# COMMONWEALTH OF VIRGINIA
## Department of Environmental Quality

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**Subject:** Division of Land Protection and Revitalization Guidance Memo No. 2015-01
**Use of Mechanically Stabilized Earth (MSE) Berms in Landfill Design**

**To:** Regional Land Protection Program Managers, Regional Solid Waste Permit Writers, Kathryn Perszyk, and Geoff Christe

**From:** Justin Williams
Director, Office Waste Permitting & Compliance

**Date:** April 24, 2015

**Copies:** Regional Directors, Jeffery Steers

**Summary:**

In the absence of regulatory requirements specific to mechanically stabilized earth (MSE) berms, this guidance has been developed to address the permitting, specific to siting, design, inspection, closure, and post-closure care of an MSE berm at a landfill.

**Electronic Copy:**

An electronic copy of this guidance is available on the Virginia Regulatory Town Hall website at: http://townhall.virginia.gov/L/GDocs.cfm?boardid=119

**Contact Information:**

Please contact the solid waste permit coordinator, Kathryn Perszyk, at (703) 583-3856 or kathryn.perszyk@deq.virginia.gov with any questions regarding the application of this guidance.

**Disclaimer:**

*This document is provided as guidance and, as such, sets forth standard operating procedures for the agency. However, it does not mandate any particular method nor does it prohibit any alternative method for the analysis of data, unless specifically required by the VSWMR. If alternative proposals are made, such proposals should be reviewed and accepted or denied based on their technical adequacy and compliance with appropriate laws and regulations.*

# I. Introduction

Use or potential use of Mechanically Stabilized Earth (MSE) Berms at landfills as a means to manage solid waste disposal and to maximize use of existing footprints, expand the facility, or increase disposal capacity at the landfill has been increasing. Although construction and use of these berms in this manner is not specifically addressed in the Virginia Solid Waste Management Regulations (VSWMR), these berms have a direct impact on the design, operation, closure, and post-closure elements of a landfill.

The VSWMR require a major permit modification of an existing landfill solid waste permit (SWP) for permit modifications requested by the permittee as identified in 9 VAC 20-81-600.F. Permittee requests to include a mechanically stabilized earth (MSE) berm in the permitted design of a landfill will be processed as a major permit modification. The major permit modification is necessary because the addition of a MSE berm will substantially alter the facility design, per 9 VAC 20-81-600.F.3.a., and require review of various design elements. In addition, all requests for inclusion of an MSE berm will be subject to public notice and a public hearing in accordance with the permit issuance procedures of 9 VAC 20-81-450.E.

The purpose of this guidance document is to provide solid waste management facilities (SWMFs) and their consultants information on the major permit application that should be submitted and provide solid waste permit writers guidance to assist with reviewing and processing MSE berm requests.

# II. Background

MSE berms have typically been used in the transportation industry and for private industrial and residential development; however, since the late 1980s, such berms have been used to allow the vertical expansion of a landfill with or without lateral expansion of the waste management boundary. In accordance with 9 VAC 20-81-600, a major permit modification is required for landfills wishing to incorporate a MSE berm; however, the VSWMR and Department issued Submission Instructions do not specifically address requirements applicable to MSE berms. This guidance aims to provide permit application specific guidance for applicants seeking to use MSE berms at existing solid waste disposal facilities.

# III. Authority

Section 10.1-1408.1 of the Code of Virginia specifies that sanitary landfills or other facilities for the disposal, treatment, or storage of nonhazardous solid waste shall not operate without a permit from the Director. This Section also identifies key components of the permit application that shall be submitted for review.

Section 10.1-1408.4. of the Code of Virginia specifies the Director shall determine, in writing, that the site on which the proposed new municipal solid waste landfill is to be constructed is suitable for the construction and operation of such a landfill.

The permit modification application required by the Code is addressed in Part V of the VSWMR [9 VAC 20-81-450 through 9 VAC 20-81-600]. An application providing the information outlined in the Department's submission instructions will contain the basic information the DEQ will use to evaluate the proposed facility. Based on the evaluation of the submitted permit application, the Department will determine if the application is administratively complete, technically adequate, and in full regulatory compliance with applicable sections of the VSWMR.

If the application is found to be technically adequate and in full compliance with the VSWMR, staff will develop a draft permit in accordance with 9 VAC 20-81-450.E. The draft permit will include conditions necessary to protect public health or the environment or to ensure compliance with the VSWMR in accordance with 9 VAC 20-81-430 and Va. Code § 10.1-1409 B. Under 9 VAC 20-81-430 and Va. Code § 10.1-1409 B., specific conditions which are necessary to protect human health and the environment may be included in a permit.

The major permit modification application for a proposed MSE berm shall contain a Notice of Intent (NOI), applicable documentation required by 9 VAC 20-81-460 and 9 VAC 20-81-470 or 9 VAC 20-81-480, and applicable major permit modification fee outlined in Table 3.1-2 of 9 VAC 20-90-120. The following discussion is provided to aid the applicant in preparing a complete application for the Department's review.

# IV. Definitions

The definitions in § 10.1-1400 of the Code of Virginia and 9 VAC 20-81-10 of the VSWMR apply to the implementation of these procedures. Key definitions applicable to this guidance from the VSWMR are identified below. Additional definitions specific to this guidance are also provided.

"Capacity" means the maximum permitted volume of solid waste, inclusive of daily and intermediate cover, that can be disposed in a landfill. This volume is measured in cubic yards.

"Critical berm failure" is synonymous with a partial or complete collapse or excessive deformation of the constructed MSE berm.

"Disposal unit boundary" or "DUB" means the vertical plane located at the edge of the waste disposal unit. This vertical plane extends down into the uppermost aquifer. The DUB must be positioned within or coincident to the waste management boundary.

"Excessive berm deformation" includes (1) obvious bowing or bulging along the berm facing; (2) outward leaning of any portion of the berm beyond the original slope; and (3) gaps or cracks in the berm facing. Presence of cracks or depressions on top of the berm's reinforced soil zone may also be signs of berm deformation.

"Expansion" means a horizontal expansion of the waste management boundary as identified in the Part A application. If a facility's permit was issued prior to the establishment of the Part A process, an expansion is a horizontal expansion of the disposal unit boundary.

"Mechanically stabilized earth (MSE) berm" is a soil berm constructed in layers with geosynthetic reinforcement, often with a steep or near vertical facing typically consisting of concrete block or vegetation.

"Waste management boundary" or "WMB" means the vertical plane located at the boundary line of the area approved in the Part A application for the disposal of solid waste and storage of leachate. This vertical plane extends down into the uppermost aquifer and is within the facility boundary.

"Vertical design capacity" means the maximum design elevation specified in the facility's permit or if none is specified in the permit, the maximum elevation based on a 3:1 slope from the waste disposal unit boundary.

