
**WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
SOLID AND HAZARDOUS WASTE DIVISION**

SOLID WASTE GUIDELINE # 20

**“Fate and Transport Modeling for the Design of Solid Waste Disposal
Facilities”**

1.0 Introduction

The purpose of this document is to provide guidance for collecting, analyzing, and submitting to the Department of Environmental Quality (Department) the information that is necessary for fate and transport modeling. This information will be used by the Department and applicants to evaluate the performance of lined and unlined landfills in Wyoming. To clarify, the term “fate” refers to the effect of chemical and biological processes that affect the ultimate form of a given contaminant during migration. The term “transport” refers to physical processes that govern the rate and extent of contaminant migration.

For purposes of this Guideline, an alternative design is one that does not include all of the components of an engineered containment system (ECS) as defined by the United States Environmental Protection Agency (EPA) Subtitle D regulations and the Wyoming Solid Waste Rules and Regulations (SWRR). An ECS includes a composite liner and a leachate collection system. A composite liner is a system consisting of two components; the upper component must consist of a minimum 30-mil flexible membrane liner (FML) and the lower component must consist of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec.

The information needed to support a proposed alternative design must be submitted as supporting documentation for the permit application for a new Type I municipal solid waste (MSW) landfill, or new trenches or lateral expansions at existing Type I MSW landfills. This process may also be useful as a screening tool to evaluate alternative landfill designs at perspective sites before permit applications are prepared and submitted. The Department stresses that fate and transport modeling is but one component of a complete application for an alternative design, and that the final decision on the acceptability of a proposed alternative design will not be based solely on the results of fate and transport modeling. Certain site specific conditions, such as fracturing, or, rarely in Wyoming, karst conditions, may preclude the use of modeling.

The information in this document should not be interpreted by applicants or Solid and Hazardous Waste Division (SHWD) staff as mandatory. Proposals for alternate approaches will be considered by the SHWD on a case-by-case basis. While focused on Type I MSW landfills due to regulatory requirements, the concepts presented in this guideline may also be useful to owners and operators of Type II MSW landfills and industrial landfills.

2.0 Background

United States Environmental Protection Agency (EPA) and Wyoming Department of Environmental Quality (Department) ECS standards apply to landfills that have received waste after September 13, 1989. Wyoming ECS requirements were effective for Type I landfills receiving more than 100 tons of waste per day on October 9, 1993 and April 4, 1994 for landfills receiving less than 100 tons of waste per day. ECS effective dates for Type II landfills are established by the Solid and Hazardous Waste Division Administrator on a case-by-case basis.

The conditions under which an ECS is required at new Type I landfills, new cells at existing Type I landfills, and horizontal expansions of area cells at existing Type I landfills are described in Chapter 2 Section 4 (j)(i) of the SWRR. An ECS is required unless the operator demonstrates to the administrator that all of the following conditions are met:

- X Native soils underlying the landfill are sufficiently impermeable to prevent potential contamination of groundwater through operation of the facility; and
- X Waste types or operating practices minimize the potential for contamination of underlying soils and/or groundwater; and
- X Site hydrologic conditions are sufficient to protect groundwater from contamination; and
- X The facility receives less than 500 short tons of unprocessed household refuse or mixed household and industrial refuse per operating day, on a monthly average.

For Type II landfills, as described in Chapter 2 Section in 4 (j) (iii) of the SWRR, the administrator may determine, after evaluating the same conditions used for Type I landfills, that an ECS is required to protect public health and the environment. To allow consideration of alternative approaches, site-specific conditions and changing technologies, the SWRR above do not contain prescriptive information regarding how an operator must demonstrate that the above conditions are met.

Historically, landfills in the arid west were not expected to generate enough leachate or landfill gas to impact groundwater. Data now shows that this assumption was wrong. Consequently, a growing number of unlined landfills in Wyoming are reporting groundwater pollution. This and other information has led the Department to conclude that a more rigorous, site-specific technical approach must be used to evaluate alternative ECS designs. Guidelines have been prepared to outline an approach that consists of:

- X Evaluating site specific geologic and hydrogeologic information;
- X Evaluating leachate generation rates using the HELP model and local climate data; and
- X Using contaminant fate and transport modeling to evaluate migration of contaminants to groundwater.

3.0 Site-specific information needs

This section provides information on the minimum site specific information that applicants must provide to the Department for fate and transport modeling. Applicants should review other SW Guidelines for related information. The Department strongly encourages applicants to discuss modeling efforts with

the Department prior to conducting the work, to arrive at mutually acceptable input parameters.

