FORM EQP 5111 ATTACHMENT MODULE A11
CLOSURE AND POSTCLOSURE CARE PLANS

This document is an attachment to the Michigan Department of Environment, Great Lakes, and Energy's (EGLE) *Instructions for Completing Form EQP 5111, Operating License Application Form for Hazardous Waste Treatment, Storage, and Disposal Facilities.* See Form EQP 5111 for details on how to use this attachment.

The administrative rules promulgated pursuant to Part 111, Hazardous Waste Management, of Michigan's Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, (Act 451), R 299.9613 and Title 40 of the Code of Federal Regulations (CFR), Part 264, Subpart G, establishes requirements for the closure and, if necessary, postclosure care of hazardous waste management facilities. All references to 40 CFR citations specified herein are adopted by reference in R 299.11003. This license application module addresses requirements for the proper closure and, if necessary, postclosure care of the hazardous waste management units and the hazardous waste management facility for the Dow Silicones Corporation Facility in Midland, Michigan. The information provided in this Module was used to prepare the closure and postclosure care cost estimate provided in Module A12, "Closure and Postclosure Care Cost Estimates."

This Module is organized as follows:

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A11.A CLOSURE PLAN

A11.A.1 Closure Performance Standard
[R 299.9613 and 40 CFR §264.111]

This Closure Plan is designed to ensure that the facility will be closed in a manner that achieves the following:

a. Minimizes the need for further maintenance; and

b. Controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, postclosure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition byproducts to the groundwater, surface water, or atmosphere; and, as applicable

c. Complies with the unit-specific closure requirements for each of the following units:

(Check as appropriate)

☒ Use and management of containers	R 299.9614 and 40 CFR §264.178
☒ Tank systems	R 299.9615 and 40 CFR §264.197
☐ Surface impoundments	R 299.9616 and 40 CFR §264.228
☐ Waste piles	R 299.9617 and 40 CFR §264.258
☐ Land treatment[a]	R 299.9618 and 40 CFR §264.280
☒ Landfill	R 299.9619 and 40 CFR §264.310

☐ Incinerators R 299.9620 and 40 CFR §264.351

☐ Drip pads[b] R 299.9621 and 40 CFR §264.575

☐ Miscellaneous units R 299.9623 and 40 CFR §§264.601-603

☐ Hazardous waste munitions and explosive storage[b] R 299.9637 and 40 CFR §264.1202

☐ Boilers and industrial furnaces R 299.9808 and 40 CFR §266.102(e)(11)

[a] Not included in the module
[b] *Not yet included in 40 CFR §264.111; therefore not considered*

This Closure Plan is for Dow Silicones Corporation (DSC's) licensed hazardous waste facility in the 800 Block of the Midland site and the hazardous waste landfill located in the 800 and 1000 Blocks of the Midland site. This plan identifies all steps necessary to close each hazardous waste management unit at this facility at the end of its active life. DSC does not plan to partially close any of the hazardous waste management units which are regulated at this facility. Also included is a description of the post-closure care to be provided for the hazardous waste landfill after closure of that unit is completed. Unit-specific closure procedures are discussed in Section A11.A.5 of this module for each unit type indicated above.

A11.A.2 Unit-Specific Information
[R 299.9613 and 40 CFR §§264.112(b)(3) and (6)]

Table A11.A.1 Hazardous Waste Management Units Information

The following table identifies each hazardous waste management unit at the DSC facility subject to the closure requirements of this hazardous waste management facility operating license. The table also includes: each unit's maximum licensed hazardous waste inventory, a list of the waste codes managed in the unit, the anticipated date of closure (if known), and the estimated duration of closure activities once closure begins. Unit-specific methods for closure and detailed schedules are discussed in Section A11.A.5 of this module.

Unit Designation	Maximum Inventory (Include Units)	Waste Codes of Hazardous Wastes Managed	Scheduled Closure Date	Estimated Duration of Closure
801 Container Storage Area	85,000-gallons – No hazardous materials are stored in this building.	N/A	N/A	180 Days
809 Container Storage Area	85,000-gallons	See Table A2-1 in Module A2 (Chemical and Physical Analyses)	N/A	180 Days
806 Tank Storage Area	60,000-gallons	See Table A2-1 in Module A2 (Chemical and Physical Analyses)	N/A	180 Days

Landfill	No hazardous waste disposal currently occurs in the landfill. Non-regulated wastes staged at the landfill for disposal will be placed in the active cell prior to closure or removed for shipment off-site.	See Table A2-1 in Module A2 (Chemical and Physical Analyses)	N/A	180 Days

A11.A.3 Schedule of Final Facility Closure
[R 299.9613 and 40 CFR §264.112(b)(6)]

The Dow Silicones facility:

(Check as appropriate)

☐ Anticipates completing final closure of the entire facility by ***[insert estimated date]***

☒ Has not determined when the facility will close and does not anticipate completing final closure of the entire facility prior to expiration of the facility's hazardous waste operating license.

Detailed Closure Schedule for Facility Closure: A detailed breakdown showing the closure schedule with the anticipated time of completions for each activity is provided in Appendix A11-1.

A11.A.4 Notification and Time Allowed for Closure
[R 299.9613 and 40 CFR §§264.112(d)(2) and 264.113(a) and (b)]

Final closure activities will be initiated within 90 days of receipt of the final volume of hazardous wastes and completed within 180 days of receipt of the final volume of waste. The tasks and estimated time required for closure shall follow the schedule specified in Section 11A.3. The Director will be notified by DSC facility 60 days before final closure begins. Final closure will be certified by both DSC facility and an independent, qualified, registered professional engineer of the state of Michigan.

A11.A.4(a) Extensions for Closure Time
[R 299.9613 and 40 CFR §264.113(a) and (b)]

In the event that an extension for closure for the facility or any unit is necessary, the DSC facility will request an extension in accordance with the requirements of 40 CFR §264.113(a).

A11.A.5 Unit-Specific Closure Procedures

Unit-specific closure procedures are provided for each unit identified in Section A11.A.2 of this module.

This section provides closure procedures for each Unit:

- Container storage area;
- Tank systems; and
- Landfill.

The two container storage areas, the tank system and related structures are all located on the landfill. Above-ground container storage and tank system structures will be decontaminated and removed. The foundations will be decontaminated and left in place for incorporation into the landfill when closed. The tanks and container storage areas have secondary containment. Releases to soil, if known, from these regulated units and releases that would be contained in the secondary containment systems may be tracked and reported as necessary. Soil sampling may be necessary to close these structures in the event a release to soil occurs or impacted soils are observed when the structures are removed.

For the hazardous waste disposal units that were historically closed, all required notices as required Under 40 CFR 264.119 were filed with the US EPA Region V and/or EGLE. The file notice dates and the agency to which the notices were submitted to are provided in Module B9, Solid Waste Management Unit (SWMU) Information, Table B9-1 (Summary of SWMUs).

A11.A.5(a) Closure of Container Storage Areas
[R 299.9614 and 40 CFR §264.178]

This section describes the procedures for closure of *801 and 809 Container Storage Areas*. The general closure requirement and specific closure procedures are discussed below.

The 809 Building is used for storage of hazardous wastes in containers and will undergo closure as required at the end of its active service life, as described in this section. Post-closure care is not required for this unit because all hazardous wastes will be removed, and all contaminated structures and equipment will be removed or decontaminated during closure. The 801 Building is only used for non-RCRA regulated wastes but will be closed at the same time and in the same manner as the 809 Building.

This Closure Plan will ensure that the 801 and 809 Building container storage areas will not require further maintenance after closure and that there will be no releases from this area of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the soil, groundwater, surface waters or atmosphere after closure has been completed.

The licensed storage capacity for 801 and 809 Buildings is 85,000 gallons of hazardous wastes. For purposes of closure calculations, it is assumed that this is stored as:

1,518 drums X 55 gal. each =	83,500 gallons
300 lab packs X 5 gal. each =	1,500 gallons
Total: 1,818 containers =	85,000 gallons

A. General Closure Requirement

Prior to closure, these units will stop accepting wastes. At closure, all hazardous waste and hazardous waste residues will be removed from the containment system. Remaining containers, liners, and bases containing or contaminated with hazardous waste or hazardous waste residues will be decontaminated or removed for proper disposal.

B. Specific Closure Procedures

Specific procedures for inventory management, unit inspection, decontamination, sampling and analysis, and additional waste management are discussed below.

1. Inventory and Remedial Waste Management Procedures

At closure of these units, liquid hazardous wastes in containers will be transferred to the appropriate hazardous waste storage tanks prior to shipment off-site, or directly to bulk tank trucks for shipment to off-site licensed treatment and disposal facilities. Those liquids that cannot be transferred for bulk shipment, and any solid hazardous wastes, will be shipped off-site in containers for treatment and/or disposal at licensed facilities.

2. Unit Inspection Procedures

With proper containment for any releases and an established spill response program (Module A7), it is unlikely that the containment area will be contaminated at the time of closure. After removal of all wastes in containers, the steel siding and frame will be disassembled, and the components visually inspected for any signs of contamination by hazardous waste or hazardous waste constituents. After removal of the steel building components, the remaining concrete slab and foundation will be visually inspected for signs of release, contamination by hazardous waste or hazardous waste constituents, cracks in concrete and/or stained soil. If visual evidence of contamination exists, soil sampling may be required as discussed below. After cleaning, the concrete foundation and floor will remain in place and will be covered with the landfill final cover.

3. Decontamination Procedures

The 801 and 809 Buildings are constructed of steel siding on a steel frame, anchored to a concrete slab. The buildings are not insulated, are open on one side, and contain no fixed equipment.

- *Decontamination procedures*

  After removal of all wastes in containers, the steel siding and frame will be disassembled, and the components visually inspected for any signs of contamination by hazardous waste or hazardous waste constituents. Although contamination of the steel building components is unlikely, if any is detected, the contaminated portions will be decontaminated using high pressure water, or steam, or other cleaning method as appropriate to the type and extent of contamination. The steel will then be recycled or disposed.

After removal of the steel building components, the remaining concrete slab and foundation will be visually inspected for signs of contamination by hazardous waste or hazardous waste constituents. All exposed concrete will be decontaminated by high pressure water blasting, steam cleaning, or scarifying, or a combination of these, in order to remove as much as possible any visible evidence of contamination. After cleaning, the concrete foundation and floor will remain in place and will be covered with the landfill final cover.

All secondary containment for container storage areas at this facility including the spill pond and conveyance structures will be decontaminated by high pressure water blasting, steam cleaning, or scarifying, or a combination of these, in order to remove as much as possible any visible evidence of contamination. All secondary containment including spill pond and conveyance structures will be visually inspected for any signs of contamination by hazardous waste or hazardous waste constituents, cracks in concrete and/or stained soil. After decontamination, if visual evidence of contamination exists, soil sampling may be required as discussed below.

- *Measures to ensure decontaminated liquids (if applicable) do not migrate to surface soils or surface waters*

  The rinse water will be collected and placed into drums after each rinse for disposal at a licensed facility off-site. No rinse water will be discharged to the facility's wastewater sewer system.

- *Criteria for determining whether decontamination is complete*

  High pressure triple-rinsing using soap and/or sodium hydroxide solution, steam cleaning, or scarifying, or a combination of these and visual inspection shall be performed to verify that all contamination has been removed.

- *Decontamination of clean-up materials and equipment*

  High pressure triple rinsing and visual inspection to verify that all contamination has been removed are adequate for solid surfaces like tanks, piping, and coated-concrete containment systems. All wastes, and water and debris resulting from cleaning of the concrete secondary containment floor, will be properly disposed in accordance with all applicable regulations. Building components and any equipment removed will be decontaminated or properly disposed. It is not planned that there will be any soils removed during closure.

4. Sampling and Analysis Procedures

Contaminated soils associated with the container storage and tank storage areas are not expected because these areas have both primary and secondary containment. If there is a release to soil or if impacted soil is observed, soils will be sampled in the potentially impacted area. The number, depth and locations of the samples will be consistent with the conditions of the release and EGLE guidance. The samples will be analyzed for parameters in accordance with RRD Operational Memorandum No. 2, Attachment 1 using SW-846 methods that commensurate with the release and all waste materials stored in the unit over time. Soils that

are hazardous will be managed and disposed of properly. Soils that are not hazardous may be stabilized and left in place for incorporation into the landfill upon closure.

5. Additional Waste Management Procedures

Concrete and other rinseates which cannot be decontaminated will be disposed of at a licensed waste disposal facility. It is not expected that any soil will be removed during closure. If impacted soils are found, soil that is hazardous will be managed and disposed of at an off-site location. Soil that is not hazardous may be incorporated into the landfill or managed and disposed of at an off-site location.

A11.A.5(b) Closure of Tank Systems

[R 299.9615 and 40 CFR §264.197]

This section describes the procedures for closure of *806 Tank Storage Area*. The general closure requirement and specific closure procedures are discussed below.

The 806 Tank Storage Area is used for storage of hazardous wastes in tanks and for loading and unloading of bulk waste shipments and will undergo closure as required at the end of its active service life, as described in this section. This hazardous waste management unit contains six storage tanks, each with a working storage capacity of 10,000 gallons. The maximum inventory of hazardous waste for this unit is therefore 60,000 gallons.

A. General Closure Requirement

At closure of the tank system, the DSC facility will remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), and structures and equipment contaminated with waste, and manage them as hazardous waste, unless 40 CFR §264.3(d) applies. If there is indication of impacted soil, the soil will be evaluated consistent with agency guidelines. Soils that are not hazardous may be incorporated into the landfill. Soils that are hazardous will be managed and disposed of properly at another facility.

B. Specific Closure Procedures

Specific procedures for inventory management, unit inspection, decontamination, sampling and analysis, and additional waste management are discussed below.

1. Inventory and Remedial Waste Management Procedures

At the time of closure of this hazardous waste management unit, the six (6) 10,000 gallon storage tanks and ancillary equipment will be emptied of hazardous wastes, cleaned of all waste residues, dismantled, and removed for scrap or disposal. Detailed procedures are described in this section.

The contents of the six (6) 10,000 gallon hazardous waste storage tanks will be pumped to bulk tank trailers for shipment off-site to licensed treatment, storage, and disposal facilities.

2. Unit Inspection Procedures

With proper containment for any releases and an established spill response program located in Module A7 (Evacuation Plan), it is unlikely that the containment area will be contaminated at the time of closure.

At the time of closure, the tanks and containment structures (including spill pond and conveyance structures) will be inspected for residues. Any remaining residues adhering to the interior of the tank and/or containment structures will be removed by high-pressure water blasting, which has been found to be very effective in cleaning these tanks, or by steam cleaning, if necessary. The containment structures will also be visually inspected for any signs of contamination by hazardous waste or hazardous waste constituents, cracks in concrete and/or stained soil. After decontamination, if visual evidence of contamination exists, soil sampling may be required as discussed below. The tanks and ancillary equipment will then be dismantled and removed for scrap or disposal.

3. Decontamination Procedures

- *List of equipment and structures to be decontaminated*

Storage tanks and associated secondary containment structures.

- *Decontamination procedures*

Tank Decontamination

After pumping out as much liquid waste as possible, the remaining sludges will be removed and placed in containers or bulk tankers for shipment to off-site facilities, as follows:

a. Waste Solvent Tanks, #19781, 19782, 19783 and 19786

Based on this facility's experience with periodic tank cleanouts, it is estimated that no more than 2,000 pounds of sludge will remain in each of the waste solvent storage tanks. Most of this material will be removed using a vacuum tank truck and/or by a tank cleaning crew entering the tank. Any remaining residues adhering to the interior of the tank will be removed by high-pressure water blasting, which has been found to be very effective in cleaning these tanks, or by steam cleaning, if necessary. The contaminated water generated by this process will be collected for proper disposal.

b. Waste Methoxysilane Tank, #19784

Based on previous experience in cleaning this tank, it is estimated that no more than 2,000 lbs. of sludges will remain after pumping out the contents. Methoxysilanes are moderately water-reactive, so after emptying, this tank and ancillary piping will be rinsed with compatible organic solvent that is low in water content. The rinse solution will be pumped or vacuumed out and disposed at a licensed facility off-site. Any remaining residues will consist primarily of reacted polymers and will have little or no reactivity to water, so further cleanout measures will use high pressure water and/or steam. All contaminated water will be collected for proper disposal.

c. Waste IPA/Siloxane Tank, #19785

Based on previous experience with cleaning the waste IPA/siloxane storage tank, it is estimated that no more than 2,000 lbs., of sludge will remain in the tank after pumping out the liquid contents. The IPA/Siloxane tank will be cleaned in the same manner as waste solvent and waste methoxysilane tanks.

Most of this material will be removed using a vacuum tank truck and/or by a tank cleaning crew entering the tank. Any remaining residues adhering to the interior of the tank will be removed by high-pressure water blasting, which has been found to be very effective in cleaning these tanks, or by steam cleaning, if necessary. The contaminated water generated by this process will be collected for proper disposal.

Ancillary Equipment

a. Piping and Pumps

Piping, pumps, valves, and any other ancillary equipment used to contain or convey hazardous wastes in the tank farm will be decontaminated by first rinsing with either water or solvent, as appropriate to the type of wastes previously contained, followed by final rinses with water. If necessary, equipment may be steam cleaned to remove any remaining residues. After cleaning, the equipment will be dismantled and if additional residues are discovered, more cleaning performed.

b. Tank Vents, Controls, and Gauges

All tank vents, controls, gauges, and any other ancillary equipment that has not been in direct contact with hazardous wastes during normal operations will be removed, disassembled, and inspected for contamination. These items will be decontaminated as needed, using solvent or water washes or steam cleaning to remove any residues that might be found.

Concrete

After decontamination and removal of the storage tanks and ancillary equipment, the secondary containment structures including the spill pond and conveyance structures at the tank farm will be decontaminated by pressure washing with water and/or steam as necessary to remove as much as possible all visible signs of contamination. These will also be visually inspected for any signs of contamination by hazardous waste or

hazardous waste constituents, cracks in concrete and/or stained soil. After decontamination, if visual evidence of contamination exists, soil sampling may be required as discussed below.

Heavy construction equipment will be used to knock down the tank farm dike walls. Since the 806 tank farm is located on top of the hazardous waste landfill, all concrete will remain in place after closure and will be capped by the landfill final cover.

Soils

Because all tank storage and transfer operations have been provided with secondary containment, and because the entire area will be capped with the landfill final cover, removal of soil will not be necessary and is not planned.

- *Measures to ensure decontaminated liquids (if applicable) do not migrate to surface soils or surface waters*

  The rinse water will be collected and placed into drums after each rinse for disposal at a licensed facility off-site. No rinse water will be discharged to the facility's wastewater sewer system.

- *Criteria for determining whether decontamination is complete*

  High pressure triple rinsing using soap and/or sodium hydroxide solution and visual inspection shall be performed to verify that all contamination has been removed.

- *Decontamination of clean-up materials and equipment*

  Tanks

  After emptying and decontamination, the six (6) hazardous waste storage tanks will be disconnected from ancillary equipment, demounted from their foundations, dismantled to the extent possible, and cut into sections to prepare them for eventual disposal or recycling as scrap metal. If, at any time during this process, additional residues of hazardous wastes are discovered, further decontamination will be performed using solvent or water washes and/or steam, as necessary to ensure thorough decontamination.

  All contaminated solvent rinses will be disposed or recycled at licensed off-site hazardous waste facilities. Contaminated water will be tested and will either be shipped off-site to licensed facilities for treatment or disposal or, if the water is found to contain less than 250 ppm Total Organic Carbon (TOC) and less than 1000 ppm Total Oxygen Demand (TOD) it will be disposed in the wastewater sewer, which flows to Dow Chemical's NPDES permitted wastewater treatment plant. Contaminated solids, including rags, absorbents, and personal protective equipment will be shipped off-site for proper disposal.

Ancillary Equipment

After decontamination, all piping will be dismantled and visually inspected for any sign of residues. If any remaining contamination is observed, further cleaning will be performed using solvent or water washes and/or steam, as necessary to ensure thorough decontamination. All contaminated cleanup materials will be disposed or recycled at off-site licensed facilities. After decontamination is completed, the piping will be cut into sections and properly disposed or recycled as scrap metal.

Pumps, valves, tank vents, gauges and other ancillary equipment that may potentially be usable will be inspected to ensure complete decontamination, and then a determination made as to whether each item can be reused elsewhere in the plant. If the item may be usable and it is cost-effective to reuse it, it will be rebuilt, reconditioned, or otherwise prepared as needed. If it is not reusable, the item will be recycled as scrap or properly disposed.

4. Sampling and Analysis Procedures

Contaminated soils associated with ancillary equipment are not expected but will be identified and managed as described for the container storage area.

5. Additional Waste Management Procedures

All waste and materials will be decontaminated as part of the Closure activities. There are no additional waste management procedures

A11.A.5(c) Closure of Surface Impoundments
[R 299.9616 and 40 CFR §264.228(a)(1) and (2)]

DSC does not store or treat hazardous wastes in surface impoundments at this facility. Therefore, this section is not applicable.

A11.A.5(d) Closure of Waste Piles
[R 299.9617 and 40 CFR §264.258]

DSC does not store or treat hazardous wastes in waste piles at this facility. Therefore, this section is not applicable.

A11.A.5(e) Closure of Landfills
[R 299.9619 and 40 CFR §264.310(a)]

This section describes the procedures for closure of *Landfill*. The general closure requirement and specific closure procedures are discussed below.

A. General Closure Requirement

At the final closure of the landfill, DSC will cover the landfill with a final cover designed and constructed to:

1. Provide long-term minimization of migration of liquids through the closed landfill;
2. Function with minimum maintenance;
3. Promote drainage and minimize erosion or abrasion of the cover;
4. Accommodate settling and subsidence so that the cover's integrity is maintained; and
5. Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoil present.

At the final closure of the landfill or upon closure of any cell, DSC will cover the landfill with a final cover consistent with the specifications is R299.9619.

Because the hazardous waste storage facility and its support structures were constructed on top of the inactive portion of the landfill, these structures will be removed prior to final closure of the landfill. Decontaminated or uncontaminated demolition debris may be disposed in the landfill prior to closure. The Closure Plan will ensure that the amount of maintenance required for the landfill after closure is minimized, and that post-closure releases of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the soil, groundwater, surface waters or atmosphere will be prevented or minimized to the extent necessary to protect human health and the environment, after closure has been completed. Collection of landfill leachate for treatment, and groundwater monitoring are provided to ensure protection of groundwater and surface waters. Operation of the Site Interceptor System, described in detail in Module B2 (Corrective Action), further ensures that no contamination will migrate off-site. The SIS will be operated until concentrations in water collected by the SIS are less than or equal to applicable Part 201 criteria or until a system that provided a similar degree of protection for adjacent properties is functioning.

DSC does not currently use the landfill for disposal of hazardous wastes and does not anticipate doing so prior to closure. If DSC should wish to resume disposal of hazardous wastes in the landfill, prior approval will be sought from EGLE and the Closure Plan will be amended to reflect this change. Until such time, no hazardous wastes are staged for disposal at the landfill, so there is no inventory of hazardous wastes to be removed during closure.

Non-RCRA regulated wastes staged at the landfill for disposal will be placed in the active cell prior to closure, in accordance with normal landfill operating procedures, or removed for shipment off-site. There is no process equipment and no structures associated with the operation of the active portion of the landfill, so there are none to be removed or decontaminated. Removal of other hazardous waste management units located on inactive portions of the landfill has been described in previous portions of this Closure Plan. Removal of other structures and equipment is described below. Non-hazardous soils present at the landfill may be incorporated into the landfill and capped with the final cover.

After final closure, DSC will comply with all postclosure requirements contained in R 299.9613 and 40 CFR §264.117, including maintenance and monitoring throughout the postclosure care period.

B. Specific Closure Procedures

The final landfill cover design, the construction quality assurance program for installing the final landfill cover, and plat of survey are presented below.

1. Landfill Cover Design

This section describes how the landfill will be closed and how the final cover will be constructed. Final closure of the landfill will control leachate migration by minimizing production of leachate, and by maintaining the existing leachate collection system. Groundwater monitoring in the area of the closed landfill during the post-closure period will evaluate if all leachate is being effectively collected and treated. All leachate is discharged to the licensed wastewater treatment facility at Dow Chemical for proper treatment.

COVER DESIGN

The cover system that will be installed at closure is designed to:

- Provide effective, long term minimization of liquid migration through the closed landfill;
- Promote drainage and minimize erosion and abrasion of the cover;
- Ensure that any settling and subsidence do not impair the integrity of the cover; and
- Satisfy regulatory requirements for permeability.

The construction of the cover system will begin after the final volume of waste has been placed in the active cell and covered. Maximum permitted final grades of the landfill are shown on drawing Y1-36615 in Appendix A11-5; however, closure may be established below the maximum grades as long as the maximum slope is greater than 4% and less than 4 horizontal :1 vertical. A final closure grading plan will be submitted for approval prior to closure activities. The landfill will then be surveyed, monitored for settlement, and repaired as necessary to provide a stable base for the cover system. A cover consistent with requirements of Rule 299.9619(6)(a) will be placed over the landfill.

A layer of low permeability clay, three feet (90 centimeters) thick, will then be applied over the entire top area of the landfill. The hydraulic conductivity of this clay layer after compaction will be less than or equal to 1.0×10^{-7} cm/sec. The hydraulic conductivity of the clay used in constructing the cover will also be less than or equal to that of the native clay used in constructing the liner of the landfill. Appendix A11-2, Native Clay Test Results, lists the test results of native clays available on site for use in constructing the cover, showing that the clays tested meet or exceed the requirements of MAC R 299.9620(3).

Alternatively, a geosynthetic clay liner (GCL) may be used as a full or partial replacement for the recompacted clay layer. A demonstration of the equivalency of the GCL will be submitted for approval along with the final closure grading plan. A reinforced GCL will be used in areas where the slope is greater than 10 percent.
A smooth 60 mil very low-density polyethylene (VLDPE) membrane will be installed over the recompacted clay and/or GCL, on the top section of the cover, and a textured (both sides) 60 mil VLDPE liner, or equivalent, will be installed over the recompacted clay and/or GCL on the 25% sloping bank at the sides of the landfill. Linear Low-Density Polyethylene (LLDPE) is considered a current equivalent of VLDPE. These synthetic membranes will protect the clay cap from moisture variation and further decrease permeability of the cover.

Over the synthetic membrane, a drainage layer will be installed. The drainage layer will consist of at least 30 cm of sand, topped with an eight ounce, non-woven, needle-punched filter fabric, or a geocomposite drainage layer. A demonstration of the equivalency of the geocomposite drainage layer will be submitted for approval along with the final closure grading plan. The vegetative layer will consist of at least six inches of vegetative support soil topped with at least 15 cm of topsoil, for a total of 60 cm of soil and drainage layer over the Flexible Liner Membrane (FLM). After installation, the topsoil will be planted with shallow rooted grasses to reduce erosion.

COVER CONSTRUCTION

Construction of the landfill final cover will be carried out in accordance with the plan detailed in Appendix A11-3, Construction Specifications for Installation of Compacted Cover System, and Appendix A11-4, Technical Specifications for FLM and Filter Fabric. See also Appendix A11-5 for drawings detailing the construction and contours of the final cover and Appendix A11-6 for technical calculations

COVER MAINTENANCE

The final cover will require only minimum maintenance to ensure its integrity. It will be covered with topsoil and seeded with grass to minimize erosion; it is not intended that the grass will be mowed; however, the side slopes will be constructed to a slope of no greater than one foot rise in four feet of run, to meet MIOSHA mowing specifications.

DRAINAGE AND EROSION PROVISIONS

The final top cover will be constructed with a minimum slope of 4 to promote drainage and eliminate ponding to minimize the hydraulic head on the cap. Drainage of precipitation from the top cover and slopes will run off into the perimeter drainage ditches, which are designed to adequately contain the runoff from a one hour, 25-year rainfall.

The perimeter drainage ditches flow to catch basins connected to the site storm sewer system and then to the site's storm water retention pond from which water may be discharged either to the wastewater sewer, for treatment if necessary, or to Lingle Drain for discharge to surface waters. To prevent contamination of surface waters, whenever storm water has been accumulated in the retention pond it is tested before discharge. See Appendix A11-6, Details of Landfill Final Cover and drawing (Y1-36625) in Appendix A11-5, for details of the drainage of the final cover and surrounding ditches.

Erosion of the final cover is minimized by seeding with grass, as described previously.

SETTLEMENT AND SUBSIDENCE

Recompacted clay cap will be constructed in lifts of no greater than 25 cm thickness, loose measure prior to compacting, and each lift will be systematically compacted to 90% of the clay's maximum density, as determined by the Modified Proctor Test (ASTM D-1557). During post-closure the cover system will be inspected regularly, as described in A11.B of this section, and any observed settlement will be promptly repaired.

2. Construction Quality Assurance (CQA) Program

See Appendix A11-7 for the Construction Quality Control/Quality Assurance Procedures for Landfill Clay Final Cover and the Quality Assurance Manual for Final Cap Geosynthetic Liner System Installation

3. Plat of Survey

No later than the submission of the certification of closure for the landfill, DSC will submit to the Midland County Department of Planning, and to the Chief of the Waste Management Division, a survey plat indicating the locations and dimensions of the landfill cells with respected to permanently surveyed benchmarks. This plat will also contain a note, prominently displayed, which states the owner's or operator's obligation to restrict disturbance of the closed landfill cells, in accordance with applicable regulations in 40 CFR 264, Subpart G.

