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# Preparing No-Migration Demonstrations for Municipal Solid Waste Disposal Facilities:

## A Screening Tool

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# Preparing No-Migration Demonstrations for Municipal Solid Waste Disposal Facilities - A Screening Tool

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# 1.0 INTRODUCTION

Federal regulations [40 Code of Federal Regulations (CFR) 258.50(b)] allow owners and operators of municipal solid waste landfills (MSWLF) to prepare a demonstration which, if successful, results in the exemption of the MSWLF from groundwater monitoring requirements. The demonstration is commonly referred to as a no-migration demonstration (NMD). The applicable federal regulations are as follows.

> Groundwater monitoring requirements under 40 CFR 258.51 through 40 CFR 258.55 of this part may be suspended by the Director of an approved State for a MSWLF unit if the operator can demonstrate that there is no potential for migration of hazardous constituents from that MSWLF unit to the uppermost aquifer (as defined in 40 CFR 258.2) during the active life of the unit and the post-closure care period. This demonstration must be certified by a qualified groundwater scientist and approved by the director of an approved State, and must be based upon:
>
> (1) Site-specific field collected measurements, sampling, and analysis of physical, chemical, and biological processes affecting contaminant fate and transport, and
>
> (2) Contaminant fate and transport predictions that maximize contaminant migration and consider impacts on human health and the environment.

States are not required to incorporate these Federal performance standards into their permitting standards. Individual states may allow exemptions based on NMDs, but states are not required to consider such demonstrations. States that do consider NMDs must use criteria that are at least as stringent as the Federal criteria. Because the federal regulations are performance standards, they allow states considerable flexibility in the choice of the criteria and methods used to evaluate no-migration demonstrations. This means that decisions about NMDs can differ from state to state, as can requirements governing the amount of data and level of detail of information required for a NMD. Many site-specific factors will influence the amount of information required to support a decision about a NMD, including predicted time of travel for hazardous constituents and other conditions.

This guidance is intended to be a screening tool to be used by owners and operators of MSWLFs to rapidly, but tentatively, determine their likelihood of preparing a successful NMD. Such rapid screening is expected to save significant time and money when the MSWLF clearly does not meet the applicable performance standards. Alternatively, the use of this guidance may result in little or no time or cost savings for those owners and operators whose MSWLFs fall just short of meeting the performance standards.

This guidance is a screening tool; it does not present in-depth discussions of technical, site-specific factors that must be measured and modeled during the latter stages of preparing a NMD. However, in-depth analysis of site specific data is a very important process and EPA expects that no NMDs would be approved without it. Obtaining site-specific data can be expensive and time-consuming. By using this guide, owners and operators of MSWLFs can evaluate the likelihood of success of the NMD and decide if collecting site-specific data is likely to be worthwhile.

This guidance is not intended to encourage or discourage owners and operators of MSWLFs from submitting NMDs to their respective states. It does not provide a definitive process for issuing a no-migration exemption. A MSWLF that is a good candidate for a successful NMD according to this guidance may later be rejected from such consideration based on more detailed sampling and analysis. The main goal in preparing this guidance is to present a profile of information from 17 NMDs filed by owners of MSWLFs who were successful in securing no-migration exemptions. The information was obtained from the files of seven states: Arizona, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming. The guidance is based on the characteristics of these 17 successful NMDs and provides a practical, step-by-step approach for applying major screening factors. The States through their permitting programs, not the U. S. Environmental Protection Agency (EPA), issue the no migration exemptions. This guidance compares successful NMDs to the Federal criteria. A favorable rating in this screening process does not guarantee that an owner or operator will be able to make a successful NMD.

The audience for this guidance is limited. The audience is composed primarily of those relatively small MSWLFs in dry areas (generally west of the Mississippi River) that do not meet the criteria for a "small and dry" landfill that are eligible for an exemption from the groundwater monitoring requirements contained in the MSWLF criteria [40 CFR § 258.1(f)(1)]. When this guidance was initiated, the exemption for small MSWLFs in dry areas had been vacated as a result of a court ruling. The exemption was reinstated on September 25, 1996.

This guidance contains a three-step process that allows evaluation of the chances of success and supports decisions about whether to continue or to abandon the NMD process, as information is collected. The three steps are presented in Sections 2.0 through 4.0 of this document, which are summarized below.

- **Section 2.0: Step 1 - Make an Early Determination of Eligibility:** Step 1 is an initial screening step that has three main parts. First, the recent reinstatement of the exemption for small, dry, remote MSWLFs is explained. For MSWLFs that are not eligible for that exemption, collection of preliminary data to assess the potential for a no-migration exemption is discussed. The final part of Step 1 describes the roles of the state or tribal authorities in the NMD process and offers some practical advice about learning about policies, requirements, and information resources.

- **Section 3.0: Step 2 - Estimate the Cost of a NMD:** Step 2 helps build a simple estimate of the cost of preparing a NMD. The estimate will include the cost of obtaining regional and site-specific information necessary for the demonstration process. The estimate also considers the costs of preparing the necessary report, including analytical and report preparation support from a consultant.

- **Section 4.0: Step 3 - Collect and Analyze Information and Data and Write the Demonstration:** Step 3 is a guide to selecting and working with a consulting firm to plan for the collection and evaluation of data and to preparing the NMD.

The approach set forth in this guidance should enable the owner or operator of a MSWLF to pursue the early decision-making stages of a no-migration demonstration as efficiently and inexpensively as possible. The approach relies on early warning signs that can lead to early abandonment of the effort.

## 2.0 STEP 1: MAKE AN EARLY DETERMINATION OF ELIGIBILITY

This section has three subsections. Section 2.1 describes the exemption from groundwater monitoring requirements for small MSWLFs in dry and remote areas. MSWLFs that qualify for and are located in states that allow this reinstated exemption need not consider a NMD because they are already exempt from requirements for groundwater monitoring. Section 2.2 introduces key hydrogeologic parameters used in collecting preliminary data to assess the potential that a MSWLF may be a good candidate for a NMD. Section 2.3 then discusses the role of state or tribal authorities in the NMD process. The discussion includes some practical advice for learning about policies, requirements, and information resources.

### 2.1 RECENT CHANGES IN FEDERAL REGULATIONS GOVERNING SMALL, DRY, REMOTE MSWLFs

The Land Disposal Program Flexibility Act of 1996 directed EPA to reinstate the groundwater monitoring exemption for certain small qualifying MSWLFs that had been vacated by a court decision. Rule changes were promulgated on September 25, 1996 (61 FR 50410). These regulations, if implemented by the States, would exempt an estimated 800 qualifying small MSWLFs from groundwater monitoring for MSWLFs that are “small and dry” or “small and remote.”

A “small and dry ” MSWLF, by definition, receives an annual average of 20 or fewer tons of waste per day, is located in an area that annually receives 25 or fewer inches of precipitation, and must exhibit no evidence of contamination of groundwater at the site. All such MSWLFs are in the western United States.

EPA's definition of a “small and remote” MSWLF is one that receives an annual average of 20 or fewer tons of waste per day, serves a community that each year experiences an interruption of surface transportation of at least three consecutive months' duration, exhibits no evidence of contamination of groundwater at the site and must serve a community that has “no practicable alternative” to landfilling of its municipal solid waste. Almost all such facilities are in the state of Alaska.

The exemptions described above, known as the small-dry-remote exemptions, are valid under federal regulations; however, no state is required to allow similar exemptions. A state can establish additional requirements for obtaining small-dry-remote exemptions, if that particular state will grant such exemptions at all. It is likely, however, that a state will base its decisions about exemptions on criteria that closely resemble those applied under federal regulations. Owners and operators of MSWLFs must work with state authorities to determine whether a particular facility is eligible for a small-dry-remote exemption. MSWLFs that are eligible for such exemptions need not pursue a NMD because they are already exempt from requirements for groundwater monitoring.

## 2.2 DETERMINATION OF AN MSWLF'S ELIGIBILITY FOR A NO-MIGRATION EXEMPTION

This section first describes key screening criteria that can be used in determining whether a MSWLF is a candidate for a no-migration exemption. It then explains how to compare some key characteristics of a facility with those of a number of other facilities that have received exemptions. Such a comparison can help the owner or operator determine the probability that a NMD will be successful. The section then describes how to calculate a conservative estimate of time of travel for hazardous constituents from the facility to the uppermost aquifer.

### 2.2.1 Key Screening Criteria

The five variables that significantly influence the time of travel of leachate from a MSWLF to the uppermost aquifer are the depth to groundwater, the permeability of the soil, the precipitation rate, the evapotranspiration potential, and the net infiltration rate. Therefore, these variables can be used at a particular MSWLF as key screening criteria for determining the eligibility of a MSWLF for a no-migration exemption. These criteria depend almost entirely on site-specific conditions and their use requires on-site measurements. In the following paragraphs, each of the five variables is described.

The depth to groundwater is the distance from the bottom of the MSWLF to the first layer of saturated soils that are capable of yielding significant quantities of water. Some state regulations define this saturated layer differently, depending on the quality of the groundwater and the quantity of groundwater yield.

The permeability of the soil refers to the rate at which water travels through it under saturated flow conditions. Permeability generally is measured in centimeters per second (cm/sec), but also can be measured in feet per year, with one foot per year roughly equivalent to $1 \times 10^{-6}$ cm/sec.

