APPENDIX C TO LPC-PA2

INSTRUCTIONS FOR THE GROUNDWATER PROTECTION EVALUATION FOR PUTRESCIBLE AND CHEMICAL WASTE LANDFILLS

(rev. 10/21/92
(2nd rev. 11/16/2010)

This Appendix sets out the type of information needed in addition to the general information requested in the LPC-PA2 Instructions. You should review Appendices A-G and Section VI of LPC-PA2 form to determine which are applicable to your facility. This Appendix explains the information required for the GROUNDWATER PROTECTION EVALUATION which shall describe the hydrogeologic site investigation, groundwater impact assessment, groundwater monitoring systems, and groundwater quality standards of the site.

I. HYDROGEOLOGIC SITE INVESTIGATIONS

The information compiled during the hydrogeologic investigation provides the foundation of data on which the monitoring system, groundwater impact assessment and groundwater quality standards are developed. Therefore, before starting the investigation, a field implementation plan should be developed which includes a schedule of implementation, a system for the collection and management of data, quality control and contingency planning for acceptable alternatives to preferred methods, practices or equipment. Reports to the Agency upon completion of each phase of the investigation are not necessary.

The study shall include the entire area occupied by the facility and any adjacent areas, if necessary for the purposes of the hydrogeologic investigation. [Section 811.315(b)(2)]

All borings should be continuously sampled. However, where a sufficient number of continuously sampled borings are drilled to document the continuity of a unit or formation, additional borings which are not continuously sampled are acceptable pursuant to 811.315(b)(3).

A. Phase One

The first phase consists of a literature survey and establishment of the regional geologic and hydrogeologic characteristics. A minimum of one continuously sampled boring near the geographic center of the site is required to confirm the literature evaluation. The borings must extend at least 50 feet (15.2 meters) below the bottom of the uppermost aquifer or through the confining layer below the bottom of the uppermost aquifer, or to bedrock, if the bedrock is below the uppermost aquifer, whichever elevation is higher.

The Agency realizes that in parts of the State, this may require boring 300 to 500 feet below ground surface to fulfill the minimum requirement of Phase I when the uppermost aquifer is a considerable thickness. Section 811.315(f) allows the Agency to consider alternate ways of collecting the hydrogeologic site information provided that the information is collected in a manner equal or superior to the requirements of this Section. Considering the purpose of the hydrogeologic investigation (i.e., to provide information to perform a groundwater impact assessment and establish a groundwater monitoring system), boring to excessive depths on site would yield data of limited use at extraordinary expense. For these extreme field conditions, the Agency recommends the following:

If the bedrock is part of or below the uppermost aquifer, borings through the entire thickness of the bedrock will not be required if supporting documentation such as that required in 811.315(c)(2)(A) can be correlated with the site data. However the borings must characterize the permeable portion of the bedrock, (usually described as being weathered, vuggy, desiccated or fractured, etc.) and include coring a minimum of 15 to 20 feet of the bedrock. Similar logic can be applied to characterizing the uppermost aquifer and confining layer when the former is a considerable thickness of unconsolidated material. The borings must extend at least 100’ into the uppermost aquifer and correlate with the supporting documentation in 811.315(c)(2)(A).

A complete search of the published documents and a request for preliminary site information from the Illinois State Geologic Survey and/or State Water Survey at a minimum is also required. This should be followed by a sufficient number of preliminary borings to evaluate the proposed site and define the study area.

B. Phase Two

The second phase consists of exploratory borings drilled at the site to establish the stratigraphy and general groundwater characteristics. A complex or unpredictable site may require a large number of borings to confirm the stratigraphic information. These borings and soil sampling techniques must comply with the procedures from the American Society for Testing and Materials (ASTM) standards D1586 (split-barrel), D1587 (thin walled tube), and D2113 (diamond core drilling) or an equivalent procedure. The information required in the investigation includes the structural, chemical, physical properties and classification of the subsurface materials in accordance with the United Soil Classification System (USCS).

Phase two requirements for the site-specific geologic and hydrogeologic information include hydraulic conductivities, extent of aquifers and the direction and velocities of groundwater movement as determined by field methods. An investigation of the subsurface conditions over the entire site should be conducted to determine the structural and lithologic characteristics of the site. Use of a site grid pattern to initially determine the boring locations is strongly recommended. The number of borings should be adequate to represent the variability in subsurface characteristics at the proposed site. No less than 20 borings per site will be acceptable when in a simple geologic setting. Additional borings will be required in areas of complex or transitional stratigraphy. Not all of the borings are required to penetrate the entire depth of the uppermost aquifer, but a sufficient number of the borings should be conducted to demonstrate the continuity or discontinuity of the uppermost aquifer and confining layer beneath the site. Wells should be located near each corner of the study area. Additional wells may be located at intermediate points within the study area to determine the hydrogeologic characteristics of the study area. Section 811.315(b)(2) requires hydrogeologic investigation of areas adjacent to but outside of the area occupied by the facility, if necessary.

All borings must be properly plugged upon abandonment of the borehole and the procedures used should be carefully documented. In addition to the requirements of Section 811.316, all borings (i.e. drill holes) and wells shall be plugged and abandoned in accordance with current Agency procedures and applicable sections of the Department of

Public Health (DPH) requirements given at 35 IAC Part 920 Illinois Water Well construction code (1/92). See Part IV of these instructions for well/piezometer construction and abandonment requirements.

C. Phase Three

The third phase includes gathering information to confirm the initial information and to validate the characterization of all known hydrogeologic units by actual field tests. The information required in this part includes identification of zones with high hydraulic conductivity, potential pathways for contaminant migration, final identification of aquifers and their confining layers, identification of any variations in groundwater quality and flow, and identification of any unusual features which may affect hydrogeologic systems. Piezometers should be installed in each hydrogeologic unit to allow testing by the use of rising or falling head techniques and pump tests. Monitoring wells should be installed in each hydrogeologic unit to begin sampling to establish the applicable groundwater quality standards for the site.

A narrative description of the site geology should be prepared which includes a detailed description of each geologic unit found within the study area, including physical and geochemical properties and a description of all water bearing strata within the study area including potentiometric maps, groundwater flow velocities, gradients, and directions.

The application should include geologic cross sections of the permit area illustrating all water bearing strata, water elevations, uppermost aquifer, confining units and all discernable geologic formations.

