SOLID WASTE PERMITTING
SUBMISSION INSTRUCTION NO. 2

DESIGN PLANS AND REPORT FOR SOLID WASTE DISPOSAL FACILITIES

Developed by:

Virginia Department of Environmental Quality
Office of Waste Permitting and Compliance
629 East Main Street
Richmond, Virginia 23219

V. 12/2011

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I. DESIGN PLANS

Submit the following design plans on 11" x 17" paper in the order provided as Part B Attachment III. A full-size set of Design Plans should also be provided in rolls and/or in pockets for review. The Design Plans shall be prepared and certified by a professional engineer registered to practice in the Commonwealth. [9 VAC 20-81-470.A.1.]

The following site features shall be included on each of the plan sheets as appropriate:

- A survey grid with base lines and bench marks to be used for field control;
- The facility, waste management, and disposal unit boundaries with limits of filling for each major waste type or phase/cell;
- All drainage patterns and surface water drainage control structures;
- Ground surface contours at the time represented by the drawing;
- Spot elevations of key features;
- Areas to be cleared, grubbed, and stripped of topsoil;
- Borrow areas for liner materials, gas venting materials, berms, roadway construction, daily cover, and final cover;
- All soil stockpiles including daily and final cover, topsoil, liner materials, gas venting materials, and other excavation;
- Access roads and traffic flow patterns;
- All temporary and permanent fencing;
- Methods of screening such as berms, vegetation, or special fencing, with 50-ft firebreak marked;
- Leachate collection, control, storage, and treatment systems;
- Gas, leachate, and groundwater monitoring devices and systems;
- Severe weather solid waste disposal areas;
- Support buildings, scale, utilities, gates and signs;
- Special waste handling areas;
- Construction notes and references to details; and
- Other site features (to include other waste management features, i.e. tire processing, remediation waste management units, etc.).

A. Title Sheet

The Title Sheet shall state the project title, preparer of the plans, the person/organization for whom the plans were prepared, a table of contents, and a location map showing the location of the site and area to be served. [9 VAC 20-81-470.A.1.a.]

B. Existing Site Conditions Plan Sheet

Show conditions existing at the site prior to facility development or modification. [9VAC20-81-470.A.1.b.]

C. Base Grade Plan Sheet

Show proposed site base grades or appearance of the site if it were excavated in its entirety to base elevation prior to installation of any engineering modifications. [9 VAC 20-81-470.A.1.c.]

D. Engineering Modification Plan Sheet

Show engineering modifications indicating the appearance of the site after installation of all engineering modifications (i.e. installation of landfill liner and leachate collection/detection systems, berms, sediment ponds, etc.). [9 VAC 20-81-470.A.1.d.]

E. Phasing Plan Sheets

Provide a series of plan sheets showing the progression of site development through time; a separate plan shall be provided for initial site preparations, for each major phase or new area where substantial site preparation must be performed, and for each closure area as identified in the facility's Closure Plan. At least one phasing plan sheet shall be provided to correspond with the midpoint of the permitted landfill life. Each plan shall include a list of construction items and quantities necessary to prepare the phase/cell indicated. [9 VAC 20-81-470.A.1.f. and A.2.]

F. Final Site Topography Plan Sheet

Show final site topography indicating the appearance of the site and final contours of the site at closure, including any detail drawings necessary to prepare the site for long-term care. See *Submission Instruction No. 6: Closure and Post-Closure Care Plans for Solid Waste Disposal and Management Facilities* for additional information regarding the final site details that should be depicted on the Design Plans. [9 VAC 20-81-470.A.1.e.]

G. Site Monitoring Plan

Show locations of the following:

- Devices for the monitoring of leachate production and detection;
- Groundwater quality monitoring wells;
- Landfill gas probes and vents;
- Odor monitoring stations, if applicable; and
- Stormwater outfalls.

[9 VAC 20-81-470.A.1.g.]

H. Cross-Section Plan Sheets

Site cross sections shall be drawn perpendicular and parallel to the site baseline at a maximum distance of 500 feet between cross sections and at points of grade break and important construction features. The location of the cross sections shall be shown on the plan sheets and the sections labeled using the site grid system. Each cross-section shall show the following:

- Existing, proposed base and final grades;
- Soil borings and monitoring wells that the section passes through or is adjacent to;
- Soil types, bedrock, and water table;
- Leachate control, collection, and monitoring systems;
- Limits of filling for each major waste type;
- Drainage control structures;
- Access roads and ramps on the site perimeter and within the active fill area;
- The filling sequence or phases/cells; and
- Other site features, as necessary.

[9 VAC 20-81-470.A.1.h.]

I. Detail Drawing Plan Sheet(s)

Show detail drawings and typical sections for the liner and final cover systems, drainage control structures, access roads, fencing, leachate control, storage, and treatment systems and monitoring devices, gas control systems and monitoring devices, buildings, signs, and other construction details. [9 VAC 20-81-470.A.1.i.]

II. DESIGN REPORT

The Design Report should include supplemental discussions and design calculations to facilitate department review of the proposed facility design. Specific design features proposed in order to meet the site specific conditions as presented in the Part A Approval letter shall be addressed in the appropriate sections of this Design Report. The Design Report shall be provided as Part B Attachment VI. [9 VAC 20-81-470.B.]

Format The format used for the Design Report should encourage clear analysis and presentation of the proposed landfill design. The Design Report should start with a title page and table of contents followed by the following sections and discussions. The title page should identify the facility name and permit number, the permit applicant, document date, and document preparer information. In addition, the header or footer of each page should include the facility name, permit number, document title, revision date, and page number.

A. Introduction

Provide a brief history outlining site development, and indicate the disposal unit(s) the Design Report has been prepared for. Be sure to identify the project title; engineering consultants; and permittee.

Provide a list reiterating the site development conditions provided in the Department's Part A Approval letter for the facility. Indicate what sections of this Design Report address the proposed measures to be taken by the facility to meet the stated conditions. The Part A Approval letter should be included as Attachment 1 to this Report.

[9 VAC 20-81-470.B.1.]

