"THIS POLICY DOES NOT HAVE THE FORCE OF LAW"

FINAL COVERS

FOR HAZARDOUS WASTE SURFACE IMPOUNDMENTS, WASTE PILES AND LANDFILLS

A Guidance on Requirements, Applicability and Design

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INTRODUCTION

The purpose of this document is to provide general guidance and to suggest design solutions which may be appropriate in evaluating alternate final cover design proposals. This document consists of a discussion of the final cover design reqiurements necessary for the closure of surface impoundments, waste piles and landfills. The discussion is based on an examination of the applicable Ohio rules as well as DHWM's recommendations and views on how the requirements of the rule can be met. These concepts can also be carried over to final covers which may be required of both tanks or container storage areas that cannot clean close in addition to sites with RCRA Corrective Action. The guidance concludes with examples of accepted final cover designs.

More specifically, the Background section of this guidance consists of an overview of the applicable rules and the role that final covers play in the ground water protection strategy. The Technical Performance Standards section describes the technical performance standards of a final cover and Ohio EPA's recommended design solution. This is followed by sections describing factors that affect the design (Factors Affecting Design Solutions) and the critical design elements of a final cover (Critical Design Elements). The final section of this guidance provides examples of approved final covers.

This document is intended to convey the general guidelines for evaluating a proposed alternate final cover design and is not to serve as a detailed instructional manual. Refer to the publications in the Resource List section for additional information.

BACKGROUND

A determination of appropriate (or acceptable) final cover (cap) design for closure must be based upon the regulatory standard. There are two types of closure requirements in the rules: (1) general requirements, which are contained in Ohio Administrative Code (OAC) Rules 3745-55-11 and 66-11, and (2) specific technical performance requirements, which are included with the unit specific requirements for surface impoundments, waste piles and landfills.

Under the general closure performance standard (OAC Rules 3745 -55-11 and 66-11) the owner or operator must close the facility in a manner that:

A. Minimizes the need for further maintenance;

B. Controls, minimizes or eliminates, to the extent necessary to prevent threats to human health and the environment, post-closure migration of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere; and

C. Complies with the applicable closure requirements of rules.

In addition to the general closure performance standard, the US EPA was required by RCRA to, among other things, issue standards applicable to owners and operators of hazardous waste management land disposal facilities. In July of 1982, the US EPA promulgated such regulations specifying requirements for closure of surface impoundments and waste piles. In order to assure that those land disposal standards were protective of human health and the environment, the US EPA developed the regulations based upon a strategy which focused on and addressed potential adverse effects on groundwater (47 FR 143, July 26, 1982 [the 1982 Federal Register] at 32283).

The fundamental goal of the regulations (as stated in the preamble to the rule) is to minimize the potential for migration into the environment of the hazardous component of waste placed in the land disposal unit. This goal is achieved by creating regulatory requirements directed towards liquids management at the unit and rules establishing a comprehensive ground water monitoring and response program. The ground water protection strategy works by combining efforts to both minimize leachate generation and migration into the subsurface along with a ground water monitoring and response program to remove leachate from the ground water if it is detected.

The regulations that were developed were, to a large degree, technical performance standards. Such standards establish an engineering objective and allow the owner or operator (or permit applicant) to develop a design or set of practices to achieve the objective. In other words, the level of environmental protection remains constant. The regulating agency, however, is required to draw a balance so that the final cover approved and implemented fits the site conditions.

Specifically, the technical performance standards for the in-place closure of surface impoundments 40 CFR 264.228 (OAC Rule 3745-56-28), waste piles 40 CFR 264.258 and 265.258 (OAC Rules 3745- 56-58 and 67-58), and landfills 40 CFR 264.310 (OAC Rule 3745-57-10) were promulgated by the US EPA in July of 1982 (see 47 FR 143 at 32274). In April of 1985 US EPA amended the interim status rule for closure of landfills 40 CFR 265.310 (OAC Rule 3745-68-10) to conform to final standards (except for post-closure groundwater monitoring). In March 1987 US EPA made similar changes for closure of surface impoundments (40 CFR 265.228 (OAC Rule 3745-67-28)) making it conform to many of the 40 CFR 264.228 requirements.