# V. Guidance Document

The intent of this guidance is to expand upon existing Department Submission Instructions Nos. 1, 2, 6, and 7 to address design and construction requirements specific to MSE berms at solid waste disposal facilities. The following discussion provides additional details which should be addressed in a facility's permit application for inclusion of a MSE berm as well as specific permit conditions that may be included in a permit approval for the MSE berm. An application review checklist is also provided as Attachment 1 to assist with submittal and review of MSE berm major permit modification requests.

## *V.A Applicability*

Installation of an MSE berm typically serves the purpose of increasing the capacity of an existing landfill. Any sanitary, CDD, or industrial landfill wishing to install a MSE berm shall apply for a major permit modification in accordance with 9 VAC 20-81-600. As indicated in Guidance Memo 01-2009: Scenarios under which a Part A Amendment is or is not Required, the increase in capacity through addition of an MSE berm may not trigger a Part A amendment; however, items identified under 9 VAC 20-81-450 and 9 VAC 20-81-460 applicable to the increase in capacity must be submitted with the Part B major permit modification application. Any expansion of the disposal unit boundary (DUB) or waste management boundary (WMB) coinciding with the MSE berm proposal would be considered an expansion and require both Part A and Part B permit modifications.

The major permit modification is also required of House Bill (HB) 1911 CDD and industrial landfill facilities. HB1911, approved March 20, 1995, allows CDD and industrial landfills to expand beyond the waste boundary existing on October 9, 1993, without obtaining a permit modification so long as the expanded area maintains setback distances specified under 9 VAC 20-81-120 and the area is constructed with a liner and leachate collection system meeting the applicable design criteria of 9 VAC 20-81-130. The bill did not change the previous language in the statute (§10.1-1408.1 N.) that limited waste acceptance at such facilities until they reached their vertical design capacity. As defined under 9 VAC 20-81-10, the vertical design capacity is

defined as the maximum design elevation specified in the facility's permit, or the maximum elevation based on a 3:1 slope from the DUB. Any airspace to be gained above the 3:1 slope from the DUB (or above the permitted final elevation) because of the MSE berm proposal is not covered under the permit exemption afforded under the statute and VSWMR for expansion of such facilities, as an expansion only applies to the horizontal expansion of the DUB and not the vertical expansion.

Also of note, when adding a MSE berm, if the landfill in question is unlined, liner and leachate collection systems meeting the current regulatory standard must be placed between the existing landfill and the landfill vertical expansion. Geotechnical investigation and calculations shall be performed to determine settlement and strength parameters of the unlined landfill waste mass and potential void locations so that an appropriate liner system can be designed to withstand the strains induced by piggybacking over the existing waste mass.

The major permit modification application for a proposed MSE berm shall contain a Notice of Intent (NOI), applicable documentation required by 9 VAC 20-81-460 and 9 VAC 20-81-470, and applicable major permit modification fee outlined in Table 3.1-2 of 9 VAC 20-90-120 as outlined below.

## *V.B. NOI and Part A Application Elements for MSE Berms (9 VAC 20-81-450 and 9 VAC 20-81-460, respectively)*

The following items shall be submitted with the permit application to satisfy the Notice of Intent and Part A permit requirements for the addition of an MSE berm at an existing SWMF assuming there is no expansion of the WMB. Specific details on the information to be included with each of the items listed below is provided in Sections III and IV of Submission Instruction No. 1: Procedural Requirements for a New or Modified Solid Waste Management Facility (SWMF) Permit Application. If an expansion of the WMB is also included with the MSE berm permit modification, be sure to provide the required additional application items identified in Submission Instruction No. 1 that are applicable to landfill expansions.

1. **Part A Form per 9 VAC 20-81-460.A. for Siting Analysis**

   As indicated in Section V.A., a Part A permit modification is not required for the addition of an MSE berm to an existing landfill that does not include an expansion of the WMB. While all waste management must occur within the WMB, the footprint of the MSE berm may be constructed outside the WMB. However, since the MSE berm becomes a critical part of the landfill disposal unit and allows for an increase in waste disposal capacity, its placement should be constructed in areas that meet the siting criteria of 9 VAC 20-81-120 (see Figure 1). By siting the berm to meet the landfill setbacks, the facility is able to maintain required site features and affords space to protect human health and the environment. To show that the footprint of the berm meets the siting criteria, the distance between the outside edge (toe) of the MSE berm and each setback should be provided on the Part A form (questions 1-10). . In addition, any documentation and/or demonstrations necessary for purposes of stability or proximity to receptors identified under 9 VAC 20-81-120 shall be included as the specified attachment to the form (and may not be listed below).

Sites that cannot meet the proposed siting criteria of 9 VAC 20-81-120 for the entire length of the proposed MSE berm should contact the appropriate DEQ Regional Office to discuss options for the facility in a pre-application meeting. These facilities should be prepared to explain and discuss the portion of the berm that cannot meet the setbacks and why that portion can not be met. DEQ anticipates that facilities should be able to have some portion of the width of the berm for the entire length to meet the siting requirements.

**2. Notice of Intent per 9 VAC 20-81-450.B.**

a. Cover Letter identifying the major permit modification request, describing the exact change(s) to be made to the existing SWP, and explaining the facility's need for the modification, accompanied by Area and Site Location Maps per 9 VAC 20-81-450.B.1. and 9 VAC 20-81-600.F.3.b. (Part A Form Attachment I);

b. Disclosure Statement per 9 VAC 20-81-450.B.2. (Part A Form Attachment II);

c. Local Government Certification per 9 VAC 20-81-450.B.3. (Part A Form Attachment III);
In addition to certification by the local government (i.e. SW-11-1 Form), the Department must receive documentation specific to approval of the MSE berm by the local government with the application. This is to ensure all local zoning and/or land use restrictions imposed by the locality are addressed prior to the application being reviewed by the Department.

d. Demonstration of Need per 9 VAC 20-81-450.B.8. (Part A Form Attachment VII);

e. SCC Certification per 9 VAC 20-81-450.B.10. (Part A Form Attachment VIII);