The precipitation rate is the amount of rain received at a MSWLF over a given time period. It usually is expressed as inches per year, but generally is averaged over a large number of years to account for annual variability.

The evapotranspiration potential is the maximum amount of water that could be lost from the soil by the actions of direct evaporation and transpiration through the leaves of vegetation in a given area. It is estimated based on such variables as average annual temperatures and humidities.

The net infiltration rate is the percentage of precipitation that enters the soils in a given area. The rate represents the portion of rain water that does not run off the area and that is not evaporated or transpired. At MSWLFs in areas that generally have significant infiltration, leachate will be formed and will move toward the groundwater. At MSWLFs in areas in which there is little or no infiltration, there will be little or no leachate generation, and little or no movement of leachate toward the groundwater.

### 2.2.2 Analysis Against Key Screening Criteria for MSWLFs That Have Received Exemptions

Presented below are the results of an informal analysis[1] of 17 NMDs filed by owners of MSWLFs who were successful in securing no-migration exemptions from requirements for groundwater monitoring at their facilities. Information about the 17 NMDs analyzed was obtained from the files of seven states: Arizona, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming. In Montana, there were 6 successful NMDs; in Wyoming, 3; in Idaho, 3; in Utah, 2 and in Arizona, Nevada, and New Mexico, 1 each.

Table 2-1 summarizes the results of the informal analysis of successful NMDs (Appendix A provides a summary of criteria used by states to make determinations about such demonstrations and site-specific data, as well as a comparison of parameters and values that were used in the analysis). Through review of the table, it is possible to make the following general observations about the characteristics of the 17 MSWLFs for which NMDs were analyzed:

- Large MSWLFs (those that receive more than 20 tons per day) and small MSWLFs (those that receive less than 20 tons per day) submitted 75 and 25 percent of the NMDs, respectively (8 MSWLFs submitted data on waste acceptance rates).
- The values for the criteria set forth in Table 2-1 do not appear to differ significantly between large and small MSWLFs.
- Annual precipitation is less than 15 inches at more than 93 percent of the MSWLFs and less than 25 inches at all the MSWLFs. Therefore, all the MSWLFs meet the definition of “dry” from the Federal criteria (16 NMDs included data on annual precipitation).

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[1] This analysis was conducted using only the data found within the main portions of 17 applications for NMDs. Some of the NMD applications did not contain data on one or more subject areas that were selected for the analysis. Although such data may have been available to and used by state officials in evaluating those applications, the collection and summary of such data are beyond the scope of this report.

**TABLE 2-1: SUMMARY OF RESULTS OF AN INFORMAL ANALYSIS OF 17 SUCCESSFUL NMDs IN SEVEN STATES[1]**
**(Page 1 of 2)**

| CRITERION SELECTED FOR ANALYSIS | VALUES FOUND IN NMDs[2] | NUMBER OF MSWLFs | LOCATIONS OF MSWLFs (State) |
|---|---|---|---|
| SIZE OF MSWLF (Tons per day) | < 20 | **2** | MT |
| | > 20 | **6** | ID, NM, UT, WY |
| | NI[2] | **9** | AZ, ID, MT, NV, UT |
| AVERAGE ANNUAL PRECIPITATION (Inches) | < 5 | **1** | NV |
| | 6 - 10 | **7** | AZ, ID, MT, NM, UT, WY |
| | 10.1 - 15 | **7** | ID, MT, WY |
| | < 25 | **1** | UT[3] |
| | NI | **1** | WY |
| MINIMUM DEPTH TO GROUNDWATER (Feet) | < 50[4] | **4** | AZ, MT, UT |
| | 51 - 100 | **3** | MT, WY |
| | 101 - 200 | **1** | WY |
| | 201 - 300 | **3** | ID, MT |
| | 301 - 400 | **3** | ID, MT, UT |
| | > 400 | **3** | ID, NM, NV |
| MAXIMUM SOIL PERMEABILITY (Feet/Year) | < 0.01 | **1** | ID |
| | 0.01 - 0.1 | **2** | UT, WY |
| | 0.11 - 1.0 | **4** | MT |
| | 1.1 - 10.0 | **1** | UT |
| | 10.1 - 100[5] | **3** | ID, MT, NM |
| | 101 - 1000[6] | **3** | ID, NV, WY |
| | > 1000[7] | **2** | AZ, WY |
| | NI | **1** | MT |

## TABLE 2-1: SUMMARY OF RESULTS OF AN INFORMAL ANALYSIS OF 17 SUCCESSFUL NMDs IN SEVEN STATES (Page 2 of 2)

| CRITERION SELECTED FOR ANALYSIS | VALUES FOUND IN NMDs [2] | NUMBER OF MSWLFs | LOCATIONS OF MSWLFs (State) |
|---|---|---|---|
| HYDROGEOLOGIC MODELS | INCLUDED | 8 | AZ, ID, NM, NV, UT |
| | NOT INCLUDED | 6 | MT |
| | NI | 3 | WY |
| AVERAGE ANNUAL EVAPOTRANSPIRATION RATE (inches) | 30 - 40 | 2 | ID, WY |
| | 41 - 60 | 5 | ID, MT, UT |
| | 61 - 95 | 2 | AZ, NM |
| | NI | 8 | MT, NV, WY |
| NMD COSTS (x $1,000) | < 5 | 2 | AZ[8], MT |
| | 5 - 10 | 2 | MT, NM |
| | 11 - 20 | 2 | UT |
| | 21 - 30 | 2 | ID, MT |
| | 84 | 1 | ID |
| | 240 | 1 | ID |
| | NI | 7 | MT, NV, UT, WY |

Notes:

1. The states and number of MSWLFs included in the analysis are: Arizona (1), Idaho (3), Montana (6), Nevada (1), New Mexico (1), Utah (2), and Wyoming (3).
2. NI = Not available for one or more MSWLFs
3. Data on precipitation at one MSWLF was reported as a range of 6 to more than 25 inches; therefore, average annual precipitation was assumed to be less than 25 inches.
4. The depth to groundwater at the MSWLF in Arizona ranged from 18 to 160 feet; the range was 6 to 30 feet at a MSWLF in Montana, and 35 to 80 feet at a MSWLF in Utah.
5. Soil permeabilities ranged from 10 to 100 feet per year at one MSWLF in Montana and from 0.001 to 100 feet per year at one MSWLF in Idaho.
6. Soil permeabilities ranged from less than 0.001 to approximately 150 feet per year at a MSWLF in Idaho, from less than 0.01 to 1000 feet per year at an MSWLF in Nevada, and from 2 to approximately 200 feet per year at an MSWLF in Wyoming.
7. Soil permeabilities ranged from less than 1 foot per year to approximately 5,200 feet per year at a MSWLF in Wyoming.
8. The cost of preparation of the demonstration could not be separated easily from the costs of other activities that were conducted at the site.

- Depths to groundwater exceeded 50 feet at more than 76 percent and 200 feet at more 53 percent of the MSWLFs analyzed. (All 17 NMDs included data on depth to groundwater).

- Maximum soil permeabilities (or hydraulic conductivities) were equal to or less than 1 foot per year ($1 \times 10^{-6}$ centimeter per second [cm/sec]) at 44 percent of the MSWLFs, and less than 10 feet per year ($1 \times 10^{-5}$ cm/sec) at 50 percent of the MSWLFs. However, at 31 percent of the MSWLFs, maximum permeabilities exceeded 100 feet per year ($1 \times 10^{-4}$ cm/sec) (16 NMDs included data on maximum soil permeabilities).

- Annual evapotranspiration rates were equal to or greater than 30 inches at all MSWLFs analyzed, exceeding 40 inches at 78 percent of MSWLFs analyzed (9 NMDs included data on evapotranspiration).

- Models were included in 57 percent of the NMDs. The 8 that included models all used the Hydrologic Evaluation of Landfill Performance (HELP) model.

- At 80 percent of the MSWLFs, the cost of a NMD was less than $30,000 (cost information was available for 10 demonstrations).

Owners and operators that already have reasonable estimates of annual precipitation, annual evapotranspiration, depth to groundwater, and maximum soil permeabilities for their MSWLFs can use Table 2-1 to make a reasonable assessment of the probability of obtaining a no-migration exemption. Figure 2-1 is provided to assist owners and operators who have such information. It is a decision tool based on the data presented in Table 2-1[2]. The four lettered bars in the figure show the various frequencies at which values for each parameter were found in successful NMDs. To use the decision tool, follow the instructions in the footnotes to Figure 2-1. Use the following example as a further guide for understanding the instructions for using the figure.

Example: Suppose a MSWLF receives 7 inches of precipitation annually and experiences 45 inches of evapotranspiration annually. Suppose further that the base of the MSWLF is 225 feet above the uppermost groundwater and that the maximum permeability of the soil in the area is $3 \times 10^{-5}$ cm/sec. The owner or operator would begin by drawing a straight line between the fourth dot from the top on Bar A to the second dot from the top on Bar B. Next, the owner or operator would draw a straight line between the fourth dot from the top of Bar C and the third dot from the top of Bar D. Finally, the owner or operator would connect the center points where the previously drawn lines intersect Bars F-1 and F-2. The result would be a fairly good probability that the MSWLF in this example would prepare a successful NMD.

