Volumetric Clearance for Disposal [VCD]

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Assessment of the Radiological Effects from the Disposal at Middle Point Landfill of Materials that are Cleared from Licensed Radioactive Material Status

Revision 2

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ATG Inc.

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ABSTRACT

Each person, the ground directly beneath that person's feet, as well as the large majority of materials that are routinely handled during each day, all contain detectable concentrations of radioactive materials. Given this, it should be no surprise that much of the waste that we send for landfill disposal, each week, contains radioactive material. In fact, the very ground, upon which the landfill sits, itself contains significant quantities of radioactive materials.

Many ordinary materials that are utilized in the vicinity of licensed radioactive materials are sometimes assigned the status of licensed radioactive materials, and controlled as such, due to possible contamination with small quantities of licensed materials (i.e., residual radioactivity). Similarly, each day, thousands of radioactive material licensees (e.g., hospitals, universities, industrial and nuclear facilities) clear potentially affected persons and materials from this status based upon commonly accepted threshold values of detectable residual radioactivity.

This assessment bounds the maximum plausible radiological effects from the clearance of materials from licensed radioactive material status for landfill disposal, as described herein. It specifically establishes: (1) volumetric clearance criteria for potential residual radioactivity that may be contained within candidate materials; and (2) associated controls that are required to ensure the adequacy of the characterization and disposal processes. The clearance criteria are based on disposal of the successfully cleared materials at Middle Point Landfill in Murfreesboro, TN.

The clearance criteria and associated controls are established such that the plausible Maximally Exposed Individual (MEI) does not receive a dose exceeding the NCRP-91 "negligible individual risk level" of one (1) mrem per year. Presented herein are the assessments of plausible exposure scenarios associated with this specific clearance activity (e.g., the shallow burial disposal model for long-lived isotopes, handling and transport of short-lived isotopes, etc.).

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1.0 Purpose

This assessment bounds the maximum plausible radiological effects from the clearance of materials from licensed radioactive material status for landfill disposal, as described herein. It specifically establishes: (1) volumetric clearance criteria for potential residual radioactivity that may be contained within candidate materials; and (2) associated controls that are required to ensure the adequacy of the characterization and disposal processes.

2.0 Scope

This assessment applies to volumetric clearance activities In Accordance With (IAW) the criteria and associated controls specified herein, as approved by the Tennessee Division of Radiological Health (TDRH) through Radioactive Materials License R-73024-I05.[1] The clearance criteria are based on disposal of the successfully cleared materials at Middle Point Landfill in Murfreesboro, TN. The assessment assumes adequate implementation of the controls listed in Section 5.0.

3.0 Background

3.1 Residual Radioactivity

Each person, the ground directly beneath that person's feet, as well as the large majority of materials that are routinely handled during each day, all contain detectable concentrations of radioactive materials. Given this, it should be no surprise that much of the waste that we send for landfill disposal, each week, contains radioactive material. In fact, the very ground, upon which the landfill sits, itself contains significant quantities of radioactive materials. In most cases these low concentrations of radioactive materials are designated as Naturally Occurring Radioactive Material (NORM), radioactive materials that are not licensed or tracked by the Nuclear Regulatory Commission (NRC), or through one of its agreement state programs.

Many ordinary materials that are utilized in the vicinity of licensed radioactive materials are sometimes assigned the status of licensed radioactive materials, and controlled as such, due to possible contamination with small quantities of licensed materials (i.e., residual radioactivity). Similarly, each day, thousands of radioactive material licensees (e.g., hospitals, universities, industrial and nuclear facilities) clear potentially affected persons and materials from this status based upon commonly accepted threshold values of detectable residual radioactivity.

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[1] Prior to approval from TDRH, this assessment serves as the technical basis for the proposed amendment to the subject license.

3.2 Established Clearance Guidance

In the case of a facility where licensed activities will no longer be conducted (i.e., license termination) a great deal of NRC regulation and guidance (e.g., 10CFR20.1401 through .1406, NRC Reg. Guide 1.86, FC 83-23, NUREG/CR-5849, MARSSIM, DG-4006, 63FR64132, 64FR68395, etc.) has been provided to establish the monitoring and clearance criteria for the potentially affected materials and grounds. License termination activities are a legal responsibility of the NRC, which occur on a relatively frequent basis. The NRC could not conduct these routine activities without implementing well established requirements for clearance of potentially affected materials associated with license termination events. Therefore, adequately well defined guidance has been provided for the subject license termination activities, but is not necessarily explicitly approved for clearance of other identical materials, which could have plausibly been affected by licensed activities (e.g., could potentially contain residual quantities of licensed radioactive materials), but are not being cleared as part of the license termination process.