1. Closure of Surface Impoundments (OAC Rules 3745-56-28 and 67-28)

Currently, Ohio rules allow the owners and operators of surface impoundments, at the time of closure, to choose between removing hazardous waste and waste residue (and terminating responsibility for the unit) or leaving the wastes in place. If the latter option is selected, the owner and operator must also eliminate free liquids, stabilize the wastes sufficient to support a final cover, place a final cover on top of the waste, and conduct post closure monitoring and maintenance including continued ground water monitoring.

Consistent with the ground water protection strategy the final cover must be designed and constructed to provide long term minimization of the migration of liquids into the closed impoundment. In fact, after closure, the protective final cover is the primary element of the liquids management strategy. A well designed and carefully maintained final cover can be quite effective in reducing the volume of liquids entering a unit and therefore can substantially reduce the potential for leachate generation at the unit for long periods. In addition, where a bottom liner is present, the cover must be at least as impermeable as the bottom liner in order to avoid the build-up of liquids in the closed impoundment. In an in-place closure, free liquids must be eliminated and the remaining waste must be stabilized to a bearing capacity to support the final cover. This will prevent differential settlement which can create cracks or depressions in the final cover, increasing infiltration. The final cover must also be designed to minimize erosion as well as to accommodate any settlement.

Once the final cover has been installed, and compliance with the closure provisions has been certified, the post-closure period begins. Post-closure care consists of maintaining the final cover and monitoring the groundwater.

2. Closure of Waste Piles (OAC Rules 3745-56-58 and 67-58)

In the case of waste piles, all waste residues and contaminated subsoils and equipment must be removed or decontaminated at closure. However, if the owner or operator after removing or decontaminating all waste residue and also making all reasonable efforts to remove or decontaminate contaminated components, subsoils, structures and equipment, finds that not all contaminated soils can be practicably removed or decontaminated, then the pile is considered a disposal unit. The unit must then be closed in accordance with the closure requirements for landfills including post closure care. The preamble of the 1982 Federal Register (at 32324) suggests that a "reasonable effort" to remove all contaminated subsoils includes first removal of all waste and waste residue in the unit, all contaminated liners and equipment, and at least some subsoil. The landfill closure standard contained in OAC Rules 3745-57-10 and 68-10 is very similar to the technical standard for final cover of surface impoundments in terms of the ground water protection strategy.

3. Closure of Landfills (OAC Rule 3745-57-10 and 68-10)

At closure the owner and operator must cover the landfill or cell with a final cover that is designed and constructed to meet the tecnical performance standards listed in OAC Rule 3745-57-10 (A)(1 thru 5) and 68-10(A)(1thru 5).

THE ISSUE

As discussed in the Background section above the technical performance standards contained in the Ohio closure rules for final cover are virtually identical to the US EPA rules. The federal rules are generic in nature and intended to meet the statutory requirement (Section 3004 of RCRA) to promulgate national standards that may be necessary to protect human health and the environment. The rules allow the owner or operator to propose a design or set of practices to achieve the regulatory objective. Using the technical performance standards as a foundation, Ohio EPA through issuance of a closure plan approval (or permit approval) establishes the site-specific closure requirements with which the owner or operator must comply. So the question is not whether alternate designs for final covers can be proposed but rather what is required in a proposed design to meet the technical performance standards. Because

such a determination is performed on a case-by-case basis, this document states the requirements of Ohio EPA' s recommended final cover design and also provides examples of approved designs that varied from the Agency's recommended design.