B. Site Features

1. *Security*

   Provide a discussion on the natural barriers, fencing, gate controls, etc. to be employed to prevent unauthorized access. [9 VAC 20-81-130.B.]

2. *Roads*

   Specify the on-site access road material from the facility entrance to the working face, indicating the roads can withstand the anticipated heavy vehicle loads during all-weather conditions. [9 VAC 20-81-130.C.]

3. *Traffic Routing*

   Describe the mechanisms or features which will be employed to provide for an even flow of traffic into, out of, and within the site. The description shall show that the waiting delivery vehicles will not back up onto the public road. [9 VAC 20-81-470.B.2.]

4. *Shelter*

   Describe the shelter, sanitation facilities, and communications provided for operating personnel. [9 VAC 20-81-130.D. and F.]

5. *Aesthetics*

   Describe the natural and/or artificial screens employed for the purpose of site screening and noise attenuation. Indicate the distance between the disposal unit boundary and the nearest tree line; at a minimum, a 50-foot fire break shall be maintained. Describe how noise will be attenuated to no more than 80 dBA at the facility boundary. The screening employed shall take into account the plan for the long-term use of the property. [9 VAC 20-81-130.E., and 130.I.]

   For those facilities with a disposal unit or leachate storage unit located within 1,000 feet of the nearest edge of the right-of-way of any interstate or primary highway or 500 feet of the nearest edge of the right-of-way of any other highway or city street, as indicated on DEQ Form SW PTA Question 3.e. or 3.f., provide information addressing the facility's compliance with the requirements of 9 VAC 20-81-120.C.1.e.

6. *Benchmarks*

   Provide a table indicating the benchmarks located within the facility boundary and their respective longitude and latitude coordinates. Reference the Design Plan provided in PTB Attachment III that shows the benchmark locations. In accordance with 9 VAC 20-81-130.G., the facility shall maintain two benchmarks on the site.

C. Site Development

1. *Landfill Phase/Cell Development*

   Provide a tentative schedule for site development, indicating the name, acreage, capacity, and life of each proposed phase/cell. Information provided here shall correspond with the Phasing Plans provided in PTB Attachment III and supported by the calculations provided in Attachment 2 of this Design Report. [9 VAC 20-81-470.B.2.]

2. *Borrow and Stockpile Estimates*

   Indicate the estimated quantity of soil needed for daily/intermediate or progressive cover, as applicable, referencing the calculations provided in Attachment 2 of this Design Report. Indicate the location and capacity of on-site soil borrow areas as identified on the Design Plans provided in PTB Attachment III. For Sanitary Landfills, indicate the quantity of soil or alternate cover material to be stockpiled for daily use as determined based on the daily disposal limit identified on DEQ Form SW PTB and calculations provided in Attachment 2.

   For those facilities lacking sufficient cover material on site, as indicated on DEQ Form SW PTA Question 7.b., provide information addressing commitments in place

to obtain cover material from off-site resources and/or availability and use of approved alternate daily cover materials. [9 VAC 20-81-120.F.1.b. and 470.B.2.]

D. Landfill Unit Design

*{**Applicable to Sanitary Landfills** – New units and expansions of existing units must be constructed with a Subtitle D liner, a FML/GCL pre-approved alternate liner, or demonstrate the adequacy of an alternate liner.*

- *The Subtitle D liner is a composite liner comprised of two feet of soil with a hydraulic conductivity of no more than $1x10^{-7}$ cm/sec, overlain by a geomembrane. The geomembrane must be in direct and uniform contact with the soil liner.*
- *The FML/GCL pre-approved alternate liner consists of a 12-inch compacted subgrade, a geosynthetic clay liner (GCL) with a hydraulic conductivity of no more than $1x10^{-9}$ cm/sec, and a flexible membrane liner (FML or geomembrane) placed in direct and uniform contact with the GCL. This is the minimum number of components required for the FML/GCL pre-approved alternate liner; additional components may be added without requiring an alternate liner demonstration.*
- *Facilities proposing to construct an alternate liner from the ones mentioned above shall provide a demonstration in accordance with the requirements of 9 VAC 20-81-130.J.1.c.*

In this Design Report, provide a description of the proposed liner system and provide a statement indicating that the design meets the requirements of the regulations or the conditions of the alternate liner demonstration.}

*{**Applicable to CDD and Industrial Landfills** – New units and expansions of existing units must be underlain by one of the low-hydraulic conductivity liners listed in the regulations:*

- *A compacted soil liner consisting of one foot of compacted soil with hydraulic conductivity of no greater than $1x10^{-7}$ cm/sec paired with a minimum one-foot thick drainage layer;*
- *A synthetic liner paired with a minimum 18-inch drainage/protective cover layer composed of materials with a hydraulic conductivity of $1x10^{-3}$ cm/sec or greater;*
- *An augmented soil liner (identified as Alternate Liner on DEQ Form SW PTB), provided a demonstration is submitted in accordance with the requirements of 9 VAC 20-81-130.J.2.c.;*
- *In-place soil liner, provided documentation is submitted in accordance with the requirements of 9 VAC 20-81-130.J.2.d.; or*
- *A double liner equipped with a witness monitoring zone for groundwater;*

In this Design Report, provide a description of the proposed liner system cross section and provide a statement indicating that the design meets the requirements of the regulations.}

1. *Liner Foundation*

   Engineering analyses of the landfill foundation should be provided which are based on the data gathered through subsurface exploration and laboratory testing programs. Identify sources of data used in the design calculations to be presented in an Attachment to this Design Report and any assumptions used, referencing the Part A Application as necessary. Provide the following information:

   a. Settlement Potential
      Provide calculated estimates of total and differential settlement, including immediate settlement, and primary and secondary consolidation. The calculation should provide an evaluation of the effects of total and differential settlements on the integrity of geomembrane and soil liner, and on the slopes of leachate collection piping. Stresses imposed by liners, wastes and equipment should be considered.

   b. Bearing Capacity and Stability
      Determine the capability of the foundation to support any expected static and dynamic loading. Provide calculated estimates of the bearing capacity and stability of foundation, demonstrating that allowable bearing capacity will not be exceeded. The stability of foundation and waste during each phase development should be considered.

   c. Bottom Heave or Blow-out
      Provide calculated estimates of the potential for bottom heave or blow-out due to unequal hydrostatic or gas pressures.

   d. Construction and Operational Loading
      Demonstrate that the foundation is capable of providing adequate support for construction and operating equipment.

