England-Thims & Miller, Inc.
ENGINEERS • PLANNERS • SURVEYORS • LANDSCAPE ARCHITECTS

Principals
James E. England, P.E., C.E.O.
Douglas C. Miller, P.E., President
N. Hugh Mathews, P.E., Exec., V.P.
Joseph A. Tarver, Exec., V.P.
Juanitta Bader Clem, P.E., V.P.
Jeffrey A. Crammond, P.E., V.P.
Scott A. Wild, P.E., P.S.M., V.P.

February 29, 2000

Mr. Steve Nguyen
Waste Management Section
Department of Environmental Regulation
7825 Baymeadows Way, Suite 200B
Jacksonville, Florida 32256

Reference: Trail Ridge Landfill - Permit Number 0013493-002-SC
Third Increment of Construction
ET&M No. E99-92

Dear Mr. Nguyen:

On behalf of Trail Ridge Landfill, Inc., please find herein revised Page 11 of the Project Specific Addenda for the liner system construction at Trail Ridge Landfill. In the approved Addenda, the bentonite mat was to be conformance tested on site, prior to installation. This revision will allow the conformance testing to be conducted either on site or at the factory, prior to installation.

If you have any questions regarding this revision, please feel free to give me a call. Thank you for your assistance.

Sincerely,

ENGLAND, THIMS & MILLER, INC.

Juanitta Bader Clem, P.E.
Vice President

cc: Greg Mathes w/attachments
Chris Pearson w/attachments

Attachment

14775 ST. AUGUSTINE RD. • JACKSONVILLE, FL 32258 • TEL: (904) 642-8990 • FAX: (904) 646-9485

13.6.1 3. Replace "The addition of bentonite to seam locations shall be in accordance with the project specifications." with "The addition of bentonite to seam locations shall be in accordance with the manufacturer's recommendations."

13.6.1 2. Replace "The amount of the bentonite is placed on the seam required by the project specifications." with "The amount of the bentonite is placed on the seam required by the manufacturer's recommendations."

13.7 Replace "The material shall extend over the entire damaged area with a minimum 24-inch overlap in all directions. Addition of bentonite to patches shall be in accordance with the project specifications" with "The material shall extend over the entire damaged area with a minimum 24-inch overlap in all directions. Addition of bentonite to patches shall in accordance with the manufacturer's recommendations."

In addition to the requirements of the "Quality Assurance Guidance Document for the Installation of Lining Systems" (WMI, August 1997), the bentonite mat shall be monitored and tested as follows:

1. Bentonite Mat

   a. Location - Prior to installation, samples shall be obtained.

   b. Standard

      (1) Hydraulic Conductivity - The hydraulic conductivity (ASTM D5084) shall be no greater than 5 x 10^{-9} cm/sec at a confining stress of 5 psi.

      (2) Moisture Content - The moisture content (ASTM D4643) shall be no greater than 12 percent.

      (3) Mass - The mass per unit area (ASTM D5261) of the sodium bentonite component of the bentonite mat shall be a minimum of 0.825 lb/ft2.

   c. Frequency - The bentonite mat shall be tested for moisture content, hydraulic conductivity and mass per unit area at least once per 40,000 square feet or once per lot, whichever is more frequent.

2/29/00

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Antonetta Bader Cam 3/29/00

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England-Thims & Miller, Inc.
ENGINEERS • PLANNERS • SURVEYORS • LANDSCAPE ARCHITECTS

'00 FEB 1 PM 1 03

STATE OF FLORIDA
DEP - NE DISTRICT
JACKSONVILLE

January 28, 2000

Mr. Steve Nguyen, P. E.
Solid Waste Section
Department of Environmental Protection
7825 Baymeadows Way, Suite B-200
Jacksonville, Florida 32256-7590

Reference: Trail Ridge Landfill
Quality Assurance Manual
ET&M Project No. 99-92

Dear Mr. Nguyen:

Per your request, attached is a signed and sealed copy of corrected Page 9 of the Project-Specific Addenda.

If you have any questions, please feel free to give me a call.

Sincerely,

ENGLAND, THIMS & MILLER, INC.

Juanitta Bader Clem, P. E.
Vice President

Attachment

Cc: Chris Pearson
Greg Mathes
Frank Adams

14775 ST. AUGUSTINE RD. • JACKSONVILLE, FL 32258 • TEL: (904) 642-8990 • FAX: (904) 646-9485

D. GEOTEXTILES

The lining system shall include two geotextiles. The followings revisions shall be made to Section 10 of the "Quality Assurance Guidance Document for the Installation of Lining Systems" (WMI, August 1997) with regard to the geotextiles.

10.3-4.e. Add "e. Grab Elongation (ASTM D4632)"

10.3-4.f. Add "f. Burst Strength (ASTM D3786)"

10.3-4.g. Add "g. Apparent Size Opening (ASTM D4751)"

10.3-4.h. Add "h. Permittivity (ASTM D4491)"

10.3-4.3. Replace "10,000 lbs" with "50,000 ft^2"

10.3-4 Add "5. Batch number" and "6. Date of manufacture" to the manufacturer's roll identification information.

10.4 Replace entire section as follows: "Conformance testing of geotextile will be conducted by an independent laboratory selected by the CQA Engineer. The laboratory will be accredited by the Geosynthetics Accreditation Institute (GAI) for the specific tests to be performed. The results of the conformance testing shall be reviewed by the Geosynthetic QAE and compared to the Project Specifications. Any nonconformance will be the basis of rejection of the material by the Geosynthetic QAE."

10.4.2 Delete columns that differentiate between different geotextiles. All tests listed shall be performed.

10.6 Replace second paragraph in its entirety with the following: "All geotextile seams shall be continuously sewn. Spot sewing or heat bonding is not allowed."

E. GEONETS

The lining system shall include geonets. The followings revisions shall be made to Section 11 of the "Quality Assurance Guidance Document for the Installation of Lining Systems" (WMI, August 1997) with regard to geonets.

11.3-2.f. Add: "f. Grab Tensile Strength (ASTM D5035)"

11.3-2. Replace "10,000 lbs" with "50,000 ft^2" and "25,000 lbs" with "100,000 ft^2"

11.3-2 Add the following: "Written certification from the manufacturer that the product to be delivered has been extruded from an approved resin will be required. The certification shall include the origin (resin supplier's name

Jeanitta Cannon 1/28/00

England-Thims & Miller, Inc.
ENGINEERS • PLANNERS • SURVEYORS • LANDSCAPE ARCHITECTS

Principals
James E. England, P.E., C.E.O.
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Juanitta Bader Clem, P.E., V.P.
Jeffrey A. Crammond, P.E., V.P.
Scott A. Wild, P.E., P.S.M., V.P.

January 5, 2000

Ms. Mary C. Nogas, P.E.
Waste Management Section
Department of Environmental Regulation
7825 Baymeadows Way, Suite 200B
Jacksonville, Florida 32256

Reference: Trail Ridge Landfill - Permit Number 0013493-002-SC
Third Increment of Construction
ET&M No. E99-92

Dear Ms. Nogas:

On behalf of Trail Ridge Landfill, Inc., please find herein the application for Solid Waste Management Facility Permit for a minor modification to revise the quality assurance plan (including the project-specific addenda) for the liner system construction at Trail Ridge Landfill. Please find herein copies of the Quality Assurance Guidance Document for the Installation of Lining Systems and Project-Specific Addenda to Quality Assurance Plan for your review. Please note that the construction quality assurance plan has been updated largely to include new testing methods. We are currently preparing plans and specification for the construction of the remaining liner phases (Phases IIIC, IVC, VA, VB, VC and VD) and hope to being construction within 60-90 days. Therefore, we would appreciate your immediate attention to the minor modification.

I would respectfully request that any questions regarding this application be directed to me.

Sincerely,
ENGLAND, THIMS & MILLER, INC.

Juanitta Bader Clem, P.E.
Vice President

cc: Greg Mathes w/attachments
Chris Pearson w/attachments

Attachments: Permit Application - 6 copies
Quality Assurance Guidance Document - 4 copies
Project Specific Addenda - 4 copies
Minor Modification Fee - $250.00

Florida Department of Environmental Protection
Twin Towers Office Bldg. • 2600 Blair Stone Road • Tallahassee, FL 32399–2400

DEP Form # 62-701.900(1)
Form Title Solid Waste Management Facility Permit
Effective Date May 19, 1994

DEP Application No. _____
(Filled by DEP)

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

SOLID WASTE MANAGEMENT FACILITY PERMIT

APPLICATION INSTRUCTIONS AND FORMS

Northwest District
160 Governmental Center
Pensacola, FL 32501–5794
850–595–8360

Northeast District
7825 Baymeadows Way, Ste. B200
Jacksonville, FL 32256–7590
904–448–4300

Central District
3319 Maguire Blvd., Ste. 232
Orlando, FL 32803–3767
407–894–7555

Southwest District
3804 Coconut Palm Dr.
Tampa, FL 33619
813–744–6100

South District
2295 Victoria Ave., Ste. 364
Fort Myers, FL 33901–3881
941–332–6975

Southeast District
400 North Congress Ave.
West Palm Beach, FL 33401
561–681–6600

INSTRUCTIONS TO APPLY FOR A SOLID WASTE MANAGEMENT PERMIT

I. General

Solid Waste Management Facilities shall be permitted pursuant to Section 403.707, Florida Statutes, (FS) and in accordance with Florida Administrative Code (FAC) Chapter 62-701. A minimum of six copies of the application shall be submitted to the Department District Office having jurisdiction over the facility. The appropriate fee in accordance with Chapter 62-4, FAC, and Rule 62-701.320(5)(c), FAC, shall be submitted with the application by check made payable to the Department of Environmental Regulation (DEP).

Complete appropriate sections for the type of facility for which application is made. Entries shall be typed or printed in ink. All blanks shall be filled in or marked "not applicable" or "no substantial change". Information provided in support of the application shall be marked "submitted" and the location of this information in the application package indicated. The application shall include all information, drawings, and reports necessary to evaluate the facility. Information required to complete the application is listed on the attached pages of this form.

II. Application Parts Required for Construction and Operation Permits

A. Landfills and Ash Monofills - Submit parts A,B, D through R, and T
B. Asbestos Monofills - Submit parts A,B,D,E,F,I,K, M through Q, and T
C. Industrial Solid Waste Facilities - Submit parts A,B, D through Q, and T
D. Volume Reduction Facilities - Submit parts A,C,D,S, and T
E. Materials Recovery Facilities - Submit parts A,C,D,S, and T

NOTE: Portions of some parts may not be applicable.

NOTE: For facilities that have been satisfactorily constructed in accordance with their construction permit, the information required for A,B,C,D, and E type facilities does not have to be resubmitted for an operation permit if the information has not substantially changed during the construction period. The appropriate portion of the form should be marked "no substantial change".

III. Application Parts Required for Closure Permits

A. Landfills and Ash Monofills - Submit parts A,B, N through R, and T
B. Asbestos Monofills - Submit parts A,B, M through Q, and T
C. Industrial Solid Waste Facilities - Submit parts A,B, N through Q, and T
D. Volume Reduction Facilities - Submit parts A,C,S, and T
E. Materials Recovery Facilities - Submit parts A,C,S, and T

NOTE: Portions of some parts may not be applicable.

IV. Permit Renewals

The above information shall be submitted at time of permit renewal in support of the new permit. However, facility information that was submitted to the Department to support the expiring permit, and which is still valid, does not need to be re-submitted for permit renewal. Portions of the application not re-submitted shall be marked "no substantial change" on the application form.

V. Application Codes

S	-	Submitted
LOCATION	-	Physical location of information in application
N/A	-	Not Applicable
N/C	-	No Substantial Change

VI. LISTING OF APPLICATION PARTS

PART A	-	GENERAL INFORMATION
PART B	-	DISPOSAL FACILITY GENERAL INFORMATION
PART C	-	MATERIALS RECOVERY / VOLUME REDUCTION FACILITY GENERAL INFORMATION
PART D	-	SOLID WASTE MANAGEMENT FACILITY PERMIT GENERAL REQUIREMENTS
PART E	-	LANDFILL PERMIT GENERAL REQUIREMENTS
PART F	-	GENERAL CRITERIA FOR LANDFILLS
PART G	-	LANDFILL CONSTRUCTION REQUIREMENTS
PART H	-	HYDROGEOLOGICAL INVESTIGATION REQUIREMENTS
PART I	-	GEOTECHNICAL INVESTIGATION REQUIREMENTS
PART J	-	VERTICAL EXPANSION OF LANDFILLS
PART K	-	LANDFILL OPERATION REQUIREMENTS
PART L	-	WATER QUALITY AND LEACHATE MONITORING REQUIREMENTS
PART M	-	SPECIAL WASTE HANDLING REQUIREMENTS
PART N	-	LANDFILL CLOSURE REQUIREMENTS
PART O	-	CLOSURE PROCEDURES
PART P	-	LONG TERM CARE REQUIREMENTS
PART Q	-	FINANCIAL RESPONSIBILITY REQUIREMENTS
PART R	-	CLOSURE OF EXISTING LANDFILL REQUIREMENTS
PART S	-	MATERIALS RECOVERY FACILITY REQUIREMENTS
PART T	-	CERTIFICATION BY APPLICANT AND ENGINEER OR PUBLIC OFFICER

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
APPLICATION FOR PERMIT TO CONSTRUCT, OPERATE, MODIFY OR CLOSE
A SOLID WASTE MANAGEMENT FACILITY

Please Type or Print

A. GENERAL INFORMATION

1. Type of facility:

Disposal [X]

Class I Landfill	[X]	Ash Monofill	[ ]
Class II Landfill	[ ]	Asbestos Monofill	[ ]
Class III Landfill	[ ]	Industrial Solid Waste	[ ]
Other	[X]	Waste Tire Processing	

Volume Reduction [ ]

Incinerator	[ ]	Pulverizer / Shredder	[ ]
Composting	[ ]	Compactor / Baling Plant	[ ]
Materials Recovery	[ ]	Energy Recovery	[ ]
Other	[ ]		

2. Type of application:

Construction	[ ]	Construction/Operation	[X]
Operation	[ ]	Closure	[ ]

3. Classification of application: This application includes a vertical expansion over the double lined landfill.

New	[ ]	Substantial Modification	[ ]
Renewal	[ ]	Minor Modification	[X]

4. Facility name: Trail Ridge Landfill

5. DEP ID number: GMS3116P02787 County: Duval

6. Facility location (main entrance): 5110 U.S. Hwy. 301

Baldwin, FL 32234

7. Location coordinates:

Section: 18, 19, 20, 21 Township: 3S Range: 23E

UTMs: Zone 17 399764 km E 3344918 km N

Latitude: 30 ° 14 ' 00 " Longitude: 82 ° 02 ' 30 "

8. Applicant name (operating authority): Trail Ridge Landfill, Inc.

Mailing address: 5110 U.S. Hwy. 301 (Street or P.O. Box) Baldwin (City) Florida (State) 32234 (Zip)

Contact person: Greg Mathes Telephone: (904) 289-9100

Title: General Manager

9. Authorized agent/Consultant: England, Thims & Miller, Inc.

Mailing address: 14775 St. Augustine Rd. (Street or P.O. Box) Jacksonville (City) Florida (State) 32258 (Zip)

Contact person: Juanitta Clem Telephone: (904) 642-8990

Title: Vice President

10. Landowner (if different than applicant): City of Jacksonville

Mailing address: 515 N. Laura St., 6th Floor, Jacksonville, Florida 32202
(Street or P.O. Box) (City) (State) (Zip)

Contact person: Chris Pearson Telephone: (904) 665-4467

11. Cities, towns and areas to be served: City of Jacksonville (Duval County) and neighboring environs.

12. Population to be served: Duval County

Current: 732,034 (1995) Five-Year Projection: 777,641 (2000)

13. Volume of solid waste to be received: 3,500± * tons/day (peak)
2,600 tons/day (monthly average)

14. Date site will be ready to be inspected for completion: N/A

15. Estimated life of facility: 17± years

16. Estimated costs:

Total Construction: $ 21.4 Million ± Closing Costs: $ 12.43 Million ±

17. Anticipated construction starting and completion dates:

From: 2000 To: 2001

* This waste receipt may increase in the case of a natural disaster and will vary due to market conditions.

RECEIVED
JAN 05 2000
STATE OF FLORIDA
DEPT. OF ENV. PROTECTION
NORTHEAST DISTRICT-JAX

B. DISPOSAL FACILITY GENERAL INFORMATION

1. Provide brief description of disposal facility design and operations planned by this application:

Modification of Quality Assurance Plan and Project Specific Addenda for Construction of Phases IIIC, IVC, and V of the Class I Landfill

2. Facility site supervisor: Greg Mathes

Title: General Manager Telephone: (904) 289-9100

3. Disposal area: Total 153 acres; Used 91 acres; Available 62 acres

4. Weighing scales used: Yes [X] No [ ]

5. Security to prevent unauthorized use: Yes [X] No [ ]

6. Charge for waste received: N/A $/yds^3 32.00 $/ton

7. Surrounding land use, zoning:

Residential	[ ]	Industrial	[ ]
Agricultural	[ ]	None	[ ]
Commercial	[ ]	Other	[X] Silviculture

8. Types of waste received:

Residential	[X]	C & D debris	[X]
Commercial	[X]	Shredded/cut tires	[X]
Incinerator / WTE ash	[ ]	Yard trash	[ ]
Treated biohazardous	[X]	Septic tank	[ ]
Water treatment sludge	[X]	Industrial	[X]
Air treatment sludge	[ ]	Industrial sludge	[X]
Agricultural	[X]	Domestic sludge	[X]
Asbestos	[X]		
Other	[X] Non-Hazardous Special Waste		

9. Salvaging permitted: Yes [ ] No [X]

10. Attendant: Yes [X] No [ ] Trained operator: Yes [X] No [ ]

11. Spotters: Yes [X] No [ ] Number of spotters used: 2

12. Site located in: Floodplain [ ] Wetlands [ ] Other [X] Upland Pine Flatwoods

13. Property recorded as a Disposal Site in County Land Records: Yes [ ] No [X]

14. Days of operation: Monday - Saturday

15. Hours of operation: 5:00 A.M. - 10:00 P.M.*

16. Days Working Face covered: Daily with cover dirt or tarpaulin

17. Elevation of water table: varies Ft. NGVD

18. Number of monitoring wells: 43 (27 wells monitored)

19. Number of surface monitoring points: 3

20. Gas controls used: Yes [X] No [ ] Type controls: Active [X] Passive [ ]

Gas flaring: Yes [X] No [ ] Gas recovery: Yes [ ] No [X]

21. Landfill Unit - liner type:

Natural soils	[ ]	Double geomembrane	[X]
Single clay liner	[ ]	Geomembrane & composite	[ ]
Single geomembrane	[ ]	Double composite	[ ]
Single composite	[ ]	None	[ ]
Slurry wall	[ ]		
Other	[ ]	w/Bentonite Mat and 6" clay subgrade	

22. Leachate collection method:

Collection pipes	[X]	Sand layer	[ ]
Geonets	[X]	Gravel layer	[ ]
Well points	[ ]	Interceptor trench	[ ]
Perimeter ditch	[ ]	None	[ ]
Other	[ ]		

23. Leachate storage method:

Tanks	[X]	Surface impoundments	[ ]
Other	[ ]		

24. Leachate treatment method:

Oxidation	[ ]	Chemical treatment	[ ]
Secondary	[ ]	Settling	[ ]
Advanced	[ ]	None	[ ]
Other	[X]	Off-site Treatment at a City Wastewater Treatment Facility	

* May vary dependent upon waste receipt.

25. Leachate disposal method:

Recirculated	[X]	Pumped to WWTP	[ ]
Transported to WWTP	[X]	Discharged to surface water	[ ]
Injection well	[ ]	Evaporation (ie: Perc Pond)	[ ]
Other	[ ]	_____	

26. For leachate discharged to surface waters:

Name and Class of receiving water: N/A

27. Storm Water: Collected: Yes [X] No [ ] Type of treatment: Wet Detention

Name and Class of receiving water: Headwaters of Deep Creek - Class III

28. Management and Storage of Surface Waters (MSSW) Permit number or status: _____

Permitted as Solid Waste Permit (DEP File Nos. 184444, 184445 and 184447). Pond was permitted, constructed and certified.

N/A

C. MATERIALS RECOVERY / VOLUME REDUCTION FACILITY GENERAL INFORMATION

1. Provide brief description of materials recovery / volume reduction facility design and operations planned by this application:

_____

_____

_____

2. Facility site supervisor: _____

   Title: _____ Telephone: (____)_____

3. Disposal area: Total _____ acres; Used _____ acres; Available _____ acres

4. Security to prevent unauthorized use: Yes [ ] No [ ]

5. Site located in: Floodplain [ ] Wetlands [ ] Other [ ] _____

6. Days of operation: _____

7. Hours of operation: _____

8. Number of operating staff: _____

9. Expected useful life: _____ Years

10. Weighing scales used: Yes [ ] No [ ]

11. Normal processing rate: _____ yd^3/day _____ tons/day _____ gal/day

12. Maximum processing rate: _____ yd^3/day _____ tons/day _____ gal/day

13. Charge for waste received: _____

14. Type of facility (check one or more):

Incinerator	[ ]	Composting	[ ]
Pulverizer / shredder	[ ]	Materials recovery	[ ]
Compactor / baling	[ ]	Energy recovery	[ ]
Sludge concentration	[ ]	Pyrolysis	[ ]
Other	[ ]	_____	

15. Material recovered, tons/week:

_____	Paper	_____	Glass
_____	Ferrous metals	_____	Non-ferrous metals
_____	Aluminum	_____	Plastics
_____	Other:	_____	

16. Energy recovery, in units shown:

_____	High pressure steam, lb/hr	_____	Chilled water, gal/hr
_____	Low pressure steam, lb/hr	_____	Oil, gal/hr
_____	Electricity, kw/hr	_____	Oil, BTU/hr
_____	Gas, ft^3/hr	_____	Gas, BTU/hr
_____	Other:	_____	

17. Process water management:

Recycled: Yes [ ] No [ ]

Treatment method used: _____

Discharged to: Surface waters [ ] Underground [ ] Other [ ]

Name and Class of receiving water: _____

18. Storm Water:

Collected: Yes [ ] No [ ] Type of treatment: _____

Name and Class of receiving water: _____

19. ERP Permit number or status: _____

20. Final residue produced:

_____ % of normal processing rate

_____ % of maximum processing rate

Disposed of at (Site name): _____

21. Supplemental fuel used:

Type: _____ Quantity used/hour: _____

22. Costs:

Estimated operating costs (material-energy revenue): $ _____

Total cost/ton: $ _____ Net cost/ton: $ _____

23. State pollution control bond financing amount: $ _____

24. Estimated amount of tax exemptions that will be requested: $ _____

D. SOLID WASTE MANAGEMENT FACILITY PERMIT GENERAL REQUIREMENTS (62-701.320, FAC)

S	LOCATION	N/A	N/C		
X	Attached	___	___	1.	Six copies, at minimum, of the completed application form, all supporting data and reports; (62-701.320(5)(a), FAC)
X	Attached	___	___	2.	Engineering and/or professional certification (signature, date and seal) provided on the applications and all engineering plans, reports and supporting information for the application; (62-701.320(6), FAC)
X	Attached	___	___	3.	A letter of transmittal to the Department; (62-701.320(7)(a), FAC)
X	Attached	___	___	4.	A completed application form dated and signed by the applicant; (62-701.320(7)(b), FAC)
X	Attached	___	___	5.	Permit fee specified in Rule 62-4.050, FAC and Rule 62-701.320(5)(c), FAC in check or money order, payable to the Department; (62-701.320(7)(c), FAC)
X	Quality Assurance Plan and Project Specific Addenda only.	___		6.	An engineering report addressing the requirements of this rule and with the following format: a cover sheet, text printed on 8 1/2 inch by 11 inch consecutively numbered pages, a table of contents or index, the body of the report and all appendices including an operation plan, contingency plan, illustrative charts and graphs, records or logs of tests and investigations, engineering calculations; (62-701.320(7)(d), FAC))
___	_____	___	X	7.	Operation Plan; (62-701.320(7)(e)1., FAC)
___	_____	___	X	8.	Contingency Plan; (62-701.320(7)(e)2., FAC)
				9.	Plans or drawings for the solid waste management facilities in appropriate format (including sheet size restrictions, cover sheet, legends, north arrow, horizontal and vertical scales, elevations referenced to NGVD) showing; (62-702.320(7)(f), FAC)
___	_____	___	X		a. A regional map or plan with the project location;
___	_____	___	X		b. A vicinity map or aerial photograph no more than 1 year old;
___	_____	___	X		c. A site plan showing all property boundaries certified by a registered Florida land surveyor;

S	LOCATION	N/A	N/C		
___	_____	___	X		d. Other necessary details to support the engineering report.
___	_____	___	X	10.	Proof of property ownership or a copy of appropriate agreements between the facility operator and property owner authorizing use of property; (62-701.320(7)(g), FAC)
___	_____	___	X	11.	For facilities owned or operated by a county, provide a description of how, if any, the facilities covered in this application will contribute to the county's achievement of recycling goals contained in Section 403.706, FS; (62-701.320(7)(h), FAC)
___	_____	___	X	12.	Provide a history and description of any enforcement actions taken by the Department against the applicant for violations of applicable statutes, rules, orders or permit conditions relating to the operation of any solid waste management facility in this state; (62-701.320(7)(i), FAC)
___	_____	X	___	13.	Proof of publication in a newspaper of general circulation of notice of application for a permit to construct or substantially modify a solid waste management facility; (62-701.320(8), FAC)
___	_____	___	X	14.	Provide a description of how the requirements f airport safety will be achieved including proof of required notices if applicable; (62-701.320(12), FAC)

E. LANDFILL PERMIT GENERAL REQUIREMENTS (62-701.330, FAC)

S	LOCATION	N/A	N/C		
___	_____	___	X	1.	Vicinity map or aerial photograph no more than 1 year old and of appropriate scale showing land use and local zoning within one mile of the landfill and of sufficient scale to show all homes or other structures, water bodies, and roads other significant features of the vicinity. All significant features shall be labeled; (62-701.330(4)(a), FAC)
___	_____	___	X	2.	Vicinity map or aerial photograph no more than 1 year old showing all airports that are located within five miles of the proposed landfill; (62-701.330(4)(b), FAC)
___	_____	___	X	3.	Plot plan with a scale not greater than 200 feet to the inch showing; (62-701.330(4)(c), FAC)
___	_____	___	X		a. Dimensions;
___	_____	___	X		b. Locations of proposed and existing water quality monitoring wells;
___	_____	___	X		c. Locations of soil borings;
___	_____	___	X		d. Proposed plan of trenching or disposal areas;
___	_____	___	X		e. Cross sections showing original elevations and proposed final contours which shall be included either on the plot plan or on separate sheets;
___	_____	___	X		f. Any previously filled waste disposal areas;
___	_____	___	X		g. Fencing or other measures to restrict access.
				4.	Topographic maps with a scale not greater than 200 feet to the inch with 5-foot contour intervals showing; (62-701.330(4)(d), FAC):
___	_____	___	X		a. Proposed fill areas;
___	_____	___	X		b. Borrow areas;
___	_____	___	X		c. Access roads;
___	_____	___	X		d. Grades required for proper drainage;
___	_____	___	X		e. Cross sections of lifts;

S	LOCATION	N/A	N/C		
___	_____	___	X		f. Special drainage devices if necessary;
___	_____	___	X		g. Fencing;
___	_____	___	X		h. Equipment facilities.
				5.	A report on the landfill describing the following; (62-701.330(4)(e), FAC)
___	_____	___	X		a. The current and projected population and area to be served by the proposed site;
___	_____	___	X		b. The anticipated type, annual quantity, and source of solid waste, expressed in tons;
___	_____	___	X		c. The anticipated facility life;
___	_____	___	X		d. The source and type of cover material used for the landfill.
___	_____	___	X	6.	Provide evidence that an approved laboratory shall conduct water quality monitoring for the facility in accordance with Rule 62-160, FAC; (62-701.330(4)(h), FAC)
___	_____	___	X	7.	Provide a statement of how the applicant will demonstrate financial responsibility for the closing and long-term care of the landfill; (62-701.330(4)(i), FAC)

F. GENERAL CRITERIA FOR LANDFILLS (62-701.340, FAC)

___	_____	___	X	1.	Describe (and show on a Federal Insurance Administration flood map, if available) how the landfill or solid waste disposal unit shall not be located in the 100-year floodplain where it will restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain unless compensating storage is provided, or result is a washout of solid waste; (62-701.340(4)(b), FAC)
___	_____	___	X	2.	Describe how the minimum horizontal separation between waste deposits in the landfill and the landfill property boundary shall be 100 feet, measured from the toe of the proposed final cover slope; (62-701.340(4)(c), FAC)
___	_____	___	X	3.	Describe what methods shall be taken to screen the landfill from public view where such screening can practically be provided; (62-701.340(4)(d), FAC)

G. LANDFILL CONSTRUCTION REQUIREMENTS (62-701.400, FAC)

S	LOCATION	N/A	N/C		
___	_____	___	X	1.	Describe how the landfill shall be designed so that solid waste disposal units will be constructed and closed at planned intervals throughout the design period of the landfill; (62-701.400(2), FAC)
				2.	Landfill liner requirements; (62-701.400(3), FAC)
				a.	General construction requirements; (62-701.400(3)(a), FAC):
___	_____	___	X		(1) Provide test information and documentation to ensure the liner will be constructed of materials that have appropriate physical, chemical, and mechanical properties to prevent failure;
___	_____	___	X		(2) Document foundation is adequate to prevent liner failure;
___	_____	___	X		(3) Constructed so bottom liner will not be adversely impacted by fluctuations of the ground water;
___	_____	___	X		(4) Designed to resist hydrostatic uplift if bottom liner located below seasonal high ground water table;
___	_____	___	X		(5) Installed to cover all surrounding earth which could come into contact with the waste or leachate.
				b.	Composite liners; (62-701.400(3)(b), FAC)
___	_____	X	___		(1) Upper geomembrane thickness and properties;
___	_____	X	___		(2) Design leachate head for primary LCRS including leachate recirculation if appropriate;
___	_____	X	___		(3) Design thickness in accordance with Table A and number of lifts planned for lower soil component.

