.1 mm) U.V. Resistant Polyethylene Sleeve of varying color depending upon GCL product

TYPICAL SHIPPING QUANTITIES:

Rolls Per Standard 48' Flatbed Trailer:	16 - 19 Rolls Per Load
Rolls Per Standard 40 ft (12 m) Container:	19 - 20 Rolls Per Load
Bags of Granular Bentonite:	50 lb (23 kg) bags

UNLOADING AND HANDLING EQUIPMENT:

Core Pipe and Spreader Bar:	18 ft (5.4 m) long
Straps or Chains:	2 to 4, approximately 10 ft (3 m) in length
"Stinger" Bar:	12 - 14 ft (3.6 - 4.2 m) long, base attachment designed for Forklift

All Terrain Forklift (Extendible Boom), Front-End Loader, and Excavator are just a few examples of apparatus and equipment that can be used. Other options may be fully suitable.



Appendix B: GSE BentoLiner EC Data Sheet

TESTED PROPERTY	TEST METHOD	FREQUENCY	VALUE (ENGLISH)	VALUE (SI)
GEOTEXTILE PROPERTY				
Cap Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	3.0 oz/yd ² MARV ⁽¹⁾	100 g/m ² MARV ⁽¹⁾
Carrier Woven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	3.1 oz/yd ² MARV	105 g/m ² MARV
BENTONITE PROPERTY				
Swell Index	ASTM D 5890	1/100,000 lb (50,000 kg)	24 ml/2 g min	24 ml/2 g min
Moisture Content	ASTM D 4643	1/100,000 lb (50,000 kg)	12% max	12% max
Fluid Loss	ASTM D 5891	1/100,000 lb (50,000 kg)	18 ml max	18 ml max
FINISHED GCL PROPERTY				
Bentonite, Mass/Unit Area ⁽²⁾	ASTM D 5993	1/40,000 ft ² (1/4,000 m ²)	0.75 lb/ft ² MARV	3.66 kg/m ² MARV
Tensile Strength ⁽³⁾	ASTM D 6768	1/40,000 ft ² (1/4,000 m ²)	30 lb/in MARV	5 kN/m MARV
Peel Strength	ASTM D 6496 ASTM D 4632 ⁽⁴⁾	1/40,000 ft ² (1/4,000 m ²)	1 lb/in MARV 6 lb MARV	175 N/m MARV 26 N MARV
Hydraulic Conductivity ⁽⁵⁾	ASTM D 5887	1/Week	5 x 10 ⁻¹¹ m/sec max	5 x 10 ⁻¹¹ m/sec max
Index Flux ⁽⁵⁾	ASTM D 5887	1/Week	1 x 10 ⁻⁸ m ³ /m ² /sec max	1 x 10 ⁻⁸ m ³ /m ² /sec max
Internal Shear Strength ⁽⁶⁾	ASTM D 6243	Periodically	150 psf Typical	7.1 kPa Typical
ROLL DIMENSIONS				
Width x Length ⁽⁷⁾	Typical	Every Roll	15.5 ft x 150 ft	4.7 m x 45.7 m
Area per Roll	Typical	Every Roll	2,325 ft ²	216 m ²
Packaged Weight	Typical	Every Roll	2,600 lb	1,179 kg

NOTES:

- ⁽¹⁾Minimum Average Roll Value.
- ⁽²⁾Oven-dried measurement. Equates to 0.84 lb/ft² (4.1 kg/m²) when indexed to a 12% moisture content.
- ⁽³⁾Tested in machine direction.
- ⁽⁴⁾Modified ASTM D 4632 to use a 4 in (100 mm) wide grip. The maximum peak of five specimens averaged in machine direction.
- ⁽⁵⁾Deaired, deionized water @ 5 psi (34.5 kPa) maximum effective confining stress and 2 psi (13.8 kPa) head pressure.
- ⁽⁶⁾Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf (9.6 kPa) normal stress.
- ⁽⁷⁾Roll widths and lengths have a tolerance of ±1%.