At this time the Department has identified the Multimedia Environmental Pollutant Assessment System (MEPAS) model as the model the Department will use to evaluate alternative designs. MEPAS was developed by the Pacific Northwest Laboratory for the Department of Energy, and has been in use for many years. The Department prefers that applicants also use this model, but other models may appropriate as well. Models selected must be approved by the Department. Several general criteria may be used by the Department to evaluate potential models, including, but not limited to the following:

- X Model selection must be based on the model's ability to represent the specific physical and chemical processes of interest at the site;
- X The model must be technically sound and legally defensible;
- X The model must have adequate technical documentation;
- X The model must have undergone independent professional peer-review, validation studies, and sensitivity testing;
- X The model's simplifying assumptions must be well-documented, justifiable, and appropriate for the specific application proposed; and
- X Adequate training of the model user and experience with the proposed model is necessary.

Regardless of the model used by the applicant, all applicants will need to provide at least the following site-specific data for the proposed facility for use in the Department's evaluation. Additional information may be needed depending on specific models used by applicants.

- X Soil Conservation Service (SCS) curve number for the facility based on proposed facility design and site specific soil data;
- X Sieve analysis data for percentages of sand, silt, and clay for each major lithologic unit encountered in the vadose and saturated zones;
- X Total organic matter content for each major lithologic unit in the vadose zone (total organic matter equals total organic carbon times 1.73);
- X Total iron and aluminum content for each major lithologic unit in the vadose zone;
- X Total porosity of each major lithologic unit in the vadose zone;
- X Permeability of each major lithologic unit encountered in the vadose zone;
- X Dry bulk density of each major lithologic unit encountered in the vadose and saturated zones;
- X Thickness of each major lithologic unit;
- X Depth to groundwater;
- X groundwater pH; and
- X Darcy groundwater velocity.

Applicants may wish to use a tiered approach to modeling, using relatively simple models and default parameters to screen a site, and then advance to a more sophisticated model with site-specific data for a more detailed analysis. The following default values may be used for screening level evaluations; however, site-specific data needs to be used for final evaluations:

- X f_{oc} (fraction organic carbon in soil) (g/g) = 0.001
- X Dry bulk density (g/cc) = 1.5

- X Soil particle density (g/cc) = 2.65
- X Water-filled soil porosity ($\text{ml}_{\text{water}}/\text{cc}_{\text{soil}}$) = 0.3
- X Soil porosity ($\text{cc}_{\text{pore}}/\text{cc}_{\text{soil}}$) = 0.434
- X Air-filled soil porosity ($\text{cc}_{\text{air}}/\text{cc}_{\text{soil}}$) = 0.134

The default values above are the same as those currently used in the Department's Voluntary Remediation Program, and may be found in the Soil Screening Guidance, EPA (1996).

Sampling techniques typically used for collection of soil samples for chemical analyses are generally not adequate for obtaining samples for geotechnical analysis (ASTM, 1999). Applicants must be sure that appropriate sampling techniques are applied for collection of representative samples for the desired analysis. As noted by ASTM (1999), care must be taken when adopting literature values for use alone or in combination with site-specific measured values, as model input parameters.

The soil to groundwater transport pathway is of primary interest for purposes of evaluating the fate and transport of contaminants from an unlined landfill. ASTM guidance (ASTM, 1999) indicates that, for the soil to groundwater transport pathway, the following parameters tend to be sensitive parameters from a model input perspective:

- X Source concentration;
- X Total soil porosity;
- X Fraction of organic carbon;
- X Carbon-water sorption coefficient; and
- X Soil-water sorption coefficient.

This information may be used by applicants in order to focus expenditure of funds on the most sensitive model input parameters. A list of default parameters and concentrations is included in Appendix A. In order to remain current with knowledge of leachate chemistry Appendix A may be updated from time to time as additional information regarding leachate chemistry becomes available. The constituents in Appendix A were selected to represent a variety of different types of contaminants that are frequently identified in leachate. Several inorganic parameters are included because these tend to be relatively conservative with respect to transport times from landfills. Also, current research suggests that some inorganics, such as nitrogen, either in the form of ammonia (anaerobic) or nitrate (aerobic), may be among the most significant long term pollution problems from a landfill (Rooker, 2000). Applicants are strongly urged to check with the Department in advance to be sure the data used for modeling is the latest version available. Because every model will have variations in input parameter sensitivity, applicants need to evaluate the specific model(s) they intend to use to identify model-specific sensitivity of the input parameters.