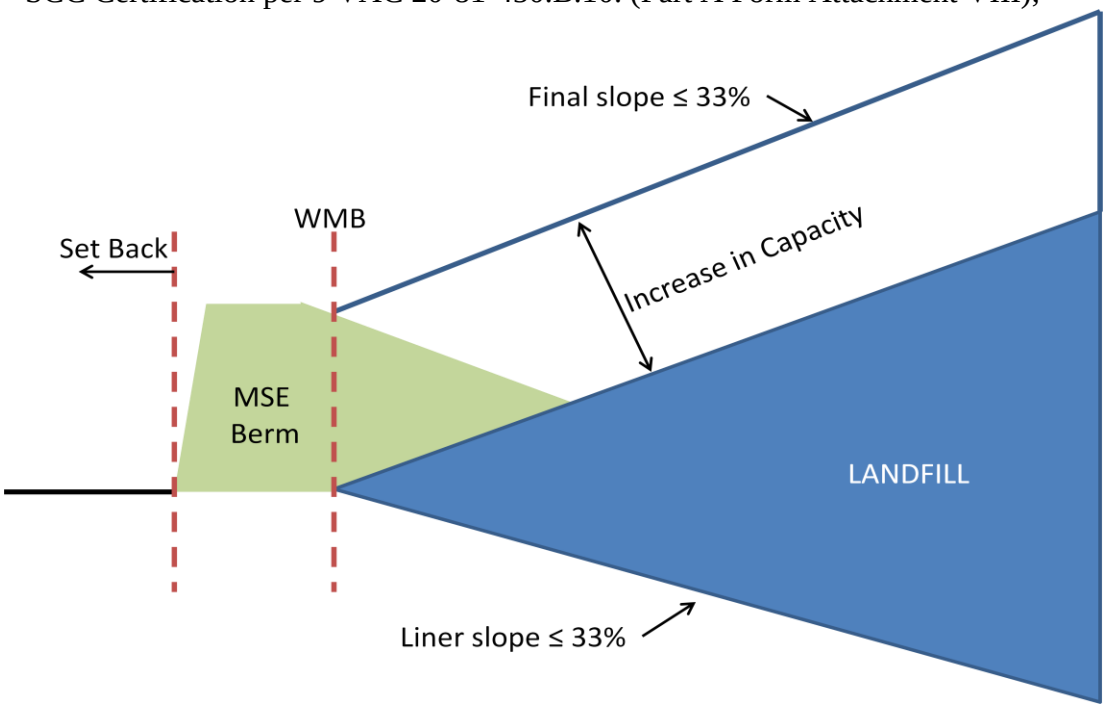


**Figure 1.**
MSE Berm addition without changing the WMB

3. **Vicinity Map per 9 VAC 20-81-460.C. (Part A Form Attachment IX)**

   Even if the facility has a current Part A including a Vicinity Map, the application shall include a Vicinity Map per the requirements of 9 VAC 20-81-460.C. showing the proposed boundary of the MSE berm facing (or toe of slope) with respect to the new or existing landfill facility (waste management boundary).

4. **Hydrogeologic & Geotechnical Report by P.G. or P.E. per 9 VAC 20-81-460.E. (Part A Form Attachment XI thru XV)**

   Facilities without a Part A Permit or whose Part A Hydrogeologic and Geotechnical Report analysis did not extend into the area of the proposed MSE berm footprint should perform the hydrogeologic and geotechnical analysis as prescribed under 9 VAC 20-81-460.E. in order to assess subsurface conditions for purposes of determining stability under proposed loads of the MSE berm. A complete Hydrogeologic and Geotechnical Report outlined in Submission Instruction No. 1 (Section IV.F.) does not need to be submitted (unless a Part A permit is required); however, information gathered during the site's suitability assessment shall be used when designing the MSE berm. At a minimum, documentation to support the design analyses discussed in Section V.C.3. shall accompany the Part B permit application.

5. **VDOT Adequacy Report per 9 VAC 20-81-460.G. (Part A Form Attachment XVI)**
   *Applicable only to landfills requesting an increase in the daily disposal limit*

6. **Landfill Impact Statement per 9 VAC 20-81-460.H. (Part A Form Attachment XVII)**
   *Applicable only to sanitary landfills.* The Landfill Impact Statement shall address impacts to parks, recreational areas, wildlife management areas, critical habitat areas of endangered species, public water supplies, marine resources, wetlands, historic sites, fish and wildlife, water quality, and tourism expected due to the addition of the MSE berm and any vertical increase in landfill airspace gained.

7. **Adjacent Property Owner Notification per 9 VAC 20-81-460.I. (Part A Form Attachment XVIII)**

## *V.C. Part B Application Elements for MSE Berms (9 VAC 20-81-470)*

The following items shall be submitted with the permit application to satisfy Part B permit requirements for the addition of an MSE berm at an existing SWMF. Details on the information to be included with each of these items is provided in Section V of Submission Instruction No. 1: Procedural Requirements for a New or Modified Solid Waste Management Facility (SWMF) Permit Application.

1. **Part B Form per 9 VAC 20-81-470.D.**
2. **Permit Application fee per 9 VAC 20-81-450.D.1.**
3. **Design Plans & Design Report per 9 VAC 20-81-470.A.1. and 9 VAC 20-81-470.B. (Part B Form Attachments III and VI), respectively**

   Generic details on the information to be included with the Design Plans and Design Report are addressed in Submission Instruction No. 2: Design Plans and Report for Solid Waste Disposal Facilities. The following discussion addresses additional analyses specific to the proposed MSE berm that shall be addressed in the Design Plans and Design Report submitted for review.

   ***a. Analyze for Failures during Berm Construction***

   Berms can be constructed as a retrofit on to existing landfill slopes or in anticipation of future landfill expansion. Both scenarios present construction scenarios that should be evaluated for failure so that construction activities can be conducted in a safe manner.

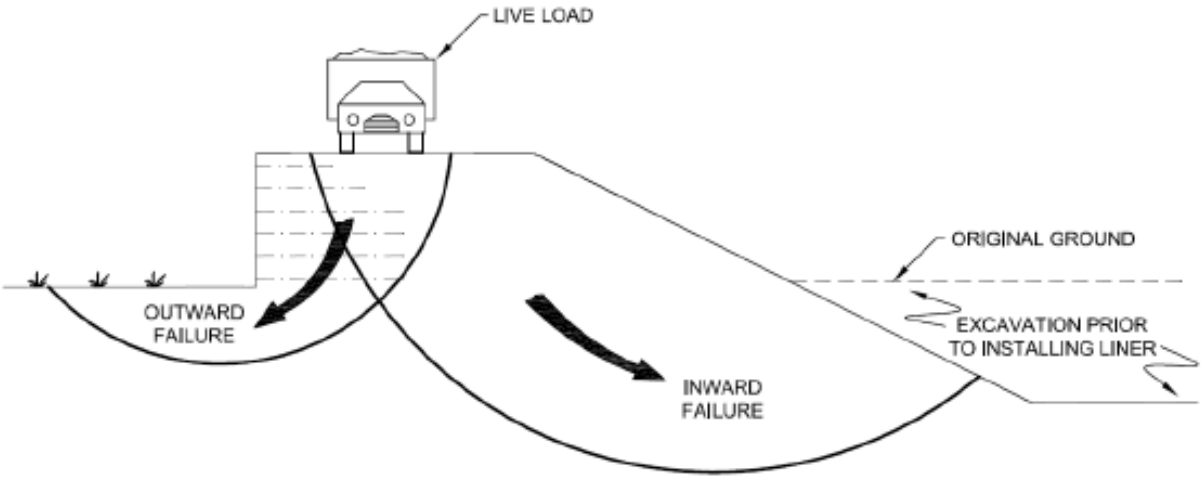


**Figure 2**

Figure credit: Scott M. Luettich and Juan D. Quiroz, Landfill Stability Analyses for the Application of Mechanically Stabilized Earth (MSE) Perimeter Berms (3rd paper of GRI Report 35)

Figure 2 depicts a scenario where the MSE berm is constructed first in anticipation of a landfill lateral expansion. In these scenarios, the MSE berm should be analyzed for both inward and outward stability during construction. Inward stability should be analyzed at critical cross-sections, which typically represent areas where the berm will be highest, with deepest excavations and weakest subsurface conditions. Outward stability should also be analyzed at critical cross sections, which typically coincide with areas where the berm will be highest with weakest subsurface conditions. Stability calculations should address live loads from heavy construction equipment, temporary stockpiling of construction materials, and consider seismic loading conditions, if applicable.