S	LOCATION	N/A	N/C		
				c.	Double liners; (62-701.400(3)(c), FAC)
___	_____	___	X	(1)	Upper and lower geomembrane thicknesses and properties;
___	_____	___	X	(2)	Design leachate head for primary LCRS to limit the head to one foot above the liner;
___	_____	___	X	(3)	Lower geomembrane sub-base design;
___	_____	___	X	(4)	Leak detection and secondary leachate collection system minimum design criteria ($k \geq 1$ cm/sec, head on lower liner ≤ 1 inch, head not to exceed thickness of drainage layer);
				d.	Standards for geomembranes; (62-701.400(3)(d), FAC)
X	Attached	___	___	(1)	Field seam test methods to ensure all field seams are at least 90 percent of the yield strength for the lining material;
___	_____	___	X	(2)	Design of 24-inch-thick protective layer above upper geomembrane liner;
___	_____	___	X	(3)	Describe operational plans to protect th liner and leachate collection system when placing the first layer of waste above 24-inch-thick protective layer.
				e.	Geosynthetic specification requirements; (62-701.400(3)(e), FAC)
X	Attached	___	___	(1)	Definition and qualifications of the designer, manufacturer, installer, QA consultant and laboratory, and QA program;
X	Attached	___	___	(2)	Material specifications for geomembranes, geotextiles, geogrids, and geonets;

S	LOCATION	N/A	N/C	
X	Attached	___	___	(3) Manufacturing and fabrication specifications including geomembrane raw material and roll QA, fabrication personnel qualifications, seaming equipment and procedures, overlaps, trial seams, destructive and nondestructive seam testing, seam testing location, frequency, procedure, sample size and geomembrane repairs;
X	Attached	___	___	(4) Geomembrane installation specifications including earthwork, conformance testing, geomembrane placement, installation personnel qualifications, field seaming and testing, overlapping and repairs, materials in contact with geomembrane and procedures for lining system acceptance;
X	Attached	___	___	(5) Geotextile and geogrid specifications including handling and placement, conformance testing, seams and overlaps, repair, and placement of soil materials;
X	Attached	___	___	(6) Geonet specifications including handling and placement, conformance testing, stacking and joining, repair, and placement of soil materials;

f. Standards for soil components (62-701.400(3)(f), FAC):

___	_____	___	X	(1) Description of construction procedures including overexcavation and backfilling to preclude structural inconsistencies and procedures for placing and compacting soil component in layers;
___	_____	___	X	(2) Demonstration of compatibility of the soil component with actual or simulated leachate in accordance with EPA Test Method 9100 or an equivalent test method;
___	_____	X	___	(3) Procedures for testing in-situ soils to demonstrate they meet the specifications for soil liners;

S	LOCATION	N/A	N/C	
				(4) Specifications for soil component of liner including at a minimum:
___	_____	___	X	(a) Allowable particle size distribution, Atterberg limits, shrinkage limit;
___	_____	___	X	(b) Placement moisture and dry density criteria;
___	_____	___	X	(c) Maximum laboratory-determined saturated hydraulic conductivity using simulated leachate;
___	_____	___	X	(d) Minimum thickness of soil liner;
___	_____	___	X	(e) Lift thickness;
___	_____	X	___	(f) Surface preparation (scarification);
___	_____	___	X	(g) Type and percentage of clay mineral within the soil component;
___	_____	___	X	(5) Procedures for constructing and using a field test section to document the desired saturated hydraulic conductivity and thickness can be achieved in the field.
				3. Leachate collection and removal system (LCRS); (62-701.400(4), FAC)
				a. The primary and secondary LCRS requirements; (62-701.400(4)(a), FAC)
___	_____	___	X	(1) Constructed of materials chemically resistant to the waste and leachate;
___	_____	___	X	(2) Have sufficient mechanical properties to prevent collapse under pressure;
___	_____	___	X	(3) Have granular material or synthetic geotextile to prevent clogging;
___	_____	___	X	(4) Have method for testing and cleaning clogged pipes or contingent designs for rerouting leachate around failed areas;

S	LOCATION	N/A	N/C	
				b. Primary LCRS requirements; (62-701.400(4)(b), FAC)
___	_____	___	X	(1) Bottom 12 inches having hydraulic conductivity ≥ 1 x 10^{-3} cm/sec;
___	_____	___	X	(2) Total thickness of 24 inches of material chemically resistant to the waste and leachate;
___	_____	___	X	(3) Bottom slope design to accommodate for predicted settlement;
___	_____	___	X	(4) Demonstration that synthetic drainage material, if used, is equivalent or better than granular material in chemical compatibility, flow under load and protection of geomembrane liner.
				4. Leachate recirculation; (62-701.400(5), FAC)
___	_____	___	X	a. Describe general procedures for recirculating leachate;
___	_____	___	X	b. Describe procedures for controlling leachate runoff and minimizing mixing of leachate runoff with storm water;
___	_____	___	X	c. Describe procedures for preventing perched water conditions and gas buildup;
___	_____	___	X	d. Describe alternate methods for leachate management when it cannot be recirculated due to weather or runoff conditions, surface seeps, wind-blown spray, or elevated levels of leachate head on the liner;
___	_____	___	X	e. Describe methods of gas management to control odors and migration of methane;
___	_____	X	___	f. If leachate irrigation is proposed, describe treatment methods and standards for leachate treatment prior to irrigation over final cover and provide documentation that irrigation does not contribute significantly to leachate generation.

S	LOCATION	N/A	N/C	
				5. Leachate storage tanks and leachate surface impoundments; (62-701.400(6), FAC)
				a. Surface impoundment requirements; (62-701.400(6)(b), FAC)
___	_____	X	___	(1) Documentation that the design of the bottom liner will not be adversely impacted by fluctuations of the ground water;
___	_____	X	___	(2) Designed in segments to allow for inspection and repair as needed without interruption of service;
				(3) General design requirements;
___	_____	X	___	(a) Double liner system consisting of an upper and lower 60-mil minimum thickness geomembrane;
___	_____	X	___	(b) Leak detection and collection system with hydraulic conductivity ≥ 1 cm/sec;
___	_____	X	___	(c) Lower geomembrane placed on subbase ≥ 6 inches thick with k ≤ $1x10^{-5}$cm/sec;
___	_____	X	___	(d) Design calculation to predict potential leakage through the upper liner;
___	_____	X	___	(e) Daily inspection requirements and notification and corrective action requirements if leakage rates exceed that predicted by design calculations;
___	_____	X	___	(4) Description of procedures to prevent uplift, if applicable;
___	_____	X	___	(5) Design calculations to demonstrate minimum two feet of freeboard will be maintained;
___	_____	X	___	(6) Procedures for controlling vectors and off-site odors.

S	LOCATION	N/A	N/C	
				b. Above-ground leachate storage tanks; (62-701.400(6)(c), FAC)
___	_____	___	X	(1) Describe tank materials of construction and ensure foundation is sufficient to support tank;
___	_____	X	___	(2) Describe procedures for cathodic protection if needed for the tank;
___	_____	X	___	(3) Describe exterior painting and interior lining of the tank to protect it from the weather and the leachate stored;
___	_____	___	X	(4) Describe secondary containment design to ensure adequate capacity will be provided and compatibility of materials of construction;
___	_____	___	X	(5) Describe design to remove and dispose of stormwater from the secondary containment system;
___	_____	___	X	(6) Describe an overfill prevention system such as level sensors, gauges, alarms and shutoff controls to prevent overfilling;
				(7) Inspections, corrective action and reporting requirements;
___	_____	___	X	(a) Overfill prevention system weekly;
___	_____	___	X	(b) Exposed tank exteriors weekly;
___	_____	X	___	(c) Tank interiors when tank is drained or at least every three years;
___	_____	___	X	(d) Procedures for immediate corrective action if failures detected;
___	_____	___	X	(e) Inspection reports available for department review.
				c. Underground leachate storage tanks; (62-701.400(6)(d), FAC)
___	_____	X	___	(1) Describe materials of construction;
___	_____	X	___	(2) A double-walled tank design system to be used with the following requirements;

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NORTHEAST DISTRICT-JAX

S	LOCATION	N/A	N/C	
___	_____	X	___	(a) Interstitial space monitoring at least weekly;
___	_____	X	___	(b) Corrosion protection provided for primary tank interior and external surface of outer shell;
___	_____	X	___	(c) Interior tank coatings compatible with stored leachate;
___	_____	X	___	(d) Cathodic protection inspected weekly and repaired as needed;
___	_____	X	___	(3) Describe an overfill prevention system such as level sensors, gauges, alarms and shutoff controls to prevent overfilling and provide for weekly inspections;
___	_____	X	___	(4) Inspection reports available for department review.
___	_____	X	___	d. Schedule provided for routine maintenance of LCRS; (62-701.400(6)(e), FAC)
				6. Liner systems construction quality assurance (CQA): (62-701.400(7), FAC)
X	Attached	___	___	a. Provide CQA Plan including:
X	Attached	___	___	(1) Specifications and construction requirements for liner system;
X	Attached	___	___	(2) Detailed description of quality control testing procedures and frequencies;
X	Attached	___	___	(3) Identification of supervising professional engineer;
X	Attached	___	___	(4) Identify responsibility and authority of all appropriate organizations and key personnel involved in the construction project;
X	Attached	___	___	(5) State qualifications of CQA professional engineer and support personnel;
X	Attached	___	___	(6) Description of CQA reporting forms and documents;

S	LOCATION	N/A	N/C	
X	Attached	___	___	b. An independent laboratory experienced in the testing of geosynthetics to perform required testing;
				7. Soil Liner CQA (62-701.400(8) FAC)
___	_____	___	X	a. Documentation that an adequate borrow source has been located with test results or description of the field exploration and laboratory testing program to define a suitable borrow source;
___	_____	___	X	b. Description of field test section construction and test methods to be implemented prior to liner installation;
___	_____	___	X	c. Description of field test methods including rejection criteria and corrective measures to insure proper liner installation.
				8. Surface water management systems; (62-701.400(9), FAC)
___	_____	___	X	a. Design of surface water management system to isolate surface water from waste filled areas and to control stormwater run-off;
___	_____	___	X	b. Details of stormwater control design including retention ponds, detention ponds, and drainage ways;
				9. Gas control systems; (62-701.400(10), FAC)
___	_____	___	X	a. Design details for gas control system including collection pipes and vents, and passive venting or vacuum extraction details;
___	_____	___	X	b. Documentation that the gas control system will not impact the liner or leachate control system;
___	_____	___	X	c. Proposed methods of odor control including flaring designs in accordance with Chapter 62-296, FAC;
				d. Description of a routine gas monitoring program to ensure gas control system is operating properly including:
___	_____	___	X	(1) Location of monitoring points;

S	LOCATION	N/A	N/C	
___	_____	___	X	(2) Requirements for quarterly sampling of all monitoring points;
___	_____	___	X	(3) Description of corrective measures to be completed within 60 days of detection of elevated levels of explosive gases;
___	_____	___	X	e. Description of condensate collection and disposal methods.
				10. Landfill gas recovery facilities; (62-701.400(11), FAC)
___	_____	___	X	a. Information required in Rules 62-701.320(7) and 62-701.330(4), FAC supplied;
___	_____	___	X	b. Information required in Rule 62-701.600(4), FAC supplied where relevant and practical;
___	_____	___	X	c. Estimate of current and expected gas generation rates and description of condensate disposal methods provided;
___	_____	___	X	d. Description of procedures for condensate sampling, analyzing and data reporting provided;
___	_____	___	X	e. Closure plan provided describing methods to control gas after recovery facility ceases operation;
___	_____	___	X	f. Performance bond provided to cover closure costs if not already included in other landfill closure costs.
___	_____	X	___	11. For landfills designed in ground water, provide documentation that the landfill will provide a degree of protection equivalent to landfills designed with bottom liners not in contact with ground water; (62-701.400(12), FAC)

H. HYDROGEOLOGICAL INVESTIGATION REQUIREMENTS (62-701.410(1), FAC)

S	LOCATION	N/A	N/C		
				1.	Submit a hydrogeological investigation and site report including at least the following information:
___	_____	___	X		a. Regional and site specific geology and hydrogeology;
___	_____	___	X		b. Direction and rate of ground water and surface water flow including seasonal variations;
___	_____	___	X		c. Background quality of ground water and surface water;
___	_____	___	X		d. Any on-site hydraulic connections between aquifers;
___	_____	___	X		e. Site stratigraphy and aquifer characteristics for confining layers, semi-confining layers, and all aquifers below the landfill site that may be affected by the landfill;
___	_____	___	X		f. Site topography and soil characteristics;
___	_____	___	X		g. Inventory of all public and private water wells within a one-mile radius of the landfill including well top of casing and bottom elevations, name of owner, age and usage of each well, stratigraphic unit screened, well construction technique and static water level;
___	_____	___	X		h. Description of topography, soil types and surface water drainage systems;
___	_____	___	X		i. An inventory of all public and private water wells within one mile of the landfill.
___	_____	___	X		j. Existing contaminated areas on landfill site.
___	_____	___	X	2.	Report signed, sealed and dated by PE or PG.

I. GEOTECHNICAL INVESTIGATION REQUIREMENTS (62-701.410(2), FAC)

S	LOCATION	N/A	N/C		
				1.	Submit a geotechnical site investigation report defining the engineering properties of the site including at least the following:
___	_____	___	X		a. Description of subsurface conditions including soil stratigraphy and ground water table conditions;
___	_____	___	X		b. Investigate for the presence of muck, previously filled areas, soft ground, lineaments and sink holes;
___	_____	___	X		c. Estimates of average and maximum high water table across the site;
					d. Foundation analysis including:
___	_____	___	X		(1) Foundation bearing capacity analysis;
___	_____	___	X		(2) Total and differential subgrade settlement analysis;
___	_____	___	X		(3) Slope stability analysis;
___	_____	___	X		e. Description of methods used in the investigation and includes soil boring logs, laboratory results, analytical calculations, cross sections, interpretations and conclusions;
___	_____	___	X		f. An evaluation of fault areas, seismic impact zones, and unstable areas as described in 40 CFR 258.13, 40 CFR 258.14 and 40 CFR 258.15.
___	_____	___	X	2.	Report signed, sealed and dated by PE or PG.

J. VERTICAL EXPANSION OF LANDFILLS (62-701.430, FAC) N/A

S	LOCATION	N/A	N/C		
___	_____	___	___	1.	Describe how the vertical expansion shall not cause or contribute to leachate leakage from the existing landfill or adversely affect the closure design of the existing landfill;
___	_____	___	___	2.	Describe how the vertical expansion over unlined landfills will meet the requirements of Rule 62-701.400, FAC with the exceptions of Rule 62-701.430(1)(c), FAC;
___	_____	___	___	3.	Provide foundation and settlement analysis for the vertical expansion;
___	_____	___	___	4.	Provide total settlement calculations demonstrating that the final elevations of the lining system, that gravity drainage, and that no other component of the design will be adversely affected;
___	_____	___	___	5.	Minimum stability safety factor of 1.5 for the lining system component interface stability and deep stability;
___	_____	___	___	6.	Provide documentation to show the surface water management system will not be adversely affected by the vertical expansion;
___	_____	___	___	7.	Provide gas control designs to prevent accumulation of gas under the new liner for the vertical expansion.

K. LANDFILL OPERATION REQUIREMENTS (62-701.500, FAC)

___	_____	___	X	1.	Provide documentation that landfill will have at least one trained operator during operation and at least one trained spotter at each working face; (62-701.500(1), FAC)
				2.	Provide a landfill operation plan including procedures for: (62-701.500(2), FAC)
___	_____	___	X		a. Designating responsible operating and maintenance personnel;
___	_____	___	X		b. Contingency operations for emergencies;
___	_____	___	X		c. Controlling types of waste received at the landfill;

S	LOCATION	N/A	N/C		
___	_____	___	X		d. Weighing incoming waste;
___	_____	___	X		e. Vehicle traffic control and unloading;
___	_____	___	X		f. Method and sequence of filling waste;
___	_____	___	X		g. Waste compaction and application of cover;
___	_____	___	X		h. Operations of gas, leachate, and stormwater controls;
___	_____	___	X		i. Water quality monitoring.
___	_____	___	X	3.	Provide a description of the landfill operation record to be used at the landfill; details as to location of where various operational records will be kept (i.e. FDEP permit, engineering drawings, water quality records, etc.) (62-701.500(3), FAC)
___	_____	___	X	4.	Describe the waste records that will be compiled monthly and provided to the Department quarterly; (62-701.500(4), FAC)
___	_____	___	X	5.	Describe methods of access control; (62-701.500(5), FAC)
___	_____	___	X	6.	Describe load checking program to be implemented at the landfill to discourage disposal of unauthorized wastes at the landfill; (62-701.500(6), FAC)
				7.	Describe procedures for spreading and compacting waste at the landfill that include: (62-701.500(7), FAC)
___	_____	___	X		a. Waste layer thickness and compaction frequencies;
___	_____	___	X		b. Special considerations for first layer of waste placed above liner and leachate collection system;
___	_____	___	X		c. Slopes of cell working face and side grades above land surface, planned lift depths during operation;
___	_____	___	X		d. Maximum width of working face;

S	LOCATION	N/A	N/C		
				e.	Description of type of initial cover to be used at the facility that controls:
___	_____	___	X		(1) Disease vector breeding/animal attraction
___	_____	___	X		(2) Fires
___	_____	___	X		(3) Odors
___	_____	___	X		(4) Blowing litter
___	_____	___	X		(5) Moisture infiltration
___	_____	___	X	f.	Procedures for applying initial cover including minimum cover frequencies;
___	_____	___	X	g.	Procedures for applying intermediate cover;
___	_____	___	X	h.	Time frames for applying final cover;
___	_____	___	X	i.	Description of litter policing methods;
___	_____	___	X	j.	Erosion control procedures.
				8.	Describe operational procedures for leachate management including; (62-701.500(8), FAC)
___	_____	___	X	a.	Leachate level monitoring, sampling, analysis and data results submitted to the Department;
___	_____	___	X	b.	Operation and maintenance of leachate collection and removal system, and treatment as required;
___	_____	___	X	c.	Procedures for managing leachate if it becomes regulated as a hazardous waste;
___	_____	___	X	d.	Agreements for off-site discharge and treatment of leachate;
___	_____	___	X	e.	Contingency plan for managing leachate during emergencies or equipment problems;
___	_____	___	X	f.	Procedures for recording quantities of leachate generated in gal/day;
___	_____	___	X	g.	Procedures for comparing precipitation experienced at the landfill with leachate generation rates.

S	LOCATION	N/A	N/C		
___	_____	___	X	9.	Describe routine gas monitoring program for the landfill as required by Rule 62-701.400(10), FAC; (62-701.500(9), FAC)
___	_____	___	X	10.	Describe procedures for operating and maintaining the landfill stormwater management system to comply with the standards of Chapters 62-3, 62-302 and 62-25, FAC; (62-701.500(10), FAC)
				11.	Equipment and operation feature requirements; (62-701.500(11), FAC)
___	_____	___	X	a.	Sufficient equipment for excavating, spreading, compacting and covering waste;
___	_____	___	X	b.	Reserve equipment or arrangements to obtain additional equipment within 24 hours of breakdown;
___	_____	___	X	c.	Communications equipment;
___	_____	___	X	d.	Personnel shelter and sanitary facilities, first aid equipment;
___	_____	___	X	e.	Dust control methods;
___	_____	___	X	f.	Fire protection capabilities and procedures for notifying local fire department authorities in emergencies;
___	_____	___	X	g.	Litter control devices;
___	_____	___	X	h.	Signs indicating operating authority, traffic flow, hours of operation, disposal restrictions.
___	_____	___	X	12.	Provide a description of all-weather access road, inside perimeter road and other roads necessary for access which shall be provided at the landfill; (62-701.500(12), FAC)

S	LOCATION	N/A	N/C	
				13. Additional record keeping and reporting requirements; (62-701.500(13), FAC)
___	_____	___	X	a. Records used for developing permit applications and supplemental information maintained for the design period of the landfill;
___	_____	___	X	b. Monitoring information, calibration and maintenance records, copies of reports required by permit maintained for at least 10 years;
___	_____	___	X	c. Background water quality records shall be maintained for the design period of the landfill;
___	_____	___	X	d. Maintain annual estimates of the remaining life of constructed landfills and of other permitted areas not yet constructed and submit this estimate annually to the Department.

L. WATER QUALITY AND LEACHATE MONITORING REQUIREMENTS (62-701.510, FAC)

S	LOCATION	N/A	N/C		
___	_____	___	X	1.	Water quality and leachate monitoring plan shall be submitted describing the proposed ground water, surface water and leachate monitoring systems and shall meet at least the following requirements;
___	_____	___	X	a.	Based on the information obtained in the hydrogeological investigation and signed, dated and sealed by the PG or PE who prepared it; (62-701.510(2)(a), FAC)
___	_____	___	X	b.	All sampling and analysis performed by organizations having Department approved Comprehensive Quality Assurance Plans; (62-701.510(2)(b), FAC)
				c.	Ground water monitoring requirements; (62-701.510(3), FAC)
___	_____	___	X		(1) Detection wells located downgradient from and within 50 feet of disposal units;
___	_____	___	X		(2) Downgradient compliance wells as required;
___	_____	___	X		(3) Background wells screened in all aquifers below the landfill that may be affected b the landfill;
___	_____	___	X		(4) Location information for each monitoring well;
___	_____	___	X		(5) Well spacing no greater than 500 feet apart for downgradient wells and no greater than 1500 feet apart for upgradient wells unless site specific conditions justify alternate well spacings;
___	_____	___	X		(6) Well screen locations properly selected;
___	_____	___	X		(7) Procedures for properly abandoning monitoring wells;
___	_____	X	___		(8) Detailed description of detection sensors if proposed.

S	LOCATION	N/A	N/C	
				d. Surface water monitoring requirements; (62-701.510(4), FAC)
___	_____	___	X	(1) Location of and justification for all proposed surface water monitoring points;
___	_____	___	X	(2) Each monitoring location to be marked and its position determined by a registered Florida land surveyor;
___	_____	___	X	e. Leachate sampling locations proposed; (62-701.510(5), FAC)
				f. Routine sampling frequency and requirements; (62-701.510(6), FAC)
___	_____	___	X	(1) Background ground water and surface water sampling and analysis requirements;
___	_____	___	X	(2) Leachate semi-annual and annual sampling and analysis requirements;
___	_____	___	X	(3) Detection well semi-annual sampling and analysis requirements;
___	_____	___	X	(4) Compliance well sampling and analysis requirements;
___	_____	___	X	(5) Surface water sampling and analysis requirements.
___	_____	___	X	g. Describe procedures for implementing assessment monitoring and corrective action as required; (62-701.510(7), FAC)
___	_____	___	X	h. Water quality monitoring report requirements; (62-701.510(9), FAC)
___	_____	___	X	(1) Semi-annual report requirements;
___	_____	___	X	(2) Bi-annual report requirements signed, dated and sealed by PG or PE.

M. SPECIAL WASTE HANDLING REQUIREMENTS (62-701.520, FAC)

S	LOCATION	N/A	N/C		
___	_____	X	___	1.	Describe procedures for managing motor vehicles; (62-701.520(1), FAC)
___	_____	___	X	2.	Describe procedures for landfilling shredded waste; (62-701.520(3), FAC)
___	_____	___	X	3.	Describe procedures for asbestos waste disposal; (62-701.520(4), FAC)
___	_____	___	X	4.	Describe procedures for contaminated soil disposal; (62-701.520(5), FAC)

N. LANDFILL FINAL CLOSURE REQUIREMENTS (62-701.600, FAC)

1. Closure schedule requirements; (62-701.600(2), FAC)

___	_____	___	X	a.	Documentation that a written notice including a schedule for closure will be provided to the Department at least one year prior to final receipt of wastes;
___	_____	___	X	b.	Notice to user requirements within 120 days of final receipt of wastes;
___	_____	___	X	c.	Notice to public requirements within 10 days final receipt of wastes.

2. Closure permit general requirements; (62-701.600(3), FAC)

___	_____	X	___	a.	Application submitted to Department at least 90 days prior to final receipt of wastes;
				b.	Closure plan shall include the following:
___	_____	___	X		(1) Closure report;
___	_____	___	X		(2) Closure design plan;
___	_____	___	X		(3) Closure operation plan;
___	_____	___	X		(4) Closure procedures;
___	_____	___	X		(5) Plan for long term care;

S	LOCATION	N/A	N/C	
___	_____	___	X	(6) A demonstration that proof of financial responsibility for long term care will be provided.

3. Closure report requirements; (62-701.600(4), FAC)

				a. General information requirements;
___	_____	X	___	(1) Identification of landfill;
___	_____	X	___	(2) Location, description and vicinity map;
___	_____	X	___	(3) Total acres of disposal areas and landfill property;
___	_____	X	___	(4) Legal property description;
___	_____	X	___	(5) History of landfill;
___	_____	X	___	(6) Identification of types of waste disposed of at the landfill.
___	_____	X	___	b. Geotechnical investigation report and water quality monitoring plan required by Rule 62-701.330(4), FAC;
___	_____	X	___	c. Land use information report indicating: identification of adjacent landowners; zoning; present land uses; and roads, highways right-of-way, or easements.
___	_____	X	___	d. Report on actual or potential gas migration at landfills containing biodegradable wastes including detailed description of test and investigation methods used;
___	_____	X	___	e. Report assessing the effectiveness of the landfill design and operation including results of geotechnical investigations, surface water and storm water management, gas migration and concentrations, condition of existing cover, and nature of waste disposed of at the landfill;

4. Closure design requirements to be included in the closure design plan: (62-701.600(5), FAC)

___	_____	___	X	a. Plan sheet showing phases of site closing;

S	LOCATION	N/A	N/C		
___	_____	___	X	b.	Drawings showing existing topography and proposed final grades;
___	_____	___	X	c.	Provisions to close units when they reach approved design dimensions;
___	_____	___	X	d.	Final elevations before settlement;
___	_____	___	X	e.	Side slope design including benches, terraces, down slope drainage ways, energy dissipators and discussion of expected precipitation effects;
				f.	Final cover installation plans including:
___	_____	___	X		(1) CQA plan for installing and testing final cover;
___	_____	___	X		(2) Schedule for installing final cover after final receipt of waste;
___	_____	___	X		(3) Description of drought-resistant species to be used in the vegetative cover;
___	_____	___	X		(4) Top gradient design to maximize runoff and minimize erosion;
___	_____	___	X		(5) Provisions for cover material to be used for final cover maintenance.
				g.	Final cover design requirements:
___	_____	___	X		(1) Protective soil layer design;
___	_____	___	X		(2) Barrier soil layer design;
___	_____	___	X		(3) Erosion control vegetation;
___	_____	___	X		(4) Geomembrane barrier layer design.
___	_____	___	X	h.	Proposed method of stormwater control;
___	_____	___	X	i.	Proposed method of access control;
___	_____	___	X	j.	Description of proposed final use of the closed landfill, if any;

S	LOCATION	N/A	N/C		
				5.	Closure operation plan shall include: (62-701.600(6), FAC)
___	_____	X	___		a. Detailed description of actions which will be taken to close the landfill;
___	_____	X	___		b. Time schedule for completion of closing and long term care;
___	_____	X	___		c. Describe proposed method for demonstrating financial responsibility;
___	_____	X	___		d. Indicate any additional equipment and personnel needed to complete closure.
___	_____	X	___		e. Development and implementation of the water quality monitoring plan required in Rule 62-701.510, FAC.
___	_____	X	___		f. Development and implementation of routine gas monitoring program required in Rule 62-701.400(10)(c), FAC.
___	_____	X	___	6.	Justification for and detailed description of procedures to be followed for temporary closure of the landfill, if desired; (62-701.600(7), FAC)

O. CLOSURE PROCEDURES (62-701.610,FAC)

S	LOCATION	N/A	N/C		
___	_____	X	___	1.	Survey monuments; (62-701.610(2), FAC)
___	_____	X	___	2.	Final survey report; (62-701.610(3), FAC)
___	_____	X	___	3.	Certification of closure construction completion; (62-701.610(4), FAC)
___	_____	X	___	4.	Declaration to the public; (62-701.610(5), FAC)
___	_____	X	___	5.	Official date of closing; (62-701.610(6), FAC)
___	_____	X	___	6.	Use of closed landfill areas; (62-701.610(7), FAC)

P. LONG TERM CARE REQUIREMENTS (62-701.620, FAC)

___	_____	___	X	1.	Right of property access requirements; (62-701.620(4), FAC)
___	_____	___	X	2.	Successors of interest requirements; (62-701.620(5), FAC)
___	_____	___	X	3.	Requirements for replacement of monitoring devices; (62-701.620(7), FAC)
___	_____	X	___	4.	Completion of long term care signed and sealed by professional engineer (62-701.620(8), FAC).

Q. FINANCIAL RESPONSIBILITY REQUIREMENTS (62-701.630, FAC)

___	_____	___	X	1.	Provide cost estimates for closing, long term care, and corrective action costs estimated by a PE for a third party performing the work, on a per unit basis, with the source of estimates indicated; (62-701.630(3)&(7), FAC).
___	_____	___	X	2.	Describe procedures for providing annual cost adjustments to the Department based on inflation and changes in the closing, long-term care, and corrective action plans; (62-701.630(4)&(8), FAC).
___	_____	___	X	3.	Describe funding mechanisms for providing proof of financial assurance and include appropriate financial assurance forms; (62-701.630(5),(6),&(9), FAC).

R. CLOSURE OF EXISTING LANDFILLS (62-701.640, FAC) N/A

S	LOCATION	N/A	N/C		
___	_____	___	___	1.	Demonstration that facility does not pose a bird hazard to aircraft as specified in Rule 62-701.320(12)(b), FAC.
___	_____	___	___	2.	Demonstration that facility does not restrict the flow of the 100-year flood, reduce water storage capacity or result in wash-out of solid waste as specified in Rule 62-701.340(4)(b), FAC.
___	_____	___	___	3.	Demonstration that facility is not located in a fault area, seismic zone or unstable area as specified in Rule 62-701.410(2)(c), FAC.
				4.	Request for extension of closure criteria as specified in Rule 62-701.640(2)(a) & (2)(b), FAC.
___	_____	___	___		a. Demonstration of no alternative disposal capacity.
___	_____	___	___		b. Demonstration of no threat to human health or the environment.

S. MATERIALS RECOVERY FACILITY REQUIREMENTS (62-701.700, FAC) N/A

___	_____	___	___	1.	Demonstration of financial assurance to cover closing costs, if required; (62-701.700(4), FAC)
___	_____	___	___	2.	Materials recovery facility requirements; (62-701.700, FAC)
___	_____	___	___		a. Submit information required in Rule 62-701.320, FAC
___	_____	___	___		b. Submit an engineering report including the following:
___	_____	___	___		(1) Description of the solid waste proposed to be collected, stored, processed or disposed;
___	_____	___	___		(2) Projection with assumptions for waste types and quantities expected in future years;

S	LOCATION	N/A	N/C	N/A
___	_____	___	___	(3) Description of operation and functions of all processing equipment with design criteria and expected performance;
___	_____	___	___	(4) Description of flow of solid waste, expected regular facility operations, procedures for start up and shut down, potential safety hazards and control methods including fire protection;
___	_____	___	___	(5) Description of loading, unloading, and processing areas;
___	_____	___	___	(6) Identification and capacity of temporary on-site storage areas for materials handled and provisions for solid waste and leachate containment;
___	_____	___	___	(7) Identification of potential ground water and surface water contamination;
___	_____	___	___	(8) Plan for disposal of unmarketable recyclables and residue and contingencies for waste handling during breakdowns.
				c. Submit the following operational information:
___	_____	___	___	(1) Operation and maintenance manual;
___	_____	___	___	(2) Waste control plan to manage unauthorized wastes;
___	_____	___	___	(3) Contingency plan for emergencies;
___	_____	___	___	(4) Closure plan including the following:
___	_____	___	___	(a) Notification to Department 180 days prior to closure;
___	_____	___	___	(b) Procedures for removal of all waste within 30 days of receipt of final waste;
___	_____	___	___	(c) Completion of closure activities within 180 days of receipt of final waste and notification to the Department that closure is complete.

T. CERTIFICATION BY APPLICANT AND ENGINEER OR PUBLIC OFFICER

A. Applicant

The undersigned applicant or authorized representative of Trail Ridge Landfill, Inc. is aware that statements made in this form and attached information are an application for a minor modification Permit from the Florida Department of Environmental Regulation and certifies that the information in this application is true, correct and complete to the best of his knowledge and belief. Further, the undersigned agrees to comply with the provisions of Chapter 403, Florida Statutes, and all rules and regulations of the Department. It is understood that the Permit is not transferable, and the Department will be notified prior to the sale or legal transfer of the permitted facility.

Signature of Applicant or Agent

Gregory W. Mathis, District Manager
Name and Title

Date: 1/5/00

Attach letter of authorization if agent is not a governmental official, owner, or corporate officer.

B. Professional Engineer Registered in Florida or Public Officer as required in Section 403.707 and 403.707(5), Florida Statutes.

This is to certify that the engineering features of this solid waste management facility have been designed/examined by me and found to conform to engineering principles applicable to such facilities. In my professional judgement, this facility, when properly maintained and operated, will comply with all applicable statutes of the State of Florida and rules of the Department. It is agreed that the undersigned will provide the applicant with a set of instructions of proper maintenance and operation of the facility.

Juanitta Bader Clem
Signature

Juanitta Bader Clem, P.E.
Name and Title (please type)

43245
Florida Registration Number
(please affix seal)

England, Thims & Miller, Inc.
14775 St. Augustine Rd.
Mailing Address

Jacksonville, FL 32258
City, State, Zip Code

(904) 642-8990
Telephone Number

• Date: 1/5/00

RECEIVED
JAN 05 2000
STATE OF FLORIDA
DEPT. OF ENV. PROTECTION
NORTHEAST DISTRICT-JAX

DEP FORM 62-701.900(1)
Effective 05-19-94

TRAIL RIDGE LANDFILL
PROJECT-SPECIFIC ADDENDA
TO QUALITY ASSURANCE MANUAL

This plan specifically addresses the quality assurance and quality control (QA/QC) for Trail Ridge Landfill, Phases IIIC, IVC, VA, VB, VC and VD. This program delineates the quality procedures and standards for the construction.

In the context of this plan, quality assurance, quality control and the plan participants are defined as follows:

Quality Assurance - A planned and systematic pattern of all means and actions designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

Quality Control - Those actions which provide a means to measure and regulate the characteristics of an item or service to contract and regulatory requirements.

Permittee - Trail Ridge Landfill, Inc.

Owner - The City of Jacksonville

Design Engineer - England, Thims & Miller, Inc.