Documentation of all activities and supporting references should be contained in the permit application. Data should be presented in summary form such as tables and graphs with the row data organized and presented in appendices.

The hydrogeologic site investigation within the application should include, but is not limited to:

- Climatic Conditions
- Regional Geology
- Regional Groundwater
- Structural Characteristics
- Chemical and Physical Properties of Strata
- Soil Characteristics
- Hydraulic Conductivities
- Vertical Extent of Aquifers
- Direction and Rate of Groundwater Flow
- Characterization of Potential Pathways
- Hydrodynamic Dispersion
- Correlation of Stratigraphic Units
- Petrographic Features
- Identification of Zones with
- High Hydraulic Conductivity
- Concentrations of Chemical Constituents

In the Groundwater Below the Unit

- Characterization of Variations in the Groundwater Quality and Flow
- Identification of Unusual Features

D. General Comments

A general three-phase investigation is suggested but, in order to allow for flexibility in conducting the studies, a performance standard was developed as Section 811.315(f) allowing the applicant to select an alternative approach. However, the information must be collected in a systematic manner that is equal to or superior to the investigation procedures discussed in this section.

II. <u>GROUNDWATER QUALITY</u>

The owner or operator is required to determine groundwater quality spatially throughout the "uppermost aquifer" within the study area; characterize the seasonal and temporal, naturally and artificially induced variations in groundwater quality; include in the application an evaluation of the background concentrations; and identify each constituent monitored. Proper identification of the "Uppermost Aquifer" is therefore essential before proceeding with the installation of a groundwater quality monitoring system.

A. Uppermost Aquifer

"Aquifers" as defined in Part 810 means saturated (with groundwater) soils and geologic materials which are sufficiently permeable to readily yield economically useful quantities of water to wells, springs, or streams under ordinary hydraulic gradients and whose boundaries can be identified and mapped from hydrogeologic data. [Section 3(b) of the Illinois Groundwater Protection Act (415 ILCS 55/3) (from Ch. 111 1/2, par. 7453).]

The "Uppermost Aquifer" means the first geologic formation above or below the bottom elevation of a constructed liner, or waste where no liner is present, which is an aquifer, and includes any lower aquifer that is hydraulically connected with this aquifer within the facility's permit area.

Groundwater within the uppermost aquifer must be classified as Class I, II, III or IV by the owner or operator in accordance with the criteria of 35 IAC Part 620.

The identification of the hydrogeologic conditions within the study area are essential to the definition of uppermost aquifer. Distinctions between the hydraulic properties of the units shall be supported by insitu testing as required during Phases 2 and 3 of the hydrogeologic investigation.

B. Establishment of the Applicable Groundwater Quality Standards

The applicable groundwater quality standards for the facility are the background concentrations determined for each parameter pursuant to 811.320(d).

The background concentrations shall be based on the chemical analysis of groundwater samples taken from an appropriate number of wells within the study area at least quarterly for one year, resulting in a minimum of 4 samples per parameter per well. The main objective of gathering background is to determine existing groundwater quality throughout the uppermost aquifer upgradient and below the unit. It is not required that all test wells be utilized to achieve this goal, however a multi-level monitoring system is usually necessary. Variations in background groundwater quality shall be determined within the three dimensional limits of the study area. The background groundwater parameter list is determined by the following criteria and are given in Attachment 1 to this Appendix:

1. The parameter is a constituent found in leachate; or,

2. The parameter must be monitored in accordance with Section 811.319(a); or,

3. The parameter is expected to be a constituent of the leachate and the Illinois Pollution Control Board has established a standard for the constituent [see Sections 811.315(e)(1)(G)(i) & (ii); or

4. The parameter is included on the list of 51 organic chemicals in drinking water described at 40 CFR 141.40 and any other organic chemical for which a groundwater quality standard or criterion has been adopted pursuant to Section 14.4 of the Act or Section 8 of the Groundwater Protection Act (i.e. Part 620); or

5. Any other constituent which is expected to be in the leachate, that may cause or contribute to groundwater contamination [see Sections 811.315(e)(1)(G)(ii) and 811.319(a)(2)(A)(ii)].

Those parameters from 1-5 above shall always be included in background determinations. However, those parameters represented in point 5 may be excluded if a justification of why it is not expected to be present in the leachate is provided. The justification should include the information from leachate testing as described in Part III.A.6 of these instructions and testing of groundwater monitoring wells downgradient of the existing unit(s).

Statistical tests and procedures shall be employed to establish the background concentrations. Specific requirements for choosing the statistical tests are included in Section 811.320(e). The data needs for the statistical methods considered must be determined and incorporated into the sampling schedule before sampling begins. For statistical purposes, the recommended minimum number of pieces of data for naturally occurring constituents is twenty (20) values. An equal number of samples must be taken from each well to ensure equal weighting. The minimum of one (1) analysis is required for non-naturally occurring constituents, assuming the results are non-detect. However for any non-naturally occurring constituent detected, additional analyses (a minimum of 4) will be necessary to establish the background concentration for that constituent.

The operator must submit a list of the background concentrations and the applicable groundwater standards for the site with the permit application.

If the background concentration for a groundwater constituent exceeds a "Board established standard" as defined in 811.320(a)(3)(B) an adjusted groundwater quality standard is not required. The background concentration is the applicable standard. However, if the owner or operator determines an adjusted groundwater quality standard is appropriate for a constituent, for example in lieu of the established background, the adjusted standard shall be included in the permit application with documentation of the Board decision.

C. Groundwater Monitoring Wells for the Establishment of Background

Monitoring wells should only be installed with proper design, materials, quality control, and sufficient understanding of the geologic and hydrogeologic conditions present on site. See Part IV of these instructions for well construction and abandonment requirements.

Specific requirements include piezometers and groundwater monitoring wells installed in all strata and extending down to the bottom of the uppermost aquifer. Wells should be located near each corner of the study area and near the site boundary in the area of upgradient groundwater flow. The number of sampling points required for establishing background is dependent on the geologic and geochemical complexity of the study area.

D. Sample Collection

Monitoring groundwater quality is a difficult task because of the complex interaction of many factors including site hydrogeology, well construction, sampling materials and methods. Monitoring programs must be designed in such a manner that sources of error or bias are minimized or controlled. A monitoring program must include a carefully designed plan, appropriate sampling protocol, applicable chemical parameters and data evaluation techniques.