2. *Limiting Site Characteristics*

   Provide a discussion on each of the limiting site characteristics specified on DEQ Form SW PTA, as applicable.

   - <u>Presence of springs, seeps, or other groundwater intrusion into the site</u>
     For those facilities with springs, seeps, or other groundwater intrusion into the site, as indicated on DEQ Form SW PTA Question 7.c., describe the engineering controls to be employed to assure compliance with the all requirements of the VSWMR. [9 VAC 20-81-120.F.1.c.]

   - <u>Presence of gas, water, sewage, or electrical or other transmission lines under the site</u>
     For those facilities with gas, water, sewage, or electrical or other transmission lines under the site, as indicated on DEQ Form SW PTA Question 7.d., describe the engineering controls to be employed to assure compliance with the requirements of the VSWMR. [9 VAC 20-81-120.F.1.d.]

- The prior existence on the site of an open dump, unpermitted landfill, lagoon, or similar unit, even if such a unit is closed
  For those facilities planning a new disposal unit or expansion of an existing disposal unit over an existing open dump, unpermitted landfill, lagoon, or similar unit, as indicated on DEQ Form SW PTA A Question 7.e., describe the engineering controls to be employed to assure compliance with all requirements of the VSWMR. Design of the proposed unit shall isolate the unit from the site defect and allow for effective groundwater monitoring. [9 VAC 20-81-120.F.1.e.]

3. *Liner System*

   Describe the liner system to be installed, as indicated on DEQ Form SW PTB. Any additional layers to the pre-approved alternate liner system (Sanitary Landfill) shall be discussed here. If the facility selected the "Additional Alternate" (Sanitary Landfill) or "Alternate Liner" (CDD or Industrial Landfill) Liner Design on DEQ Form SW PTB, the liner layers shall be discussed here, and the demonstration assessing the design's suitability should be provided in PTB Attachment XIV (see Section V below for additional information). For facilities proposing multiple liner systems, the following discussions should be provided for each proposed liner design, as applicable. [9 VAC 20-81-130.J. and 470.B.2.,]

   a. Base Grades
      Describe the necessary construction work to be completed to bring the disposal unit to the base grades identified on the Base Grade Plan Sheet provided in PTB Attachment III. Reference the appropriate Technical Specifications provided in PTB Attachment VII. The lowest base grade of the proposed disposal unit(s) cannot be lower than the base grade specified in the Part A Approval letter. [9 VAC 20-81-130.J.1.a.(1), J.1.b.(2), J.1.c., J.2.b.(3), J.2.e.(1), and 470.B.2.]

   b. Soil Layer
      Provide a description of the soil layer to be installed. Be sure to address the layer's height, material, and hydraulic conductivity. Reference the appropriate Technical Specification(s) provided in PTB Attachment VII. [9 VAC 20-81-130.J.1.a.(2), J.1.b.(2), J.1.c., J.2.a.(1), J.2.c.(1), J.2.d.(1), J.2.e.(2) and (4)]

   c. Geosynthetic Layer(s)
      Provide a description of the geosynthetic layer(s) to be installed. Be sure to address the type and thickness of the geomembrane or geosynthetic clay liner and reference the appropriate Technical Specification(s) provided in PTB Attachment VII. [9 VAC 20-81-130.J.1.a.(3), J.1.b.(3) and (4), J.1.c., J.2.b.(1), J.2.e.(2) and (4)]

   d. Drainage and Protective Layer(s)
      Provide a description of the drainage and protective layer(s) to be installed. Be sure to address the layer's thickness, material, and hydraulic conductivity or

transmissivity, referencing the Design Plans (PTB Attachment III) and Leachate Management Plan (PTB Attachment VIII) as necessary. [9 VAC 20-81-130.J.1. b.(4)(d), J.1.c., J.2.a.(3), J.2.b.(5), J.2.e.(3) and (5), and 470.B.2.]

e. Cells for Stumps, Brush, Leaves, and Land-Clearing Debris
If the facility will maintain a disposal unit for the disposal of stumps, brush, leaves, and land-clearing debris, the disposal unit may be constructed without a liner or leachate collection system as specified in 9 VAC 20-81-130.J. Instead, provide a demonstration that a 5-foot separation from the seasonal high groundwater exists in the area of the proposed disposal unit. [9 VAC 20-81-130.J.2.f. and 470.B.2.]

4. *Liner Slopes*

Provide information that addresses the minimum and maximum slopes for the bottom and interior liner slopes to allow for leachate collection, adequate runoff, and erosion controls. Reference appropriate calculations demonstrating the stability of the liner system on internal slopes (see Attachment 2.e.). [9 VAC 20-81-130.J.1.a.(3)(c), J.1.b.(4)(c), J.1.c., J.2.a.(2), J.2.b.(4), J.2.c.(3), and J.2.d.(2)]

5. *Prevention of Exposure.*

Discuss the measures to be implemented to protect the liner from damage or degradation during liner construction and during the period when liner construction has been completed and the Certificate to Operate is granted.

E. Run-on and Run-off Control Systems

1. *Run-on Control System*

a. Peak Flow
Indicate the peak discharge expected as a result of a 24-hour, 25-year storm, referencing the calculations provided in an attachment to this Design Report. Describe the data sources and methods used to make the peak discharge calculations. [9 VAC 20-81-130.H.1.]

b. Design and Performance
Describe the run-on control system design. Demonstrate that the designed system will prevent run-on from reaching active portions of the landfill.

2. *Run-off Control System*

a. Design Volume
Indicate the peak run-off flow expected as a result of a 24-hour, 25-year storm, referencing the calculations provided in an attachment to this Design Report. Describe data sources and methods used to make the peak flow calculations. [9 VAC 20-81-130.H.2. and 470.B.2.]

b. Design and Performance
Describe the run-off collection and control system design. Demonstrate that the system has sufficient capacity to collect and hold the total run-off volume and prevent the discharge of pollutants in accordance with 9 VAC 20-81-130.H.2.a. and b.