The QA/QC Program for this project includes General QA/QC, Soils QA/QC, and Synthetic Liner System QA/QC. These QA/QC activities (including monitoring, sampling and testing) shall be directed and conducted by the third parties whom are independent of the Contractor.

The General QA/QC includes full-time services to periodically observe the contractor's work to verify substantial compliance with permits, plans, specifications and design concepts.

General Quality Control Monitor - shall monitor the construction for compliance with the permits, plans, specifications and design including construction to proper lines and grades, maintain daily logs and weekly progress reports of the construction (including observation data sheets, problem identification and correction logs), make note of construction deviations, coordinate qualifying and testing of materials, and monitor filling. This individual shall be experienced in civil site construction and solid waste regulations.

General Quality Assurance Engineer - shall supervise the construction monitoring to verify compliance with permits, plans, specification and design concepts. This individual shall be experienced in civil site construction and solid waste regulations and shall be a registered Professional Engineer.

The General QA/QC Program includes monitoring the following activities:

1. General Earthwork
2. Drainage Installation
3. Leachate Pump System Installation
4. Leachate Forcemain Installation
5. Overall Liner System Installation
6. General Construction Quality Control

The Soils QA/QC for this project includes soil material qualifying, sampling and testing to verify substantial compliance with the material standards.

Soils Quality Control Monitor - shall pre-qualify soil materials, monitor the installation of soil materials, determine where in-place soil materials shall be tested, and test the in-place soil materials. This individual shall be responsible for assuring that all soil materials have been pre-qualified and have a chain-of-custody from the pre-qualified source to the project site, prior to installation. This individual shall be experienced in civil site construction and soil testing standards and procedures.

Soils Quality Assurance Engineer - shall supervise the soil material pre-qualifying and testing of in-place soil materials to assure compliance with the test standards and testing frequency requirements, and verify compliance with the plans, specification and design. This individual shall be experienced in civil site construction and soil testing procedures and shall be a registered Professional Engineer.

The QA/QC Plan shall include monitoring and testing of the following:

A. SUBGRADE

Prior to construction of the liner system including the clay subbase, a subgrade shall be prepared. The subgrade shall be placed and compacted in 12" lifts.

1. Subgrade

   a. Location - The Soils Quality Control Monitor shall visually inspect the fill material and test the material in-place.

   b. Standard - Soil shall be free of brush, weeds, and other litter; and free of roots 3/8" diameter or greater, stumps, stones 1" diameter or greater and any other extraneous or toxic matter.

      The soil shall be cohesionless soil with a fines content of 15% or less.

Compacted to 96%* of Modified Proctor maximum dry density (ASTM D 1557) and a firm unyielding surface. Testing by Drive Cylinder (ASTM D2937), Nuclear (ASTM D2922) or Sand Cone (ASTM D1556) Methods

* If the required densities are achieved at a moisture content exceeding 2% of optimum moisture content, the soil will be proof rolled and visually inspected by the Soils Quality Control Monitor to determine if it is unyielding and not pumping. Clay subbase shall not be placed on a yielding subgrade.

c. Frequency - Density tests shall be conducted at the frequency of two tests per acre of finished subgrade including the same frequency for each 12-inch lift of fill.

B. CLAY SUBBASE

Prior to placement of the synthetic liner system, a clay subbase shall be prepared. The subbase shall be a minimum of 6" in thickness.

1. Clay Subbase

a. Borrow Source - Prior to clay subbase installation, an appropriate borrow source shall be located. Suitability of the subbase construction materials from that source shall be determined in accordance with the following:

(1) If demonstrated field experience is available from at least three prior successful projects of five or more acres each to document that a given borrow source can meet the requirements of the project specifications, then extensive laboratory testing of the borrow source will not be required. However, the source of material shall be geologically similar to and the methods of excavating and stockpiling the material shall be consistent with those used on the prior projects. Furthermore, a minimum of three representative samples from the appropriate thickness of the in-situ stratum or from stockpiles of the borrow material proposed for subbase construction shall be submitted to the Soils Quality Assurance Engineer to document through index testing that the proposed material is consistent with the material used on prior successful projects. At a minimum, index testing shall consist of percent fines, Atterberg limits and moisture content determinations.

(2) If demonstrated field experience as defined above is not available or cannot be documented, then the following requirements shall be met.

(a) A field exploration and laboratory testing program shall be conducted by the Soils Quality Assurance Engineer to document the horizontal and vertical extent and the homogeneity of the soil strata proposed for use as subbase material. A sufficient number of index tests from each potential borrow stratum shall be performed to quantify the variability of the borrow materials and to document that the proposed borrow material complies with specifications. At a minimum, the index tests shall consist of percent fines (ASTM D1140), Atterberg limits (ASTM D4318) and moisture content (ASTM D2216) determinations.

(b) Sufficient laboratory hydraulic conductivity tests shall be conducted on samples representative of the range invariability of the proposed borrow source (ASTM D5084). At a minimum, the tests shall be taken once per 20,000 cubic yards of soil. For each such sample, test specimens shall be prepared and tested to cover the range of molding conditions (moisture content and dry density) required by project specifications. The hydraulic conductivity tests shall be conducted in triaxial type permeameters. The test specimens shall be consolidated under an isotropic consolidation stress no greater than 10 pounds per square inch and permeated with water under an adequate backpressure to achieve saturation of the test specimens. The inflow to and outflow from the specimens shall be monitored with time and the hydraulic conductivity calculated for each recorded flow increment. The test shall continue until steady state flow is achieved and relatively constant values of hydraulic conductivity are measured (ASTM D5084). The borrow source will only be considered suitable if the hydraulic conductivity of the material, as documented on laboratory test specimens, can be shown to meet the requirements of the project specifications at the 98 percent confidence level.

(3) The Soils Quality Assurance Engineer shall review the pre-qualification data and shall approve or reject the material for use.

b. Test Strip - Prior to full-scale clay subbase installation, a field test section or test strip shall be constructed at the site above a prepared subgrade. The test strip shall be considered acceptable if the measured hydraulic conductivities of undisturbed samples from the test strip meet the requirements of the project specifications at the 98 percent confidence level. If the test section fails to achieve the desired results, additional test sections shall be constructed in accordance with the following requirements:

(1) The test section shall be of sufficient size (40' wide x 60' long at a minimum) such that full-scale clay subbase installation procedures can be duplicated within the test section;

(2) The test section shall be constructed using the same equipment for spreading, kneading and compaction and the same construction procedures (e.g., number of passes, moisture addition and homogenization, if needed) that are anticipated for use during full-scale clay subbase installation;

(3) At a minimum, the clay subbase test section shall be subject to the following field and laboratory testing requirements by the Soils Quality Control Monitor:

(a) A minimum of five random samples of the clay subbase construction material delivered to the site during test section installation shall be tested for moisture content (ASTM D2216), percent fines (ASTM D1140) and Atterberg limits (ASTM D4318);

(b) At least five field density and moisture determinations shall be performed on the compacted clay subbase test section;

(c) Upon completion of the test section, the thickness of the section shall be measured at a minimum of five random locations to check for thickness adequacy; and

(d) A minimum of five Shelby tube or drive cylinder (ASTM D2937) samples shall be obtained from each test section for laboratory hydraulic conductivity testing. Laboratory hydraulic conductivity testing shall be conducted in triaxial type permeameters (ASTM D5084). The test specimens shall be consolidated under an isotropic consolidation stress no greater than 10 pounds per square inch and permeated with water under an adequate backpressure to achieve saturation of the test specimens. The inflow to and outflow from the specimens shall be monitored with time and the hydraulic conductivity calculated for each recorded flow increment. The test shall continue until steady state flow is achieved and relatively constant values of hydraulic conductivity are measured (ASTM D5084).

(e) The test strip shall meet or exceed the standards established below except the field density which shall be established by the Soils Quality Assurance Engineer based upon the test strip

results. If the test strip fails to meet these standards, the construction methods and/or material will be rejected and the test strip shall be performed again.

c. Clay Subbase Installation - Full scale clay subbase installation may begin only after completion of a successful test section. During clay subbase construction, quality control testing shall be provided to document that the installed clay subbase conforms to project specifications. The testing frequency for quality control testing are specified below. However, during construction of the first five acres of the clay subbase, the frequencies shall be doubled. The clay subbase shall be installed in one 6" lift.

(1) Location - The clay subbase shall be tested in-place at random locations. These locations of tests shall be determined by the Soils Quality Control Monitor. If there are indications of a change in product quality or construction procedures during clay subbase construction, additional tests shall be performed to determine compliance.

(2) Standard

(a) Subgrade - Compacted to 96% of Modified Proctor maximum dry density (ASTM D1557) (See Subgrade).

(b) Field Density - The field density shall be established by the Soils Quality Assurance Engineer based upon the test strip results and shall be determined by Standard Proctor Density (ASTM D698). In no case shall the field density be less than 80% of Standard Proctor Density (ASTM D698).

(c) Thickness - The clay subbase shall have a minimum in-place thickness of 6"

(d) Hydraulic Conductivity - The compacted clay subbase shall have an in-place hydraulic conductivity no greater than 1×10^{-5} cm/sec (ASTM D5084).

(3) Field Testing Frequency

(a) Prior to the laying of the clay subbase materials, the subgrade shall be compacted to the specified density. Density tests shall be conducted at a minimum rate of two tests per acre of finished subgrade.

(b) A minimum of two moisture content and field density determinations shall be conducted per acre of compacted clay

subbase. The degree of compaction shall be checked using the one-point field Proctor test or other appropriate test procedures; and

(c) A minimum of four thickness measures shall be conducted per acre of the compacted clay subbase.

(4) Laboratory Testing Frequency

(a) Percent fines (ASTM D1140) of the subbase construction material shall be determined at a minimum frequency of two tests per acre of installed clay subbase;

(b) Atterberg limits determinations shall be performed on one sample per acre of installed clay subbase; and

(c) Hydraulic conductivity testing of Shelby tube or drive cylinder (ASTM D-2937) samples of the compacted clay subbase shall be performed at a minimum frequency of one test per acre. Laboratory hydraulic conductivity tests shall be conducted in triaxial type permeameters (ASTM D-5084). The test specimens shall be consolidated under an isotropic consolidation stress no greater than 10 pounds per square inch and permeated with water under an adequate backpressure to achieve saturation of the test specimens. The inflow to and outflow from the specimens shall be monitored with time and the hydraulic conductivity calculated for each recorded flow increment. The test shall continue until steady state flow is achieved and relatively constant values of hydraulic conductivity are measured.

(5) Deficiency - If the test data from a clay subbase section does not meet the requirements of the project specifications, additional random samples shall be tested from that clay subbase section. If such additional testing demonstrates that the thickness and hydraulic conductivity meet the requirements of the project specifications at the 95 percent confidence level, that clay subbase section will be considered acceptable. If not, that clay subbase section shall be reworked or reconstructed so that it does meet these requirements.

C. BASE LINER GEOMEMBRANE

The lining system shall include a primary and secondary geomembrane liner. The followings revisions shall be made to Section 9A of the "Quality Assurance Guidance Document for the Installation of Lining Systems" (WMI, August 1997) with regard to the geomembrane liners.

9.3A-3.f. Add Puncture Resistance (ASTM D4833)

9.3A-3. Replace "15,000 lb of resin" with "50,000 ft^2 of geomembrane sheet, except for thickness (ASTM D5199/ASTM D5944), which will be performed for every roll."

9.3A-4 Add the following: "Written certification from the manufacturer that the geomembrane product to be delivered has been extruded from an approved resin will be required. The certification shall include the origin (resin supplier's name and resin production plant), identification (brand name and number), resin production date, and quality control certificates issued by the resin supplier."

9.3A-4 Added "6. Batch number" and "7. Date of manufacture" to the manufacturer's roll identification information.

9.4A Replace entire section as follows: "Conformance testing of geomembrane will be conducted by an independent laboratory selected by the CQA Engineer. The laboratory will be accredited by the Geosynthetics Accreditation Institute (GAI) for the specific tests to be performed. The results of the conformance testing shall be reviewed by the Geosynthetic QAE and compared to the Project Specifications. Any nonconformance will be the basis of rejection of the material by the Geosynthetic QAE."

9.5.1A-1. Replace "licensed land surveyor qualified according to project requirements" with "Professional Land Surveyor registered by the State of Florida."

9.5.1A-2. Replace "Professional Engineer" with "Professional Engineer, registered by the State of Florida, or his designee."

9.6.3A Replace "The normal acceptable weather conditions for seaming" with "The normal acceptable weather conditions for deployment".

9.8.2A-2.e. Replace "the maximum permissible pressure differential as outlined in the project specifications" with "3 psi".

9.9.2A-1. Replace "A minimum frequency of one test location per 1000 ft (305 m)" with "A minimum frequency of one test location per 500 ft (150 m)".

D. GEOTEXTILES

The lining system shall include two geotextiles. The followings revisions shall be made to Section 10 of the "Quality Assurance Guidance Document for the Installation of Lining Systems" (WMI, August 1997) with regard to the geotextiles.

10.3-4.e. Add "e. Grab Elongation (ASTM D4632)"

10.3-4.f. Add "f. Burst Strength (ASTM D3786)"

10.3-4.g. Add "g. Apparent Size Opening (ASTM D4751)"

10.3-4.h. Add "h. Permittivity (ASTM D4491)"

10.3-4.3. Replace "10,000 lbs" with "50,000 ft^2"

10.3-4 Add "5. Batch number" and "6. Date of manufacture" to the manufacturer's roll identification information.

10.4 Replace entire section as follows: "Conformance testing of geotextile will be conducted by an independent laboratory selected by the CQA Engineer. The laboratory will be accredited by the Geosynthetics Accreditation Institute (GAI) for the specific tests to be performed. The results of the conformance testing shall be reviewed by the Geosynthetic QAE and compared to the Project Specifications. Any nonconformance will be the basis of rejection of the material by the Geosynthetic QAE."

10.4.2 Delete columns that differentiate between different geotextiles. All tests listed shall be performed.

10.6 Replace second paragraph in its entirety with the following: "All geotextile seams shall be continuously sewn. Spot sewing or heat bonding is not allowed."

E. GEONETS

The lining system shall include geonets. The followings revisions shall be made to Section 11 of the "Quality Assurance Guidance Document for the Installation of Lining Systems" (WMI, August 1997) with regard to geonets.

11.3-2.e. Add: "e. Grab Tensile Strength (ASTM D5035)"

11.3-2 Add the following: "Written certification from the manufacturer that the product to be delivered has been extruded from an approved resin will be required. The certification shall include the origin (resin supplier's name

and resin production plant), identification (brand name and number), resin production date, and quality control certificates issued by the resin supplier."

11.3-2 Added "5. Batch number" and "6. Date of manufacture" to the manufacturer's roll identity information.

11.4 Replace entire section as follows: "Conformance testing of geonet will be conducted by an independent laboratory selected by the CQA Engineer. The laboratory will be accredited by the Geosynthetics Accreditation Institute (GAI) for the specific tests to be performed. The results of the conformance testing shall be reviewed by the Geosynthetic QAE and compared to the Project Specifications. Any nonconformance will be the basis of rejection of the material by the Geosynthetic QAE."

11.4.2-4 Add "4. Transmissivity (ASTM D4716)"

F. BENTONITE MAT (Geosynthetic Clay Liner)

The lining system shall include a bentonite mat (geosynthetic clay liner). The followings revisions shall be made to Section 13 of the "Quality Assurance Guidance Document for the Installation of Lining Systems" (WMI, August 1997) with regard to the bentonite mat.

13.3-2. Replace "100,000 lbs" with "50,000 ft^2"

13.3-4.c. Replace "Mass per unit area (ASTM D5261)" with "Mass per unit area (ASTM D5993)".

13.4 Replace entire section as follows: "Conformance testing of GCL will be conducted by an independent laboratory selected by the CQA Engineer. The laboratory will be accredited by the Geosynthetics Accreditation Institute (GAI) for the specific tests to be performed. The results of the conformance testing shall be reviewed by the Geosynthetic QAE and compared to the Project Specifications. Any nonconformance will be the basis of rejection of the material by the Geosynthetic QAE."

13.4.2-1 Replace "Samples for index flux conformance tests" with "Samples for hydraulic conductivity tests".

13.4.2-2 Delete "Index Flux (ASTM D5887) or"

13.4.2-3 Replace "Mass per unit area (ASTM D5261)" with "Mass per unit area (ASTM D5993)".

13.6.1 3. Replace "The addition of bentonite to seam locations shall be in accordance with the project specifications." with "The addition of bentonite to seam locations shall be in accordance with the manufacturer's recommendations."

13.6.1 2. Replace "The amount of the bentonite is placed on the seam required by the project specifications." with "The amount of the bentonite is placed on the seam required by the manufacturer's recommendations."

13.7 Replace "The material shall extend over the entire damaged area with a minimum 24-inch overlap in all directions. Addition of bentonite to patches shall be in accordance with the project specifications" with "The material shall extend over the entire damaged area with a minimum 24-inch overlap in all directions. Addition of bentonite to patches shall in accordance with the manufacturer's recommendations."

In addition to the requirements of the "Quality Assurance Guidance Document for the Installation of Lining Systems" (WMI, August 1997), the bentonite mat shall be monitored and tested as follows:

1. Bentonite Mat

   a. Location - Upon delivery of the bentonite mat rolls to the site (prior to installation) samples shall be obtained.

   b. Standard

      (1) Hydraulic Conductivity - The hydraulic conductivity (ASTM D5084) shall be no greater than 5×10^{-9} cm/sec at a confining stress of 5 psi.

      (2) Moisture Content - The moisture content (ASTM D4643) shall be no greater than 12 percent.

      (3) Mass - The mass per unit area (ASTM D5261) of the sodium bentonite component of the bentonite mat shall be a minimum of 0.825 lb/ft2.

   c. Frequency - The bentonite mat shall be tested for moisture content, hydraulic conductivity and mass per unit area at least once per 40,000 square feet or once per lot, whichever is more frequent.

G. PROTECTIVE SAND BLANKET

After the synthetic liner system has been installed, it shall be covered with a protective sand blanket. The protective sand blanket shall be a minimum of 24" in thickness.

1. Protective Sand Blanket

a. Location - Material shall be pre-qualified by hydraulic conductivity, particle size, and calcium carbonate content testing at the borrow location.

Truck tickets shall be utilized for chain of custody to site.

Thickness shall be verified by as-built survey.

b. Standard - Sand shall be reasonably free of brush, weeds, and other litter; and relatively free of roots, stumps, stones and any other extraneous or toxic matter. The Soils Quality Control Monitor shall visually inspect the sand during placement.

Hydraulic Conductivity shall be greater than or equal to 1×10^{-3} cm/sec at a density of 96 percent Modified Proctor maximum dry density (ASTM D1557). Hydraulic Conductivity testing by Constant Head Method (ASTM D2434).

Thickness shall be no less than 24 inches at each location.

The sand shall be non-calcareous (ASTM D3042).

Compatibility of protective sand cover grain size with geotextile to be determined, prior to initial placement.

c. Frequency - Hydraulic Conductivity testing shall be on-going as necessary to support fill borrow operations with minimum of one test per 500 cubic yards.

Prior to placement, the sand shall be tested for particle size and calcium carbonate content. The test shall be taken at least once per 5,000 cubic yards and for each change in material source.

d. Miscellaneous - The material shall be placed loose and spread on top of the liner system to a minimum depth of 24 inches. No equipment shall come in direct contact with liner. Low

ground pressure equipment shall be used for the placement and spreading of the sand cover. Temporary haul roads and access roads over the liner for the delivery of material shall include a minimum of 36 inches of sand cover depth. These temporary facilities shall be removed during the finish grading of the protective sand blanket.

The leading edge of sand placement over the synthetic liner system shall be by vertical placement versus pushing sand horizontally.

H. CLAY ANCHOR BERM

A clay anchor berm shall be constructed in accordance with the Contract Drawings.

1. Clay Anchor Berm

   a. Location - The clay anchor berm shall be sampled in place. Hydraulic conductivity testing shall be conducted in the laboratory.

   b. Standard - Hydraulic conductivity shall be less than 1×10^{-7} cm/sec. Hydraulic conductivity testing by Falling Head Method (ASTM D5084).

   c. Frequency - One testing location per 100 linear feet of anchor trench.

I. LEACHATE COLLECTION TRENCH AND SUMP AGGREGATE

Aggregate shall be placed in leachate collection trenches and sumps.

1. Aggregate

   a. Location - The aggregate shall be sampled on site, prior to placement.

   b. Standard - Gradient shall meet AASHTO No. 3 coarse aggregate (ASTM D448). Testing by Sieve Analysis (ASTM C136).

   The aggregate shall be non-calcareous (ASTM D3042).

   c. Frequency - Prior to placement, one gradation test per sump plus one testing location per trench with a minimum of one test per 500 cubic yards of aggregate.
   Prior to placement, the aggregate shall be tested for calcium carbonate content. The test shall be taken once for 2,600 LF of trench or once per change in material source.

QUALITY ASSURANCE GUIDANCE DOCUMENT
FOR THE INSTALLATION OF
LINING SYSTEMS

August 1997

QUALITY ASSURANCE MANUAL FOR THE INSTALLATION OF LINING SYSTEMS

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APPENDIX - SPECIFICATIONS FOR HDPE GEOSYNTHETICS

1.0 GENERAL

1.1 SCOPE

This Quality Assurance Resource Document (QAGD) addresses the quality assurance of the installation of soil and geosynthetic materials used in lining systems by Waste Management companies (Owner) for their land disposal, surface impoundment and other waste containment facilities. This QAGD is applicable for lining systems which include base liner and final cover systems. Extreme care and detailed documentation are required in the selection and installation of all materials used in lining systems for waste containment applications.

This QAGD primarily addresses quality assurance and is directed toward the Quality Assurance Consultant. In the context of this manual, **quality assurance** refers to means and actions employed by the Owner to assure conformity of the lining system production and installation with the project-specific Quality Assurance Plan (QAP), contractual and regulatory requirements. **Quality control** refers only to those actions taken to ensure that materials and workmanship meet the requirements of the project plans and specifications. Quality control is provided by the manufacturers, suppliers, contractors and installers of the various components of the lining system.

The QAGD is one component of the overall QAP. **A PROJECT-SPECIFIC QAP IS REQUIRED FOR EACH PROJECT.** At a minimum, the QAP shall consist of the following:

1. Pertinent Sections of this QAGD or other applicable QAGDs.

2. Project-Specific Addenda to the QAGD Sections. Project-Specific Addenda shall be used to provide for additions, deletions, and changes necessary to the QAGD Sections used for a particular project.

3. Project-Specific Plans and Specifications.

The QAP should contain all of the elements necessary to ensure that the project is constructed in accordance with project plans and specifications as well as regulatory requirements. This QAGD serves as a foundation for a QAP, and is not a QAP in itself.

1.2 PARTIES

The parties discussed in this section are associated with the ownership, design, supply, manufacture, transportation, installation, and quality assurance of a lining system. The definitions, responsibilities, qualifications, and submittals of these parties are outlined in the following subsections.

1.2.1 Project Manager

1.2.1.1 *Definitions*

The Project Manager is the official representative of the Owner. In this manual, the term Project Manager shall apply equally to "Construction Coordinator" or "Construction Manager", defined as the individual who coordinates construction and quality assurance activities for the project.

1.2.1.2 *Responsibilities*

The Project Manager is responsible for coordination of all construction quality assurance activities. The Project Manager is responsible for the organization and implementation of the QAP for the project as outlined in Section 1.1 of this manual. Other responsibilities include selection or approval of Earthwork Contractor, Geosynthetic Installer, Quality Assurance Consultant and the Quality Assurance Laboratory.

The Project Manager shall serve as communications coordinator for the project, initiating the resolution, pre-construction and construction meetings outlined in Section 1.3. As communications coordinator, the Project Manager shall serve as a liaison between all parties involved in the project to ensure that communications are maintained. The Project Manager shall also be responsible for proper resolution of all quality assurance issues that arise during construction.

1.2.1.3 *Qualifications*

The selection of the Project Manager is the direct responsibility of the Owner. Qualifications for this position include familiarity with the following:

1. Sections of this QAGD or other applicable QAGDs.

2. General earthwork construction techniques.

3. General geosynthetic installation techniques.

4. All applicable regulatory requirements.

5. Company policies and procedures for project management.

1.2.2 Designer

1.2.2.1 *Definitions*

The Designer is the individual and/or firm who prepares the design, including project plans and specifications for the lining system.

1.2.2.2 *Responsibilities*

The Designer is responsible for performing the engineering design and preparing the associated project plans and specifications for the lining system. The Designer is responsible for approving all design and specification changes and making design clarifications necessitated during construction of the lining system. Upon the request of the Project Manager, the Designer shall attend the resolution and pre-construction meetings outlined in Section 1.3 of this manual.

1.2.2.3 *Qualifications*

The Designer shall be a qualified engineer, certified or licensed as required by regulation. The Designer shall be familiar with the use of soils and/or geosynthetics including detailed design methods and procedures. In addition, the Designer should be familiar with applicable regulatory requirements.

1.2.2.4 *Submittals*

The Designer shall submit the project plans, specifications and associated engineering reports to the Project Manager. The Designer shall also submit completed design clarification forms to the Project Manager in a timely manner upon request. Other information may also be required by the Owner.

1.2.3 Manufacturer

1.2.3.1 *Definitions*

The Manufacturer is the firm which produces any of the various geosynthetic lining system components outlined in this QAGD. In the case of a geocomposite, the Manufacturer is the firm which combines the components into the final product.

1.2.3.2 *Responsibilities*

Each Manufacturer is responsible for the production of its geosynthetic product. In addition, each Manufacturer is responsible for the condition of the geosynthetic product until the material is accepted by the Project Manager upon delivery. Each Manufacturer shall produce a consistent product that meets the project specifications. Each Manufacturer shall provide quality control documentation for its product as specified in this QAGD.

1.2.3.3 *Qualifications*

Each Manufacturer shall:

1. Be pre-qualified and approved by the Owner.

2. Provide sufficient production capacity and qualified personnel to meet the demands of the project.

3. Have an internal quality control program for its product that meets the requirements presented in this QAGD.

1.2.3.4 *Submittals*

Pre-qualification: At a minimum, the Manufacturer shall meet the following requirements and submit the following information to the Project Manager to be considered for pre-qualification:

1. Corporate background and information.

2. Manufacturing capabilities:
   a. Information on plant size, equipment, personnel, number of shifts per day, and capacity per shift.
   b. Daily production quantity of the specified product available for the Owner's facilities.
   c. A list of material properties including certified test results with attached geosynthetic samples.
   d. A list of at least 15 completed landfill or surface impoundment facilities totalling a minimum of 15,000,000 ft^2 (1,500,000 m^2), for which the Manufacturer has manufactured a geosynthetic. For each facility, the following information shall be provided:
      (1) Name and purpose of facility, its location and date of installation.
      (2) Name of Owner, Project Manager, Designer, Installer and Fabricator (if any).
      (3) Type of geosynthetic and surface area of geosynthetic manufactured.
      (4) Available information on the performance of the lining system.

3. The Manufacturer's quality control manual, including a description of the quality control laboratory facilities.

4. The origin (supplier's name and production plant) and identification (brand name and number) of resin used to manufacture the product.

Additional information may need to be submitted if requested by the Project Manager.

Pre-installation: Prior to the installation of any geosynthetic material, the Manufacturer shall submit to the Project Manager all quality control documentation required by the appropriate section of this QAGD. This documentation shall be reviewed by the Geosynthetic Quality Assurance Consultant as outlined in Section 1.2.7 of this QAGD before installation can begin.

1.2.4 Earthwork Contractor

1.2.4.1 *Definitions*

The Earthwork Contractor is the firm which performs the site earthwork preparation and construction of the soil components of the lining system. The Earthwork Superintendent is the individual responsible for the Earthwork Contractor's field crew. The Earthwork Superintendent may represent the Earthwork Contractor at all site meetings and acts as the Earthwork Contractor's spokesman on the project.

1.2.4.2 *Responsibilities*

The Earthwork Contractor is responsible for constructing soil components of the lining systems in conformance to the project plan and specifications. The Earthwork Contractor may also be responsible for supplying and transporting the required earth and granular materials, concrete, piping, and other work, as outlined in the project specifications.

1.2.4.3 *Qualifications*

The Earthwork Contractor shall be:

1. Pre-qualified and approved by the Owner.

2. Able to provide qualified personnel to meet the demands of the project.

At a minimum, the Earthwork Contractor shall provide a Superintendent as described below.

The Superintendent must be qualified based on previously demonstrated experience, management ability, and authority. The Superintendent shall be approved by the Project Manager.

1.2.4.4 *Submittals*

Pre-qualification: At a minimum, the Earthwork Contractor shall meet the following requirements and submit the following information to the Project Manager to be considered for prequalification:

1. Company background and information

2. Demonstration of bonding capability

3. List of outstanding contracts

4. List of readily available equipment required to perform the work (i.e., scrapers, graders, scarifiers, compactors, disking equipment, water trucks, and admixing equipment, if required)

5. List of at least five comparable projects with the following information for each project:
   a. Name of the facility, its location, date of installation.
   b. Name of project manager or contact person for the installation.
   c. Description and purpose of installation and definition of contractor's scope of work.

   Additional information may need to be submitted if requested by the Project Manager.

Pre-installation: Prior to commencement of the earthwork activities, the Earthwork Contractor shall submit to the Project Manager:

1. Resume of the Earthwork Superintendent to be assigned to this project, including the dates and duration of employment.

2. Schedule of construction activities.

3. List of specific equipment and personnel to be used on the project.

4. List of proposed subcontractors and suppliers.

Completion: Upon completion of the installation, the Earthwork Contractor shall submit a Certificate of Completion.

1.2.5 Geosynthetic Installer

1.2.5.1 *Definitions*

The Geosynthetic Installer (Installer) is the firm which installs the geosynthetic components of the lining system. The Geosynthetic Superintendent is the individual responsible for the Installer's field crew. The Geosynthetic Superintendent shall represent the Installer at all site meetings and act as the Installer's spokesman on the project.

1.2.5.2 *Responsibilities*

The Installer is responsible for field handling, storing, deploying, seaming, temporary restraining and all other aspects of the geosynthetics installation. The Installer may also be responsible for transportation of these materials to the site and for anchor systems, if required by the project specifications. The Installer shall be responsible for submittal of the documentation listed in Section 1.2.5.4.

1.2.5.3 *Qualifications*

The Installer shall be pre-qualified and approved by the Owner. The Installer shall be able to provide qualified personnel to meet the demands of the project. At a minimum, the Installer shall provide a Geosynthetic Superintendent.

The Geosynthetic Superintendent shall be qualified based on previously demonstrated experience, management ability and authority. The Geosynthetic Superintendent shall be approved by the Project Manager.

For geomembrane installation, all personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests.

1.2.5.4 *Submittals*

Pre-qualification: At a minimum, the Installer shall submit the following information to the Project Manager to be considered for pre-qualification:

1. Corporate background and information

2. Description of installation capabilities:
   a. Information on equipment (numbers and types), and personnel (number of Superintendents, number of crews).
   b. Average daily production anticipated.
   c. Samples of field geomembrane seams and a list of minimum values for geomembrane seam properties.

3. A list of at least ten completed facilities, totalling a minimum of 2,000,000 ft^2 (200,000 m^2) for which the Installer has installed geosynthetics. For each installation, the following information shall be provided:
   a. Name and purpose of facility, its location, and date of installation.
   b. Name of owner, project manager, designer, manufacturer, fabricator (if any), and name of contact at the facility who can discuss the project.
   c. Name and qualifications of the Superintendent(s) of the Installer's crew(s).
   d. Type of geosynthetic, and surface area installed.
   e. Type of seaming and type of seaming apparatus used.
   f. Duration of installation.
   g. Available information on the performance of the lining system.

4. The Installer's quality control manual.

5. A copy of a letter of recommendation supplied by the geomembrane manufacturer.

Pre-installation: Prior to commencement of the installation, the Installer must submit to the Project Manager:

1. Resume of the Geosynthetic Superintendent to be assigned to this project, including dates and duration of employment.

2. A panel layout drawing showing the installation layout identifying field seams as well as any variance or additional details which deviate from the project plans or specifications. The layout shall be adequate for use as a construction plan and shall include dimensions and details as appropriate.

3. Installation schedule.

4. A list of personnel performing field seaming operations along with pertinent experience information.

5. All geosynthetic quality control certificates as required by this QAGD, unless submitted directly to the Project Manager by the Manufacturer.