A11.A.5(f) Closure of Incinerators
[R 299.9620 and 40 CFR §264.351]

DSC does not treat hazardous wastes in incinerators at this facility. Therefore, this section is not applicable.

A11.A.5(g) Closure of Miscellaneous Units
[R 299.9623 and 40 CFR §§264.601 through 264. 603]

DSC does not have miscellaneous units at this facility. Therefore, this section is not applicable.

A11.A.5(h) Closure of Boilers and Industrial Furnaces (BIF)
[R 299.9808 and 40 CFR §266.102(e)(11)]

DSC does not have boilers and industrial furnaces at this facility. Therefore, this section is not applicable.

A11.A.5(i) Other Closure Activities
[R 299.9504(1)(c), R 299.9508(1)(b), and R 299.9613(1) and 40 CFR §§270.14(b)(13) and 264.112(b)(5)}

A final round of sampling will be completed to verify that the regulated units meet relevant standards. No other closure activities are anticipated.

A11.A.6 Certification of Closure
[R 299.9613]

Within 60 days of completion of closure DSC will submit to the Director, by registered mail, a certification that the hazardous waste management unit or facility, as applicable, has been closed in accordance with the specifications in the approved closure plan. The certification will be signed by DSC and by an independent registered professional engineer. Documentation supporting the independent registered engineer's certification will be furnished to the Director in accordance with R 299.9613(3), including:

1. The results of all sampling and analysis;
2. Sampling and analysis procedures;
3. A map showing the location where samples were obtained;
4. Any statistical evaluations of sampling data;
5. A summary of waste types and quantities removed from the site and the destination of these wastes; and
6. If soil has been excavated, the final depth and elevation of the excavation and a description of the fill material used.

The certification wording will be as follows:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

The DSC facility will maintain financial assurance for closure until the Director releases the DSC facility from the financial assurance requirements for closure under R 299.9703.

A11.A.7 Postclosure Notices Filed

[R 299.9504(1)(c) and R 299.9508(1)(b) and 40 CFR §270.14(b)(14)]

DSC will provide documentation that the postclosure notices required under 40 CFR §264.119 have been filed for hazardous waste disposal units that have been closed at the facility. These notices include the following:

Record of Wastes Disposed [40 CFR 270.14(b)(14), 264.119(a), MAC R 299.9613(1)]

Within 60 days after certification of closure of the hazardous waste landfill, DSC will submit to the Midland County Department of Planning and the Director of the EGLE, a record of the type, location, and quantity of hazardous wastes disposed of within each landfill cell.

Within 60 days of certification of closure of the hazardous waste landfill, DSC will record a notation on the deed to the facility property, or on some other instrument which would be normally examined during title search, notifying any potential future purchaser of the property that:

- The property has been used to manage hazardous wastes; and

- The use of the property is restricted under the provisions of 40 CFR Subpart G regulations; and
- The survey plat and record of the type, location, and quantity of hazardous wastes disposed of within each cell of the landfill have been filed with the Midland County Department of Planning and the Director of EGLE.

DSC will submit a certification, signed by an authorized representative, that the notation described above has been recorded, with a copy of the notation to accompany the certification.

Modification of Post-Closure Permit [40 CFR 270.14(b)(14), 264.119(c), MAC R 299.9613(1)]

If DSC chooses to remove from the landfill any hazardous wastes, hazardous waste residues, the landfill liner, or any contaminated soils, a modification will be requested to the Post-Closure Plan in accordance with all applicable requirements, including those at 40 CFR 124, 270, and 264.117(c).

Certification of Completion of Post-Closure Care [40 CFR 270.14(b)(14), 264.120, MAC R 299.9613(5)]

The post-closure care period for the hazardous waste landfill will be 30 years after the closure of the hazardous waste landfill. Within 60 days after completion of the established post-closure care period for the hazardous waste landfill, DSC will submit to the Director of EGLE, by registered mail, a certification that the post-closure care period for the landfill was performed in accordance with the specifications in the approved Post-Closure Plan. This certification will be signed by an authorized representative of DSC and an independent, registered, professional engineer. Documentation supporting the professional engineer's certification will be supplied to the Director of EGLE upon request until he releases DSC from the final assurance requirements for post-closure care.

A11.B POSTCLOSURE PLAN

[R 299.9613 and 40 CFR §264.118]

A11.B.1 Applicability

(Check as appropriate)

☐ **Not applicable**: Hazardous waste will not be left behind at closure. A survey plat, postclosure care, postclosure certifications, and other notices are not required.

☒ **Applicable**:

☐ Contingent plan
☒ Landfill unit

A11.B.2 Postclosure Care Objectives

The DSC facility will complete the activities listed in Table A.11.B.1 in order to achieve the following:

1. Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;
2. Operate the leachate collection and removal system until leachate is no longer generated by landfill or concentrations of constituents in the leachate are less than applicable Part 201 criteria;
3. Maintain and monitor the leak detection system in accordance with R 299.9613 and 40 CFR §§264.301(c)(3)(iv) and (4) and 264.303(c), and comply with all other applicable leak detection system requirements of this part. This landfill was constructed prior to January 29, 1992 and has had no horizontal expansions since that date. The landfill is therefore exempt from the requirements of 40 CFR 264.301© for use of a double synthetic liner and leak detection system;
4. Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of R 299.9612 and 40 CFR, Part 264, Subpart F;
5. Prevent run-on and run-off from eroding or otherwise damaging the final cover; and
6. Protect and maintain surveyed benchmarks used in complying with R 299.9613 and 40 CFR §264.309.

A11.B.3 Postclosure Care Period Point of Contact

The planned monitoring and maintenance activities and the associated frequencies are designed to ensure the integrity of the cap and final cover system and the proper functioning of the monitoring system for each unit listed in Table A11.B.1.

Because closure of the landfill is not planned, the contact person or office for the post-closure care period will not be designated at this time. Prior to closure of the landfill, at the time of the filing of the notification of closure and final, updated closure plan, the contact person or office for post-closure care will be designated.

A11.B.4 Postclosure Care Activities

Table A11.B.1 Postclosure Monitoring and Maintenance

The following table identifies, for each unit requiring postclosure care, planned monitoring and maintenance activities and the frequency at which these activities will be performed.

Unit	Planned Monitoring Activities	Frequency	Planned Maintenance Activities	Frequency
Landfill, 806 Tank Farm, 801 & 809 Container Storage Areas	Groundwater Monitoring	Semiannual	As Needed (see Module A11, Section A11.B.4)	As Needed
Landfill	Leachate Monitoring	Quarterly	As Needed (see Module A11, Section A11.B.4)	As Needed

Lingle Drain upstream & downstream from the regulated unit	Surface Water Monitoring	Annual for minimum of five years	As Needed (see Module A11, Section A11.B.4)	As Needed
Landfill	Landfill Cover Inspection	Twice each year for the first 3-5 years	As Needed (see Module A11, Section A11.B.4)	As Needed
Drainage Ditch	Perimeter Drainage Ditch Inspection	Quarterly	As Needed (see Module A11, Section A11.B.4)	As Needed

Planned Monitoring Activities [40 CFR 270.14(b)(13), 264.118(b)(1), MAC R 299.9613(1)]

Post-closure monitoring of the landfill will be carried out by sampling a series of groundwater monitoring wells, the leachate collection system, and Lingle Drain, which is the nearest surface water. Monitoring plans for each are described below. The condition of the landfill final cover and perimeter drainage ditches will also be monitored by inspection, as described below.

1. **Groundwater Monitoring**

   The purpose of the groundwater monitoring program is to detect the migration of hazardous waste or hazardous waste constituents from materials disposed in the landfill so that actions can be taken to halt the release. Parameters chosen for monitoring are based on knowledge of the types of wastes previously disposed in the landfill and/or present in the landfill leachate. The current monitoring program is described in Module B5, “Environmental Monitoring Programs”, of this license application. Post-closure groundwater monitoring will be a continuation of the monitoring program, with appropriate revisions. Groundwater monitoring wells and equipment will be maintained during the post-closure care period.

2. **Leachate Monitoring**

   The purpose of the leachate monitoring program is to detect changes in concentrations of hazardous waste or hazardous waste constituents in the leachate before those wastes or constituents can reach groundwater, so that appropriate remedial action can be taken. The groundwater monitoring program is described in Module B5, “Environmental Monitoring Programs”, of this license application. Post-closure leachate monitoring will be a continuation of the current monitoring program with appropriate revisions. The leachate collection system and sampling points will be maintained during the post-closure care period.

3. **Surface Water Monitoring**

   The purpose of the surface water monitoring program is to detect the migration of hazardous waste or hazardous waste constituents from the landfill to the nearest surface

water, so that appropriate remedial action can be taken. The surface water monitoring program is described in Module B5, “Environmental Monitoring Programs”, of this license application. Post-closure monitoring will be a continuation of the monitoring program with appropriate revisions.

4. Landfill Final Cover Inspection

The condition of the final cover will be inspected twice each year for the first 3-5 years of the post-closure period. If the cover and sidewalls are well maintained and show good stability, and the volume of leachate collected is reduced by 80-90% from average volumes collected prior to closure, then a proposal will be submitted to EGLE for approval requesting the inspection frequency be reduced to once each year. The inspection frequency change will not be implemented until approval is received by EGLE. Detailed inspection procedures are described in Appendix A11-8. Survey benchmarks used in establishing monitoring well and landfill elevations will also be maintained during the post-closure care period. DSC maintains a record of wastes placed in the landfill and their location with respect to permanently surveyed benchmarks in accordance with 40 CFR 264.309 & 310, as described in Module C3, Use and Management of Landfill, Section C3.G.

5. Perimeter Drainage Ditch

The perimeter drainage ditches are used to control run-on and runoff of water at the landfill. In order to ensure proper functioning, the drainage ditches will be inspected quarterly for any potential drainage problems, such as ditch erosion or blockage. Detailed inspection procedures are described in Appendix A11-8.

Planned Maintenance Activities [40 CFR 270.14(b)(13), 264.118(b)(2), MAC R 299.9613(1)]

Maintenance activities in the post-closure period will be performed as needed, based on the results of monitoring and inspection activities described above. Expected maintenance activities are described below.

Landfill Cover Maintenance [40 CFR 270.14(b)(13), 264.118(b)(2)(i), MAC R 299.9613(1)]

Based on the results of the landfill final cover, sidewall and perimeter ditch inspections, as described in Appendix A11-8, repairs will be made as needed during the post-closure care period to maintain the integrity of the closed unit. Maintenance activities may include seeding and mulching, erosion repair, cleaning of ditches and catch basins and the use of erosion control mats on the landfill sidewalls, if needed.

Monitoring Equipment Maintenance [40 CFR 270.14(b)(13), 264.118(b)(2)(ii), MAC R 299.9613(1)]

Routine maintenance for this system will include cleaning of the leachate collection pipes and manholes. Repairs to leachate piping, the flow measuring system, and manholes will be performed as needed, based on observations made during sampling and at regular landfill inspections.

Shallow and deep groundwater monitoring wells will be maintained throughout the post-closure care period to permit continued monitoring as required. The Waste Management Division will be notified if any wells must be replaced due to damage. Survey benchmarks used in establishing monitoring well and landfill elevations will also be maintained during the post-closure care period.

A11.B.5 Postclosure Care Plan Amendment

[R 299.9613 and 40 CFR §264.118(d)]

The Postclosure Care Plan will be amended whenever:

1. Changes in the operations or facility design will affect closure and postclosure care; or
2. There is a change in the expected year of closure, if applicable; or
3. Unexpected events during closure require a modification to the plan; or
4. The monitoring is ineffective or inefficient.

A11.B.6 Certification of Postclosure

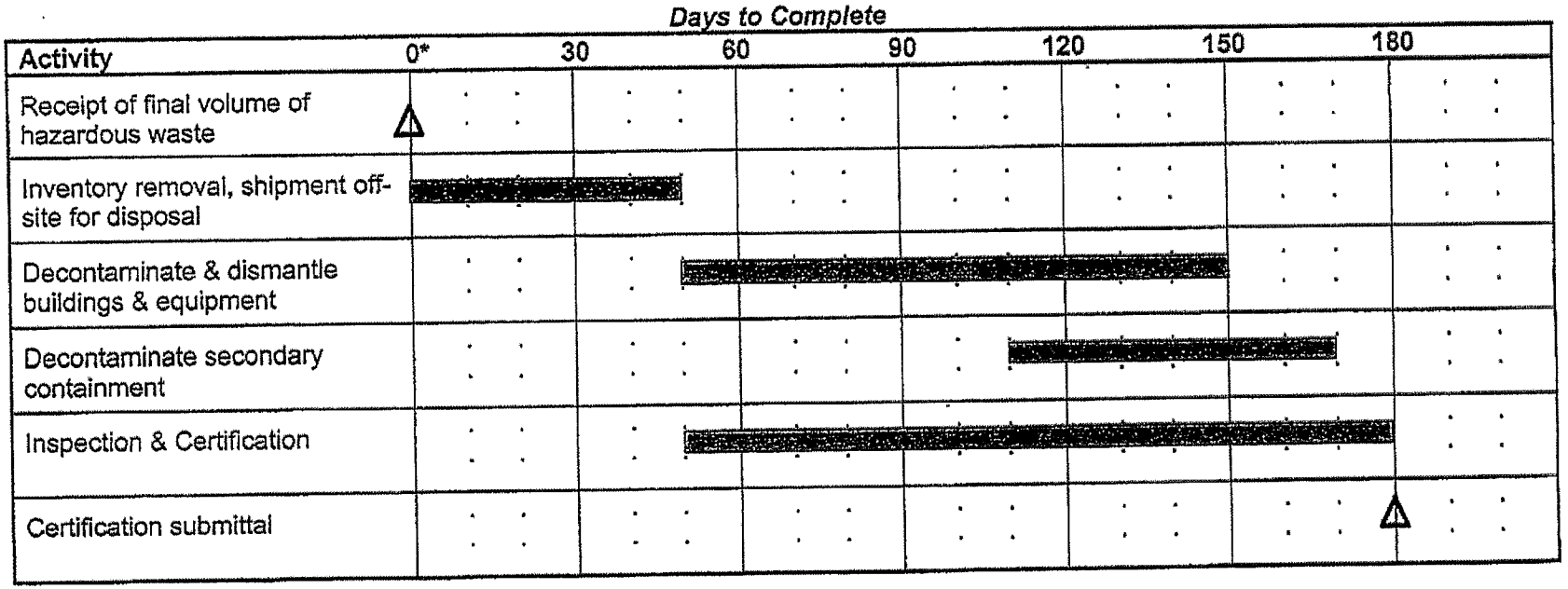
[R 299.9613]

Within 60 days of completion of postclosure care DSC will submit to the Director, by registered mail, a certification that postclosure care for the hazardous waste management unit or facility, as applicable, has been completed in accordance with the specifications in the approved postclosure plan. The certification will be signed by the owner/operator of Dow Silicones and by an independent registered professional engineer. Documentation supporting the independent registered engineer's certification will be furnished to the Director in accordance with R 299.9613(5). The DSC facility will maintain financial assurance for postclosure until the Director releases the DSC facility from the financial assurance requirements for postclosure under R 299.9703 and 40 CFR §264.143(i).

The certification must be worded as follows:

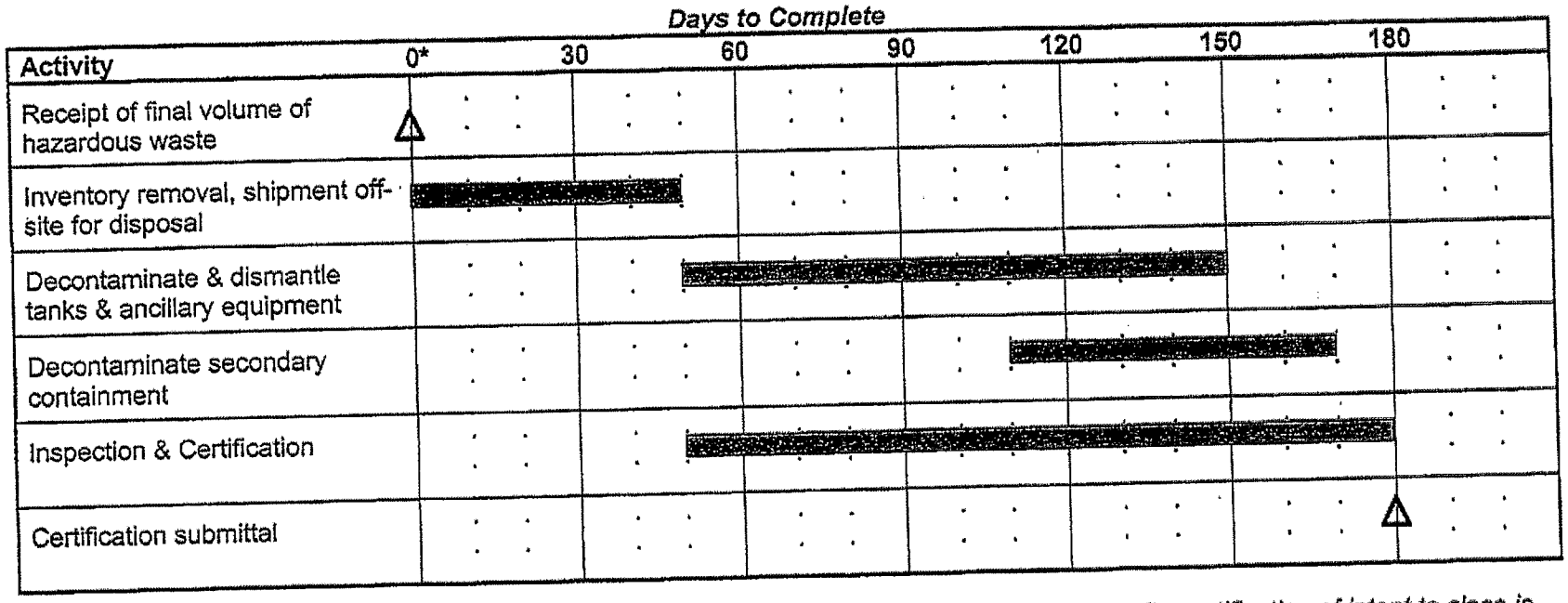
I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Closure Schedule for 801 & 809 Container Storage Areas
Dow Corning Midland Site



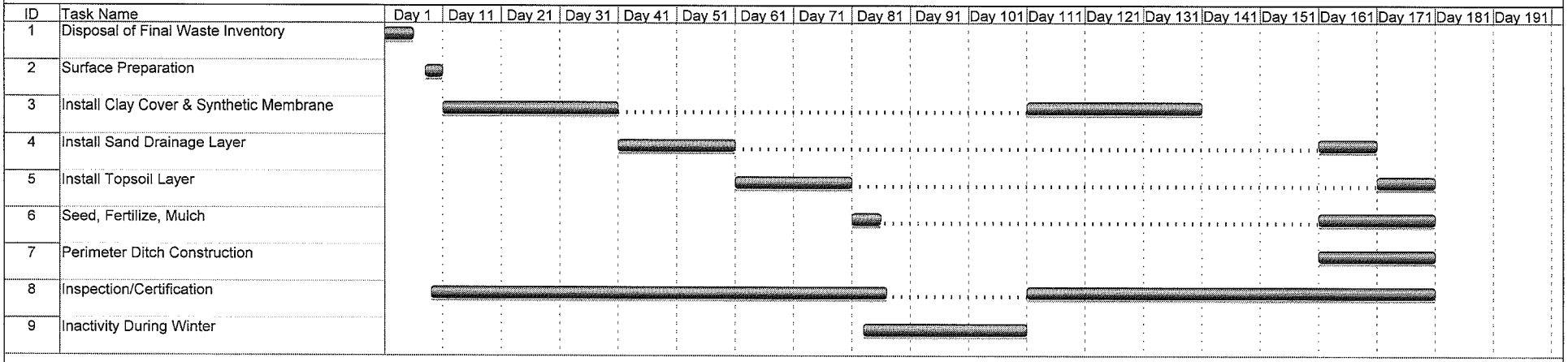
** Disposal of final waste inventory will begin after receipt of final waste volume, at least 60 days after notification of intent to close is submitted, with current or updated Closure Plan, to Michigan Department of Environmental Quality.*

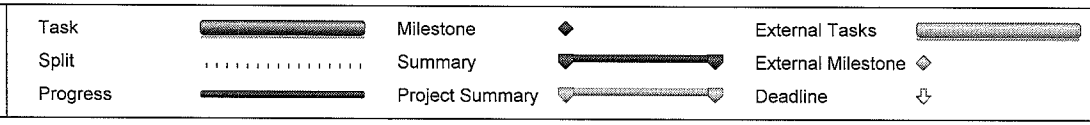
Closure Schedule for 806 Tank Storage Area
Dow Corning Midland Site



** Disposal of final waste inventory will begin after receipt of final waste volume, at least 60 days after notification of intent to close is submitted, with current or updated Closure Plan, to Michigan Department of Environmental Quality.*

Closure Schedule for 800/1000 Block Landfill
Dow Corning Midland Site





* Disposal of final waste inventory will begin after receipt of final waste volume, at least 60 days after notification of intent to close is submitted, with current or updated Closure Plan, to Michigan Department of Natural Resources and Environment.

Native Clay Test Results

Test	Method	Sample 1 Results	Sample 2 Results	Specification	Meets/Exceeds Specification?
1. Hydraulic Conductivity (@ compaction > 90%)	Falling Head	3.5×10^{-8} to 4.4×10^{-8} cm/sec.	1.7×10^{-8} to 5.8×10^{-8} cm/sec.	$< 1.0 \times 10^{-7}$ cm/sec.	Yes
2. Particle Size Distribution	ASTM C-136	82% < 5 μm	77% < 5 μm	Minimum 25% < 5 μm	Yes
3. Unified Soil Classification (Atterberg limits)	ASTM D-423, D-424	CL	CL	Must be type CL or CH	Yes
4. Soil density/moisture relationships: (No regulatory specification, but data will be used during cover construction to ensure required moisture content range after compaction is met.)					
a. Maximum density	ASTM D-1557	119.2 lb/ft^3	118.5 lb/ft^3	none	n/a
b. Optimum moisture	ASTM D-1557	13.9	14.5	none	n/a
c. Natural moisture	ASTM D-2216	15.0	16.1	none	n/a

Construction Specifications for
Installation of Compacted Cover System

Hazardous Waste Land Disposal Facility

Dow Corning Corp.
Midland, Michigan

CONTENTS

Installation of Compacted Cover System

Section 1: Excavating and Backfilling

I. Summary of Work

A. The following work will be performed to implement closure of the landfill:

1. Grade existing surfaces.
2. Place fill material as required.
3. Grade and compact fill material.
4. Install compacted clay layer.
5. Install drainage layers and discharge toe aggregate.
6. Construct flat bottom ditch around perimeter.
7. Install culverts and access road.
8. Place rip rap at discharge areas to Lingle Drain.
9. Spread topsoil, seed, and sod.
10. All equipment and materials to perform the work provided by contractor.

B. Sequence of Construction

1. Cover system to be completed within two construction seasons.
2. A "construction season" is defined as the period between April 15 and November 15.
3. Maximum uncompleted portion of cover system carried over into second construction season is 15,000 yd^2.

II. Excavation and Backfilling

A. This section encompasses the work required for all excavating and backfilling , including the following:

1. Grading and preparation of cover system waste foundation;
2. Providing and placing compacted clay layer;
3. Providing and placing sand layer.

B. Definitions:

1. Maximum density: Maximum dry weight in pounds per cubic foot of a specific soil (ASTM D-1557-70).
2. Optimum moisture: Percentage of water at maximum density.

C. Job Conditions

1. Protection to underground utilities: Report all damage, and make repairs to utility owner's standard.
2. Interrupted utility service:
   a. Notice: Eight hours to occupants, of time and duration.
   b. Stand-by service: As required, not to exceed four hours.
3. Other jurisdictions: Comply with permit conditions.
4. Scheduling: Clean up promptly following utility installation backfilling.
5. Maintenance: Unimproved areas: Fill settlement to adjacent grade

D. Materials

1. Backfill:
   a. Cover system waste foundation: Suitable on-site nonregulated waste material or soil borrow from site, as designated by Dow Corning representative.
   b. Clay layer:

i. Unified Soil Classification: CL or CH, as determined by ASTM D-4318.
ii. Gradation of particles: Greater than 25% of particles must be less than 5 microns in diameter, as determined by ASTM D-1140.
iii. Permeability: Less than 1.0×10^{-7} cm/sec, as determined by the falling head method (reference *Engineering Properties of Soils and Their Measurement*; Bowles, Joseph E.; 1970, McGraw-Hill Publishing Company), or ASTM D-2435-80.
iv. Free of cinders, ashes, refuse, sod, vegetable or other organic matter, and boulders, rock, or pavement.

c. Sand drainage gravel layer: MDOT 8.02.06, Class IIa.
d. Toe discharge aggregate: MDOT 6AA, maximum particle size 2 inches.
e. Geotextile fabric: Mirafi 700X or similar approved.
f. Culvert:
i. Corrugated metal pipe (CMP)
ii. Wall thickness: 0.064 inches

III. Execution

A. Clearing
1. Clear as Required

B. Excavation
1. General: Surplus and rejected unsuitable excavated material becomes property of Contractor for disposal.
2. Trenches:
a. Storage: Avoid property damage.
b. Depth: Provide a uniform and continuous bearing and support on solid and undisturbed material.
c. Minimum width: Allow space for jointing and bedding.
d. Unsuitable material below payment line: Notify Engineer and obtain instructions to proceed.

C. Backfilling
1. Trenches
a. Bedding area: Compact granular material to 90% of maximum density.
b. Trench backfill area:
i. Undercut structures:
(a) Pervious soils: Compact native suitable excavated material to 85% of maximum density.
(b) Impervious soils: Compact native suitable excavated material in top 4 feet and balance native or optional granular material to 75% of maximum density.
ii. Under unpaved rights-of-way areas: Compact suitable excavated material to 85% of maximum density.
iii. Under unimproved areas:

(a) Suitable excavated material: Compact to 75% of maximum density and round neatly over trench.
(b) Unsuitable excavated material: Replace and round neatly over trench.

2. Landfill
   a. Waste used for backfill: Compact to 85% of maximum density.
   b. Compacted clay layer:
      i. Compact to 90% of maximum density.
      ii. Maximum lift thickness 9.0 inches loose measure, 6.0 inches compacted.
      iii. Compact at moisture content between 2% below and 5% above optimum moisture content, as determined by the Modified Proctor Test (ASTM D-1557-70).
   c. Sand drainage layer: Compact to 85% of maximum density.
   d. Tolerances
      i. Vertical, ± 0.2 ft.
      ii. Horizontal, ± 0.5 ft.

IV. Field Quality Control
   A. General Testing & Inspection
      1. Supervision: By Engineer
      2. Description: See "Construction Quality Control/Quality Assurance Procedures", Appendix 2M-5.
      3. Access to test location and depth: Contractor to furnish equipment and personnel.
      4. Frequency of test: As described in "Construction Quality Control/Quality Assurance Procedures", Appendix 2M-5.
   B. Compaction Testing
      1. Performance and test equipment: By Engineer
      2. Moisture - density relation: ASTM D-1557-70 (Modified Proctor).
      3. Field Density: ASTM D-2922.
   C. Grading
      1. Surveyed 100-foot grid by Engineer.
      2. Tolerances: Vertical, ± 0.2 ft.; Horizontal, ± 0.5 ft.

Section 2: Drainage Water Collection System

I. General
   A. Description
      1. Work Included: This section encompasses the work required for all drainage pipe and structures.
      2. Definitions: Line and grade control terminology: Article III.E. Schedules.
   B. Submittals
      1. Test Specimens: Division 1 Submittals and Quality Control
      2. Line and Grade Control: Specify
   C. Job Conditions
      1. Existing Drainage System: Maintain operational.

2. Scheduling: Service line, catch basin, and inlet lead installation: As drainage pipe laying progresses and within clean-up limitations.