Owners and operators that do not have reasonable estimates of annual precipitation, annual evapotranspiration, depth to groundwater, and maximum soil permeabilities for their MSWLFs can collect

[2] The decision tool in Figure 2-1 was developed using all available data regarding four key screening criteria from 17 successful NMDs. Data regarding average annual precipitation was not available in one NMD. Another NMD did not contain any data regarding soil permeability, and eight NMDs did not contain data regarding average annual evapotranspiration. These missing data may have resulted in a reduction in the accuracy of the decision tool, however any such reduction is expected to be slight because the eight NMDs that lacked average annual evapotranspiration rates are associated with three states (Montana, Nevada, and Wyoming) that would be expected to have evapotranspiration rates that are similar to those reflected in NMDs that contained data regarding evapotranspiration.

such estimates inexpensively and then apply the decision tool presented in Figure 2-1. Those owners and operators usually can obtain such values by contacting the sources of information shown in Table 2-2.

In general, information about permeability will be the most difficult to collect from the sources listed in Table 2-2. Usually, the owner or operator will receive a description of the type or types of soil that lie between the ground surface and the uppermost aquifer -- the water table -- at the MSWLF. Each description should include an estimate of the thickness of the soil layer being described. If the sources listed above do not include estimates of permeabilities, but will provide soil descriptions, Table 2-3 can be used to estimate the permeability of each soil type.

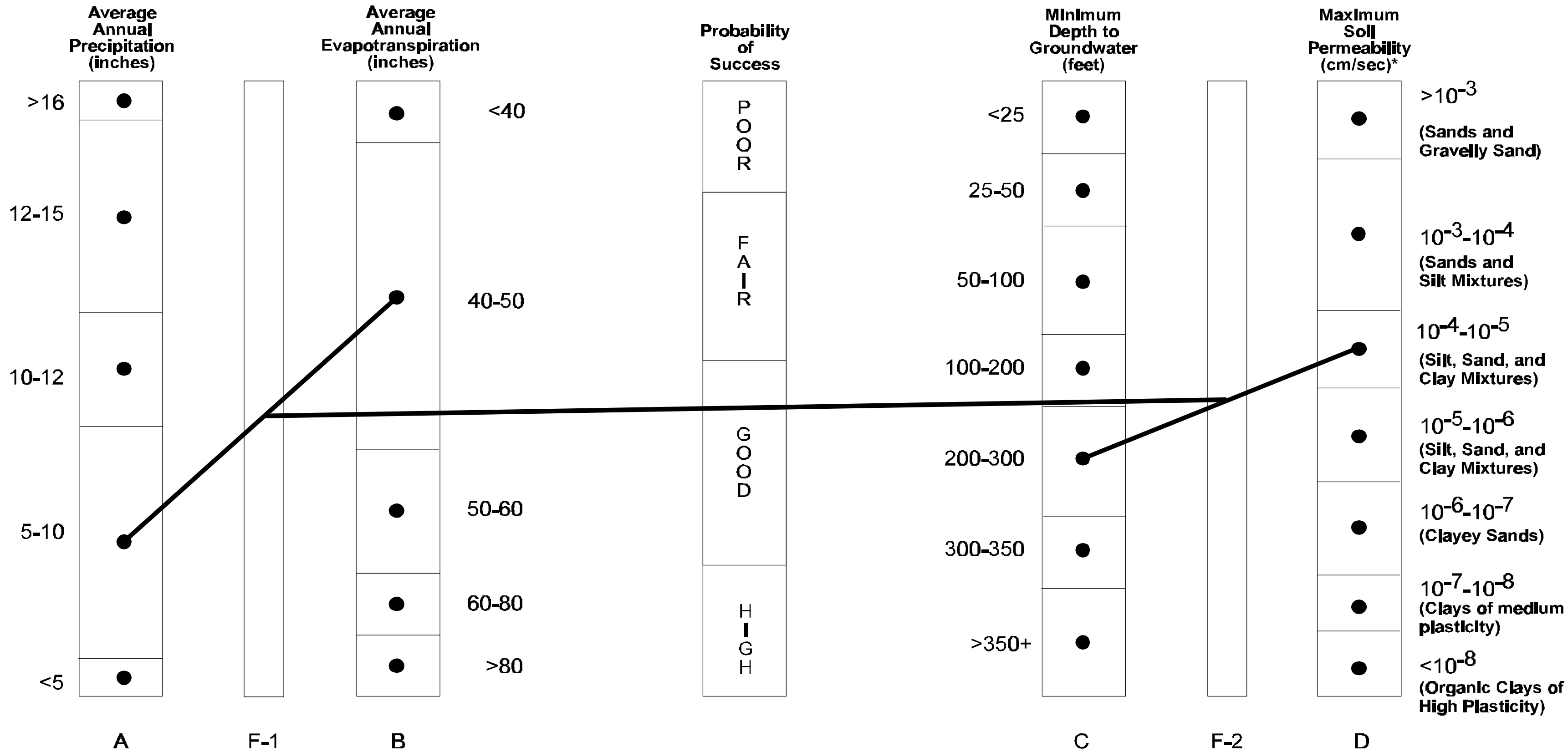
Once the permeability and thickness of each layer of soil beneath the facility have been estimated, the average permeability can be calculated by multiplying the thickness of each soil layer by its corresponding permeability, adding the products, and dividing that sum by the total depth to the water table.

The decision tool provides a broad screening only. Its results should not discourage the owner or operator from continuing to pursue a NMD, unless the site appears to be at an extreme disadvantage under all criteria. In addition, the quality of the decision made by applying the decision tool in Figure 2-1 is related directly to the quality of the estimates for each of the four parameters. However, it is not advisable to expend significant funds to obtain highly accurate estimates of the values for the MSWLF at this point in the screening process. Finally, if it would require too much time or expense to find values for all the parameters in Figure 2-1, those that would require unreasonable expenditures can be grossly estimated for the screening effort.

### 2.2.3 Estimation of Time of Travel

Another method of quickly and cheaply evaluating the probability that the NMD for an MSWLF will be successful is to estimate the time required for hazardous constituents from the MSWLF to travel to the water table. This method requires knowledge of the predominant soil type beneath the MSWLF and an estimate of the net annual infiltration rate for precipitation at the MSWLF. Both parameters are available from the sources listed in Table 2-2 (the U.S. Soil Conservation Service should be particularly helpful in

# Figure 2-1: Decision Tool for Determining the Probability of a Successful NMD




**1] To use this tool:**

a) Find the dot within the range of values that correspond to your MSWLF on Bars A through D.
b) Draw a line from the value for your MSWLF on Bar A to that on Bar B.
c) Repeat the above procedure and draw a line from Bar C to Bar D.
d) Draw a line from bar F-1 to Bar F-2 at the points of intersection from your first two lines.
e) Read the center bar at the point of intersection of the line last drawn.
f) **The lines drawn on this figure correspond to the example described on page 9.**

* To convert cm/sec to ft/yr multiply by $1 \times 10^6$; note that $1 \times 10^{-6}$ cm/sec equals approximately 1 ft/yr.

**TABLE 2-2: SOURCES OF SITE-SPECIFIC DATA ON KEY VARIABLES USED TO EVALUATE NO-MIGRATION DEMONSTRATIONS**

| Variable | Sources |
|---|---|
| Depth to groundwater | Water resources investigation reports at U.S. Geological Survey (USGS) regional libraries throughout the country. USGS has published hundreds of detailed reports of groundwater investigations. The reports show well locations.<br><br>State and local geologic and natural resources and soil services offices and libraries. |
| Soil permeability | Water resources investigation reports at USGS regional libraries throughout the country. USGS has published hundreds of detailed reports of groundwater investigations. The reports show well locations.<br><br>State and local geologic and natural resources and soil service offices and libraries. |
| Annual precipitation | Publications of the National Climatic Data Center, of the National Environmental Satellite Data and Information Service (NESDIS), in the National Oceanographic and Atmospheric Administration (NOAA), under the U.S. Department of Commerce (DOC).<br><br>State and local meteorological and agricultural offices and services.<br><br>Local airports. |
| Annual evapotranspiration | Publications of the National Climatic Data Center, of the NESDIS, in the NOAA, under the DOC.<br><br>State and local meteorological and agricultural offices and services<br><br>Local airports. |
| Infiltration | Publications of the National Climatic Data Center, of the NESDIS, in the NOAA, under the DOC.<br><br>State and local meteorological and agricultural offices and services<br><br>Local airports. |

**TABLE 2-3: PERMEABILITY RANGES FOR VARIOUS TYPES OF SOILS**

| Description [1] | USCS Soil Class (USDA Soil Class)[2] | Permeabilities[3] | |
|---|---|---|---|
| | | Centimeters per Second (cm/sec) | Feet per Year (ft/yr) |
| Sandy gravels with very little fines | GW and GP (GS) | $> 1.0 \times 10^{-2}$ | > 10,000 |
| Silty gravels, gravel-sand-silt mixtures | GM | $1 \times 10^{-6}$ to $10^{-3}$ | 1 to 1,000 |
| Clayey gravels, gravel-sand-clay mixtures | GC | $1 \times 10^{-8}$ to $10^{-6}$ | 0.01 to 1 |
| Sands and gravely sands with very little fines | SW and SP (S) | $> 1 \times 10^{-3}$ | > 1,000 |
| Silty-sands, sand-silt mixtures | SM (FS, LS, LFS) | $1 \times 10^{-6}$ to $10^{-3}$ | 1 to 1,000 |
| Clayey sands, sand-clay mixtures | SC | $1 \times 10^{-8}$ to $10^{-6}$ | 0.01 to 1 |
| Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, clayey silts with slight plasticity | ML (SL, FSL) | $1 \times 10^{-6}$ to $10^{-3}$ | 1 to 1,000 |
| Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | CL (L, SIL) | $1 \times 10^{-8}$ to $10^{-4}$ | 0.01 to 100 |
| Organic silts and organic silt-clays of low plasticity | OL | $1 \times 10^{-6}$ to $10^{-4}$ | 1 to 100 |
| Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts | MH | $1 \times 10^{-6}$ to $10^{-4}$ | 1 to 100 |
| Inorganic clays of high plasticity, fat clays | CH | $1 \times 10^{-8}$ to $10^{-6}$ | 0.01 to 1 |
| Organic clays of medium to high plasticity, organic silts | OH | $1 \times 10^{-8}$ to $10^{-6}$ | 0.01 to 1 |

Source: Agricultural Handbook Number 456, U.S. Department of Agriculture (USDA)

[1] The following definitions apply as used in these descriptions:

***Sand*** is loose and single-grained. The individual grains can be seen or felt readily. Squeezed in the hand when dry, it will fall apart when the pressure is released. Squeezed when moist, it will form a cast, but will crumble when touched.