6. Certification that extrudate to be used is comprised of the same resin as the geomembrane to be used.

This documentation shall be reviewed by the Geosynthetic Quality Assurance Consultant before installation of the geosynthetic can begin.

Installation: During installation, the Installer shall be responsible for the submission of:

1. Quality control documentation recorded during installation.

2. Subgrade surface acceptance certificates signed by the Installer for each area to be covered by the lining system.

Completion: Upon completion of the installation, the Installer shall submit:

1. The warranty obtained from the Manufacturer.

2. The installation warranty.

1.2.6 Soil Quality Assurance Consultant

1.2.6.1 *Definitions*

The Soil Quality Assurance Consultant (Soil QAC) is the firm which observes and documents activities related to the quality assurance of the installation of the soil components of the lining system on behalf of the Owner. The Soil QAC and Geosynthetic QAC may be the same party.

In this QAGD, the term Soil Quality Assurance Engineer (Soil QAE) refers to the engineer employed by the QAC who is personally in charge of the quality assurance work. In some cases, the duties of the Soil QAE may be shared by two individuals: a Soil Quality Assurance Certifying Engineer and a Soil Quality Assurance Resident Engineer. Although not located at the site, the Soil Quality Assurance Certifying Engineer shall visit the site often enough to be familiar with the details of the project. The Soil Quality Assurance Certifying Engineer may also be known as the Soil Quality Assurance Officer.

The personnel of the Soil QAC also include Soil Quality Assurance Monitors (Soil QA Monitors) who are located at the site for construction observation and documentation.

1.2.6.2 *Responsibilities*

The Soil QAC is responsible for observing and documenting activities related to the quality assurance of the construction of the soil components of the lining systems. The Soil QAC is responsible for the implementation of the project QAP prepared by the Project Manager. The Soil QAC is also responsible for issuing a final Quality Assurance Report, sealed by a licensed Professional Engineer, as outlined in Section 2.0 of this QAGD. Other duties of the Soil QAC shall include overseeing the soil laboratory testing.

The specific duties of the Soil QAC personnel are as follows:

1. The Soil QAE:
   a. Reviews all project plans and specifications.
   b. Reviews other site-specific documentation.
   c. Develops site-specific addenda for quality assurance of soil components with the assistance of the Project Manager as necessary.
   d. Administers the soil portions of the QAP, including assigning and managing all soil quality assurance personnel, reviews all field reports, and provides engineering review of all quality assurance related issues.
   e. Familiarizes himself with all applicable changes to project plans and specifications as issued by the Designer.
   f. Acts as on-site (resident) representative of the Soil QAC.
   g. Familiarizes all Soil QA Monitors with the site and the project QAP.
   h. Assigns Soil QA Monitors to observe and document all activities requiring monitoring.
   i. Attends all quality assurance related meetings, including resolution, pre-construction, daily, weekly meetings.
   j. Reviews the calibration certification of the on-site soil testing equipment.
   k. Manages the preparation of the record drawings.
   l. Reviews the Soil QA Monitors' daily reports, logs, and photographs.
   m. Notes any on-site activities that could result in damage to the installed soil components.
   n. Reports to the Project Manager, and logs in the daily report, any relevant observations reported by the Soil QA Monitors.
   o. Prepares his own daily report.
   p. Prepares a daily summary of the soil component quantities estimates installed each day of construction activity.
   q. Prepares a weekly summary of soil quality assurance activities at the end of each week of the construction activity.
   r. Oversees marking, packaging and shipping of all laboratory test samples.
   s. Reviews the results of laboratory testing and makes appropriate recommendations.
   t. Recommends the approval of the final soils acceptance to the Project Manager.
   u. Designates a Soil QA Monitor to represent the QAE whenever he is absent from the site while operations are ongoing.
   v. Reports any unapproved deviations from the QAP to the Project Manager.
   w. Maintains field files of all logs and reports.
   x. Maintains qualifications of all personnel and calibration of equipment.
   y. Prepares the final Quality Assurance Report.

2. The Soil QA Monitor:
   a. Monitors, logs, photographs and/or documents all soil component installation operations. Photographs shall be taken routinely and in critical areas of the installation sequence. These duties shall be assigned by the Soil QAE.
   b. Monitors and documents the following operations for all soil components:
      (1) Material delivery
      (2) Unloading and on-site transport and storage
      (3) Sampling and conformance testing

(4) Deployment operations
(5) Condition of the soil components as placed
(6) Visual observation, by walkover, of the finished soil components
(7) Sampling and field testing of the finished soil components
(8) Repair operations, if and when necessary

c. Conducts soil sampling and testing.
d. Documents any on-site activities that could result in damage to the constructed soil components. Any problems noted shall be reported as soon as possible to the Soil QAE.

Any differences of the Soil QAC's interpretation of the project plans and specifications from the Earthwork Contractor's interpretation shall be properly and adequately assessed by the Soil QAC through discussion with the Earthwork Contractor. If such assessment indicates any actual or suspected work deficiencies, the Soil QAC shall inform the Earthwork Contractor of these deficiency issues.

1.2.6.3 *Qualifications*

The Soil QAC shall be pre-qualified and approved by the Owner. The Soil QAC shall be experienced in the preparation of quality assurance documentation including quality assurance forms, reports, certifications and manuals.

The Soil QAE shall hold a B.S., M.S., or Ph.D degree in civil engineering or related fields and be licensed as a Professional Engineer. If the duties of the Soil QAE are shared by two parties, only the Soil Quality Assurance Certifying Engineer shall be required to be a licensed Professional Engineer. The Soil QAE shall be specifically experienced in the installation of soil liners and shall have the necessary training and certification by the Soil QAC in the duties of a Soil QAE. The Soil QAE shall be approved by the Project Manager.

Soil QA Monitors shall have specific training in construction quality assurance of engineered soil structures and be so designated by the Soil QAE. The Monitors shall be approved by the Project Manager.

1.2.6.4 *Submittals*

Pre-qualification: At a minimum, the Soil QAC shall submit the following information in writing to the Project Manager to be considered for pre-qualification:

1. Corporate background and information:
   a. General company information
   b. Proof of insurance
      (1) Professional liability
      (2) "Umbrella" coverage
      (3) Other coverages as required by statute and/or proposed contractual agreement

2. Quality assurance capabilities:
   a. A summary of the firm's experience in quality assurance, specifically quality assurance of soil components of lining systems.
   b. A summary of quality assurance documentation and methods used by the firm, including sample quality assurance forms, reports, certifications, and manuals prepared by the firm.
   c. Resumes of key personnel.

Additional information may need to be submitted if required by the Project Manager.

Pre-construction: Prior to beginning work on a project, the Soil QAC shall, in writing, provide the Project Manager with the following:

1. Resumes of personnel to be involved in the project including Soil QAE and Soil Quality Assurance Monitors.

2. Proof of professional engineering registration in the appropriate state of the engineer to be designated as the Soil Quality Assurance Certifying Engineer, as well as proof of B.S., M.S. or Ph.D in civil engineering or related field degree.

3. Proof of the required soil components quality assurance experience of all of the quality assurance personnel.

4. Examples of forms to be used in documentation of the project.

1.2.7 Geosynthetic Quality Assurance Consultant

1.2.7.1 *Definitions*

The Geosynthetic Quality Assurance Consultant (Geosynthetic QAC) is the firm which observes and documents activities related to the quality assurance of the production and installation of the geosynthetic components of the lining systems on behalf of the Owner. The Geosynthetic QAC and Soil QAC may be the same party.

In this QAGD, the term Geosynthetic Quality Assurance Engineer (Geosynthetic QAE) shall be used to designate the engineer working for the Geosynthetic QAC in charge of the quality assurance work. In some cases the duties of the Geosynthetic QAE may be shared by two individuals: a Geosynthetic Quality Assurance Certifying Engineer and a Geosynthetic Quality Assurance Resident Engineer. Although not located at the site, the Geosynthetic Quality Assurance Certifying Engineer shall visit the site often enough to be familiar with the details of the project. The Geosynthetic Quality Assurance Certifying Engineer may also be known as the Geosynthetic Quality Assurance Officer.
The personnel of the Geosynthetic QAC also include Geosynthetic Quality Assurance Monitors who are located at the site for construction observation and documentation.

1.2.7.2 *Responsibilities*

The Geosynthetic QAC is responsible for observing and documenting activities related to the quality assurance of the production and installation of the geosynthetic components of the lining systems. The Geosynthetic QAC is responsible for implementation of the project QAP prepared by the Project Manager as well as reviewing work products of the Geosynthetic Quality Assurance Laboratory. The Geosynthetic QAC is also responsible for issuing a final Quality Assurance Report, sealed by a licensed Professional Engineer, as outlined in Section 2.0 of this QAGD.

The specific duties of the Geosynthetic QAC personnel are as follows:

1. The Geosynthetic QAE:
   a. Familiarizes himself with all project plans and specifications.
   b. Reviews other site-specific documentation, including proposed layouts, and manufacturer's and installer's literature.
   c. Develops site-specific addenda for quality assurance of geosynthetics with the assistance of the Project Manager, as necessary.
   d. Administers the geosynthetic portions of the QAP, including assigning and managing all geosynthetic quality assurance personnel, reviewing all field reports, and providing engineering review of all quality assurance related issues.
   e. Reviews for familiarity all appropriate changes to design drawings and project specifications as issued by the Designer.
   f. Acts as the on-site (resident) representative of the Geosynthetic QAC.
   g. Familiarizes all Geosynthetic Quality Assurance Monitors with the site and the project QAP.
   h. Assigns Geosynthetic Quality Assurance personnel to observe and document geosynthetic installation activities requiring certification.
   i. Attends all quality assurance related meetings, including resolution, pre-construction, daily, weekly.
   j. Reviews all Manufacturer and Installer certifications and documentation and makes appropriate recommendations.
   k. Reviews the Installer's personnel qualifications for conformance with those qualifications preapproved for work on site.
   l. Manages the preparation of the record drawings.
   m. Reviews the calibration certification of the on-site testing equipment, as required.
   n. Reviews all Geosynthetic Quality Assurance Monitor's daily reports, logs and photographs.
   o. Notes any on-site activities that could result in damage to the geosynthetics.
   p. Reports to the Project Manager, and logs in the daily report, any relevant observations reported by the Geosynthetic Quality Assurance Monitors.
   q. Prepares his own daily report.
   r. Prepares a daily summary of the quantities estimates of geosynthetics installed that day.
   s. Prepares the weekly summary of geosynthetic quality assurance activities.
   t. Oversees the marking, packaging and shipping of all laboratory test samples.
   u. Reviews the results of laboratory testing and makes appropriate recommendations.
   v. Recommends the approval of the final liner acceptance to the Project Manager.

w. Designates a Geosynthetic Quality Assurance Monitor to represent the QAE whenever he is absent from the site while operations are ongoing.
x. Reports any unapproved deviations from the QAP immediately to the Project Manager.
y. Prepares the final Quality Assurance Report.

2. The Geosynthetic Quality Assurance Monitor:
   a. Monitors, logs, photographs and/or documents all geosynthetic installation operations. Photographs shall be taken routinely and in critical areas of the installation. These duties shall be assigned by the Geosynthetic QAE.
   b. Monitors the following operations for all geosynthetics:
      (1) Material delivery*
      (2) Unloading and on-site transport and storage*
      (3) Sampling for conformance testing*
      (4) Deployment operations
      (5) Joining and/or seaming operations
      (6) Condition of panels as placed
      (7) Visual inspection by walkover
      (8) Repair operations
   c. Monitors and documents the geomembrane seaming operations, including:
      (1) Trial seams
      (2) Seam preparation
      (3) Seaming
      (4) Nondestructive seam testing
      (5) Destructive seam testing
      (6) Field tensiometer testing
      (7) Laboratory sample marking
      (8) Repair operations
      (9) Measurements of uninstalled quantities
   d. Documents any on-site activities that could result in damage to the geosynthetics. Any problems noted shall be reported as soon as possible to the Geosynthetic QAE.

Any differences between the Geosynthetic QAC's and Installer's interpretation of the project plans and specifications shall be properly and adequately assessed by the Geosynthetic QAC. If such assessment indicates any actual or suspected work deficiencies, the Geosynthetic QAC shall inform the Installer, or the Installer's representative, of these deficiencies.

1.2.7.3 *Qualifications*

The Geosynthetic QAC shall be pre-qualified by the Owner. The Geosynthetic QAC shall be experienced in quality assurance of geosynthetics with emphasis on polyethylene geomembranes. The Geosynthetic QAC shall be experienced in the preparation of quality assurance documentation including quality assurance forms, reports, certifications, and manuals.

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*when appropriate

The Geosynthetic Quality Assurance Certifying Engineer shall hold a B.S., M.S. or Ph.D degree in civil engineering or related fields and be licensed as a Professional Engineer. If the duties of the Geosynthetic QAE are shared by two parties, only the Certifying Engineer shall be required to be licensed as a Professional Engineer. The Geosynthetic Quality Assurance Resident Engineer shall be specifically experienced in the installation of geosynthetics and shall be trained and certified by the Geosynthetic QAC in the duties of a Geosynthetic QAE. The Geosynthetic QAC shall be approved by the Project Manager.

Geosynthetic Quality Assurance Monitors shall be quality assurance personnel who have been specifically trained in the quality assurance of geosynthetics. The Monitors shall be approved by the Project Manager.

1.2.7.4 *Submittals*

Pre-qualification: At a minimum, the Geosynthetic QAC shall provide the following information in writing to the Project Manager to be considered for pre-qualification:

1. Corporate background and information.
   a. General company information
   b. Proof of insurance
      (1) Professional liability
      (2) "Umbrella" coverage
      (3) Other coverages as required by statute and/or proposed contractual agreement

2. Quality assurance capabilities:
   a. A summary of the firm's experience with geosynthetics.
   b. A summary of the firm's experience in quality assurance, including installation quality assurance of geosynthetics.
   c. A summary of quality assurance documentation and methods used by the firm, including sample quality assurance forms, reports, certifications, and manuals prepared by the firm.
   d. Resumes of key personnel.

Additional information may need to be submitted if required by the Project Manager.

Pre-installation: Prior to beginning work on a project, the Geosynthetic QAC must provide the Project Manager with the following information:

1. Resumes of personnel to be involved in the project including Geosynthetic QAE and Geosynthetic Quality Assurance Monitors.

2. Proof of professional engineering registration in the appropriate state for the engineer to be designated as the Geosynthetic QAE, as well as proof of B.S., M.S., or Ph.D in civil engineering or related field degree.

3. Proof of the required quality assurance experience of all of the quality assurance personnel with emphasis on polyethylene geomembranes.

4. Examples of forms to be used in documentation of the project.

1.2.8 Soil Quality Assurance Laboratory

1.2.8.1 *Definitions*

The Soil Quality Assurance Laboratory (Soil QAL) is the firm which conducts tests on soil samples taken from the site. The Soil QAL and Geosynthetic QAL may be the same party.

1.2.8.2 *Responsibilities*

The Soil QAL is responsible for conducting the appropriate laboratory tests as directed by the Soil QAE. The test procedures shall be done in accordance with the test methods outlined in this QAGD and/or the project QAP. The Soil QAL shall be responsible for providing tests results as outlined in Section 1.2.8.4.

1.2.8.3 *Qualifications*

The Soil QAL shall be pre-qualified by the Owner and approved by the Project Manager. The Soil QAL shall have properly maintained and periodically calibrated appropriate testing equipment. The Soil QAL shall also ensure that laboratory soil testing is performed by personnel with experience and/or training in soil testing fundamentals. The laboratory personnel shall be familiar with American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), Federal Test Method Standard (FTMS) and other applicable test standards. The Soil QAL shall be capable of providing test results within project deadlines throughout the soil prequalification and installation phase of the soil components.

The Soil QAL shall submit sample data and analysis to be used during the lab tests to the Project Manager.

1.2.8.4 *Submittals*

The Soil QAL shall submit all written test results within project deadlines to the Soil QAE. Soil test results shall be provided to the Soil QAE as soon as possible after test completion. Written test results shall be in an easily readable format and include references to the standard test methods used.

1.2.9 Geosynthetic Quality Assurance Laboratory

1.2.9.1 *Definitions*

The Geosynthetic Quality Assurance Laboratory (Geosynthetic QAL) is the firm which conducts tests on samples of geosynthetics taken from the site. The Geosynthetic QAL and the Soil QAL may be the same party.

1.2.9.2 *Responsibilities*

The Geosynthetic QAL is responsible for conducting the appropriate laboratory tests as directed by the Geosynthetic QAE. The test procedures shall be done in accordance with the test methods outlined in this QAGD and/or the project QAP. The Geosynthetic QAL shall be responsible for providing test results as outlined in Section 1.2.9.4.

1.2.9.3 *Qualifications*

The Geosynthetic QAL shall be pre-qualified by the Owner and approved by the Project Manager. The Geosynthetic QAL shall have properly maintained and periodically calibrated appropriate testing equipment. The Geosynthetic QAL shall also ensure the laboratory testing is performed by personnel with experience and/or training in geosynthetic testing fundamentals.

The Geosynthetic QAL shall be familiar with ASTM, FTMS, National Sanitation Foundation (NSF), Geosynthetic Research Institute (GRI), and other applicable test standards. The Geosynthetic QAL shall be capable of providing results of destructive seam tests within 24 hours of receipt of test samples and shall maintain that standard throughout the installation. On-site laboratory facilities may be used by the Geosynthetic QAL, provided they are appropriately equipped and approved by the Geosynthetic QAC and Project Manager.

1.2.9.4 *Submittals*

The Geosynthetic QAL shall submit all destructive seam test results to the Geosynthetic QAE in written form within 48 hours of receipt of test samples unless otherwise specified by the Project Manager. Geomembrane destructive test results shall typically be provided to the Geosynthetic QAE within 24 hours of receipt of test samples. Written test results shall be in an easily readable format and include references to the standard test methods used.

1.3 COMMUNICATION

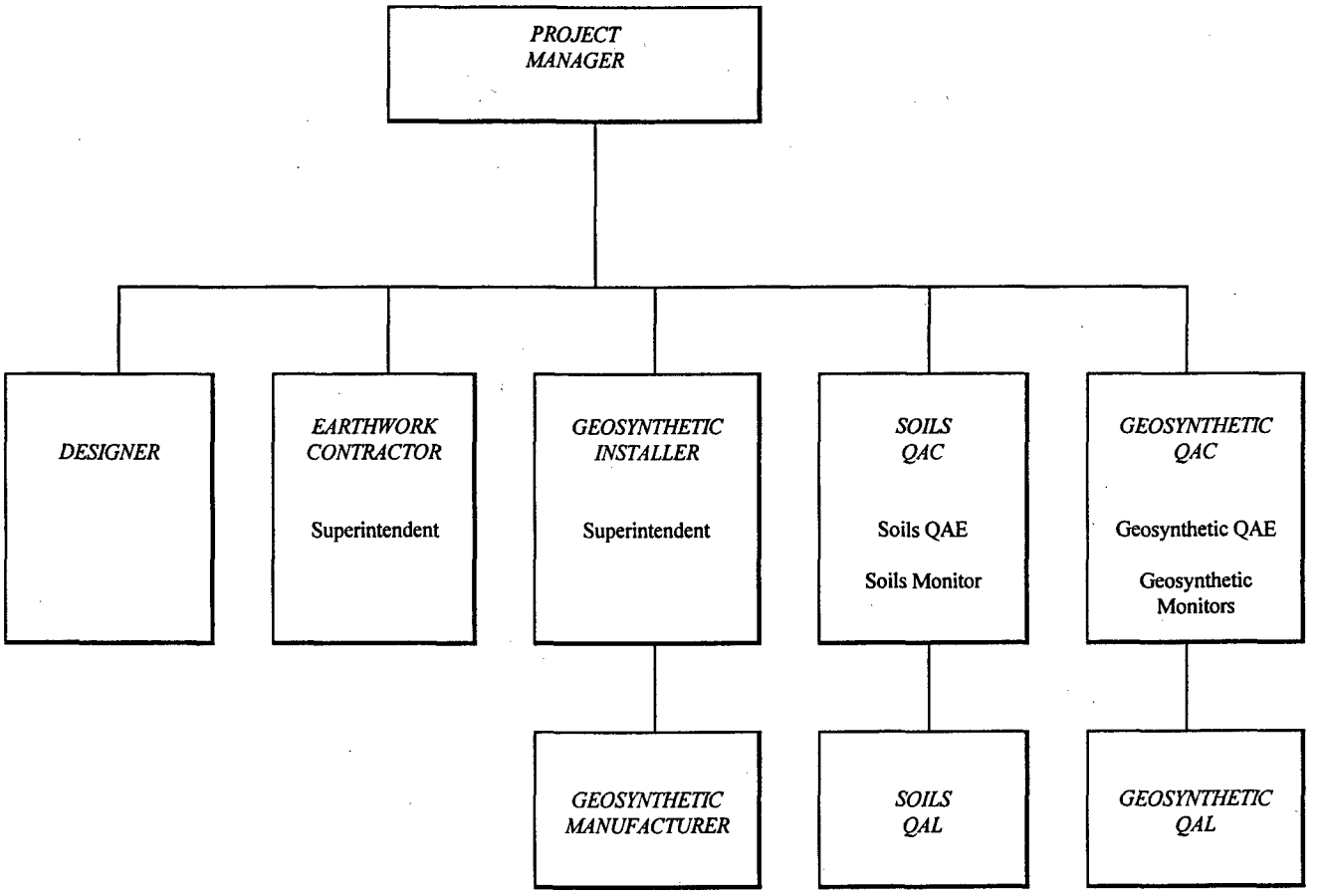
To help ensure a high degree of quality during installation and assure a final product that meets all project specifications, clear, open channels of communication are essential between all parties. This section discusses appropriate lines of communication and describes all meetings that will be necessary to achieve project goals.

1.3.1 Lines of Communication

The typical lines of communication necessary during a project are illustrated in Exhibit 1-1. The Soil QAE and Geosynthetic QAE shall be capable of direct communication with the Project Manager at all times.

Exhibit 1-1

LINES OF COMMUNICATION



1.3.2 Resolution Meeting

Following permit approval and the completion of the project plans and specifications, a resolution meeting may be held. If a Project Manager determines a resolution meeting is necessary, it shall be held prior to bidding the construction work and include all parties involved, typically including the Project Manager, Designer, Soil/Geosynthetic QAE and the Owner's technical representative. If appropriate, this meeting may be held in conjunction with the pre-bid meeting.

The purpose of the resolution meeting is to establish lines of communication, review project plans and specifications for completeness and clarity, begin planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and complete the QAP. The design shall be discussed during this meeting so that clarification and/or design changes may be made before the construction work is bid. In addition, the guidelines regarding quality assurance testing and problem resolution must be known and accepted by all.

A recommended agenda for the resolution meeting is presented in Exhibit 1-2. The meeting shall be documented by a person designated at the beginning of the meeting, and minutes shall be transmitted to all parties.

1.3.3 Pre-Construction Meeting

A pre-construction meeting shall be held at the site prior to beginning of lining system installation. Typically, the meeting shall be attended by the Project Manager, Designer, Earthwork Contractor, Geosynthetic Installer, Soil/Geosynthetic QAE, surveyor, and the Owner's technical representative.

Specific topics considered for this pre-construction meeting include review of the project QAP for any problems or additions. The responsibilities of each party should also be reviewed and understood clearly. A recommended agenda with specific topics for the pre-construction meeting is presented in Exhibit 1-3. The meeting shall be documented by a person designated at the beginning of the meeting, and minutes shall be transmitted to all parties.

1.3.4 Progress Meetings

A weekly progress meeting shall be held between the Soil/Geosynthetic QAE, Earthwork Contractor's/Installer's Superintendent, Project Manager and any other concerned parties. This meeting shall discuss current progress, planned activities for the next week, issues requiring resolution, and any new business or revisions to the work. The Soil/Geosynthetic QAE shall log any problems, decisions, or questions arising at this meeting in his weekly report. If any matter remains unresolved at the end of this meeting, the Project Manager shall be responsible for the resolution of the matter and the communication of the decision to the appropriate parties. The Project Manager may require daily progress meetings at his discretion.

Exhibit 1-2
RESOLUTION MEETING AGENDA
EXAMPLE

1. Introductions
   A. Assign Minute Taker
   B. Identify Parties
      1. Project Manager
      2. Designer
      3. Soil/Geosynthetic Quality Assurance Consultant
      4. Owner technical representative
      5. Others
2. Tour Project Site
3. Review Documents
   A. Project Plans
   B. Project Specifications
   C. Construction Quality Assurance Manuals
   D. Permit Documents
4. Complete Quality Assurance Plan
   A. Project-specific Addendum to Quality Assurance Manual(s)
   B. Project-specific Addendum to project specifications
5. Discuss Contract Administration and Construction Issues
6. Define Lines of Communication
7. Define Project Deliverables
8. Determine Schedule

Exhibit 1-3
PRE-CONSTRUCTION MEETING AGENDA
EXAMPLE

1. Introductions
   A. Assign Minute Taker
   B. Identify Parties
      1. Project Manager
      2. Designer
      3. Surveyor
      4. Earthwork Contractor
      5. Geosynthetic Installer
      6. Soil/Geosynthetic Quality Assurance Consultant
      7. Soil/Geosynthetic Quality Assurance Laboratory
      8. Owner technical representative
      9. Others
2. Tour Project Site
3. Review Documents
   A. Project Plans
   B. Project Specifications
   C. Geosynthetic Panel Layout
   D. Project Quality Assurance Plan
   E. Health and Safety Plan
4. Define Lines of Communication
   A. Lines of Communication
   B. Reporting Methods
   C. Distribution Methods
   D. Progress Meetings
   E. Procedures for Approving Design Clarifications and Changes During Installation
5. Review Site Requirements
   A. Safety Rules
   B. Site Rules
   C. Work Schedule
   D. Storage of Materials
   E. Available Facilities

F. Contractor Submittals

6. Discuss Construction Issues
   A. Scope of Work
   B. Review Design
      1. Construction Drawings
      2. Specifications
      3. Geosynthetic Panel Layout
   C. Construction Procedures
      1. Proposed Construction Sequencing
      2. Location of Soil Stockpile Areas
      3. Location of Geosynthetic Storage Area
      4. Equipment
      5. Construction Water Management
   D. Construction Schedule
   E. Procedures for Preparing and Approving Change Orders
7. Complete Construction Quality Assurance Plan
   A. Soils
   B. Geosynthetics
   C. Structural Systems (e.g., risers, piping, etc.)
8. Establish Project Deliverables
   A. Responsibilities
      1. Designer
      2. Installer
      3. Earthwork Contractor
      4. Soil/Geosynthetic Quality Assurance Consultant
      5. Soil/Geosynthetic Quality Assurance Laboratory
      6. Project Manager
   B. Distribution of Deliverables
   C. Approval Procedures

2.0 DOCUMENTATION

An effective QAP depends largely on identification of those construction activities that require monitoring, and on assigning responsibilities for the monitoring of each activity. This is most effectively verified by the thorough documentation of quality assurance activities. The Soil/Geosynthetic QAC shall document that all requirements in the lining portions of the project QAP have been addressed and satisfied.

The Soil/Geosynthetic QAC shall provide the Project Manager with signed descriptive remarks, data sheets, and checklists to verify that required monitoring activities have been carried out. The Soil/Geosynthetic QAC shall also maintain at the job site a complete file of all documents which comprise the QAP, including plans and specifications, this QAGD, checklists, test procedures, daily logs, and other pertinent documents.

2.1 DAILY REPORTS

2.1.1 Soils Reports

Each Soil Quality Assurance Monitor shall complete a daily report and/or logs on prescribed forms outlining all monitoring activities for that day. The report at a minimum shall consist of field notes, observations, test data sheets, construction problems and solution data sheets. A summary of all supporting data sheets along with final testing results and Soils QAE's approval of the work shall be required upon completion of construction.

The Project Manager shall immediately be made aware of any nonconformance with the project specifications. In particular, the Project Manager shall be informed before the work in question is covered by overlying system layers. The Project Manager shall then determine its cause and recommend direct appropriate changes or recommend the appropriate changes. When this type of evaluation is made, the results shall be documented, and any revision to procedures or project specifications shall be approved in writing by the Owner and Designer.

2.1.2 Geosynthetic Reports

Each Geosynthetic Quality Assurance Monitor shall complete a daily report and/or logs on prescribed forms outlining all monitoring activities for that day. The precise areas worked on, panel numbers, seams completed and approved, measures taken to protect unfinished areas overnight and other appropriate data and information shall be identified. Failed seams, other panel areas, or other geosynthetics requiring remedial action shall be identified with regard to nature of action, required repair, and precise location. Repairs completed must also be identified. Any problems or concerns with regard to operations on site should be noted. The report should also include information regarding the weather conditions. This report must be completed at the end of each monitor's shift, prior to leaving the site, and submitted to the Geosynthetic QAC.

The Geosynthetic QAE shall review the daily reports submitted by the Quality Assurance Monitors, and incorporate a summary of their reports into the QAE's daily report. Any matters requiring action by the Project Manager shall be identified. The report shall include a summary of the

quantities of all material installed that day. This report must be completed daily, summarizing the previous day's activities, and a copy submitted to the Project Manager at the beginning of the work day following the report date.

2.2 TEST REPORTS

2.2.1 Soils Testing Reports

Records of field and laboratory testing performed on the soil components of the liner shall be collated by the Soil QAC. A summary list of test results shall be prepared by the Soil QAC on an ongoing basis, and submitted with the weekly progress reports.

2.2.2 Geosynthetic Testing Reports

The destructive test reports from all sources shall be collated by the Geosynthetic QAC. This includes field tests, Installer's laboratory tests (if performed), and Geosynthetic QAL tests. A summary list of test samples pass/fail results shall be prepared by the Geosynthetic QAC on an ongoing basis, and submitted with the weekly progress reports. The report shall also contain resolution on failed tests clearly documenting complete quality assurance conformance with established procedures.

2.3 PROGRESS REPORTS

Progress reports shall be prepared by the Soil and Geosynthetic QAEs and submitted to the Project Manager. These reports shall be submitted every week, starting the first Friday of soil placement or geosynthetics deployment on site or other day as approved by the Project Manager. This report shall include an overview of progress to date and an outline of any deviation from the project plans or specifications. The report shall also include any problems or deficiencies in installation at the site, an outline of any action taken to remedy the situation, a summary of weather conditions and a brief description of activities anticipated for the next reporting period. All daily reports for the period should be appended to each progress report.

2.4 RECORD DRAWINGS

2.4.1 Soils Drawings

Record drawings shall be prepared by the Soil QAC or surveyor. The record drawings shall include, at a minimum, the following information for soil components:

1. Surveyed grade of the prepared subgrade.

2. Surveyed grade of the clay layer and other soil components.

3. Measured dimensions of any excavation within the subgrade and also within the soil layers.

4. Locations of all field tests and samples obtained for laboratory testing.

5. Locations of all repairs performed on soil components.

6. Locations of grade changes relative to site survey grid.

If necessary, for the purpose of clarity in the drawings, separate sheets shall be used to illustrate the locations of test sampling points. The drawings shall be shown in both plan and in cross section views as applicable. All surveying shall be performed by a licensed land surveyor or approved by the Project Manager.

2.4.2 Geosynthetic Drawings

Record drawings shall be prepared by the Geosynthetic QAC or surveyor. The record drawings shall include, at a minimum, the following information for geomembranes:

1. Dimensions of all geomembrane field panels.

2. Location, as accurately as possible, of each panel relative to the site survey grid furnished by the Project Manager.

3. Identification of all seams and panels with appropriate numbers or identification codes.

4. Location of all patches and repairs.

5. Location of all destructive testing samples.

The record drawings shall illustrate each layer of geomembrane, and if necessary, other drawings shall identify problems or unusual conditions of the geotextile or geonet layers. In addition, applicable cross sections shall show layouts of geonets, geotextiles or geogrids in sump areas or any other areas which are unusual or differ from the design drawings. All surveying for as-built information shall be performed by a licensed land surveyor or approved by the Project Manager.

2.5 FINAL QUALITY ASSURANCE REPORT

Upon completion of the work, the Soil/Geosynthetic QAC shall submit a final Quality Assurance Report to the Project Manager. This report shall summarize the activities of the project, and document all aspects of the quality assurance program performed.