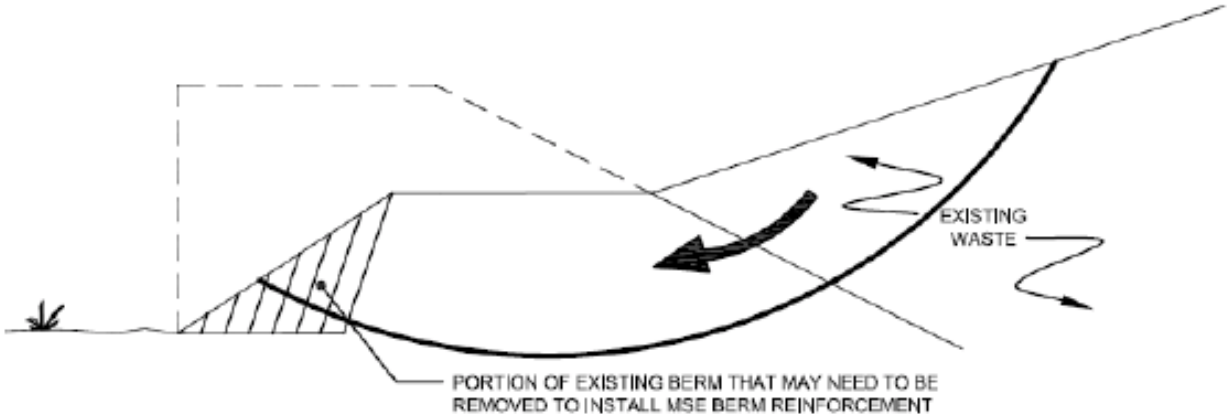


**Figure 3**

Figure credit: Scott M. Luettich and Juan D. Quiroz, Landfill Stability Analyses for the Application of Mechanically Stabilized Earth (MSE) Perimeter Berms (3rd paper of GRI Report 35)

Figure 3 depicts scenarios where the MSE berm is added to an existing landfill requiring the excavation of an existing unreinforced soil berm or toe of the landfill slope. In these scenarios, the outward stability for the temporary construction condition should be analyzed for critical cross-sections, which typically coincides with the combination of weakest subsurface conditions, highest/steepest adjacent waste configuration, and at locations where the maximum amount of the existing berm or toe must be removed. Depending on the calculated factors of safety, the facility may need perform incremental excavation or install temporary bracing in order to prevent failure of the landfill slope due to the construction activity.

***b. MSE Berm Internal Stability Analysis***

The Design Report shall include calculations and discussion addressing the selected berm backfill, reinforcements, and spacing to ensure internal stability of the MSE berm. The internal berm stability calculations shall evaluate for potential rupture of the berm reinforcement based on its tensile strength and potential for pullout of the reinforcement within the MSE berm. Also, the report shall discuss the design of berm stormwater drainage and leachate removal features within/adjacent to the berm and measures to be employed to minimize hydrostatic pressures against the berm.

***c. Global Stability and Critical Failure Analysis***

It is standard for landfill Design Reports or Closure Plans to address global stability of the waste mass by looking at potential circular and block failure modes along critical cross-sections as seen in Figures 4 and 5. For landfills incorporating MSE berms, these cross-sections should represent the combination of highest and steepest waste slope and weakest subsurface conditions.

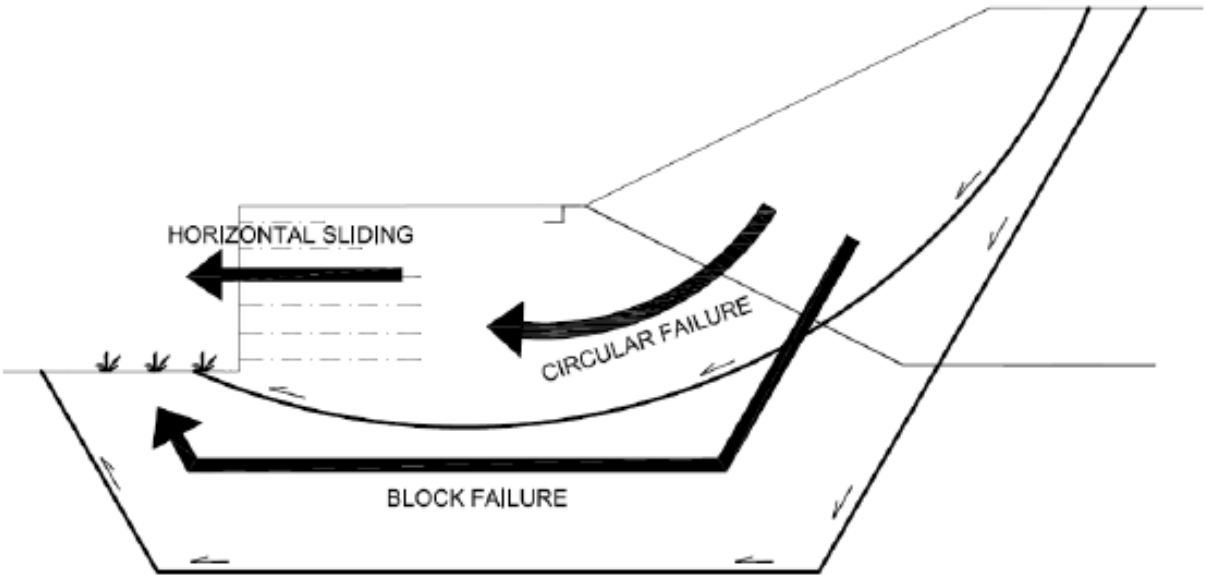


**Figure 4**
Figure credit: Scott M. Luettich and Juan D. Quiroz, Landfill Stability Analyses for the Application of Mechanically Stabilized Earth (MSE) Perimeter Berms by (3rd paper of GRI Report 35)