TECHNICAL PERFORMANCE STANDARDS

1. Regulatory Performance Requirements

From the previous discussion, it follows that final covers must be designed and constructed to:

(a) Provide long-term minimization of the migration of liquids through the closed impoundment;

(b) Function with minimum maintenance;

(c) Promote drainage and minimize erosion or abrasion of the final cover;

(d) Accommodate settling and subsidence so that the integrity of the final cover is maintained; and

(e) Have a permeability less than or equal to the permeability of any bottom liner system present.

2. Ohio EPA's Recommended Design Solution

Based upon various federal guidelines[1] and Ohio EPA's experience with closures, the Ohio EPA's recommended design of a RCRA final cover to meet the above technical performance standards calls for:

(a) First low permeability layer -- a two-foot thick layer of recompacted clay with a maximum permeability of $1x10^{-7}$ cm/sec;

(b) Second low permeability layer -- a flexible membrane liner (40 mil minimum thickness,[2] or more if required for successful welding, if HDPE is used, or 40 mil if another suitable material is used.);

(c) Drainage layer -- at least 12 inch thick soil drainage layer with a minimum permeability of $1x10^{-2}$ cm/sec, or an equivalent geosynthetic drainage layer; and

(d) Protection layer -- at least 18 inch thick soil vegetative/frost protection

[1] Resource List Documents 2, 3 and 7.

[2] Note. The Ohio EPA Closure Plan Review Guidance for RCRA Facilities, March 1999, recommends 60 mil but based on more recent experience with welding seams a 40 mil HDPE can be used if appropriate.

layer. (Note: 18 inches of the soil protection layer combined with 12 inches of soil drainage layer provide a total of 30 inches of soil frost protection. Some areas of Ohio require 36 inches of soil for frost protection.)

If a geosynthetic drainage layer is used, the soil vegetative/frost protection layer must be at least 30 inches or 36 inches thick, as required.

FACTORS AFFECTING DESIGN SOLUTION

The above recommended design may be appropriate in many instances. However, sometimes there are reasonable constraints which make this design impractical or impossible to construct. In such a case the following additional factors which affect the design must be carefully considered.

1. Spatial setting -- For example, a relatively small area to be covered (about 1/2 acre or less, i.e. 150'x150'); a particular prohibitive location (e.g., between two factory buildings; inside a building; on a portion of a roadway); and a pending corrective action which encompasses the unit.

2. Hydrogeological setting -- This includes the geological attributes as well as identification of aquifers and saturated zones.

3. Future land use of the site -- Future use may dictate a particular design; but that design must not pose a threat to humans or to the environment.

   The owner or operator should provide information about how the unit and the site will be used. Both current and future land use at the site and the unit must not jeopardize the integrity of the final cover design.

4. Concentration, mobility, toxicity and persistence of the waste or waste constituents -- Site specific information on constituents contained in materials that are proposed to remain at the site after closure.

Reasons justifying an alternative solution for the final cover must be clearly stated, i.e., why is construction of the Ohio EPA recommended design impractical (or impossible).

CRITICAL DESIGN ELEMENTS

The following elements are critical to the design of the final cover. In developing a proposed alternative solution all these elements should be considered, then based upon the site-specific factors the applicable design elements should be selected, and the design developed and evaluated.

1. Size -- In general, an alternative final cover must completely cover the contaminated soils and then extend several feet beyond the horizontal extent of contamination (2 to 3 feet minimum, or more if delineation is not clear) - *in full thickness and with all designed features.* In cases where the final cover must extend to a structure, an appropriate interface must be designed.

2. Structural Intergity-- The final cover must have sufficient structural strength, static and dynamic (including seismic) stability, such that it will not fail.

   General assistance with issues of structural strength, static and dynamic stability is available through the DHWM's ERAS in CO.

   Specific assistance with issues on slope stabilty is available through the DSIWM's Geotechnical Resource Group by either contacting the DHWM's reprentative on that group (presently Dan Lukovic) or working through engineering staff at the DO-DISWM level. The Geotechnical Resource Group is developing policies and guidance including a more formal means to access DSIWM resources.