The final Quality Assurance Report shall include, at a minimum, the following information:

1. Parties and personnel involved with the project.

2. Scope of work.

3. Outline of project.

4. Quality assurance methods.

5. Test results (conformance, destructive and non-destructive, including laboratory tests).

6. Signature page, sealed and signed by a licensed Professional Engineer or licensed Surveyor.

7. Record drawings, sealed and signed by a licensed Professional Engineer.

The Soils/Geosynthetic QAC shall state in the report that the installation has proceeded in accordance with the project QAP except as noted to the Project Manager. A recommended outline for the final Quality Assurance Report is given in Exhibit 2-1. The items shown in Exhibit 2-1 shall be considered the minimum content. The Soils/Geosynthetic QAC may expand the content as required.

Exhibit 2-1
FINAL CONSTRUCTION QUALITY ASSURANCE REPORT
(CERTIFICATION REPORT)
GENERAL OUTLINE

1. Cover Sheet stamped by P.E. as required.
2. Introduction
   A. Purpose
   B. Scope
   C. Unit Description
   D. Project Parties
3. Project QAP
   A. Scope
   B. Design Changes
   C. Project-Specific Addenda
   D. Permit Conditions
   E. Regulations
4. Work Performed
   A. Weather Constraints
   B. Pre-construction Testing
   C. Conformance Testing (as required)
   D. Visual Monitoring
   E. Photo Documentation
   F. Construction Testing
   G. Repairs
5. Summary and Conclusions
6. Project Certification
7. Appendices
   A. Geosynthetic and/or Soils QAC Personnel
   B. Contractor Personnel
   C. Quality Assurance Plan (QAP) with Project-Specific Addenda
   D. Design Change Forms
   E. Earthwork Testing Records (if required)

Exhibit 2-1 (Continued)
FINAL CONSTRUCTION QUALITY ASSURANCE REPORT
GENERAL OUTLINE

F. Conformance Testing Records (as required)
G. Manufacturer Quality Control Records
H. Quality Assurance Reports
I. Subgrade Acceptance Certificates
J. Panel Placement and Seaming Records
K. Trial Weld Records
L. Non-Destructive Seam Testing Records
M. Destructive Seam Testing Records
N. Repairs
O. Record Drawings stamped by licensed surveyor or P.E. as required.

3.0 LINING SYSTEM ACCEPTANCE

3.1 SOIL COMPONENTS ACCEPTANCE

Upon written recommendation by the Soil QAC, the Project Manager shall consider accepting the soil components of the lining system. The Earthwork Contractor will retain all ownership and responsibility for the soil lining components until acceptance by the Project Manager. At the Project Manager's discretion, the lining system may be accepted in sections or at points of substantial completion.

The soil components of the lining system will be accepted by the Project Manager when:

1. The installation of the soil components is finished.

2. Verification of the adequacy of the constructed components, including repairs, if any, is completed in accordance with the project-specific QAP.

3. All documentation of installation is completed.

4. The Soil QAC is able to recommend acceptance.

The Soil QAC shall certify that installation of the soil components has proceeded in accordance with the soil portions of the project-specific QAP except as noted to the Project Manager. This certification shall be provided in the final Quality Assurance Report as outlined in Section 2.5.

3.2 GEOSYNTHETIC COMPONENTS ACCEPTANCE

Upon written recommendation by the Geosynthetic QAC, the Project Manager shall consider accepting the geosynthetic components of the lining system. The Installer will retain all ownership and responsibility for the geosynthetics in the lining system until acceptance by the Project Manager. At the Project Manager's discretion, the lining system may be accepted in sections or at points of substantial completion.

The geosynthetic components of the lining system will be accepted by the Project Manager when:

1. The installation of the geosynthetic components is finished.

2. Verification of the adequacy of all seams including associated testing and repairs, if any, is completed in accordance with the project-specific QAP.

3. All documentation of installation is completed.

4. The Geosynthetic QAC is able to recommend acceptance.

The Geosynthetic QAC shall certify that installation has proceeded in accordance with the geosynthetic portions of the project-specific QAP except as noted to the Project Manager. This certification shall be provided in the final Quality Assurance Report as outlined in Section 2.5.

4.0 SOIL LINER MATERIAL

4.1 DESCRIPTION AND APPLICABILITY

Soil liner material generally consists of native cohesive soils with low hydraulic conductivity used as a barrier element in lining systems. Soils used in soil liners shall consist of clean, select material free of debris, excessive coarse particles or other deleterious matter. Soils with a visibly identifiable organic content, or soils classified according to the Unified Soil Classification System as organic silt or organic clay (OL, OH) shall not be used. This Section does not address quality assurance procedures for bentonite admixtures or geosynthetic clay liners (GCL).

4.2 QUALITY CONTROL DOCUMENTATION

Prior to the construction of a soil liner, soil evaluation tests shall be performed to confirm the adequacy of soil liner materials procured from each on-site or off-site source area. All tests shall be performed in a geotechnical laboratory or in the field as required, which may be the Soil QAL or another laboratory approved by the Project Manager. The Earthwork Contractor shall submit the results of source evaluation tests to the Project Manager. Previous testing and evaluations of the soil sources may also be used to evaluate the soil material. The material shall be accepted or rejected by the Project Manager according to these results.

At a minimum, the following tests shall be conducted:

1. Moisture content (ASTM D2216)

2. Particle size (ASTM D1140, D422)

3. Atterberg limits (ASTM D4318)

4. Laboratory compaction (ASTM D1557 for Modified or ASTM D698 for Standard)

5. Laboratory hydraulic conductivity at a specified compaction (ASTM D5084)

Unless otherwise specified in the project specifications, these tests shall be performed at a frequency of one per 20,000 yd^3 (15,000 m^3) of liner soil, or upon visual observation of changes in the material type. Previous soil testing and evaluations may be used in determining testing frequencies.

If identification of additional soil liner material sources becomes necessary during construction, the same material qualification and testing procedures shall be applied to each new source. Additional testing may be required by the project specifications. Project specifications may modify testing frequencies if the soil liner material has been previously evaluated or used.

4.3 CONFORMANCE TESTING

Conformance testing of the soil liner materials shall be performed to ensure the consistency of the properties of the soil obtained from on or off-site borrow sources. These tests shall be performed on or off-site prior to placement, compaction and any necessary conditioning of the soil liner.

At a minimum, the following tests shall be conducted:

1. Moisture content (ASTM D2216)

2. Particle size (ASTM D1140, D422)

3. Atterberg limits (ASTM D4318)

4. Laboratory compaction (ASTM D1557 for Modified or ASTM D698 for Standard)

5. Laboratory hydraulic conductivity at a specified compaction (ASTM D5084)

Unless otherwise specified in the project specifications, particle size tests shall be performed at a frequency of one per 1,000 yd^3 (750 m^3) of liner soil, or upon visually observable changes in the material type. The other tests shall be performed at a frequency of one per 5,000 yd^3 (3,500 m^3) of liner soil, or upon visually observable changes in the material type.

The Soil QAE shall examine all test results and report any nonconformance to the Project Manager. The Project Manager shall accept or reject the soil based on this review and the requirements of the project specifications prior to construction.

4.4 SUBGRADE PREPARATION

The Earthwork Contractor shall be responsible for preparing the subgrade soil for placement of overlying materials including all fill and recompacted separation layers and underdrains. Upon completion of the subgrade preparation work, the Soil QAC shall examine the subgrade and prepare a certificate of acceptance to be submitted to the Project Manager. In this certificate of acceptance, the Soil QAC shall verify, at a minimum, that:

1. The surveyor has verified all lines and grades.

2. A qualified engineer has verified that the subgrade soil meets the criteria in the project specifications.

At any time during construction of the soil liner, the Soil QAC shall indicate to the Project Manager any locations which are not adequate for placement of the soil liner. Such defects in the subgrade soil shall be repaired by the Earthwork Contractor, at the direction of the Project Manager, such that the properties of the repaired areas meet the project specifications.

4.5 CONSTRUCTION OBSERVATION

Observation of the soil liner construction shall be coordinated with construction testing. Acceptance criteria for construction work shall be as identified in the project specifications.
At a minimum, the Soil QAC shall observe and record the following during the construction of soil liners:

1. Moisture content and consistency of the soil during processing, placement, and compaction.

2. Type and level of compactive effort
   a. Roller type
   b. Roller weight
   c. Number of coverages (if required)

3. Action of compaction equipment on the soil surface (sheepsfoot penetration, pumping, cracking, etc.)

4. Maximum clod size (if required)

5. Loose and compacted lift thickness

6. Method of bonding lifts together

7. Dimensions of the compacted embankment

8. Stones which may damage overlying geosynthetic components

9. Areas where damage due to excess moisture, insufficient moisture, freezing, or excessive dessication may have occurred.

4.6 CONSTRUCTION TESTING

All construction quality assurance testing shall be conducted in accordance with the project specifications, or as directed by the Project Manager, and as documented in the site-specific addenda to this QAGD. All field and laboratory tests shall be conducted on samples taken from the soil liner materials during the course of the construction work. Testing and sampling procedures shall be observed and documented by the Soil QAC. Documentation and reporting of test results shall be in accordance with the requirements identified in this QAGD.

4.6.1 Field Testing

The Soil QAC shall perform the following field tests on each lift of the compacted soil:

1. Field moisture content (ASTM D2216 or D3017)

2. Field density (ASTM D2922, D1556, D2167, or D2937)

Unless otherwise specified in the project specifications, these tests shall be performed at a frequency of one per 10,000 ft^2 (1,000 m^2) area or less of each compacted lift. Sampling locations shall be selected by the Soil QAC.

Nuclear density tests (ASTM D2922) shall be preferred for density (dry unit weight) testing for most projects. The location of routine in-place density tests can be determined using a non-biased sampling plan based on random selection of testing locations. Questions concerning the accuracy of any single test shall be addressed by retesting in the same general location. Periodic checks using the Drive Cylinder Method (ASTM D2937), Sand-Cone Method (ASTM D1556), Rubber Balloon Method (ASTM D2167) or other standard techniques required in the project specifications may be performed to verify the nuclear density test results.

Unless otherwise noted in the project specifications, or as directed by the Project Manager, all perforations of the soil liner shall be backfilled. Perforations that must be backfilled shall include, but not limited to, the following:

Nuclear density test probe locations

Sand-cone test locations

Rubber balloon test locations

Hydraulic conductivity sampling locations

Drive cylinder test locations

All perforations shall be backfilled with bentonite, a mixture of bentonite and soil or compacted soil liner material as specified in the project specifications. Compaction shall be performed with a tamping rod, Modified or Standard Proctor hammer, or a hand tamper as specified in the project specifications. At a minimum, the Soil QAC shall perform observations and routine tests on the backfilled areas to ensure a proper seal.

Based on recommendations from the Soil QAC and at the discretion of the Project Manager, an increased frequency of testing may be required if one or more of the following conditions develop during construction:

1. Rollers slip during operation
2. Lift thickness is greater than specified
3. Soil is at improper and/or variable moisture content
4. Fewer than the specified number of roller coverages are made
5. Clogged rollers are used to compact the material
6. Soils fail to meet the project specifications

7. Soil liner materials differ substantially from those specified

8. Degree of compaction and remolding of the material is suspect

Additional testing may also be considered when:

1. Weather conditions are adverse

2. Rollers have not used optimum ballast

3. Equipment breaks down frequently

4. Grading is being started or finished

4.6.2 Laboratory Testing

Hydraulic conductivity tests (ASTM D5084) may be performed to confirm the soil in the compacted lining system meets the project specifications. Unless specified in the project specifications, hydraulic conductivity of the compacted soil shall be determined on undisturbed samples obtained from the constructed soil liner at the frequency of one test per lift per acre. Acceptability criteria shall be as identified in the project specifications.

Laboratory hydraulic conductivity samples shall be taken such that the sample tube is inserted into the liner perpendicular to the plane of the constructed surface. The tube shall be inserted into the lift being tested by applying a gradually increasing pressure.

4.7 DEFECTS AND REPAIRS

4.7.1 Identification

Acceptability criteria for testing shall be as identified in the project specifications. Recommended maximum percentage of failing material tests and maximum allowable variations may be specified in the project specifications. At locations where the testing indicates the requirements of the project specifications are not met, the Soil QAC shall determine the extent and the nature of the defect and recommend corrective actions to the Project Manager.

The Soil QAC shall confirm that no stones or roots are present which may damage overlying geosynthetic components. If the compacted soil liner has been subject to adverse weather conditions, the Soil QAC shall reexamine the soil for possible damage.

4.7.2 Notification

After determining the extent and nature of any defect, the Soil QAC shall promptly notify the Earthwork Contractor and the Project Manager. A work deficiency meeting shall be held as needed between the Earthwork Contractor, Soil QAC, Designer, Project Manager and other appropriate parties to assess the problem, review alternative solutions, and implement an action plan.

4.7.3 Repairs and Retesting

The Earthwork Contractor shall correct all deficiencies to meet the project specifications. If a project specification criteria cannot be met, or unusual weather conditions hinder work, the Soil QAC and Designer shall develop and present to the Project Manager suggested solutions for his approval.

The Soil QAC shall schedule appropriate retests when the work defect has been corrected. All retests by the Soil QAC shall verify that the defect has been corrected before any additional work is performed by the Earthwork Contractor in the area of the deficiency.

The Soil QAC shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

5.0 GRANULAR DRAINAGE MEDIA

5.1 DESCRIPTION AND APPLICABILITY

Granular drainage materials consist of highly permeable materials used in leachate collection, final cover drainage and gas venting systems. The materials may consist of clean sands and/or gravels or other permeable material generally classified according to the Unified Soil Classification System as SW, SP, GW or GP. Variation to these material classifications may be required by project specifications.

5.2 QUALITY CONTROL DOCUMENTATION

Prior to the construction of a granular drainage layer, source evaluation tests shall be performed to confirm the adequacy of the granular drainage materials procured from each on or off-site source area. All material evaluation tests are to be performed in a geotechnical laboratory, which may be the Soil QAL or another laboratory approved by the Project Manager. The Earthwork Contractor shall submit the results of source evaluation tests to the Project Manager. The material shall be accepted or rejected by the Project Manager according to these results.

At a minimum, the following tests shall be conducted:

1. Particle Size (ASTM D1140, D422, C136, or C117)

2. Laboratory Hydraulic Conductivity at a specified density (ASTM D2434)

Unless otherwise specified in the project specifications, one series of these tests shall be performed per source, or upon visually observable changes in the material type. If identification of additional drainage material sources becomes necessary during construction, the same material qualification and consistency checking procedures shall be applied to each such source.

For granular drainage materials used in the leachate collection systems, the amount of soluble carbonates shall be determined as required by the project specifications. For granular drainage materials used in leachate collection trenches and sumps, laboratory hydraulic conductivity tests may not be required. Additional testing may be specified by the project specifications.

5.3 CONFORMANCE TESTING

Conformance testing of the granular drainage materials shall be performed to ensure the consistency of the drainage layer material properties obtained from the borrow source.

At a minimum, the following tests shall be conducted:

1. Particle size (ASTM D1140, D422, C136, C117)

2. Laboratory hydraulic conductivity at a specified density (ASTM D2434)

Unless otherwise specified in the project specifications, particle size tests shall be performed at a frequency of one per 3,000 yd^3 (2,500 m^2) of drainage layer material, or upon visually observable changes in the material type. The laboratory hydraulic conductivity tests shall be performed upon visually observable changes in the material type or, as required in the project specifications.

The Soil QAE shall examine all test results and report any nonconformance to the Project Manager. The Project Manager shall accept or reject the material based on this review and the requirements of the project specifications prior to construction.

5.4 CONSTRUCTION OBSERVATION

The Soil QAC shall observe the procedures used by the Earthwork Contractor during placement of the drainage material to ensure that the materials meet the project specifications. The thickness of the drainage layer shall be verified by a licensed land surveyor following completion of the drainage layer placement. The Soil QAC shall prepare a certificate of acceptance for the drainage layer to be submitted to the Project Manager.

If placement on a geomembrane, the Soil QAC or Geosynthetic QAC, as determined by Project Manager, shall verify:

1. Placement of materials on the geomembrane shall not proceed at an ambient temperature below 32□F (0□C) nor above 104□F (40□C) unless otherwise approved.

2. Placement of materials on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.

3. Equipment used for placing materials shall not be driven directly on the geomembrane.

4. A minimum thickness of 1 ft (0.3 m) of materials is specified between a light dozer, ground pressure of 5 psi (35 kPa) or lighter, and the geomembrane. (or as required by project specification)

5. In any areas traversed by any vehicles other than low ground pressure vehicles approved by the Project Manager, the soil layer shall have a minimum thickness of 3 ft (0.9 m). This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Geosynthetic QAC to ensure that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

5.5 DEFECTS AND REPAIRS

5.5.1 Identification

If a defect is identified in the drainage layer, the Soil QAC shall determine the extent and the nature of the defect. If the defect is indicated by an unsatisfactory test result, the Soil QAC shall determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the Soil QAC deems appropriate.

5.5.2 Notification

After determining the extent and nature of the defect, the Soil QAC shall promptly notify the Earthwork Contractor and the Project Manager. A work deficiency meeting shall be held as required between the Earthwork Contractor, Soil QAC, Designer, Project Manager and other appropriate parties to assess the problem, review alternative solutions, and implement an action plan.

5.5.3 Repairs and Retesting

The Earthwork Contractor shall correct all deficiencies to meet the project specifications. If project specification criteria cannot be met, or unusual weather conditions hinder work, the Soil QAC and Designer shall develop and suggest solutions to the Project Manager for his approval.

The Soil QAC shall schedule appropriate retests when the work defect has been corrected. All retests by the Soil QAC shall verify that the defect has been corrected before any additional work is performed by the Earthwork Contractor in the area of the deficiency.

The Soil QAC shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

6.0 PROTECTIVE SOIL COVER

6.1 DESCRIPTION AND APPLICABILITY

Protective soil covers consist of soils used to protect the components of the lining systems. Other materials (tire chips, glass cullet, foundry sand, etc.) are suitable for this use if performance requirements are met. This material prevents direct contact between the lining system and the refuse or between the leachate collection system and the refuse. Particles of the protective soil cover shall not be of a size or shape which may damage an underlying geosynthetic component.

6.2 QUALITY CONTROL DOCUMENTATION

Prior to construction of the protective soil cover, source evaluation tests shall be performed to confirm the adequacy of protective soil cover materials procured from each on or off-site source area. The Soil QAC shall verify that the grain-size distribution of the protective layer material is as specified in the project specifications. All required testing shall be performed by the Soil QAL or another laboratory approved by the Project Manager. The Earthwork Contractor shall submit the results of source evaluation tests to the Project Manager. The material shall be accepted or rejected by the Project Manager according to these results.

The particle size distribution tests (ASTM D1140, D422, C136, C117) as appropriate shall be performed at a frequency of one per 20,000 yd^3 (15,000 m^3) or upon visual observation of changes in the protective layer soil. If identification of additional soil sources becomes necessary during construction, the same material qualification and testing procedures shall be applied to each new source.

If the project specifications require the use of cohesive protective layer materials, the Soil QAC shall obtain the moisture content of the material at the source as specified in the project specifications to evaluate its workability. Additional testing may be performed if required by the project specifications.

6.3 CONFORMANCE TESTING

Conformance testing of the protective soil cover shall be performed to ensure the consistency of the properties of the soil obtained. The Soil QAC shall conduct particle size tests at the frequency of one per 5,000 yd^3 (3,500 m^3) of protective layer soil before placement. If cohesive soil is used to construct the protective layer on the sideslopes, the Soil QAC shall obtain the moisture content of the protective layer soil at the time of placement at a frequency specified in the project specifications.

The Soil QAC shall examine all test results and report any nonconformance to the Project Manager. The Project Manager shall accept or reject the material based on this review and the requirements of the project specifications prior to construction.

6.4 CONSTRUCTION OBSERVATION

The Soil QAC shall verify the protective layer thickness by spot checks and direct measurements after placement. The Soil QAC shall also observe the placement of any geosynthetic placed in direct contact with the protective soil.

If placing on a geomembrane or geocomposite (i.e. texnet), the Soil QAC or Geosynthetic QAC as determined by Project Manager shall verify:

1. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 32□F (0□C) nor above 104□F (40□C) unless otherwise approved.

2. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.

3. Equipment used for placing soil shall not be driven directly on the geomembrane.

4. A minimum thickness of 1 ft (0.3 m) of soil is specified between a light dozer, ground pressure of 5 psi (35 kPa) or lighter, and the geomembrane. (or as required by project specification)

5. In any areas traversed by any vehicles other than low ground pressure vehicles approved by the Project Manager, the soil layer shall have a minimum thickness of 3 ft (0.9 m). This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Geosynthetic QAC to ensure that wrinkle formation is minimized and, in all cases, that the geomembrane is not folded over on itself. The minimum thickness shall be certified by the surveyor in accordance with the project specifications.

6.5 DEFECTS AND REPAIRS

6.5.1 Identification

If a defect is identified in the protective soil cover layer, the Soil QAC shall determine the extent and the nature of the defect. If the defect is indicated by an unsatisfactory test result, the Soil QAC shall determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the Soil QAC deems appropriate.

6.5.2 Notification

After determining the extent and nature of the defect, the Soil QAC shall promptly notify the Earthwork Contractor and the Project Manager. A work deficiency meeting shall be held as needed between the Earthwork Contractor, the Soil QAC, Designer, Project Manager and other appropriate parties to assess the problem, review alternative solutions, and implement an action plan.

6.5.3 Repairs and Retesting

The Earthwork Contractor shall correct all deficiencies to meet the project specifications. If a project specification criteria cannot be met, or unusual weather conditions hinder work, the Soil QAC and Designer shall develop and present to the Project Manager suggested solutions for his approval.

The Soil QAC shall schedule appropriate retests when the work defect has been corrected. All retests by the Soil QAC must verify that the defect has been corrected before any additional work is performed by the Earthwork Contractor in the area of the deficiency.

The Soil QAC shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

7.0 VEGETATIVE SOIL COVER

7.1 DESCRIPTION AND APPLICABILITY

Vegetative soil cover material generally consists of medium-textured soils capable of supporting vegetative growth. Establishment of vegetation reduces cover erosion due to water and wind, and protects the soil and/or geosynthetic cover against damage. The vegetation also enhances the aesthetic appearance of the landfill.

Site-specific criteria for the vegetative layer shall be specified in the project specifications. Alternative cover designs in certain climatic regions may not require a vegetative soil cover. In such cases, the site-specific project specifications are to be used instead of this Section as a guide for construction quality assurance purposes.

7.2 QUALITY CONTROL DOCUMENTATION

Prior to the construction of a vegetative layer, any required tests shall be conducted to verify that proposed sources meet the project specifications. Testing shall be performed by the Soil QAL or other laboratory approved by the Project Manager.

The Earthwork Contractor shall submit the results of these tests to the Project Manager. The Project Manager shall accept or reject the material based on these test results.

7.3 CONSTRUCTION OBSERVATION

The vegetative cover layer shall be compacted to the specified thickness. The firmness of the compacted vegetative cover varies with the type of vegetation specified for the cover, and should be indicated in the project specifications.

The Soil QAC shall:

1. Verify the actual thickness of the vegetative soil cover after compaction by direct measurements. The thickness of the soil layer shall not be less than the thickness required by the project specifications. Thickness measurements shall be taken at spaced points as required by project specifications. The vegetative soil cover layer final grades shall be verified by the surveyor as required.

2. Ensure that care is taken in the vicinity of riser pipe and other protrusions to prevent physical damage by the construction equipment.

3. Observe the quantity and the uniformity of any soil amendment incorporated within the tilled depth before seeding.

4. Ensure that the seeding application equipment is appropriate for the job. The rate of seed and mulch application, amount and uniformity of coverage, and watering instructions as provided in the project specifications shall be closely observed.

5. Examine the perimeter areas to ensure that no unseeded area remain.

The Soil QAC shall report any nonconformance to the Project Manager.

7.4 DEFECTS AND REPAIRS

7.4.1 Identification

If a defect is identified in the vegetative soil layer, the Soil QAC shall determine the extent and the nature of the defect. If the defect is indicated by an unsatisfactory test result, the Soil QAC shall determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the Soil QAC deems appropriate. If the vegetative layer has been subject to adverse weather conditions during construction, the Soil QAC shall reexamine the vegetative layer for possible damage in overly wet, desiccated or windblown areas.

7.4.2 Notification

After determining the extent and nature of the defect, the Soil QAC shall promptly notify the Earthwork Contractor and the Project Manager. If necessary, a work deficiency meeting may be held as needed between the Earthwork Contractor, Soil QAC, Designer, Project Manager and other necessary parties to assess the problem, review alternative solutions, and implement an action plan.

7.4.3 Repairs and Retesting

The Earthwork Contractor shall correct all deficiencies to meet the project specifications. If project specification criteria cannot be met, or unusual weather conditions hinder work, the Soil QAC and Designer shall develop and present to the Project Manager suggested solutions for his approval.

The Soil QAC shall schedule appropriate retests when the work defect has been corrected. All retests by the Soil QAC must verify that the defect has been corrected before additional work is performed by the Earthwork Contractor in the area of the deficiency.

The Soil QAC shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

8.0 GENERAL EARTHFILL

8.1 DESCRIPTION AND APPLICABILITY

General earthfill consists of random, granular or cohesive material taken from on-site, approved off-site excavations or stockpiles and used for non-critical applications. General earthfill material consists of a broad range of soils relatively free of organics, debris, or other deleterious matter which can be used for the purpose of earthfill construction. Specific tests to determine the suitability of earth materials for use in general earthfill shall be specified in the project specifications.

8.2 QUALITY CONTROL DOCUMENTATION

Prior to construction of the general earthfill, any required tests shall be performed to determine conformance with the project specifications. Testing shall be performed by the Soil QAL or other laboratory approved by the Project Manager.

If required, the general fill material shall be processed such that it does not contain particles exceeding the maximum size established in the project specifications. The Earthwork Contractor shall submit the results of these tests to the Project Manager. The Project Manager shall accept or reject the material based on these tests.

8.3 CONSTRUCTION OBSERVATION

The Soil QAC shall verify that the requirements of the project specifications are met. The Soil QAC shall report any nonconformance to the Project Manager.

8.4 DEFECTS AND REPAIRS

8.4.1 Identification

If a defect is identified in the finished general earthwork, the Soil QAC shall determine the extent and the nature of the defect. If the defect is indicated by an unsatisfactory test result, the Soil QAC shall determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the Soil QAC deems appropriate.

8.4.2 Notification

After determining the extent and nature of the defect, the Soil QAC shall promptly notify the Earthwork Contractor and the Project Manager. A work deficiency meeting shall be held as needed between the Earthwork Contractor, Soil QAC, Designer, Project Manager and other necessary parties to assess the problem, review alternative solutions, and implement an action plan.

8.4.3 Repairs and Retesting

The Earthwork Contractor shall correct all deficiencies to meet the project specifications. If a project specification criteria cannot be met, or unusual weather conditions hinder work, the Soil QAC shall develop and present to the Project Manager suggested solutions for his approval.

The Soil QAC shall schedule appropriate retests, if any required, when the work defect has been corrected. All retests by the Soil QAC must verify that the defect has been corrected before any additional work is performed by the Earthwork Contractor in the area of the deficiency.

The Soil QAC shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

9.0A BASE LINER GEOMEMBRANES

9.1A DESCRIPTION AND APPLICABILITY

Geomembranes are low permeability geosynthetic barriers used in lining systems. This Section is applicable to smooth and textured high density polyethylene (HDPE) geomembranes for base lining systems. The base lining system is defined as the liner on the bottom and inside sideslope surfaces of a landfill cell. This Section may need to be modified when using other geomembranes.

9.2A MANUFACTURING PLANT INSPECTION [OPTIONAL]

The Owner or other appropriate representative may conduct an annual inspection of the Manufacturer's plant. The Manufacturer will document annual inspections of manufacturing plants for products which they distribute. ISO 9000 certification may be accepted as a substitute. In addition, the Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the product for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection may include:

1. Verification that properties guaranteed by the Manufacturer are met and meet all the project specifications.

2. Verification that the measurement of properties by the Manufacturer is properly documented and test methods used are acceptable. (including calibrations)

3. Spot inspection of the rolls and verification that they are free of imperfections or any sign of contamination by foreign matter.

4. Review of handling, storage, and transportation procedures, and verification that these procedures will not damage the geomembrane.

5. Verification that roll packages have a label indicating the name of the manufacturer, type of geomembrane, thickness, roll number, and roll dimensions.

6. Verification that extrusion rods and/or beads are produced from the same base resin type as the geomembrane.

A report describing the inspection shall be retained by the Owner for annual inspections and by the Project Manager for project-specific inspections.

9.3A QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geomembrane, the Manufacturer or Installer shall provide the Project Manager with the following information:

1. Copies of dated quality control certificates issued by the resin supplier.

2. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.

3. Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. At a minimum, results shall be given for:
   a. Density (ASTM D1505)
   b. Carbon black content (ASTM D4218)
   c. Carbon black dispersion (ASTM D5596)
   d. Thickness (ASTM D5199-smooth/ASTM D5944-textured)
   e. Tensile properties (ASTM D638)

   These quality control tests shall be performed in accordance with the test methods for every 15,000 lbs. of resin.

4. Results of environmental stress crack resistance tests (ASTM D5397 - single point). At a minimum, tests shall be performed once every resin lot (180,000 lbs.).

The following shall be maintained by the Manufacturer and will be available upon request:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the resin used to manufacture the geomembrane.

2. Results of tests conducted by the Manufacturer to verify that the resin used to manufacture the geomembrane meets the project specifications.

3. A list of the materials which comprise the geomembrane, expressed in the following categories as percent by weight: polyethylene, carbon black, other additives.

The Manufacturer shall identify all rolls of geomembranes with the following:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Roll number
5. Roll dimensions

The Geosynthetic QAE shall review these documents and shall report any discrepancies with the above requirements to the Project Manager. The Geosynthetic QAE shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Rolls are appropriately labeled.

5. Certified minimum properties meet the project specifications.

6. Project specifications and a copy of the QAP are provided by the Project Manager to the Installer.

9.4A CONFORMANCE TESTING

In general, conformance testing is not required except under the following conditions:

1. A specific regulatory or permit condition requiring independent material conformance testing to be performed.

2. The Geosynthetic QAC is required by contract to provide a professional engineer's certification that the material meets certain specifications (as opposed to certifying that the material supplied is marked and identified as that which is specified for the project).

3. Conformance testing may be required by the Project Manager at any time.

9.4.1A Sampling Procedures

Upon delivery of the rolls of the geomembrane, the Geosynthetic QAC shall ensure that conformance test samples are obtained for the geomembrane. The geomembrane rolls to be sampled shall be selected by the Geosynthetic QAC. Samples shall be taken across the entire width of the roll judged by the Geosynthetic QAC not to be damaged. Unless otherwise specified by the Project Manager, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic QAC shall mark the machine direction on the samples with an arrow.

If the Project Manager desires, the Geosynthetic QAC can perform the conformance test sampling at the manufacturing plant. This may be advantageous in expediting the installation process for very large projects.

Unless otherwise specified in the project specifications, samples shall be taken at a rate of not less than one per 100,000 ft^2 (10,000 m^2) of geomembrane. These samples shall be forwarded to the Geosynthetic QAL for testing.

9.4.2A Conformance Tests

The following conformance tests shall be conducted:

1. Density (ASTM D1505)
2. Carbon black content (ASTM D4218)
3. Carbon black dispersion (ASTM D5596)
4. Thickness (ASTM D5199)
5. Tensile properties (ASTM D638)

Other conformance tests may be required by the project specifications.

9.4.3A Test Results

All conformance test results shall be reviewed and accepted or rejected by the Geosynthetic QAE prior to the deployment of the geomembrane. The Geosynthetic QAE shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The Geosynthetic QAE shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications.

If the Manufacturer has reason to believe that non-conforming tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic QALs. If both laboratories produce conforming results, the material shall be accepted. If both laboratories do not produce conforming results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with non-conforming test results is subject to the approval of the Project Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting the project specification. This procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line. To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

9.5A SUBGRADE PREPARATION

9.5.1A Surface Preparation

The Earthwork Contractor shall be responsible for preparing the underlying soil prior to geomembrane placement. The Project Manager shall coordinate the work of the Earthwork Contractor and the Installer so that the requirements of the project-specific QAP are met.

Before the geomembrane installation begins, the Geosynthetic QAC shall verify that:

1. A land surveyor qualified according to project requirements has verified all lines and grades.

2. A Professional Engineer qualified according to project requirements has verified that the underlying soil meets the criteria specified in the project specifications.

3. The underlying soil surface to be lined has been rolled, compacted, or hand-worked so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade.