II. Products
A. Materials
1. Underdrains
a. 6.0 inch perforated underdrain - Polyvinyl Chloride (PVC) conforming to MDOR 8.10.04 j & k, or Polyethylene conforming to ASTM 405.
b. Underdrains 3-6 inch diameter shall be wrapped with a continuous filter sock weighing approximately 3 oz. per square yard, as manufactured by Advanced Drainage Systems, or equal.
c. Corrugated Polyethylene Tubing 8-15 inch, ASTM F-667
2. Junction Boxes
a. Concrete pip - 24 inch ASTM C76 Class III.
b. Cover - East Jordan #6324
3. Rip Rap - MDOT 819.02

III. Execution
A. Preparation
1. Alignment and Grade
a. Deviations: Notify Engineer and obtain instructions to proceed where there is a grade discrepancy or an obstruction not shown on the plans.
b. Line and grade control
i. Laser beam
(a) Check points: At set-up point, 25 feet, 50 feet, 100 feet and 100 foot points thereafter to the next set-up point.
(b) Projector advancement: Reset at each manhole with 600 foot maximum.
ii. Batter and grade boards.
iii. Other - Engineer approval required.
2. Bedding
a. Method: Article III.E. Schedules
b. Bedding area backfill: Section 2, "Excavating and Backfilling"
c. Bearing: Support entire length of pipe barrel evenly.
B. Installation
1. Laying pipe
a. General
i. Direction: Upstream with spigot or tongue end downstream.
ii. Joints: Smooth and clean.
iii. Bedding: Method I or II.
iv. Placement: Pipe length and bedding as a unit in a frost free, dry trench.
v. Special supports and saddles: Article III.E., "Schedules".
2. Jointing
a. General

i. Standard
(a) Joint space: fill completely.
(b) Inside: Remove excess material and trowel over 24 inch diameter.
ii. Premium
(a) Solvents, adhesives, and lubricants: Furnished by Manufacturer.
(b) Seating: Fully
(c) Gasket position: Check

3. Junction Boxes
a. Base
i. Cast in place: On undisturbed, frost, free, dry subgrade.
ii. Precast unit - On pea gravel with full and even bearing.
b. Precast: Fill joint space completely and trowel.
c. Casting
i. Manhole Setting
(a) Existing pavement: Existing grade.
(b) Gravel grade: 4 inches below.
(c) Unpaved areas: Finished grade.
ii. Catch basin setting
(a) Gutter grade: ½ inch below.
(b) Unpaved areas: 6 inches below finished grade.

4. Connections
a. Existing drainage system
i. Structures: Relay and repoint loose blocks and bricks.

C. Field Quality Control
1. Testing and Inspection
a. General
i. Supervision: By Engineer.
ii. Completion: Before connecting to active system.
iii. Notification: Clean and arrange with Engineer for inspection.
b. Line and Grade: Allowable drift between structures from proposed alignment,
i. Line: 0.40 foot.
ii. Grade: 0.05 foot.

D. Adjust and Clean
1. General
a. Keep pipe and structures clean as work progresses.

E. Schedules
1. Standard Details
a. Line and grade control terminology.
b. Special supports for underground utilities.
c. Pipe saddles.
d. Methods of bedding pipe.

Section 3: Grass and Ground Covers

I. General
- A. Description
  1. Work included: This section encompasses work required for topsoil, seeding, sodding, fertilizing, and mulching.
- B. Submittals
  1. Topsoil analysis: Certification of suitability by local agricultural agent.
  2. Seed analysis: Certification of purity and germination by manufacturer.
- C. Job Conditions
  1. Landfill cover area: Restoration by seeding.
  2. Ditch area: Restoration by sodding.
  3. Seasonal limitations
     - a. Sodding: None
     - b. Seeding: Spring, summer and fall, with mulching June 1 to September 1.
  4. Scheduling
     - a. Restoration: Promptly following the installation.
     - b. Cleanup: Promptly following lawn placement.

II. Products
- A. Materials
  1. Chemical fertilizer: Grade 12:12:12
  2. Grass seed, cover area: MDOT 8.21.09: 20% perennial ryegrass, 30% Kentucky bluegrass, 10% red top, 10% alsike, 30% creeping red fescue.
  3. Sod, ditch area: MDOT 6.51.02 Class B.
  4. Mulch: Straw, marsh hay or wood excelsior.
  5. Hydraulic seeding: Meet paragraphs 1 and 2, above, and provide manufactured mulch.

III. Execution
- A. Preparation
  1. Inspection, landfill cover and ditches: Approval required.
- B. Performance
  1. Seeding
     - a. Construction methods: MDOT 6.52.03 through 6.52.05, with following rates:
       - i. Topsoil: 6 inches minimum.
       - ii. Fertilizer: 25 pounds per 1000 square feet.
       - iii. Sowing: Cover area - 3 pounds per 1000 square feet.
       - iv. Mulch: 150 pounds per 1000 square feet.
  2. Sodding
     - a. Construction methods: MDOT 6.51.03 and 6.51.04, with 4 inch topsoil, MDOT 6.52.03.

Section 4: Soil and Erosion Control

I. General
   - A. Description: Provide temporary erosion and sedimentation control.
   - B. Submittals
     1. Submit plan for approval, indicating what steps will be taken to control any soil erosion and sedimentation.
     2. Upon approval of plan, a soil erosion permit from the Midland County Drain Commission may be obtained.
   - C. Job Conditions: The Contractor shall clean up temporary facilities within one week after erosion control measure is no longer needed.

II. Execution
   - A. Performance: The Contractor shall abide by all applicable rules and regulations as established by the State of Michigan and Midland County Drain Commission, in conjunction with Soil Erosion and Sedimentation Control Act (Act 347 P.S. of 1972) as amended.

TECHNICAL SPECIFICATION

FOR FLEXIBLE LINER MEMBRANE AND FILTER FABRIC

The geosynthetic clay liner and non-woven needle punched filter fabric that will be considered at the time of closure are:

1. GUNDLINE VLDPE smooth and textured liner, 60 mil thick by Gundle Lining Systems, Inc., Houston, TX.
   Similar products on the market at the time of closure will be looked at as well.

2. Non-woven filter fabric for separation of vegetative soils from drainage media.

   Polyfelt #700, 8 oz/sq.yd, by Polyfelt Inc., Atlanta, Ga.

   Supac # 8NP, by Phillips Fibers Corporation, Greenville, SC.

Specification of above products are attached herewith.

SPECIFICATIONS FOR GUNDLINE VLDPE SMOOTH LINER

Property	Test Method	Unit	20	30	40	60
Thickness	ASTM D1593	Mils	18-23	27-35	36-46	54-69
Density	ASTM D1505 Condition A	g/cc	.89 min.	.89 min.	.89 min.	.89 min.
Melt Flow Index	ASTM D1238 Condition E (190°c,2.16 kg.)	1.1 max.	1.1 max.	1.1 max.	1.1 max.	1.1 max.
Carbon Black % Carbon Black Dispersion	ASTM D1603 ASTM D3015	%	2-3 A-1,A-2,B-1	2-3 A-1,A-2,B-1	2-3 A-1,A-2,B-1	2-3 A-1,A-2,B-1
Tensile Properties	ASTM D638 Modified Type IV Dumb-bell @ 2 ipm					
Strength Yield		PPI	63	94	126	189
Elongation at Break		PPI	900	900	900	900
Tear Resistance	ASTM D1004 Die C	Pounds	10	12	18	27
Puncture Resistance	FTMS 101B 2065	Pounds	38	51	64	75
Environmental Stress Crack	ASTM D1693 10 % Igepal, 50°C	Hours	1500 min.	1500 min.	1500 min.	1500 min.
Dimensional Stability	ASTM D1204 212°F 1 hour	% of change	+ /-2	+ /-2	+ /-2	+ /-2
Resistance to Soil Burial	ASTM D3083 Using ASTM D 638	% of change	+ /-10	+ /-10	+ /-10	+ /-10
Thermal Stability OIT	ASTM D3083 130°C, 800 $PSIO_2$	Minutes	2000 min.	2000 min.	2000 min.	2000 min.
Low Temp. Brittleness	ASTM D746 Procedure B	Degree F	-112 max.	-112 max.	-112 max.	-112 max.
Coefficient of Linear Thermal Expansion	ASTM D696	$x10^{-4}$/cm /cm°C	2.0	2.0	2.0	2.0
Harness Type D	ASTM D2240		40	40	40	40
Volatile Loss	ASTM D1203	%	.3 max.	.3 max.	.3 max.	.3 max.
Water Absorption	ASTM D570	%	.1 max.	.1 max.	.1 max.	.1 max.
Hydrostatic Resistance	ASTM D571	PSI	100	140	180	220
Water Vapor Transmission	ASTM E96	g/m^2/day	.1 max.	.1 max.	.1 max.	.1 max.

SPECIFICATIONS FOR GUNDLINE VLDPE TEXTURED LINER

Property	Test Method	Unit	30	40	60	80
Thickness	ASTM D1593	Mils	27-35	36-46	54-69	72-92
Density	ASTM D1505 Condition A	g/cc	.89 min.	.89 min	.89 min.	.89 min.
Melt Flow Index	ASTM D1238 Condition E (190°c,2.16 kg.)	1.1 max.	1.1 max.	1.1 max.	1.1 max.	1.1 max.
Carbon Black %	ASTM D1603	%	2-3	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D3015		A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1	A-1,A-2,B-1
Tensile Properties	ASTM D638 Modified Type IV Dumb-bell @ 2 ipm					
Strength Yield		PPI	45	55	70	85
Elongation at Break		PPI	300	300	300	300
Tear Resistance	ASTM D1004 Die C	Pounds	12	16	24	30
Puncture Resistance	FTMS 101B 2065	Pounds	26	38	57	70
Environmental Stress Crack	ASTM D1693 10 % Igepal, 50°C	Hours	1500 min.	1500 min.	1500 min.	1500 min.
Dimensional Stability	ASTM D1204 212°F 1 hour	% of change	+/-2	+/-2	+/-2	+/-2
Resistance to Soil Burial	ASTM D3083 Using ASTM D 638	% of change	+/-10	+/-10	+/-10	+/-10
Thermal Stability OIT	ASTM D3083 130°C, 800 PSIO_2	Minutes	2000 min.	2000 min.	2000 min.	2000 min.
Low Temp. Brittleness	ASTM D746 Procedure B	Degree F	-112 max.	-112 max.	-112 max.	-112 max.
Coefficient of Linear Thermal Expansion	ASTM D696	$x10^{-4}$/cm /cm°C	2.0	2.0	2.0	2.0
Harness Type D	ASTM D2240		35	35	35	35
Volatile Loss	ASTM D1203	%	.3 max.	.3 max.	.3 max.	.3 max.
Water Absorption	ASTM D570	%	.1 max.	.1 max.	.1 max.	.1 max.
Hydrostatic Resistance	ASTM D571	PSI	100	140	180	220
Water Vapor Transmission	ASTM E96	g/m^2/day	.1 max.	.1 max.	.1 max.	.1 max.

Product Specifications

TYPICAL ROLL PROPERTIES

PROPERTY	TEST PROCEDURE	UNIT	POLYFELT 420	550	559	599	610	709	759	800	900	1000	PGM 13	15	20
PHYSICAL															
Weight	ASTM D3776	oz/yd²	3.8	4.5	5.5	6.0	7.0	8.3	10.3	12.0	14.0	16.2	3.6	4.2	6.0
Thickness	ASTM D1777	mils	55	60	70	80	90	105	120	130	150	160	55	60	80
Asphalt Retention	ITI 25 Mem. 8	gal/yd²											0.22	0.27	0.33
MECHANICAL															
Grab Tensile	ASTM D4632	lbs	110	125	150	170	190	225	280	325	380/320	470/350	100	120	160
Grab Elongation	ASTM D4632	%	>50	>50	>50	>50	>50	>50	>50	>60	85/90	90/95	>50	>50	>50
Wide Width Tensile	ASTM D4595	lb/in	45	50	65	75	85	100	120	135	145	150			
Elongation at Break	ASTM D4595	%	>50	>50	>50	>50	>50	>50	>55	>55	>80	>80			
Puncture Resistance	ASTM D4833	lbs	55	65	70	85	100	115	130	150	155	170	55	60	85
Trapezoidal Tear	ASTM D4533	lbs	50	60	70	75	85	100	115	130	150/135	170/140	50	55	75
Mullen Burst	ASTM D3786	psi	155	185	230	255	295	345	425	450	470	490			
HYDRAULIC															
Water Flow Rate	ASTM D4491	gpm/ft²	250	220	190	170	140	130	100	90	80	65			
Permittivity	ASTM D4491	sec⁻¹	2.9	2.7	2.3	2.0	1.8	1.6	1.3	1.2	0.9	0.8			
Permeability K_n	ASTM D4491	cm/sec	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.35	0.35			
Transmissivity at	ASTM D4716	gpm/ft (x10⁻²)													
0.3 psi			6.7	7.0	8.5	9.5	10.0	11.0	11.5	12	13.0	15.0			
14.5 psi			2.7	3.0	3.8	4.0	5.0	7.0	7.0	7.0	7.0	7.0			
29.0 psi			1.6	2.0	2.5	3.0	3.5	4.0	4.0	4.0	4.0	4.0			
AOS	ASTM D4751	sieve size	70-35	80-40	80-45	100-60	100-70	120-80	140-100	140-100	>140	>140			
		mm	0.20-0.5	0.18-0.42	0.18-0.35	0.15-0.25	0.15-0.21	0.12-0.18	0.10-0.15	0.10-0.15	<0.10	<0.10			
ENDURANCE															
UV Resistance (500 hours)	ASTM D4355	% str. ret.	>85	>85	>85	>85	>85	>85	>90	>90	>90	>90			
pH Resistance			2-13	2-13	2-13	2-13	2-13	2-13	2-13	2-13	2-13	2-13	2-13	2-13	2-13

MINIMUM AVERAGE ROLL PROPERTIES

PROPERTY															
Grab Tensile	ASTM D4632	lbs	90	110	130	140	170	205	245	300	310	320	90	100	140
Grab Elongation	ASTM D4632	%	50	50	50	50	50	50	50	60	80	80			
Puncture Resistance	ASTM D4833	lbs	45	50	60	70	85	95	115	130	135	140	45	50	70
Trapezoidal Tear	ASTM D4533	lbs	45	50	60	65	75	85	95	105	110	120	45	50	65
Mullen Burst	ASTM D3786	psi	135	160	200	220	260	300	380	400	425	450			

*MD/CD

PACKAGING

ROLL*														
Width, ft	15	15	15	15	15	15	14	12	10	10	12.5	12.5	12.5	
Length, ft	360	360	360	360	360	360	300	300	300	300	400	575	360	
Area, yd²	600	600	600	600	600	600	467	433	333	333	556	799	500	
Weight, lbs	150	180	215	235	275	320	310	335	300	345	148	231	200	

Nonstandard roll dimensions are available on request and subject to a minimum quantity. Mechanical properties based on standard roll width.

11/89

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Polyfelt's worldwide manufacturing, distribution and application engineering services are available to assist you with your geotextile project. Please contact our regional office nearest you.

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Telefax: 6 (031 7347197

polyfelt

UPAC® geotextiles — no. .oven and woven fabrics

NONWOVENS

		AASHTO M-288					GENERAL USE											EXTENDED UV EXPOSURE	
PROPERTY	STANDARD TEST PROCEDURE	3 NPH L17854	4 NPH L17856	4.5 NPH L17858	7 NPH L17853	8 NPH L17855	3.5 NP L17001	4 NP L17002	5 NP L17004	6 NP L17005	8 NP L17009	10 NP L17013	11 NP L17015	12 NP L17017	13.5 NP L17020	16 NP L17025	30 NP L17863	4 NPX L17902	8 NPX L17909
APPLICATION		DRAIN-AGE CLASS B	EROSION CONTROL CLASS B	MED-SURV SEP/STAB	DRAINAGE CLASS A HIGH SURV SEP/STAB	EROSION CONTROL CLASS A	D, S/S, F	D, S/S, F,P,E	D, S/S, F,P,E	D, S/S, F,P,E	D, S/S, F,P,E O/C, R	D, S/S F,P,E O/C, R	D, S/S, F,P,E O/C, R	D, S/S, F,P,E O/C, R	D, S/S, F,P,E O/C, R	D, S/S, F,P,E O/C, R	D, S/S, F,P,E O/C, R	D, S/S F,P,E	D, S/S F,P,E O/C, R
TENSILE STRENGTH pounds	ASTM D-4632	80	90	115	180	200	90	100	130	145	200	250	280	300	330	390	630	100	200
ELONGATION percent	ASTM D-4632	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	70	50	50
PUNCTURE STRENGTH pounds	ASTM D-4833	25	40	40	80	80	52	60	75	82	112	142	155	165	180	205	340	60	112
MULLEN BURST STRENGTH, psi	ASTM D-3786	130	150	150	290	320	185	215	265	295	400	505	540	585	640	740	1000	215	400
TRAPEZOIDAL TEAR STRENGTH, pounds	ASTM D-4533	25	30	40	75	50	37	42	53	58	75	93	100	106	115	130	210	42	75
ABRASION RESISTANCE % Str. Ret.	ASTM D-4885						80	80	80	80	90	90	90	90	90	90	90	80	90
COEFFICIENT of PERMEABILITY, cm/sec	ASTM D-4491	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.1	0.10	0.15	0.2	0.2	0.2	0.2	0.2	0.25	0.2	0.15
FLOW RATE gpm/sf	ASTM D-4491	135	135	130	130	115	110	140	115	110	105	85	80	75	65	50	25	140	105
PERMITTIVITY second-1	ASTM D-4491	1.5	1.5	1.4	1.8	1.4	1.7	2.0	1.55	1.5	1.3	1.1	1.0	0.9	0.75	0.49	0.30	2.0	1.3
APPARENT OPENING SIZE, US Std Sieve	ASTM D-4751	70 - 100	70 - 100	70 - 100	70	70	70 - 100	70 - 100	70 - 100	70	70	70	100	100	100	100	140	70 - 100	70 - 140
UV STABILITY strength % @ ___ hrs.	ASTM D-4355	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 150	70 500	70 500
STANDARD ROLL SIZES 180'	LINEAR YARDS	100	100	100	60	60	100	100	100	100	60	60	60	60	60	40		100	60
	SQUARE YARDS	500	500	500	300	300	500	500	500	500	300	300	300	300	300	200		500	300
150'	LINEAR YARDS	120	120	120	72	72	120	120	120	120	72	72	72	72	72	48	33	120	72
	SQUARE YARDS	500	500	500	300	300	500	500	500	500	300	300	300	300	300	200	137.5	500	300

PHILLIPS FIBERS CERTIFIABLE PROPERTIES MINIMUM AVERAGE ROLL VALUES WEAKEST PRINCIPAL DIRECTION

S/S SEPARATION/STABILIZATION
R REINFORCEMENT
F FILTRATION
D DRAINAGE
P PROTECTION
E EROSION CONTROL
O/C OTHER OR COMBINATION

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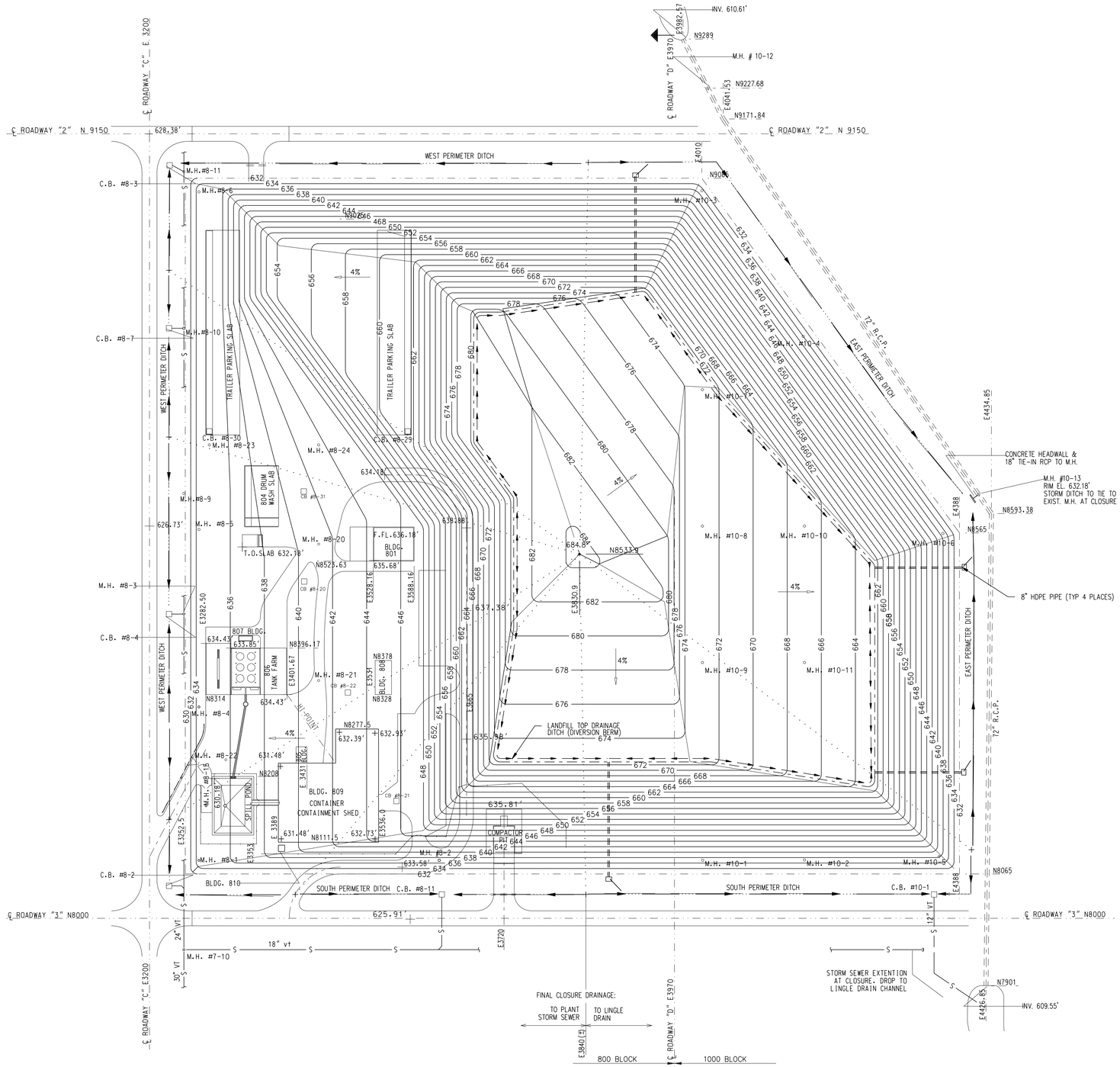
PHILLIPS FIBERS CORPORATION
A SUBSIDIARY OF PHILLIPS PETROLEUM COMPANY
ENGINEERED PRODUCTS MARKETING
P.O. BOX 66 GREENVILLE, SC 29602 (803) 242-6500

February 1993

When quoting on a Tensile Strength value that is tested wet, increase the Tensile Strength value listed in the chart for 3NP through 6NP by 20% and for 6.5NP and higher weight fabrics by 10%
When quoting on a Tensile Strength value that is tested employing a 1" x 1" jaw instead of the standard 1" x 2" jaw of ASTMD-4632, decrease the listed Tensile Strength chart results by 10%

see other side



NOTES:

1. FINAL CONTOURS ARE BASED ON:
   A. TOTAL FILL VOLUME AT OR VERY CLOSE TO MAXIMUM LANDFILL VOLUME AS SPECIFIED IN LANDFILL CLOSURE PLAN DATED 5 – 1988.
   B. SIDE SLOPE = 4:1
      PLATEAU SLOPE = 4% MINIMUM
2. CONTOURS REPRESENT ELEVATION OF A CLOSURE CAP. ACTUAL ELEVATION OF FILL MATERIAL WILL BE 5.0' LOWER.

LAST GENERAL UPDATE: 04JAN2010

CADD

MARK	LOC.	REVISIONS	BY	DATE	APP
A	GEN	ADDED DRAINAGE DITCH & DRAINAGE PIPES	MCC	9-7-90	PC
B	GEN	UPDATED FINAL CLOSURE STORM DRAINAGE SYSTEM	RJF	25FEB93	PC
C	K-3	REVISED NOTE 2.	JKL	20NOV95	PC
D	GEN	UPDATED DRAWING	JAM	06NOV09	SFH
E	GEN	AECOM PERIMETER DITCH AND DIVERSION BERM FEATURES	DRB	09MAY11	TCR

DESIGNED BY: P. CHMELAR	DATE 5-11-90	
DRAWN BY: M.C. CARPENTER, W.A. KIBBE & ASSOC	DATE 5-11-90	
TECHNICAL APPROVAL: M.J. BUSH	DATE 5-25-90	
APPROVED FOR ISSUE: M.L. MARCHIONE	DATE 5-25-90	

REFERENCES

NUMBER	TITLE
Y1-36614	LANDFILL EXISTING TOPOGRAPHY
Y1-36619	LANDFILL SECTIONS
Y1-36620	LANDFILL SECTIONS

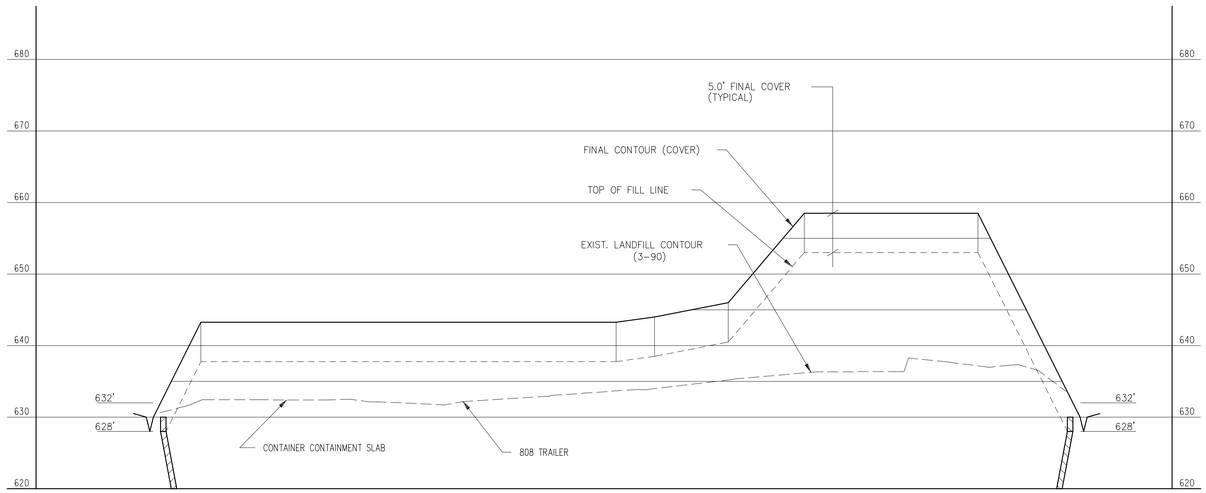
PWSS INFORMATION	ENGRG. DISC.	DWG. TYPE
	CA TOPO	PLAN

DOW CORNING CORPORATION

MIDLAND PLANT — 800 / 1000 BLOCK

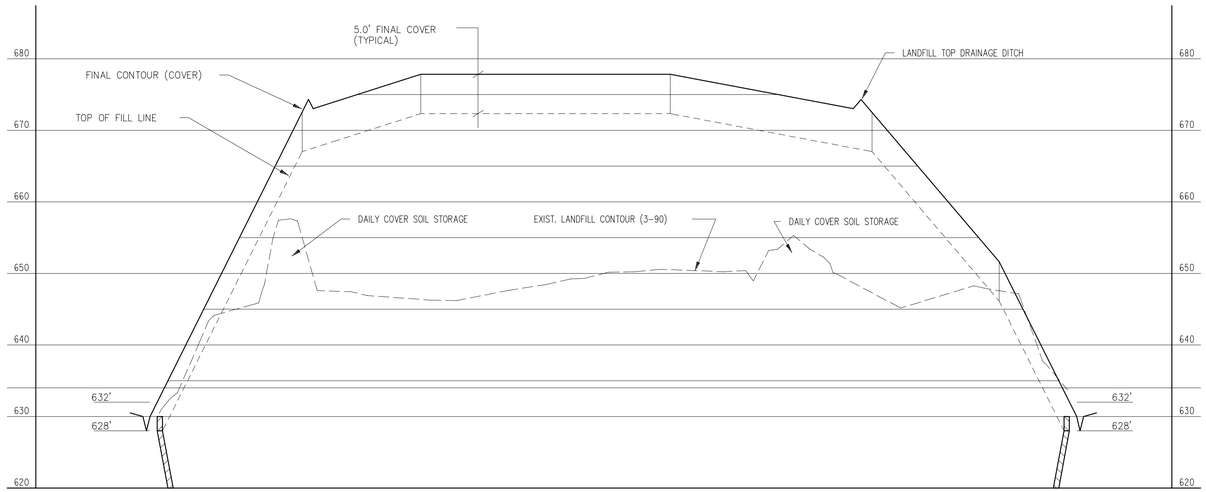
CLOSURE PLAN FOR
HAZARDOUS WASTE LANDFILL
FINAL TOPOGRAPHY

SCALE	INCH FOOT	DRAWING NUMBER	REVISION
	1" = 80'	Y1-36615	D



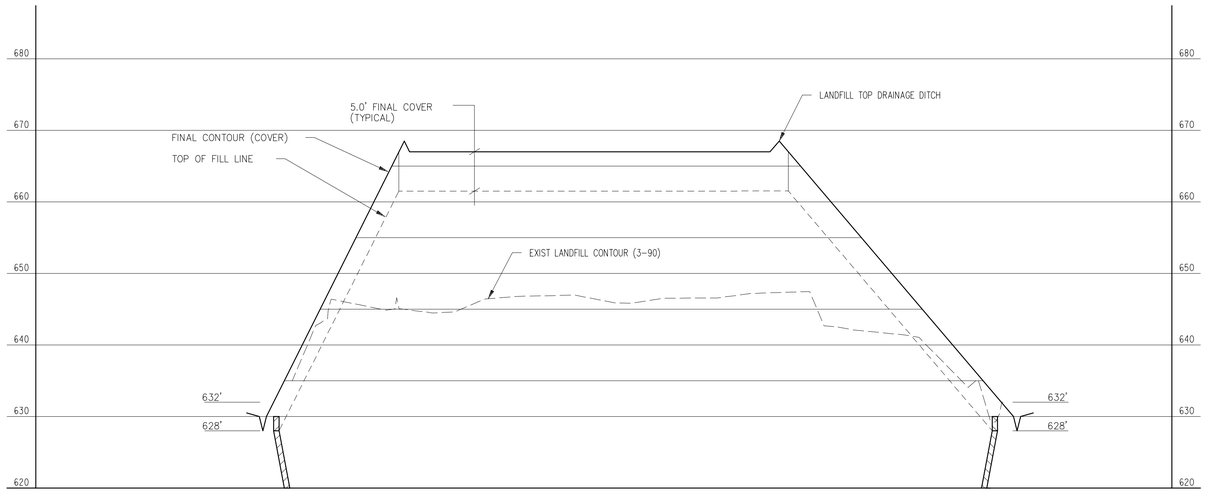
NORTH-SOUTH SECTION AT E3500 (LOOKING WEST)