The sampling protocol includes methods of development and purging and determination of optimum purge volume. Because the response of a well is controlled by transmissivity of the geologic materials near the well and by the design of the well, each well must be analyzed individually to obtain representative samples prior to sampling.

Samples shall be analyzed for both the dissolved and total concentrations of inorganic parameters during the initial background sampling period. General practice for dissolved concentrations is field filtering prior to preservation through a 0.45 micron membrane filter. The difference between total and dissolved concentrations may vary due to well construction, sampling procedures or natural physical or geochemical processes occurring in the aquifer. If the difference between total and dissolved metals is greater than one magnitude, then both analyses may be required individually for routine monitoring after the establishment of background concentrations at non-MSWLF sites.

III. GROUNDWATER IMPACT ASSESSMENT

The purpose of the groundwater impact assessment is to provide an integrated evaluation of the acceptability of the physical setting and design of the landfill units through contaminant transport modeling. The impacts of leachate seepage from the unit must be addressed (i.e., modeled) in a systematic fashion using the techniques described in 35 IAC 811.317 and 812.316.

A written evaluation and analysis of the results of the groundwater impact assessment must be submitted with the permit application. Every application requiring a groundwater impact assessment should include a report addressing the following issues:

A. Groundwater Impact Assessment

This portion of the instructions provides a systematic method to assess the impacts of leachate seepage from the unit, as referenced under 35 IAC 811.317. This is essentially an outline of the modeling process presented as an organized sequence of events, along with a brief description of what the Agency is looking for under each outline topic. Applications that follow this format will facilitate Agency review of the application.

1. Conceptual Model

The conceptual model used to simulate contaminant transport at the facility should be described in the groundwater impact assessment portion of the Groundwater Protection Evaluation report. This should include both a diagrammatic representation of the hydrogeologic setting being modeled, and a narrative description of the concepts or processes of contaminant transport used to assess the impacts of leakage from the unit accounted for in the model.

The diagrammatic representation of the facility should present the hydrogeologic setting in a simplified form, as it will be viewed by the model, versus the more complex features of the site that may have been discovered during the hydrogeologic site investigations but which are not accounted for in the model.

The diagrammatic representation should reflect the entirety of the facility including any existing regulated areas along the length of the flow direction.

The narrative description of the conceptual model should elaborate on the simplifications inherent in modeling the site (e.g., how the hydrogeologic setting can be represented in this simplified manner and still adequately assess the impacts of leakage from the unit).

The narrative description should also discuss and describe the transport processes that are considered as leachate constituents move through each of the hydrogeologic units considered in the model.

This section of the report should allow the Agency reviewer an understanding of exactly which transport processes and site conditions were considered in the model and how these were modeled. It should be readily apparent to the Agency reviewer that the facility is adequately represented in the model and that releases from unit(s) will be adequately simulated.

2. Translation to Mathematical Model

The conceptual model should be translated into a mathematical model, expressed in the same terms as those presented in the transport model user’s guide and/or associated model documentation. This should include equations for each transport process under consideration. These equations should then be coupled into the full mathematical model that will be used to simulate contaminant transport at the facility.

From this point, the Agency reviewer should be able to use the documentation provided with the model to assess the theoretical basis of those equations (see instructions regarding model documentation below). Any modifications or deviations from the generic expression(s) of these equations, as presented in the model documentation, that may be needed for site-specific application of the model should be fully explained and theoretically justified.

3. Model Input Values

The report should provide a narrative description of how model input values (e.g., dispersivities, leachate concentrations, hydraulic conductivities, etc.) were obtained, their applicability to conditions at the proposed site, and an assessment of any uncertainty in the selection of those values. If confidence in the selection of a parameter value is low, particularly for those parameters to which the model is sensitive, conservative values must be used for model input.

4. Seepage from the Unit

The procedures for performing the groundwater impact assessment require the operator to estimate the amount of seepage from the unit using the minimum design standards for slope configuration, cover, liner, leachate drainage and leachate collection, and assuming that the actual design standards planned for the unit apply. For example, if the actual design of the landfill includes leachate withdrawal during the active life and during the entire 100 year period following closure, this can be accounted for in estimates of seepage from the unit.

[Note: Additional financial assurance for leachate collection beyond the minimum design period would be required under the example given above.]

5. Site-Specific Values

Site-specific data should be used for model input whenever possible. Hydrogeologic site investigations should provide most of the input data required for contaminant transport modeling. Sampling strategies should be designed to obtain estimates of both the magnitude and variability of site hydrogeologic characteristics and landfill data. Sensitivity analyses must be performed on these parameters and represent the extremes in the range of data.

If it is not practical to obtain site-specific data, the Agency will consider use of other data for model input provided that the applicant selects reasonably conservative values for model input (i.e., conservative in the sense that the values used generate the greatest predicted contaminant concentrations at or beyond the limit of the zone of attenuation). The validity of any model input that is not based on site-specific data must be well documented and the conservative nature of the selected value must be demonstrated by the sensitivity analysis. If the applicant does not wish to use a reasonably conservative value in the baseline model, then the selected value for that parameter must be based on site-specific data.

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6. Leachate Constituents and Concentrations

The concentrations of chemical constituents in leachate chosen as inputs in performing the groundwater impact assessment must reflect conservative estimates of concentrations expected at the specific facility during the design period. These may be developed in any of the following three ways:

a. Testing leachate from an existing landfill;

i. The samples should be from the subject landfill or from a landfill which would be analogous with regards to expected leachate generation.

ii. The landfill must be sampled to accurately reflect the expected leachate quality, accounting for both spatial and temporal variability (i.e., location in the landfill, the types of waste placed there, and the age of the leachate).

Conservative leachate quality estimates for model input values may be chosen as the maximum value from of the leachate sampling results for a given constituent; or, the same statistical approach used for calculating the background groundwater concentrations should be used to calculate the leachate input values. For instance an upper confidence limit is acceptable if justified.

iii. Testing of actual leachate or synthetic leachate in (b) below must include at a minimum all of those parameters listed in Attachment 1 as expected to be in leachate. Again, the concentrations to be used as inputs shall be calculated with the goal of evaluating the greatest concentrations expected during the life of the landfill. Landfills which do not receive municipal waste must consider actual types of waste received and the expected resultant leachate.

b. Testing a “Synthetic Leachate” (i.e., laboratory derived extract of a representative sample of the waste expected to be disposed in the proposed unit). Once again the overall estimate should consider the greatest expected concentration of each parameter during the design period; or

c. Using the values shown in Attachment 1, pages C-22 through C-24. However, in instances where the proposed unit is not analogous to the landfills from which the Attachment 1values were derived (municipal waste landfills), the Agency may require adjustments to the concentrations and the parameter list.