3. *Drainage Structure Maintenance*

Indicate the maintenance to be performed on drainage structures to prevent ponding and erosion and to minimize infiltration of water into solid waste cells. [9 VAC 20-81-130.H.2.c.]

F. Attachments

1. *Part A Approval Letter and Near Vicinity Map*
2. *Calculations*

a. Refuse-cover balance
Provide an estimate of cover soil needs based on average and daily disposal limits.

b. Stockpile sizing
Indicate the required soil stockpile size needed for daily cover based on the daily disposal limit.

c. Estimate of site life
Provide an estimate of site life for each planned phase/cell based on its capacity and the facility's average and daily disposal limits.

d. Liner Foundation Calculations
Provide calculations for the following, based on information requested in Section II.D.1.

- Settlement Potential
- Bearing Capacity and Stability
- Bottom Heave or Blow-out
- Construction and Operational Loading

e. Liner Slope Stability
Demonstrate that there will be adequate friction between the components of the liner system particularly the soil subgrade and the geomembrane, so that slippage and sloughing do not occur on the slopes of the unit. Specifically, the foundation slopes and the subgrade materials must be considered in design equations to evaluate:

- The ability of a geomembrane to support its own weight on the side slopes;

- The ability of a geomembrane to withstand down-dragging during and after waste placement;
- The best anchorage configuration for the geomembrane; and
- The stability of a soil cover/drainage material on top of a geomembrane.

f. Run-on and Run-off volume
Provide calculations supporting the peak run-on and run-off expected resulting from a 24-hour, 25-year storm. Reference the Virginia Erosion and Sediment Control Handbook as necessary.

III. CONSTRUCTION QUALITY ASSURANCE PLAN

The Construction Quality Assurance Plan shall be provided as Part B Attachment VII. The Construction Quality Assurance Plan should have two principal components. The first is the Construction Materials Quality Control, which is designed to ascertain that materials used meet specifications. The second component is the Construction Quality Assurance Program, which is designed to ascertain that the constructed facility meets the requirements described in the plans and specifications. The CQA Plan shall address both components as they pertain to (as applicable):

- Foundations;
- Low-conductivity soil liners;
- Synthetic membrane liners;
- Leachate collection and removal systems including the 18-inch drainage/protective layer;
- Gas management components; and
- Final cover systems.

For each of the above components, this CQA plan shall provide a plan for initial site preparation and discuss the field measurements, photographs, and sampling and testing procedures to verify that the field conditions encountered were the same as those defined in the geotechnical report. Discuss the methods that will be used to document that the site was constructed according to the plans and specifications upon which the permit was based. [9 VAC 20-81-130.Q. and 470.B.3.b.]

EPA Technical Guidance Document – Quality Assurance and Quality Control for Waste Containment Facilities (1993) EPA/600/R-93/182 provides information that can be used to develop a comprehensive quality assurance plan. This document provides quality control and quality assurance procedures relating to compacted soil liners, geomembrane, geosynthetics clay liner, soil drainage systems, geosynthetic drainage systems, vertical cutoff walls, ancillary materials, and appurtenances.

A. Introduction

1. *Applicable Units*

   Since CQA Plans are often updated prior to commencing construction activities, indicate the applicable phase/cell or other landfill features that are to be constructed in accordance with this plan version. [9 VAC 20-81-130.Q.2.a.]

2. *Key Personnel*

   Identify the key personnel responsible for the development and implementation of this CQA Plan. Specify qualifications necessary for each key personnel identified. As specified under 9 VAC 20-81-130.Q.1.a., the CQA Officer shall be a professional engineer. [9 VAC 20-81-130.Q.2.b.]

B. Foundations and Soil Liners

Quality control testing performed on materials used in construction of the foundations and soil liners includes source testing and construction testing. Describe the inspection, monitoring, sampling and testing methods and frequencies employed during foundation and liner installation to assure that the foundation and soil liner, as installed, meet the design requirements.

1. *Construction Materials Quality Control*

   Source testing shall be performed to characterize soil properties, to ensure soils from borrow sources meet soil liner specifications, and to ensure consistency of borrow soils. Source testing shall include moisture content, soil density, Atterberg limits, grain size, proctor test, and laboratory hydraulic conductivity. The plan shall specify methods and frequencies of sampling and analysis.

2. *Construction Quality Assurance*

   Construction testing ensures that landfill construction has been performed in accordance with the plans and technical specifications. Construction testing in the soil liner generally includes soil moisture content/density tests, lift thickness tests, and hydraulic conductivity tests. The method of determining if the soil meets the required maximum hydraulic conductivity shall be specified in the QA/QC plan. The sample collection program shall be compatible with the testing to be performed. Selection of sample collection points should be made on a random basis. The CQA procedures to be used shall be selected from those generally accepted in the field.[1] If nuclear methods are used for moisture and density measurements, alternate methods shall also be used to verify the accuracy of the faster nuclear methods. In-situ testing for hydraulic conductivity must be performed either on the test fill or the constructed soil liner.

3. *Test Pad*

   To demonstrate the ability of the soil to be used as a soil liner material, at least one test pad is required for every source of low-permeability soil or soil type, unless soil sources are consistent and the third-party quality control firm agree that one test pad is adequate. [9 VAC 20-81-130.Q.2.g.]

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[1] U.S. EPA, "Design, Construction and Evaluation of Clay Liners for Waste Management Facilities," EPA/530/SW-86/007F; U.S. EPA; Office of Solid Waste and Emergency Response; Washington, DC 20460. NTIS PB-86-184496 (1988).