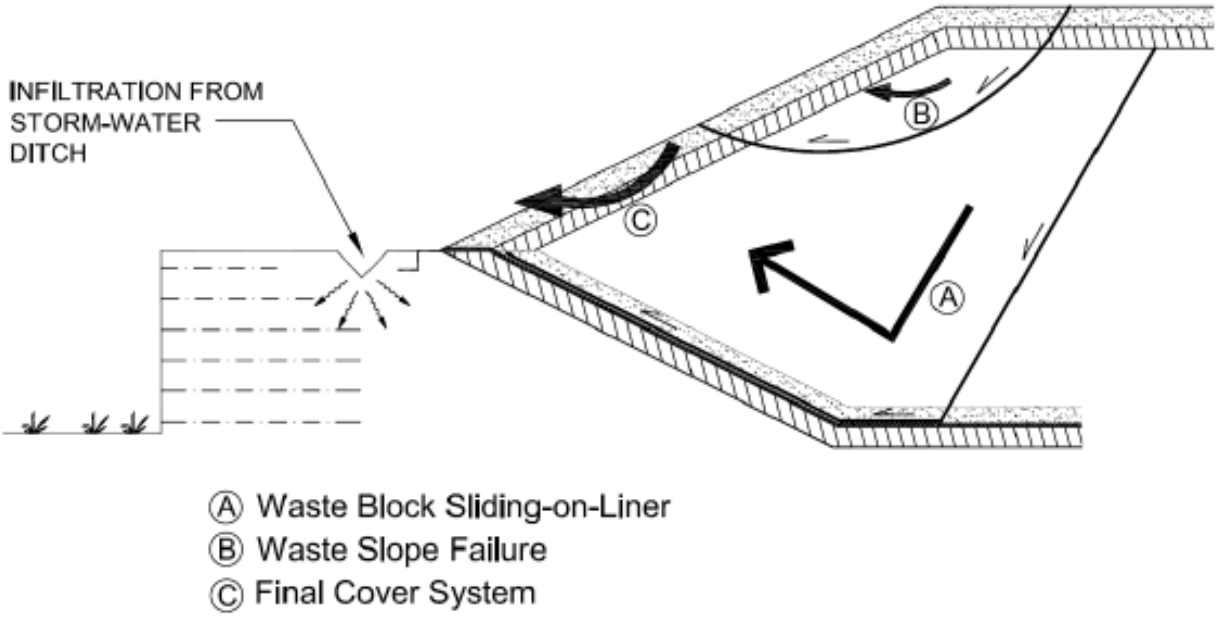


**Figure 5**
Figure credit: Scott M. Luettich and Juan D. Quiroz, Landfill Stability Analyses for the Application of Mechanically Stabilized Earth (MSE) Perimeter Berms (3rd paper of GRI Report 35)

As part of this analysis, the applicant shall attempt to demonstrate what a critical berm failure would look like by manipulating the design calculations and modeling to result in a berm collapse. This failure analysis shall be performed along one or more critical cross-sections where failure could potentially impact an off-site receptor(s) (i.e. private property, surface water, etc.).

The berm itself should also be analyzed for horizontal sliding. Critical cross-sections for berm sliding typically represent the combination of highest and steepest waste slope and weakest near-surface soil conditions along the interface where the berm is constructed over the ground surface.

**4. Closure Plan per 9 VAC 20-81-470.A.1. (Part B Form Attachment IV)**

Details on the information to be included with the Closure Plan is provided in Section I of Submission Instruction No. 6: Closure and Post-Closure Care Plans for Solid Waste Disposal and Management Facilities. The facility's Closure Plan shall be updated to address revised closure design plans (if not included with Part B Form Attachment III), and closure stability analysis (i.e. stability of the final waste slopes and final cover veneer stability—see items B and C of Figure 5).

**5. Postclosure Care Plan per 9 VAC 20-81-470.A.2. (Part B Attachment V)**

The Inspection Plan portion of the Postclosure Care Plan shall be revised to include details of the inspection program to be implemented specifically regarding the MSE berm. The following items shall be included, at a minimum, and inspected on a regular basis as part of the inspection program:

- Condition of the facing;
- Evidence of seepage/erosion through the MSE berm;
- Evidence of differential settlement along the MSE berm;
- Condition of the top of the MSE berm;
- Condition of the base of the MSE berm;
- Stormwater structure integrity; and
- Prior repair to the berm.

In addition, the annual berm inspections and reporting discussed in Section V.D.2. shall continue during postclosure.

The length of the postclosure care period shall be as specified in accordance with 9 VAC 20-81-170.B.2. At a request for reduction or termination of the postclosure care period in accordance with 9 VAC 20-81-170.B. 3. or C., respectively, the facility shall provide the Termination of Post-Closure Activity (TPCA) Evaluation as specified in Submission Instruction No. 20: Termination of Post-Closure Activity Evaluation. The TPCA Evaluation should include a section specifically addressing the MSE berm that includes the following items:

(1) A discussion of historical MSE berm inspection and maintenance performed during the postclosure care period; the dates and types of any major repairs; and a summary of the current condition of the berm, to include current condition of the berm facing, top and base of the berm, and stormwater structure integrity;

(2) A discussion of the MSE berm maintenance requirements contained in the facility permit, applicable regulations, postclosure care plan, or any order or agreement entered into with the DEQ and a status report on how these requirements were met; and

(3) A discussion of the potential for harm to human health or the environment if MSE berm inspection and maintenance activities were discontinued.

The TPCA Evaluation shall also include postclosure inspection records maintained in accordance with the Inspection Plan discussed above. The Department will consider this information when evaluating such requests for reduction or termination of the postclosure care period. Depending on the age of the MSE berm, historical maintenance activities, and current berm condition, the Department may decide to lengthen the postclosure care or require other actions before terminating postclosure care.

**6. CQA Plan & Technical Specifications per 9 VAC 20-81-470.B.3. (Part B Attachment VII)**

The Construction Quality Assurance (CQA) Plan and Technical Specifications shall be revised to account for materials and construction quality assurance/quality control procedures to be employed when constructing the MSE berm. These documents shall address all MSE berm components, to include but not limited to, the berm foundation, backfill materials, geosynthetic reinforcements (i.e. geogrid), berm facing, utilities, guardrail, and perimeter roads, as applicable. Construction equipment shall be chosen so as to not exceed the construction loads evaluated during the stability analysis.

**7. Leachate Management Plan per 9 VAC 20-81-210.A. (Part B Attachment VIII)**

Details on the information to be included with the Leachate Management Plan is provided in Submission Instruction No. 7: Leachate Management Plan for Solid Waste Management Facilities. The facility's Leachate Management Plan shall be updated to address any changes in leachate management (to include methods of collection, monitoring, removal, treatment, and disposal) that will change as a result of the proposed MSE berm design.

**8. Financial Assurance Documentation per 9 VAC 20-81-470.C. (Part B Attachment XII)**

The post-closure cost estimate shall account for all berm maintenance activities, to include, but not limited to, costs of reseeding, fertilizer costs, mobilization / demobilization for berm erosion repair, removal of woody vegetation, annual P.E. inspection, and the annual berm survey (see details in V.D.2.).