4. The surface of the underlying soil does not contain stones which may be damaging to the geomembrane.

5. There is no area excessively softened by high water content.

6. There is no area where the underlying soil surface contains desiccation cracks which may damage the geomembrane.

The Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. A certificate of acceptance shall be given by the Installer to the Geosynthetic QAC prior to commencement of geomembrane deployment in the area under consideration. The Project Manager shall be given a copy of this certificate by the Geosynthetic QAC.

After the underlying soil has been accepted by the Installer, it is the Installer's responsibility to indicate to the Project Manager any change in the underlying soil condition that may require repair work. The Project Manager may consult with the Geosynthetic QAC regarding the need for repairs. If the Geosynthetic QAC concurs with the Installer, the Project Manager shall ensure that the underlying soil is repaired.

At any time before or during the geomembrane installation, the Geosynthetic QAC shall indicate to the Project Manager any locations which may not be adequately prepared for the geomembrane.

9.5.2A Anchor Trench

The Geosynthetic QAC shall verify:

1. The anchor trench has been constructed according to the project plans and specifications.

2. Rounded corners are provided in the trench so as to avoid sharp bends in the geomembrane.

3. Excessive amounts of loose soil are not allowed to underlie the geomembrane in the anchor trench.

4. The anchor trench is adequately drained to prevent ponding or softening of the adjacent soils while the trench is open.

5. The anchor trench is backfilled and compacted promptly after geomembrane deployment as outlined in the project specifications.

Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic components. The Geosynthetic QAC shall observe the backfilling operation and advise the Project Manager of any problems. Any problems shall be documented by the Geosynthetic QAC in his daily report.

9.6A GEOMEMBRANE DEPLOYMENT

9.6.1A Panel Nomenclature

A field panel is defined as a unit of geomembrane which is to be seamed in the field. A field panel is a roll or a portion of a roll cut in the field. The Geosynthetic QAC shall be responsible to ensure that each field panel is given an identification code (number or letter-number) consistent with the layout plan. This identification code shall be as simple and logical as possible and shall be agreed upon by the Project Manager, Installer and Geosynthetic QAC.

In general, it is not appropriate to identify panels using roll numbers since roll numbers established in the manufacturing plant are usually cumbersome and are not related to location in the field. The Geosynthetic QAC shall establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

9.6.2A Panel Deployment Procedure

The Geosynthetic QAC shall review the panel deployment progress of the Installer and advise the Project Manager on changes in panel deployment. The Geosynthetic QAC shall also review the panel deployment for suitability to actual field condition such as issues relating to wind, rain, soil liner desiccation and other site-specific conditions. The Geosynthetic QAC shall verify that the condition of the underlying soil does not change detrimentally during installation. The Geosynthetic QAC shall record the identification code, location, and date of installation of each field panel.

9.6.3A Deployment Weather Conditions

Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment.

The normal acceptable weather conditions for seaming are as follows:

1. Ambient temperature between 32°F (0°C) and 104°F (40°C).

2. Dry conditions (no precipitation or other excessive moisture)

3. No excessive winds.

Ambient temperature shall be measured and ambient conditions appraised by the Geosynthetic QAC in the area in which the panels are to be placed.

The Geosynthetic QAC shall inform the Project Manager of any weather-related problems which may not allow geomembrane placement to proceed. The Project Manager will determine if the installation is to be stopped or special procedures are to be used.

9.6.4A Method of Deployment

Before the geomembrane is handled on site, the Geosynthetic QAC shall verify that deployment equipment and method of deployment proposed by the Installer to be used on the site is adequate and does not pose risk of damage to the geomembrane or underlying subgrade. If vehicles are used which must operate on the geomembrane, drivers shall proceed with caution during deployment of the geomembrane to prevent spinning of tires, sharp turns and quick stops. During handling, the Geosynthetic QAC shall observe and verify that the Installer's personnel handle the geomembrane with care.

The Geosynthetic QAC shall verify the following:

1. Equipment used does not damage the geomembrane or underlying subgrade by handling.

2. The prepared surface underlying the geomembrane is acceptable immediately prior to geomembrane placement.

3. Geosynthetic elements immediately underlying the geomembrane are clean and free of debris.

4. Personnel do not smoke or wear damaging shoes while working on the geomembrane, or engage in other activities which could damage the geomembrane.

5. The method used to unroll the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting soil.

6. The method used to place the panels minimizes wrinkles especially differential wrinkles between adjacent panels.

7. Adequate temporary loading and/or anchoring (such as sand bags or tires), not likely to damage the geomembrane, are placed to prevent uplift by wind. In case of high winds,

continuous loading is recommended along edges of panels to minimize risk of wind flow under the panels.

8. Direct contact with the geomembrane is minimized, and the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where repeated traffic use may be expected. See Section 9.11 for geomembrane protection.

9. Liner has promptly been anchored in trench where applicable.

The Geosynthetic QAC shall inform the Project Manager if the above conditions are not fulfilled.

9.6.5A Damage and Defects

Upon delivery to the site, the Geosynthetic QAC shall conduct a surface observation of all rolls for defects and for damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected. The Geosynthetic QAC shall advise the Project Manager, in writing, of any rolls or portions of rolls which should be rejected and removed from the site because they have severe flaws, and/or minor repairable flaws.

The Geosynthetic QAC shall examine each panel, after placement and prior to seaming, for damage and/or defects. The Geosynthetic QAC shall advise the Project Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels, or portions of damaged panels, which have been rejected shall be marked and their removal from the work area recorded by the Geosynthetic QAC. Repairs shall be made using procedures described in Section 9.10.

9.6.6A Writing on the Liner

To avoid confusion, the Installer and the Geosynthetic QAC shall each use different colored markers or other materials approved by the Project Manager that are readily visible for writing on the geomembrane. The markers used must be semi-permanent and compatible with the geomembrane. The Installer shall use a white marker to write on the geomembrane while the Geosynthetic QAC shall use a yellow marker.

9.7A FIELD SEAMING

9.7.1A Seam Layout

Before installation begins, the Installer shall provide the Project Manager and the Geosynthetic QAC with a panel layout drawing. This drawing shall present all the proposed seams of the lining system at the facility. The Geosynthetic QAE shall review the panel layout drawing and verify that it is consistent with accepted state-of-practice.

In general, seams should be oriented parallel to the line of maximum slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe or crest of the slope, or from areas of potential stress concentrations, unless otherwise authorized by the Project Manager.

Horizontal seams shall be allowed under the following conditions:

1. Seams are offset in adjacent panels by one panel width.

2. Seams are "shingled" downhill.

A seam numbering system compatible with the panel numbering system shall be used by the Geosynthetic QAC.

9.7.2A Accepted Seaming Methods

Approved processes for field seaming are fusion welding and extrusion welding. Proposed alternate processes shall be documented and submitted by the Installer to the Project Manager for approval. The Project Manager shall submit all documentation regarding seaming methods to be used to the Geosynthetic QAC for review.

9.7.2.1A *Fusion Process*

The Geosynthetic QAC shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Project Manager.

The Geosynthetic QAC shall also verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus agreed upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane and any fuel spills promptly cleaned up. Fuel shall not be stored on liner surface.

4. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs to the geomembrane.

5. A movable protective layer is used as required by the Installer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between the sheets and to prevent debris from collecting around the pressure rollers.

6. In general, the geomembrane panels are aligned to have an overlap of 4 to 6 in (100 mm to 150 mm) for fusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

7. No solvent or adhesive is used.

8. The geomembrane is protected from damage in heavy traffic areas.

9.7.2.2A *Extrusion Process*

The Geosynthetic QAC shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Project Manager.

The Geosynthetic QAC shall verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus agreed upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. Prior to beginning a seam, the extruder is purged until all heat-degraded extrudate has been removed from the barrel.

4. Clean and dry welding rods or extrudate pellets are used.

5. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

6. Grinding is completed no more than one hour prior to seaming.

7. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs.

8. The geomembrane is protected from damage in heavy traffic areas.

9. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instance shall exposed grinding marks extend more than ¼ in (6 mm) from the finished seamed area.

10. In general, the geomembrane panels are aligned to have a nominal overlap of 3 in (75 mm) for extrusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

11. No solvent or adhesive is used.

12. The procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any temporary welding apparatus is controlled such that the geomembrane is not damaged.

9.7.3A Seam Preparation

The Geosynthetic QAC shall verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the Geosynthetic QAC must ensure that the process is completed according to the Manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane. The Geosynthetic QAC shall also verify that seams are aligned with the fewest number of wrinkles and "fishmouths".

9.7.4A Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours, for each production seaming apparatus used that day. Trial seams shall be made under the same conditions as production seams.

The trial seam sample shall be at least 5 ft (1.6 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as indicated in Section 9.7.2. Two specimens shall be cut from the sample with a 1 in (25 mm) wide die. The specimens shall be cut by the Installer at locations selected randomly along the trial seam sample by the Geosynthetic QAC.

The specimens shall be tested in peel using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. They should not fail in the seam as described in Section 9.9.5. If a specimen fails, the entire trial seam operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. The Geosynthetic QAC shall observe all trial seam procedures.

The remainder of the successful trial seam sample shall be retained until project completion in the QAC's archives for possible laboratory testing. Each sample shall be assigned a number and marked accordingly by the Geosynthetic QAC, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

If agreed upon between the Project Manager and the Geosynthetic QAE, and documented by the Geosynthetic QAE in his daily report, the remaining portion of the trial seam sample can be subjected to destructive testing as indicated in Section 9.9.6. If a trial seam sample fails a test conducted by the Geosynthetic QAL, then a destructive seam test sample shall be taken from each of the seams completed by the seamer during the shift related to the subject trial seam. These samples shall be forwarded to the Geosynthetic QAL and, if they fail the tests, the procedure indicated in Section 9.9.7 shall apply. The conditions of this paragraph shall be considered satisfied for a given seam if a destructive seam test sample has already been taken.

9.7.5A General Seaming Procedures

During general seaming, the Geosynthetic QAC shall ensure the following:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in (150 mm) beyond the cut in all directions.

2. If seaming operations are carried out at night, adequate illumination shall be provided.

3. Seaming shall extend to the outside edge of panels placed in the anchor trench.

4. All cross seam tees should be extrusion welded to a minimum distance of 4 in (100 mm) on each side of the tee.

5. A firm substrate may be required to be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

The Geosynthetic QAC shall verify that the above seaming procedures or any other procedures agreed upon and indicated in the project QAP are followed, and shall inform the Project Manager of any nonconformance.

9.7.6A Seaming Weather Conditions

9.7.6.1A *Cold Weather Conditions*

To ensure a quality installation, if seaming is conducted when the ambient temperature is below 32□F (0□C), the following conditions shall be met:

1. Geomembrane surface temperatures shall be determined by the Geosynthetic QAC at intervals of at least once per 100 feet (30 m) of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32□F (0□C).

2. For fusion welding, preheating may be waived by the Project Manager based on a recommendation from the Geosynthetic QAE, if the Installer demonstrates to the Geosynthetic QAE's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the Geosynthetic QAC shall observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.

4. Care shall be taken to confirm that wind chill does not adversely affect the pre-heat requirements specified for welding. It may be necessary to provide wind protection for the seam area.

5. All preheating devices shall be approved prior to use by the Project Manager.

6. Sheet grinding may be performed before preheating, if applicable.

7. Trial seaming, as described in Section 9.7.4, shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10□F from the initial trial seam test conditions. Such new seams shall be conducted upon completion of seams in progress during temperature drop.

9.7.6.2A *Warm Weather Conditions*

At ambient temperatures above 104□F, no seaming of the geomembrane shall be permitted unless the Installer can demonstrate to the satisfaction of the Project Manager that geomembrane seam quality is not compromised. Trial seaming, as described in Section 9.7.4, shall be conducted under the same ambient temperature conditions as the production seams. At the option of the Geosynthetic QAC, additional destructive tests may be required for any suspect areas.

9.8A NONDESTRUCTIVE SEAM TESTING

9.8.1A Concept

The Installer shall nondestructively test all field seams over their full length using an air pressure test (for double fusion seams only), a vacuum test or other approved method. Air pressure testing and vacuum testing are described in Sections 9.8.2 and 9.8.3 respectively. The purpose of nondestructive tests is to check the continuity of seams. It does not provide quantitative information on seam strength. Nondestructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

For all seams, the Geosynthetic QAC shall:

1. Observe nondestructive testing procedures.

2. Record location, data, test unit number, name of tester, and outcome of all testing.

3. Inform the Installer and Project Manager of any required repairs.

9.8.2A Air Pressure Testing

Air pressure testing is applicable to double fusion welding which produces a double seam with an enclosed space.

1. The equipment for air pressure testing shall consist of the following:
   a. An air pump (manual or motor driven), equipped with pressure gauge and capable of generating and sustaining a pressure between 25 and 30 psi (160 and 200 kPa) and mounted on a cushion to protect the geomembrane.
   b. A rubber hose with fittings and connections.
   c. A sharp hollow needle, or other pressure feed device, approved by Project Manager.

2. The following procedures shall be followed:
   a. Seal both ends of the seam to be tested.
   b. Insert needle or other approved pressure feed device into the air channel created by the fusion weld.
   c. Insert a protective cushion between the air pump and the geomembrane.
   d. Pressurize the air channel to a pressure of approximately 30 psi (200K Pa). Close valve, allow 2 minutes for pressure to stabilize, and sustain pressure for at least 5 minutes.
   e. If loss of pressure exceeds the maximum permissible pressure differential as outlined in the project specifications or does not stabilize, locate faulty area and repair in accordance with Section 9.10.3.
   f. Cut opposite end of tested seam area once testing is completed to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area. Seam the cut end of the air channel.
   g. Remove needle or other approved pressure feed device and seal the hole in the geomembrane.

9.8.3A Vacuum Testing

Vacuum testing is applicable to extrusion welding and to non-seam areas of the liner.

1. The equipment shall consist of the following:
   a. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a porthole or valve assembly, and a vacuum gauge.
   b. A pump assembly equipped with a pressure controller and pipe connections.
   c. A rubber pressure/vacuum hose with fittings and connections.
   d. A soapy solution. (Geosynthetic QAC shall ensure solution makes bubbles when air is passed through. Windshield washer fluid shall be used as anti-freeze in cold weather.)
   e. A bucket and wide paint brush, or other means of applying the soapy solution.

2. The following procedures shall be followed:
   a. Wet a strip of geomembrane approximately 12 in x 48 in (0.3 m x 1.2 m) with the soapy solution.
   b. Place the box over the wetted area.

c. Close the bleed valve and open the vacuum valve.
d. Ensure that a leak-tight seal is created.
e. Energize the vacuum/venturi pump and reduce the applied pressure to approximately 5 psi (10 in of Hg/35 kPa) gauge.
f. For a minimum of 10 seconds, apply vacuum with the box placed and maintaining a seal, examine the geomembrane through the viewing window for the presence of soap bubbles.
g. If no bubble appears after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in (75 mm) overlap, and repeat the process.
h. All areas where soap bubbles appear shall be marked and repaired in accordance with Section 9.10.3.

9.8.4A Test Failure Procedures

The Installer shall complete any required repairs in accordance with Section 9.10. For repairs, the Geosynthetic QAC shall:

1. Observe the repair and testing of the repair.

2. Mark on the geomembrane that the repair has been made.

3. Document the repair procedures and test results.

9.9A DESTRUCTIVE SEAM TESTING

9.9.1A Concept

The purpose of destructive tests is to evaluate seam strength. Destructive seam tests shall be performed at selected locations. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

9.9.2A Location and Frequency

The Geosynthetic QAC shall select where seam samples will be cut out for laboratory testing. The frequency and locations shall be established as follows:

1. A minimum frequency of one test location per 1000 ft (305 m) of production seam length performed by each welding machine. This frequency is to be determined as an average taken throughout the entire facility.

2. Test locations shall be determined during seaming at the Geosynthetic QAC's discretion. Special consideration shall be given to locations where the potential for imperfect welding, such as overheating, contamination, offset welds exists.

The Installer shall not be informed in advance of the locations where the seam samples will be taken.

9.9.3A Sampling Procedures

Samples shall be cut by the Installer at locations chosen by the Geosynthetic QAC as the seaming progresses so that laboratory test results are available before the geomembrane is covered by another material. The Geosynthetic QAC shall:

1. Observe sample cutting.

2. Assign a number to each sample, and mark it accordingly.

3. Record sample location on layout drawing.

4. Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be repaired in accordance with repair procedures described in Section 9.10.3 immediately following receipt of successful test results. The continuity of the new seams in the repaired area shall be tested according to Section 9.8.3.

9.9.4A Sample Dimensions

At each sampling location, two types of samples shall be taken by the Installer. First, two specimens for field testing should be taken. Each of these samples shall be cut with a 1 in (25 mm) wide die, with the seam centered parallel to the width. The distance between these two samples shall be 30 in (0.8 m). If both samples pass the field test described in Section 9.9.5, a sample for laboratory testing shall be taken.

The sample for laboratory testing shall be located between the samples for field testing. The sample for laboratory testing shall be 12 in (0.3 m) wide by 30 in (0.8 m) long with the seam centered lengthwise. The sample shall be cut into two parts and distributed as follows:

1. One 12 in wide x 18 in long (0.3 m x 0.5 m) portion for Geosynthetic QAL testing.

2. One 12 in wide x 12 in long (0.3 m x 0.3 m) portion to the QAC.

Final determination of the sample sizes shall be made at the pre-construction meeting.

9.9.5A Field Testing

The two 1 in (25 mm) wide specimens mentioned in Section 9.7.4 and Section 9.9.4 shall be tested in the field using a tensiometer for peel adhesion and shall not fail according to the criteria in the project specifications. The tensiometer shall be capable of maintaining a constant jaw separation rate of two inches per minute. If the test passes in accordance with this section, the sample qualifies for testing in the laboratory. If it is non-conforming, the seam should be repaired in accordance with Section 9.9.7. Final judgement regarding seam acceptability, based on the conformance criteria provided in the project specifications, rests with the Geosynthetic QAE.

The Geosynthetic QAC shall witness all field tests and mark all samples and portions with their number. The Geosynthetic QAC shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description, and attach a copy to each sample portion.

9.9.6A Laboratory Testing (on or off-site)

Destructive test samples shall be packaged and shipped, if necessary, under the responsibility of the Geosynthetic QAC in a manner which will not damage the test sample. The sample shall be shipped as soon as possible to expedite laboratory testing. The QAC will be responsible for storing the archive samples. Test samples shall be tested by the Geosynthetic QAL.

Testing shall include seam strength and peel adhesion (ASTM D4437). The minimum acceptable values to be obtained in these tests shall be provided in the project specifications. At least 4 specimens shall be tested successfully, each in both shear and peel. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear). A passing test shall meet the minimum acceptable values in at least 4 of the 5 specimens tested for each method.

The Geosynthetic QAL shall provide test results within 24 hours of receiving the samples. The Geosynthetic QAE shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

9.9.7A Destructive Test Failure

When a sample fails a destructive test, whether that test is conducted by the Geosynthetic QAL or by field tensiometer, the Installer has two options:

1. The Installer can repair the seam between any two passing destructive test locations.

2. The Installer can trace the welding path to an intermediate location 10 ft (3 m) minimum from the point of the failed test in each direction and take a sample with a 1 in (25 mm) wide die for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is repaired between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be repaired.

All acceptable repaired seams shall be bound by two locations from which samples passing laboratory destructive tests have been taken. Passing laboratory destructive tests of trial seam samples taken as indicated in Section 9.7.4 may be used as a boundary for the failing seam. In cases exceeding 150 ft (50 m) of repaired seam, a sample taken from the zone in which the seam has been repaired must pass destructive testing. Repairs shall be made in accordance with Section 9.10.

The Geosynthetic QAC shall document all actions taken in conjunction with destructive test failures.

9.10A DEFECTS AND REPAIRS

9.10.1A Identification

All seams and non-seam areas of the geomembrane shall be examined by the Geosynthetic QAC for identification of defects, holes, blisters, undispersed raw materials, large wrinkles and any sign of contamination by foreign matter. The geomembrane surface shall be cleaned by the Installer prior to examination if the Geosynthetic QAC determines that the amount of dust or mud inhibits examination.

9.10.2A Evaluation

Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in Section 9.8. Each location which fails the nondestructive testing shall be marked by the Geosynthetic QAC and repaired by the Installer. Work shall not proceed with any materials which will cover locations which have been repaired until successful nondestructive and/or laboratory tests are obtained.

When seaming of the geomembrane is completed, and prior to placing overlying materials, the Geosynthetic QAC shall indicate to the Project Manager any large wrinkles which should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation period, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. Wrinkles are considered to be large when the geomembrane can be folded over on to itself which is generally a wrinkle that extends 12 in (0.3 m) from the subgrade. Seams produced while repairing wrinkles shall be nondestructively tested.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Geosynthetic QAC to ensure that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

9.10.3A Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Project Manager, Installer, Designer, and Geosynthetic QAC.

1. The repair procedures available include:
   a. Patching, used to repair holes, tears, undispersed raw materials, and contamination by foreign matter.
   b. Spot welding used to repair pinholes, or other minor, localized flaws.
   c. Capping, used to repair large lengths of failed seams.
   d. Extrusion welding the flap, used to repair areas of inadequate fusion seams which have an exposed edge.
   e. Removing bad seam and replacing with a strip of new material welded into place.

2. For any repair method, the following provisions shall be satisfied:
   a. Surfaces of the geomembrane which are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair.
   b. All surfaces shall be clean and dry at the time of the repair.
   c. All seaming equipment used in repairing procedures shall meet the requirements of the project QAP.
   d. Patches or caps shall extend at least 6 in (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 in (75 mm).

9.10.4A Repair Verification

The Geosynthetic QAC shall observe all nondestructive testing of repairs and shall record the number of each repair, date and test outcome. Each repair shall be nondestructively tested using the methods described in Section 9.8 as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs more than 150 consecutive feet (50 m) long require destructive test sampling. Failed tests require that the repair shall be redone and retested until a passing test results.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Geosynthetic QAC to ensure that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

9.11A GEOMEMBRANE PROTECTION

The quality assurance procedures indicated in this Section are intended only to assure that the installation of adjacent materials does not damage the geomembrane. The quality assurance of the adjacent materials themselves are covered in separate Sections of this manual.

9.11.1A Soils

A copy of the project specifications prepared by the Designer for placement of soils shall be given to the Geosynthetic QAE by the Project Manager. The Geosynthetic QAE shall verify that these project specifications are consistent with geosynthetic state-of-practice such as:

1. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 32□F (0□C) nor above 104□F (40□C) unless otherwise specified.

2. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.

3. Equipment used for placing soil shall not be driven directly on the geomembrane.

4. A minimum thickness of 1 ft (0.3 m) of soil is specified between a light dozer, ground pressure of 5 psi (35 kPa) or lighter, and the geomembrane.

5. In any areas traversed by construction traffic (any vehicles other than deployment equipment approved by the Project Manager) the soil layer shall have a minimum thickness of 3 ft (0.9 m). This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

The Geosynthetic QAC shall measure soil thickness and verify that the required thickness is present. The Geosynthetic QAC must also verify that final thickness is consistent with the design and verify that placement of the soil is done in such a manner that geomembrane damage is unlikely. The Geosynthetic QAE shall inform the Project Manager if the above conditions are not fulfilled.

9.11.2A Sumps and Appurtenances

A copy of the plans and project specifications prepared by the Designer for sumps and appurtenances shall be given by the Project Manager to the Geosynthetic QAC. The Geosynthetic QAC shall review these plans and verify that:

1. Installation of the geomembrane in sump and appurtenant areas, and connection of geomembrane to sumps and appurtenances have been made according to project specifications.

2. Extreme care is taken while welding around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas.

3. The geomembrane has not been visibly damaged while making connections to sumps and appurtenances.

4. A representative of the Geosynthetic QAC shall be present at all times when the Installer is welding geomembrane to appurtenant structures.

The Geosynthetic QAC shall inform the Project Manager in writing if the above conditions are not fulfilled.

9.11.3A Concrete

A copy of the project specifications prepared by the Designer for placement of concrete shall be given by the Project Manager to the Geosynthetic QAC. The Geosynthetic QAC shall verify that these specifications are consistent with the state-of-practice, including the use of geosynthetic layers between concrete and geomembrane. The Geosynthetic QAC shall verify that geosynthetic layers are placed between the concrete and the geomembrane according to design specifications. The Geosynthetic QAC will also verify that construction methods used are not likely to damage the geomembrane.

9.0B FINAL COVER GEOMEMBRANES

9.1B DESCRIPTION AND APPLICABILITY

Geomembranes are low permeability geosynthetic barriers used in lining systems. This Section is applicable to smooth and textured polyethylene (all types) geomembranes used in final cover systems. This Section may need to be modified when using other geomembranes.

9.2B QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geomembrane, the Manufacturer or Installer shall provide the Project Manager with the following information:

1. A specification for the geomembrane which includes all properties contained in the project specifications measured using the appropriate test methods.

2. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.

3. Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. At a minimum, results shall be given for:
   a. Density (ASTM D1505)
   b. Carbon black content (ASTM D4218)
   c. Thickness (ASTM D5199-smooth/ASTM D5994-textured)
   d. Tensile properties (ASTM D638)
   e. Multi-Axial Tensile Elongation (ASTM D5617)

   These quality control tests shall be performed in accordance with the test methods for every 30,000 lbs except Multi-Axial Tensile Elongation which will be tested every 75,000 lbs.

The Manufacturer shall identify all rolls of geomembranes with the following:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Roll number
5. Roll dimensions

The Geosynthetic QAE shall review these documents and shall report any discrepancies with the above requirements to the Project Manager. The Geosynthetic QAE shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Rolls are appropriately labeled.

5. Certified minimum properties meet the project specifications.

6. Project specifications and a copy of the QAP are provided by the Project Manager to the Installer.

9.3B SUBGRADE PREPARATION

9.3.1B Surface Preparation

The Earthwork Contractor shall be responsible for preparing the underlying soil prior to geomembrane placement. The Project Manager shall coordinate the work of the Earthwork Contractor and the Installer so that the requirements of the project-specific QAP are met.

Before the geomembrane installation begins, the Geosynthetic QAC shall verify that the underlying surface has been prepared to meet the project requirements.

The Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. A certificate of acceptance shall be given by the Installer to the Geosynthetic QAC prior to commencement of geomembrane deployment in the area under consideration. The Project Manager shall be given a copy of this certificate by the Geosynthetic QAC.

After the underlying soil has been accepted by the Installer, it is the Installer's responsibility to indicate to the Project Manager any change in the underlying soil condition that may require repair work. The Project Manager may consult with the Geosynthetic QAC regarding the need for repairs. If the Geosynthetic QAC concurs with the Installer, the Project Manager shall ensure that the underlying soil is repaired.

At any time before or during the geomembrane installation, the Geosynthetic QAC shall indicate to the Project Manager any locations which may not be adequately prepared for the geomembrane.

9.3.2B Anchor Trench

The Geosynthetic QAC shall verify:

1. The anchor trench has been constructed according to the project plans and specifications.

2. Rounded corners are provided in the trench so as to avoid sharp bends in the geomembrane.

3. Excessive amounts of loose soil are not allowed to underlie the geomembrane in the anchor trench.

4. The anchor trench is adequately drained to prevent ponding or softening of the adjacent soils while the trench is open promptly after geomembrane deployment.

5. The anchor trench is backfilled and compacted promptly after deployment as outlined in the project specifications.

Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic components. The Geosynthetic QAC shall observe the backfilling operation and advise the Project Manager of any problems. Any problems shall be documented by the Geosynthetic QAC in his daily report.

9.4B GEOMEMBRANE DEPLOYMENT

9.4.1B Panel Nomenclature

A field panel is defined as a unit of geomembrane which is to be seamed in the field. A field panel is a roll or a portion of a roll cut in the field. The Geosynthetic QAC shall be responsible to ensure that each field panel is given an identification code (number or letter-number) consistent with the layout plan. This identification code shall be as simple and logical as possible and shall be agreed upon by the Project Manager, Installer and Geosynthetic QAC.

In general, it is not appropriate to identify panels using roll numbers since roll numbers established in the manufacturing plant are usually cumbersome and are not related to location in the field. The Geosynthetic QAC shall establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

9.4.2B Panel Deployment Procedure

The Geosynthetic QAC shall review the panel deployment progress of the Installer and advise the Project Manager on changes in panel deployment. The Geosynthetic QAC shall also review the panel deployment for suitability to actual field condition such as issues relating to wind, rain, soil liner desiccation and other site-specific conditions. The Geosynthetic QAC shall verify that the condition of the underlying soil does not change detrimentally during installation. The Geosynthetic QAC shall record the identification code, location, and date of installation of each field panel.

9.4.3B Deployment Weather Conditions

Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment.

The normal acceptable weather conditions for seaming are as follows:

1. Ambient temperature between 32°F (0°C) and 104°F (40°C).

2. Dry conditions (no precipitation or other excessive moisture)

3. No excessive winds.

Ambient temperature shall be measured and ambient conditions appraised by the Geosynthetic QAC in the area in which the panels are to be placed.

The Geosynthetic QAC shall inform the Project Manager of any weather-related problems which may not allow geomembrane placement to proceed. The Project Manager will determine if the installation is to be stopped or special procedures are to be used.

9.4.4B Method of Deployment

Before the geomembrane is handled on site, the Geosynthetic QAC shall verify that deployment equipment and method of deployment proposed by the Installer to be used on the site is adequate and does not pose risk of damage to the geomembrane or underlying subgrade. Drivers shall proceed with caution during deployment of the geomembrane to prevent spinning of tires, sharp turns and quick stops. During handling, the Geosynthetic QAC shall observe and verify that the Installer's personnel handle the geomembrane with care.

The Geosynthetic QAC shall verify the following:

1. Equipment used does not damage the geomembrane by handling.

2. The prepared surface underlying the geomembrane is acceptable immediately prior to geomembrane placement.

3. Geosynthetic elements immediately underlying the geomembrane are clean and free of debris.

4. Personnel do not smoke or wear damaging shoes while working on the geomembrane, or engage in other activities which could damage the geomembrane.

5. The method used to unroll the panels does not cause excessive scratches or crimps in the geomembrane and does not damage the supporting soil.

6. The method used to place the panels minimizes wrinkles especially differential wrinkles between adjacent panels.

7. Adequate temporary loading and/or anchoring (such as sand bags or tires), not likely to damage the geomembrane, are placed to prevent uplift by wind. In case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind flow under the panels.

8. Direct contact with the geomembrane is minimized, and the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected. See Section 8.0 for geomembrane protection.

The Geosynthetic QAC shall inform the Project Manager if the above conditions are not fulfilled.

9.4.5B Damage and Defects

Upon delivery to the site, the Geosynthetic QAC shall conduct a surface observation of all rolls for defects and for damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected. The Geosynthetic QAC shall advise the Project Manager, in writing, of any rolls or portions of rolls which should be rejected and removed from the site because they have severe flaws.

The Geosynthetic QAC shall examine each panel, after placement and prior to seaming, for damage and/or defects. The Geosynthetic QAC shall advise the Project Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels, or portions of damaged panels, which have been rejected shall be marked and their removal from the work area recorded by the geosynthetic QAC. Repairs shall be made using procedures described in Section 7.0.

9.4.6B Writing on the Geomembrane

To avoid confusion, the Installer and the Geosynthetic QAC shall each use different colored markers or other materials approved by the Project Manager that are readily visible for writing on the geomembrane. The markers used must be semi-permanent and compatible with the geomembrane.

9.5B FIELD SEAMING

9.5.1B Seam Layout

Before installation begins, the Installer shall provide the Project Manager and the Geosynthetic QAC with a panel layout drawing. This drawing shall present all the proposed seams of the lining system at the facility. The Geosynthetic QAE shall review the panel layout drawing and verify that it is consistent with accepted state-of-practice.

In general, seams should be oriented parallel to the line of maximum slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 5 ft (1.5 m) from the toe or crest of the slope, or from areas of potential stress concentrations, unless otherwise authorized by the Project Manager.

Horizontal seams shall be allowed under the following conditions:

1. Seams are offset in adjacent panels by one panel width.

2. Seams are "shingled" downhill.

A seam numbering system compatible with the panel numbering system shall be used by the Geosynthetic QAC.

9.5.2B Accepted Seaming Methods

Approved processes for field seaming are fusion welding and extrusion welding. Proposed alternate processes shall be documented and submitted by the Installer to the Project Manager for approval. The Project Manager shall submit all documentation regarding seaming methods to be used to the Geosynthetic QAC for review.