Note: If actual sampling data show less strength for any parameter shown in Attachment 1 an explanation of why it is expected to be less at the facility being permitted should be included.

7. Surrogate Modeling

Every chemical constituent expected to be present in leachate must be modeled in the groundwater impact assessment. However, surrogate models representing groups of leachate constituents may be used in lieu of modeling each leachate constituent individually. The following procedure should be used if the applicant wishes to conduct surrogate modeling for a given group of leachate constituents:

a. Make a list of the group of leachate constituents to be represented in the surrogate model(s).

b. Tabulate all of the chemical data required for model input for each of those leachate constituents (e.g., leachate concentrations, partitioning coefficients, etc). This table should also include the groundwater standard (AGQS) for each of the leachate constituents to be represented by the surrogate model.

c. Select the most conservative value for each input parameter, from the entire table of values, for use in the surrogate model. The conservative nature of that value must be supported by sensitivity analysis.

d. Using this data, run the surrogate model just as if it were an individual leachate constituent and compare the results to the lowest groundwater standard (AGQS) in the table.

e. The groundwater impact assessment is considered acceptable for those leachate constituents represented by the surrogate model only if the lowest groundwater standard is not exceeded at or beyond the zone of attenuation at any time during the modeling period.

While the surrogate modeling approach can optimize the use of resources, the conservative nature of surrogate modeling can also make it more difficult for the applicant to demonstrate an acceptable groundwater impact assessment. Any combination of surrogate groups and/or individual leachate constituents may be used for groundwater impact assessments, depending on the needs of the applicant, as long as all leachate constituents are modeled.

8. Dispersivity

Model input parameters related to the processes of dispersion are particularly problematic in conducting groundwater impact assessments. Site-specific dispersivity tests are not routinely conducted during the hydrogeologic site investigations. Longitudinal dispersivity values used for model input may be based on site-specific dispersivity tests or on published literature values.

Acceptable sources for evaluating dispersivity include: Gelhar, et.al, 1992 for all distances; Xu and Eckstein, 1995 for distances greater than 100 m; and

Schulze-Makuch, Dirk, 2005 for distances less than 100 m. For the purposes of the groundwater impact assessment, the scale used to determine the determine dispersivity may conservatively be assumed to be ½ the landfill length, in the direction of flow, plus 50 ft to the MAPC well locations. If the property boundary is less than 50ft, then the smaller value must be used.

Transverse dispersivities may be estimated as 1 to 10% of the longitudinal dispersivity value (Gelhar, 1992). Obviously, no single "rule-of-thumb" for selection of dispersivity values from the literature is universally applicable for all models, and, without site-specific data, the Illinois EPA has no way of estimating what the appropriate values for model input might be. Therefore, if literature values are used to estimate dispersivity, reasonably conservative values must be selected for model input. This must be based on sensitivity analysis conducted by the applicant. The more sensitive the model, the greater the degree of conservatism required for model input.

9. Retardation

The process of retardation of leachate constituents may be considered in the groundwater impact assessment. Most contaminant transport models account for this process through the use of distribution or partitioning coefficients (K_d). For inorganic leachate constituents, the applicant may use K_d values from literature sources as input to the model. For organic leachate constituents, K_d values must be calculated according to the formula:

$$K_d = K_{oc} \times f_{oc}$$

where, K_{oc} = the organic carbon partitioning coefficient

f_{oc} = the organic carbon fraction of the medium

Literature values for K_{oc} may be used in these calculations, but the organic carbon fraction of the medium must be based on site-specific sampling results that account for spatial variability. The horizontal and vertical variability of organic carbon content should be determined for each of the hydrogeologic units in which retardation is simulated, with equal weighting for each sampling depth. The lower 95% confidence limit of the organic carbon fraction should then be used to calculate the K_d value for each organic leachate constituent using the formula given above.

10. Table of Values

Summary table(s) of all input parameter values used in the model should be provided in the Groundwater Impact Assessment Report.

11. Flow Model Calibration

The model should be calibrated to observed site-specific field conditions. Generally, it will only be practical to calibrate the model to groundwater flow conditions, particularly at new landfills, since releases to groundwater in the vicinity will not have occurred, or due to lack of knowledge of the nature of previous releases that may have occurred.

12. Sensitivity Analysis

Sensitivity analyses must be conducted to measure the response of the model to change in the values of assigned to major model input parameters, boundary conditions, specified error tolerances, and numerically assigned space and time discretions. The results of the sensitivity analyses must be presented in the groundwater impact assessment report.

Sensitivity analysis should be conducted separately for each model input parameter, boundary condition, etc., using baseline model results (i.e., results of models used to demonstrate an acceptable groundwater impact assessment) as the standard for comparison. Each sensitivity analysis should include the full range of reasonable values or model options potentially considered for use in the model. The range of values investigated should include values both greater than and less than those used in baseline models.

13. Model Reliability

This section of the application should present a narrative discussion of the reliability of the modeling results. How reliable are the results? Discussion of model reliability should include an assessment of model uncertainty, particularly with regard to selection of model input parameter values and the results of the sensitivity analyses conducted. This section should also assess the effects of any deviations from the assumptions inherent in the model (see section on model documentation below).

14. Groundwater Standards

The groundwater standards (AGQS) used to determine the acceptability of the groundwater impact assessment are background concentrations as determined in accordance with 35 IAC 811.320(d). Board established standards are not directly applicable unless they have been adjusted by the IPCB in accordance with requirements of 35 IAC 811.320(b).

15. Concentration vs. Time Profiles

Concentration vs. time profiles should be presented graphically for at least three points within the zone of attenuation for each leachate constituent. Surrogate modeling results may be used to represent corresponding groups of leachate constituents. The selected locations should include points of greatest predicted concentrations at the limit of the zone of attenuation, and 1/3 and 2/3 of the distance between the waste management boundary and the limit of the zone of attenuation.