***Sandy loam*** is a soil containing much sand, but which has enough silt and clay to make it somewhat coherent. The individual sand grains can be seen and felt readily. Squeezed when dry, it will form a cast that will fall apart readily, but if squeezed when moist, will form a cast that will bear careful handling without breaking.

***Silt loam*** is a soil having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called 'silt'. When dry, it may appear cloddy, but the lumps can be broken readily, and when pulverized, it feels soft and floury. When wet, the soil readily runs together and puddles. Either dry or moist, it will form casts that can be handled freely without breaking, but will give a broken appearance.

***Clay loam*** is a fine-textured soil that usually breaks into clods or lumps that are hard when dry. When the moist soil is pinched between the thumb and finger, it will form a thin 'ribbon' that will break readily, barely sustaining its own weight. The moist soil is plastic and will form a cast that will bear much handling. When kneaded in the hand, it does not crumble readily but tends to work into a heavy, compact mass.

***Clay*** is a fine textured soil that usually forms very hard lumps or clods when dry and is quite plastic and usually sticky when wet. When the moist soil is pinched between the thumb and finger, it will form a long, flexible 'ribbon.' Some fine clays very high in colloids are friable and lack plasticity in all conditions of moisture.

***Loam*** is a soil having a relatively even mixture of different grades of sand and of silt and clay. It is mellow, with a somewhat gritty feel, yet fairly smooth and slightly plastic. Squeezed when dry, it will form a cast that will bear careful handling, while the cast formed by squeezing the moist soil can be handled quite freely without breaking.

[2] The Unified Soil Classification System (USCS) is one of two nationally recognized and widely used systems for estimating soil properties. The other is the USDA scale, which also is based on the soil texture and the various percentages of sand, silt, and clay. Therefore, the descriptions of a soil's texture can be used to classify it under either system and to convert from one system to another.

[3] To convert cm/sec to ft/yr multiply by 1,034,645.6. Thus, $1 \times 10^{-6}$ cm/sec equals approximately 1 ft/yr.

obtaining the information). When the net infiltration rate and the predominant soil textures at the MSWLF are known, Table 2-4 can be used to estimate the minimum depth to groundwater necessary for a no-migration exemption at an MSWLF that will operate for 30 years and undergo post-closure care for an additional 30 years. It should be noted that the permeability of many clays is well below 17 feet per year, therefore the use of Table 2-4 will yield conservative results at many sites where clays are the predominant soil type (The method used to construct the table is based on equations taken from the Superfund Site Assessment Manual [EPA 1988]).

When the net infiltration rate is not known, but the predominant soil texture is known, conservative estimates can be used to estimate the minimum depth to groundwater necessary for a no-migration exemption at an MSWLF that will operate for 30 years and undergo post-closure care for an additional 30 years. These estimates of minimum depths are 120 feet for sand; 78 feet for sandy loam; 60 feet for silt loam; 48 feet for clay loam; and 24 feet for clay.

The estimates were derived by assuming an annual average precipitation rate of 25 inches per year, minus values for surface runoff and evapotranspiration rates taken from Table C-8 in Hydrologic Simulation on Solid Waste Disposal Sites, Office of Water and Waste Management, EPA (SW-868), September, 1980. If you know your average annual precipitation rate and you are in a relatively dry area, you can assume that only 15 percent of the average annual precipitation will infiltrate. That assumption represents conservative values of 15 percent runoff and 70 percent evapotranspiration rates.

## 2.3 CONTENT OF A NMD

The previous sections of this chapter described how to apply limited and inexpensively gathered information to determine whether a NMD can be expected to be successful. This section suggests the specific types and amounts of information that state officials will expect to see before making a decision about a no-migration exemption. Officials typically responsible for such matters include individuals

**TABLE 2-4: MATRIX FOR GROSS ESTIMATING OF THE VELOCITY OF MIGRATION OF HAZARDOUS CONSTITUENTS TO THE WATER TABLE[1]**

| Average Annual Net Infiltration or Percolation Rate[2] | | Soil Texture (Permeability Value Used in Calculating Velocity in Feet per Year)[3] | Estimated Velocity of Contaminant Migration (Feet per Year)[4] | Minimum Depth to the Water Table for a MSWLF With a 60-year Total Operating Life and Post-Closure Care Period (Feet) |
|---|---|---|---|---|
| Inches per Year | Feet per Year | | | |
| 1 | 0.0834 | Sand (6,000) | 0.6 | 36 |
| 5 | 0.417 | | 2.5 | 150 |
| 10 | 0.834 | | 4.7 | 282 |
| 15 | 1.25 | | 6.8 | 408 |
| 20 | 1.67 | | 8.8 | 529 |
| 1 | 0.0834 | Sandy loam (745) | 0.4 | 24 |
| 5 | 0.417 | | 1.7 | 102 |
| 10 | 0.834 | | 3.3 | 198 |
| 15 | 1.25 | | 4.8 | 288 |
| 20 | 1.67 | | 6.2 | 372 |
| 1 | 0.0834 | Silt loam (196) | 0.3 | 18 |
| 5 | 0.417 | | 1.3 | 80 |
| 10 | .834 | | 2.6 | 156 |
| 15 | 1.25 | | 3.7 | 222 |
| 20 | 1.67 | | 4.9 | 294 |
| 1 | 0.0834 | Clay loam (66) | 0.2 | 12 |
| 5 | 0.417 | | 1.1 | 66 |
| 10 | 0.834 | | 2.2 | 132 |
| 15 | 1.25 | | 3.2 | 192 |
| 20 | 1.67 | | 4.2 | 253 |
| 1 | 0.0834 | Clay (17.5) | 0.2 | 12 |
| 5 | 0.417 | | 1 | 60 |
| 10 | 0.834 | | 1.9 | 114 |
| 15 | 1.25 | | 2.9 | 174 |
| 20 | 1.67 | | 3.8 | 228 |

1 This table was adapted from instruction for calculating the velocity of infiltrating rainwater in the Superfund Exposure Assessment Manual, Office of Emergency and Remedial Response, EPA (EPA/540/1-88/011). It is intended for use as a general tool, and should not be applied to MSWLFs that are located over poorly-sorted sand, gravel, fractured rock, or karst terrains.

2 You can obtain net infiltration or percolation rates for your area by contacting the local offices of the U.S. Soil Conservation Service or your state geological survey office. The rate is equal to the total annual average precipitation rate, minus losses of moisture through runoff and evapotranspiration.

3 Note that these permeabilities are higher than those measured in many clayey soils; therefore, they contribute to a conservative estimate of velocities at sites that have clayey soils.

[4] Calculations of velocities of migration of contaminants were based on the following formula:

$V = q / p$

where:

q = Average percolation or recharge rate (depth per unit time)
p = Volumetric moisture content of the unsaturated zone (decimal fraction representing volume of water per volume of soil)

The values used to represent "p" above were specific for each soil texture shown in the table and originally were derived through laboratory tests on numerous soils having those textures, as reported in the Superfund Exposure Assessment Manual.

having such titles as solid waste engineer, solid waste management official, or director of a solid waste permit section. To contact such officials, call the headquarters of the state department of environmental protection and ask for the office of solid waste. Make an appointment to visit with an official of that office. Ask whether the state has specific guidance for NMDs or any written decision criteria that can be obtained before the meeting. Explain to the state official the need to know exactly what types of data must be submitted. For example, Table 2-5 is a data collection form for keeping track of the information needed for the NMD. It is important that the information recorded be as complete and accurate as possible because that information will be used to estimate the probable total costs of preparing the NMD. Be prepared to answer questions about the MSWLF. In addition, inform the official of the location and design of the MSWLF and its waste acceptance rate. Ask which characteristics of the MSWLF would increase or decrease the probability that it will receive a no-migration exemption.

During the meeting with the state official, verify that all the written guidance and forms necessary to complete the NMD have been provided. Review each type of data listed in Table 2-5 and ask whether it is required. If a particular type of data is required, ask whether the information must be determined from on-site measurements or whether the results of similar measurements taken at nearby facilities are sufficient. As an alternative, ask whether values in the literature that describe the general hydrogeologic setting in the area can be used in place of on-site measurements for certain items. Ask for recommendations of any specific literature that provides values for particular data elements. For data that must be collected on a site-specific basis, ask whether there is a minimum number of samples that must be collected. In addition, ask whether there is a minimum number of borings that must be drilled to collect data on certain parameters and how deep the borings must be.