In addition to providing a financial assurance mechanism(s) to cover the costs of landfill closure, postclosure care, and groundwater corrective action, applicants proposing to construct an MSE berm shall provide additional financial assurance and/or environmental liability insurance to cover remediation and clean up in the event of a critical berm failure. Per GRI Report No. 40, the average cost to remediate excessively deformed or collapsed berms is almost twice the initial cost of construction. The additional financial assurance should account for these costs in addition to costs to clean up any solid waste that shifts outside the waste management boundary (as determined per the critical failure analysis discussed in Section V.C.3.c.).

## *V.D. Landfill Operations Manual*

In accordance with 9 VAC 20-81-485, all solid waste management facilities shall prepare and maintain an Operations Manual in the facility's operating record. The following elements of the Operations Manual should be updated to address the MSE berm. While these plans are part of the facility's operating record, portions addressing the MSE berm shall be submitted to the Department for review as part of the permit application.

1. **Emergency Contingency Plan**

   The Emergency Contingency Plan shall address "any unplanned sudden or nonsudden releases of harmful constituents to the air, soil, or surface water" (see 9 VAC 20-81-485.A.5.a.). To meet this requirement with reference to the MSE berm, the Emergency Contingency Plan shall address actions and procedures to be followed by facility personnel in the event of a berm failure. Berm failure should consider both excessive berm deformatoin and berm collapse.

2. **Inspection Plan**

   All components of the MSE berm should be inspected and maintained throughout the life of the landfill. The MSE berm should be inspected regularly by site personnel to assess its condition. The Inspection Plan shall include a list of anticipated maintenance items, such as, but not limited to, repair of berm facing issues (e.g. sparse/dead vegetation, erosion of topsoil, exposed/damaged geogrid, etc.), stormwater ponding or flow issues, and other expected inspection and maintenance activities. Inspections shall also focus on looking for indicators of potential failure such as cracking in access roads, seepage in the berm face, bulging or movement of soils at the toe or along the face of the berm, or damage to utilities or drainage features within the berm. The plan shall identify immediate actions that shall be taken if any of these indicators are observed, with follow-up actions to assess berm stability

   The berm shall also be inspected annually by a qualified professional engineer (P.E.). The P.E. shall review inspection records and repair logs prepared by site personnel in addition to performing an annual survey to record any vertical and/or horizontal movement of the MSE berm. An inspection report addressing historical and current survey data shall be completed and submitted to the DEQ annually.

   Maintenance of the MSE berm shall be conducted based on the results of routine inspections conducted by site personnel and annual inspections by a P.E. All required maintenance and repairs shall be performed in a timely manner to minimize the impacts of the issues noted during the inspection, and the maintenance or repair work shall be recorded in repair logs that are made available to the P.E. and DEQ staff. Significant repairs made to the berm shall be observed and documented by a qualified P.E.

## *V.E. Specific Permit Conditions*

Based upon the nature of MSE berms and the additional submittals outlined above, specific permit conditions may be included within a permit modification approving the construction of the MSE berm. These conditions are necessary to carry through to the permit the submittals and

approvals provided in the submittals outlined above. Additionally, other conditions may be added to address potential future issues that may arise related to the construction of MSE Berms.

MSE berm specific permit conditions are provided in Attachment 2 and should be incorporated in the final approved permit modification for the landfill. Based upon facility specific factors, additional conditions may be added as well.

# VI. Collaboration Process

No project team was formed to develop this guidance; however, DEQ Central Office and Regional staff were given opportunity to comment during development. Additionally, comments from interested parties were solicited and considered in the final version.

# VII. Attachments

1. MSE Berm Application Review Checklist
2. MSE Berm Applicable Permit Conditions

# VIII. References


Dudding, C.L., Sheridan, S., & Brown, D.N. Introduction of a Novel Approach – Beneficial Reuse of CCP's to Dramatically Reduce Landfill Airspace Construction Costs.

Koerner, R.M., & Koerner, G.R. (2008). A Collection of Papers on Design, Construction and Behavior of Large Engineered Berms at Landfills (GRI Report No. 35). Folsom, PA: Geosynthetic Institute.

Koerner, R.M., & Koerner, G.R. (2010). Remediation of Excessively Deforming MSE Retaining Walls (GRI Report No. 39). Folsom, PA: Geosynthetic Institute.

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**Attachment 1. MSE Berm Application Review Checklist**

| **MSE Berm Application Review Checklist**<br>_____<br>Facility Name | Provided (y/n) | Complete (y/n) | Technically Adequate (y/n) | Date Received_____<br>Date CR Due _____<br>Comments |
|---|---|---|---|---|
| **Part A Application Form (DEQ Form PTA)** | **Applicant Response** | | | **Comments** |
| **1.** Is the landfill located in the 100-year floodplain (§ 9 VAC 20-81-120.A)? | | | | |
| **2.** Is the landfill located in a geologically stable area (§ 9 VAC 20-81-120.B)? | | | | |
| **3.a.** Distance to any residence, school, daycare center, hospital, nursing home or recreational park area in existence at the time of application (§ 9 VAC 20-81-120.C.1.a.): | | | | |
| **3.b.** Distance from any perennial stream or river (§ 9 VAC 20-81-120.C.1.b): | | | | |
| **3.c.** Distance from the Facility Boundary (§ 9 VAC 20-81-120.C.1.c): | | | | |
| **3.d.** Distance from any well, spring or other ground water source of drinking water in existence at the time of application (§ 9 VAC 20-81-120.C.1.d): | | | | |
| **3.e.** Distance from the nearest edge of the right-of-way of any interstate or primary highway (§ 9 VAC 20-81-120.C.1.e): | | | | |
| **3.f.** Distance from the nearest edge of right-of-way of any other highway or city street (§ 9 VAC 20-81-120.C.1.e): | | | | |
| **4.** Is the landfill located in a park or recreational area, wildlife management area or area designated by the federal or state agency as the critical habitat of any endangered species (§ 9 VAC 20-81-120.C.2)? | | | | |
| **5.a.** Does the landfill have the ability to conduct groundwater monitoring in accordance with 9 VAC 20-81-250 (§ 9 VAC 20-81-120.D.1) | | | | |
| **5.b.** Does the landfill have the ability to characterize the rate and direction of ground water flow within the uppermost aquifer (120.D.1.a) | | | | |
| **5.c.** Does the landfill have the ability to characterize and define any releases from the landfill so as to determine what corrective actions are necessary (120.D.1.b) | | | | |
| **5.d.** Does the landfill have the ability to perform corrective action as necessary (120.D.1.c) | | | | |
| **6.** Is the landfill located in a tidal or nontidal wetland (9 VAC 20-81-120.E.)? | | | | |
| **6.a.** If yes, list total number of nontidal wetland acres to be impacted: | | | | |
| **7.a.** Does the proposed landfill include excessive slopes (> 33%)? | | | | |
| **7.b.** Does the proposed landfill lack daily cover materials? | | | | |
| **7.c.** Does the proposed landfill site include springs, seeps, or other groundwater intrusion? | | | | |
| **7.d.** Does the proposed landfill site include the presence of gas, water, sewage, or electrical or other transmission lines under the site? | | | | |
| **7.e.** Does the proposed landfill site include the prior existence of an open dump, unpermitted landfill, lagoon, or similar unit? | | | | |
| **8.** Does the facility have adequate area and terrain for leachate management? | | | | |
| **9.a.** Distance to existing surface or groundwater public water supply intake or reservoir that are downgradient of the landfill (in miles): | | | | |
| **9.b.** Distance to existing surface or groundwater public water supply intake or reservoir that are upgradient of the landfill (in miles): | | | | |
| **9.c.** Is the landfill located in an area vunerable to flooding caused by dam failures? | | | | |
| **9.d.** Is the landfill located over a sinkhole or within 100 feet of a solution cavern associated with karst topography? | | | | |
| **9.e.** Is the landfill located over a fault that has had displacement in Holocene time? | | | | |
| **9.f.** Distance from a fault that has had displacement in Holocene time (in feet): | | | | |
| **9.g.** Is the landfill located within a seismic impact zone? | | | | |
| **9.h.** Distance from any airport runway end used by turbojet or piston-type aircraft: | | | | |
| **10.a.** For CDD Landfills, is the facility located in a strip mine pit? | | | | |
| **10.b.** If yes, indicate minimum distance between coal seams/coal outcrops and solid waste materials: | | | | |