SCALE: VERT. 1"=10'
HORZ. 1"=80'



NORTH-SOUTH SECTION AT E3970 (LOOKING WEST)

SCALE: VERT. 1"=10'
HORZ. 1"=80'



NORTH-SOUTH SECTION AT E4160 (LOOKING WEST)

SCALE: VERT. 1"=10'
HORZ. 1"=80'

LAST GENERAL UPDATE: 04JAN2010

CADD

MARK	LOC.	REVISIONS	BY	DATE	APP
A	GEN	ADDED DRAINAGE DITCH	MCC	9-18-90	PC
B	GEN	ADDED ALTERNATIVE COVER SYSTEM OUTLINE	RJF	26FEB93	PC
C	GEN	REVISED FINAL COVER COMPOSITION	RJF	270CT93	PC

DESIGNED BY: P. CHMELAR	DATE 5-18-90	
DRAWN BY: R.T.P. W.-T./EDMANDS	DATE 5-18-90	
TECHNICAL APPROVAL: M.J.BUSH	DATE 5-25-90	
APPROVED FOR ISSUE: M.L.MARCHIONE	DATE 5-25-90	

REFERENCES

NUMBER	TITLE
Y1-36614	LANDFILL EXISTING TOPOGRAPHY
Y1-36615	LANDFILL TOPOGRAPHY
Y1-36619	LANDFILL SECTIONS

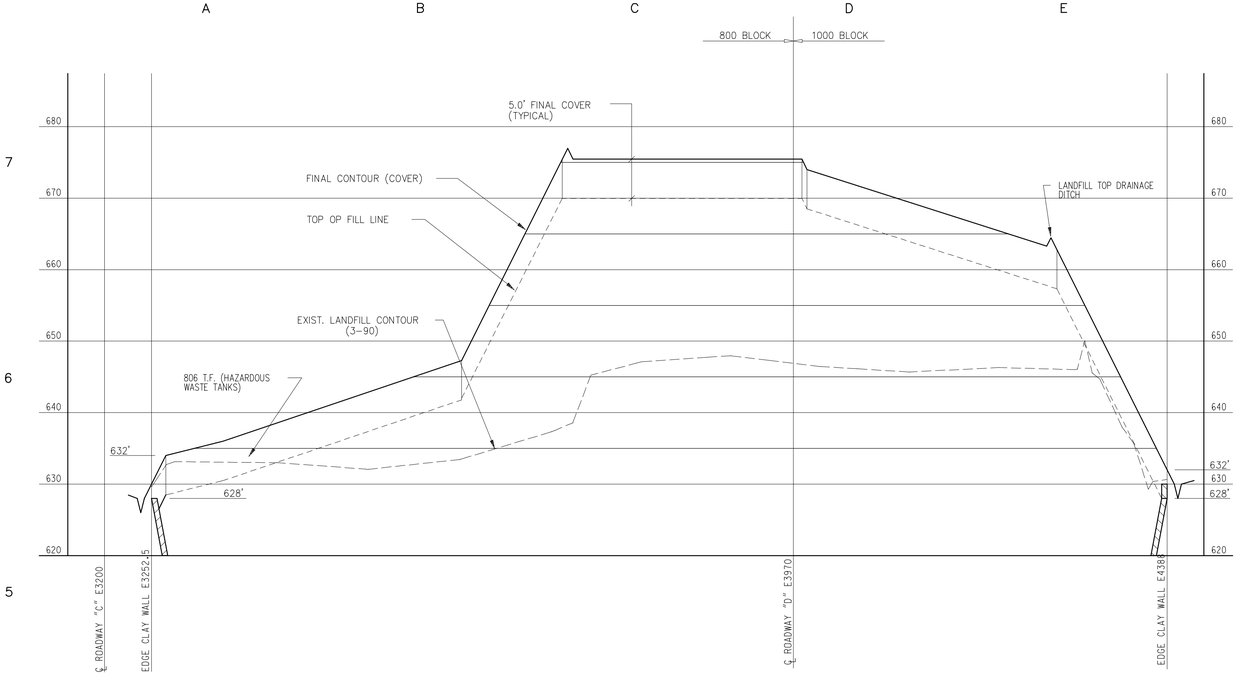
DOW CORNING CORPORATION

MIDLAND PLANT 800 / 1000 BLOCK

CLOSURE PLAN FOR
HAZARDOUS WASTE LANDFILL
FINAL TOPOGRAPHY - NORTH-SOUTH SECTIONS

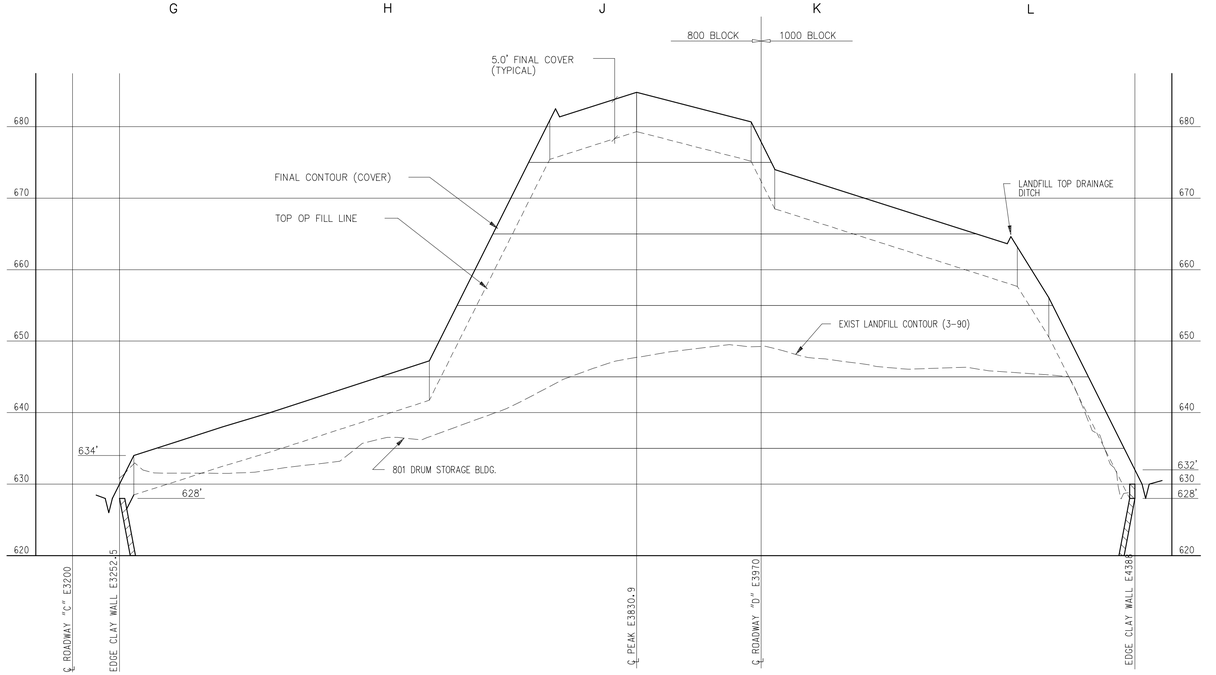
PMSS INFOR-MATION	ENGRG. DISC.	DWG. TYPE
	CA TOPO	SECTION

SCALE	INCH	FOOT	DRAWING NUMBER	REVISION
	1"	= 80'	Y1-36620	C



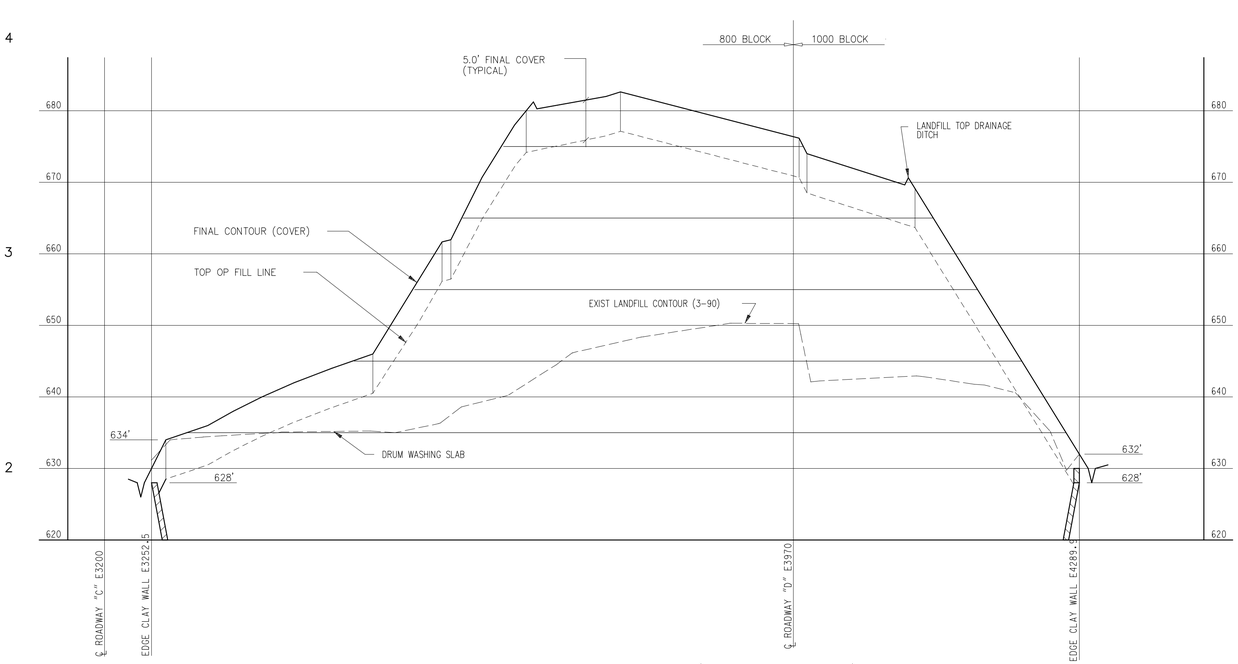
EAST–WEST SECTION AT N8300 (LOOKING NORTH)

SCALE: VERT. 1"=10'
HORZ. 1"=80'



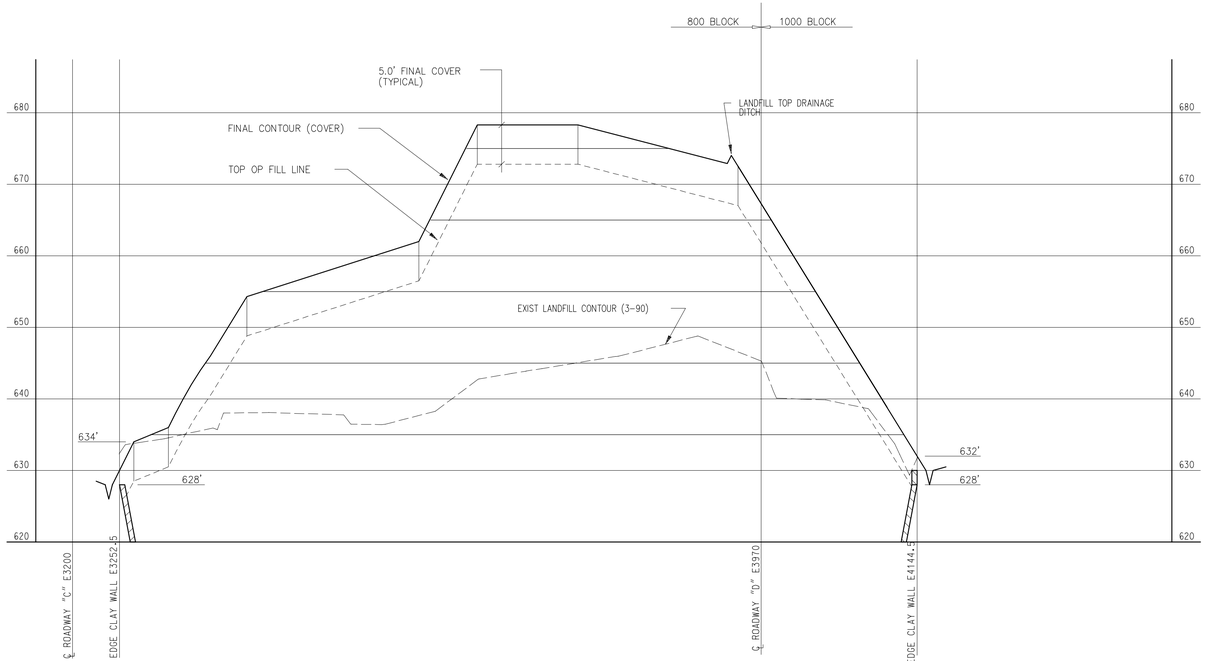
EAST–WEST SECTION AT N8533.9 (THROUGH PEAK)

SCALE: VERT. 1"=10'
HORZ. 1"=80'



EAST–WEST SECTION AT N8700 (LOOKING NORTH)

SCALE: VERT. 1"=10'
HORZ. 1"=80'



EAST–WEST SECTION AT N8900 (LOOKING NORTH)

SCALE: VERT. 1"=10'
HORZ. 1"=80'

LAST GENERAL UPDATE: 04JAN2010

CADD

MARK	LOC.	REVISIONS	BY	DATE	APP
A	GEN	ADDED DRAINAGE DITCH	MCC	9-18-90	PC
B	GEN	ADDED ALTERNATE COVER SYSTEM OUTLINE	RJF	26FEB93	PC
C	GEN	REVISED FINAL COVER COMPOSITION	RJF	27OCT93	PC

DESIGNED BY: P. CHMELAR	DATE 5-18-90	REFERENCES
DRAWN BY: R.T.P. W.-T./EDMANDS	DATE 5-18-90	NUMBER TITLE Y1-36614 LANDFILL EXISTING TOPOGRAPHY Y1-36615 LANDFILL TOPOGRAPHY Y1-36620 LANDFILL SECTIONS
TECHNICAL APPROVAL: M.J. BUSH	DATE 5-25-90	
APPROVED FOR ISSUE: M.L. MARCHIONE	DATE 5-25-90	PMSS INFORMATION: ENGRG. DISC. CA TOPO; DWG. TYPE SECTION

DOW CORNING CORPORATION

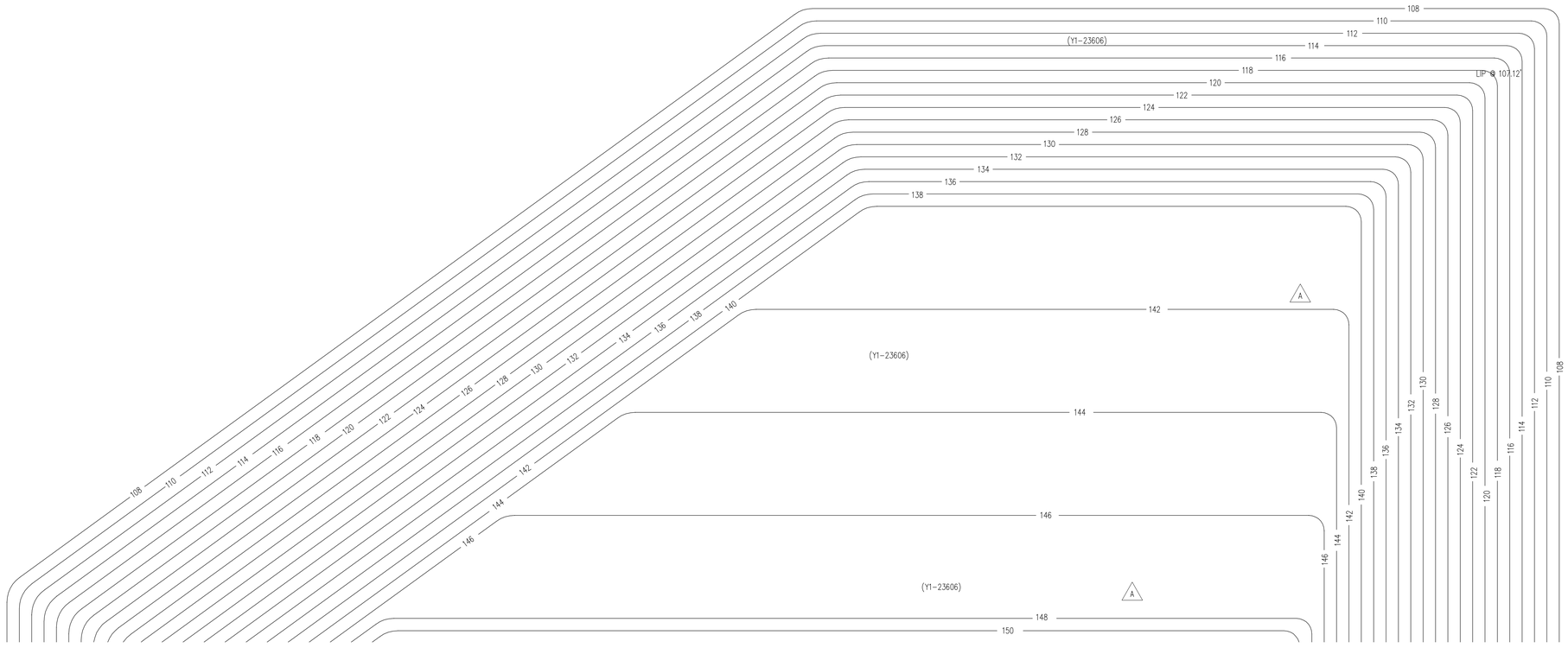
MIDLAND PLANT — 800 / 1000 BLOCK

CLOSURE PLAN FOR
HAZARDOUS WASTE LANDFILL
FINAL TOPOGRAPHY – EAST–WEST SECTIONS

SCALE	INCH FOOT	DRAWING NUMBER	REVISION
	1" = 80'	Y1-36619	C

NOTES:

1. THIS DRAWING REPRESENTS CURRENT SURFACE DRAINAGE IN 1000 BLOCK LANDFILL AREA SHOWING ACTIVE CATCH BASINS, CURRENT LANDFILL CELL AND PROJECTED FINAL CLOSURE CONTOURS BASED ON NATURAL CLAY COVER CLOSURE SYSTEM, AS SHOWN ON DWG. Y1-36615 – CLOSURE PLAN FINAL TOPOGRAPHY.
2. 4% SLOPE CHANGE IS NOT SHOWN ON THIS FIGURE. PRIOR TO CLOSURE, THIS DRAWING WILL BE UPDATED AND SUBMITTED FOR APPROVAL.



LAST GENERAL UPDATE: 04JAN2010

CADD

MARK	LOC.	REVISIONS	BY	DATE	APP
A	GEN	ADJUST ELEVATION ON C.B. #10-3 AND M.H. #10-9	RJF	23NOV92	PC
B	GEN	ADDED NOTE AND REFERENCE DWG.	RJF	02MAR93	PC
C	GEN	ADDED CHEM. SEWER LATERALS TO 800 BLOCK	RJF	12MAY93	NSD
D	GEN	GENERAL REVISIONS TO DATE	RJF	19APR94	NSD

DESIGNED BY: P. Chmelar	DATE 27FEB92
DRAWN BY: R.J. Fortier	DATE 30MAR92
TECHNICAL APPROVAL: P. Chmelar	DATE 31MAR92
APPROVED FOR ISSUE: M.J. Bush	DATE 31MAR92

REFERENCES

NUMBER	TITLE
Y1-33071	UNDERGROUND-NORTHEAST SECTION
Y1-33072	UNDERGROUND-SOUTHEAST SECTION
Y1-29958	UNDERGROUND-SOUTHWEST SECTION
Y1-33070	UNDERGROUND-NORTHWEST SECTION
Y1-86195	1000 BLOCK DRAINAGE
Y1-23606	LEACHATE COLLECTION SYSTEM

PMSS INFORMATION | ENGRG. DISC. CA TOPO | DWG. TYPE PLAN

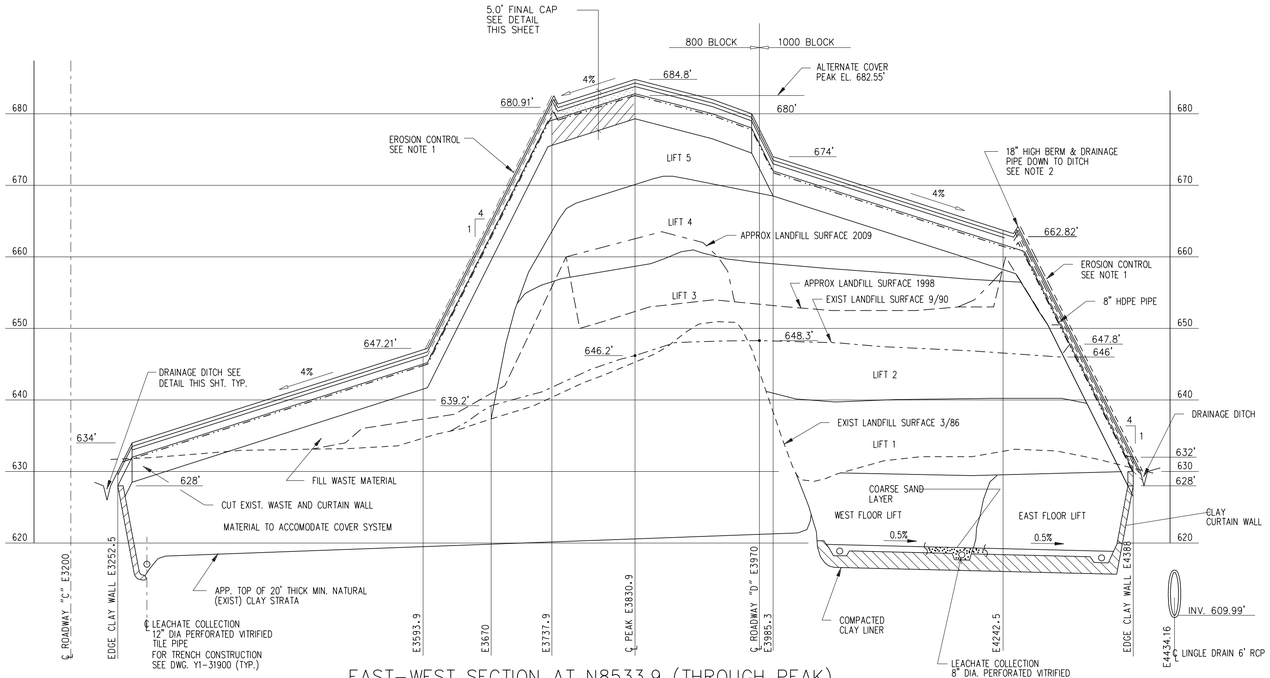
DOW CORNING CORPORATION

MIDLAND — 1000 BLOCK

LANDFILL CONTOURS
FINAL CLOSURE PLAN

SCALE	INCH	FOOT	DRAWING NUMBER	REVISION
	1"	= 40'	Y1-90671	D

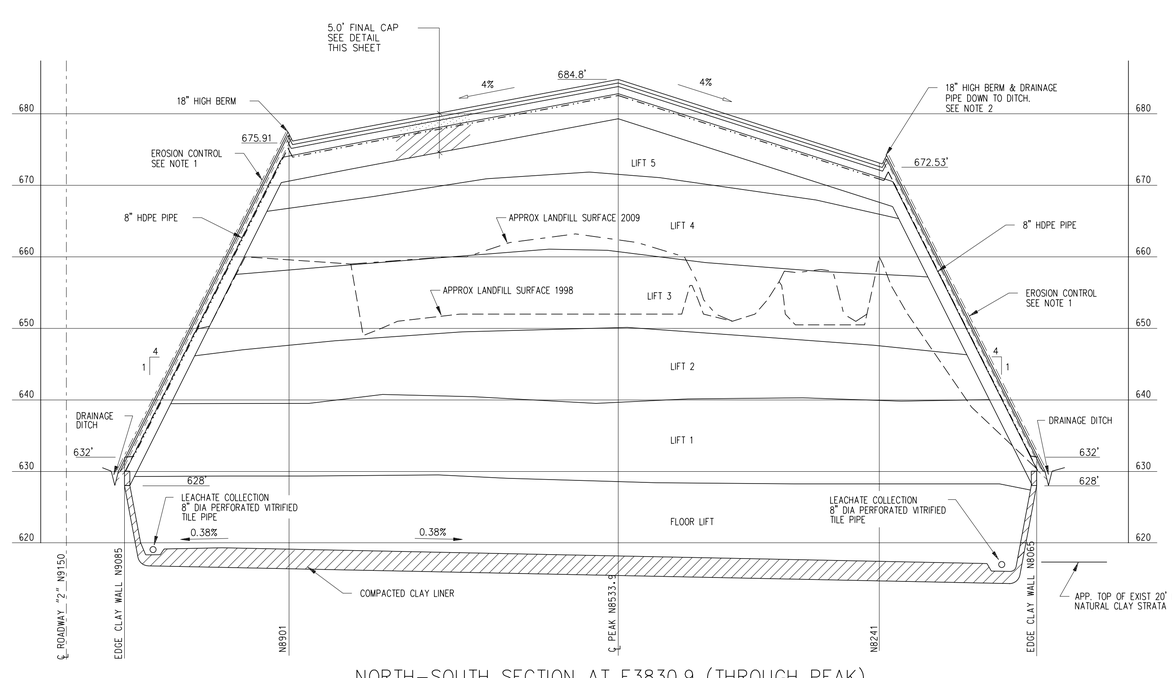
RF=Y1-34600 RF=Y1-36659 RF=Y1-36661



EAST–WEST SECTION AT N8533.9 (THROUGH PEAK)

SCALE: VERT. 1"=10'
HORZ. 1"=80'

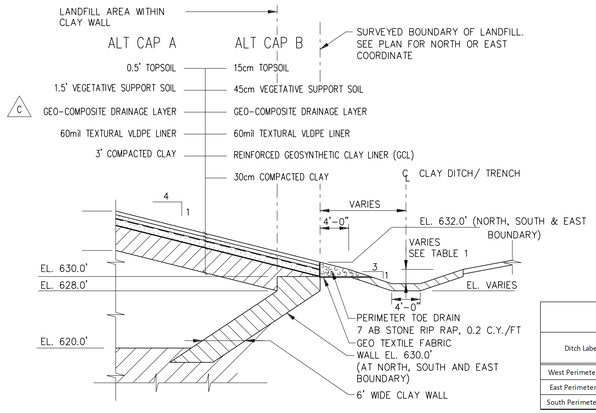
LOOKING NORTH



NORTH–SOUTH SECTION AT E3830.9 (THROUGH PEAK)

SCALE: VERT. 1"=10'
HORZ. 1"=80'

LOOKING EAST



NOTE
TOP OF CLAY WALL AT WEST BOUNDARY IS AT ELEVATION 628.0' TOP OF FINISHED COVER AT THIS SIDE IS 630.0'

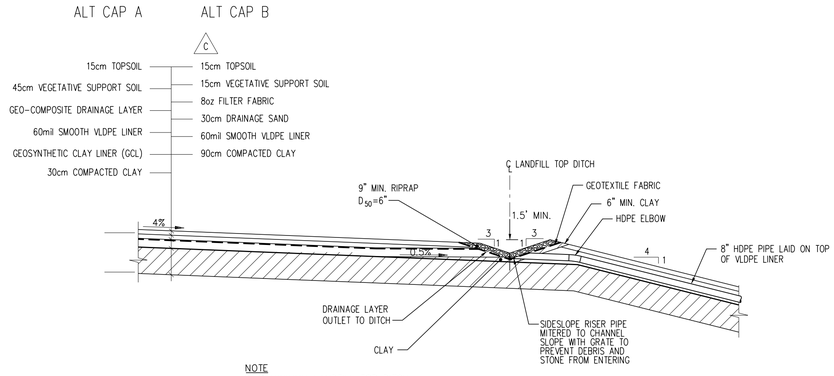
TYPICAL
LANDFILL PERIMETER

Table 1
Perimeter Ditch Schedule

Ditch Label	Depth	Minimum Slope (%)	Bottom Width (ft)	Ditch Side Slopes (H:V)	Lining
West Perimeter Ditch	2.00	0.50	4.00	3:1	Grass
East Perimeter Ditch	2.25	0.50	4.00	3:1	Grass
South Perimeter Ditch	2.50	0.25	4.00	3:1	Grass

△D LANDFILL PERIMETER DITCH DETAIL
SCALE: 1" = 10'-0"

FINAL CAP COMPOSITION DETAIL



NOTE
0.5% MINIMUM LANDFILL TOP DITCH (DIVERSION BERM) SLOPE.