Be certain to ask the state official whether there are any types of data that are not listed in Table 2-5 that must be included in the NMD. List the additional items in the blank spaces in the table, and complete all columns of the table for those items, just as the other items in the table.

**TABLE 2-5: NMD DATA COLLECTION FORM**
**(Page 1 of 2)**

| Types of Data | Information Required? (Y/N/M)[1] | Sources of Information Not Requiring Measurement[2] | Numbers and Methodologies for Required On-Site Testing [3] |
|---|---|---|---|
| Depth to groundwater | | | |
| Soil permeability (hydraulic conductivity) | | | |
| Soil porosity | | | |
| Bulk density of soil | | | |
| Moisture content of soil | | | |
| Moisture content of waste | | | |
| Soil moisture at field capacity | | | |
| Soil moisture at the wilting point | | | |
| Soil classification/soil texture | | | |
| Models (list type[s]) | | | |
| Maximum depth of MSWLF | | | |
| Average annual precipitation | | | |
| Average runoff rate | | | |

## TABLE 2-5: NMD DATA COLLECTION FORM
## (Page 2 of 2)

| Types of Data | Information Required? (Y/N/M) | Sources of Information Not Requiring Measurement[2] | Numbers and Methodologies for Required On-Site Testing[3] |
|---|---|---|---|
| Infiltration or percolation rate | | | |
| Average annual evapotranspiration rate | | | |
| Thickness of liner (each material) | | | |
| Permeability of liner (each material) | | | |
| Thickness of cover (each layer) | | | |
| Permeability of cover | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Notes:

1 Y = Yes
N = No
M = Maybe, because the state appears to be strongly recommending this type of data.

2 Ask the state official about sources of data for those data requirements that can be satisfied with data from previous studies of the soils or climate in the area of the MSWLF. Ask whether there is a maximum distance from the MSWLF beyond which the state will not allow the use of data from the literature.

3 Ask the state official about the types of testing that must be performed directly at the MSWLF. If any such testing already has been performed, ask the official whether the results are adequate to meet the state's requirements without additional testing.

Finally, ask the state official which, if any, hydrogeological models must be run to demonstrate the migration rates of hazardous materials from the MSWLF. Ask whether the state will run such models and whether officials can use default values to make a decision about the MSWLF without requiring the submittal of a NMD. Determine whether the state has predesignated certain portions of the state as good or poor locations for candidates for no-migration exemptions.

After Table 2-5 has been completed, the next step is to develop a ballpark estimate of the costs of completing a NMD for the MSWLF. The next chapter of this manual is a guide to completing that task.

## 3.0 STEP 2: ESTIMATE AND ANALYZE THE COST OF THE NMD

This chapter includes two sections. Section 3.1 presents an approach to determining a ballpark estimate of the costs of preparing a NMD. Section 3.2 presents an approach to determining whether the preparation of a demonstration is cost-effective in any particular case.

### 3.1 ESTIMATE THE COST OF A NMD

Using the data collection form filled out as described in Section 2.3 (see Table 2-5), identify the information that already has been collected. For example, much of the information needed might be found in the permit application for the MSWLF. Next, identify the information listed on the data collection form (Table 2-5) that the state will allow to be obtained from literature. In many cases, an owner or operator can obtain literature free or for a nominal fee from local, state, and federal government sources and from universities. Assume that the cost of obtaining each source of information is $150.00, except for information that obviously will require little time to collect. (The figure of $150.00 is based on the assumption that it would require approximately four hours of a junior consultant's time, and $50.00 in other direct costs, to retrieve information from each literature source.) Some of the information needed for a particular site may not be available in the literature; therefore, it may be necessary to revise the cost estimate after a review of information from the various sources suggested by the state solid waste official.

After entering the information from literature on the data collection form, review the types of information listed on the form that must be collected at the MSWLF through sampling. Use Table 3-1 to prepare a ballpark estimate of the cost of each such item. If items required by the state are not listed in Table 3-1, obtain estimated unit prices from local soil laboratories, local drillers, consulting firms, state officials, universities, or owners or operators of nearby MSWLFs where such testing has been performed. The estimate will be much more accurate if such contacts provide information to support the estimates of the costs of all the items listed in Table 2-5. However, the rates listed in Table 3-1 can be used to construct a quick ballpark estimate before making telephone calls to refine the unit costs upon which the estimate would be based.

**TABLE 3-1: RATES FOR COSTING VARIOUS ON-SITE MEASUREMENTS THAT MAY BE REQUIRED BY THE STATE (1996)**
**(Page 1 of 2)**

| Types of Data | Procedure | Unit Cost | Number Required[1] | Total Cost |
|---|---|---|---|---|
| Depth to groundwater | Drilled boring | $30/foot[2] | | |
| Soil permeability (hydraulic conductivity) | Laboratory test | $100/test | | |
| Soil porosity | Laboratory test | $25/test | | |
| Bulk density of soil | Laboratory test | $25/test | | |
| Moisture content of soil | Laboratory test | $25/test | | |
| Moisture content of waste | Laboratory test | $25/test | | |
| Soil moisture at field capacity | Laboratory test | $25/test | | |
| Soil moisture at the wilting point | Laboratory test | $25/test | | |
| Soil classification/soil texture | Laboratory test | $25/test | | |
| Models (list type[s]) | Computer analysis | $2,000/ analysis[3] | 1 | $2,000 |
| Maximum depth of MSWLF | Drilled boring | $20/foot[4] | | |
| Average annual precipitation | NA | NA | NA | NA |
| Average runoff rate | Field measurement | $100 | | |
| Infiltration or percolation rate | Field measurement | $100 | | |
| Average annual evapotranspiration rate | NA | NA | NA | NA |
| Thickness of liner (each material)[5] | Drilled boring | $20/foot[6] | | |
| Permeability of liner (each material) | Laboratory analysis | $100/Test | | |
| Thickness of cover (each layer) | Hand augering | $500 | | |

**TABLE 3-1: RATES FOR COSTING VARIOUS ON-SITE MEASUREMENTS THAT MAY BE REQUIRED BY THE STATE**
**(Page 2 of 2)**

| Types of Data | Procedure | Unit Cost | Number Required | Total Cost |
|---|---|---|---|---|
| Permeability of cover | Laboratory analysis | $100/test | | |
| **TOTAL COSTS** | NA | NA | NA | |

Notes:

[1] The number of measurements needed for each data type often is expressed in terms of the depths of the borings to be made. Therefore, it is important to consider both the total depth and the number of borings when estimating the total number of each test to be conducted at your MSWLF.

[2] This unit cost is based on the assumption that the boring will be six inches in diameter, will exceed 100 feet in depth, and will be drilled with an air rotary drill by a three-man crew consisting of one operator and two unskilled laborers, and that the boring will be cased, capped, and fitted with a concrete pad. The diameter of six inches is recommended for borings done at your site because such borings can be converted into groundwater monitoring wells if the NMD is not successful. The added cost of that approach is approximately $10 per foot.

[3] Assumes that data already have been collected and are available to the modeler. Also assumes 24 hours of a junior modeler's time and 8 hours of a senior modeler's time, plus materials.

[4] The diameter of the boring is assumed to be two inches.

[5] It is not likely that many states will require this test because it could jeopardize the integrity of the containment structures of the MSWLF.

[6] The diameter of this boring is assumed to be two inches.

NA = Not Applicable

After completing Table 3-1, add the costs and record the total at the bottom of the right-hand column. Add that figure to the total cost estimated for collection of the information that can be obtained from the literature. Add to the new total $5,000 to retain a consultant to communicate with the state, analyze information about your site, and prepare the NMD. In most cases, the consultant should be able to perform those tasks for less than that amount; however, a ballpark estimate should err on the high side rather than the low.

The total cost of groundwater monitoring calculated as described above should be compared with the estimated cost of preparing a NMD. In many cases, preparing a NMD costs far less than groundwater monitoring.

## 3.2 ANALYZE THE COST OF THE NMD

A method of analysis is to compare the cost of a NMD to the cost of groundwater monitoring. Once a reasonable estimate of the costs of the NMD has been prepared, compare that amount with the cost of installing a groundwater monitoring system and monitoring the groundwater over the active life of the

MSWLF, plus the post-closure care period. To estimate the cost of installing a groundwater monitoring system:

- Multiply $90 by the depth to groundwater at the site (in feet), and multiply the result by the number of wells that are likely to be needed. (A state solid waste official will be able to provide an estimate of the number of groundwater monitoring wells that may be needed at a given MSWLF.)

- Add to that number $600 per well per year for 30 years of post-closure care at the MSWLF.

- For monitoring in the first year, add $1,800 per well

- For all annual monitoring conducted after the first year, add $600 per well for each remaining year of operation of the MSWLF.

**EXAMPLE COST ESTIMATE FOR A GROUNDWATER MONITORING SYSTEM**

| | |
|---|---|
| Installation [1]: | $90/feet/well x 200 feet x 3 wells = $54,000 |
| Monitoring [2]: | $1,800/well x 3 wells = $5,400 |
| Monitoring [3]: | $600/well/year x 3 wells x 19 years + I = $41,935 |
| Post-closure [4]: | $600/well/year x 3 wells x 30 years + I = $108,500 |
| **TOTAL** | **$209,835** |

1 1998 dollars.
2 First year of the remaining life of the landfill (1998 dollars).
3 Second through twentieth year of the remaining life of the landfill; I = inflation of 2 percent per year.
4 Monitoring for thirty years after the end of the remaining life of the landfill; I = inflation of 2 percent per year.