3. Surface Layer -- The purpose of the surface layer is to support all expected loads without sustaining damage.

   The surface layer may consist of any material (such as concrete, asphalt, etc.) that will best serve the purpose of an alternative solution for the final cover. It must be weather resistant and easy to maintain and repair.

   The surface layer must be designed and constructed with sufficient slopes to ensure the efficient removal of precipitation along with considerations for erosion protection. In situations where impermeable final covers (Type 1) are warranted, it is recommended that the surface layer of the final cover have a minimum slope of 5 percent. Runon, runoff, and erosion protection become progressively less critical in Type 2 and Type 3 situations.

4. Protection Layer -- The purpose of the protection layer is to protect the underlying drainage and low-permeability layers from the frost/thaw process, and from any physical damage resulting from the loads imposed on the surface layer.

   The protection layer may be constructed of any clean soil material which will

satisfy this purpose. It must have sufficient thickness to provide protection based on the anticipated frost depth and the type of material used in the construction of the underlying layers. It must be constructed in a manner which does not permit settlement to occur.

5. Drainage layer -- The purpose of the drainage layer is to drain the water percolated from the top protective media, and to keep it from collecting on the liner.

Ohio EPA makes the following recommendations for the design and construction of the drainage layer:

(a) Slope

Minimum Slope 1%.

(b) Hydraulic Conductivity

For the drainage layer constructed from granular materials with a minimum thickness of 1 foot:

Minimum Hydraulic Conductivity $1x10^{-2}$ *cm/sec.*

(c) Hydraulic Transmissivity

For the drainage layer constructed from synthetic drainage materials:

Minimum Hydraulic Transmissivity $3x10^{-5}$ m^2*/sec*.

(d) The drainage layer must have a free exit flow to a designed ditch, sewer, or other structure capable of handling maximum expected flow without unintended discharge;

(e) The drainage layer's outlets must have the means to prevent any sort of soil, trash, or animals from entering into the pipes. In addition, they must be accessible for a periodic inspection and maintenance.

NOTE: The Hydrologic Evaluation of Landfill Performance (HELP) computer program is a qausi-two-dimensional model of water movement across, into, through and out of landfills. The program was developed to conduct water balance analysis of landfill and cover systems. The model provides a means of estimation of the amounts of runoff, evapotranspiration, drainage, leachate collection and liner leakage that may be expected to result from operation of various landfill designs.

The primary purpose of the HELP model is to assist in the comparison of design alternatives as judged by their water balances. Since all models have limitations, test pads can be constructed to verify that the materials and methods of construction will meet proposed design criteria.

6. Low-permeability layer(s) -- The purpose of the low-permeability layers is to minimize the infiltration of leachate into the subsurface soils below thus eliminating the potential of ground water contamination.

A solution for the final cover may have *one* or *more* low-permeability layers.

A low-permeability layer can be constructed of either natural soil or of synthetic materials.

The soil low-permeability layer can be constructed by compacting the natural soil to a required specification. The construction and testing requirements for the soil low-permeability layer are given in Section 3.17 of the Ohio EPA Closure Plan Review Guidance for RCRA Facilities, March 1999. These requirements may be modified with the approval from Ohio EPA to accommodate a particular solution for the final cover.

The synthetic low-permeability layer can be constructed from either a single

flexible membrane liner (FML), or from a single geosynthetic clay liner (GCL), or from a combination of both. The synthetic materials must be able to withstand any predictable mechanical, chemical, and thermal stress, during the construction period and during the anticipated long-term use. They must be installed according to their manufacturers' recommended QA/QC procedures.

Final cover designs employing a geomembrane and a recompacted soil layer provide more protection and are hydraulically more effective than either type of layer alone.