△D △A LANDFILL TOP DRAINAGE
SCALE: NTS

NOTES:

1. EROSION CONTROL AND SLOPE STABILIZATION WILL BE ACHIEVED BY VARIOUS NATURAL (DECAYING) AND PERMAMENT (PLASTIC) EROSION PRODUCTS SUCH AS EXCELSIOR MATS AND PLASTIC MATS ALLOWING GRASS GROWTH AND PREVENTING SOIL WASHOUT, AT LONG 4:1 SLOPES. SIMILAR SYSTEM WILL BE USED AT STEEP SECTIONS AND BANKS OF DITCH.
2. DRAINAGE OF LANDFILL TOP WILL BE ACHIEVED BY PLASTIC PIPES BURIED IN COVER MATERIAL RUNNING FROM TOP BERM TO DRAINAGE DITCH. USE USBR TYPE VI BAFFLE WALL ENERGY DISSIPATOR AT PIPE DISCHARGE AND LIGHTER STONE EROSION PROTECTION AT BERM PIPE INLET.

△D

DATE LAST GENERAL UPDATE: 04JAN2010

CADD

MARK	LOC.	REVISIONS	BY	DATE	APP
A	GEN	ADDED LIFTS, NOTES, DRAINAGE DETAILS	MCC	7SEP90	PC
B	GEN	ADDED ALTERNATE COVER SYSTEM OUTLINE & DETAILS	RJF	26FEB93	PC
C	GEN	REVISED COVER SYSTEM COMPOSITION	RJF	27OCT93	PC
D	GEN	ACCOM MODIFIED DETAILS AND NOTE 2	DRB	09MAY11	TCR

DESIGNED BY: P. CHMELAR	DATE 5-31-90	REFERENCES
DRAWN BY: M.C. CARPENTER, W.A. KIBBE & ASSOC	DATE 5-31-90	NUMBER: Y1-36615 TITLE: LANDFILL FINAL TOPOGRAPHY
TECHNICAL APPROVAL: M.J. BUSH	DATE 5-31-90	
APPROVED FOR ISSUE: M.L. MARCHIONE	DATE 5-31-90	PMSS INFOR-MATION: ENGRG. DISC. CA TOPO; DWG. TYPE SECTION

DOW CORNING CORPORATION

MIDLAND PLANT 800 / 1000 BLOCK

CLOSURE PLAN FOR
HAZARDOUS WASTE LANDFILL
FINAL TOPOGRAPHY–PEAK SECTIONS & DITCH DETAIL

SCALE	INCH FOOT	DRAWING NUMBER	REVISION
	1" = 80'	Y1-36625	C

I. FINAL COVER DRAINAGE LAYER FLOW

Removed, May 2011.

Replaced with attached Cover Infiltration Evaluation.

II. FINAL COVER SLOPE STABILITY ANALYSIS

Removed, May 2011.

Replaced with attached Final Slope Stability Analysis and Final Global Slope Stability Analysis.

III. ANNUAL SOIL LOSS FROM THE FINAL COVER.

Landfill final cover will be seeded in order to establish grass growth per this Closure Plan. Erosion control is part of the maintenance post-closure program. Regardless of this, erosion potential is calculated below based on USDA Universal Soil Loss Equation as follows:

$$A = R * K * LS * C * P$$

where

- A average anual soil loss (t/acre)
- R rainfall and erosivity index
- K soil erodibility factor (t/acre)
- L slope steepness factor
- C cover management factor
- P practice factor

Values taken from the USDA literature:

R = 80 based on geographical location
K = 0.24 for fine sandy loam with 4% organic matter
LS= 0.44 for 400 ft long slope, 3% slope(min. final cover slope = 4%)
8.30 for 200 ft long 25% slope
use the calculated average value 4.37
C = 0.01 for grass meadow, moderate
P = 1.00 for no support practice

Then:

$$A = 80*0.24*4.37*0.01*1 = 0.84 \text{ t/acre}$$

This is approximate calculated values based on a given factors and is of no concern. For comparision, calculate weight of 1/16" of soil on 1 acre:

$$w = 0.0625"/12 * 43560 \text{ ft} * 100 \text{ pcf}/2000 \# = 11.3 \text{ tons}$$

Yearly loss of soil off the landfill final cover with grass vegetation is about 1 t/acre.

IV. AVERAGE DAILY AND MONTHLY LEACHATE QUANTITIES.

Currently Midland plant Landfill has not installed any final cover. With the exception of temporary grass cover on the 25% slope banks, landfill surface is either paved (stone, asphalt or concrete) or covered with the daily cover soil.
All water being collected from the surface due to precipitation, landfill daily operation (such as wash-down facilities) is combined with the 1000 block leachate collection and drained to chemical sewer for further processing in a waste water treatment plant.

No on-site holding tanks or ponds are provided.
Total average flow from the landfill area (24 acres within clay wall boundary) is:

1993 year measured flow	32,500,000 gal
Monthly average	2,708,300 gal
Daily average	89,040 gal

Due to location of catch basins over the leachate field manholes, actual leachate flow can't be measured separately. Once the final cap will be built, that flow will be measurable.

V. LEACHATE HEAD ON THE BASE OF THE LANDFILL.

There are two separate cases of the leachate head within the landfill during the life span of the landfill.

A. During the active landfill operation
B. After landfill closure.

Situation A. Open Landfill.

Description of operation.
Landfill drainage is accomplished by series of catch basins with

all collected runoff discharged to chemical sewer for further treatment.
Surface water runoff is documented in Appendix A-4D in this license.

Water balance.

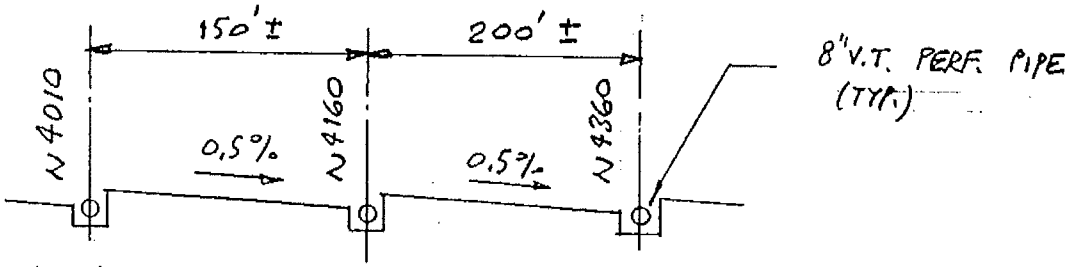
Total yearly precipitation	34"
Coefficients:	
Runoff	0.355*
Evapotranspiration	0.59
Impingement	0.055

Note: * From two separate areas per Appendix A-4D
Average runoff R=(0.3*4.71 ac + 0.4*5.84ac)/(4.71+5.84)=0.355

Impingement rate is comparatively low due to the waste characteristics. Waste combined with daily cover soil and compacted is comparable to permeability of sandy silt to silty clay. Assumed permeability is in the order of $k=5*10^{-5}$ cm/sec.

From drawing Y1-31900:
Maximum distance l contributing to leachate drain collection is 200 ft.
Slope of the cross section (perpendicular to collection pipe) is 0.5% (tan = 0.005).

Leachate pipes are installed within 2 ft x 2 ft trench filled with peastone and capped with coarse sand. Collection tile is 8" perforated vitrified clay pipe. Layer of coarse sand min. 10" thick with permeability $k= 1*10^{-4}$ m/sec was placed on top of the native clay bottom.



For the calculation of h max, use metric units.

$e = (0.055*34"*0.0254)/(365*24*60*60) = 1.50*10^{-9}$ m/sec

$k= 1*10^{-4}$ m/sec
l= 200*0.305=61 m

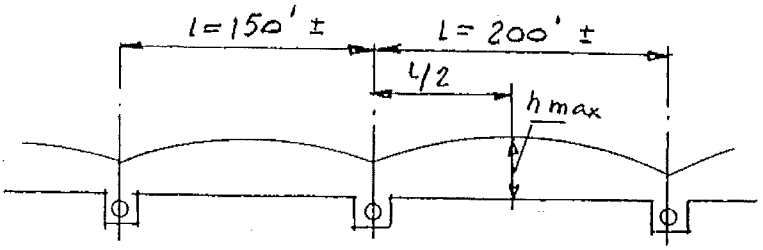
Then

$$h_{max} = l \left(\sqrt{e/k + \tan^2\beta} - \tan\beta \right)$$

Calculate maximum head of leachate.

$$h_{max} = 61*(\sqrt{1.5*10^{-9}/1*10^{-4} + 0.0005^2} - 0.0005)$$
$$= 61 * 0.0034 = .20 \text{ m} = 8.17"$$

Due to the height of the head, the influence of the minimal slope of the bottom is negligible and can be discounted. Use the equation for the flat bottom landfill per model below:



L/2 = 100ft = 30.5m

From the EPA Publication SW-868 considering maximum water distance to travel being 1/2,

Equation for h will be:

$$h_{max} = 1/2\sqrt{e/k} = 30.5*\sqrt{1.5*10^{-9}/1*10^{-4}}$$
$$= 0.118 \text{ m} = 4.65"$$

Situation B - Closed Landfill.

Final cap includes flexible liner membrane. Amount of the water entering the waste will be reduced significantly compared to the situation A. Use maximum impingement coefficient of 0.01 which is conservatively high for well constructed landfill cap with seam welded flexible liner membrane (FLM).

Recalculate h max based on this impingement rate.

$$e = (0.01*34*0.0254)/(365*24*60*60) = 2.7*10^{-10} \text{ m/sec}$$
$$h = 30.5*\sqrt{2.7*10^{-10}/1*10^{-4}} = 0.05 \text{ m} = 2"$$

Conclusion: It is reasonable to expect leachate head to be well within the thickness of the sand layer as demonstrated in this calculation even in the case of possible higher impingement rate through the waste layers. Permeability of the waste may not be uniform due to the ununiformity of the waste material.

This concludes the supplemental Closure Plan Final Cover calculations.

Dow Corning Corporation

Quality Assurance Manual For Final Cap Geosynthetic Liner System Installation at Dow Corning Plant Midland, Michigan

Prepared for:
Dow Corning Corporation
3901 South Saginaw Road
Midland, Michigan 48686

Prepared by:
AECOM
5555 Glenwood Hills Parkway Southeast
Grand Rapids, Michigan 49512

May 2011

QUALITY ASSURANCE MANUAL
FOR THE INSTALLATION OF
FINAL CAP LINING SYSTEM

TABLE OF CONTENTS

PAGE

1.0 GENERAL

1.1 SCOPE

This plan addresses the quality assurance procedures for the installation of the geosynthetic components of the final cap lining system at the Dow Corning Facility in Midland, Michigan. The Construction Quality Control/Quality Assurance Procedures for Landfill Clay Final Cover addresses the soil components of the final cover. Adherence to this plan should ensure both the proper implementation of construction techniques and the conformance of all materials with the applicable project specifications.

This Quality Assurance Plan (QAP) establishes a protocol by which problems can be identified and corrected prior to the completion of construction. To award completion, the program requires a certification report indicating that the facility has been constructed in accordance with the approved design standards and specifications. All testing required by this QAP shall be conducted in accordance with the latest revision of the referenced ASTM or other standard. The Certifying Engineer designated by the Owner shall prepare this report from the information gathered through the course of implementing this plan.

In the context of this manual, **quality assurance** refers to the means and actions employed by the Owner to ensure that the installation of the lining system conforms to all contractual and regulatory requirements. In contrast, **quality control** refers only to those actions provided by the manufacturers, suppliers, contractors and installers of the various components of the lining system to ensure that materials and workmanship meet the requirements of the project plans and specifications.

1.2 PARTIES

This section discusses the parties associated with the ownership, design, supply, manufacture, transportation, installation, and quality assurance of the lining system, each of whom shall receive a complete copy of this QAP or pertinent sections thereof. The definitions, responsibilities, qualifications, and submittals required of these parties are outlined in the following subsections.

1.2.1 Project Manager

1.2.1.1 *Definitions*

As the official representative of the Owner, the Project Manager shall coordinate 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, including the selection or approval of the 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 pre-construction and progress meetings outlined in Section 1.3 and serving as a liaison between all parties involved in the project. The Project Manager shall also be responsible for proper resolution of any quality assurance issue that may arise during construction.

1.2.1.3 *Qualifications*

The Project Manager shall be familiar with this QAP, general earthwork and geosynthetic installation techniques, and all applicable regulatory requirements.

1.2.2 Designer

1.2.2.1 *Definitions*

The Designer is the individual and/or firm who prepare the engineering design and associated project plans and specifications for the lining system.

1.2.2.2 *Responsibilities*

In addition to the initial engineering design and specifications for the lining system, the Designer is also responsible for approving all design and specification changes and for making design clarifications required during construction of the lining system, as directed by the Project Manager.

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 detailed design methods and procedures related to the use of soils and/or geosynthetics and with all applicable regulatory requirements.

1.2.2.4 *Submittals*

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

1.2.3 Geosynthetic Manufacturer

1.2.3.1 *Definitions*

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

1.2.3.2 *Responsibilities*

Each Manufacturer (unless there is a Fabricator) is responsible for the condition of the geosynthetic product until the material is accepted by the General Contractor upon delivery (or by the Fabricator, if applicable). Each Manufacturer shall produce a consistent product that meets the project specifications.

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 QAP.

1.2.3.4 *Submittals*

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

1. Corporate background and information. The Manufacturer shall have at least five years continuous experience in the manufacture of the geosynthetic products specified for this project.

2. The Manufacturer shall have at least five years continuous experience in the manufacture of the geosynthetic products specified for this project. Information on manufacturing capabilities shall include the following:
   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 10 completed facilities totaling a minimum of 10,000,000 ft^2 (1,000,000 m^2), for which the Manufacturer has manufactured the specified 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 (if known) 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: Ten (10) days prior to the delivery of the geosynthetic material to the site, the Manufacturer shall submit to the Project Manager all quality control documentation required by the appropriate section of this QAP. This documentation shall be reviewed by the Geosynthetic Quality Assurance Consultant as outlined in Section 1.2.8 of this QAP prior to installation.

1.2.4 Aggregate Supplier (if applicable)

1.2.4.1 *Definitions*

The Aggregate Supplier is the firm that provides to the General Contractor the aggregate required for the drainage layer of the liner system.

1.2.4.2 *Responsibilities*

Each supplier is responsible for the aggregate until accepted by the General Contractor upon delivery. Each supplier shall provide aggregate that meets the project specifications.

1.2.4.3 *Qualifications*

Each Supplier shall:

1. Be approved by the Owner.

2. Have sufficient aggregate stockpiles or borrow sources to meet the demands of the project.

1.2.4.4 *Submittals*

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

1. Corporate background and information.

2. Material evaluations to ensure that the aggregate can meet the specifications.

3. The Project Manager may also request evidence that the Supplier has an approved erosion and sedimentation plan.

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

1.2.5 Fabricator (if applicable)

1.2.5.1 *Definitions*

The Fabricator is responsible for the assembly of geomembrane panels from rolls or sheeting supplied by the Manufacturer.

1.2.5.2 *Responsibilities*

Each Fabricator is responsible for the condition of the geosynthetic product until the material is accepted by the Project Manager upon delivery. Each Fabricator shall produce a consistent product that meets the project specifications.

1.2.5.3 *Qualifications*

Each Fabricator shall:

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

2. Be approved and/or licensed by the Manufacturer.

2. Provide sufficient fabrication 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 QAP.

1.2.5.4 *Submittals*

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

1. Corporate background and information.

2. The Fabricator shall have at least five years continuous experience in the fabrication of the specified geosynthetic. Information on fabrication capabilities shall include the following:
   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 10 completed landfill or surface impoundment facilities totaling a minimum of 10,000,000 ft^2 (1,000,000 m^2), for which the Fabricator has assembled the specified 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, Manufacturer and Installer (if known).
      (3) Type of geosynthetic and surface area of geosynthetic manufactured.
      (4) Type of seaming and seaming apparatus used.
      (5) Available information on the performance of the lining system.

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

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

Pre-installation: Ten (10) days prior to the delivery of the geosynthetic material to the site, the Fabricator shall submit to the Project Manager all quality control documentation required by the appropriate section of this QAP. This documentation shall be reviewed by the Geosynthetic Quality Assurance Consultant as outlined in Section 1.2.8 of this QAP prior to installation.

1.2.6 General Contractor

1.2.6.1 *Definitions*

The General Contractor will be responsible for coordination of all work activities performed by the Earthwork Contractor, the Geosynthetics Installer, and the Quality Assurance Consultant. The General Contractor shall be responsible for maintaining the schedule established for the project. The General Contractor's Superintendent may act as the General Contractor's representative at all site meetings and may serve as the General Contractor's spokesman on the project.

The General Contractor and the Earthwork Contractor may be the same party.

1.2.6.2 *Responsibilities*

The General Contractor is responsible for the coordination of all activities required to complete the work. The General Contractor may also be responsible for supplying and transporting materials, as outlined in the project specifications.

1.2.6.3 *Qualifications*

The General Contractor shall be:

1. Pre-qualified and approved by the Owner.

2. Able to provide qualified personnel to meet the demands of the project, including a Superintendent with applicable experience and proven management ability and authority.

1.2.6.4 *Submittals*

Pre-qualification: At a minimum, the General 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

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 General Contractor shall submit to the Project Manager:

1. Resume of the 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 General Contractor shall submit a Certificate of Completion.

1.2.7 Earthwork Contractor

1.2.7.1 *Definitions*

The Earthwork Contractor is the firm that 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.

The General Contractor and the Earthwork Contractor may be the same party.

1.2.7.2 *Responsibilities*

The Earthwork Contractor is responsible for constructing soil components of the lining systems in accordance with 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.

1.2.7.3 *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, including a Superintendent with applicable experience and proven management ability and authority.

1.2.7.4 *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.

1.2.8 Geosynthetic Installer

1.2.8.1 *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 shall act as the Installer's spokesman on the project.

1.2.8.2 *Responsibilities*

The Installer is responsible for the field handling, storing, deploying, seaming, provision of temporary restraints 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.

1.2.8.3 *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 with applicable experience and proven management ability and authority.

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

1.2.8.4 *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. The Installer shall have at least five years continuous experience in the installation of the geosynthetic products specified for this project. Description of installation capabilities shall include the following:
   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, totaling a minimum of 5,000,000 ft^2 (450,000 m^2) for which the Installer has experience with the specific type of geosynthetic to be installed. 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 and/or Fabricator.

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 Quality Assurance Plan (QAP), unless submitted directly to the Project Manager by the Manufacturer.

6. If applicable, 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. Certification and Factory Seaming Test Logs from the Fabricator (if applicable).

3. The installation warranty.

1.2.9 Soil Quality Assurance Consultant

1.2.9.1 *Definitions*

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

In this QAP, 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 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.

1.2.9.2 *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. 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 QAP. Other duties of the Soil QAC shall include review and documentation of 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 as appropriate 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.

1.2.9.3 *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. 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 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.

1.2.9.4 *Submittals*

Pre-qualification: At a minimum, the Soil QAC, if a firm, 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 quality assurance experience with the required soil components of all of the quality assurance personnel.

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

1.2.10 Geosynthetic Quality Assurance Consultant

1.2.10.1 *Definitions*

The Geosynthetic Quality Assurance Consultant (Geosynthetic QAC) is the firm or agency 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 QAP, 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 shall also include Geosynthetic Quality Assurance Monitors who are located at the site for construction observation and documentation.

1.2.10.2 *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 literature from the manufacturer, fabricator, and installer.
    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.

1.2.10.3 *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 the geomembrane types used for this project. The Geosynthetic QAC shall be experienced in the preparation of quality assurance documentation including quality assurance forms, reports, certifications, and manuals.

*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. 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.

1.2.10.4 *Submittals*

Pre-qualification: At a minimum, the Geosynthetic QAC, if a firm, 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.

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

1.2.11 Soil Quality Assurance Laboratory

1.2.11.1 *Definitions*

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

1.2.11.2 *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.

1.2.11.3 *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.

1.2.11.4 *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.

1.2.12 Geosynthetic Quality Assurance Laboratory

1.2.12.1 *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.

1.2.12.2 *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.

1.2.12.3 *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.

1.2.12.4 *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

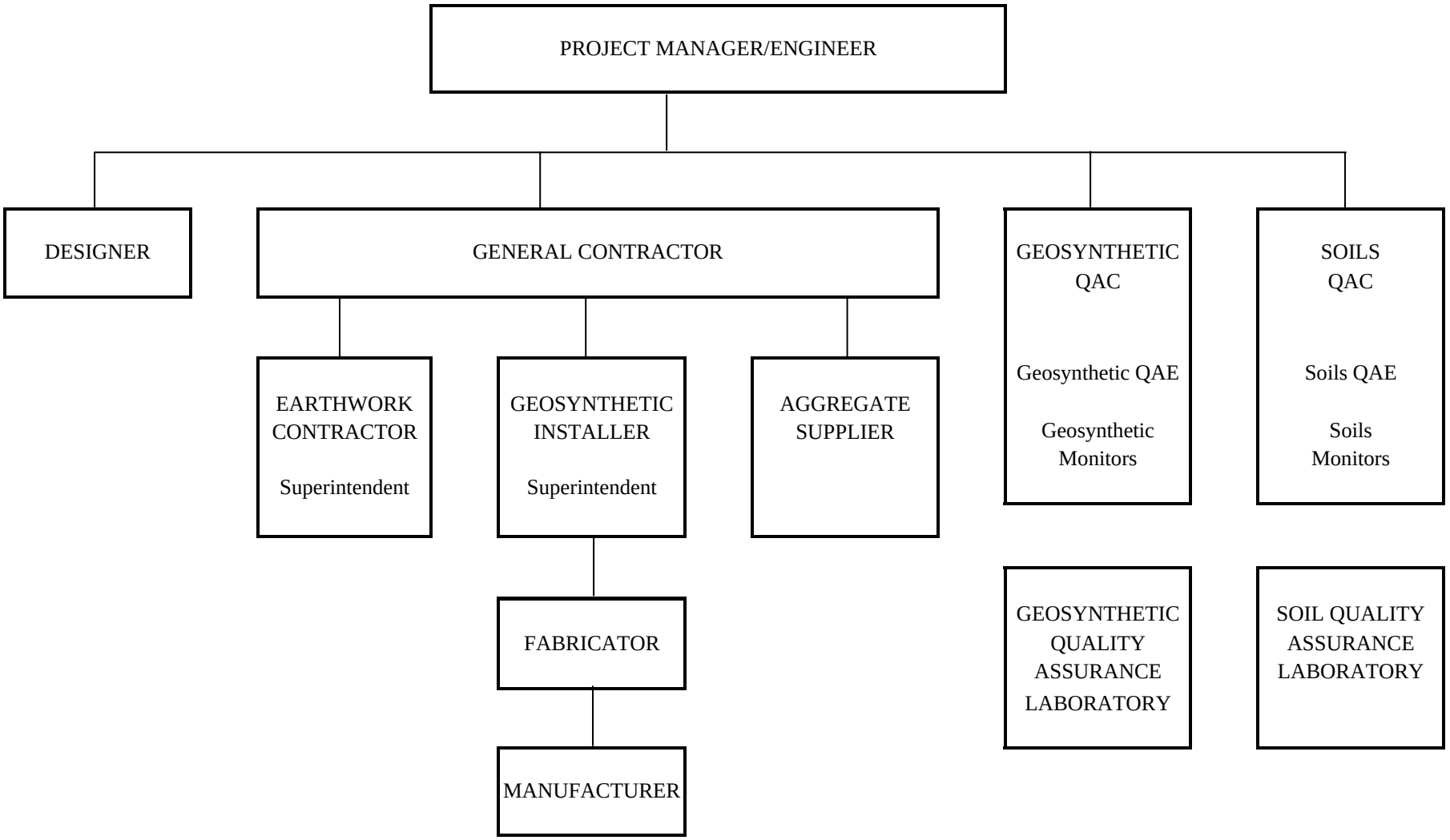
To help ensure a high degree of quality during installation and to ensure a final product that meets all project specifications, clear, open channels of communication are essential between all parties. This section discusses appropriate lines of communication and describes all meetings that will be necessary 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 able to directly communicate with the Project Manager at all times.

Exhibit 1-1

LINES OF COMMUNICATION



1.3.2 Pre-Construction Meeting

A pre-construction meeting, attended by Project Manager, Designer, Earthwork Contractor, Geosynthetic Installer, Soil/Geosynthetic QAE, surveyor, and the Owner's technical representative, shall be held at the site prior to beginning of lining system installation to review the responsibilities of each party and to address any other project concerns.

1.3.3 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 to discuss current progress, planned activities for the next week, issues requiring resolution, and any new business or revisions to the work.

2.0 DOCUMENTATION

Geosynthetic quality assurance activities shall be thoroughly documented using the means described in the following subsections.

2.1 DAILY REPORTS

2.1.1 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. Provided information shall include the precise areas worked on, panel numbers, seams completed and approved, seams failed and rejected, any seam repair work, measures taken to provide unfinished areas with overnight protection, weather conditions and other appropriate data and information. 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, identifying any matters requiring action by the Project Manager. 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 Geosynthetic Testing Reports

The Geosynthetic QAC shall collate all destructive test reports from all sources including 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.

2.3 PROGRESS REPORTS

Progress reports shall be prepared by the Soil and Geosynthetic QAEs and submitted to the Project Manager each 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 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 other geosynthetic layers. All surveying for as-built information shall be performed by a licensed land surveyor or as 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, summarizing the activities of the project, and documenting 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

3.0 LINING SYSTEM ACCEPTANCE

3.1 SOIL COMPONENTS ACCEPTANCE

The soil components of the lining system will be accepted by the Geosynthetics Installer 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 and/or Owner's field representative 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. Forms agreed upon at the pre-construction meeting shall be used to document acceptance of the liner system by the Geosynthetics Installer.

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 GEOMEMBRANES

4.1 GENERAL

Assurance that the geomembrane has been installed in accordance with the project plans and specifications shall be achieved by implementation of the following:

- Verification that the minimum property values certified by the Manufacturer meet project specifications;
- Conformance testing to ensure that the material meets the property values contained in the specifications;
- Visual observation and testing to ensure that proper construction techniques and procedures are used to deploy the geomembrane; and
- Non-destructive and destructive testing to evaluate field seaming quality.

All tests shall be performed in an approved geosynthetics laboratory or in the field as required. At a minimum, the criteria used to determine the acceptability of the geomembrane and of the installed liner shall be as defined in the project specifications.

Potential geomembrane options include high density polyethylene (HDPE), linear low density polyethylene (LLDPE), un-reinforced flexible polypropylene (fPP) and reinforced flexible polypropylene (fPP-R). As the testing requirements and installation procedures will vary with the type of material chosen, these materials will be addressed separately as necessary. Subsections applicable only to specific geomembrane types will be duly noted.

4.2 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geomembrane, the Manufacturer, Fabricator 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:

   For HDPE Geomembranes:

   - Thickness - ASTM D 5199
   - Density - ASTM D 1505/D 792
   - Tensile Properties - ASTM D 6693-IV
   - Tear Resistance - ASTM D 1004
   - Puncture Resistance - ASTM D 4833
   - Stress Crack Resistance - ASTM D 5397 (single point)
   - Carbon Black Content - ASTM D 1603
   - Carbon Black Dispersion - ASTM D 5596
   - Oxidative Induction Time - ASTM D 3895 or D 5885

- Oven Aging at 85°C - ASTM D 5721, D 3895 or D 5885
- UV Resistance - GM 11, ASTM D 3895 or D 5885
- Asperity Height - ASTM D 7466 (textured liner only)

For LLDPE Geomembranes:

- Thickness - ASTM D 5199
- Density - ASTM D 1505/D 792
- Tensile Properties - ASTM D 6693-IV
- 2% Modulus - ASTM D 5323
- Tear Resistance - ASTM D 1004
- Puncture Resistance - ASTM D 4833
- Axi-Symmetric Break - ASTM D 5617
- Carbon Black Content - ASTM D 1603
- Carbon Black Dispersion - ASTM D 5596
- Oxidative Induction Time - ASTM D 3895 or D 5885
- Oven Aging at 85°C - ASTM D 5721, D 3895 or D 5885
- UV Resistance - ASTM D 3895 or D 5885
- Asperity Height - ASTM D 7466 (textured liner only)

For Reinforced and Unreinforced fPP Geomembranes:

- Mass per Unit Area - ASTM D 5261
- Thickness - ASTM D 5199
- Tensile Properties - ASTM D 6693-IV
- Multiaxial Elongation - ASTM D 5617
- Tear Resistance - ASTM D 1004 nonreinforced, D5844 reinforced
- Puncture Resistance - ASTM D 4833
- Axi-Symmetric Break - ASTM D 5617
- Ply Adhesion - ASTM D 6636
- Low Temperature Flexibility ASTM D 2316
- Carbon Black Content - ASTM D 1603
- UV Resistance - ASTM D 7238, D6693(IV), GM16, GM23

These quality control tests shall be performed in accordance with the test methods at the frequency defined in the specifications.

The following shall be maintained by the Manufacturer and/or Fabricator and will be made 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:

   HDPE/LLDPE - polyethylene, additives, carbon black or other colorants,.
   fPP - flexible polypropylene resin, additives, carbon black or other colorants,.