U.S. EPA, "Relationship of Laboratory- and Field-Determined Hydraulic Conductivity in Compacted Clay Layer," EPA/600/2-90/025; U.S. EPA; Risk Reduction Engineering Office; Cincinnati, Ohio 45268. NTIS PB-90-25775 (1990)

U.S. EPA, "Seminar Publication: Design and Construction of RCRA/CERCLA Final Covers," CERI 90-50; U.S. EPA; Office of Research and Development; Washington, DC 20460 (1990)

U.S. EPA, “Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities,” EPA/600/R-93/182; U.S. EPA, Office of Research and Development; Washington DC 20460 (1993)

The test pad shall establish the range of criteria (compaction, moisture content, USCS classification, and grain size) that can be expected to achieve a low permeability soil liner meeting the requirements of the permit. The test pad's permeability shall be correlated with grain size analysis, liquid and plastic limits, moisture content, relative compaction, remolded permeability, undisturbed Shelby tube sample permeability, and the in-situ permeability determined by field tests performed on the test pad. [9 VAC 20-81-130.Q.2.g.(1)]

4. *Soil Liner Testing Certification*

The low permeability soil liner placed shall be certified by testing the constructed liner to determine its conformance to the acceptable criteria determined during the test pad construction. The low permeability soil liner shall be tested for compaction, moisture content, grain size and the liquid and plastic limits of the soil. Any area(s) that doesn't conform to the established criteria shall be further tested by obtaining an undisturbed Shelby tube sample of the constructed liner and performing a laboratory permeability on it. In addition, a minimum of one additional laboratory permeability test shall be performed on each acre of constructed liner. [9 VAC 20-81-130.Q.2.g.(2)]

C. Geomembranes

Installation of geomembrane liners shall be in conformance with a quality assurance/quality control plan which includes the following:

- Observation and documentation of liner storage area and liners in storage, and handling of the liner as the panels are positioned in the cell;
- Observation and documentation of seam overlap, seam preparation prior to seaming, and material underlying the liner;
- Observation and documentation of destructive testing conducted on trial welds prior to seaming;
- Observation and documentation of non-destructive seam testing;
- Observation and documentation of destructive seam sampling, submission of the samples to an independent testing laboratory, and review of results for conformance to specifications;
- Observation and documentation of all seams and panels for defects due to manufacturing and/or handling and placement;
- Observation and documentation of repairs;
- Observation and documentation of all pipe penetration boots, welds, and testing in the liner;
- Preparation of reports indicating sampling conducted and sampling results, locations of destructive samples, locations of patches, locations of seams constructed, and any problems encountered; and
- Preparation of record drawings of the liner installation.

1. *Geomembrane Materials Quality Control*

   The QA/QC plan shall prescribe the manufacturers quality control testing that shall be performed to determine if the properties of the synthetic materials delivered to the site meet the specifications required by the design.

   {For rolls of geomembrane that were stored from a previous construction project at the landfill or other location} Conformance samples shall be taken to confirm that the material stored is consistent with what was required in the facility design and the construction specifications. The following tests should be performed on samples of geomembrane:

   - Thickness (ASTM D-5199);
   - Tensile strength and elongation (ASTM D-638 for polyethylene materials, ASTM D-882 for PVC, ASTM D-751 for CSPE-R);
   - Puncture resistance (FTM std 101C for polyethylene materials only);
   - Tear resistance(ASTM D-1004, Die C not for CSPE-R);
   - Ply adhesion (ASTM D413, Machine method, type A for CSPE-R);

   The quality control plan should specify the method of membrane sampling and the frequency of the conformance sampling. For rolled products the outermost 1 meter of material on the roll is usually cut for the entire width of the roll. Samples are usually taken on the basis of one sample for every 100,000 feet of geomembrane or one sample /lot - "lot" must be clearly defined in the plan.

2. *Construction Quality Assurance*

   a. Inspection Activities
      Inspection activities, including both nondestructive and destructive quality control field testing of the sheets and seams during installation of the geomembrane. Describe how the following will be taken into account:

      - Ambient temperature at which the seams are made;
      - Relative humidity;
      - Control of panel lift up by wind;
      - Water content of the subsurface beneath the geomembrane;
      - Supporting surface on which the seaming is bonded;
      - Skill of the seaming crew;
      - Quality and consistency of the chemical or welding material;
      - Proper preparation of the liner surfaces to be joined; and
      - Cleanliness of the seam interface (e.g., the amount of airborne dust and debris present).

In the case of composite liner construction, provide the description how intimate contact between the synthetic and the soil liners will be determined.

In addition to the inspection requirements shown in above the QA/QC plan shall provide for testing of the integrity of geomembrane seams. The following test methods shall be used:

b. Non-destructive Testing
Non-destructive test methods are to be conducted in the field on an in-place geomembrane. Typically non-destructive seem testing is conducted on all seams. These test methods determine the integrity of the geomembrane field seams. Nondestructive test methods include the probe test, air lance, vacuum box, ultrasonic pulse echo, ultrasonic impedance plane, electrical spark test, pressurized dual seam, electrical resistivity, and hydrostatic tests. Detailed discussion of these test methods may be found in USEPA guidance document cited below.

c. Destructive Testing
Destructive peel and shear field tests are to be performed on samples from installed seams. The samples may be collected randomly or in areas of suspect quality. Sampling protocols should follow those shown in U.S. EPA, "Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182; U.S. EPA; Office of Research and Development; Washington, DC 20460 (1993). Normal sampling frequency is one destructive sample per 500 feet of seam. Destructive samples of installed seam welds shall be cut into several pieces and distributed for the following purposes to:

- The installer to perform construction quality control field testing;
- The owner/operator to retain and appropriately catalog or archive; and
- An independent laboratory to perform peel and shear testing.

D. Geosynthetic Clay Liners (GCLs)

Installation of GCL liners shall be in conformance with a quality assurance/quality control plan which includes the following:

- Observation and documentation of liner storage area and liners in storage, and handling of the liner as the panels are positioned in the cell;
- Observation and documentation of panel overlap, seam augment, and material underlying the liner;
- Observation and documentation of panels for defects due to manufacturing and/or handling and placement;
- Observation and documentation of repairs;

1. *GCL Materials Quality Control*

   The QA/QC plan shall prescribe the manufacturers quality control testing that shall be performed to determine if the properties of the synthetic materials delivered to the site meet the specifications required by the design.

2. *Construction Quality Assurance*

   Describe how the following will be taken into account:

   - Weather conditions during GCL deployment;
   - Water content of the subsurface beneath the GCL;
   - Inspection of GCL panel overlap and placement of bentonite augment;
   - Procedures for patching holes, tears, or rips in the covering geotextile of the GCL and procedures for installing full GCL patches; and
   - Procedures for covering the GCL with the next liner layer.