EXAMPLES OF APPROVED FINAL COVERS

Type 1 - **Impermeable Final Covers --** Design must include two separate low-permeability layers (at least one of which must be a geomembrane strong enough to allow overlap welding without developing cracks or holes - a minimum 40-mil High-density polyethylene HDPE, or equivalent), a drainage layer, a protection layer, and a surface layer.

Applicability -- To cover an outside area containing contaminated media, where contamination could reach ground water if the media is subjected to water percolation.

Example **--** Eljer Plumbingware, Inc., Salem, Ohio - Foundry Sand Waste Pile

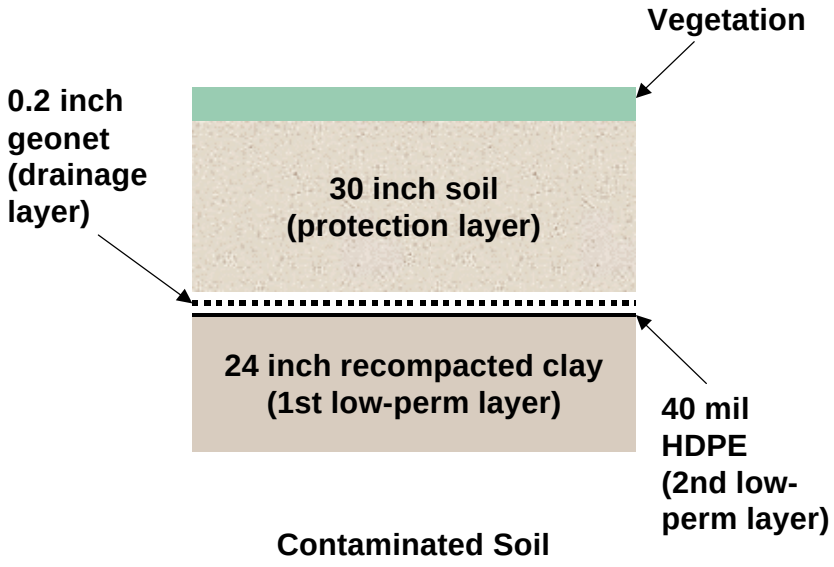
The final cover was needed to cover an outside area containing contaminated media, where contamination could reach ground water if the media is subjected to water percolation.

This suggested that a final cover consisting of the Ohio EPA recommended design (i.e. the design incorporating two low-permeability layers, a drainage layer, and a protection layer) would adequately address the regulatory performance requirements.

The selected final cover consisted of the following design elements:

Size	-- The final cover completely covers the contaminated soils and then extends to 2 feet beyond the horizontal extent of contamination - *in full thickness and with all design elements.*
Protection layer	-- 30-inch thick frost protection/vegetative soil layer; the protection layer was placed on the drainage layer;
Drainage layer	-- 0.2-inch thick synthetic drainage layer (geonet) with a non-woven geosynthetic fabric bonded to both sides; (synthetic drainage materials with a minimum permeability of $1x10^{-2}$ cm/sec. Minimum slope 1%.); the drainage layer was placed on the second low-permeability layer;
Second low-permeability layer	-- 40- mil thick textured HDPE geomembrane; the second low-permeability layer was placed on the first low-permeability layer;
First low permeability layer	-- 24-inch thick recompacted clay layer with a maximum permeability of $1x10^{-7}$ cm/s; natural soil was recompacted to specifications approved by Ohio EPA; the first low-permeability layer was placed over the contaminated soil.

Type 1 - Example



Type 2 - **Low Permeability Final Covers --** Design must include at least one low permeability layer, a drainage layer, a protection layer, and a surface layer.

Applicability -- To cover an outside area of contamination, where contaminants are less mobile, and the chances of contamination spreading to an aquifer are minimal.

Example **--** Cowan Lake State Park, Ohio - Wood Treating Plant

The final cover was needed to close (cover) an outside area with contaminated soil. The contamination originated from spilled fluids containing hazardous chemical compounds (mainly fuel oil and pentachlorophenol) used at the former wood treating plant. The ground water investigation indicated that the chances of contamination spreading to the relatively deep aquifer were minimal. This suggested that a final cover, consisting of a single low-permeability layer, a drainage layer, a protection layer, and a surface layer, would adequately address the regulatory performance requirements.