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. Any geomembrane sample that does not comply with the Specifications will result in rejection of the roll from which the sample was obtained. The Manufacturer shall replace any rejected rolls at no additional cost to the Owner. If a roll is rejected, the Geomembrane Manufacturer shall sample and test each roll manufactured in the same lot or at the same time as the failing roll. Additional testing may be conducted at the Manufacturer's discretion and expense to more closely identify the non-complying rolls.
6. Project specifications and a copy of the QAP are provided by the Project Manager to the Installer.

4.3 CONFORMANCE TESTING

4.3.1 Sampling Procedures

Upon delivery of the geomembrane, the Geosynthetic QAC shall select geomembrane rolls for sampling. 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 geomembrane. These samples shall be forwarded to the Geosynthetic QAL for testing.

4.3.2 Conformance Tests

At a minimum, the following conformance tests shall be conducted, unless otherwise indicated in the project specifications:

For HDPE Geomembranes:

- Thickness - ASTM D 5199
- Density - ASTM D 1505/D 792
- Tensile Properties - ASTM D 6693-IV
- Tear Resistance - ASTM D 1004
- Puncture Resistance - ASTM D 4833
- Carbon Black Content - ASTM D 1603
- Carbon Black Dispersion - ASTM D 5596
- Asperity Height - ASTM D 7466 (textured liner only)

For LLDPE Geomembranes:

- Thickness - ASTM D 5199
- Density - ASTM D 1505/D 792
- Tensile Properties - ASTM D 6693-IV
- Tear Resistance - ASTM D 1004
- Puncture Resistance - ASTM D 4833
- Carbon Black Content - ASTM D 1603
- Carbon Black Dispersion - ASTM D 5596
- Asperity Height - ASTM D 7466 (textured liner only)

For Unreinforced fPP Geomembranes:

- Mass per Unit Area - ASTM D 5261
- Thickness - ASTM D 5199
- Tensile Properties - ASTM D 638-IV

For Reinforced fPP Geomembranes:

- Mass per Unit Area - ASTM D 5261
- Thickness - ASTM D 5199
- Tensile Properties - ASTM D 751-A

Prior to construction, direct shear testing (ASTM D 5321) of the geosynthetic-to-geosynthetic and geosynthetic-to-soil interfaces must be completed using the actual materials selected for liner components for the Engineer's use in verifying slope stability.

4.3.3 Test Results

Prior to the deployment of the geomembrane, the Geosynthetic QAE shall review all conformance test results to ensure that all test results meet or exceed the property values listed in the project specifications. Any nonconformance shall be reported to the Project Manager. If the Manufacturer and/or Fabricator disputes the results of the conformance testing, retesting may be conducted at his expense at two different geosynthetics testing laboratories approved by the Owner.

If a test result reveals 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 isolate the portion of the lot not meeting the project specification. To isolate the out-of-specification material, additional samples must be taken from rolls that have roll numbers immediately adjacent to the sampled roll that had 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.

The Manufacturer and/or Fabricator shall bear the cost of any additional tests required as a result of failed tests. The cost of any conformance testing of replacement materials shall also be borne by the Manufacturer and/or Fabricator.

4.4 SUBGRADE PREPARATION

4.4.1 Surface Preparation

Immediately prior to any geomembrane deployment, the Geosynthetic QAC shall verify that the subgrade has been prepared to the lines and grades specified and that the underlying soil surface is free of rocks, roots, vegetation, irregularities, protrusions, wind blown debris, chicken bones, or any other deleterious materials. The surface shall provide a firm, unyielding foundation for the geomembrane with no sharp or abrupt changes in grade.

Before commencing geomembrane installation, the Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable.

4.4.2 Anchor Trench

The Geosynthetic QAC shall verify and document that:

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.

4.5 GEOMEMBRANE DEPLOYMENT

4.5.1 Panel Nomenclature

The Geosynthetic QAC shall ensure that each field panel receives an identification code (number or letter-number) consistent with the layout plan. 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. The geomembrane rolls or panels shall be stored in their original packaging until installation begins.

4.5.2 Panel Deployment Procedure

The Geosynthetic QAC shall review the panel deployment progress of the Installer, taking note of wind, rain, rilling of the subgrade surface and any other adverse site-specific conditions that may prevent proper liner installation. Deployment under windy conditions is generally not recommended. If the Installer elects to place liner under such conditions, they shall take all necessary steps to avoid damaging the geomembrane.

Geomembrane deployment shall not be undertaken if weather conditions will preclude material seaming following deployment. The number of panels to be deployed in any one day shall be limited to the number of panels which can be seamed or secured that day.

The normal acceptable weather conditions for seaming are as follows:

1. Ambient temperature, as measured 1 foot above the liner, between 32ºF (0ºC) and 104ºF (40ºC).

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.

4.5.4 Method of Deployment

Before the geomembrane is handled on site, the Geosynthetic QAC shall verify the adequacy of the deployment equipment and procedures proposed by the Installer. The equipment and methodology shall not pose risk of damage to the geomembrane or underlying subgrade. Vehicles may not operate directly on the geomembrane or the geocomposite clay liner (GCL). 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, GCL, or underlying subgrade by handling.

2. The GCL upon which the geomembrane is placed 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.

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

4.5.5 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 4.9.

4.5.5 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.

4.6 FIELD SEAMING

4.6.1 Seam Layout

With the submittal of the Fabricator for approval, 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. The Project Manager and Geosynthetic QAC must approve the panel layout drawing.

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.

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

4.6.2 Accepted Seaming Methods

Approved processes for field seaming geomembranes are as follows:

For HDPE Geomembranes:

- Extrusion Welding
- Thermal Fusion Welding

For fPP/fPP-R Geomembranes:

- Thermal Fusion Welding
- Extrusion Welding (for patches and repairs)

For PVC Geomembranes:

- Thermal Fusion Welding
- Chemical Fusion

For LLDPE Geomembranes:

- Extrusion Welding
- Thermal Fusion Welding

Proposed alternate processes shall be documented and submitted by the Installer to the Project Manager for approval.

4.6.2.1 *Thermal Fusion Process*

Standard hot wedge welding will create a single, seam of uniform width, whereas a dual track (or split) hot wedge will form two parallel seams with a uniform, unbonded, air space between them. Both methods are acceptable, however, dual tank welding is preferred.

The Geosynthetic QAC shall log seaming apparatus, and ambient temperatures, as measured one foot above the geomembrane surface, at appropriate intervals and report any noncompliance to the Project Manager. Prior to field seaming, the seam area shall be clean and free of moisture, dust, dirt, debris, chicken bones, or foreign material of any kind.

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 will not 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 can be promptly cleaned without contacting the geomembrane. 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.

4.6.2.2 *Extrusion Process*

The Geosynthetic QAC shall log seaming apparatus and ambient temperatures, as measured 1 foot above geomembrane surface, at appropriate intervals and report any noncompliance 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 will not 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. The Geosynthetic QAC shall review the grinding prior to extrusion welding.

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. No exposed grinding marks shall be evident.

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.

4.6.2.3 *Chemical Fusion (For PVC only)*

Chemical fusion of PVC geomembranes may be achieved through the use of solvents. This method of seaming shall only be used if thermal fusion cannot be used, as determined by the Geosynthetic QAC.

The Geosynthetic QAC shall verify that:

1. In general, the geomembrane panels shall be aligned so as to create a "shingling" effect down gradient, with a nominal overlap of 6 in (75 mm) to 8 inches (200 mm) to produce a 4-inch wide seam. The final overlap shall be sufficient to allow peel tests to be performed on the seam.

2. Care shall be taken to clean the seam area with a rag prior to the application of any solvents.

3. The chemical fusion agent shall be applied to both surfaces to be joined, the lower of which shall be completely wetted by the agent. A sufficient amount of solvent shall be placed to ensure a continuous 4-inch weld path.

4. After solvent application, the seam area should be rolled with a seam roller to release any air bubbles and to form a continuous seam path.

4.6.3 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming. For each combination of seaming apparatus and seaming technician used each day, trial seams shall be made at the beginning of each seaming period, if power outages to equipment occur, if conditions or equipment settings change, and at least once every five hours. 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 6.6.2. Two 1-inch wide specimens shall be cut by the Installer at the locations selected randomly along the trial seam sample by the Geosynthetic QAC.

The specimens shall be tested in peel and shear using a field tensiometer. The tensiometer shall be capable of maintaining a constant jaw separation rate of twenty inches per minute (two inches per minute for HDPE). They should not fail in the seam. 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. Note that such field testing does not apply to PVC chemical fusion seams. The Geosynthetic QAC shall observe all trial seam procedures.

4.6.4 General Seaming Procedures

During general seaming, the Geosynthetic QAC shall ensure that the Installer employs the following seaming procedures:

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. All overlaps shall be oriented down gradient to produce a "shingling" effect.

2. If seaming operations are carried out at night, adequate illumination as determined by the Geosynthetic QAC shall be provided.

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

4. If applicable, all cross seam tees should be extrusion welded to a minimum distance of 4 inches on each side of the tee.

5. To achieve proper support, a flat board, a conveyor belt, or similar hard surface may be placed directly under the seam overlap.

4.6.5 Seaming Weather Conditions

4.6.5.1 *Cold Weather Conditions*

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

1. The Geosynthetic QAC shall determine the ambient temperature, as measured 1 foot above the geomembrane surface, 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 ambient temperature is below 32ºF. For chemical fusion field seaming, preheating is generally necessary if the temperature falls below 40ºF.

2. For fusion welding, preheating may be waived 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 4.6.3, shall be conducted under the same ambient temperature and preheating conditions as the production seams.

4.6.5.2 *Warm Weather Conditions*

Should ambient temperatures, as measured 1 foot above the geomembrane, rise above 104ºF, 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 4.6.3, 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.

4.7 NONDESTRUCTIVE SEAM TESTING

4.7.1 General

The Installer shall nondestructively test all field seams over their full length using an air pressure test (for dual track thermal welds only), an air lance test (generally for PVC and fPP single track thermal welds), a vacuum test (not recommended for PVC liners) or other approved method to verify the continuity of the seams. The Geosynthetic QAC shall observe and document (location, data, test unit number, name of tester, and outcome) the nondestructive testing.

4.7.2 Air Pressure Testing

Air pressure testing is applicable to double wedge seaming which produces a double seam with an enclosed air channel. This air space is filled with air, allowing the detection of unbonded sections, voids, and discontinuities by monitoring pressure drops.

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 7.9.3.
   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. Repair the cut end of the air channel.
   g. Remove needle or other approved pressure feed device and patch the hole in the geomembrane in a manner applicable to the geomembrane type.

4.7.3 Vacuum Testing

Vacuum testing is applicable to extrusion welding and to non-seam areas of the liner. This method is not recommended for PVC liners.

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.

4.7.4 Air Lance Testing

Air Lance Testing is applicable to all solvent and single-wedge welded seams. This method works best for relatively thin (40 mil), PVC and fPP liners. Note that this method will only detect defects that are open at the location where the air pressure is directed.

1. The equipment for air lance testing shall consist of the following:
   a. an air compressor, air hose, and an air lance wand equipped with a pressure gauge capable of measuring the air flow at the tip
   b. The air lance shall be capable of supplying 80 psi through a 3/16-inch diameter nozzle

2. The following procedures shall be followed:
   a. Place the air lance wand ¼ inch to ½ inch from the edge of the completed seam, directing the air pressure beneath the upper edge of the overlapped seam to detect unbonded areas.
   b. Any fluttering or inflation of the localized area is a sign of air penetration through the seam. Unbonded areas may also be detected by an audible sound.
   c. If any unbonded areas are detected, locate faulty area and repair in accordance with Section 4.9.3.

4.8 DESTRUCTIVE SEAM TESTING

4.8.1 General

Destructive tests shall be performed as seaming work progresses to evaluate seam strength. This will ensure the availability of test results before the geomembrane is covered by another material.

4.8.2 Sampling Procedures

The Geosynthetic QAC shall select the locations for seam sampling. 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 or as indicated in the project specifications. This frequency is to be determined as an average taken throughout the entire facility. The Geosynthetic QAC shall document the destructive samples taken for each combination of seaming apparatus and technician.

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, or offset welds exists.

As the Installer cuts samples at the chosen locations, 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).

At each sampling location, samples for field and laboratory testing shall be taken by the Installer. Sample dimensions shall be as indicated in the project specifications.

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 4.8.3, 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 as indicated in the project specifications. This sample shall be cut into two portions and distributed to the Geosynthetic QAC for archiving and to the Geosynthetic QAL for testing.

Field seams produced using chemical fusion agents must be allowed to cure until the required seam strength values can be achieved.

All holes in the geomembrane resulting from destructive seam sampling shall be repaired in accordance with repair procedures described in Section 6.9.3 immediately following receipt of successful test results. The continuity of the new seams in the repaired area shall be tested according to Section 6.7.

4.8.3 Field Testing

The two specimens designated for field testing shall be tested using a tensiometer for peel and shear 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 4.9.3. Note that such field testing does not apply to PVC chemical fusion seams. Final judgment 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.

4.8.4 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 bonded seam strength and peel adhesion using the ASTM test method applicable to the geomembrane material type.

HDPE	LDPE	fPP	fPP-R
ASTM D 6392	ASTM D 6392	ASTM D 6392	ASTM D 751*

*As modified by the National Sanitation Foundation Joint Committee on Flexible Membrane Liners Standard 54-1991.

The minimum acceptable values to be obtained in these tests shall be provided in the project specifications. 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 fifth must meet or exceed 80% of the given values.

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.

4.8.5 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 6.6.3 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 4.10.

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

4.9 DEFECTS AND REPAIRS

4.9.1 Identification

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

4.9.2 Evaluation

Each suspect location both in seam and non-seam areas shall be nondestructively tested using the methods described in Section 4.7. Each location which fails the nondestructive testing shall be marked by the Geosynthetic QAC and repaired by the Installer. Other lining system materials shall not cover locations which have been repaired until successful nondestructive and/or laboratory tests are obtained.

After the completion of seaming, and prior to the placement of overlying materials, the Geosynthetic QAC shall determine if any wrinkles should be cut and reseamed by the Installer. Seams produced while repairing wrinkles shall undergo nondestructive testing.

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. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The Geosynthetic QAC shall observe the placement of cover materials to ensure that wrinkle formation is minimized and that, in all cases, the geomembrane is not folded over on itself.

4.9.3 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, including, but not limited to, use of welded patches, cap strips, sealants and/or patching tapes. The final decision as to the appropriate repair procedure shall be agreed upon between the Project Manager, Installer, Designer, and Geosynthetic QAC.

The repair procedures available may 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.

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 4.7 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.

4.10 GEOMEMBRANE PROTECTION

The intent of the quality assurance procedures indicated in this Section is to ensure that the installation of adjacent materials does not damage the geomembrane. The quality assurance procedures related to the adjacent materials themselves are covered in separate Sections of this manual.

4.10.1 Aggregate/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 32ºF (0ºC) nor above 104ºF (40ºC) unless otherwise specified.

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

3. A minimum thickness of 6 inches (0.15 m) of soil is specified between a light dozer, ground pressure of 5 psi (35 kPa) or lighter, and the geomembrane.

4. 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.

4.10.2 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.

5.0 GEOSYNTHETIC CLAY LINERS

5.1 DEFINITIONS AND APPLICABILITY

Assurance that the geosynthetic clay liner (GCL) has been installed in accordance with the project plans and specifications shall be achieved by implementation of the following:

- Verification that the minimum property values certified by the Manufacturer meet project specifications;
- Conformance testing to ensure that the material meets the property values contained in the specifications; and
- Visual observation and testing to ensure that proper construction techniques and procedures are used to deploy and seam the GCL.

All tests shall be performed in an approved geosynthetics laboratory. At a minimum, the criteria used to determine the acceptability of the GCL shall be as defined in the project specifications.

5.2 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:

   - Swell Index - ASTM D 5890
   - Fluid loss - ASTM D 5891

   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 finished GCL product shall be given for:

   - Mass of GCL - ASTM D 5993
   - Mass of Bentonite - ASTM D 5993
   - Moisture Content - ASTM D 5993
   - Tensile Strength (MD) - ASTM D 6768
   - Peel Strength - ASTM D 6496
   - Permeability, or - ASTM D 5887
   - Flux - ASTM D 5887
   - Long-Term Permeability - ASTM D 6766

At least one test for mass of GCL, mass of bentonite, moisture content, and peel strength shall be performed in accordance with the test methods for every 5,000 yd^2 (4,000 m^2). At least one test for tensile strength shall be performed in accordance with the test methods for every 25,000 yd^2 (20,000 m^2). At least one test for permeability or index flux shall be performed in accordance with the test methods for every 30,000 yd^2 (25,000 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.

5.3 CONFORMANCE TESTING

5.3.1 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 that 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 500,000 ft^2 (10,000 m^2) of

GCL. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance with the project specifications.

5.3.2 Conformance Tests

At a minimum, the following conformance tests shall be conducted on the finished GCL product, unless otherwise indicated in the project specifications:

- Mass of GCL - ASTM D 5993
- Mass of Bentonite - ASTM D 5993
- Tensile Strength - ASTM D 6768
- Permeability, or - ASTM D 5887
- Flux - ASTM D 5887

Prior to construction, direct shear testing (ASTM D 5321) of the geosynthetic-to-geosynthetic and geosynthetic-to-soil interfaces must be completed using the actual materials selected for liner components for the Engineer's use in verifying slope stability.

5.3.3 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 disputes the results of the conformance testing, retesting may be conducted at the expense of the Manufacturer at two different geosynthetic testing laboratories approved by the Owner.

If a test result reveals 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 sampled roll that had 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.

The Manufacturer shall bear the cost of any additional tests required as a result of failed tests. The cost of any conformance testing of replacement materials shall also be borne by the Manufacturer.

5.4 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 a manner that precludes damage and that GCL installation is in accordance with the following procedures:

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. The Installer shall take any necessary precautions to prevent damage to the prepared subgrade.

4. 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.

5. After installation, a visual examination of the GCL shall be carried out over the entire surface to ensure the absence of potentially harmful foreign objects, contaminated soil or damaged.

6. 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 with the geomembrane. GCL deployment shall not be undertaken during precipitation events or when there is an immediate threat of precipitation.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

5.5 SEAMING PROCEDURES

5.5.1 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 (0.3 m).

3. GCL roll end seams are typically not allowed on slopes. If they are required, the Geosynthetic QAC shall contact the Designer to verify that the method used to attach the GCLs has adequate tensile strength.

4. Those GCLs with a nonwoven needle-punched geotextile on both the upper and lower surfaces must have bentonite powder or paste placed within the overlap area. The amount of bentonite added shall be as recommended by the manufacturer (typically 0.4 kg/m)

Prior to granting approval of the GCL, the Geosynthetic QAC shall visually verify that the following requirements are met:

1. The required overlaps are provided. For GCL materials with a moisture content $\geq$12%, the overlap shall be doubled and monitored to ensure the appropriate overlap is maintained since the panels may be subjected to shrinkage.

2. The amount of the bentonite placed on the seam is as required by the project specifications.

The Geosynthetic QAC shall note any noncompliance and report it to the Project Manager.

5.6 DEFECTS AND REPAIRS

Any portion of the GCL that exhibits 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 de-lamination 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 bentonite displacement caused by light foot traffic. The hydrated material shall be removed and replaced with new dry GCL material. All defects and repairs shall be reported to the Project Manager.

5.7 GCL PROTECTION

The deployment of all materials on top the GCL shall be performed 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 stresses 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.

6.0 GEOCOMPOSITES

6.1 DEFINITION AND APPLICABILITY

Assurance that the geocomposite has been installed in accordance with the project plans and specifications shall be achieved by implementation of the following:

- Verification that the minimum property values certified by the Manufacturer meet project specifications;
- Conformance testing to ensure that the material meets the property values contained in the specifications; and
- Visual observation and testing to ensure that proper construction techniques and procedures are used to deploy and seam the geocomposite.

All tests shall be performed in an approved geosynthetics laboratory. At a minimum, the criteria used to determine the acceptability of the geocomposite shall be as defined in the project specifications.

6.2 QUALITY CONTROL DOCUMENTATION

Prior to the installation of any geocomposite, 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 finished geocomposite, as well as the geonet and geocomposite components thereof, meet the project specifications.
2. A specification for the geocomposite that includes all properties published by the Manufacturer, measured using the appropriate test methods.
3. The origin (resin supplier's name and resin production plant) and identification (brand name and number) of the resin used to manufacture the geocomposite.
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. 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:

- Geocomposite Transmissivity - ASTM D 4716
- Geocomposite Ply Adhesion - ASTM D 7005
- Geonet Core Thickness - ASTM D 5199
- Geonet Core Density - ASTM D 1505
- Geonet Core Tensile Strength - ASTM D 5036
- Geonet Core Carbon Black Content - ASTM D 1603
- Geotextile Mass per Unit Area - ASTM D 5261
- Grotextile grab Tensile Strength - ASTM D 4632
- Geotextile Grab Tensile Elongation - ASTM D 4632
- Geotextile Trapezoidal Tear Strength - ASTM D 4533
- Geotextile Puncture (pin) Strength - ASTM D 4833

The quality control tests for the completed geocomposite shall be performed in accordance with the test methods for at least every 50,000 ft^2 of geocomposite produced for ply adhesion and at least every 540,000 ft^2 of geocomposite produced for transmissivity. The quality control tests for the geonet core shall be performed in accordance with the test methods for at least every 50,000 ft^2 of geocomposite produced. The quality control tests for the geotextile shall be performed in accordance with the test methods for at least every 100,000 ft^2 of geocomposite produced.

The Manufacturer shall identify all rolls of geocomposites 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.

6.3 CONFORMANCE TESTING

6.3.1 Sampling Procedures

Upon delivery of the rolls of geocomposites, the Geosynthetic QAC shall select geocomposite rolls for sampling. 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.

Samples shall be taken at a rate indicated below in Section 6.3.2. These samples shall then be forwarded to the Geosynthetic QAL for testing to ensure conformance with the project specifications.

6.3.2 Conformance Tests

At a minimum, the following conformance tests shall be performed on geocomposites unless otherwise indicated in the project specifications:

- Geocomposite Transmissivity - ASTM D 4716
- Geocomposite Ply Adhesion - ASTM D 7005
- Geonet Core Thickness - ASTM D 5199
- Geonet Core Density - ASTM D 1505
- Geonet Core Tensile Strength - ASTM D 5036
- Geonet Core Carbon Black Content - ASTM D 1603
- Geotextile Mass per Unit Area - ASTM D 5261
- Grotextile grab Tensile Strength - ASTM D 4632
- Geotextile Grab Tensile Elongation - ASTM D 4632
- Geotextile Trapezoidal Tear Strength - ASTM D 4533
- Geotextile Puncture (pin) Strength - ASTM D 4833

The quality control tests for the completed geocomposite shall be performed in accordance with the test methods for at least every 100,000 ft^2 of geocomposite produced for ply adhesion and at least every 500,000 ft^2 of geocomposite produced for transmissivity. The quality control tests for the geonet core shall be performed in accordance with the test methods for at least every 100,000 ft^2 of geocomposite produced, except for carbon black to be tested for at least every 200,000 ft^2 of geocomposite produced. The quality control tests for the geotextile shall be performed in accordance with the test methods for at least every 100,000 ft^2 of geocomposite produced.

Prior to construction, direct shear testing (ASTM D 5321) of the geosynthetic-to-geosynthetic and geosynthetic-to-soil interfaces must be completed using the actual materials selected for liner components for the Engineer's use in verifying slope stability.

6.3.3 Test Results

The Geosynthetic QAC shall review and accept or reject all conformance test results prior to the deployment of the geocomposite. Any nonconformance shall be reported 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 disputes the results of the conformance testing, retesting may be conducted at his expense at two different geosynthetics testing laboratories approved by the Owner.

If a test result reveals 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 sampled roll that had 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.

The Manufacturer shall bear the cost of any additional tests required as a result of failed tests. The cost of any conformance testing of replacement materials shall also be borne by the Manufacturer.

6.4 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 or deleterious conditions. Geocomposite 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 and report apparently damaged or improperly wrapped rolls to the Project Manager.

The Installer shall ensure that geocomposites are not damaged during handling. The QAC shall ensure that the geocomposite is deployed as described below:

1. On slopes, the geocomposites shall be securely anchored and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension.

2. In the presence of wind, the Contractor shall weigh down all geocomposites with sandbags or the equivalent. These ballast materials shall be installed during deployment and shall remain until replaced with cover material.

3. 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 other materials from potential damage caused by the cutting of the geocomposites.

4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.

5. During placement of geocomposites, care shall be taken not to entrap stones, excessive dust, or moisture in or beneath the geocomposite 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.

6.5 SEAMING PROCEDURES

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. At the option of the Geosynthetic CQA, a stronger thread and stitch may be required.

At a minimum, the following requirements shall be met:

1. Adjacent geocomposite shall be overlapped so that the geonet overlaps by at least 4 inches and the geotextile overlaps by at least 3 inches.
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 slope and, every 6 in. (0.15 m) in anchor trench and along end-to-end seams on the base of the landfill.
4. In corners of side slopes where overlaps between perpendicular geonet strips are required, an extra layer of geonet shall be unrolled along the slope, on top of the previously installed geocomposites, from top to bottom of slope.
5. When more than 1 layer of geonet is installed, joints shall be staggered.
6. On slopes steeper than 10:1 (horizontal:vertical), all geocomposites shall be continuously sewn. Spot sewing is not allowed. On bottoms and slopes shallower than 10:1, geocomposites shall be continually sewn, or thermally bonded if overlying an aggregate layer, with the written approval of the Project Manager.
7. 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. Unless otherwise noted in the Contract Documents, the seam type shall be Federal Standard Type (No. 751.a) SSN-1, and the stitch shall be Type 401.

6.6 DEFECTS AND REPAIRS

6.6.1 Identification

If a defect is identified in the geocomposite, the Geosynthetic QAC shall determine the extent and nature of the defect. If the defect is indicated by unsatisfactory test results, 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.

6.6.2 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.

6.6.3 Repair Procedures

If in the Geosynthetic QAC's judgment, the defect is determined to be small, (typically smaller than 3 ft by 3 ft), 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 provide a minimum 12-inch seam 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 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 overlap in all directions. Sew patch in place or thermally bond. Thermal bonding on nonwoven geocomposite cushion shall require approval from the Geosynthetic QAC.

If in the Geosynthetic QAC's judgement, the defect is determined to be large (typically larger than 3 ft by 3 ft), the geocomposite shall be replaced.

The final decision as to the appropriate repair shall be agreed upon between the Project Manager, Installer, Designer, and Geosynthetic QAE.

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

6.7 GEOCOMPOSITE PROTECTION

All soil materials located on top of a geocomposite shall be deployed in such a manner as to ensure:

1. The geocomposite and underlying lining materials are not damaged.

2. Minimal slippage and wrinkling of the geocomposite on underlying layers occurs.

3. No excess tensile stresses occur in the geocomposite.

At a minimum, any noncompliance with these guidelines or the project specifications shall be noted by the Geosynthetic QAC and reported to the Project Manager.

Construction Quality Control/Quality Assurance Procedures for Landfill Clay Final Cover

March 1994

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I. INTRODUCTION

This Construction Quality Assurance (CQA) Plan is written as part of Dow Corning's Closure Plan for the hazardous waste landfill located at their Midland, Michigan facility. The purpose of this CQA Plan is to ensure that the cover system will be constructed to meet or exceed all applicable design criteria, plans and specifications. The technical guidance document: "Construction Quality Assurance for Hazardous Waste Land Disposal Facilities", EPA October 1986, has been used as a reference for this plan. As recommended in the guidance document, the following elements are included in this site-specific CQA Plan.

A. Responsibility and Authority

Clear communication during the implementation of a CQA Plan facilitates effective decision-making. The first element of this site-specific CQA Plan ensures effective of communication by assigning responsibility and authority to the organizations involved in the design and construction of the cover system and by establishing guidelines for project meeting.

B. CQA Personnel Qualifications

The second element of this CQA Plan describes the necessary training and experience for CQA personnel. Since the construction of the cover system is not scheduled until after the year 2000, specific personnel will not be assigned to the identified CQA responsibilities at this time. An updated version of this CQA Plan, prepared prior to cover system construction, will list the names and qualifications of the CQA personnel.

C. Inspection Activities

The observations and tests that will be performed by the CQA personnel to ensure that each component of the cover system meets or exceeds all design criteria, plans, and specifications is outlined delineated in the third element of this CQA Plan.

D. Sampling Strategies

Sampling requirements, including sample size and methods for determining sample locations, frequency of sampling, and acceptance and rejection criteria are discussed in the fourth element of this CQA Plan.

E. Documentation

The final element of this CQA Plan describes the recordkeeping required for the implementation of the CQA Plan. The ultimate purpose of this CQA Plan is to provide improved confidence in the construction of cover system. This will be provided through written documentation that the CQA Plan was implemented as proposed and that the construction proceeded in accordance with plans and specifications.

II. RESPONSIBILITY AND AUTHORITY

A. Organizations Involved in the CQA Plan

The organizations involved in regulating, designing and constructing the landfill cover system are listed below with their assigned responsibilities and authorities.

