DRAFT LANDFILL GUIDANCE ON ALTERNATIVE LINER DEMONSTRATIONS

PERMITTING & COMPLIANCE DIVISION
WASTE & UNDERGROUND TANK MANAGEMENT BUREAU
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INTRODUCTION

The regulatory standard established for Class II and Class IV landfill liners is a hydraulic barrier based on the federal prescriptive standard-composite-liner (PSCL) system composed of a flexible synthetic geomembrane directly overlying a two-foot thick, compacted clay layer. Conditions for an alternative-liner design proposal are, however, most favorable when either: (i) advances in liner technology provide for substitution of alternate materials for one component of the PSCL; or (ii) the natural subgrade properties beneath the new landfill unit are such that it will adequately retain leachate for removal when in a natural or modified state. Prior to construction, Department approval of a landfill alternative-liner demonstration (ALD) is required to ensure that the proposed alternative-liner design will (a) adequately retain leachate and (b) lower the concentration of contaminants that could migrate through the subsurface attenuating layer to the uppermost aquifer beneath the facility.

The Department may accept an ALD that passes some form of equivalence to the PSCL when an alternative-composite-liner (ACL) proposal includes the prescribed flexible geomembrane component. Otherwise site-specific material properties and analytic or numerical models for transport and attenuation of contaminants during leachate seepage through the alternative liner, or possibly the subgrade attenuating layer, to the uppermost aquifer are necessary to support alternative-liner design proposals. Three ALD conditions determine the basis for acceptance and approval. Quality Assurance (QA) field testing and performance monitoring are required to verify conformance of actual liner field properties with design and to establish data on baseline performance of the constructed alternative liner. The Department may require groundwater (GW) monitoring at any time to validate the continued long-term performance of installed alternative liner components at the relevant point of compliance (RPOC).

Although successful demonstration of a no-migration seepage condition (NMD) beneath a landfill unit during the active life plus 30-yr post-closure care period may allow for a leachate collection system and monitoring waiver [*ARM 17.50.1205(1)(a)* and *-1303(2)*], any approach strictly based on predicted contaminant travel time to the uppermost aquifer is typically not sufficient to demonstrate the capability of an alternative liner to maintain adequate long-term attenuation of all *Table-I* contaminants of concern at the established RPOC. The federal EPA has previously commented during rulemaking that the additional effects of climate, leachate volume, and leachate characteristics must also be evaluated to predict contaminant levels while considering contaminant fate and transport for an ALD. For instance, the transport of volatile organic compounds (VOCs like vinyl chloride) may be largely controlled by gas diffusion versus advection by saturated flow;

contaminant travel time and concentrations thereby strongly depend on overall thickness, density, porosity, and wetness of the attenuating layer regardless of its saturated hydraulic conductivity. The Department will determine what content is necessary for a complete ALD based on the site-specific circumstances at the Class II or IV landfill unit, the landfill liner design rules, and the ALD demonstration conditions listed below.

LANDFILL DESIGN RULES

The required content of an ALD is based on the Montana regulatory standards [*Administrative Rules of Montana (ARM) Title 17, Chapter 50, subchapter 12*] that determine liner design, performance, and construction criteria for new Class II and IV landfill units:

(1) Performance design standard [*ARM 17.50.1204*]: Contaminant concentrations cannot exceed the most restrictive of either the Maximum Contaminant Level (MCL) or *Circular DEQ-7* ground-water health standards for *Table-I* contaminants at the RPOC wells for alternative liner design [*ARM 17.50.1204(1)(a)*]. The RPOC must be located in the uppermost aquifer no more than 150 meters from edge of the unit liner as approved by the Department [*ARM 17.50.1204(3)*]. The minimum time limit for demonstrating the predicted RPOC concentrations is determined by the Department based on site-specific conditions [*ARM 17.50.1204(2)*], but it must be adequately long to ensure compliance of the landfill unit with appropriate GW protection standards as necessary.