9.5.2.1B *Fusion Process*

The Geosynthetic QAC shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Project Manager.

The Geosynthetic QAC shall also verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus agreed upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane and any fuel spills promptly cleaned up. Fuel shall not be stored on liner surface.

4. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs to the geomembrane.

5. In general, the geomembrane panels are aligned to have an overlap of 4 to 6 in (100 mm to 150 mm) for fusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

6. The geomembrane is protected from damage in heavy traffic areas.

9.5.2.2B *Extrusion Process*

The Geosynthetic QAC shall log ambient, seaming apparatus, and geomembrane surface temperatures at appropriate intervals and report any noncompliances to the Project Manager.

The Geosynthetic QAC shall verify that:

1. The Installer maintains on-site the number of spare operable seaming apparatus agreed upon at the pre-construction meeting.

2. Equipment used for seaming is not likely to damage the geomembrane.

3. Prior to beginning a seam, the extruder is purged until all heat-degraded extrudate has been removed from the barrel.

4. Clean and dry welding rods or extrudate pellets are used.

5. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane and any fuel spills promptly cleaned up. Fuel shall not be stored on liner surface.

6. Grinding is completed prior to seaming.

7. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage such that no damage occurs.

8. The geomembrane is protected from damage in heavy traffic areas.

9. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instance shall exposed grinding marks extend more than ¼ in (6 mm) from the finished seamed area.

10. In general, the geomembrane panels are aligned to have a nominal overlap of 3 in (75 mm) for extrusion welding. In any event, the final overlap shall be sufficient to allow peel tests to be performed on the seam.

11. The procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any temporary welding apparatus is controlled such that the geomembrane is not damaged.

9.5.3B Seam Preparation

The Geosynthetic QAC shall verify that prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris or foreign material of any kind. If seam overlap grinding is required, the Geosynthetic QAC must ensure that the process is completed according to the Manufacturer's instructions seaming operation, and in a way that does not damage the geomembrane. The Geosynthetic QAC shall also verify that seams are aligned with the fewest number of wrinkles and "fishmouths".

9.5.4B Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours, for each production seaming apparatus used that day. Trial seams shall be made under the same conditions as production seams.

The trial seam sample shall be at least 5 ft (1.6 m) long by 1 ft (0.3 m) wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as indicated in Section 5.2. The specimens

shall be cut by the Installer at locations selected randomly along the trial seam sample by the Geosynthetic QAC.

The specimens shall be tested for peel adhesion and seam strength using a tensiometer. The minimum acceptable values to be obtained in these tests shall be provided in the project specifications. At least 4 specimens shall be tested, each in both shear and peel. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear). A passing test shall meet the minimum acceptable values in at least 4 of the 5 specimens tested for each method. If a specimen fails, the entire trial seam operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. The Geosynthetic QAC shall observe all trial seam procedures.

The remainder of the successful trial seam sample shall be retained by the QAC for possible additional testing. Each sample shall be assigned a number and marked accordingly by the Geosynthetic QAC, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

9.5.5B General Seaming Procedures

During general seaming, the Geosynthetic QAC shall ensure the following:

1. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in (150 mm) beyond the cut in all directions.

2. If seaming operations are carried out at night, adequate illumination shall be provided.

3. Seaming shall extend to the outside edge of panels placed in the anchor trench.

The Geosynthetic QAC shall verify that the above seaming procedures or any other procedures agreed upon and indicated in the project QAP are followed, and shall inform the Project Manager of any nonconformance.

9.5.6B Seaming Weather Conditions

9.5.6.1B *Cold Weather Conditions*

To ensure a quality installation, if seaming is conducted when the ambient temperature is below 32°F (0°C), the following condition shall be met:

Trial seaming, as described in Section 5.4, shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10°F from the initial trial seam test conditions. Such new seams shall be conducted upon completion of seams in progress during temperature drop.

9.5.6.2B *Warm Weather Conditions*

At ambient temperatures above 104°F, no seaming of the geomembrane shall be permitted unless the Installer can demonstrate to the satisfaction of the Project Manager that geomembrane seam quality is not compromised. Trial seaming, as described in Section 5.4, shall be conducted under the same ambient temperature conditions as the production seams.

9.6B NONDESTRUCTIVE SEAM TESTING

As described in Section 5.2, seams can be made using fusion or extrusion welding procedures. Fusion welding can be done by either a solid heated wedge which will produce a single seam or by a double wedge which will produce two parallel but narrower seams. Of the three testing procedures which follow, air lance and vacuum tests may be used for all seam types, while air pressure testing can only be used on double fusion welds.

One of, or in some cases, a combination of these three procedures shall be designated by the Owner and shall be applied in accordance with the following procedures:

9.6.1B Concept

The Installer shall nondestructively test all field seams over their full length using an air lance, air pressure test (for double fusion seams only), a vacuum test or other approved method. Air lance testing, air pressure testing and vacuum testing are described in following Sections 9.6.2, 6.3 and 6.4, respectively. The purpose of nondestructive tests is to check the continuity of seams. It does not provide quantitative information on seam strength. Nondestructive testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

For all seams, the Geosynthetic QAC shall:

1. Observe nondestructive testing procedures.

2. Record location, data, test unit number, name of tester, and outcome of all testing.

3. Inform the Installer and Project Manager of any required repairs.

9.6.2B Air Pressure Testing

Air pressure testing is applicable to double fusion welding which produces a double seam with an enclosed space.

1. The equipment for air pressure testing shall consist of the following:
   a. An air pump (manual or motor driven), equipped with pressure gauge and capable of generating and sustaining a pressure required by the project specifications and mounted on a cushion to protect the geomembrane.
   b. A rubber hose with fittings and connections.
   c. A sharp hollow needle, or other pressure feed device, approved by Project Manager.

2. The following procedures shall be followed:
   a. Seal both ends of the seam to be tested.
   b. Insert needle or other approved pressure feed device into the air channel created by the fusion weld.
   c. Insert a protective cushion between the air pump and the geomembrane.
   d. Pressurize the air channel, close valve, allow for pressure to stabilize, and sustain pressure according to project specifications.
   e. If loss of pressure exceeds the maximum permissible pressure differential as outlined in the project specifications or does not stabilize, locate faulty area and vacuum test in accordance with Section 6.4. If the vacuum test fails, repair in accordance with Section 7.3
   f. Cut opposite end of tested seam area once testing is completed to verify continuity of the air channel. If air does not escape, locate blockage and retest unpressurized area. Seam the cut end of the air channel.
   g. Remove needle or other approved pressure feed device and seal the hole in the geomembrane.

9.6.3B Vacuum Testing

Vacuum testing is applicable to any type of seam.

1. The equipment shall consist of the following:
   a. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a porthole or valve assembly, and a vacuum gauge.
   b. A pump assembly equipped with a pressure controller and pipe connections.

c. A rubber pressure/vacuum hose with fittings and connections.
d. A soapy solution. (Geosynthetic QAC shall ensure solution makes bubbles when air is passed through.)
e. A bucket and wide paint brush, or other means of applying the soapy solution.

2. The following procedures shall be followed:
   a. Wet a strip of geomembrane approximately 12 in x 48 in (0.3 m x 1.2 m) with the soapy solution.
   b. Place the box over the wetted area.
   c. Close the bleed valve and open the vacuum valve.
   d. Ensure that a leak-tight seal is created.
   e. Energize the vacuum/venturi pump and reduce the applied pressure to approximately 5 psi (10 in of Hg/35 kPa) gauge.
   f. For a minimum of 10 seconds, apply vacuum with the box placed and maintaining a seal, examine the geomembrane through the viewing window for the presence of soap bubbles.
   g. If no bubble appears after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in (75 mm) overlap, and repeat the process.
   h. All areas where soap bubbles appear shall be marked and repaired in accordance with Section 7.3.

9.6.4B Test Failure Procedures

The Installer shall complete any required repairs in accordance with Section 7.0. For repairs, the Geosynthetic QAC shall:

1. Observe the repair and testing of the repair.

2. Mark on the geomembrane that the repair has been made.

3. Document the repair procedures and test results.

9.7B DEFECTS AND REPAIRS

9.7.1B Identification

All seams and non-seam areas of the geomembrane shall be examined by the Geosynthetic QAC for identification of defects, holes, blisters, undispersed raw materials, large wrinkles and any sign of contamination by foreign matter. The geomembrane surface shall be cleaned by the Installer prior to examination if the Geosynthetic QAC determines that the amount of dust or mud inhibits examination.

9.7.2B Evaluation

Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in Section 9.6B. Each location which fails the nondestructive testing shall be marked by the Geosynthetic QAC and repaired by the Installer. Work shall not proceed with any materials which will cover locations which have been repaired until successful verification by, nondestructive tests are obtained.

When seaming of the geomembrane is completed, and prior to placing overlying materials, the Geosynthetic QAC shall indicate to the Project Manager any large wrinkles which should be cut and reseamed by the Installer. The number of wrinkles to be repaired should be kept to an absolute minimum. Therefore, wrinkles should be located during the coldest part of the installation period, while keeping in mind the forecasted weather to which the uncovered geomembrane may be exposed. Wrinkles are considered to be large when the geomembrane can be folded over on to itself which is generally a wrinkle that extends 12 in (0.3 m) from the subgrade. Seams produced while repairing wrinkles shall be nondestructively tested.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Geosynthetic QAC to ensure that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

9.7.3B Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Project Manager, Installer, Designer, and Geosynthetic QAC.

1. The repair procedures available include:
   a. Patching, used to repair holes, tears, undispersed raw materials, and contamination by foreign matter.
   b. Spot welding used to repair pinholes, or other minor, localized flaws.
   c. Capping, used to repair large lengths of failed seams.
   d. Extrusion welding the flap, used to repair areas of inadequate fusion seams which have an exposed edge.
   e. Removing bad seam and replacing with a strip of new material welded into place.

2. For any repair method, the following provisions shall be satisfied:
   a. Surfaces of the geomembrane which are to be repaired using extrusion methods shall be ground prior to the repair.
   b. All surfaces shall be clean and dry at the time of the repair.
   c. All seaming equipment used in repairing procedures shall meet the requirements of the project QAP.

d. Patches or caps shall extend at least 6 in (150 mm) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 in (75 mm).

9.7.4B Repair Verification

The Geosynthetic QAC shall observe all nondestructive testing of repairs and shall record the number of each repair, date and test outcome. Each repair shall be nondestructively tested using the methods described in Section 6.0 as appropriate. Repairs which pass the nondestructive test shall be taken as an indication of an adequate repair.

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. In addition, small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Geosynthetic QAC to ensure that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

9.8B GEOMEMBRANE PROTECTION

The quality assurance procedures indicated in this Section are intended only to assure that the installation of adjacent materials does not damage the geomembrane. The quality assurance of the adjacent materials themselves are covered in separate Sections of this manual.

9.8.1B Soils

A copy of the project specifications prepared by the Designer for placement of soils shall be given to the Geosynthetic QAE by the Project Manager. The Geosynthetic QAE shall verify that these project specifications are consistent with geosynthetic state-of-practice such as:

1. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 32□F (0□C) nor above 104□F (40□C) unless otherwise specified.

2. Placement of soil on the geomembrane should be done during the coolest part of the day to minimize the development of wrinkles in the geomembrane.

3. Equipment used for placing soil shall not be driven directly on the geomembrane.

4. A minimum thickness of 1 ft (0.3 m) of soil is specified between a light dozer, ground pressure of 5 psi (35 kPa) or lighter, and the geomembrane.

5. In any areas traversed by heavy construction equipment or any vehicles other than deployment equipment approved by the Project Manager, the soil layer shall have a minimum thickness of 3 ft (0.9 m). This requirement may be waived if provisions are made to protect the geomembrane through an engineered design. Drivers shall proceed with caution when on the overlying soil and prevent spinning of tires or sharp turns.

The Geosynthetic QAC or surveyor shall measure soil thickness and verify that the required thickness is present. The Geosynthetic QAC must also verify that final thickness is consistent with the design and verify that placement of the soil is done in such a manner that geomembrane damage is unlikely. The Geosynthetic QAE shall inform the Project Manager if the above conditions are not fulfilled.

9.8.2B Appurtenances

A copy of the plans and project specifications prepared by the Designer for appurtenances such as the pipe risers for gas or leachate collection systems shall be given by the Project Manager to the Geosynthetic QAC. The Geosynthetic QAC shall review these plans and verify that:

1. Installation of the geomembrane appurtenant areas, and connection of geomembrane to risers and appurtenances have been made according to project specifications.

2. Extreme care is taken while welding around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas.

3. The geomembrane has not been visibly damaged while making connections to appurtenances.

4. A representative of the Geosynthetic QAC shall be present at all times when the Installer is welding geomembrane to appurtenant structures.

The Geosynthetic QAC shall inform the Project Manager in writing if the above conditions are not fulfilled.

9.8.3B Concrete

A copy of the project specifications prepared by the Designer for placement of concrete shall be given by the Project Manager to the Geosynthetic QAC. The Geosynthetic QAC shall verify that these specifications are consistent with the state-of-practice, including the use of geosynthetic layers between concrete and geomembrane. The Geosynthetic QAC shall verify that geosynthetic layers are placed between the concrete and the geomembrane according to design specifications. The Geosynthetic QAC will also verify that construction methods used are not likely to damage the geomembrane.

10.0 GEOTEXTILES

10.1 DEFINITION AND APPLICABILITY

Geotextiles are used in protection and filtering applications in lining systems. This Section does not describe procedures for other applications such as erosion control or reinforcement. This Section is applicable to nonwoven geotextiles made of polyester or polypropylene and not applicable to nonwoven geotextiles made of other materials or woven geotextiles.

10.2 MANUFACTURING PLANT INSPECTION

The Owner or other appropriate representative may conduct an annual inspection of the Manufacturer's plant. Manufacturer will document annual inspections of manufacturing plants for products which they distribute. ISO 9000 certification may be accepted as a substitute. In addition, the Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the product for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

1. Verification that properties of the geotextile guaranteed by the Manufacturer are met and meet the project specifications.

2. Verification that the measurement of properties by the Manufacturer is properly documented and test methods used are acceptable.

3. Spot inspection of the rolls and verification that they are free of imperfections or any sign of contamination by foreign matter.

4. Review of packaging, handling, storage, and transportation procedures and verification that these procedures will not damage the geotextile.

5. Verification that roll packages have a label indicating the name of the manufacturer, type of geotextile, roll number and roll dimensions.

6. Verification that the geotextiles are inspected continuously for the presence of needles using a metal detector.

A report describing the inspection will be retained by the Owner for periodic inspections and by the Project Manager for project-specific inspections.

10.3 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geotextile, the Manufacturer or Installer shall provide the Project Manager with the following information:

1. Reports on quality control tests conducted by the Manufacturer to verify that the geotextile manufactured for the project meets the project specifications.

2. A specification for the geotextile which includes all properties published by the Manufacturer, measured using the appropriate test methods.

3. Written certification that the Manufacturer has continuously inspected the geotextile for the presence of needles and found the geotextile to be needle-free.

4. Written quality control certificates, signed by a responsible party employed by the Manufacturer and stating that the product will meet the minimum average roll values (MARV) given in the specification are guaranteed by the Manufacturer. The quality control certificates shall include roll identification numbers, testing procedures and results of quality control tests. At a minimum, results shall be given for:
   a. Mass per unit area (ASTM D5261)
   b. Grab strength (ASTM D4632)
   c. Trapezoidal tear strength (ASTM D4533)
   d. Puncture strength (ASTM D4833)

   These quality control tests shall be performed in accordance with the test methods for at least every 10,000 lbs of geotextile produced.

The following shall be maintained by the Manufacturer and will be available upon request:

1. The origin (resin supplier's name and resin production plant) and identification (brand name and number) of the resin used to manufacture the geotextile.

2. Reports on tests conducted by the Manufacturer to verify that resin used to manufacture the geotextile meets the Manufacturer's resin specifications.

3. A list of the materials which comprise the geotextile, expressed in the following categories as percent by weight: base polymer, carbon black, other additives.

The Manufacturer shall identify all rolls of geotextiles with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The Geosynthetic QAE shall review these documents and shall report any discrepancies with the above requirements to the Project Manager. The Geosynthetic QAE shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum average roll values meet the project specifications.

6. Project specifications and a copy of the QAP were submitted by the Project Manager to the Installer.

10.4 CONFORMANCE TESTING

In general, conformance testing is not required except under the following conditions:

1. A specific regulatory or permit condition requiring independent material conformance testing to be performed.

2. The Geosynthetic QAC is required by contract to provide a professional engineer's certification that the material meets certain specifications (as opposed to certifying that the material supplied is marked and identified as that which is specified for the project).

3. Conformance testing may be required by the Project Manager at any time.

If required, conformance tests should be tailored to the intended application of the geosynthetic (i.e. filtration, cushioning, or reinforcement)

10.4.1 Sampling Procedures

Upon delivery of the rolls of geotextiles, the Geosynthetic QAC shall ensure that conformance test samples are obtained for the geotextile. The rolls to be sampled shall be selected by the Geosynthetic QAC. Samples shall be taken from any portion of a roll which has not been damaged. Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic QAC shall mark the machine direction on the samples with an arrow. All lots of material and the particular test sample that represents each lot should be defined before the samples are taken.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic QAC based on a review of all roll information including quality control documentation and manufacturing records.

Unless otherwise specified in the project specifications, samples shall be taken at a rate of not less than one per 100,000 ft^2 (10,000 m^2) of geotextile. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance with the project specifications.

10.4.2 Conformance Tests

At a minimum, the following conformance tests shall be performed on geotextiles:

	cushion	*filter*	*reinforcement*
1. Mass per unit area (ASTM D5261)	√	√	√
2. Grab strength (ASTM D4632)			√
3. Trapezoidal tear strength (ASTM D4533)			√
4. Puncture strength (ASTM D4833)	√		
5. A.O.S. (ASTM D4751)		√	

Other conformance tests may be required by the project specifications.

10.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the Geosynthetic QAC prior to the deployment of the geotextile. The Geosynthetic QAC shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The Geosynthetic QAC shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Project Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting project specifications (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of-

specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

10.5 GEOTEXTILE DEPLOYMENT

During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, moisture, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions. Geotextile rolls shall be shipped and stored in relatively opaque and watertight wrappings. Wrappings shall not be removed until shortly before deployment.

The Geosynthetic QAC shall observe rolls upon delivery at the site. Any apparently damaged or improperly wrapped rolls shall be reported to the Project Manager.

The Installer shall ensure that geotextiles are not damaged during handling. The geotextile shall be deployed as described below:

1. On slopes, the geotextiles shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geotextile sheet in tension.

2. In the presence of wind, all geotextiles shall be weighted with sandbags or the equivalent. Such sand bags shall be installed during deployment and shall remain until replaced with cover material.

3. Geotextiles shall be cut using a geotextile cutter (hook blade) only. If in place, special care shall be taken to protect other materials from damage which could be caused by the cutting of the geotextiles.

4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.

5. During placement of geotextiles, care shall be taken not to entrap, in or beneath the geotextile, stones, excessive dust, or moisture that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

10.6 SEAMING PROCEDURES

Geotextiles shall be overlapped a minimum of 3 in (75 mm) prior to seaming. In general, no horizontal seams shall be allowed on sideslopes (seams along, not across, the slope) except as part of a patch. When horizontal seams are necessary, adjacent seams shall be offset in adjacent panels and shall be "shingled" downhill.

On slopes steeper than 10:1 (horizontal:vertical), all geotextiles shall be continuously sewn. Dry clean material may also be fusion heat bonded. Spot sewing is not allowed. On bottoms and slopes shallower than 10:1, geotextiles shall be continually sewn or thermally bonded with the written approval of the Project Manager.

Any sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile. The color of the sewing thread shall contrast the background color of the geotextile. Sewing shall be done using machinery and stitch types specified in the project specifications or as approved in writing by the Project Manager and the Geosynthetic QAE.

10.7 DEFECTS AND REPAIRS

10.7.1 Identification

If a defect is identified in the geotextile, the Geosynthetic QAC shall determine the extent and nature of the defect. If the defect is indicated by unsatisfactory test result, the Geosynthetic QAC shall determine the extent of the deficient area by additional tests, observations, a review of records and other means that the Geosynthetic QAC deems appropriate.

10.7.2 Notification

After determining the extent and nature of the defect, the Geosynthetic QAC shall promptly notify the Installer and Project Manager. A work deficiency meeting shall be held as required between the Installer, Geosynthetic QAC, Designer, Project Manager and any other necessary parties to assess the problem, review alternative solutions, and implement an action plan.

10.7.3 Repair Procedures

The final decision as to the appropriate repair shall be agreed upon between the Project Manager, Installer, Designer, and Geosynthetic QAE.

Any holes or tears in the geotextile shall be repaired using the following two procedures.

On sideslopes, a patch made from the same geotextile shall be thermally bonded or sewn into place in accordance with the project specifications.

On non-sideslope areas, a patch made from the same geotextile shall be thermally bonded or sewn into place with a minimum of 12-inch overlap in all directions. Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile.

The Geosynthetic QAC shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

10.8 GEOTEXTILE PROTECTION

All soil materials located on top of a geotextile shall be deployed in such a manner as to ensure:

1. The geotextile and underlying lining materials are not damaged.

2. Minimal slippage of the geotextile on underlying layers occurs.

3. No excess tensile stresses occur in the geotextile.

Any noncompliance with these guidelines or the project specifications shall be noted by the Geosynthetic QAC and reported to the Project Manager.

11.0 GEONETS

11.1 DEFINITION AND APPLICABILITY

Geonets are geosynthetic nets used as a drainage medium in lining systems. This Section is applicable to geonets made of high density polyethylene (HDPE) but is not applicable to geonets made of other polymers.

11.2 MANUFACTURING PLANT INSPECTION

The Owner or other appropriate representative may conduct an annual inspection of the Manufacturer's plant. Manufacturer shall document annual inspections of manufacturing plants for products which they distribute. ISO 9000 certification may be accepted as a substitute. In addition, the Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the product for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

1. Verification that properties guaranteed by the Manufacturer are met and meet all project specifications.

2. Verification that the measurement of properties by the Manufacturer is properly documented and test methods used are acceptable.

3. Spot inspection of the rolls and verification that they are free of imperfections or any sign of contamination by foreign matter.

4. Review of packaging, handling, storage, and transportation procedures and verification that these procedures will not damage the geonet.

5. Verification that roll packages have a label indicating the name of the manufacturer, type of geonet, roll number and roll dimensions.

A report describing the inspection will be retained by the Owner for periodic inspections and by the Project Manager for project-specific inspections.

11.3 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geonet, the Manufacturer or Installer shall provide the Project Manager with the following information:

1. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.

2. Quality control certificates, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, sampling procedures and results of quality control tests. At a minimum, results shall be given for:
   a. Density (ASTM D1505)
   b. Mass per unit area (ASTM D5261)
   c. Thickness (ASTM D5199)
   d. Carbon black content (ASTM D4218)
   e. Transmissivity (ASTM D4716)

   Quality control tests shall be performed in accordance with the test methods for every 10,000 lbs of geonet produced. Transmissivity tests shall be performed every 25,000 lbs of geonet produced.

The following shall be maintained by the Manufacturer and will be available upon request:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the resin.

2. Results of tests conducted by the Manufacturer to verify that the resin used to manufacture the geonet meets the project specifications.

3. A list of the materials which comprise the geonet, expressed in the following categories as percent by weight: polyethylene, carbon black, other additives.

The Manufacturer shall identify all rolls of geonets with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The Geosynthetic QAE shall review these documents and shall report any discrepancies with the above requirements to the Project Manager. The Geosynthetic QAE shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum properties meet the project specifications.

6. Project specifications and a copy of the QAP were submitted by Project Manager to the Installer.

11.4 CONFORMANCE TESTING

In general, conformance testing is not required except under the following conditions:

1. A specific regulatory or permit condition requiring independent material conformance testing to be performed.

2. The Geosynthetic QAC is required by contract to provide a professional engineer's certification that the material meets certain specifications (as opposed to certifying that the material supplied is marked and identified as that which is specified for the project).

3. Conformance testing may be required by the Project Manager at any time.

11.4.1 Sampling Procedures

Upon delivery of the rolls of geonet, the Geosynthetic QAC shall ensure that conformance test samples are obtained for the geonet. The rolls to be sampled shall be selected by the Geosynthetic QAC. Samples shall be taken from any portion of a roll which has not been damaged. Unless otherwise specified by the Project Manager, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic QAC shall mark the machine direction on the samples with an arrow.

Unless otherwise specified in the project specifications, samples shall be taken at a rate of not less than one per 100,000 ft^2 (10,000 m^2) of geonet. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance to the project specifications.

11.4.2 Conformance Tests

At a minimum, the following tests shall be performed:

1. Density (ASTM D1505)
2. Mass per unit area (ASTM D5261)
3. Thickness (ASTM D5199)

Other conformance tests may be required by the project specifications.

11.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the Geosynthetic QAE prior to the deployment of the geonet. The Geosynthetic QAE shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The Geosynthetic QAE shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Project Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out of specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

11.5 GEONET DEPLOYMENT

The Geosynthetic QAC shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Project Manager.

The geonet rolls should be protected against dust and dirt during shipment and storage since geonet cleanliness is essential to its performance. The Geosynthetic QAC shall verify that the geonet is free of dirt and dust prior to installation. The Geosynthetic QAC shall report any rolls judged dirty to the Project Manager. If the geonet is judged dirty, the Installer shall clean geonet prior to installation. Cleaning operations shall be observed by the Geosynthetic QAC and improper cleaning operations shall be reported to the Project Manager.

The Installer shall handle all geonet in such a manner as to ensure that it is not damaged in any way, and the following shall be complied with:

1. On slopes, the geonet shall be secured and rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet shall be positioned by hand after being unrolled to minimize wrinkles.

2. In the presence of wind, all geonet shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.

3. Unless otherwise specified, geonet shall not be welded to geomembrane.

4. Geonet shall only be cut using scissors or other cutting tools approved by the Project Manager that will not damage the underlying geosynthetics. Care shall be taken not to leave tools in the geonet.

5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geonet.

6. During placement of geonet, care shall be taken not to entrap dirt, excessive dust, or fugitive bentonite clay in the geonet that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geonet, it should be cleaned prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags, to prevent puncturing the sand bag.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

11.6 SEAMS AND OVERLAPS

At a minimum, the following requirements for joining the adjacent geonet shall be met:

1. Adjacent rolls shall be overlapped by at least 4 in (100 mm).

2. The geonet overlaps shall be tied with plastic fasteners. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.

3. Tying shall be every 5 ft (1.5 m) along the length at the adjacent rolls, every 6 in (0.15 m) in the anchor trench and every 6 in (0.15 m) along end-to-end seams.

4. In general, no horizontal seams shall be allowed on sideslopes, except as part of a patch. When horizontal seams are necessary, they shall be offset in adjacent panels and shall be "shingled" downhill.

5. When more than one layer of geonet is installed, joints shall be staggered.

6. When several layers of geonet are stacked, rolls shall be deployed in the same direction to minimize strands of one layer from penetrating the channels of the adjacent layer.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

11.7 DEFECTS AND REPAIRS

11.7.1 Identification

If a defect is identified in the geonet, the Geosynthetic QAC shall determine the extent and nature of the defect. If the defect is indicated by unsatisfactory test result, the Geosynthetic QAC shall determine the extent of the deficient area by additional tests, observations, a review of records and other means that the Geosynthetic QAC deems appropriate.

11.7.2 Notification

After determining the extent and nature of the defect, the Geosynthetic QAC shall promptly notify the Installer and Project Manager. A work deficiency meeting shall be held as required between the Installer, Geosynthetic QAC, Designer, Project Manager and any other necessary parties to assess the problem, review alternative solutions, and implement an action plan.

11.7.3 Repair Procedures

The final decision as to the appropriate repair shall be agreed upon between the Project Manager, Installer, Designer, and Geosynthetic QAE.

If the hole or tear width is less than 50% of the width of the roll, the damaged area shall be repaired as follows:

1. A patch shall be placed extending 1 ft (0.3 m) beyond the edges of the hole or tear.

2. The patch shall be secured to the original geonet by tying every 6 in (0.15 m). Tying devices shall be as indicated in Section 11.6.

If the hole or tear width across the roll is equal to or more than 50% of the width of the roll, the damaged area shall be cut out and the two portions of the geonet shall be joined as indicated in Section 11.6.

The Geosynthetic QAC shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

11.8 GEONET PROTECTION

Soil should never be placed in direct contact with geonet. Soil materials near the geonet shall be placed in such a manner as to ensure:

1. The geonet and underlying lining materials are not damaged.

2. Minimal slippage of the geonet on underlying layers occurs.

3. No excess tensile stresses occur in the geonet.

Any noncompliance with these guidelines or the project specifications shall be noted by the Geosynthetic QAC and reported in writing to the Project Manager.

12.0 GEOTEXTILE/GEONET COMPOSITE

12.1 DEFINITION AND APPLICABILITY

Geotextile/geonet composites are geocomposites used as a filter and drainage media in lining systems. This Section is applicable to drainage geocomposites made of polyester or polypropylene nonwoven geotextiles and high density polyethylene (HDPE) geonet. The geotextiles may be bonded to one side or both sides of the geonet. This Section is not applicable to geocomposites made with other material or components. The specific type of geocomposite shall be specified in the project specifications.

12.2 MANUFACTURING PLANT INSPECTION

The Owner or other appropriate representative may conduct an annual inspection of the Manufacturer's plant. Manufacturer shall document annual inspections of manufacturing plants for products which they distribute. ISO 9000 certification may be accepted as a substitute. In addition, the Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the product for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

1. Verification that the proper quality control documentation has been received by the Manufacturer from the component manufacturers.

2. Verification that properties guaranteed by the Manufacturer are met and meet all project specifications.

3. Verification that the measurement of properties by the Manufacturer is properly documented and test methods used are acceptable.

4. Spot inspection of the rolls and verification that they are free of imperfections or contamination by foreign matter.

5. Review of packaging, handling, storage, and transportation procedures and verification that these procedures will not damage the geocomposite.

6. Verification that roll packages have a label indicating the name of the manufacturer, type of geocomposite, roll number, and roll dimensions.

A report describing the inspection will be retained by the Owner for periodic inspections and by the Project Manager for project-specific inspections.

12.3 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geocomposite, the geocomposite Manufacturer or Installer shall provide the Project Manager with the following information:

1. The origin (supplier's name and production plant) and identification (brand name and number) of the geotextile and geonet used to fabricate the geocomposite.

2. Copies of dated quality control certificates issued by the geotextile and geonet supplier. These certificates shall contain the results of the quality control tests performed on the geocomposite components outlined in Section 10 and 11 of this QAGD.

3. A specification for the geocomposite which includes all properties published by the Manufacturer measured using the appropriate test methods.

4. Written certification that minimum values given in the specification are guaranteed by the Manufacturer.

5. Quality control certificates for the geocomposite, signed by a responsible party employed by the Manufacturer. The quality control certificates shall include roll identification numbers, testing procedures and results of quality control tests. At a minimum, results shall be given for:
   a. Mass per unit area (ASTM D5261)
   b. Thickness (ASTM D5199)
   c. Geotextile-geonet adhesion (ASTM D413)
   d. Transmissivity (ASTM 4716)

   Quality control tests shall be performed in accordance with the test methods for at least every 40,000 ft^2 (4,000 m^2) of geocomposite produced, except for transmissivity which shall be at a rate of one test per 120,000 ft^2 (11,200 m^2).

The Manufacturer shall identify all rolls of geocomposite with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The Geosynthetic QAE shall review these documents and shall report any discrepancies with the above requirements to the Project Manager. The Geosynthetic QAE shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Roll packages are appropriately labeled.

5. Certified minimum roll properties meet the project specifications.

6. Project specifications and the QAP were submitted by the Project Manager to the Installer.

12.4 CONFORMANCE TESTING

In general, conformance testing is not required except under the following conditions:

1. A specific regulatory or permit condition requiring independent material conformance testing to be performed.

2. The Geosynthetic QAC is required by contract to provide a professional engineer's certification that the material meets certain specifications (as opposed to certifying that the material supplied is marked and identified as that which is specified for the project).

3. Conformance testing may be required by the Project Manager at any time.

12.4.1 Sampling Procedures

Upon delivery of the rolls of geocomposite, the Geosynthetic QAC shall ensure that conformance test samples are obtained for the geocomposite.