The intended future use of a portion of the site as a machine/vehicle service area, and the presence of several buildings in the area, imposed specific final cover design requirements. These included 1) the need to have a pavement surface, 2) the need to design a surface layer with shallow slopes to drain precipitation, because of available surface elevations, and 3) the need to construct the interfaces with existing and new buildings.

The selected final cover consisted of the following design elements:

Size -- The final cover completely covers the horizontal extent of contaminated soil - *in full thickness and with all design elements.* In this case the final cover extended to a structure, and an appropriate interface was designed.

Surface layer -- 4-inch thick asphalt layer with a maximum permeability of $1x10^{-7}$ cm/sec; the surface layer was placed on the protection layer;

Protection layer -- aggregate base (varied thickness) with an asphalt aggregate base (minimum thickness 8 inches) on top; the protection layer was placed on the drainage layer;

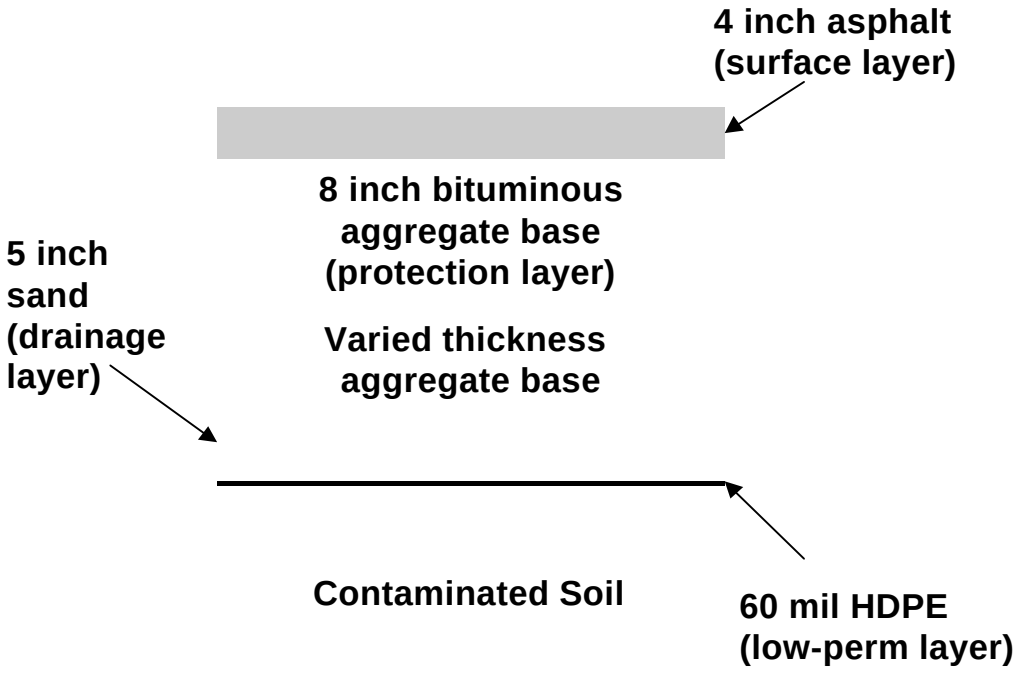
(Note: Typically, when a final cover has an impermeable barrier layer constructed from clay, a soil protection layer should be between 30 and 36 inches thick (depending on the geographic location) to protect the clay and the drainage layer from a damaging freeze-thaw process. This requirement was modified because a geomembrane was used instead of the clay, and less water was expected to permeate to the drainage layer due to the installation of a low permeability asphalt layer.)