Appendix C: GSE BentoLiner NSL Data Sheet

TESTED PROPERTY	TEST METHOD	FREQUENCY	VALUE (ENGLISH)	VALUE (SI)
GEOTEXTILE PROPERTY				
Cap Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	6.0 oz/yd ² MARV ⁽¹⁾	200 g/m ² MARV ⁽¹⁾
Carrier Woven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	3.1 oz/yd ² MARV	105 g/m ² MARV
BENTONITE PROPERTY				
Swell Index	ASTM D 5890	1/100,000 lb (50,000 kg)	24 ml/2 g min	24 ml/2 g min
Moisture Content	ASTM D 4643	1/100,000 lb (50,000 kg)	12% max	12% max
Fluid Loss	ASTM D 5891	1/100,000 lb (50,000 kg)	18 ml max	18 ml max
FINISHED GCL PROPERTY				
Bentonite, Mass/Unit Area ⁽²⁾	ASTM D 5993	1/40,000 ft ² (1/4,000 m ²)	0.75 lb/ft ² MARV	3.66 kg/m ² MARV
Tensile Strength ⁽³⁾	ASTM D 6768	1/40,000 ft ² (1/4,000 m ²)	30 lb/in MARV	5 kN/m MARV
Peel Strength	ASTM D 6496 ASTM D 4632 ⁽⁴⁾	1/40,000 ft ² (1/4,000 m ²)	3.5 lb/in MARV 21 lb MARV	610 N/m MARV 93 N MARV
Hydraulic Conductivity ⁽⁵⁾	ASTM D 5887	1/Week	5 x 10 ⁻¹¹ m/sec max	5 x 10 ⁻¹¹ m/sec max
Index Flux ⁽⁵⁾	ASTM D 5887	1/Week	1 x 10 ⁻⁸ m ³ /m ² /sec max	1 x 10 ⁻⁸ m ³ /m ² /sec max
Internal Shear Strength ⁽⁶⁾	ASTM D 6243	Periodically	500 psf Typical	24 kPa Typical
ROLL DIMENSIONS				
Width x Length ⁽⁷⁾	Typical	Every Roll	15.5 ft x 150 ft	4.7 m x 45.7 m
Area per Roll	Typical	Every Roll	2,325 ft ²	216 m ²
Packaged Weight	Typical	Every Roll	2,600 lb	1,179 kg

NOTES:

- ⁽¹⁾Minimum Average Roll Value.
- ⁽²⁾Oven-dried measurement. Equates to 0.84 lb/ft² (4.1 kg/m²) when indexed to a 12% moisture content.
- ⁽³⁾Tested in machine direction.
- ⁽⁴⁾Modified ASTM D 4632 to use a 4 in (100 mm) wide grip. The maximum peak of five specimens averaged in machine direction.
- ⁽⁵⁾Deaired, deionized water @ 5 psi (34.5 kPa) maximum effective confining stress and 2 psi (13.8 kPa) head pressure.
- ⁽⁶⁾Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf (9.6 kPa) normal stress.
- ⁽⁷⁾Roll widths and lengths have a tolerance of ±1%.



Appendix D: GSE BentoLiner NWL Data Sheet

TESTED PROPERTY	TEST METHOD	FREQUENCY	VALUE (ENGLISH)	VALUE (SI)
GEOTEXTILE PROPERTY				
Cap Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	6.0 oz/yd ² MARV ⁽¹⁾	200 g/m ² MARV ⁽¹⁾
Carrier Scrim Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	6.0 oz/yd ² MARV	200 g/m ² MARV
BENTONITE PROPERTY				
Swell Index	ASTM D 5890	1/100,000 lb (50,000 kg)	24 ml/2 g min	24 ml/2 g min
Moisture Content	ASTM D 4643	1/100,000 lb (50,000 kg)	12% max	12% max
Fluid Loss	ASTM D 5891	1/100,000 lb (50,000 kg)	18 ml max	18 ml max
FINISHED GCL PROPERTY				
Bentonite, Mass/Unit Area ⁽²⁾	ASTM D 5993	1/40,000 ft ² (1/4,000 m ²)	0.75 lb/ft ² MARV	3.66 kg/m ² MARV
Tensile Strength ⁽³⁾	ASTM D 6768	1/40,000 ft ² (1/4,000 m ²)	45 lb/in MARV	7.8 kN/m MARV
Peel Strength	ASTM D 6496 ASTM D 4632 ⁽⁴⁾	1/40,000 ft ² (1/4,000 m ²)	3.5 lb/in MARV 21 lb MARV	610 N/m MARV 93 N MARV
Hydraulic Conductivity ⁽⁵⁾	ASTM D 5887	1/Week	5 x 10 ⁻¹¹ m/sec max	5 x 10 ⁻¹¹ m/sec max
Index Flux ⁽⁵⁾	ASTM D 5887	1/Week	1 x 10 ⁻⁸ m ³ /m ² /sec max	1 x 10 ⁻⁸ m ³ /m ² /sec max
Internal Shear Strength ⁽⁶⁾	ASTM D 6243	Periodically	500 psf Typical	24 kPa Typical
ROLL DIMENSIONS				
Width x Length ⁽⁷⁾	Typical	Every Roll	15.5 ft x 150 ft	4.7 m x 45.7 m
Area per Roll	Typical	Every Roll	2,325 ft ²	216 m ²
Packaged Weight	Typical	Every Roll	2,600 lb	1,179 kg