For example, groundwater monitoring at a facility that has three, 200-foot-deep wells and 20 years of remaining active life would cost a total of $209,835 (see text box for details on this example). In addition, at least 60 hours of consulting time would be needed for well design and placement and oversight, estimated at approximately $5,000, bringing the total costs of groundwater monitoring for the facility to $214,835. The cost of a NMD for the same facility could be expected to be approximately $15,000, assuming that only one boring is required and that all soil tests would be repeated at 20-foot intervals. That cost should be reduced by the cost of the boring (approximately $30/foot times 200 feet or $6,000), because the boring can be used to install a groundwater monitoring well should the NMD be unsuccessful. Therefore, for a MSWLF that meets the description above, a NMD can be prepared for an incremental cost of approximately $9,000, or about four percent of the cost of installing and operating a groundwater monitoring system. Such differences between the costs of groundwater monitoring and those of preparing a NMD are expected to be common to most, if not all, MSWLFs. In addition, the approach described in the following chapter allows the owner or operator to recognize at the earliest possible point that a NMD is likely to be unsuccessful, so that the effort can be abandoned before large expenditures of time and effort are made.

## 4.0 STEP 3: FOLLOW COST-EFFECTIVE METHODS OF PREPARING THE NMD

The following four steps are the most cost-effective approach to preparing a NMD:

- Prepare a clear written description of needs and discuss those needs with state solid waste officials
- Discuss the needs with consulting firms that specialize in the field
- Using standard practices, select a consultant
- If state does analysis, no consultant needed

The four steps are discussed in the following subsections.

### 4.1 PREPARE A CLEAR WRITTEN DESCRIPTION OF NEEDS

This step was completed substantially during the visit with the state solid waste official. However, it is important to document all the information that will be needed for a NMD in a one- or two-page description supported by a table similar to Table 2-5. Once that description has been prepared, it may become apparent that there are some areas of uncertainty concerning the number or types of tests that must be reported in the NMD. However, even if there are no information gaps in the description, an attempt should be made to obtain comments from state officials on the information required in a NMD. In addition, attempt to obtain comments from those state officials on the types of information that will be crucial to their decision and the types of information that almost certainly will cause the rejection of a NMD. Explain that the rationale for asking such questions is to limit expenditures for consultants to complete the NMD by terminating the preparation of the NMD at the earliest indication that it will not succeed. Use the results of the discussions with state officials to determine whether to engage a consultant to prepare the NMD. Some states may have in place formal or informal procedures for analyzing information about MSWLFs in such a way that only the raw data on an MSWLF must be presented to them. In those states, a consultant might not be needed to prepare the demonstration. However, use of a consultant to oversee the collection of any field data required by the state is recommended.

### 4.2 DISCUSS NEEDS WITH CONSULTING FIRMS

Contact three or more consulting firms that specialize in hydrogeological evaluations. Such firms are listed in local telephone directories. Recommendations of competent firms can also be obtained from other owners or operators of MSWLFs. Call each firm and ask to speak with a senior hydrogeologist. Explain to that person that you are considering submittal of a NMD for a MSWLF, and ask to speak with the appropriate person in the company. Describe to that person pertinent facts about the MSWLF -- its size, the depth to groundwater, and the climate -- and explain the information needs identified in cooperation with state officials. Agree to provide the firm with an invitation to bid on the preparation of the NMD, if the firm is interested. Ask each firm about its experience in preparing such demonstrations, and encourage the contact to offer an opinion about the probability that the NMD will be successful. Ask each contact to comment on whether the information about data needs identified appear to be complete and accurate, in light of the firm's experience. Discuss any major discrepancies related to information needs with state officials. Ask them to reconfirm the need for information that one or more consulting firms believed to be unnecessary, or to reconfirm that there is no need for information that one or more consulting firms believed to be crucial.

## 4.3 SELECT A CONSULTANT

Prepare an invitation for bid for three or more consulting firms believed to be reputable, in light of the recommendations of past clients and the opinion formed during telephone conversations with their staffs. The invitation for bid should state clearly exactly what is expected of the contractor in preparing the NMD. It is recommended that each contractor be required to provide a brief summary of the experience of its staff and its company in preparing such demonstrations, both successful and unsuccessful. In lieu of such experience, a contractor should explain how the experiences of its staff and its company are relevant to the preparation of a successful NMD. In addition, the bid package should request that each contractor describe specific criteria that could be used to trigger the abandonment of the NMD at any of a number of stages in the preparation process. Such a step-by-step approach could reduce the cost of preparation of a NMD by allowing the owner or operator to cease such efforts if success begins to appear unlikely. For example, a company may propose to conduct a visual evaluation of coring samples from borings at the site and make a decision about whether to proceed with the preparation of the demonstration. Such interim evaluations could produce significant savings at sites for which more than one boring or numerous laboratory tests on soil samples are needed to support a NMD. At the very least, each firm should be asked to provide a subtotal of costs for collection and presentation of all required information, with a preliminary conclusion about the probability that a NMD would be successful. Such an approach could save the cost of preparing a demonstration in cases in which there is very little probability of success.

The instructions in the bid package should state clearly how the firm awarded the contract will be selected. For example, the owner or operator may elect to use three criteria, such as experience, approach, and total cost, in evaluating the bids. In such a case, each of the bidders would be rated on a scale of 1 to 10 for its responses to each of the evaluation criteria. For example, a total cost that is twice the amount of the lowest offer might receive a rating of 2 and a bidder that proposes three or more decision points that collectively have the potential to save 50 percent of the total estimated cost of the project might receive a rating of at least 8. Next, the score of each bidder under each criterion would be multiplied by a weighing factor that represents the relative importance of that criterion in the evaluation. Finally, the results in each category would be added to obtain a total score for each bidder. The bidder having the highest score should be selected for negotiations to encourage the bidder to reduce its costs or increase its proposed activities. In all cases, it is important to maintain control over the evaluation process, so that no bidder is selected if none meets the requirements.

# Appendix

## Information Used to Analyze
## No-Migration Demonstrations
## in Seven States

## TABLE OF CONTENTS

**Table** **Page**

**Table A-1**

**CRITERIA USED BY STATES TO MAKE DETERMINATIONS ABOUT NO-MIGRATION EXEMPTIONS**

**(Page 1 of 3)**

| State | Regulatory Criteria Used to Make Determination | References |
|---|---|---|
| Arizona[3] | **Exemption from groundwater monitoring requirements**<br>• Demonstration that there is no potential for migration of hazardous constituents from that MSWLF to the uppermost aquifer<br>- Measurements collected at specific field sites and sampling and analysis of physical, chemical, and biological processes affecting the fate and transportation of contaminants<br>- Predictions of the fate and transport of contaminants that maximize migration of contaminants and a consideration of the effects on public health and safety and the environment<br>• Certification by a qualified groundwater scientist<br>• Approval by the director of the Department of Environmental Quality | 40 CFR 258.50(b)(1)(2) |
| Idaho | **Exemption from groundwater monitoring requirements**<br>• Demonstration that there is no potential for migration of hazardous constituents from the landfill to the uppermost aquifer during the active life of the unit and the post-closure care period<br>• Certification by a qualified groundwater scientist<br>• Approval by the director of the Idaho Environmental Council | Solid Waste Facilities Act, Title 39, Chapter 7410 |
| Montana | **Exemption from groundwater monitoring requirements**<br>• Demonstration that there is no potential that hazardous constituents will contaminate the uppermost aquifer<br>• Provision of facility-specific data and studies certified by a qualified groundwater scientist<br>- Site-specific, field-collected measurements, sampling, and analysis of physical, chemical, and biological processes affecting contaminant fate and transport<br>- Predictions of contaminant fate and transport that maximize migration of contaminant and consider effects on human health and the environment<br>• Demonstration that groundwater will not become contaminated for at least 30 years after the facility is closed<br>• Installation of vadose zone monitoring devices, piezometers, or saturated zone monitor wells as required by the department as part of an ongoing no-migration demonstration | Solid Waste Management, Subchapter 7, 16.14.714(1)(2)(3)(5) (p. 16-793) |

[1] Arizona Department of Environmental Quality (ADEQ) recommends the use of Hydrologic Evaluation of Landfill Performance (HELP) and MULTIMED models with site-specific data to satisfy the requirements of 40 CFR 258.50(b)(1)&(2). Arizona does not use the form displayed in Table 2-5.