4.0 Reporting

A thorough, detailed, and comprehensive report of any and all modeling efforts must be presented as supporting documentation. This report must include:

- X The name, version and date of the model used

- X A list of all assumptions used in the model and justification for their use
- X A list of all input data required by the model, including justification for any manipulation of input data. All site specific data must be clearly identified
- X Information on model calibration and validation
- X Results of sensitivity and uncertainty analysis

In all cases, supporting documentation needs to be provided as an exhibit or appendix and be properly referenced in the narrative.

5.0 Professional Geologist Certification

Geological services or work must be stamped, signed, and dated by a professional geologist (see W.S. § 33-41-115).

6.0 Additional Information

Further information or clarification can be obtained from the following Solid and Hazardous Waste Division offices. Comments and suggestions for improvements are always appreciated.

Casper: (307) 473-3450
Cheyenne: (307) 777-7752
Lander: (307) 332-6924

7.0 References

Individuals desiring additional information may wish to consult additional resources listed below. Ideas and concepts in some of the references listed below were considered during development of this document.

Bonaparte, R., 1995, Long-Term Performance of Landfills, in: GEOENVIRONMENT 2000, edited by Y.B. Acar and D.E. Daniel, ASCE Special Publication No. 46, p. 514-553.

EPA Center for Subsurface Modeling Support (CSMoS) available on line:
<http://www.epa.gov/ada/csмос.html>

ASTM, 1999, RBCA Fate and Transport Models: Compendium and Selection Guidance, available on line: <http://www.epa.gov/oust/rbдm>

Rooker, A.P., 2000, A Critical Evaluation of Factors Required to Terminate the Post-Closure Monitoring Period at Solid Waste landfills, Master of Science Thesis, North Carolina State University, Department of Civil Engineering.

U.S. EPA, December 2002, Assessment and Recommendations for Improving

Performance of Waste Containment Systems, EPA/600/R-02/099, available on line:
<http://www.epa.gov/nrmrl/pubs/600r02099/600R02099.pdf>

U. S. EPA, April 1996, Soil Screening Guidance: User's Guide. EPA/540/R-60/018.

U. S. EPA, April 1992, Groundwater Issue - Fundamentals of Ground-Water Modeling, OSWER,
EPA/540/S-92/005, 11p.

8.0 Guideline Approval

I have reviewed and approved the policies and procedures described in this guidance document.

Signed



7/15/09

Carl Anderson, Ph.D.
Administrator
Solid and Hazardous Waste Division
Department of Environmental Quality

Date

Attachments

Appendix A "Leachate Data for Fate and Transport Modeling" (June 6, 2003)
Appendix B "Methods for Laboratory Analysis" (June 6, 2003)

Guideline History

August 22, 2002 Workgroup Draft Version 1 - DO NOT CITE
June 6, 2003 Workgroup Draft Version 2 - DO NOT CITE
June 23, 2009 Final Version

**Solid Waste Guideline #20 (June 23, 2009) Appendix A
“Leachate Data for Fate and Transport Modeling”**

Organic Constituents

Chemical	Model Concentration
acetone	3.0 mg/l
benzene	0.165 mg/l
ethylbenzene	0.205 mg/l
methylene chloride	4.0 mg/l
methyl ethyl ketone	19.5 mg/l
toluene	0.75 mg/l
trichloroethene	0.14 mg/l
vinyl chloride	0.31 mg/l

Inorganic Constituents

Chemical	Model Concentration
ammonia	2,250 mg/l
chloride	3600 mg/l
arsenic	0.37 mg/l
cadmium	0.1 mg/l
nitrate	2,250 mg/l

**Solid Waste Guideline #20 (June 23, 2009) Appendix B
“Methods for Laboratory Analysis”**

Analysis	Methods
Sieve Analysis	ASTM D1140, D422
Total organic carbon	ASA Monograph No. Method 29-3.5.2, ASTM D2974-00,
Fe, Al	6010
Dry Bulk Density	Calculation
Total Porosity	Calculation
Permeability - field	D4630-96, D4630-95, D5084, Bureau of Reclamation, D3385-94
Permeability - lab	ASTM D5084, D4630-96 (2002), D2434-68 (2002)
Field Capacity	D2325-68 (2000), D3152-72 (2000), ASA 36-2.2.2, ASA 36-4.2
Moisture Content	ASTM D2216-98, D4643-00, D4959-00