NOTES:

- ⁽¹⁾Minimum Average Roll Value.
- ⁽²⁾Oven-dried measurement. Equates to 0.84 lb/ft² (4.1 kg/m²) when indexed to a 12% moisture content.
- ⁽³⁾Tested in machine direction.
- ⁽⁴⁾Modified ASTM D 4632 to use a 4 in (100 mm) wide grip. The maximum peak of five specimens averaged in machine direction.
- ⁽⁵⁾Deaired, deionized water @ 5 psi (34.5 kPa) maximum effective confining stress and 2 psi (13.8 kPa) head pressure.
- ⁽⁶⁾Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf (9.6 kPa) normal stress.
- ⁽⁷⁾Roll widths and lengths have a tolerance of ±1%.



Appendix E: GSE BentoLiner NWL-60 Data Sheet

TESTED PROPERTY	TEST METHOD	FREQUENCY	VALUE (ENGLISH)	VALUE (SI)
GEOTEXTILE PROPERTY				
Cap Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	6.0 oz/yd ² MARV ⁽¹⁾	200 g/m ² MARV ⁽¹⁾
Carrier Scrim Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	6.0 oz/yd ² MARV	200 g/m ² MARV
BENTONITE PROPERTY				
Swell Index	ASTM D 5890	1/100,000 lb (50,000 kg)	24 ml/2 g min	24 ml/2 g min
Moisture Content	ASTM D 4643	1/100,000 lb (50,000 kg)	12% max	12% max
Fluid Loss	ASTM D 5891	1/100,000 lb (50,000 kg)	18 ml max	18 ml max
FINISHED GCL PROPERTY				
Bentonite, Mass/Unit Area ⁽²⁾	ASTM D 5993	1/40,000 ft ² (1/4,000 m ²)	0.89 lb/ft ² MARV	4.34 kg/m ² MARV
Tensile Strength ⁽³⁾	ASTM D 6768	1/40,000 ft ² (1/4,000 m ²)	50 lb/in MARV	8.7 kN/m MARV
Peel Strength	ASTM D 6496 ASTM D 4632 ⁽⁴⁾	1/40,000 ft ² (1/4,000 m ²)	12 lb/in MARV 60 lb MARV	2,100 N/m MARV 266 N MARV
Hydraulic Conductivity ⁽⁵⁾	ASTM D 5887	1/Week	5 x 10 ⁻¹¹ m/sec max	5 x 10 ⁻¹¹ m/sec max
Index Flux ⁽⁵⁾	ASTM D 5887	1/Week	1 x 10 ⁻⁸ m ³ /m ² /sec max	1 x 10 ⁻⁸ m ³ /m ² /sec max
Internal Shear Strength ⁽⁶⁾	ASTM D 6243	Periodically	500 psf Typical	24 kPa Typical
ROLL DIMENSIONS				
Width x Length ⁽⁷⁾	Typical	Every Roll	15.5 ft x 150 ft	4.7 m x 45.7 m
Area per Roll	Typical	Every Roll	2,325 ft ²	216 m ²
Packaged Weight	Typical	Every Roll	2,600 lb	1,179 kg