1. **Regulatory Agency**: Michigan Department of Natural Resources (MDNR), Hazardous Waste Management Division. The MDNR has the responsibility and authority to:

    a. Review and accept or reject Dow Corning's closure plan which includes this CQA Plan.

    b. Review and accept or reject any design revisions or requests for permit modifications submitted by Dow Corning after their permit is issued.

    c. Review all CQA documentation during or after cover system construction to verify compliance with the closure plan.

2. **Facility Owner**: Dow Corning Company, Midland Michigan. Dow Corning has the responsibility and authority to:

    a. Design and construct the cover system.

    b. Submit all CQA documentation to the MDNR.

    c. Select and direct organizations assigned to design, CQA, and construction responsibilities.

    d. Review and accept or reject design plans and specifications, CQA documents, reports and recommendations of the CQA officer, and materials and workmanship of the contractor.

    e. Schedule regular progress review meetings as necessary to assure that the work is progressing in a timely manner and in accordance with the approved plans and specifications.

    f. Maintain record drawings.

3. **Design Engineer**: EDI Engineering & Science (EDI). EDI has the responsibility and authority to:

   a. Design a cover system that fulfills the performance requirements of the regulatory agency.

   b. Design a cover system that fulfills the operational requirements of Dow Corning.

   c. Formulate a cover system CQA Plan.

   d. Conduct periodic project meetings during construction.

   e. Review CQA documentation and stipulate specific corrective measures where necessary.

   f. Schedule problem or work deficiency meetings as necessary.

4. **CQA Personnel**: CQA personnel will be employees of EDI Engineering & Science. EDI will assign a CQA officer and inspection personnel at the time of closure. The primary responsibility of the CQA personnel is to perform the activities described in the CQA Plan.

   a. The CQA officer's responsibilities include:

      (1) Reviewing the plans and specifications for clarity, completeness, and accuracy.

      (2) Implementing the CQA Plan.

      (3) Reporting CQA activities to the design engineer and Dow Corning.

      (4) Assuring that CQA inspection personnel are trained in CQA procedures.

      (5) Scheduling and coordinating CQA activities.

      (6) Providing general direction and support to the CQA inspection personnel including but not limited to:

         - reviewing CQA inspection personnels' reports.

         - confirming that testing equipment is properly calibrated and the calibration is documented.

         - confirming that this CQA Plan is consistently followed throughout construction.

- confirming that testing equipment, personnel, and procedures do not change over time or ensuring that any changes do not adversely impact the inspection process.

- confirming that all reports and data are properly recorded, validated, summarized, and interpreted.

(7) Providing Dow Corning with a summary and interpretation of CQA inspection data.

(8) Identifying, for Dow Corning, work that should be accepted, rejected, observed, or corrected.

(9) Rejecting defective work and verifying corrective measures.

(10) Conducting daily meetings with CQA personnel.

(11) Interacting with the contractor so that the work is performed in compliance with the plans and specifications.

(12) Scheduling problem or work deficiency meetings if necessary.

(13) Assuring that all project meetings are properly documented.

(14) Interacting with the contractor to provide assistance in modifying the materials where necessary.

(15) Maintaining proper records, daily logs, and other documentation of work.

b. The CQA personnel responsibilities include:

(1) Performing independent on-site inspection of the work in progress to assess compliance with design criteria, plans, and specifications.

(2) Verifying that the equipment used in testing meets the test requirements and that the tests are conducted and documented according to the standardized procedures defined by the CQA Plan.

(3) Reporting to the CQA officer the results of all inspections including work that is not of acceptable quality or that fails to meet the specified design.

(4) Reporting to the contractor the results of all observations and inspections as the work progresses.

5. **Construction Contractor**: The identity of the construction contractor is unknown at this time. It will be the responsibility of the construction contractor to construct the cover system in strict accordance with design criteria, plans, and specifications.

B. Project Meetings

Periodic project meetings will be held to ensure that those involved with the facility are familiar with design, construction procedures, and any necessary design changes. The following periodic meetings will be held during the cover system construction.

1. **Preconstruction CQA Meeting**: A meeting will be held to resolve any uncertainties following the completion of the facility design and the award of the construction contract. The facility owner, design engineer, CQA personnel, and construction contractor will all be present. The owner will specify the time and place for this meeting. Minutes of the meeting will be taken as part of the CQA documentation by the CQA officer or by designated CQA inspection personnel and will be reviewed and signed by the CQA officer. The functions of this meeting will include but are not limited to:

    a. Providing each organization with all relevant CQA documents and supporting information.

    b. Familiarizing each organization with the CQA Plan and its role relative to the design criteria, plans, and specifications.

    c. Determining any changes to the CQA Plan that are needed to ensure that the facility will be constructed to meet or exceed the specified design.

    d. Reviewing the responsibilities of each organization.

    e. Reviewing lines of authority and communication for each organization.

    f. Discussing the established procedures or protocol for observations and tests, including sampling strategies.

    g. Discussing the established procedures or protocols for handling construction deficiencies, repairs, and retesting.

    h. Reviewing methods for documenting and reporting inspection data.i. Reviewing methods for distributing and storing documents and reports.

    j. Reviewing work area security and safety protocols.

    k. Discussing procedures for the location and protection of construction materials and for the prevention of damage to the materials from inclement weather or other

adverse events.

A site walk-around will be conducted during the preconstruction CQA meeting. During this site tour, the CQA officer will verify that the construction contractor understands the design criteria, plans, and specifications. Material and equipment storage locations will also be reviewed.

2. **Daily Progress Meetings**: A progress meeting will be held daily at the work area just prior to commencement of work. At a minimum, the meeting will be attended by the construction contractor and the CQA inspection personnel. The minutes of this meeting will be documented by a member of the CQA inspection personnel and reviewed by the CQA officer. The purpose of these meetings are to:

   a. Review the previous day's activities and accomplishments.

   b. Review the work location and activities for the day.

   c. Identify the contractor's personnel and equipment assignments for the day.

   d. Discuss any potential construction problems.

3. **Problem or Work Deficiency Meetings**: A special meeting may be held when and if a problem or deficiency is present or likely to occur. These meetings may be called by any of the organizations involved. At a minimum, the meeting would be attended by the construction contractor and CQA personnel. The minutes of the meeting will be documented by a member of the CQA inspection personnel and reviewed by the CQA officer. The purpose of a problem or work deficiency meeting would be to define and resolve a problem or recurring work deficiency in the following manner:

   a. Define and discuss the problem or deficiency.

   b. Review alternative solutions.

   c. Implement a plan to resolve the problem or deficiency.

III. CQA PERSONNEL QUALIFICATIONS

At this time, specific CQA personnel have not been chosen. Because the functioning of the cover system is highly dependent on quality control during construction, guidelines on the selection of CQA personnel are outlined below.

A. CQA Officer

As a minimum, the CQA officer will:

1. Have a bachelor's degree in engineering, or a closely related discipline.

2. Have a minimum of five years engineering experience, including sufficient practical, technical and managerial experience to oversee and implement this CQA Plan.

B. CQA Inspection Personnel

As a minimum, the CQA inspection personnel will:

1. Be a certified engineering technicians.

2. Have a minimum of two years experience in construction inspection.

3. Have knowledge of the required testing, documentation and site safety procedures.

IV. INSPECTION ACTIVITIES

A. General Preconstruction Activities

Prior to the preconstruction CQA meeting, the CQA officer will review the plans and specifications for clarity. Any portion of the plans or specifications that need clarification will be modified by the design engineer. Prior to construction, the CQA officer will hold a meeting with the CQA personnel to explain the scope of the plans and specifications, expected site conditions, and methods of construction.

B. Foundation for Cover System

The foundation for the cover system will be prepared by grading the waste in the landfill. The objective of the grading is to provide a structurally stable subbase for the cover system and to provide proper grades for surface drainage of the cover system.

1. **Preconstruction**: The CQA officer and personnel and contractor will review existing information regarding the site conditions before construction to ensure that they are familiar with the site. If unexpected site conditions are discovered that will affect the performance of the contractor or the design of the facility, the design engineer will be contacted by the CQA officers for an evaluation of the situation.

2. **Construction**: The CQA personnel will carefully perform the following visual observations during grading of the cover foundation. Observations will be recorded daily and reviewed by the CQA officer to assure that the foundation is constructed to meet or exceed the specified design.

    a. Observation of subgrade materials. Soft, compressible, or highly organic materials

in the subgrade will cause settlement that may adversely affect cover integrity. Proof rolling of the subgrade under the observation of the CQA personnel will be used to delineate soft areas. Any material unsuitable for the foundation will be removed, backfilled with waste, and compacted.

b. Inspection for depressions, voids or fissures. Any depression, void or fissure will be patched by scoring the fissure or void along its entire depth with a sharp instrument, backfilling with waste, and compacting.

c. Inspection for irregular surfaces. Any irregularity in the surface will be corrected by machine regrading of the surface. If the irregularity is caused by rubble, the material will be removed, backfilled with waste, and compacted.

3. **Post Construction**: Immediately following the grading of the foundation, the CQA inspection personnel will give a final visual inspection of the subbase. If there are deficiencies, the CQA personnel will notify the contractor that a correction must be made.

The CQA officer will then arrange for a site survey by registered surveyors to verify that the proper slopes and elevations of the subgrade have been achieved. The landfill foundation will be cross sectioned at 100-foot intervals by the survey crew. Specification will require elevation accuracy within 0.2 foot. If the foundation does not have the specified slope, the foundation will be regraded and resurveyed. The survey will be reviewed and validated by the CQA officer. A signed foundation approval report by the CQA officer will be prepared before placement of low permeability layer.

Following the final preparation of the foundation, the surface will be monitored for settlement by the CQA personnel, under the direction of the design engineer, for at least one month. It will be the design engineer responsibility to determine whether continued monitoring is necessary or whether the cover can be constructed without damage due to settlement.

C. Compacted Clay Layer

The compacted clay layer will be composed of on-site and possibly off-site clay material. The purpose of the compacted clay layer is to provide long-term minimization of surface water infiltration into the landfill, thereby minimizing leachate production. To prevent surface water infiltration, the layer must resist subsidence and settlement and satisfy permeability and thickness requirements. CQA activities will control construction so that these requirements are met.

1. **Preconstruction**: Preconstruction CQA activities consist of cover material inspection and test fill construction.

a. Material Inspection - All cover materials will be inspected to ensure that they are uniform and meet contract specifications. Material inspection will begin as a

preconstruction activity and will continue throughout the cover construction period.

At this time, the quantity of material that will be available on site is unknown. The landfill liner material was obtained on-site beneath approximately 10 feet of sand. It is believed that sufficient clay material for the cover will be available at a similar depth in the vacant land located east of Lingle Drain.

Currently there is a stockpile of the clay liner material located on the vacant land. It is believed that this material is representative of the area's subsurface material. Two samples were taken from the stockpile for laboratory testing. The testing results are listed in Table 1 along with the methods and material specifications that must be met. As can be seen from Table 1, the material will meet project specifications.

An inspection of the on-site material will be performed with unsuitable materials being rejected before the material is transported to the landfill. Material will be rejected if it contains roots, stumps, large rocks, organic or other unsuitable material. The material will also be rejected if it visually does not meet any of the specifications listed in Table 1.

Clay from an off-site location will be used if necessary. The clay will be pretested by the CQA personnel prior to approval of the source. Tests will include those listed in Table 1 in addition to a visual inspection of the source site for uniformity and the presence of undesirable materials. Inspection of the off-site clay soil will also be conducted as it arrives at the construction site. Off-site material rejection criteria are the same as those listed for on-site materials. If the borrow areas contain non-uniform materials, the CQA inspection personnel may choose to guide excavating equipment to avoid or segregate substandard soil material as it is excavated at the source. CQA inspection personnel will observe segregation operations carefully and continuously to ensure that only suitable material is retained for liner construction.

b. Test Fill Construction - A test fill will be used to verify the adequacy of the materials, design, equipment, and construction procedures proposed for the construction of the low permeability layer. The construction of a test fill will be used to minimize the potential dangers and expense of constructing an unacceptable compacted clay cover. In addition, the test fill will be used for evaluating permeability, the most critical performance standard of the compacted clay cover layer.

Figures 1 and 2 show the construction of the test fill. The following guidelines will be followed so that the test fill will accurately represent the full scale fill.

(1) Construction of the test fill will use the same clay soil material, design specifications, equipment, and procedures proposed for the full-scale

facility.

(2) All applicable parts of the CQA Plan will be followed precisely to monitor and document test fill construction and testing.

(3) The test fill will be constructed at least four times wider than the widest piece of construction equipment to be used on the full-scale facility (Fig. 1).

(4) The test fill will be long enough to allow construction equipment to achieve normal operating speed before reaching the area within the test fill that will be used for testing (Fig. 1).

(5) The test fill will be constructed with at least three lifts.

(6) To evaluate the proposed method for repair of defective portions of the full-scale compacted clay layer, a portion of the test fill clay layer, not less than 6 ft x 6 ft square, will be removed and replaced. The size of the portion removed will not be less. Repair of the removed section will be as described in the construction section.

During test fill construction, data on the following variables will be recorded by the CQA personnel. If the materials, equipment or methods change significantly, additional test fills will be constructed.

(1) The compaction equipment type, configuration, and weight.
(2) The number of passes of the compaction equipment.
(3) The method used to control and adjust moisture content.
(4) The speed of the compaction equipment traveling over the clay layer.
(5) The uncompacted and compacted lift thicknesses.

After the test fill construction, samples from the test fill will be laboratory or field tested for the following characteristics:

(1) Compaction testing/field density - ASTM D-2922
(2) Laboratory permeability - falling head method.
(3) Particle size distribution - ASTM D-421 and 422.
(4) Atterberg limits - ASTM D-423 and 424.
(5) Natural moisture content - ASTM D-2216.
(6) Thickness determination - hand auger through fill.

The six test samples will be from the four corners of the fill, the center of the fill, and on the area removed and replaced. After the samples are taken, the voids will be properly patched as described in the construction section. The results of the testing will be evaluated by the CQA officer for compliance with specifications.

After the sampling voids have been repaired according to the methods in the following construction section, a field permeability test will be conducted by the CQA inspection personnel. The results of this test must be compared with laboratory results, reviewed, and approved by the CQA officer.

2. **Construction**: CQA personnel must observe placement of the barrier soil at all times. It is the responsibility of CQA personnel to observe the following characteristics of the cover system materials before, during and after placement. CQA personnel will report any deficiencies to the contractor for correction and also to the CQA officer. The CQA officer is responsible for making sure the deficiency is corrected.

   a. Presence of roots, rocks, rubbish or off-spec soil in the clay or sand materials - These materials may be removed by hand or machine as long as the integrity of the earlier lifts or of the cover system base is not damaged. The void created by the removed material will be made large enough that the exposed surfaces can be scored with a sharp implement and patched with clay that meets construction specifications. Patched areas will be rolled with a sheeps foot roller a minimum of four times and tested for proper density.

   b. Presence of off-spec soil in the clay or sand materials - Small areas of in-place soil suspected to be off-spec such as sand lenses may be removed at the discretion of the CQA inspection personnel or contractor. If the amount of soil in question is large or if it is questionable as to whether it is within specifications, the material may be tested at the discretion of the CQA officer. If the soil is off-spec, it will be removed and patched as described above.

   c. Adequate loose lift thickness - The CQA personnel will watch spreading of the lift to ensure that no more than the specified loose lift thickness specified is placed.

   d. Adequate clod reduction - CQA personnel will observe the spreading and compaction process to verify that the clod size is being adequately reduced by the sheeps foot roller.

   e. Proper moisture control - CQA personnel will check the moisture of the fill to ensure the moisture content is within the specified compaction range. Moisture will be checked with a speedy moisture gauge, nuclear, or laboratory methods. If the soil is too wet to be compacted, the soil will be worked with a sheeps-foot roller and allowed to dry until proper moisture content is attained. As an alternative, the soil may be removed and replaced. Soil which is too dry will be evenly sprayed with water. The water will then be worked into the soil with the sheeps-foot roller. After the moisture adjustment is complete, it will be tested at the top and bottom of the lift to verify proper moisture content. After the completion of the clay cover, the surface will be protected as necessary from drying and cracking by placement of temporary mulch layer.

f. Proper use of equipment - CQA personnel will record equipment configuration, weight, speed, and number of passes. The equipment variables must be the same as those used to construct the test fill. Any changes in equipment, speed, or number of passes will necessitate a new test fill.

g. Proper and consistent soil density and permeability - The soil density and moisture content of the fill material will be tested at the frequency described under Sampling Strategies. Additional testing locations will be selected by CQA personnel to monitor areas which are difficult to compact such as fill edges, equipment turnarounds, designed liner protrusions, and the tops or bottoms of slopes. A laboratory permeability test using the falling head method will also be taken at the frequency described under Sampling Strategies.

h. Proper tying of layers together - The in-place lift of the clay layer will be scarified before placement of the upper layer to properly tie these layers together. CQA personnel will observe the contractor performing this procedure. Use of a sheeps foot roller will also be used to aid in tying the lifts together.

3. **Post-Construction**: Immediately before placement of any protective cover, the compacted clay layer will be inspected for cracks, holes, defects, or any other features that may increase its field permeability. All defective areas will be removed and replaced as described in 2a above. If the underlying foundation is defective (i.e., soft or wet), then this material will also be removed and replaced as described under Section IV.B Foundation Construction. Excavated areas will be repaired by the method verified during test fill construction and density testing will be used to ensure that there is continuity between the repaired and undisturbed areas. The completed clay cover layer will be protected from desiccation, erosion, and freezing immediately following completion of the uppermost lift. Verification of cover system thickness and slope will be done by cross sectioning by registered surveyors at 50-foot intervals. Results of the survey will be reviewed and validated by the CQA officer.

D. Sand Drainage Layer

The sand layer will be placed above the clay barrier at a 3% slope to provide drainage above the clay layer. The soils used for this layer will be clean, inorganic, free-draining, and granular.

1. **Preconstruction**: At this time, the source of the sand soils is not known. Prior to construction the source material will be tested by CQA personnel to confirm the material meets material specifications. The CQA officer must approve the source prior to use.

2. **Construction**: The following characteristics of materials and methods will be controlled by the CQA personnel.

a. Proper materials - The material will be rejected if it contains roots, stumps, rocks, rubble, organics, or any other unsuitable material. The sand material will be visually inspected during placement for an excessive amount of fine or organic materials. If a visual analysis indicates that the soil does not meet the specified gradation, the soil will be sieved according to ASTM C-136. Any off-spec soil will be removed from the site.

b. Proper methods - The density and moisture content of the sand drainage material will be tested after placement according to the frequency described under Sampling Strategies. The soil will also be tested, at the discretion of CQA inspection personnel, at points that are difficult to compact. These locations could include fill edges, equipment turnarounds, and the tops and bottoms of slopes. ASTM D-1557 will be used to determine the maximum density and the optimum moisture content. Sand with less than the maximum density will be recompacted or replaced with compacted sand.

3. **Post-Construction**: After construction, the sand drainage layer surface will be surveyed by a registered surveyor to verify that it has been placed at a proper slope and thickness.

E. Topsoil and Seeding

1. **Preconstruction**: During preconstruction activities, the topsoil will be tested for the specified organic content. Seed content will also be confirmed by reviewing manufacturers data sheets before seeding.

2. **Construction**: During the construction of the topsoil and seeding, the following characteristics will be observed:

a. Uniformity and compaction of topsoil - The soil spreading process will be observed to ensure that the soil is uniformly placed and not overly compacted.

b. Proper slope and thickness - A survey by a professional surveyor will be used to verify the soil thickness and slope.

c. Proper seeding methods - The equipment, seeding rate, uniformity of coverage, and timing of seeding will be monitored and noted by CQA personnel.

3. **Post-Construction**: After construction, a visual check of the cover will be made. A final survey will be made by registered surveyors to verify slope and thickness. Once a month a qualified specialist will inspect the cover vegetation for a minimum of four months after germination. The contractor will be responsible for maintaining the integrity of the cover for the first year. Repair and maintenance of the cover will be the responsibility of Dow Corning after this first year.

V. SAMPLING STRATEGIES

The sampling strategy for the installation of the cover system at Dow Corning consists of two parts: (1) sampling of areas representative of work, and (2) sampling of areas suspected to be deficient. Table 2 outlines the tests, test methods, minimum sample sizes, frequency, and acceptance criteria for the various tests described under Inspection Activities.

The testing frequency listed in Table 2 indicates a minimum sampling frequency that will provide a high degree of assurance that the cover is constructed according to specifications. These samples will be taken in areas which CQA inspection personnel determine are representative of the work as a whole. The U.S. Department of Navy; Design Manual; Soil Mechanics, Foundations and Earth Structures and the State of Michigan Department of Highways Construction Manual and Guidelines for Quality Control Programs (MDNR) were used as references to determine the sampling frequencies.

The Navy Design Manual requires one compaction test for every 2,000 cubic yards of material placed for mass earthwork and one compaction test for every 1,000 cubic yards of material placed in relatively thin sections for canal or reservoir lining. The State of Michigan Construction Manual requires one compaction test for every 3,000 cubic yards of Class IIa sand material in place. MDNR Guidelines for Quality Control recommend one compaction test for each 500 to 1,000 c.y. placed with a minimum of one test per day of construction and one per layer placed. Using these requirements as guidance, compaction testing frequency for both the sand drainage layer (Class IIa sand) and the low permeability layer will be for every 1,000 cubic yards of sand or clay material placed. The soil density moisture relationship will be determined every 5,000 cubic yards. The U.S. Navy Design Manual require one soil density/moisture relationship for every 10-20 compaction tests.

Other testing frequencies for the sand drainage layer and the low permeability soil layer will be every 3,000 cubic yards and 5,000 cubic yards, respectively. The State of Michigan requires a particle size distribution test once every 3,000 cubic yards in place for Class IIa sand material.

Other sampling locations will be chosen in regions of questionable construction quality or material quality. All samples must meet the acceptance criteria of Table 2, and be assembled into sample blocks as outlined below.

A. Sample Blocks

Sample blocks are areas of work closely associated that may be accepted or rejected as a unit. To be defined as a block, all tests, observations, and other data in the block must be accepted by the CQA officer. The following units are defined as sample blocks:

1. Clay Layer - every 5,000 cubic yards placed.
2. Sand Layer - Every 6,000 cubic yards placed.
3. Topsoil - Entire lift
4. Seeding - Entire process.

Documentation of the acceptance of a block will be discussed in the last section.

VI. DOCUMENTATION

A. Daily Recordkeeping

Standard daily reporting procedures will include a daily field report with supporting inspection data sheets and, when appropriate, problem identification/corrective measure reports. If photography is used to record CQA activities, it will also become part of the daily recordkeeping.

1. **Daily Field Report**: Figure 3 is a copy of the form that will be used as a Daily Field Report. The Daily Field Report will be completed by the CQA inspection personnel and reviewed and signed by the CQA officer. The reports will be identified by a consecutive report number which will be used to reference all other CQA documentation reported on a given day. The CQA personnel will use the checklist below to assure the completeness of the Daily Field Report. The letters below refer to the space the data should be entered in on the Daily Field report (Fig. 3)

    a. Report Number: A unique, consecutive report number will be assigned and recorded in this blank. This number will be used on all CQA inspection reports produced on the same day as a report reference number.

    b. Client: Dow Corning, Midland, Michigan.

    c. Date: The date of the report will be recorded. The report will always be completed on the day of inspection.

    d. Location: 800 and 1000 Block, Midland.

    e. Project No.: EDI's project number will be recorded.

    f. Work Description: Installation of cover system for hazardous waste landfill.

    g. Contractors: The contracting and subcontracting firms will be listed.

    h. Safety Precautions: The level of safety as described by the U.S. Environmental Protection Agency will be entered. This system describes levels of safety as A, B, C or D levels.

    i. Staff: All CQA staff present during the day will be listed.

j. Contractor: The contractor's foreman and supervisor will be listed.

k. Conditions: A brief description of the weather will be provided.

l. Temperature: The temperature from an on-site thermometer will be recorded. Both the low and high temperatures observed during daily construction activities will be indicated.

m. Manpower and Equipment: The contractors and subcontractors personnel and equipment, as well as the number of hours which were spent on-site will be recorded. Size and model of all equipment will be recorded. The space mark "disposal quantities" will be used for any general remarks such as number of passes, equipment function, equipment description, etc.

n. Sampling and Testing Locations and Methods: A summary of the daily laboratory and field data and calibration information will be prepared and recorded. Any data collected on that day will be identified by the reference number shown in a.

o. Visitors: All visitors to the construction site, as well as the organization they represent and the purpose of the visit will be recorded.

p. Principal Work Performed: A detailed description of the construction processes and their locations will be provided. A description of the manpower and equipment used for these processes and the material types and volumes brought to the site will be recorded. Areas of inspection will be noted. Data to be referenced here as described under Other Daily Data Sheets will include any block evaluation reports, meeting minutes, photographic reports, and miscellaneous reports.

q. Incident Report or Significant Observations: Problem/corrective measures, reports or miscellaneous reports will be described and referenced as described under Other Daily Data Sheets. Any corrective measures will be summarized.

r. Inspector: The Daily Field Report will be signed by the CQA inspection personnel and after review, by the CQA officer.

2. **Other Daily Data Sheets**: Other daily data sheets include meeting minutes, field data, laboratory data, problem/corrective measure reports, photographic data, and miscellaneous data. Each sheet will be identified with the Daily Field Report reference number followed by a letter that denotes the type of data sheet.

M - Project meeting minutes (problem, periodic, daily)
F - Field data sheets (visual inspections, density tests, moisture tests, etc.)
L - Laboratory data sheets (proctors, gradations, lab permeabilities, etc.)
P - Photographic reports
C - Problem identification/corrective measure reports
X - Miscellaneous (calibrations, etc.)

If there is more than one sheet in any of the above categories, they will be lettered consecutively (a, b, c, etc.). An example of this reference system would be 22Fb. This designation would mean the sheet is the second sheet of field data taken on the twenty-second day of construction.

a. Project Meeting Minutes (M) - Minutes of each project meeting will be taken by CQA personnel (see Figure 4). The minutes will be taken and signed by the CQA inspector and reviewed and signed by the CQA officer.

b. Field Data Sheets (F) - Field data sheets will contain all field data taken during inspection. These sheets include but are not limited to the following:

- Survey notes
- Moisture and Density Determinations of Soils (Fig. 5)
- Water Content Determinations (Fig. 6)
- Visual inspections

Many field inspection activities are not in the format of Figures 5 and 6. These activities will be recorded with the following minimal amount of information.

- Unique report reference number for cross-referencing and document control;
- Description or title of the inspection activity;
- Location of the inspection activity or location from which the sample increment was obtained;
- Type of inspection activity; procedure used (reference to standard method when appropriate);
- Recorded observation or test data, with all necessary calculations;
- Results of the inspection activity, including comparison to specification

requirements;

- Personnel involved in the inspection activity; and
- Signature of the appropriate CQA inspection personnel and concurrent signature by the CQA officer.

c. Laboratory Data Sheets (L) - Laboratory data sheets will contain all the laboratory data taken during the duration of the project. These sheets include but are not limited to the following:

- Coefficient of Permeability (Fig. 7)
- Compaction Test results (Fig. 8)
- Grain Size Analysis - Mechanical (Fig. 9)
- Atterberg Limits Determination (Fig. 10)
- Hydrometer Testing Results (Fig. 11)

Some of the laboratory activities are not in the format of Figures 8 through 11. These activities will be recorded with the same minimal amount of information required for Field Data Sheets.

d. Photographic Records (P) - Photographs may be used as a record of progress, problems, and corrective measures. They will be kept in a protective photo album with the following information on the back of the photographs:

- A unique identifying number on data sheets and photographs for cross-referencing and document control;
- The date, time and location where the photograph was taken and weather conditions;
- The size, scale and orientation of the subject matter photographed;
- Location and description of the work;
- The purpose of the photograph; and
- Signature of the photographer and concurrence of the CQA officer.

Negatives will be stored separately from the photographs in a binder with envelopes labeled as above.

e. Problem Identification/Corrective Measures Report (C): The format for problem identification and corrective measures is shown on Figure 12.

B. Block Evaluation Report

At the completion of each inspection block, the data sheets will be organized into a block evaluation report. Original data sheets will be kept in chronological order. Copies of data sheets will be used for the Block Evaluation Reports. These block evaluation reports will be used to summarize all of the site construction activities within a construction block.

Block evaluation reports will be prepared by the CQA officer and will include the following information:

1. A unique identifying sheet number for referencing and document control.

2. A description of the block (using project coordinate system to identify areas, and appropriate identifiers for other units of material or work).

3. The quality characteristic being evaluated with references to design criteria, plans, and specifications.

4. Sampling requirements for the inspected block and how they were established.

5. Sample item locations (described by project coordinates or by a location sketch on the reverse of the sheet).

6. Inspections (define procedure will be defined by name or other identifier; including the unique identifying sheet number for inspection data sheets).

7. Acceptance criteria (block inspection data will be compared with design specification requirements). Compliance or noncompliance with specifications will be indicated. In the event of noncompliance, documentation will be provided that gives reasons for acceptance outside of the specified designs).

8. Signature of the CQA officer.

C. Acceptance of Completed Components

All daily inspection summary reports, inspection data sheets, problem identification and corrective measures reports, and block evaluation reports will be reviewed by the CQA officer. The documentation will be evaluated and analyzed for internal consistency and for consistency with similar work. Timely review of these documents will ensure that errors, inconsistencies, and other problems will be detected and corrected as they occur.