   In the case of composite liner construction, provide the description how intimate contact between the synthetic and the soil liners will be determined.

E. Leachate Collection and Removal System (LCRS)

Installation of leachate collection and removal system shall be in conformance with a quality assurance/quality control plan which includes the following:

1. *LCRS Materials Quality Control*

   The plan shall require that prior to construction, all materials should be inspected to confirm that they meet the construction plans and specifications. These include:

   - Geonets;
   - Geotextiles;
   - Geocomposites;
   - Pipe size, materials, and perforations;
   - Granular material gradation and prefabricated structures (sumps, manholes, etc.);
   - Mechanical, electrical, and monitoring equipment; and
   - Concrete forms and reinforcement.

2. *LCRS Construction Quality Assurance*

   The plan shall describe how the leachate collection system foundation (geomembrane or low permeability soil liner) shall be inspected, protected during installation, and surveyed upon its completion to ensure that it has proper grading and is free of debris and liquids. During construction, the following activities, as appropriate, shall be observed and documented:

- Pipe bedding placement including quality, thickness, and areal coverage;
- Granular filter layer placement including material quality and thickness;
- Pipe installation including location, configuration, grades, joints, filter layer placement, and final flushing;
- Granular drainage layer placement including protection of underlying liners, thickness, overlap with filter fabrics and geonets if applicable, and weather conditions;
- Geocomposite placement including layout, overlap, and protection from clogging by granular material carried by wind or runoff during construction;
- Geotextile/geofabric placement including coverage and overlap;
- Sumps and structure installation; and
- Mechanical and electrical equipment installation including testing.

In addition to field observations, actual field and laboratory testing shall be performed to document that the materials meet the design specifications. These activities shall include the following:

- Granular drainage and filter layer sampling and testing for grain size distribution and permeability; and
- Testing of pipes for leaks and obstructions.

Upon completion of construction, each component shall be inspected to identify any damage that may have occurred during its installation or during construction of another component (e.g., pipe crushing during placement of granular drainage layer). Any damage that does occur shall be repaired, and these corrective measures shall be documented in the CQA records.

F. Gas Management Components

Installation of gas management components shall be in conformance with a quality assurance/quality control plan which includes the following:

1. *Materials Quality Control*

   The plan shall require that prior to construction, all materials should be inspected to confirm that they meet the construction plans and specifications. These include:

   - Pipe size, materials, and perforations;
   - Granular material gradation
   - Geocomposite, if used; and
   - Mechanical, electrical, and monitoring equipment.

2. *Construction Quality Assurance*

   The plan shall describe how the landfill gas monitoring, control, and management components shall be inspected. During construction, the following activities, as appropriate, shall be observed and documented:

   - Pipe bedding placement including quality, thickness, and areal coverage;
   - Pipe installation including location, configuration, grades, joints, filter layer placement, and final flushing;
   - Mechanical and electrical equipment installation including testing; and
   - Testing of pipes for leaks and obstructions.

   Upon completion of construction, each component shall be inspected to identify any damage that may have occurred during its installation or during construction of another component. Any damage that does occur shall be repaired, and these corrective measures shall be documented in the CQA records.

G. Final Cover Systems

Installation of the final cover system shall be in conformance with a quality assurance/quality control plan which includes components of the above Sections III.B., III.C., and III.D., as appropriate. In addition, procedures for placing topsoil, protective cover, and any drainage layers should also be discussed. Section III.E. contains some discussion for QA/QC procedures to be addressed for geosynthetic drainage layers.

H. Certification

1. *Certification by CQA Officer*

   Once construction is complete, the owner or operator shall submit to the DEQ Regional Office, by certified mail or other equivalent method with a return receipt or hand delivery, a certification signed by the CQA Officer that the approved CQA Plan has been successfully carried out and that the constructed unit meets requirements of 9 VAC 20-81-130 along with documentation supporting the certification. [9 VAC 20-81-130.Q.3.]

2. *Certification by Design Engineer*

   In accordance with the requirements of 9 VAC 20-81-490.A.1., the above certification shall be accompanied by an additional certification by a professional engineer (typically the Design Engineer) stating that construction has been completed in accordance with the approved plans and specifications and is ready to begin operation. This certification must be provided by someone other than the CQA Officer.

[9 VAC 20-81-130.Q.3.]

IV. TECHNICAL SPECIFICATIONS

Technical Specifications shall be provided as an attachment to the Construction Quality Assurance Plan provided as Part B Attachment VII. Specifications shall be provided for the following site activities:

- Clearing and Grubbing;
- Topsoil stripping;
- Other excavations;
- Berm construction;
- Drainage control structures;
- Leachate collection system;
- Access roads and entrance;
- Screening;
- Fencing;
- Groundwater monitoring;
- Landfill Gas monitoring;
- Each layer of the proposed landfill liner and cap; and
- Any other special design features.

[9 VAC 20-81-470.B.3.a.]

A. Liners and Final Covers

1. *Soil Liners*

a. Borrow Source
Specify the frequency of sampling and tests to be performed on each proposed borrow source prior to construction of the test pad and soil liner as part of the characterization of the borrow source. Tests can be completed on soil samples obtained during borrow soil excavation or delivery of the soil materials if time or circumstances do not permit characterization of the borrow soil prior to the construction.

b. Test Pad
In accordance with 9 VAC 20-81-130.Q.2.g.(1) and (2) a test pad is required for each source of low-permeability liner soil. The test pad shall establish the range of criteria (compaction, moisture content, USCS classification, and grain size) that can be expected to achieve a low permeability soil liner meeting the requirements of the permit.

c. Construction
Specify the methods to be used to compact soil to achieve conformance to the acceptable criteria established during the test pad construction. Specify the range of moisture contents and corresponding soil densities that will be considered appropriate to achieve the required hydraulic conductivity. Describe the following parameters:

- Lift thickness;
- Full scale or segmented placing;
- Equipment used (*compaction and rolling machinery*);
- Estimated number of equipment passes;
- Scarification between lifts;
- Control of soil water content;
- Hydraulic conductivity
- Limits on clod sizes; and
- Special considerations for tie-ins to existing liners.

d. Amended Soil Liners
In addition to the above requirements, when soil additives are to be used specify the type of additive, the concentration to be added, and the methods that will be used to mix and spread the material.

e. Placement on Slopes
Describe the method that will be used to place the liner on slopes. If sidewalls are compacted horizontally, describe how the edges will be tied in with the bottom of the soil liner.

f. Liner Thickness
For soil liners, describe how vertical and horizontal cracks and other imperfections will be detected and prevented. Describe the lift thickness and how it was derived. Describe methods to achieve sufficient compaction and homogeneous bonding between lifts. In case of larger area fills, describe how the old and new liner segments will be bonded together.