| **MSE Berm Application Review Checklist**<br>_____<br>Facility Name | Provided (y/n) | Complete (y/n) | Technically Adequate (y/n) | Date Received_____<br>Date CR Due _____<br>Comments |
|---|---|---|---|---|
| **Notice of Intent (9 VAC 20-81-450.B.)** | | | | See Submission Instruction No. 1 |
| **Cover Letter & Area/Site Location Maps, PTA Attachment I** | | | | |
| **Disclosure Statement, PTA Attachment II** | | | | |
| **Local Government Certification, PTA Attachment III** | | | | |
| **Demonstration of Need, PTA Attachment VII** | | | | |
| **Demonstration based on 9 VAC 20-81-450.B.8.a.** (**All Landfills**) - Facility must provide information demonstrating that there is a need for the additional capacity, to include: | | | | |
| **(1)** Anticipated area to be served; | | | | |
| **(2)** Similar or related WMFs that are located in the same service area and could impact the proposed facility, and the capacity and service life of those facilities; | | | | |
| **(3)** Present quantity of waste generated within the proposed service area; | | | | |
| **(4)** The disposal needs specified in the local solid waste plan; | | | | |
| **(5)** Projected future waste generation rates for the anticipated area to be served during the proposed life of the facility; | | | | |
| **(6)** Recycling, composting or other waste management activities within proposed service area; | | | | |
| **(7)** The additional SW disposal capacity that the facility would provide to the proposed area of service; | | | | |
| **(8)** Information demonstrating that the capacity is needed to enable localities to comply with solid waste plans developed pursuant to 10.1-1411 of the Code of Virginia; | | | | |
| **(9)** Any additional factors that provide justification for additional capacity provided by the facility | | | | |
| **Demonstration based on 9 VAC 20-81-450.B.8.b.** (**Sanitary Landfills Only**) - Based on current or projected disposal rates, facility must provide information demonstrating there is less than 10 years of capacity remaining in the facility and information demonstrating either of the following: | | | | |
| **(1)** Available disposal capacity for the state is **< 20 years** based on the most current reports submitted pursuant to the Waste Information and Assessment Program in § 9 VAC 20-81-80 OR | | | | |
| **(2)** The available permitted disposal capacity is **< 20 years** in either: | | | | |
| **(a)** The planning region, or regions, immediately contiguous to the planning region of the host community | | | | |
| **(b)** The facilities within a 75 miles radius of the proposed facility | | | | |
| **Director's Determination based on § 10.1-1408.1 D.1 (Both for 450.B.8.a and 450.B.8.b)** | | | | |
| **(1)** The proposed facility, expansion or increase protects present and future human health and safety and the environment; | | | | |
| **(2)** There is a need for the additional capacity; | | | | |
| **(3)** Sufficient infrastructure will exist to safely handle the waste flow; | | | | |
| **(4)** The increase is consistent with locality-imposed or state-imposed daily disposal limits; | | | | |
| **(5)** The public interest will be served by the proposed facility's operation or the expansion or increase in capacity of a facility; and | | | | |
| **(6)** The additional capacity is consistent with regional and local SWMPs developed pursuant to §10.1-1411. | | | | |
| **SCC Certification, PTA Attachment VIII** | | | | |

**Attachment 1. MSE Berm Application Review Checklist**

| **MSE Berm Application Review Checklist**<br>_____<br>Facility Name | Provided (y/n) | Complete (y/n) | Technically Adequate (y/n) | Date Received_____<br>Date CR Due _____<br>Comments |
|---|---|---|---|---|
| **Vicinity Map, PTA Attachment IX** | | | | |
| **(1)** All homes, buildings or structures including the layout of the buildings which will comprise the proposed facility; | | | | |
| **(2)** Facility boundary; | | | | |
| **(3)** Limits of actual waste disposal operations within facility boundary; | | | | |
| **(4)** Lots, blocks, and all contiguous properties; | | | | |
| **(5)** Base floodplain or a note indicating the expected flood occurrence period for the area; | | | | |
| **(6)** Existing land and zoning classification; | | | | |
| **(7)** All water supply wells, springs or intakes, both public and private; | | | | |
| **(8)** All utility lines, pipelines or land based facilities; | | | | |
| **(9)** All parks, recreation areas, surface water bodies, dams, historic areas, wetland areas, monument areas, cemeteries, wildlife refuges, unique natural areas or similar features. | | | | |
| **Hydrogeolo gic & Geotechnical Report, PTA Attachment XI thru XV** | | | | See Submission Instruction No. 1 |
| **Is Site Hydrogeologic and Geotechnical Report certified by Commonwealth of Virginia by P.E. or P.G.?** | | | | |
| **I. Purpose and Methods** | | | | |
| **II. Boring Records** | | | | |
| A. Number of Borings | | | | |
| B. Location of Borings | | | | |
| C. Depth of Borings | | | | |
| D. Samplings | | | | |
| E. Observation Wells | | | | |
| G. In-situ Hydraulic Conductivity | | | | |
| H. Sealing of Borings | | | | |
| **III. Geotechnical Report** | | | | |
| A. Description of Soil Units | | | | |
| B. Remolded Hydraulic Conductivity | | | | |
| C. Volume of Materials | | | | |
| **IV. Hydrogeologic Report** | | | | |
| A. Water Table Information | | | | |
| 1. Groundwater Level Measurements | | | | |
| 2. Vertical Flow Components | | | | |
| 3. Seasonal and Temporal Factors | | | | |
| B. Field Procedures and Results | | | | |
| C. Description of Site Geology | | | | |
| D. Description of Aquifer | | | | |
| **VDOT Adequacy Report, PTA Attachment XVI** | | | | |
| **Landfill Impact Statement, PTA Attachment XVII** | | | | See Submission Instruction No. 1 |
| **I. Executive Summary** | | | | |
| **II. Purpose of and Need for Action** | | | | |
| **III. Alternatives, including the Selected Alternative** | | | | |
| **IV. Affected Environments of the Selected Alternative (460.H.1 and H.3)** | | | | |
| A. Parks and Recreation Areas | | | | |