The information outlined above will be assembled and summarized into periodic acceptance reports. Acceptance reports will be written for the foundation, the low permeability layer, the sand drainage layer, and the topsoil seeding. These reports will demonstrate that the materials and construction processes comply with the specified design. They will be included in project records and submitted to the facility owner. Copies of these reports will be submitted to the permitting agency upon request.

D. Final Documentation

At the completion of the project, the facility owner will submit a final report to the permitting agency. This report will include all of the daily inspection summary reports, inspection data sheets, problem identification and corrective measures reports, block evaluation reports, photographic reporting data sheets, acceptance reports, deviation from design and material specifications (with justifying documentation), and as-built drawings. This document will be certified and included as part of the CQA Plan documentation. Final documentation will include a copy of the CQA Plan signed by the facility owner/operator, design engineer, CQA officer, and the contractor. These signatures will be used to document that each party understood and accepted their areas of responsibility and lines of authority and that they performed their function(s) in accordance with the CQA Plan.

E. Storage of Records

During the construction of a hazardous waste land disposal facility, the CQA officer will be responsible for all facility CQA documents. This includes the CQA officer's copy of the design criteria, plans and specifications, the CQA Plan, and the originals of all the data sheets and reports. Duplicate records will be kept by the facility owner to avoid loss of this information if the originals are accidentally destroyed.

Once facility construction is complete, the document originals should be stored by the owner/operator in a manner that will allow for easy access while still protecting them from any damage. An additional copy will be kept at the facility if this is in a different location from the owner/operator's files. A final copy should be kept by the permitting agency in a publicly acknowledged repository. All documentation will be maintained through the operating and post-closure monitoring periods of the facility.

PROBLEM IDENTIFICATION/CORRECTIVE MEASURES REPORT

Report Reference #_____

Cross-Reference # _____

Location:

Date:
Date Problem Identified:

Problem Description:

How problem was discovered:

Probable Cause:

Estimation of how long and what locations problem exist:

Documentation of correction (may be by cross-reference):

Final Results:

Prevention of similar problems:

CQA Inspector: _____

CQA Officer: _____

TABLE 1: CLAY MATERIAL TESTING RESULTS

	Test	Method	Sample 1 Results	Sample 2 Results	Specification	Meets or Exceeds Specification
1.	Permeability (samples greater than 90% compaction)	Falling Head	$3.5x10^{-8}$ to $4.4x10^{-8}$ cm/s1	$1.7x10^{-8}$ to $5.8x10^{-8}$ cm/s	$1x10^{-7}$ cm/s	Yes
2.	Particle Size Distribution	ASTM C-136	82% of particles are 5 microns	77% of particles are 5 microns	5% particles must be 5 microns	Yes
3.	Unified Soil Classification (Atterberg limits)	ASTM D-423 and 424	CL	CL	Must be a CL or CH	Yes
4.	Soil density/moisture relationships					
	a. Maximum density	ASTM D-1557	119.2 pcf[2]	118.5 pcf	none[3]	-
	b. Optimum moisture	ASTM D-1557	13.9	14.5	none[3]	-
	c. Natural moisture	ASTM D-2216	15.0	16.1	none[3]	-

---

1 Centimeters per second.

2 Pounds per cubic foot.

3 These parameters will be used for construction inspection, clay must be compacted to 90% of the maximum density at a moisture not less than 2% below or greater than 5% above optimum moisture. Natural moisture content gives an indication to the contractor whether or not to add moisture.

TABLE 2: SAMPLING AND TESTING STRATEGY

Test	Test Method	Minimum Sample Size	Frequency[4]	Acceptance Criteria
A. Low Permeability Layer				
1. Atterberg Limits	ASTM D-4318	120 grams	1/5,000 cu.yd.	Unified Soil Classification of CL.
2. Compaction Testing/ Field Moisture	ASTM D-2922	In place[1]	1/1,000 cu.yd. lift and 1 per day	Density 90% of maximum density by ASTM D-1557. Moisture -2% to +5% of ASTM D-1557 optimum.
3. Laboratory Permeability	USEPA SW 925 Falling Head or ASTM D-2434	1 sample[2]	1/7,500 cu.yd.	1x10-7 cm/s or less
4. Moisture Content (lab)	ASTM D-2216	50 grams	1/10,000 cu.yd.	Moisture -2% to +5% of ASTM D-1557 optimum.
5. Particle Size Distribution	ASTM D-1140	60 grams	5,000 cu.yd.	More than 25% < 5 microns
6. Soil Density/Moisture Relationship	ASTM D-1557	25 pounds	/5,000 cu.yd. or change in in soil texture	Note 3
B. Sand Drainage Layer				
1. Compaction Testing/ Field Moisture	ASTM D-2922	In place[1]	1/1,000 cu.yd.	Density 90% of maximum
2. Loss by Washing	ASTM C-117	500 grams	1/3,000 cu.yd.	Must not be more than 7%
3. Particle Size Distribution	ASTM C-136	500 grams	1/3,000 cu.yd.	Must meet MDOT Class II
4. Soil Density/Moisture Relationship	ASTM D-1557	25 pounds	1/5,000 cu.yd.	Note 3

TABLE 2: SAMPLING AND TESTING STRATEGY (continued)

C. Topsoil

1.	Organic Content	AASHTO T194-70	1 grams	2/source	Must be 5% to 20%
2.	pH	-	-	2/source	Must be 5.5 to 7.6.

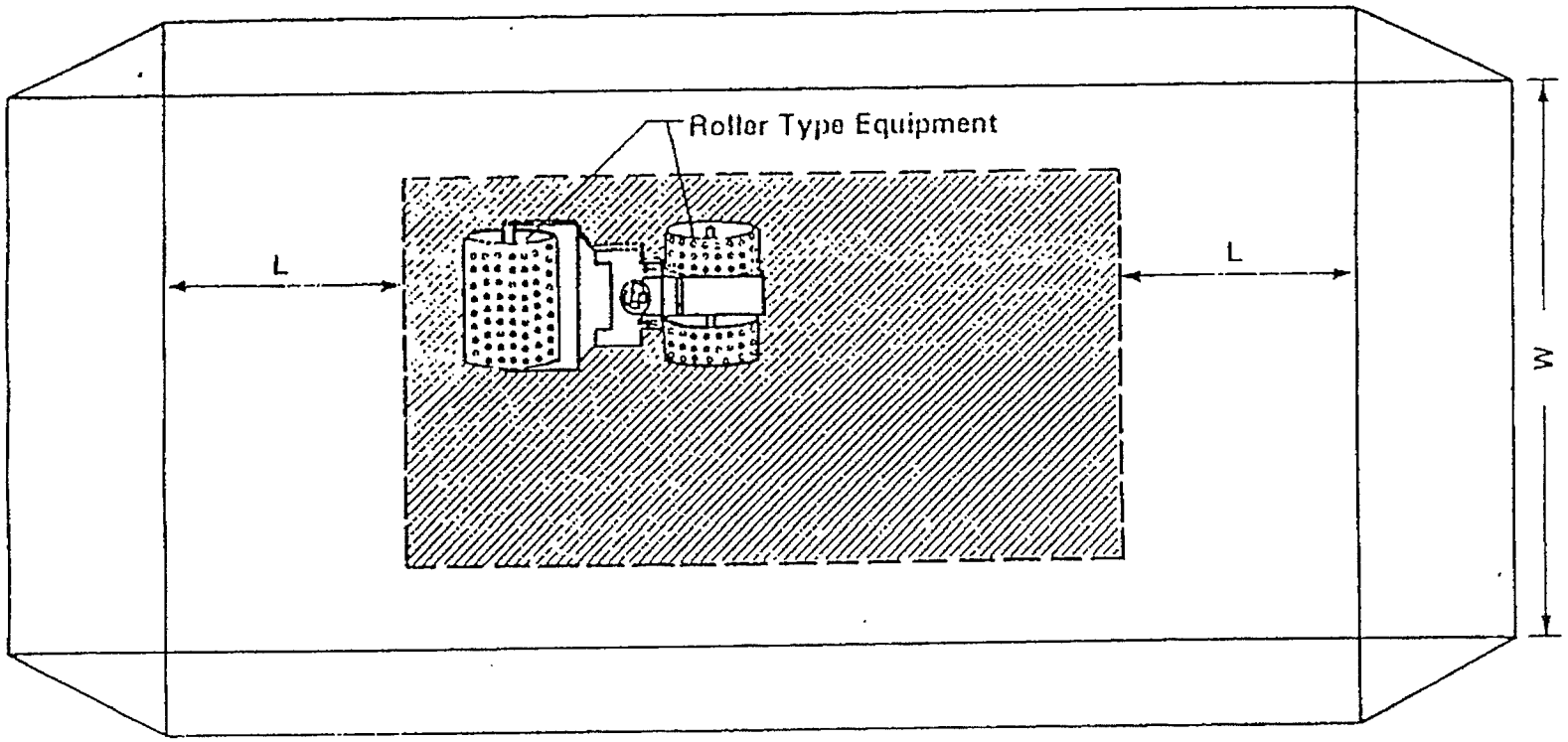
---

[1] Test is field performed, in place.

[2] Sample size depends on test method chosen. Samples must be relatively undisturbed.

[3] Produces maximum density and optimum moisture data necessary for Compaction Testing/Field Moisture test.

[4] Guidelines for Quality Control Certification Programs, Michigan Department of Natural Resources

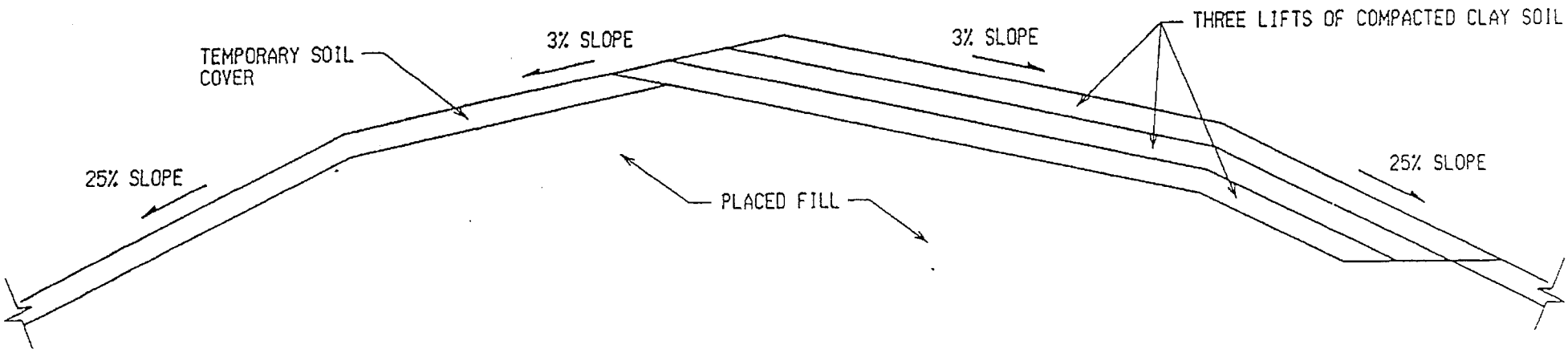


L = Distance required for construction equipment to reach normal running speed
W = Distance at least four times wider than the widest piece of construction equipment
▨ = Area to be used for testing

FIGURE 1

PLAN VIEW OF TEST FILL

REV. 1 1/94 P.C.



LANDFILL FINAL COVER CLAY LINER

FIGURE 2
CROSS SECTION OF TEST FILL

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Report # _____

Figure 3
DAILY FIELD REPORT

Client: b. Date: C.

Location: d. Proj. No.: E.

Work Description: F

Contractors:

Safety Precautions (level A B C D, equipment & methods): H.

EDI Staff: I.

Contractor: J.

Manpower	Crew 1 No	Crew 1 Hrs	Crew 2 No	Crew 2 Hrs	Crew 3 No	Crew 3 Hrs	Crew 4 No	Crew 4 Hrs
M. Supt.								
Foreman								
Operator								
Laborer								
Other								

Weather

Conditions: K.

Temperature: L.

Equipment	Model No.	Size	Disposal Quantities
Backhoe			
Bulldozer			
Crane			
Loader			
Dump truck			
Scraper pan			
Hazardous waste truck			
Air comoressor			
Roll-off			
Vacuum truck			
Portable pump & tank			
Steam generator			
Water blaster			
Boring equipment			
Other			
Other			

Sampling and Testing Locations and Methods (attach map): N.

Visitors (title, company, purpose): O.

Principal Work Performed: P.

Incident Report or Significant Observations: Q.

COA Inspector: _____

COA Offices: _____

MEETING MINUTES

Report Reference #_____

Location:

Date:

Time:

Purpose:

Present/Organization:

Minutes:

CQA Inspector: _____

CQA Officer: _____

FIGURE 4

WATER CONTENT DETERMINATION

Cross Reference #_____

Project _____ Job No. _____

Location of Project _____

Description of Soil _____

Tested By _____ Date of Testing _____

Date of Weighing _____

Boring no.					
Container no. (cup)					
Wt. of cup + wet soil					
Wt. of cup + dry soil					
Wt. of cup					
Wt. of dry soil					
Wt. of water					
Water content, $w\%$					

Boring no.					
Container no. (cup)					
Wt. of cup + wet soil					
Wt. of cup + dry soil					
Wt. of cup					
Wt. of dry soil					
Wt. of water					
Water content, $w\%$					

CQA Inspector _____

CQA Officer _____

Figure 5

Tested by ____________________ Proj

...al No.	Recheck Test No.	MOISTURE DETERMINATION — Weight in Grams: Wet Soil + Can	Dry Soil + Can	Water	Can	Dry Soil	Per cent Moisture	VOL. OF SAMPLE (In Cu. Ft.): Rainhart	Mold	DENSITY DETERMINATION — Weight in Grams: Wet Soil + Pan	Pan	Wet Soil	Wet Soil, lbs.	Pounds per cu. ft.: Compacted Soil Wet	Compacted Soil Dry	Max. Density	Per Cent of Compaction	LOCATION OF TEST
		1	2	3	4	5*	6*	7	8	9	10	11	12*	13*	14*	15	16*	

Col 5 = Col 2 − Col 4 | Col 6 = $\frac{\text{Col. 3}}{\text{Col. 5}} \times 100$ | Col. 12 = $\frac{\text{Col. 11}}{453.59}$ or Col. 11 × 0.0022 | Col. 13 = $\frac{\text{Col. 12}}{\text{Col. 7 or 8}}$ | Col. 14 = $\frac{\text{Col. 13}}{\text{Col. 6 + 100}} \times 100$ | Col. 16 = $\frac{\text{Col. 14}}{\text{Col. 15}} \times 100$

...ARKS. ____________ CQA Inspector

CQA Officer

Figure 6

COEFFICIENT OF PERMEABILITY (Constant Head, Falling Head)

Project _____ Job No. _____

Location of Project _____

Description of Soil _____

Tested by _____ Date of Testing _____

Sample Dimensions: Diam. _____ cm; Area _____ cm²; Ht. _____ cm

Wt. soil + pan Init. _____ g

Wt.soil + pan Final _____ g

Wt. of Sample _____ g

Vol. _____ cm³

Unit wt. _____ kN/m³

Constant Head

Test data *Test data used*

Test No.	t, s	Q, cm³	T, °C	Test No.	t, s	Q, cm³	T, °C
1							
2							
3							
4							
				Average[a]			

$k_T = QL/Aht =$ _____

$\eta_T/\eta_{20} =$ _____

= _____ cm/s $k_{20} = k_T\eta_T\eta_{20} =$ _____ cm/s

Falling Head

Standpipe = [burette, other (specify)] _____

Area of standpipe, $a =$ _____ cm²

Test data[b] *Test data used*

Test no.	h_1, cm	h_2, cm	t, s	Q_{av}, cm³	Q_{av}, cm³	T, °C	Test no.	h_1, cm	h_2, cm	t, s	T, °C
1											
2											
3											
4											
							Average				

$\eta_T/\eta_{20} =$ _____

$k_T = \frac{aL}{At} \ln h_1/h_2 =$ _____ = _____ cm/sec

$k_{20} = k_T\eta_T/\eta_{20} =$ _____ = _____ cm/sec

[a]Use averaged values only if there is a small difference in test temperature, say, 1–2°C.

[b]This test can be considerably simplified by using the same values of h_1 and h_2 each time, otherwise you cannot average these values regardless of T.

CQA Inspector _____

CQA Officer _____

Figure 7

COMPACTION TEST

Project _____ Job No. _____

Location of Project _____ Boring No. _____ Sample No. _____

Description of Soil _____

Test Performed By _____ Date of Test _____

Blows/Layer _____ No. of Layers _____ Wt. of Hammer _____ N

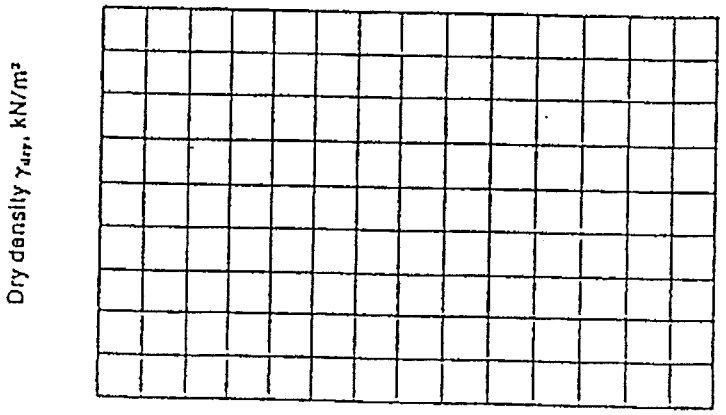
Mold dimensions: Diam. _____ cm Ht. _____ cm Vol. _____ cm^3

Water Content Determination

Sample no.	1		2		3		4		5		6	
Moisture can no.												
Wt. of can + wet soil												
Wt. of can + dry soil												
Wt. of water												
Wt. of can												
Wt. of dry soil												
Water content, w%												

Density Determination

Assumed water content						
Water content, w%						
Wt. of soil – mold						
Wt. of mold						
Wt. of soil in mold, g						
Wet density, kN/m^3						
Dry density γ, kN/m^3						



Optimum moisture = _____% Maximum dry density = _____ kN/m^3

CQA Inspector _____

CQA Officer _____

Figure 8

GRAIN SIZE ANALYSIS–MECHANICAL

Project _____ Job No. _____

Location of Project _____ Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By _____ Date of testing _____

Soil Sample Size (ASTM D1140-54)

Nominal diameter of largest particle	Approximate minimum Wt. of sample, g
No. 10 sieve	200
No. 4 sieve	500
3/4 in.	1500

Wt. of dry sample + container	
Wt. of container	
Wt. of dry sample, W_s	

Siece analysix and grain shape

Sieve no.	Diam. (mm)	Wt. retained	% retained	% passing

% passing = 100 − $\sum$ % retained.

CQA Inspector _____

CQA Officer _____

Figure 9

ATTERBERG LIMITS DETERMINATION

Cross Reference # _____

Project _____ Job No. _____

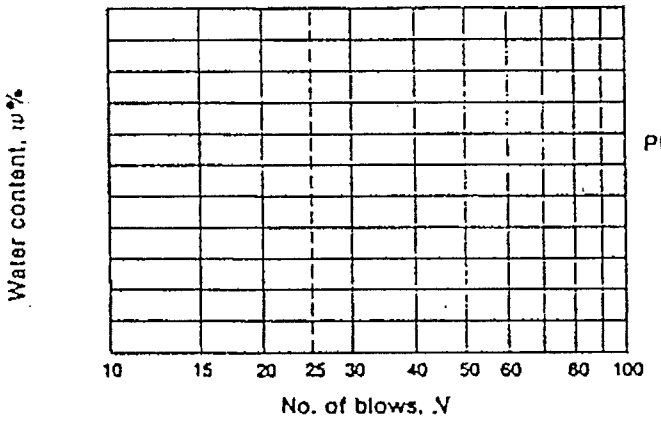
Location of Project _____ Boring No. _____ Sample No. _____

Description of Soil _____

Depth of Sample _____ Tested By _____ Date _____

Liquid Limit Determination

Can no.						
Wt. of wet soil + can						
Wt. of dry soil + can						
Wt. of can						
Wt. of dry soil						
Wt. of moisture						
Water content, w%						
No. of blows, N						



Flow index F_f = _____

Liquid limit = _____

Plastic limit = _____

Plasticity index I_p = _____

Plastic Limit Determination

Can no.				
Wt. of wet soil + can				
Wt. of dry soil + can				
Wt. of can				
Wt. of dry soil				
Wt. of moisture				
Water content, w% = w_p				

CQA Inspector _____

CQA Officer _____

Figure 10

GRAIN SIZE ANALYSIS-HYDROMETER METHOD

Project _____ Job No. _____

Location of Project _____ Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By _____ Date of Testing _____

Hydrometer analysis

Hydrometer no. _____ G_s of solids = _____ a = _____

Dispersing agent _____ Amount _____ Wt. of soil, W_s _____

Zero correction _____ Meniscus correction _____

Date	Time of reading	Elapsed time, min	Temp., °C	Actual Hyd. reading R_a	Corr. Hyd. reading R_c	% Finer	Hyd. Corr. only for meniscus, R	L from Table 6-5	$\frac{L}{t}$	K from Table 6-4	D, mm

$R_c = R_{actual} - \text{zero correction} + C_T$ % liner $= R_c(a)/W_s$ $D = K\sqrt{L/t}$

Figure 11

Date : 3/14/94
Revision Date :

PROBLEM IDENTIFICATION/CORRECTIVE MEASURES REPORT

Report Reference #_____

Cross-Reference # _____

Location:
Date:
Date Problem Identified:

Problem Description:

How problem was discovered:

obable Cause:

Estimation of how long and what locations problem exist:

Documentation of correction (may be by cross-reference):

Final Results:

Prevention of similar problems:

CQA Inspector: _____
CQA Officer: _____

FIGURE 12

Postclosure Landfill Cap Inspection Procedure

1. Grid System

A simple grid system will be established to divide the cap into discrete areas for inspection by using small stakes and the following procedure to establish a grid system:

a. Place one stake at each corner of the top of the cap (drive the stake 2-3 inches into the topsoil to avoid puncturing the geomembrane). Label one of the stakes as coordinate 0,0 as shown in Figure 1 (typically the southwest corner).

b. Measure the area of the top of the cap around the perimeter (area 'abcda,' Figure 1).

c. Sketch the area in your field book and establish a reasonable grid interval (i.e. 200 feet along the perimeter and 400 feet within the top of the cap as shown in Figure 1). Record the staking information in your field book (stake locations and coordinates).

d. Transfer the grid system established in c. to the top of the cap (using stakes and a measuring tap). Label the areas you have delineated as shown in Figure 1.

e. Establish a grid system for the side slopes. The grid system for the side slopes should be constructed by placing stakes along the toe of the slopes. Use the same procedure outlined in 1.a. through 1.d. and Figure 1.

2. Procedure for Visual Inspection

Once the grid system has been established, the top of the cap and side slopes are ready for inspection. Now use the inspection log (Figure 2) to record the visual observation of the cap conditions. Note that on the top of the inspection log staff are asked to fill in the coordinates inspected and recorded in inspection log. Inspection of each is to include the observation and identification of the following:

a. Identify undesirable plant species (species that are capable of developing deep roots and adversely affect the integrity of the cover).

b. Identify vegetative cover that is damaged or destroyed.

c. Identify patches of sparse growth.

d. Identify areas of surface erosion, erosion rifts, and/or surface cracks.

e. Identify evidence of burrowing by animals

f. Identify disruption of original grade.

g. Identify settlement, ponding, and/or localized subsidence.

h. Identify areas with inadequate thickness of topsoil (areas with less than six inches of loamy topsoil).

i. Identify areas of slope instability or failure.

j. Inspect the base (toe) of the slope for saturation.

k. Identify areas of exposed liner.

l. Identify seepage of leachate from the side slopes.

m. Identify damage to spillways and diversion berms; look for excessive sediment build-up or other blockage that could restrict flow and cause erosion of the final cover.

n. Review records of leachate volume removed from the leachate collection and removal system (LCRS) to evaluate the behavior of leachate collection versus time; look for any unusual increase.

3. Final Cover Inspection Log and Company's Documentation

The Final Cover Inspection Log, Figure 2, will be completed during the final cover inspections. Unacceptable conditions will be identified in the remarks or comments section. The cause of damage will be investigated and determined. Corrective action will be performed immediately on minor repairs. If major corrective action is necessary, a written report summarizing the corrective action will be provided to the Waste Management Division for their approval.

Following a final cover inspection Dow Corning will send a letter to the Waste Management Division indicating the date of the inspection, identifying any problems or damage, suspected cause of the problem, and the appropriate course of action to remedy the problem or repair the damage. The letter will include the amount of time it took or the amount of time necessary to complete repairs. Inspection logs and/or inspection check list must be submitted with the letter.

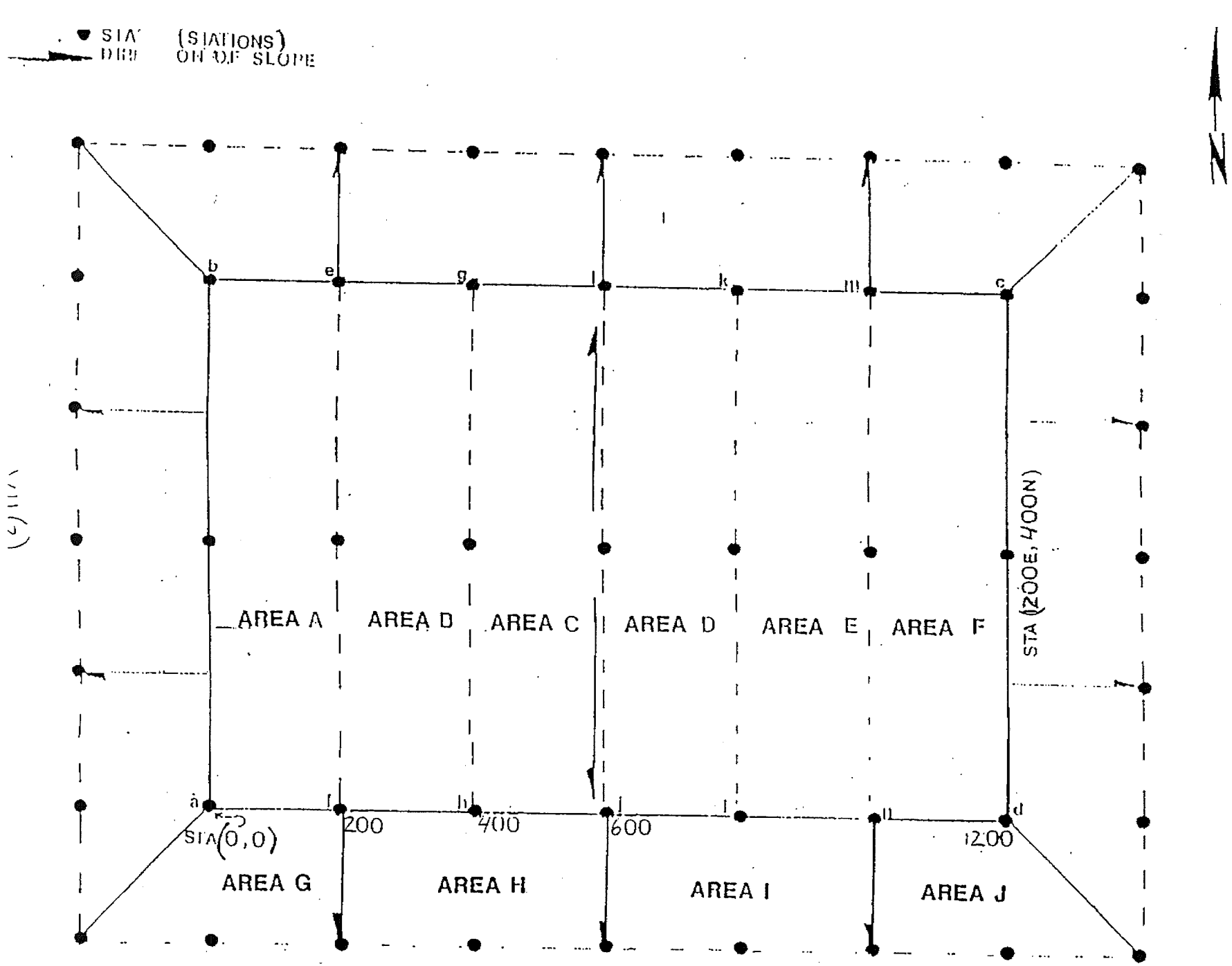


Figure 1. Top of cap and side slopes.

FIGURE 2 4/14/94

Final Cover (Cap) Inspection Log

Date: Time: Inspector: Weather:

Facility: MID: Coordinates:

	Location(s)	Remarks	Location(s)	Remarks
Undesirable plant species				
Patches of sparse growth				
Distruction in the vegetative cover				
Burrowing by animals				
Destruction of original grade				
Evidence of ponding				
Effect of settlement on surface run-off				
Erosion rifts or surface cracks				
Inadequate thickness of top layer to support grass growth				
Clay/Geomembrane liner exposure				
Sediment problems				
Saturation at the base of the slope				
Conditions of ditches and swales (are they adequately conveying the storm water)				
Other comments				