2. *Geomembrane Liners*

g. Material Specifications
Describe the polymer type, fabric reinforcement, thickness and texture (e.g., smooth or textured). Design specifications should indicate the type of raw polymer and manufactured sheet to be used as well as the requirements for delivery, storage, installation, and sampling of the geomembrane. Specific raw polymer and manufactured sheet specifications and test procedures should conform to those identified on specifications provided by the Geosynthetic Research Institute (http://www.geosynthetic-institute.org/specs.htm).

h. Chemical Compatibility
In case of industrial waste landfills, include a statement on the chemical compatibility of the liner and the leachate and cite the basis for the statement. If necessary, include the data from EPA Method 9090, SW-846.

i. Installation Specifications

Installation specifications should cover installation procedures specific to the properties of the liner installed.

- Ensuring that sufficient bedding will be provided above and below the liner to prevent rupture during installation and operation.
- Visual inspection and acceptance of the soil liner subgrade to be conducted prior to placing the geomembrane.
- Techniques to minimize wrinkles caused by shrinkage and expansion during installation and service performance.
- Information for protection of the material during shipping, storage and handling, quality control certifications required from the manufacturer or fabricator (if panels are constructed), and quality control testing by the contractor, installer, or a construction quality assurance (CQA) agent.
- A geomembrane layout plan, deployment of the geomembrane at the construction site, seam preparation, seaming methods, seaming temperature constraints, and seating of the geomembrane to appurtenances, both adjoining and penetrating the liner must be provided.

3. *Geosynthetic Clay Liners*

j. Material Specifications
Describe the GCL and its materials of construction. Design specifications should indicate the type of clay, geotextile or geomembrane, and manufactured sheet to be used as well as the requirements for delivery, storage, installation, and sampling of the GCL. Specific clay, geotextile or geomembrane, and manufactured sheet specifications and test procedures should conform to those identified on specifications provided by the Geosynthetic Research Institute (http://www.geosynthetic-institute.org/specs.htm).

k. Installation Specifications
Installation specifications should cover installation procedures specific to the properties of the GCL installed.

- Ensuring that sufficient bedding will be provided above and below the liner to prevent rupture during installation and operation.
- Visual inspection and acceptance of the liner subgrade to be conducted prior to placing the geomembrane.
- Information for protection of the material during shipping, storage and handling, quality control certifications required from the manufacturer or fabricator (if panels are constructed), and quality control testing by the contractor, installer, or a construction quality assurance (CQA) agent.
- Deployment of the GCL at the construction site, overlap and augment, and seating of the GCL to appurtenances, both adjoining and penetrating the liner must be provided.

B. Leachate Collection and Removal System

All components of the leachate collection system must have sufficient strength to support the weight of the overlying waste, cover system, and post-closure loadings, as well as stresses from operating equipment. The filter media, drainage layer, and pipe network specified should be compatible and represent an integrated design. The specifications for thickness and type of materials shall be identified on the drawings and shall be consistent with the design calculations. Describe any methods of placement and seaming, if any. Specify the design of any anchor trench.

1. *Grading*

   The LCRS must be appropriately graded to assure that leachate will be drained to the system and equals or exceeds the minimum slope of two percent (the same slope as the cell liner).

2. *High Permeability Drainage Layer*

   Specify the materials that will be used to construct the layer, which shall be consistent with the design calculations. Note that the drainage material must have no more than 15 percent calcium carbonate equivalent

   a. Soil Drainage Layer
      i. <u>Material Specification</u>
      Indicate the material to be used, specifying the gradation and hydraulic conductivity. Generally, gravel soil with a group designation of GW or GP on the Unified Soils Classification Chart can be expected to have a hydraulic conductivity of greater than 0.01 cm/sec, while sands identified as SW or SP can be expected to have a coefficient of permeability greater than 0.001 cm/sec. Specify the material for the soil drainage layer and frequency and test methods to be employed to ensure the material delivered meets the permit requirements.

      i. <u>Placement</u>
      Describe the equipment that will be used in layer placement and compaction, and the methods that will be used to check the thickness of the drainage layer.

   b. Geosynthetic Drainage Layers
      The specifications for thickness and type of materials shall be identified on the drawings. Describe method of placement and seaming and joining methods. Specify the design of the anchor trench and the placement of the geocomposite.

3. *Filter Media*

   a. Hydraulic Conductivity
   The hydraulic conductivity of the geotextile filter generally should be at least ten times the soil it is retaining. Assess the adequacy of flow by comparing the material (allowable) permittivity to the design imposed permittivity.[2]

   b. Retention
   If a geotextile filter media is used, specify the apparent opening size (AOS) of the geotextile. The material specifications should contain a range of AOS values for the geotextile, and these AOS values should match those used in the design.

4. *Pipe Specifications*

   The collection system specifications shall include:

   - Type of piping material to ensure that it is compatible with the leachate;[3]
   - Manufacturer's quality control specification for the pipe material;
   - Diameter and wall thickness sufficient to provide necessary flow and strength characteristics as indicated below;
   - Method of joining the pipes;
   - Description of pipe fittings;
   - Size, location, and distribution of slots and perforations;
   - Type of coatings (if any) used in the pipe manufacturing;
   - Packaging shipping and storage of pipe;
   - When pipe is imbedded in drainage materials, no unplugged ends can be allowed;
   - Indicate the type of bedding to be used under the pipes and the dimensions of any trenches;
   - For gravity-flow lines, a method for verifying the slope and alignment of the pipe after installation; and
   - For pressurized lines (solid wall pipes), a means to test for leaks and quality installation.