16. Concentration vs. Distance Profiles

Concentration vs. distance profiles should be presented graphically for each leachate constituent modeled at five year increments covering the entire modeling period. These should be presented along a line parallel to the direction of groundwater flow that intersects the points of greatest predicted concentrations over time. The distance covered should be from the limit of the waste management boundary, to the zone of attenuation or to the point at which the predicted concentration is lower than the detection limit for that leachate constituent, whichever is greater. Surrogate modeling results may be used to represent corresponding groups of leachate constituents.

B. Groundwater Impact Assessment Report

The results of the groundwater impact assessment should be summarized and presented in a report in the application to show that it is acceptable. This should include summary tables and graphs, and well as a narrative discussion of the results. An acceptable groundwater impact assessment must demonstrate that the concentrations of leachate constituents in groundwater will be less than the applicable groundwater quality standards of Section 811.320 at any point at or beyond the limit of the zone of attenuation at any time during operation and within 100 years following closure of the unit.

Raw data must also be submitted to verify the accuracy of the data summaries. Raw data must be submitted as a hard copy: an original and 3 to 4 copies, although if the program outputs are extremely large, a hard copy original w/ the remaining copies on electronic storage may be considered. The applicant must contact the Illinois EPA to discuss this option on a case-by-case basis.

The application should include a clear explanation identifying what each of the raw data points represent and the units in which they are presented. Templates may be presented as an identification guide for highly repetitive data.

C. Model Selection

The selected model must be able to adequately represent and simulate groundwater flow and contaminant transport in the specific hydrogeologic setting at the proposed site, considering such features as water table vs. confined aquifer conditions, porous media vs. fracture flow, homogeneous vs. heterogeneous conditions, dispersivity characteristics, and multi-dimensional components of groundwater flow and contaminant transport.

[Note: Additional guidance on model selection can be found in USEPA’s “Selection Criteria for Mathematical Models used in Exposure Assessments: Groundwater Models.” EPA/600/8-88/075. Office of Health and Environmental Assessment. Washington, D.C. May 1988.]

D. Model Documentation

A contaminant transport model must be utilized in the groundwater impact assessment, in accordance with the requirements of Sections 811.317 and 812.316. Agency review of model acceptability will be gauged on a site-specific basis. Documentation must be provided to show that the selected model is capable of simulating groundwater flow and contaminant transport under the conditions identified in the hydrogeologic site investigations.

1. Software and User Support

   If a commercially available model is utilized, a copy of that model along with full documentation and user support must be provided to the Agency (unless one has been previously provided) directly from the vendor as part of the application.

2. Groundwater Flow & Contaminant Transport

   The applicant must submit documentation that establishes the ability of the model to represent groundwater flow and contaminant transport. This documentation should include validation and verification studies, and any history of it's previous applications. Studies published in professional journals are preferable and should be used for model documentation when possible. When using a model without a great deal of supporting documentation, a greater burden is placed on the applicant in terms of site-specific validation and/or verification of the model.

3. Equations and Numerical Solution Techniques

   The applicant must provide documentation to support the validity of the equations used to simulate groundwater flow and contaminant transport, and the numerical solution techniques. Usually this type of information will be detailed in model documentation supplied from the commercial vendor, along with a copy of the software. If this is not the case, the applicant must supply this documentation with the groundwater impact assessment report. Any modifications or deviations from the generic expression(s) of these equations and solution techniques that may be needed for site-specific application of the model should be fully explained and theoretically justified.

4. Model Assumptions

   The applicant should summarize the set of assumptions that are inherent in the selected model. This should also include an assessment of the applicability of these assumptions to the setting at the facility. Any deviations from these assumptions should be addressed in terms of model reliability.

E. Maximum Allowable Predicted Concentrations

Maximum allowable predicted concentrations (MAPCs) are projected concentrations of leachate constituents in the uppermost aquifer that, when exceeded within the zone of attenuation, indicate potential for exceedance of a groundwater quality standard at the limit of the zone of attenuation. The applicant must use the same calculation methods, data and assumptions used in the groundwater impact assessment to predict the concentration over time and space of all constituents chosen to be monitored in accordance with Section 811.319 at all monitoring points. The predicted values must be used to establish MAPCs for each monitoring point within the zone of attenuation.

MAPCs must be developed for all constituents monitored in accordance with Section 811.319.

This assumes that the applicant has demonstrated an acceptable groundwater impact assessment. In order to obtain predicted concentrations that, when exceeded within the zone of attenuation, would indicate future exceedance of the groundwater standard at zone of attenuation, the applicant must adjust the baseline model until the predicted concentration at the limit of the zone of attenuation just equals the groundwater standard. The manner by which this can be accomplished may vary depending on the contaminant transport model being utilized. There is no single correct method. The most generally accepted method of accomplishing this task is by altering model input to affect an increase in leakage rate. Once a model scenario that accomplishes this task has been developed, this same model should be used to establish predicted concentrations for each monitoring well located within the zone of attenuation. These will be the MAPCs for those monitoring points.

If modeling for the groundwater impact assessment fails to predict significant attenuation to occur within the zone of attenuation, then the applicant may use the established background concentrations (AGQS) described in Part II.A. of these instructions as MAPCs for monitoring points within the zone of attenuation. For leachate constituents which were not detected during the background sampling period, an Agency approved method detection limit (MDL) or practical quantitation limit (PQL) will be accepted as the MAPC.

F. Updated Groundwater Impact Assessments

The applicant must conduct a new groundwater impact assessment as described above if any of the following changes in the facility or its operation will result in an increase in the probability of exceeding a groundwater standard beyond the zone of attenuation:

1. New or changed operating conditions;
2. Changes in the design and operation of the liner and leachate collection system;
3. Changes due to more accurate geological data;
4. Changes due to modified groundwater conditions due to off-site activity;
5. Changes due to leachate characteristics.

IV. GROUNDWATER MONITORING SYSTEMS

The purpose of the groundwater monitoring system is to assess the success of the design of the facility, to confirm the results of the groundwater impact assessment over time, and to detect any discharge of contaminants from any part of a potential source over the design period. The design period includes the active phase of the operation of the unit and the post closure care period.

The groundwater monitoring system is the network of groundwater monitoring wells established within and at the edge of the zone of attenuation in accordance with Sections 811.318 and 811.319. Assuming a zone of attenuation of 100 ft. from the edge of the waste, the majority of the wells (MAPC wells) must be located at 50 ft or less from the edge of the waste. A minimum of one (1) well (AGQS or Compliance Boundary well) must be located 100 ft from the edge of the waste, or at the property boundary, if closer.