Drainage layer -- sand layer (minimum thickness 5 inches); the drainage layer was placed on the low-permeability layer;

(Note: Typically, the minimum thickness of a granular material drainage layer constructed under a soil protection layer should not be less than 12 inches. In this case, the drainage layer was constructed under an asphalt-aggregate protection layer which is expected to permeate less water than a soil protection layer.)

Low-permeability layer -- 60-mil thick HDPE geomembrane with a geotextile protective layer on top; the low-permeability layer was placed over the contaminated soil.

Type 2 - Example



<u>Type 3</u> - **Protective Final Covers --** Design must include a permanent and durable barrier which separates contaminated media from the space in use.

Applicability -- To cover a contaminated area (inside a building or outside) where the contamination does not pose a significant environmental threat.

Example-1 **--** Cold Metal Products Company, Youngstown, Ohio, Drum Storage Area

The final cover was needed to cover a "hot spot" (a chromium contaminated area) that was left in place under an 18-inch thick reinforced concrete slab. The area was located inside a multi-story factory building. The contamination did not pose an environmental threat. This suggested that a final cover consisting of a permanent and durable barrier, which separates contaminated media from the space in use, would adequately address the regulatory performance requirements.

The existing 18-inch thick reinforced concrete slab itself (which is a permanent and durable barrier that separates the contaminated media from the space in use) was considered a final cover which satisfies the regulatory performance standards.

The selected final cover consisted of the following design elements:

Size -- The final cover completely covers the contaminated area.

Surface layer -- 18-inch thick concrete slab.

Example-2 **--** Water Tower Square (formerly known as Sherwin Williams), North Olmsted, Ohio, Drum Storage Area

The final cover was needed to cover the former D001/F005 solvent container storage area and provide space for some useful purpose (a parking lot) and to protect the media underneath from any additional contamination due to this usage.

All contaminated media under the container storage area had been removed and was replaced with 8-foot thick clean backfill soil. However, the ground water remained contaminated. The ground water is not being used for any purpose. The area was located outside, in the center of the hazardous waste facility. Therefore, the contamination did not pose any significant environmental threat.

This suggested that a final cover consisting of a permanent and durable barrier, which separates contaminated media from the space in use, would adequately address the regulatory performance requirements.

A composite asphalt layer consisting of a 5-inch thick aggregate base, under 3-inch thick asphalt concrete with coarse aggregate, under 1.5-inch thick asphalt concrete with fine aggregate, was considered as a final cover which satisfies the regulatory performance standards.

The selected final cover consisted of the following design elements:

Size - The final cover completely covers the container storage area.

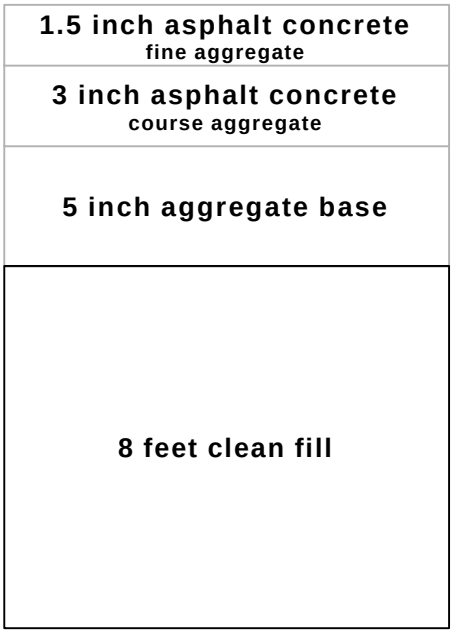
Surface layer - 9.5- inch composite asphalt layer consisting of 5-inch thick ODOT-304 aggregate base, under 3-inch thick asphalt-concrete with ODOT-402 (coarse) aggregate, under 1.5-inch thick asphalt-concrete with ODOT-304 (fine) aggregate.

Type 3 - Example 1

18 inch concrete slab

Contaminated Soil

Type 3 - Example 2



Contaminated Soil

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