| **MSE Berm Application Review Checklist**<br>_____<br>Facility Name | Provided (y/n) | Complete (y/n) | Technically Adequate (y/n) | Date Received_____<br>Date CR Due _____<br>Comments |
|---|---|---|---|---|
| B. Wildlife Management Areas | | | | |
| C. Public Water Supplies | | | | |
| D. Marine Resources | | | | |
| E. Wetlands | | | | |
| F. Historic Sites | | | | |
| G. Fish and Wildlife | | | | |
| H. Water Quality | | | | |
| I. Tourism | | | | |
| **V. Environmental Consequences of the Alternatives (460.H.2)** | | | | |
| **VI. Coordination** | | | | |
| **VII. List of Contributors** | | | | |
| **VIII. References** | | | | |
| **Adjacent Property Owner Notification, PTA Attachment XVIII** | | | | |
| (1) Signed Statement | | | | |
| (2) Copy of the Notice | | | | |
| (3) List of Names and Addresses | | | | |
| **Part B Application Form (DEQ Form PTB)** | | | | |
| **Application Fee** | | | | |
| **Design Plans, PTB Attachment III** | | | | See Submission Instruction No. 2 and checklist |
| **Closure Plan, PTB Attachment IV** | | | | See Submission Instruction No. 6 and checklist |
| **Post-Closure Care Plan, PTB Attachment V** | | | | See Submission Instruction No. 6 and checklist |
| **Design Report, PTB Attachment VI** | | | | See Submission Instruction No. 2 and checklist |
| Analyzes for Failures during berm construction | | | | |
| MSE Berm Internal Stability Analysis | | | | |
| Global Stability & Critical Failure Analysis | | | | |
| **CQA Plan & Technical Specs, PTB Attachment VII** | | | | See Submission Instruction No. 2 and checklist |
| CQA Plan addresses construction of MSE Berm? | | | | |
| Tech Spec for berm foundation | | | | |
| Tech Spec for berm backfill material(s) | | | | |
| Tech Spec for berm geosynthetic support (geogrid) | | | | |
| Tech Spec for berm facing | | | | |
| Tech Spec for berm utilities | | | | |
| Tech Spec for guardrail | | | | |
| Tech Spec for perimeter berm roads | | | | |
| **Leachate Management Plan, PTB Attachment VIII** | | | | See Submission Instruction No. 7 and checklist |
| **Financial Assurance Documentation, PTB Attachment XII** | | | | |
| (1) Postclosure Cost Estimate accounts for berm maintenance activities | | | | |
| (2) Environmental Liability Insurance | | | | |

# PERMIT DOCUMENTS

The documents listed below are hereby incorporated into this permit and the permittee is subject to all conditions contained therein. It is the responsibility of the permittee to properly maintain and update these documents. Any version with a revision date other than as listed below is not considered to be the official approved version and is subject to Department review and approval prior to being recognized as the "permitted" version.

*{List application documents submitted in support of the MSE Berm design}*

*Plan Title*, prepared by Consultant, dated/last revised DATE.

# PERMIT MODULE I
## GENERAL PERMIT CONDITIONS

I.B. DUTIES AND REQUIREMENTS

I.B.13. The closure cost estimate must reflect the maximum cost of closure at all times. The owner has the responsibility to maintain the closure and post closure cost estimate and associated financial assurance funding as conditions change.

*{Add for MSE Berm}* The facility shall maintain additional financial assurance and/or environmental liability insurance that has been reviewed and approved by the Department until the landfill is released from postclosure care to cover the costs of remediation and clean up in the event of failure of the MSE berm. The facility shall not alter the amount or mechanism without prior approval by the Department.

I.F. SITE SPECIFIC CONDITIONS

The provisions of this section are in addition to the permit conditions and regulatory requirements and are specifically developed for this facility. The permittee shall comply with all conditions of this section, as follows:

I.F.1. The final permit is based on permit application submittals (drawings and reports) that may contain the word "proposed' and similarly tentative language. The documents that are incorporated into Permit No. XXX have been evaluated for administrative and technical adequacy and have been approved as proposed. Therefore, any references to a design, construction, operation, monitoring or closure criteria are considered to be approved as proposed.

I.F.2. The facility is subject to the conditions listed in the Part A approval letter dated DATE.

I.F.3. *List other site-specific conditions. These should be conditions that don't fit in other Modules (II, III/IV/V, X, XI, XII, XIII, or XIV), and should focus more on requested additional submittals.*

*{Add for MSE Berm}*

I.F.4. The facility shall be operated in a manner so as to not affect or impact the MSE berm unless needed to address berm movement, bulging, or blowout. The facility shall not alter, amend, or change the MSE berm without prior approval of the Department except as needed to respond to a blowout or similar emergency.

I.F.5. The Operations Manual, Emergency Contingency Plan, shall be revised to address actions and procedures to be followed by facility personnel in the event of a MSE berm failure. Berm failure should consider both excessive berm deformation and berm collapse.

I.F.6. The Operations Manual, Inspection Plan, shall be revised to address self-inspection items applicable to the MSE berm (see Permit Condition II.G.).

I.F.7. The MSE berm shall be inspected annually *(by survey or other method as specified in the application)* to assess berm movement and certified by a qualified professional engineer. The annual inspections shall continue through the postclosure care period and be submitted to the Department no later than December 31 of each year. The facility shall take corrective measures immediately to address any movement of the wall as identified during the inspection or otherwise.

# PERMIT MODULE II
## CONDITIONS OF OPERATION

II.G. SELF-INSPECTION PROGRAM

The landfill shall implement an inspection routine including a schedule for inspecting all applicable major aspects of facility operations necessary to ensure compliance with the requirements of this chapter. Records of these inspections must be maintained in the operating record and available for review. At a minimum, the following aspects of the facility shall be inspected on a monthly basis: erosion and sediment controls, storm water conveyance system, leachate collection system, safety and emergency equipment, internal roads, and operating equipment.

*{Add for MSE Berm}* Specific to the MSE berm, the following items shall be included in the self-inspection program, at a minimum, and inspected on a regular basis:

- Condition of the facing;
- Evidence of seepage/erosion through the MSE berm;
- Evidence of differential settlement along the MSE berm;
- Condition of the top of the MSE berm;
- Condition of the base of the MSE berm;
- Stormwater structure integrity; and
- Prior repair to the berm.