The rolls to be sampled shall be selected by the Geosynthetic QAC. Samples shall not be taken from any portion of a roll which has been damaged. Unless otherwise specified, samples shall be 3 ft (1 m) long by the roll width. The Geosynthetic QAC shall mark the machine direction on the samples with an arrow. All lots of material and the particular test sample that represents each lot should be defined before the samples are taken.

A lot shall be defined as a group of consecutively numbered rolls from the same manufacturing line. Alternatively, a lot may be designated by the Geosynthetic QAC based on a review of all roll information including quality control documentation and manufacturing records.

Unless otherwise specified, samples shall be taken at a rate of one per lot, not to be less than one per 100,000 ft^2 (10,000 m^2) of geocomposite. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance with the project specifications.

12.4.2 Conformance Tests

At a minimum, the following conformance tests shall be performed on the geocomposite as a unit:

1. Mass per unit area (ASTM D5261)

2. Geotextile-geonet adhesion (ASTM D413)

Other conformance tests may be required by the project specifications.

12.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the Geosynthetic QAE prior to the deployment of the geocomposite. The Geosynthetic QAE shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The Geosynthetic QAE shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the Manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic QALs at the expense of the Manufacturer. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Project Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of-specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

12.5 GEOCOMPOSITE DEPLOYMENT

During shipment and storage, the geocomposite shall be protected from ultraviolet light exposure, moisture, mud, dirt, dust, puncture, cutting, or any other damaging conditions. Geocomposite rolls shall be shipped and stored in relatively opaque and watertight wrappings. The roll wrappings shall be removed shortly before deployment.

For one-sided geocomposite, the Geosynthetic QAC shall verify that the geonet is free of dirt and dust prior to installation. The Geosynthetic QAC shall identify any dirty rolls and report them to the Project Manager. If the geonet is judged to be dirty or dusty by the Geosynthetic QAE, it shall be cleaned by the Installer prior to installation. Washing operation shall be observed by the Geosynthetic QAC and improper washing operations shall be reported to the Project Manager.

The Geosynthetic QAC shall observe rolls upon delivery at the site and any deviation from the above requirements shall be reported to the Project Manager.

The Installer shall handle all geocomposite in such a manner as to ensure they are not damaged, and the following shall be complied with:

1. On slopes, the geocomposite shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

2. In the presence of wind, all geocomposites shall be weighted with sandbags or the equivalent. Sandbags shall be installed during deployment and shall remain until replaced with cover material.

3. Unless otherwise specified, single-sided geocomposite shall not be welded to the geomembrane.

4. Geocomposites shall be cut using a hook blade or other tool approved by the Project Manager. If in place, special care shall be taken to protect underlying geosynthetics from damage which could be caused by the cutting of the geocomposite. Care shall be taken not to leave the tools in the geocomposite.

5. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

6. During placement of geocomposite, care shall be taken not to entrap in or beneath the geocomposite, stones, or dirt that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming. If dirt or excess dust is entrapped in the geonet of single-sided geocomposite, it should be washed clean prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags, to prevent puncturing the sandbag.

7. A visual examination of the geotextile component of the geocomposite shall be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects are present.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

12.6 SEAMING PROCEDURES

In general, no horizontal seams shall be allowed on sideslopes thus seams shall be along, not across, the slope, except as part of a patch. If horizontal seams are required, offset adjacent horizontal seams.

Horizontal seams shall be allowed under the following conditions:

1. Seams are offset in adjacent panels by one panel width.

2. Seams are "shingled" downhill.

At a minimum, the following requirements shall be met:

1. Adjacent geocomposite shall be overlapped so that the geonet overlaps by at least 4 in (100 mm) and geotextile overlap by at least 3 in (75 mm).

2. If two sided geocomposite or the geotextile is on bottom, overlap geotextile.

3. The geonet overlaps shall be tied with plastic fasteners. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.

4. Tying shall be every 5 ft (1.5 m) along the slope, every 6 in (150 mm) in the anchor trench, and every 6 in (150 mm) along end-to-end seams on the base of the landfill.

5. In the corners of the sideslopes where overlaps between perpendicular strips are required, an extra layer shall be unrolled along the slope, on top of the previously installed geocomposite, from top to bottom of the slope.

6. When more than one layer of geocomposite is installed, joints shall be staggered.

7. Once geonet is tied, the top layer of geotextile of the geocomposite shall be seamed. On slopes steeper than 10:1 (horizontal:vertical), all geotextiles shall be continuously sewn. Spot sewing is not allowed. On bottoms and slopes shallower than 10:1, geotextiles shall be sewn (preferred), or thermally bonded with the written approval of the Project Manager. The Installer shall pay particular attention to seams to ensure that no earth cover material could be inadvertently inserted beneath the geotextile if applicable.

8. Any sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile. Sewing shall be done using machinery and stitch types specified in the project specifications or as approved in writing by the Project Manager and the Geosynthetic QAE.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

12.7 DEFECTS AND REPAIRS

12.7.1 Identification

If a defect is identified in the geotextile/geonet composite, the Geosynthetic QAC shall determine the extent and nature of the defect. If the defect is indicated by unsatisfactory test result, the Geosynthetic QAC shall determine the extent of the deficient area by additional tests, observations, a review of records and other means that the Geosynthetic QAC deems appropriate.

12.7.2 Notification

After determining the extent and nature of the defect, the Geosynthetic QAC shall promptly notify the Installer and Project Manager. A work deficiency meeting shall be held as required between the Installer, Geosynthetic QAC, Designer, Project Manager and any other necessary parties to assess the problem, review alternative solutions, and implement an action plan.

12.7.3 Repair Procedures

The final decision as to the appropriate repair shall be agreed upon between the Project Manager, Installer, Designer, and Geosynthetic QAE. Prior to acceptance of the geocomposite, the Installer shall locate and repair all damaged areas as directed by the Geosynthetic QAC. Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile. The Geosynthetic QAC shall observe any repair and report any noncompliance with the following requirements in writing to the Project Manager.

If in the Geosynthetic QAC's judgement, the defect is determined to be small, typically smaller than 3 by 3 feet (1 m by 1 m), the geocomposite shall be repaired as follows:

1. If the geonet is judged to be undamaged but the geotextile is damaged, a patch of geotextile shall be placed. The geotextile patch shall be thermally bonded in place with a minimum of 12 inch (0.3 m) overlap in all directions.

2. If the geonet is judged to be damaged, the damaged geonet shall be removed. A section of geonet shall be cut to replace the removed section. The geonet shall be tied to the existing geonet using white plastic fasteners placed at least every 6 inches (150 mm) on overlap. A geotextile patch shall be placed over the repaired geonet section. The geotextile patch shall be thermally bonded in place with a minimum of 12 inch (0.3 m) overlap in all directions.

If in the Geosynthetic QAC's judgement, the defect is determined to be large, typically larger than 3 by 3 feet (1 m by 1 m), the geocomposite shall be replaced.

The Geosynthetic QAC shall observe any repair and report any noncompliance with the above requirements in writing to the Project Manager.

12.8 GEOCOMPOSITE PROTECTION

For single-sided geocomposites, soils should never be placed in direct contact with geonet. All soil materials located on top of the geocomposite shall be deployed in such a manner as to ensure:

1. The geocomposite and underlying lining materials are not damaged.

2. Minimal slippage of the geocomposite on underlying layers occurs.

3. No excess tensile stresses occur in the geocomposite.

Any noncompliance with these guidelines or the project specifications shall be noted by the Geosynthetic QAC and reported to the Project Manager.

13.0 GEOSYNTHETIC CLAY LINERS

13.1 DEFINITIONS AND APPLICABILITY

Geosynthetic Clay Liners (GCLs) are geocomposite materials that consist of a uniform layer of low hydraulic conductivity, sodium bentonite clay which is encapsulated between two geotextile layers. GCLs are used as the clay component of barriers in lining systems.

13.2 MANUFACTURING PLANT INSPECTION

The Owner or other appropriate representative may conduct an annual inspection of the Manufacturer's plant. Manufacturer will document annual inspections of manufacturing plants for products which they distribute. ISO 9000 certification may be accepted as a substitute. In addition, the Project Manager, or his designated representative, may visit the manufacturing plant for a project-specific inspection if deemed necessary. If possible, the project-specific inspection shall be prior to or during the manufacturing of the product for that particular project. The purpose of the plant inspection is to review the manufacturing process and quality control procedures.

The manufacturing plant inspection shall include:

1. Verification that properties guaranteed by the Manufacturer are met and meet all project specifications.

2. Verification that the measurement of properties by the Manufacturer is properly documented and test methods used are acceptable.

3. Spot inspection of the rolls and verification that they are free of imperfections or contamination by foreign matter.

4. Review of handling, storage, and transportation procedures, and verification that these procedures will not damage the GCL.

5. Verification that rolls are labeled with the name of the manufacturer, roll number, and roll dimensions.

6. Verification that overlap lines are printed on the rolls.

A report describing the inspection shall be retained by the Owner for periodic inspections and by the Project Manager for project-specific inspections.

13.3 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any GCL, the Manufacturer or Installer shall provide the Project Manager with the following information:

1. Copies of dated quality control information issued by the bentonite supplier.

2. Results of quality control tests conducted by the GCL Manufacturer to verify that the bentonite supplied met the GCL Manufacturer's specifications. The following quality control tests shall be performed on the bentonite:
   a. Swell Index (ASTM D5890)
   b. Fluid loss (ASTM D5891)
   c. Moisture Content (ASTM D4643)

   Tests will be performed at a frequency of one per 100,000 lbs. of sodium bentonite clay.

3. Written certification that the minimum values given in the project specifications are guaranteed by the Manufacturer.

4. Quality control certificates, signed by a responsible party employed by the Manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. At a minimum, results for the GCL as a unit shall be given for:
   a. Moisture content (ASTM D4643)
   b. Index Flux (ASTM D5887)
   c. Mass per unit area (ASTM D5261)
   d. Peel strength (ASTM D4632) - modified as per Table 10, Note #4.
   e. Grab strength (ASTM D4632)

   Moisture content, mass per unit area, and peel adhesion quality control tests shall be performed in accordance with the test methods for at least every 40,000 ft^2 (4,000 m^2). Hydraulic conductivity and fluid loss tests shall be performed in accordance with the test methods for at least every 100,000 ft^2 (10,000 m^2) of GCL produced.

The following shall be maintained by the Manufacturer and be available upon request:

1. The origin (supplier's name and location of material source) and identification of the bentonite used for production of the GCL.

2. Copies of dated quality control information provided by the geotextile Manufacturer.

The Manufacturer shall identify all rolls of GCL with the following:

1. Manufacturer's name
2. Product identification
3. Roll number
4. Roll dimensions

The Geosynthetic QAE shall review these documents and shall report any discrepancies with the above requirements to the Project Manager. The Geosynthetic QAE shall verify that:

1. Property values certified by the Manufacturer meet all of its guaranteed specifications.

2. Measurements of properties by the Manufacturer are properly documented and that the test methods used are acceptable.

3. Quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

4. Rolls are appropriately labeled.

5. Project specifications and the QAP were submitted by Project Manager to the Installer.

13.4 CONFORMANCE TESTING

In general, conformance testing is not required except under the following conditions:

1. A specific regulatory or permit condition requiring independent material conformance testing to be performed.

2. The Geosynthetic QAC is required by contract to provide a professional engineer's certification that the material meets certain specifications (as opposed to certifying that the material supplied is marked and identified as that which is specified for the project)

3. Conformance testing may be required by the Project Manager at any time.

13.4.1 Sampling Procedures

Upon delivery of the rolls of GCL, the Geosynthetic QAC shall ensure that conformance test samples are obtained in accordance with industry accepted standards such as ASTM D6072. The rolls to be sampled shall be selected by the Geosynthetic QAC. Samples shall not be taken from any portion of a roll which has been damaged. Unless otherwise specified, samples shall be 2 ft (0.6 m) long by the roll width. The Geosynthetic QAC shall mark the machine direction on the samples with an arrow.

If the Project Manager desires, the Geosynthetic QAC can perform the conformance test sampling at the manufacturing plant. This may expedite the installation process for certain projects. Unless otherwise specified in the project specifications, samples shall be taken at a rate of one per 100,000 ft^2 (10,000 m^2) of GCL. Samples for index flux conformance tests shall be taken at least every 250,000 ft^2 (25,000 m^2). These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance to the project specifications.

13.4.2 Conformance Tests

At a minimum, the following conformance tests shall be conducted on the GCL as a unit:

1. Moisture content (ASTM D4643)

2. Index Flux (ASTM D5887) or Hydraulic Conductivity (ASTM D5084)

3. Mass per unit area (ASTM D5261)

Additional conformance tests may be required by the project specifications.

13.4.3 Test Results

All conformance test results shall be reviewed and accepted or rejected by the Geosynthetic QAE prior to the deployment of the GCL. The Geosynthetic QAE shall examine all results from laboratory conformance testing and shall report any nonconformance to the Project Manager. The Geosynthetic QAE shall be responsible for checking that all test results meet or exceed the property values listed in the project specifications.

If the Manufacturer has reason to believe that failing tests may be the result of the Geosynthetic QAL incorrectly conducting the tests, the Manufacturer may request that the sample in question be retested by the Geosynthetic QAL with a technical representative of the manufacturer present during the testing. Alternatively, the Manufacturer may have the sample retested at two different Owner-approved Geosynthetic QALs. If both laboratories produce passing results, the material shall be accepted. If both laboratories do not produce passing results, then the original Geosynthetic QAL's test results shall be accepted. The use of these procedures for dealing with failed test results is subject to the approval of the Project Manager.

If a test result is in nonconformance, all material from the lot represented by the failing test should be considered out-of-specification and rejected. Alternatively, at the option of the Project Manager, additional conformance test samples may be taken to "bracket" the portion of the lot not meeting specification (note that this procedure is valid only when all rolls in the lot are consecutively produced and numbered from one manufacturing line). To isolate the out-of- specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the roll that was sampled and failed. If both additional tests pass, the roll that represents the initial failed test and the roll manufactured immediately after that roll (next larger roll number) shall be rejected. If one or both of the additional tests fail, then the entire lot shall be rejected or the procedure repeated with two additional tests that bracket a greater number of rolls within the lot.

13.5 GCL DEPLOYMENT

During shipment and storage, the GCL shall be protected from ultraviolet light exposure, moisture, excessive humidity, puncture, cutting, or any other damaging conditions. GCL rolls shall be shipped and stored in relatively opaque and water resistant wrappings. GCL rolls shall be stored on a flat dry surface and covered with a tarp or under a roof. The roll wrappings shall only be removed shortly before deployment.

The Geosynthetic QAC shall observe rolls and track log numbers upon delivery and prior to deployment at the site and report any deviations from the above requirements to the Project Manager.

The Geosynthetic QAC shall review the GCL panel deployment progress and advise the Project Manager on its conformance with the actual field conditions. The Geosynthetic QAC shall verify that the Installer handles the GCL material in such a manner as to ensure that it is not damaged, and the following are complied with:

1. On slopes, the GCL rolls shall be deployed down the slope in such a manner as to keep slack out of the GCL panel.

2. The GCL should be installed with the proper side of the material facing upward. The proper orientation of the material should be as specified by the project specifications.

3. If the GCL is cut in place, special care shall be taken to protect underlying geosynthetic materials from damage which could be caused by cutting of the GCL.

4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the GCL.

5. During placement of the GCL, care shall be taken not to entrap beneath the GCL any stones, excessive dust or moisture that could damage the GCL or any underlying geosynthetics.

6. After installation, a visual examination of the GCL shall be carried out over the entire surface to ensure that no potentially harmful foreign objects, contaminated soil or damaged areas are present.

7. Excess loss of bentonite on edges during deployment should be minimized.

The Geosynthetic QAC shall verify that no more GCL material is deployed during one working day than can be covered by the end of that day. Exceptions to this requirement may be given by the Project Manager if dry weather is forecast for several consecutive days. GCL deployment shall not be undertaken during precipitation or when there is an immediate threat of precipitation.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

13.6 SEAMING PROCEDURES

13.6.1 Seam Overlap

Adjacent GCL panels shall be joined according to project plans and specifications. At a minimum, the Geosynthetic QAC shall verify the Installer complies with the following requirements:

1. Edge seam overlaps shall be a minimum of 6 in (150 mm).

2. Roll end seam overlaps shall be a minimum 12 in (.3 m).

3. The addition of bentonite to seam locations shall be in accordance with the project specifications.

4. End to end seams on slopes shall be minimized. If they are required, the Geosynthetic QAC shall contact Designer to verify the method used to attach the GCLs has adequate tensile strength.

Prior to approval of the GCL by the Geosynthetic QAC, the following requirements should be visually verified by the QAC:

1. The required overlaps are provided. For GCL materials with a moisture content ≥ 20%, the overlap shall be doubled and monitored to assure the appropriate overlap is maintained since the panels may be subjected to shrinkage.

2. The amount of the bentonite is placed on the seam required by the project specifications.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

13.7 DEFECTS AND REPAIRS

Any portion of the GCL exhibiting flaws shall be repaired. Prior to acceptance of the installed GCL, the Installer shall locate and repair all damaged areas of the liner as directed by the Geosynthetic QAC. Defects or damage can be identified by either rips, tears, premature hydration of the GCL or delamination of the geotextiles.

Rips or tears in the GCL shall be covered by another piece of material meeting the project specifications. The material shall extend over the entire damaged area with a minimum 24-inch overlap in all directions. Addition of bentonite to patches shall be in accordance with the project specifications.

The QAC shall be notified when the GCL has been exposed to excessive moisture and has significantly hydrated prior to placement of overlying material. Significant hydration is indicated by dissociation of the geotextiles from the bentonite core or significant bentonite displacement caused by light foot traffic. The hydrated material shall be covered with new dry GCL material,

removed and replaced with new dry GCL material, or used "as-is" at the discretion of the QAC. All defects and repairs shall be reported to the Project Manager.

13.8 GCL PROTECTION

All soil materials located on top of the GCL shall be deployed in such a manner as to ensure:

1. The GCL and underlying liner materials are not damaged.

2. Minimal slippage of the GCL on underlying layers occurs.

3. No excess tensile stress occur in the GCL.

Any noncompliance with these guidelines or the project specifications shall be noted by the Geosynthetic QAC and reported to the Project Manager.

APPENDIX

SPECIFICATIONS FOR HDPE GEOSYNTHETICS

GEOSYNTHETIC MATERIAL SPECIFICATIONS

TABLE 1 – HDPE SMOOTH GEOMEMBRANE

Property	Qualifier	Unit	Specified Value[1]	All Thicknesses	Test Method
Thickness	min. average	Mils	40 60 80 100		ASTM D5199
Thickness	min. reading	Mils	36 54 72 90		ASTM D5199
Density (geomembrane)	min.	g/cc	0.940		ASTM D1505
Melt Index (resin)	max.	g/10 min.	1.0		ASTM D1238
Tensile Properties: (each direction)					
1. Yield strength	min.	lb/in² width	84 126 168 210	2100 psi	ASTM D638[2]
2. Break strength	min.	lb/in	152 228 304 380	3800 psi	ASTM D638[2]
3. Elongation at yield	min.	%	12		ASTM D638[2]
4. Elongation at break	min.	%	700		ASTM D638[2]
Tear Strength	min.	Lb	28 42 56 70	700 lb/in	ASTM D1004
Puncture Resistance	min.	Lb	72 108 144 180	1800 lb/in	ASTM D4833
Low Temperature	max.	Deg. C	-60		ASTM D746
Carbon Black Content	range	%	2.0 to 3.0		ASTM D4218
Carbon Black Dispersion	rating	N/A	A-1, A-2, or B-1		ASTM D5596
Environmental Stress Crack	min.	Hours	200		ASTM D5397 (single point)

Note:
[1] Property values listed in this table correspond with the current version of GRI (Geosynthetic Research Institute) GM-13.
[2] Test Methods modified per Table 9.

GEOSYNTHETIC MATERIAL SPECIFICATIONS

TABLE 2 – HDPE TEXTURED GEOMEMBRANE

Property	Qualifier	Unit	Specified Value[1]	All Thicknesses	Test Method
Thickness [2]	min. average	Mils	40 60 80		ASTM D5994
Thickness (min. average) Lowest Individual Lowest Individual	min. reading	Mils	for 10 Values for 8 of 10 Values for 2 of 10 Values	nom. (-5%) -10% -15%	ASTM D5994
Density (geomembrane)[2]	min.	g/cc	0.940		ASTM D1505
Melt Index (resin)	max.	g/10 min.	1.0		ASTM D1238
Tensile Properties: (each direction)					
1. Yield strength	min.	lb/in² width	84 126 168	2100 psi	ASTM D638[3]
2. Break strength	min.	Lb/in	60 90 120	1500psi	ASTM D638[3]
3. Elongation at yield	min.	%	12		ASTM D638[3]
4. Elongation at break	min.	%	100		ASTM D638[3]
Tear Strength	min.	lb	28 42 56	700 lb/in	ASTM D1004
Puncture Resistance	min.	lb	60 90 120	1500 lb/in	ASTM D4833
Low Temperature	max.	Deg. C	-60		ASTM D746
Carbon Black Content[2]	range	%	2.0 to 3.0		ASTM D4218
Carbon Black Dispersion[2]	rating	N/A	A-1, A-2, or B-1		ASTM D5596
Environmental Stress Crack[2]	min.	Hours	200		ASTM D5397 (single point)

Note:
[1] Property values listed in this table correspond with the current version of GRI (Geosynthetic Research Institute) GM-13.
[2] Properties tested in weld zone.
[3] Test Methods Modified per Table 9.

GEOSYNTHETIC MATERIAL SPECIFICATIONS				
TABLE 3 – 35 MIL SMOOTH GEOMEMBRANE				
Property	**Qualifier**	**Unit**	**Specified Value**	**Test Method**
Thickness	min. average	Mils	35	ASTM D5199
Thickness	min. reading	Mils	33	ASTM D5199
Density (geomembrane)	min.	g/cc	0.92	ASTM D1505
Tensile Properties: (each direction)				
1. Stress at Break	min.	Psi	3800	ASTM D638[1]
2. Strain at Break (2" gage length)	min.	%	750	ASTM D638[1]
3. Strain at Break (2.5" gage length [NSF])	min.	%	600	ASTM D638[1]
Carbon Black Content	min.	%	2.0	ASTM D4218
Multi-Axial Elongation	min.	%	30	ASTM D5617
Note: [1]Test Methods Modified per Table 9.				

GEOSYNTHETIC MATERIAL SPECIFICATIONS

TABLE 4 - 35 MIL TEXTURED GEOMEMBRANE

Property	Qualifier	Unit	Specified Value	Test Method
Thickness[1]	min. average	mils	35	ASTM D5199
Thickness[1]	min. reading	mils	33	ASTM D5199
Density (geomembrane)[1]	min.	g/cc	0.92	ASTM D1505
Tensile Properties: (each direction)				
1. Stress at Break	min.	psi	2300	ASTM D638[2]
2. Strain at Break (2" gage length)	min.	%	300	ASTM D638[2]
3. Strain at Break (2.5" gage length [NSF])	min.	%	240	ASTM D638[2]
Carbon Black Content[1]	min.	%	2.0	ASTM D4218
Multi-Axial Elongation	min.	%	25	ASTM D5617

Note:
[1] Properties apply to base sheet
[2] Test Methods Modified per Table 9.

GEOSYNTHETIC MATERIAL SPECIFICATIONS				
TABLE 5 - 40 MIL SMOOTH GEOMEMBRANE				
Property	**Qualifier**	**Unit**	**Specified Value**	**Test Method**
Thickness	min. average	Mils	40	ASTM D5199
Thickness	min. reading	Mils	36	ASTM D5199
Density (geomembrane)	min.	g/cc	0.92	ASTM D1505
Tensile Properties: (each direction)				
1. Stress at Break	min.	Psi	3800	ASTM D638[1]
2. Strain at Break (2" gage length)	min.	%	750	ASTM D638[1]
3. Strain at Break (2.5" gage length [NSF])	min.	%	600	ASTM D638[1]
Carbon Black Content	min.	%	2.0	ASTM D4218
Multi-Axial Elongation	min.	%	30	ASTM D5617

Note:
[1]Test Methods Modified per Table 9.

GEOSYNTHETIC MATERIAL SPECIFICATIONS				
TABLE 6 - 40 MIL TEXTURED GEOMEMBRANE				
Property	**Qualifier**	**Unit**	**Specified Value**	**Test Method**
Thickness[1]	min. average	mils	40	ASTM D5199
Thickness[1]	min. reading	mils	36	ASTM D5199
Density (geomembrane) [1]	min.	g/cc	0.92	ASTM D1505
Tensile Properties: (each direction)				
1. Stress at Break	min.	psi	2300	ASTM D638[2]
2. Strain at Break (2" gage length)	min.	%	300	ASTM D638[2]
3. Strain at Break (2.5" gage length [NSF])	min.	%	240	ASTM D638[2]
Carbon Black Content[1]	min.	%	2.0	ASTM D4218
Multi-Axial Elongation	min.	%	25	ASTM D5617

Note:
[1] Properties apply to base sheet.
[2] Test Methods Modified per Table 9.

GEOSYNTHETIC MATERIAL SPECIFICATIONS

TABLE 7 - HDPE GEOMEMBRANE SEAMS

Property	Qualifier	Unit	Specified Value	All Thicknesses	Test Method
Thickness	min. average	mils	40 60 80 100		
Bonded Seam Strength	min.	lb/in	80 120 160 200	2000 psi	ASTM D4437[1]
Peel Adhesion:					
Fusion	min.	lb/in	60 90 120 150	1500 psi	ASTM D4437[1]
Extrusion	min.	lb/in	52 78 104 130	1300 psi	ASTM D4437[1]

Note:
[1]Test Methods Modified per Table 9.

GEOSYNTHETIC MATERIAL SPECIFICATIONS				
TABLE 8 – HDPE SOLID GEONET				
Property	**Qualifier**	**Unit**	**Value**	**Test Method**
Thickness	min.	Mils	200	ASTM D5199
Mass per Unit Area	min.	Lb/ft^2	0.16	ASTM D5261
Polyethylene Content	min.	%	95	- - -
Density (black resin)	min.	G/cc	0.940	ASTM D1505
Carbon Black Content	range	%	2.0 min.	ASTM D4218
Melt Index	max.	g/10 min.	1.0	ASTM D1238 (Condition 190/2.16)
Tensile Strength (machine direction)	min.	Lb/in	40	ASTM D5035
Transmissivity	min.	m^2/sec	1×10^{-3}	ASTM D4716[1]

Note:
[1]Test Methods Modified per Table 9.

GEOSYNTHETIC MATERIAL SPECIFICATIONS		
TABLE 9 -TEST METHOD MODIFICATIONS		
Property	**Test Method**	**Modifications**
Tensile Properties	ASTM D638	Type IV Die. ASTM D638 test specimen shall be used. The grip separation shall be 2.5 inches. This test does not require the use of extensometers. The rate of grip separation will be 2 inches per minute (20 inches for Coverseal). A gauge length of 1.3 inches for yield values, and 2.0 inches for break values shall be used to calculate elongation from grip movement.
Dimension Stability	ASTM D1204	100□C for 1 hour.
Tensile Strength	ASTM D5035	Test method modified as follows: 1) Use 4 in × 8 in specimens. 2) Use grip separation of 4 in. 3) Use test rate of 8 in/min. 4) Continue test until first strand separates completely.
Bonded Seam Strength and Peel Adhesion	ASTM D4437	For shear tests, the sheet shall yield before failure of the seam. For peel adhesion, seam separation shall not extend more than 10% into the seam. For either test, testing shall be discontinued when the sample has visually yielded. Sample failure shall conform to a passing configuration as outlined in (NSF Std. 54 Figure A-1).
Transmissivity	ASTM D4716	Gradient = 1.0; Confining Pressure = 15,000 psf (solid geonet), 4,000 psf Cap net measured between two steel plates one hour after application of confining pressure.

GEOSYNTHETIC MATERIAL SPECIFICATIONS

TABLE 10 – GEOSYNTHETIC CLAY LINER MATERIAL SPECIFICATIONS

BENTONITE[1]	Procedure	Frequency	English Units	SI Units
Swell Index	ASTM D5890	1/100,000 lbs. (50,000 kg)	24 ml / 2g min.	24 ml / 2g min.
Moisture Content	ASTM D4643	1/100,000 lbs. (50,000 kg)	12% max.	12% max.
Fluid Loss	ASTM D5891	1/100,000 lbs. (50,000 kg)	18 ml max.	18 max.
FINISHED GCL				
Bentonite Mass Per Unit Area[2]	ASTM D5261	1/40,000 ft^2 (1/4,000 m^2)	0.825 lb./sq. ft. MARV	4.02 kg/m^2 MARV
Grab Strength[3]	ASTM D4632	1/40,000 ft^2 (1/4,000 m^2)	95 lbs MARV	418 N MARV
Grab Elongation[3]	ASTM D4632	1/40,000 ft^2 (1/4,000 m^2)	75% Typical	75% Typical
Peel Strength[4]	ASTM D4632	1/40,000 ft^2 (1/4,000 m^2)	15 lb^2 min	66 N
Hydraulic Conductivity[5]	ASTM D5084	1/100,000 ft^2 (1/10,000 m^2)	5 x 10^{-9} cm/sec max.	5 x 10^{-9} cm/sec max.
Index Flux[5]	ASTM D5887	Once weekly (production)	1 x 10^{-8} m^3/m^2 /sec	1 x 10^{-8} m^3/m^2 /sec

1) Tests performed and values reported are for the "as received" bentonite, prior to incorporation into the final product.
2) Dried to a crystalline moisture content of approximately 6%.
3) Measured at final peak, in the weakest principal direction.
4) Modified to use a four inch wide grip. Reported as the average of the maximum peak for each specimen.
5) De-Aired Tap Water @ 5 psi maximum effective confining stress and 2 psi head.

MARV - Minimum Average Roll Value

GEOSYNTHETIC MATERIAL SPECIFICATIONS				
TABLE 11A – GEOMEMBRANE SEAMS				
Property	**Qualifier**	**Unit**	**Specified Value**	**Test Method**
Bonded Seam Strength	min.	lb/in	35	ASTM D4437[1]
Peel Adhesion:				
Fusion	min.	lb/in	30	ASTM D4437[1]
Extrusion	min.	lb/in	25	ASTM D4437[1]
Note: [1]Test Methods Modified Below				

GEOSYNTHETIC MATERIAL SPECIFICATIONS		
TABLE 11B – GEOMEMBRANE TEST METHOD MODIFICATIONS		
Property	**Test Method**	**Modifications**
Tensile Properties	ASTM D638	Type IV Die. ASTM D638 test specimen shall be used. The Grip separation shall be 2.5 inches. This test does not require the use of extensometers. The rate of grip separation will be 20 inches per minute. A gauge length of 1.3 inches for yield values, and 2.0 inches for break values shall be used to calculate elongation from grip movement.
Bonded Seam Strength and Peel Adhesion	ASTM D4437	For shear tests, the sheet shall yield before failure of the seam. For peel adhesion, seam separation shall not extend more than 50% into the seam. For either test, testing shall be discontinued when the sample has visually yielded or reaches the specified value, whichever comes first.

GEOSYNTHETIC MATERIAL SPECIFICATIONS					
TABLE 11C – GEOMEMBRANE AIR PRESSURE TEST					
Minimum Pressure		**Maximum Pressure**		**[2]Maximum Pressure Drop**	
(KPA)	(lb/in^2)	(KPA)	(lb/in^2)	(KPA)	(lb/in^2)
140	20	200	30	35	5.0
Note: [2]Maximum pressure drop over two minutes.					

GEOSYNTHETIC MATERIAL SPECIFICATIONS				
TABLE 12 - "CAP NET" GEONET				
Property	**Qualifier**	**Unit**	**Value**	**Test Method**
Thickness	min.	Mils	200	ASTM D5199
Mass per Unit Area	min.	Lbs/ft	0.13	ASTM D5261
Polyethylene Content	min.	%	95	---
Density (black resin)	min.	g/cc	0.940	ASTM D1505
Carbon Black Content	min.	%	2.0	ASTM D4218
Melt Index	max.	g/10 min	1.0	ASTM D1238 (Condition 190/2.16)
Tensile Strength (machine direction)	min.	lb/in	23	ASTM D5035[1]
Transmissivity	min.	m^2/sec	1×10^{-3}	ASTM D4716[1]

Note:
[1] Test Methods Modified per Table 9.