OR

(2) Prescriptive design standard [*ARM 17.50.1204(1)(b)*]: The prescriptive standard-composite-liner (PSCL) must be an engineered system composed of a minimum 30-mil thick (60-mil if HDPE), flexible synthetic geomembrane (FML) installed in direct and uniform contact with an underlying compacted clay barrier layer (CCL) of at least 2-ft thickness and hydraulic conductivity no more than 1×10^{-7} cm/sec.

AND

(3) Leachate Collection and Removal System (LCRS) [*ARM 17.50.1205(3)*]: Each PSCL landfill unit must be constructed to continually maintain less than 30-cm (12-in) depth of leachate at any location immediately over the landfill liner [*ARM 17.50.1204(1)(b)*]. Equivalence to this prescriptive standard-leachate-collection system must be demonstrated for any ALD based on PSCL equivalence. A leachate removal system is, however, required for any proposed alternative unit design. The function of every LCRS must provide for accurate monitoring of the leachate depth (± 1.0 cm) and the volume of leachate removed from the unit. All landfill units must be designed with a minimum slope of two degrees at the base to at least provide leachate removal and monitoring for compliance. Leachate may only be recirculated over landfill units with a composite liner that includes the prescriptive FML component in (2). All landfill unit designs must provide an adequate frost protection layer that allows reasonable drainage of leachate over the proposed liner to the collection sump.

LANDFILL ALTERNATIVE-LINER DEMONSTRATION

The licensee shall first submit to the Department for approval an ALD Work Plan outlining its approach to: (i) proposed landfill unit liner, attenuating layer, and aquifer material properties based on testing by manufacturers or the Soils and Hydrogeology Study; (ii) representative lab and *in situ* testing of the landfill unit subgrade; (iii) sampling and testing of all proposed offsite borrow sources

or amended soils; (iv) leachate and landfill gas (LFG) characterization; (v) equivalence; (vi) contaminant transport and attenuation models including software; and (vii) sensitivity analysis and statistics. The final ALD must fully justify the selection of leachate and LFG volume and characteristics, selection of site-specific characteristics and properties, and their effects on the contaminant fate and transport. Conclusions must be discussed and justified in comparison with related equivalent studies in the current literature.

The complexity of the Class II and IV landfill ALD is determined by three conditions that are evaluated in sequence: (A) FML equivalence, (B) contaminant level equivalence at the base of liner; and (C) travel time for VOC gas diffusion to RPOC. **The Department adopts the PSCL as the baseline standard to demonstrate liner performance** according to (1) so that the ALD may first pass the evaluation based on whether the alternative liner performs in a manner equivalent to the PSCL, as long as LCRS (3) is fully met.

If the concentration levels for contaminant breakthrough at the base of the proposed alternative liner (PAL) do not exceed those at the base of the PSCL, the alternative liner equivalence is shown because concentrations will then be attenuated at the same levels in either case after seepage through the same subgrade attenuating layer(s). Yet it must be recognized that the mechanisms for breakthrough depend both on the liner properties and the contaminants involved—this distinction is critical to recognizing the difference between NMDs strictly based on travel time and ALDs. Demonstration of PSCL equivalence is allowed because the GW monitoring standards for corrective action ultimately remain the same [*ARM 17.50.1307(8)*] for all Class II and IV landfill unit liners and depend on the location [*ARM 17.50.1303(3)*].

Department approval of an ALD depends on whether it passes the criteria for condition A, B, or C as defined below:

(A) Whenever the PAL is a **composite liner system** that includes the same FML component installed according to (2), and (3) is fully met, the Department evaluates the ALD by first considering equivalence between the alternative lower barrier component (ALBC) and the CCL barrier component of the PSCL. Attenuation of *Table-I* contaminant levels for transport through the ALBC must meet or exceed those for the prescriptive standard CCL performance to pass, otherwise continue to (C).