5. *Run-on and Run-off Control*

   Describe the materials and methods to be employed to construct the run-on and the run-off control system. Based on the design calculations specify the type and size of the ditch or pipe used for run-on/off control. For ditches include the channel

[2] Use ASTM D-4491 to measure permittivity.

[3] In case of industrial waste facilities, demonstrate that the LCRS components are chemically resistant to the waste managed in the landfill and the leachate expected to be generated.

geometry and the liner material appropriate to the flow velocity for the design storm.

If sediment basins, or sediment ponds are used at the facility specify the volume of the basin, and specify the materials of construction.

V. ALTERNATE LINER DEMONSTRATION

If the solid waste disposal facility selected the "Additional Alternate" Sanitary Landfill Liner Design or "Alternate Liner" CDD or Industrial Landfill Liner Design on DEQ Form SW PTB, the liner layers shall be depicted on the Design Plans (Section I, above), discussed in the Design Report (Section II, above), and the demonstration assessing the design's suitability should be provided in PTB Attachment XIV. [9 VAC 20-81-130.J.1.c. and J.2.c.]

A. Sanitary Landfill Alternate Liner Demonstration

The demonstration provided in this PTB Attachment should provide information on the following factors and provide assurances that the proposed alternate liner system will not cause the maximum contaminant levels (MCL) promulgated under the §1412 of the Safe Drinking Water Act (40 CFR Part 141) to be exceeded in the uppermost aquifer at the disposal unit boundary. [9 VAC 20-81-130.J.1.c.]

1. *Liner design*

   Include a brief description of the proposed liner system (figure), number of layers, thickness, and materials. For soil liners, indicate the thickness and the hydraulic conductivity that will be achieved for the proposed design. Drawings should be provided in PTB Attachment III depicting the proposed liner design and associated details. [9 VAC 20-81-130.J.1.c.]

2. *Hydrogeologic characteristics of the landfill and surrounding land*

   Provide a brief description of the site location, general information (including boring logs, field data collected during site investigation and Part A), regional geology, site geology, aquifer description, and soil classification. This section should identify the changes in the surface run-off pattern due to landfill construction as applicable to the facility. [9 VAC 20-81-130.J.1.c.(1)(a)(1)]

3. *Climatic factors*

   Provide details on climatic conditions and location/station used for collecting the meteorological data. For evaluating a site-specific liner design, the climate data should be representative of the site conditions. If site-specific measurements are available, the measured data should be used for modeling. If the site-specific measurements are unavailable, the facility may use data from a station representative of the meteorological conditions of the site. For the purpose of modeling, the Department advises the facilities to use data that will result in conservative estimates (highest) of infiltration for the proposed design. The HELP model default values should be modified in situations where the site-specific data is available. [9 VAC 20-81-130.J.1.c.(1)(a)(2)]

4. *Leachate data*

   Provide any site-specific information available on leachate physical and chemical characteristics, and indicate if the point of compliance has been impacted by any activity associated with the landfill unit. [9 VAC 20-81-130.J.1.c.(1)(a)(3)]

5. *Groundwater*

   From the Part A Hydrogeologic Report (for new facilities) or Annual Groundwater Report (for existing facilities), include details on groundwater flow, aquifer testing, groundwater withdrawal location and rates, availability of alternate drinking water supplies (surface water), and quality of the groundwater at the site. [9 VAC 20-81-130.J.1.c.(1)(a)(4) – (7)]

6. *Potential impact to public health, safety, and welfare*

   Describe the potential impact of the alternate liner on public health, safety, and welfare. [9 VAC 20-81-130.J.1.c.(1)(a)(8)]

7. *Mathematical models*

   The HELP model is used to estimate infiltration rates from the bottom of the landfill, and the MULTIMED model is used to estimate contaminant attenuation in the subsurface as the landfill leachate migrates to the point of compliance or the waste disposal boundary. [9 VAC 20-81-130.J.1.c.(1)(b)]

   a. HELP Model
      Provide a brief description of the model selected to support the proposed liner design. For HELP model runs, discuss the number of years considered for modeling, head calculated on FML or appropriate layer, maximum leakage predicted by the model, and annual leakage predicted by the model. It is important to ensure that the model has reached equilibrium during the simulation. The purpose of HELP modeling is to predict the worst case infiltration that is likely to occur for the proposed design.

   b. MULTIMED Model
      Include a brief description of data available and test methods considered for collecting or estimating the field values. For literature values, include a justification on applicability of the selected value. The facility must attempt to collect the site-specific data for running the MULTIMED model. Provide the site-specific values and literature values used and the source for the information along with a justification on applicability of these values to the model simulation. Also, include the calculated dilution-attenuation factor along with an electronic copy of the MULTIMED input and output files.

   c. Other Model
      As allowed in the VSWMR, the facility may use a recent version of HELP and MULTIMED models or any other appropriate model to demonstrate the

performance of the proposed liner. If the facility intends to use any other model than MULTIMED, prior to modeling, the facility should demonstrate the applicability of the proposed model to the site-specific conditions.

B. CDD or Industrial Landfill Alternate Liner Demonstration

1. Include a brief description of the proposed liner system, number of layers, thickness, and materials. For soil liners, indicate the thickness and the hydraulic conductivity that will be achieved for the proposed design. Drawings should be provided in PTB Attachment III depicting the proposed liner design and associated details.
2. Provide documentation and calculations indicating the proposed augmented compacted clay or soil liner achieves an equivalent thickness and the hydraulic conductivity will be equal to or less than the hydraulic conductivity of the specified compacted clay liner (The compacted clay liner, 9 VAC 20-81-130.J.2.a., shall be at least one-foot thick and have a hydraulic conductivity of no more than 1×10^{-7} cm/sec).
3. Indicate laboratory tests to be performed to confirm the effectiveness of the proposed liner.

[9 VAC 20-81-130.J.2.c.]