**TABLE A-1**
**CRITERIA USED BY STATES TO MAKE DETERMINATIONS ABOUT NO-MIGRATION EXEMPTIONS**
**(Page 2 of 3)**

| State | Regulatory Criteria Used to Make Determination | References |
|---|---|---|
| Nevada | **Exemption from groundwater monitoring requirements**<br>• Demonstration that there is no potential for migration of hazardous constituents from that unit to the uppermost aquifer during the active life of the unit, including the period of closure and post-closure care period<br>- Site-specific measurements and the sampling and analysis of physical, chemical, and biological processes affecting the fate and transport of contaminants<br>- Predictions of the fate and transport of contaminants that are based on the maximum possible rate of migration of the contaminant and consideration of the effects on public health and safety and the environment<br>• Certification by a qualified groundwater scientist<br>• Approval by the solid waste management authority | Solid Waste Disposal, General Provisions, 444.7481(a)(b) (p.444-116) |
| New Mexico | **Exemption from part or all of groundwater monitoring requirements under Sections 802 to 806**<br>• Demonstration that there is no potential for migration of hazardous constituents from the landfill to the uppermost aquifer during the active life and the post-closure care period<br>- Site-specific field measurements and sampling and analysis of physical, chemical, and biological processes affecting fate and transport of contaminant(s)<br>- Predictions of the fate and transport of the contaminant(s) that maximize migration of the contaminant(s) and consideration of the effects on public health and welfare and the environment<br>• Certification by a qualified groundwater scientist<br>• Approval by the secretary of the Department of the Environment | Solid Waste Management Regulations, Part VIII, 801.C.1.2 (p. 103) |
| Utah | **Exemption from groundwater monitoring requirements**<br>• Demonstration that there is no potential for migration of hazardous substances from the facility to the groundwater during the active life of the facility and the post-closure care period<br>- Site-specific, field-collected measurements and sampling and analysis of physical, chemical, and biological processes affecting fate and transport of the contaminant(s)<br>- Predictions of the fate and transport of the contaminant(s) that maximize migration of the contaminant(s) and consideration of the effects on human health and the environment<br>• Certification by a qualified groundwater scientist<br>• Approval by the Executive Secretary of the Department of Environmental Quality | Solid Waste Permitting and Management Rules, R315-308-1(3)(a)(b) (p. 22) |
| | **Exemption from some design criteria and groundwater monitoring requirements (new or existing facilities that are seeking expansions)**<br>• Requirement that the MSWLF be located over an area where<br>- Groundwater has total dissolved solids (TDS) of 10,000 milligrams per liter (mg/L) or higher<br>- There is extreme depth to groundwater<br>- There is a natural impermeable barrier over groundwater<br>- There is no groundwater | R315-302-1(2)(vi) |

**TABLE A-1**
**CRITERIA USED BY STATES TO MAKE DETERMINATIONS ABOUT NO-MIGRATION EXEMPTIONS**
**(Page 3 of 3)**

| State | Regulatory Criteria Used to Make Determination | References |
|---|---|---|
| Wyoming | **Exemption from groundwater monitoring requirements**,<br>**Type I landfill**<br>• Demonstration that there is no potential for migration of hazardous constituents from the facility to the uppermost aquifer<br>- Site-specific field measurements<br>- Information about the specific wastes to be disposed of at the facility<br>- Predictions of fate and transport of contaminants, including use of the hydrologic evaluation of landfill performance model, that maximize migration of contaminants and consider effects on human health and the environment<br><br>**Type II landfill**<br>• Groundwater monitoring systems are not automatically required for Type II landfills, but may be required after the department reviews the permit application | Solid Waste Rules and Regulations Chapter 2, Section 6 (b)(I)(A)(I), (P2-32) |

**TABLE A-2: VALUES FOUND FOR KEY[1] PARAMETERS IN SUCCESSFUL NO-MIGRATION DEMONSTRATIONS FOR SPECIFIC MSWLFS IN ARIZONA**
**(Page 1 of 7)**

| Name of Facility | Size (acres) and Disposal Rate (tons/day) | Active Life of Facility (yr) | Thickness and Permeability of Daily Cover | Depth to Groundwater (ft) | Average Permeability of Soil or Hydraulic Conductivity | Annual Precipi-tation Rate (in) | Annual Evapotranspiration Rate (in) | Models Used | Cost To Prepare Demonstration ($) |
|---|---|---|---|---|---|---|---|---|---|
| Cerbat | 160; NI | 30 - 40 | 6 in; compacted cover material | 18 - 160 | Silty and gravelly sand; $1.23x10^{-3}$ cm/sec* (sandy loam) | 10 | 76 | HELP, vers. 2.05, WHPA, vers. 2.0 (RESSQC)*** | NI<br>4,100 to 5,000** |

Note:

(1) The term "key" as used here reflects professional judgement concerning those items that may have been most crucial to the state in granting no-migration exemptions.

NI Information not included

* Typical hydraulic conductivity for a sandy loam was used for the Hydrologic Evaluation of Landfill Performance (HELP) program.

** The cost to produce the demonstration is unclear. Modeling was being done for various reasons when it was decided to apply for a no-migration exemtion. At that point, substantial information was available to be included in the demonstration, thereby keeping the cost to a minimum.

*** Trademark model names.

TABLE A-2: VALUES FOUND FOR KEY[1] PARAMETERS IN SUCCESSFUL NO-MIGRATION DEMONSTRATIONS FOR SPECIFIC MSWLFS IN IDAHO
(Page 2 of 7)

| Name of Facility | Size (acres) and Disposal Rate (tons/day) | Active Life of Facility (yr) | Thickness and Permeability of Daily Cover | Depth to Groundwater (ft) | Average Permeability of Soil or Hydraulic Conductivity | Annual Precipitation Rate (in) | Annual Evapotranspi-ration Rate (in) | Models Used | Cost To Prepare Demonstration ($) |
|---|---|---|---|---|---|---|---|---|---|
| Clay Peak | 120; 44.45 | 68 | 6 in; fine-grained soil | 297.9 to 334.9 | $1.4 \times 10^{-4}$ to $4.2 \times 10^{-4}$ cm/sec; $1.1 \times 10^{-5}$ to $4.0 \times 10^{-18}$ cm/sec; 1.7 to 3 inches per foot of soil | 10.21 | 59.85 | HELP, CHEMFLO, MULTIMED | approx. 240K |
| Lemhi County Landfill | 16.5; NI | > 40 | 6 in; any soil type | > 325 | Clay with high plasticity; $1.8 \times 10^{-9}$ to $3.6 \times 10^{-9}$ cm/sec | 9.39 | 30 | HELP ver. 2.0, CHEMFLO, SUTRA | 84K* |
| Pickles Butte | 370; NI | > 200 | 6 in; fine-grained soil | > 400 | NI; $1.0 \times 10^{-4}$ to $1.8 \times 10^{-9}$ cm/sec | 6-8 | 50 | HELP | 25K to 30K |

Note:

(1) The term "key" as used here reflects professional judgement concerning those items that may have been most crucial to the state in granting no-migration exemptions.

NI Information not included

* This number is a factor in the cost of a no-migration demonstration. The cost actually incorporates overall design of the landfill, as well as design of the collection system.

**TABLE A-2: VALUES FOUND FOR KEY[1] PARAMETERS IN SUCCESSFUL NO-MIGRATION DEMONSTRATIONS FOR SPECIFIC MSWLFS IN MONTANA**
**(Page 3 of 7)**

| Name of Facility | Size (acres) and Disposal Rate (tons/day) | Active Life of Facility (yr) | Thickness and Permeability of Daily Cover | Depth to Groundwater (ft) | Average Permeability of Soil or Hydraulic Conductivity | Annual Precipitation Rate (in) | Annual Evapotranspiration Rate (in) | Models Used | Cost To Prepare Demonstration ($) |
|---|---|---|---|---|---|---|---|---|---|
| Former Laurel Sanitary Landfill (License No. 203) | NI; NI | NI (closed in 1995) | NI; NI (In accordance with Subtitle D Regs.) | 6 - 30 | Vertical mitigation rate of gw: 0.2 - 2.3 ft/yr; 8.11 x $10^{-8}$ cm/sec | 14 | 45 | Not used | 25K |
| Chester Landfill | 48; 1.7 | 70 | 6 in to 1 ft; NI | 200 to 250 | NI; NI | 10.64 | NI | Not used | NI |
| Coral Creek Landfill | 70; 9 | 28 | 6 in; NI | avg. 300 | Tight soils approx. permeability = $10^{-6}$ or $10^{-7}$ cm/sec; NI | 14 | NI | Not used | *5K + 2yrs. |
| Existing Landfill (Big Horn County and City of Hardin) | 76; NI | NI | 6 in; NI | 60 | 9.5 x $10^{-8}$ cm/sec; NI | 12.3 | NI | Not used | 4565.45 |
| Valley County Landfill | 40; NI | 73 | 6 in; NI | 50 | 5.1 - 9.6 x $10^{-8}$ cm/sec; 4.63 x $10^{-7}$ cm/sec | 11 | NI | Not used | 18K initial study; $9,935-secondary study & no-mig. recommended |
| Beaverhead County | < 100; NI | 74 | approx 6 in; NI | > 350 | 1 x $10^{-5}$ to 1 x $10^{-4}$ cm/sec; 1 x $10^{-4}$ cm/sec | 9.53 | 48 | Not used | 8K to 9K |

Note:

(1) The term "key" as used here reflects professional judgement concerning those items that may have been most crucial to the state in granting no-migration exemptions.

NI Information not included

* $5,000 was spent on the engineering portion; however, two or more unrecorded years of personal time were expended on the project.