The monitoring system will monitor all potential sources of discharges within the facility, including all waste disposal units and leachate collection and storage systems. The wells must be located in zones identified during the investigation phase that could serve as contaminant migration pathways. The groundwater monitoring wells must be capable of yielding samples of a sufficient quantity for the completion of the required analysis.

The water quality will be statistically compared to the established background concentrations over time. Wells must be installed hydraulically upgradient and downgradient from the facility. All wells must be screened to access groundwater from a specific interval. The number and location of the monitoring wells is determined on a site specific basis. The Agency recommends using a hypothetical liner failure combined with the advective-dispersive calculation to determine plume dimensions to justify well spacing.

A. Modeling for Well Spacing

The applicant may use contaminant transport modeling to design a groundwater monitoring program, or to demonstrate the adequacy of an existing program.

1. Criterion for Acceptability

The groundwater monitoring well system should be capable of detecting a contaminant plume that exceeds the groundwater standard by the time it would reach the limit of the zone of attenuation. Contaminant transport modeling must demonstrate that the proposed monitoring system has a reasonable chance of meeting this goal.

2. Modeling Procedures

a. Attenuation within the aquifer should not be considered in the model.

b. A small areal source (e.g., 1 sq. meter), located near the downgradient boundary of the potential leachate source area, should be used to simulate the effect of a tear in a synthetic liner, or a crack or fissure in a clay liner.

c. Other reasonable failure scenarios may be used as needed to affect a significant release from the unit.

d. If a plume is modeled, a contaminant plume is defined as a specific concentration contour with a downgradient boundary near, but not at, the zone of attenuation. The specific concentration used to define the plume is not consequential, as long as the plume width is defined by the same concentration. Maximum allowable well spacing is then determined by the predicted width of the plume at 50 ft from the waste boundary.

e. If efficiency is modeled, a 99% efficiency is the goal.

B. Monitor Well Construction

The application must provide detailed documentation of the monitoring well and piezometer construction. Casing and screen material must be inert to avoid contributing contamination or causing interference with the analysis of the water sample. Teflon, Stainless Steel 316, and Stainless Steel 304 are recommended as durable, corrosion-resistant materials. Since plastic (PVC) may have a significant effect on the ability to obtain a "representative" sample, the Agency only allows the use of plastic casing for piezometers or through the unsaturated zone for wells.

The well casing must have a minimum inside diameter of not less than two inches. The joints must be flush threaded and water-tight. The well casing must be straight and free of any obstructions. The wells must be screened at appropriate intervals to monitor the permeable zones encountered. The well screens must be not less than 2 feet or more than 10 feet in length. The slot size must be compatible with the grain size of the annular filter pack to prevent silting in by the surrounding formation. Screens must be continuous slot wire wound or machine cut.

Annular space along the screened section must be packed with silica sand or gravel 2 ½ - 3 times larger than the 50% grain size of the zone being monitored. The top of the sand pack shall not extend past 2 feet above the well screen. A clean, well rounded and uniform (mainly one grain size) filter pack is preferred; however, in sand and gravel deposits where cave-ins occur, the natural sand and gravel is acceptable.

To insure that the sealing material does not interfere with the screen, the filter pack shall extend two feet above the top of the well screen. The sealing material above the filter pack must prevent the migration of fluids from the surface and between subsurface sediments. A pure bentonite seal must be installed above the filter pack and extend no less than 2 feet above the filter pack extension. Pure bentonite should be hydrated at the surface and installed from the bottom of the annular opening upward in one continuous operation using a "tremie tube" or "tremie pipe". A sealing material of expanding cement grout with 1% bentonite, by weight, added to the appropriate amount of water before being added to the cement or 5% bentonite, by volume, added to the cement before mixing with water should be used above the bentonite seal. This also should be installed using the tremie method as formerly described. No quick setting cements that contain additives will be allowed. Any bentonite used must also be free of additives.

At the surface, a concrete cap shall be installed around the protective casing. The cap shall extend below the frost zone and slope away from the well casing on the surface so that rain water will be diverted away from the well casing and bore hole. The portion of the well casing above the ground surface must be protected to minimize damage or tampering. These precautions should include a locking cap. Wells must be identified by a monitor point number, using an Agency approved designation. The location of the wells in relation to the waste management area must be located on a topographic map (scale 1"=200' or larger). This map must include county, site name, township, range, and section.

The Illinois Department of Public Health Water Well Construction Code, 77 IAC Part 920 (effective 1/1/92) contains minimum standards for groundwater monitoring wells and piezometers. The code also includes reporting well construction and decommissioning to the IDPH within specified timeframes. Alternate designs may be submitted for Agency approval in writing, prior to installation.

C. Sampling Frequency

The monitoring programs consist of routine quarterly and semi-annual lists of parameters. The quarterly and semi-annual parameter lists are found in Section 811.319(a)(2) and (3).

D. Monitor Well Development

After the monitor well has been constructed and allowed to sit for 24 hours, the well must be adequately developed to minimize turbidity within the well and increase flow into the well. To be effective, development procedures require reversal or surges in flow to avoid bridging by particles, which is common when flow is continuous in one direction. This action can be created by using surge blocks, bailers, or pumps. An insitu test must be conducted for each monitor well to determine hydraulic conductivity near the well. The test method (i.e., slug tests, pumping tests) used, calculations and interpretations must be submitted to the Agency. The tests shall be conducted after the well is properly developed.

E. Monitor Well Plugging and Abandonment

Monitoring wells and borings, which are no longer being used, must be properly plugged/sealed and abandoned so that groundwater is protected from surface contamination and potential degradation between stratigraphic units. Procedures which have been developed for guidance in the plugging of monitoring wells are based upon geologic materials and well construction.

All open drill holes must be marked and covered until properly abandoned. Soil borings and test wells are to be plugged upon abandonment of the borehole using the procedures for monitoring wells if they penetrate a water bearing sediment. Those that do not contain water can be filled from the surface, as long as methods are used which ensure that pure cement slurry will reach the bottom of the hole. There may also be abandoned drinking water wells onsite that should be plugged because they can serve as routes for contamination.

When a well has been damaged, such as when the casing has been broken off at or below the surface, it should be bailed to remove any material that entered it before plugging is initiated. The depth of the well should be checked to detect the presence of any obstructions that may interfere with sealing. Any obstructions in the well must be retrieved and the well casing and screen removed prior to plugging. The operator is to restore the areas around the drill holes to their original condition.