NOTES:

- ⁽¹⁾Minimum Average Roll Value.
- ⁽²⁾Oven-dried measurement. Equates to 1.0 lb/ft² (4.9 kg/m²) when indexed to a 12% moisture content.
- ⁽³⁾Tested in machine direction.
- ⁽⁴⁾Modified ASTM D 4632 to use a 4 in (100 mm) wide grip. The maximum peak of five specimens averaged in machine direction.
- ⁽⁵⁾Deaired, deionized water @ 5 psi (34.5 kPa) maximum effective confining stress and 2 psi (13.8 kPa) head pressure.
- ⁽⁶⁾Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf (9.6 kPa) normal stress.
- ⁽⁷⁾Roll widths and lengths have a tolerance of ±1%.



Appendix F: GSE BentoLiner CNSL Data Sheet

TESTED PROPERTY	TEST METHOD	FREQUENCY	VALUE (ENGLISH)	VALUE (SI)
GEOTEXTILE PROPERTY				
Cap Nonwoven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	6.0 oz/yd ² MARV ⁽¹⁾	200 g/m ² MARV ⁽¹⁾
Carrier Woven, Mass/Unit Area	ASTM D 5261	1/200,000 ft ² (1/20,000 m ²)	3.1 oz/yd ² MARV	105 g/m ² MARV
BENTONITE PROPERTY				
Swell Index	ASTM D 5890	1/100,000 lb (50,000 kg)	24 ml/2 g min	24 ml/2 g min
Moisture Content	ASTM D 4643	1/100,000 lb (50,000 kg)	12% max	12% max
Fluid Loss	ASTM D 5891	1/100,000 lb (50,000 kg)	18 ml max	18 ml max
FINISHED GCL PROPERTY				
Bentonite, Mass/Unit Area ⁽²⁾	ASTM D 5993	1/40,000 ft ² (1/4,000 m ²)	0.75 lb/ft ² MARV	3.66 kg/m ² MARV
Tensile Strength ⁽³⁾	ASTM D 6768	1/40,000 ft ² (1/4,000 m ²)	40 lb/in MARV	7 kN/m MARV
Peel Strength	ASTM D 6496 ASTM D 4632 ⁽⁴⁾	1/40,000 ft ² (1/4,000 m ²)	3.5 lb/in MARV 21 lb MARV	610 N/m MARV 93 N MARV
Hydraulic Conductivity ⁽⁵⁾	ASTM D 5887	Periodically	5 x 10 ⁻¹² m/sec max	5 x 10 ⁻¹² m/sec max
Index Flux ⁽⁵⁾	ASTM D 5887	Periodically	1 x 10 ⁻⁹ m ³ /m ² /sec max	1 x 10 ⁻⁹ m ³ /m ² /sec max
Internal Shear Strength ⁽⁶⁾	ASTM D 6243	Periodically	500 psf Typical	24 kPa Typical
ROLL DIMENSIONS				
Width x Length ⁽⁷⁾	Typical	Every Roll	15.5 ft x 150 ft	4.7 m x 45.7 m
Area per Roll	Typical	Every Roll	2,325 ft ²	216 m ²
Packaged Weight	Typical	Every Roll	2,600 lb	1,179 kg

NOTES:

- ⁽¹⁾Minimum Average Roll Value.
- ⁽²⁾Oven-dried measurement. Equates to 0.84 lb/ft² (4.1 kg/m²) when indexed to a 12% moisture content.
- ⁽³⁾Tested in machine direction.
- ⁽⁴⁾Modified ASTM D 4632 to use a 4 in (100 mm) wide grip. The maximum peak of five specimens averaged in machine direction.
- ⁽⁵⁾Deaired, deionized water @ 5 psi (34.5 kPa) maximum effective confining stress and 2 psi (13.8 kPa) head pressure.
Hydraulic Conductivity and Index Flux are performed only on a periodic basis because the polypropylene coating is essentially impermeable.
- ⁽⁶⁾Typical peak value for specimen hydrated for 24 hours and sheared under a 200 psf (9.6 kPa) normal stress.
- ⁽⁷⁾Roll widths and lengths have a tolerance of ±1%.



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