**TABLE A-2: VALUES FOUND FOR KEY[1] PARAMETERS IN SUCCESSFUL NO-MIGRATION DEMONSTRATIONS FOR SPECIFIC MSWLFS IN NEVADA**
**(Page 4 of 7)**

| Name of Facility | Size (acres) and Disposal Rate (tons/day) | Active Life of Facility (yr) | Thickness and Permeability of Daily Cover | Depth to Groundwater (ft) | Average Permeability of Soil or Hydraulic Conductivity | Annual Precipi-tation Rate (in) | Annual Evapotranspi-ration Rate (in) | Models Used | Cost To Prepare Demonstration ($) |
|---|---|---|---|---|---|---|---|---|---|
| City of Mesquite Municipal Waste Landfill | 40; NI | NI | > 6 in; compacted cover material | > 400 | 1 x $10^{-8}$ cm/sec (silt & clay) and 1 x $10^{-3}$ - 1 x $10^{-4}$ cm/sec (fine sands); NI | 4.1 | NI | HELP II, vers. 2.5 | NI |

Note:

(1) The term "key" as used here reflects professional judgement concerning those items that may have been most crucial to the state in granting no-migration exemptions.

NI Information not included

**TABLE A-2: VALUES FOUND FOR KEY[1] PARAMETERS IN SUCCESSFUL NO-MIGRATION DEMONSTRATIONS FOR SPECIFIC MSWLFS IN NEW MEXICO**
**(Page 5 of 7)**

| Name of Facility | Size (acres) and Disposal Rate (tons/day) | Active Life of Facility (yr) | Thickness and Permeability of Daily Cover | Depth to Groundwater (ft) | Average Permeability of Soil or Hydraulic Conductivity | Annual Precipitation Rate (in) | Annual Evapotranspi-ration Rate (in) | Models Used | Cost To Prepare Demonstration ($) |
|---|---|---|---|---|---|---|---|---|---|
| Corralitos Landfill | 480 (East phase: 200 acres); 350 | 20 (East phase) | 6 in; NI | > 430 | 1.0 x $10^{-4}$ cm/sec; NI | 9.56 | 93.95 | HELP | 10K and public hearing costs |

Note:

(1) The term "key" as used here reflects professional judgement concerning those items that may have been most crucial to the state in granting no-migration exemptions.

NI Information not included

**TABLE A-2: VALUES FOUND FOR KEY[1] PARAMETERS IN SUCCESSFUL NO-MIGRATION DEMONSTRATIONS FOR SPECIFIC MSWLFS IN UTAH**
**(Page 6 of 7)**

| Name of Facility | Size (acres) and Disposal Rate (tons/day) | Active Life of Facility (yr) | Thickness and Permeability of Daily Cover | Depth to Groundwater (ft) | Average Permeability of Soil or Hydraulic Conductivity | Annual Precipi-tation Rate (in) | Annual Evapotranspi-ration Rate (in) | Models Used | Cost To Prepare Demonstration ($) |
|---|---|---|---|---|---|---|---|---|---|
| Millard County Landfill | 80; 20-25 | 200* | 6 in; compacted cover material | 35 - 80 | $6 \times 10^{-9}$ to $1 \times 10^{-8}$ cm/sec; NI | 6 to > 25 | 60 | HELP II, vers, 2.05 WHPA | 18K |
| Long Hollow Sanitary Landfill | NI; NI | 20+ | 6 in; $3 \times 10^{-3}$ cm/sec | > 300 | $1.9 \times 10^{-6}$ cm/sec; NI | < 10 | 50 | HELP | NI |

Note:

(1) The term "key" as used here reflects professional judgement concerning those items that may have been most crucial to the state in granting no-migration exemptions.

NI Information not included

* The active life of facility is estimated from the information about the size of the facility (80 acres) and the size (0.8 acre) and active life (two years) of each cell.

**TABLE A-2: VALUES FOUND FOR KEY[1] PARAMETERS IN SUCCESSFUL NO-MIGRATION DEMONSTRATIONS FOR SPECIFIC MSWLFS IN WYOMING**
**(Page 7 of 7)**

| Name of Facility | Size (acres) and Disposal Rate (tons/day) | Active Life of Facility (yr) | Thickness and Permeability of Daily Cover | Depth to Groundwater (ft) | Average Permeability of Soil or Hydraulic Conductivity | Annual Precipitation Rate (in) | Annual Evapotranspi-ration Rate (in) | Models Used | Cost To Prepare Demonstration ($) |
|---|---|---|---|---|---|---|---|---|---|
| Green River #1 Landfill | 40[2]; 47.5[3] | 10 | 6 in; sandy, rocky loam | > 130 (no gw encountered)[4] | $5 \times 10^{-3}$ to < $1 \times 10^{-6}$ cm/sec | 4-8 | 37 | NI[5] | NI* |
| Rock Springs Sanitary #1 Landfill | 47; 273[6] | 4 | 6 in; compacted earth | 52 to >100[7] | $2 \times 10^{-4}$ to $2 \times 10^{-6}$ cm/sec | NI | NI | NI | NI* |
| Sublette County Marbleton Sanitary #2 Landfill | 40; 52[8] | 15 | 6 in; NI | 80[8] | $6 \times 10^{-8}$ cm/sec | 15 | NI | NI | NI* |

Note:

* Exemptions from groundwater monitoring requirements were granted during permit renewal processes. Therefore, it appears that it did not cost the landfill owner a separate amount to apply for a no-migration demonstration.
(1) The term "key" as used here reflects professional judgement concerning those items that may have been most crucial to the state in granting no-migration exemptions.
(2) 40 acres indicate expansion of the landfill after closure of a 55-acre site.
(3) 47.5 tons per day were estimated, from the annual disposal rate, 12,350 tons per year (260 operating days per year).
(4) Groundwater monitoring is not required, because there is no groundwater up to a depth of 130 feet.
(5) The state permit application review file indicates that the HELP model was used primarily for the waiver of the requirement for an engineering containment system.
(6) 273 tons per day were estimated from the estimated monthly disposal rate, 6,550 cubic yards per month, assuming 24 days (Monday through Saturday working days at the landfill) per month.
(7) According to site-specific geology and poor water quality data, groundwater monitoring is not required. However, as an alternative, lysimeters have been installed at this site to measure fluid content of the substrata.
(8) The daily disposal rate was calculated from the annual disposal rate of 19,000 tons per year, assuming seven working days per week.
(9) No groundwater was detected during the drilling operation. The depth to groundwater, 80 feet, was obtained from information about domestic wells from the state engineer’s office.

**TABLE A-3: COMPARISON OF PARAMETERS AND VALUES USED BY EACH STATE**

| | KEY[1] PARAMETERS AND RANGE VALUES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Name of Facility** | **Size (acres) and Disposal Rate (tons/day)** | **Active Life of Facility (yr)** | **Thickness and Permeability of Daily Cover** | **Depth to Groundwater (ft)** | **Average Permeability of Soil or Hydraulic Conductivity** | **Annual Precipi-tation Rate (in)** | **Annual Evapotranspi-ration Rate (in)** | **Models Used** | **Cost To Prepare Demonstration ($)** |
| Arizona* | 160; NI | 30 - 40 | 6 in; compacted cover material | 18 - 160 (>120) | Silty and gravelly sand; $1.23 \times 10^{-3}$ cm/sec* (sandy loam) | 10 | 76 | HELP, vers. 2.05, WHPA, vers. 2.0 (RESSQC) | NI 4.1K to 5K |
| Idaho | 16.5 to 370; 44.45 | >40 to >200 | 6 in; any soil type and fine grained soil | 297.9 to >400 | $1.4 \times 10^{-4}$ to $4.2 \times 10^{-4}$ cm/sec and clay w/high plasticity; $1.0 \times 10^{-4}$ to $4.0 \times 10^{-18}$ cm/sec | 6 to 10.21 | 30 to 59.85 | HELP, CHEMFLO, MULTIMED SUTRA | 25K to 240K |
| Montana | 40 to <100; 1.7 to 9 | 28 to 74 | 6 to 12in; NI | 6 to >350 | $1 \times 10^{-4}$ to $9.6 \times 10^{-8}$ cm/sec (vertical migration of gw: 0.2-2.3 ft/yr); $1 \times 10^{-4}$ to $8.11 \times 10^{-8}$ cm/sec | 9.53 to 14 | 45 to 48 | Not used | 5 to 25K |
| Nevada* | 40; NI | NI | > 6 in; compacted cover material | > 400 | $1 \times 10^{-8}$ cm/sec (silt & clay) and $1 \times 10^{-3}$ - $1 \times 10^{-4}$ cm/sec (fine sands); NI | 4.1 | NI | HELP II, vers. 2.5 | NI |
| New Mexico* | 480 (East phase: 200 acres); 350 | 20 (East phase) | 6 in; NI | > 430 | $1.0 \times 10^{-4}$ cm/sec; NI | 9.56 | 93.95 | HELP | 10K and public hearing costs |
| Utah | 80; 20 to 25 | $20^{+}$ to 200 | 6 in; compacted cover material and $3 \times 10^{-3}$ cm/sec | 35 to >300 | $1.9 \times 10^{-6}$ to $6 \times 10^{-9}$ cm/sec; NI | 6 to >25 | 60 | HELP, WHPA | 18K |
| Wyoming | 40 to 47; 47.5 to 273 | 4 to 15 | 6 in; sandy, rocky loam and compacted earth | 52 to >130 | $5 \times 10^{-3}$ to $6 \times 10^{-8}$ cm/sec | 4 to 15 | 37 | HELP | NI |

Note:

[1] The term "key" as used here reflects professional judgement concerning those items that may have been most crucial to the state in granting no-migration exemptions.

NI Information not included

* Only one facility within the state has been approved for a no-migration exemtion at this time.