Accurate records of plugging and abandonment procedures should be maintained for future reference and documentation for closure. See Part B. Monitor Well Construction in this Part.

F. Monitoring Well Construction Reports

Boring logs must be completed for all test borings and monitor wells. Also, all test boring should be continuously sampled and have the elevations surveyed and reported in relation to Mean Sea Level (MSL) to the nearest 0.01 ft. Well completion ("as-built") diagrams which have been surveyed by a registered surveyor must be submitted to the Agency on Agency forms, as in Attachments.

A scale drawing showing monitor well and test boring locations must be submitted to the Agency. The drawing should also show buildings, roads, the site's property boundary, permitted waste boundary and currently filled area. In addition, a Cartesian coordinate grid for the site should be established, shown on the map, and all test borings and monitor wells should have coordinates surveyed and reported.

All necessary permits, licenses, and reporting regarding well construction, operation and plugging must be in accordance with the requirements of the Illinois Department of Public Health and the Illinois Department of Mines and Minerals if applicable.

V. GROUNDWATER MONITORING PROGRAM

A groundwater monitoring program must be included in the application. The program must include a sampling and analysis plan (SAP) describing the procedures for collecting and analyzing data in accordance with Section 811.318(e). The program must also describe the parameters and frequency of sampling for each location and the evaluation method(s) of data.

A. Parameters

For new facilities establishing background in accordance with Section 811.320(d), groundwater samples will be collected and analyzed for the parameter list given in Attachment 1 to this appendix at a minimum frequency of quarterly for one year, plus any additional parameters which may be unique to the waste handled by the facility or site conditions.

Parameters for routine and semi-annual monitoring will be proposed by the applicant in accordance with Section 811.319(a)(2) and (3).

B. Sampling Frequency

Routine parameters, listed under Section 811.319(a)(2) will be sampled and analyzed quarterly. The parameters listed under Section 811.319(a)(3) will be sampled and analyzed semi-annually.

C. Quality Assurance/Quality Control (QA/QC)

A sufficient number of QA/QC samples will be prepared for evaluating field, transport and laboratory procedures. The samples such as equipment, trip and lab blanks must be fully described in the facility sampling and analysis plan. The Agency recommends QA/QC for groundwater sampling and analysis as described in SW846.

D. Statistics

All groundwater sample results will be evaluated to determine if an increase in a constituent has occurred in accordance with Section 811.319(a)(4). Statistical methods must meet the minimum standards of Section 811.320(e).

E. Groundwater Quality Reporting

Groundwater data will be reported in a format prescribed by the Agency within the following time periods:

Sampling Quarter	Report Due Date
January-February (1st)	April 15
April-May (2nd)	July 15
July-August (3rd)	October 15
October-November (4th)	January 15

A statistical increase is any exceedence of the established AGQS (see B.2, B.3 and E.4). Any statistical increase is subject to the confirmation procedures described in Section 811.319(a)(4). A confirmation of a statistical increase must be addressed through the application process to the Illinois EPA. The application must either establish an alternate source or propose groundwater assessment.

VI. ELECTRONIC REPORTING OF DATA

The Illinois EPA requires groundwater and leachate data be submitted in electronic format in accordance with http://www.epa.state.il.us/land/waste-mgmt/groundwater-monitoring.html.

REFERENCES

1. Scientific/Technical Section, 1990, Response to Additional Comments on proposed Part 807, and 810 through 815, Illinois Pollution Control Board.

2. ASTM, 1990, Design and Installation of Ground Water Monitoring Wells in Aquifers, Designation: D 5092-90.

3. USEPA, 1991, "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells", EPA/600/4-89/034, Office of Research and Development, Washington DC.

4. IEPA, 1991, Groundwater Quality Standards, 35 Ill. Adm. Code 620, R89-14 (Rulemaking), Proposed Rule, Second Notice, Illinois Pollution Control Board.

5. USEPA, 1986, "RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD)", OSWER-9950.1.

6. USEPA, 1986, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", EPA Publication SW846 (Third Edition and updates), Document number PB89-148076.

7. Gelhar, L.W, C. Welty and K.R. Rehfeldt, 1992, “A Critical Review of Data on Field-Scale Dispersion in Aquifers”, Water Resources Research, Vol. 28, No. 7, pp 1955-1974.

8. Xu, M. and Y. Eckstein, 1995, “Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Field Scale”, Ground Water, Vol. 33, No. 6, pp 905 – 908.

9. Schulze-Makuch, Dirk, 2005, “Longitudinal Dispersivity Data and Implications for Scaling Behaviour”, Ground Water, Vol.43, No. 3, pp 443-456.

Attachment 1 to Appendix C
Chemical Parameters Associated with Putrescible and Chemical Landfills

Parameters	General Predicted Values for Municipal Solid Waste Landfills* ug/l	40 CFR Appx. II	Basis for Inclusion on List Expected in Leachate	35 IAC Part 620	35 IAC Part 302	40 CFR 141.40	4- CFR** Appx. I
1,1,1,2-tetrachloroethane		X				X	51
1,1,1-trichloroethane	2,000	X	X				55
1,1,2,2-tetrachloroethane	400	X	X	X		X	52
1,1,2-trichloroethane	630	X	X			X	56
1,1-dichloroethane	3,000	X	X			X	33
1,1-dichloroethene (or ethylene)		X		X			35
1,1-dichloropropene		X				X	
1,2,3-trichlorobenzene						X	
1,2,3-trichloropropane	500	X	X	X		X	59
1,2,4-trichlorobenzene		X				X	
1,2,4-trimethylbenzene						X	
1,2-dibromo-3-chloropropane		X		X		X	28
1,2-dichloroethylene (or ethene)							
cis-1,2-dichloroethylene	500	X	X	X	X		36
trans-1,2-dichloroethylene	1,000	X	X	X	X		37
1,2-dichloroethane	4,000	X	X	X			34
1,2-dichloropropane	200	X	X	X		X	38
1,3,5-trimethylbenzene						X	
1,3-dichloropropane		X				X	
1,3-dichloropropene						X	
cis-1,3-dichloropropene		X				X	39
trans-1,3-dichloropropene		X				X	40
1,4-dichloro-2-butene							32
1,4-diflurobenzene							
2,2-dichloropropane		X				X	
2,4,5-tp (silvex)		X		X	X		
2,4-dichlorophenoxyacetic acid (2,4-D)		X		X	X		
2,4-dimethyl phenol	30	X	X				
1-butanol phenol	400		X				
1-propanol	200,000		X				
2-butanone (methyl ethyl ketone)	8,000	X	X				47
2-chloroethyl vinyl ether	1,100		X				
2-chloronaphthalene	100	X	X				
2-hexanone	500	X	X				42
2-propanol	20,000		X				
4-bromofluorobenzene							
4-methyl-2-pentanone	700	X	X				49
4-nitrophenol	40	X	X				
acetone	5,000	X	X				16
acrolein	400	X	X				
acrylonitrile		X					17
alachor				X			
aldicarb				X			
aldrin		X			X		
aluminum	6,000		X				
ammonia (as N)	600,000		X				
antimony	9,000	X	X	X			1
arsenic	100	X	X	X	X		2
atrazine				X			
barium	10	X	X	X	X		3
benzene	500	X	X	X			18
benzo(a)pyrene		X		X			
beryllium		X		X			4
bicarbonate							
BOD	5,000,000		X				
boron	200		X	X			
bromobenzene			X			X	
bromochloromethane		X	X			X	19
bromodichloromethane		X	X			X	20