OR

(B) If the PAL does not include the same FML component installed according to (2), and (3) is fully met, the Department evaluates the ALD by considering the equivalence between the entire PAL system and complete PSCL. If the alternative liner barrier is solely composed of recompacted *in situ* native, or compacted clay-rich or amended soil from borrow sources, the engineered thickness must be at least 1 or 3 feet, respectively. Attenuation of *Table-I* contaminant levels for transport through the PAL must meet or exceed those for the PSCL performance to pass, otherwise continue to (C).

OR

(C) Whenever the PAL fails PSCL equivalence according to either (A) or (B), or (3) is not fully met, the Department evaluates the ALD by considering *Table-I* contaminant levels at the RPOC based on tested physical, chemical, and biological properties of the attenuating layer(s) between the

base of the liner and uppermost aquifer. Total travel time for VOC gases (vinyl chloride, etc...) to reach the uppermost aquifer in the worst case must at least be more than twice the sum of the landfill active life and the post closure period to avoid modeling LFG impacts. Additionally it must be shown that contaminant levels meet (1) after modeling representative dissolved contaminant migration, transport, dilution and attenuation within the attenuating layer(s).

The ALD typically requires site-specific data that specify alternative-liner material characteristics, soils, hydrostratigraphy, ground water quality, pertinent subgrade hydraulic properties, climate, water balance conditions, aquifer heads, aquifer flow paths, aquifer transit times, aquifer flow rates, hydraulic connection of and distance to nearest supply wells, withdrawal rates, leachate and landfill gas (LFG) properties and volumes, and the nature, extent, migration, transport, and fate of any potential VOC or dissolved contaminants, health risks, and other applicable information. These data are used to develop a worst –case quantitative hydrogeologic model of the uppermost aquifer and to assist in the evaluation of associated environmental and health risks that support the demonstration.

Upon Department approval of the ALD, the licensee must then submit to the Department for approval the complete alternative liner design and specifications according to appropriate engineering standards [*ARM 17.50.1205(2)*]. All liner components must meet adequate static slope and applicable dynamic seismic stability requirements for the area during operations and post closure care [*ARM 17.50.1007*]. A construction QA/QC Plan and QA/QC Report for testing and installation practices must be approved both prior to and following certified construction, respectively [*ARM 17.50.1205(5)-(7)*].

ALTERNATIVE LINER EXAMPLE

A facility could propose to substitute a GCL for the CCL of (2), as long as (i) the GCL hydraulic conductivity is not higher than 1×10^{-7} cm/sec, (ii) the GCL is in direct uniform contact with the FML component and engineered subgrade (native or amended soil), and (iii) rule (3) is fully met. The equivalent GCL may be thinner than the required 2-ft CCL thickness, because GCLs are typically 100 times less permeable than most CCLs. Thus, contaminant breakthrough concentrations for GCL may be adequate to establish equivalence to the standard CCL performance. The GCL is protected from desiccation by the overlying geomembrane unless the subgrade attenuating layer is overly dry. The GCL must also be frost protected and adequately loaded by an overlying granular leachate collection or operations layer prior to hydration.

Due to the relatively recent acceptance of GCL, the long-term attenuation and retardation of leachate contaminants by GCL has not yet been proven through monitoring of its field performance. Although EPA has recognized (*Fact Sheet EPA530-F-97-002, dated 12/01*) that GCL performance generally exceeds most federal alternative liner demonstration criteria for landfills, it has not changed the federal regulations. Because the alternative GCL-FML composite liner meets condition (A), however, an PSCL equivalence demonstration of GCL contaminant attenuation relative to the standard 2-ft CCL barrier component could be proposed based on the site-specific soils, literature, and case studies. Sensitivity analysis must include any potential site-specific effects of the adjacent attenuating layer on the GCL performance. Some particular circumstances (*e.g.* any shallow uppermost aquifer or close proximity of the license boundary) may require the consideration of LFG effects or appropriate GW protection standards to protect beneficial uses.