bromoform		X	X			X	21

Parameters	General Predicted Values for Municipal Solid Waste Landfills* ug/l	40 CFR Appx. II	Basis for Inclusion on List				
			Expected in Leachate	35 IAC Part 620	35 IAC Part 302	40 CFR 141.40	4- CFR** Appx. I
bromomethane	400	X	X			X	43
butanol	15,000	X	X				
n-butylbenzene						X	
sec-butylbenzene						X	
butyl benzyl phthalate	150	X	X				
cadmium (total)	100	X	X	X	X		5
calcium	1,200,000		X				
carbofuran				X			
carbon disulfide	6	X	X				22
carbon tetrachloride	400	X	X	X			23
chemical oxygen demand	10,000,000		X				
chlordane		X		X	X		
chloride	3,000,000		X	X	X		
chlorobenzene	400	X	X	X		X	24
chloroethane	400	X	X			X	25
bis (2-chloroethoxy)methane	25	X	X				
chloroform	400	X	X			X	26
chloromethane	400	X	X			X	44
bis (chloromethyl)ether	400	X	X			X	
o-chlorotoluene						X	
p-chlorotoluene						X	
chromium (total)	50	X	X	X	X		6
chlorodibromomethane		X				X	27
cobalt	130	X	X	X			7
copper	1,000	X	X	X	X		8
p-cresol		X					
cyanide	300	X	X	X	X		
dalapon							
DDT		X		X	X		
dibromomethane	10	X	X			X	45
m-dichlorobenzene		X				X	
o-dichlorobenzene		X				X	30
p-dichlorobenzene		X		X			31
dichlorodifluoromethane	450	X	X			X	
dichloromethane		X		X		X	46
dieldrin		X			X		
diethyl phthalate	200	X	X				
dimethyl phthalate	60	X	X				
di-n-butyl phthalate	150		X				
dinoseb		X		X			
endothall		X		X			
endrin		X	X				
ethyl acetate	130		X				
bis(2-ethylhexyl)phthalate	400		X				
ethyl methacrylate		X					
ethylbenzene	500	X	X	X		X	41
ethylene dibromide (EDB)		X		X		X	29
fluoride				X			
fluorotrichloromethane						X	
gross alpha (pCi/l)				X			
heptachlor		X		X	X		
heptachlor epoxide		X		X	X		
hexachlorobutadiene		X				X	
hexachlorocyclopentadiene		X		X			
iodomethane		X		X	X		48
iron	500,000		X	X	X		
isophorone	2,500	X	X				
isopropylbenzene						X	
p-isopropyltoluene						X	
lead	500	X	X	X	X		9
lindane	025		X	X	X		
magnesium	500,000		X				
manganese	20,000		X	X	X		

Parameters	General Predicted Values for Municipal Solid Waste Landfills* ug/l	40 CFR Appx. II	Basis for Inclusion on List Expected in Leachate	35 IAC Part 620	35 IAC Part 302	40 CFR 141.40	4- CFR** Appx. I
mercury	10	X	X	X			
methoxychlor				X	X		
methylene chloride (Chloromethene)	46	X	X				
naphthalene	75	X	X			X	
nickel	1,000	X	X	X			10
nitrate				X	X		
nitrobenzene	120	X	X				
oil (hexane-soluable or equivalent)					X		
parathion		X			X		
pentachlorophenol	400	X	X	X			
pH	5-9		X	X			
phenanthrene	3	X	X				
phenols	5,000	X	X	X	X		
picloram				X			
polychlorinated biphenyls		X		X			
potassium	500,000		X				
n-propylbenzene						X	
radium				X			
selenium	50	X	X	X	X		11
silver	50	X	X	X			12
simazene							
sodium	1,500,000		X	X			
strontium - 90				X			
styrene		X		X		X	50
sulfate	1,000,000		X	X	X		
TDS	10,000,000		X	X	X		
TOC	6,000,000		X				
tert-butylbenzene						X	
tetrachloroethylene	300	X	X	X		X	53
tetrahydrofuran	1,000		X				
thallium	500	X	X	X			13
tin	2,000	X	X				
toluene	2,000	X	X	X		X	54
toxaphene	2	X	X	X	X		
trichloroethylene(or ethene)	400	X	X	X			57
trichlorofluoromethane	150	X	X				58
tritium				X			
vanadium	30	X	X				14
vinyl chloride	60	X	X	X			61
vinyl acetate							60
xylenes (total)	300	X	X	X			62
m-xylene	200	X	X			X	
o-xylene						X	
p-xylene						X	
zinc	20,000	X	X	X			15

* References
1. Gasper, James A. and Jeff M. Harris, Management of Leachate from Sanitary Landfills (for Browning Ferris Industries).

2. Dolan, David, Helen Keougl, R.L. O'Hara and Kevin O'Leary, 1991, A Comparison of Chemical Constituents in Industrial Hazardous Waste Municipal Waste Landfill Leachates (for Waste Management of North America, Inc.).

** From 40 CFR Part 258 Appendix I & II numbered as presented in Federal Register, Vol. 56, No. 196, October 9, 1991 pages 51032-51038.