On a less well defined scale, the NRC has provided, or been involved in providing, regulatory guidance (i.e., not regulation) for clearance of materials that could plausibly contain residual radioactive material, but are not being cleared as a part of a license termination process. The aforementioned Policy and Guidance Directive FC 83-23, "Guidelines for Decontamination of Facilities and Equipment prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," applies to both license termination activities, and more routine clearance activities. ANSI/HPS N13.12-1999, "Surface and Volume Radioactivity Standards for Clearance," as well as NUREG-1640, Radiological Assessments for Clearance of Equipment and Materials from Nuclear Facilities," have been published, presenting reasonably well-defined methods for developing and implementing clearance criteria for materials not being cleared as part of the license termination process.

Despite these attempts at providing uniform guidance for the subject clearance activities, most licensees continue to implement clearance activities based upon approved criteria specific to each individual license, which is most commonly based upon the antiquated criteria of from Reg. Guide 1.86 or FC 83-23 (i.e., by "antiquated" it is meant that these criteria have been superceded in their license termination applications). Furthermore, no regulation explicitly authorizes clearance activities for licensed residual radioactivity within solid materials that are not associated with the license termination process. However, it should be noted that, until recently, there was no 10CFR20.1401 through .1406 regulations explicitly authorizing clearance of residual radioactive materials in the license termination process. Therefore, for many years the NRC established the precedent of authorizing case-by-case clearance criteria outside of explicitly approved regulation.

There is no technical basis for classifying materials differently because they are not materials being cleared as part of the license termination process. Similarly, except through the precedent of their piecemeal inclusion in individual licenses, the antiquated surface contamination clearance requirements of license termination guidance documents Reg. Guide 1.86 or FC 83-23 are in no way more legally applicable, nor, in any case, more technically correct than the more recent clearance requirements established in license termination documents: NUREG-1575, "MARSSIM;" DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination;" or Federal Register 63FR64132 and 64FR68395, "Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination."

Based upon the NRC precedent of establishing case-by-case clearance criteria in individual licenses, this assessment provides the technical basis for a specific disposal model with associated controls for one such case-by-case criteria for clearance of materials that could contain residual licensed radioactive materials.

4.0 Assessment Methodology

4.1 Primary Standard

The clearance criteria and associated controls are established such that the plausible Maximally Exposed Individual (MEI) does not receive a dose exceeding the NCRP-91 "negligible individual risk level" of one (1) mrem per year. Presented herein are the assessments of plausible exposure scenarios associated with this specific clearance activity (e.g., the shallow burial disposal model for long-lived isotopes, handling and transport of short-lived isotopes, etc.).

4.2 The Disposal Scenario

The radiological assessment of the maximum dose due to disposal was performed using the RESRAD 6.0 computer code with the landfill-specific model in the most conservative exposure scenarios plausible as defined in NRC Guidance and Policy Directive PG-8-08, "Scenarios for Assessing Potential Doses Associated with Residual Radioactivity," a copy of which is included as Appendix J.

4.2.1 RESRAD

The RESRAD computer code is utilized to calculate doses, risks, and guidance values for residual concentrations of radionuclides in material. The code was designed by the Department of Energy (DOE) to demonstrate compliance with DOE Order 5400.5.

The radiation dose, as determined by RESRAD, is the Total Effective Dose Equivalent (TEDE) from the sum of external radiation plus the Committed Effective Dose Equivalent (CEDE) from internally deposited radionuclides. The critical population group is a relatively small, homogeneous group that is representative of those individuals in the population expected to receive the largest dose.

PG-8-08 specifies three (3) scenarios for exposure pathways. Scenario A, represents typical exposures associated with the use of a contaminated site for light industrial purposes. Scenario B is intended to represent a homeowner, who spends most of the time on-site, but works at an off-site location. Scenario C represents the reasonable maximally exposed resident farmer, who resides, works, grows crops, and raises livestock on site.

Doses were calculated using Scenario A (i.e., Industrial scenario) for the first 30 years after material placement (i.e., a very conservative estimate of the institutional control period). Doses were also calculated after 20 years (i.e., providing a conservative ten (10) year overlap) using Scenario C (i.e., Resident Farmer), which is generally considered to be the most conservative scenario, since it bounds the other scenarios in terms of total time spent in proximity to the source and includes garden and livestock consumption. Because this scenario is based on "prudently conservative" assumptions that tend to overestimate potential doses, use of this scenario results in estimated doses that will be greater than exposure to future residents. The highest dose per year for each isotope was used to determine the clearance limit for that isotope (e.g., the clearance limit for ^{60}Co is based on the TEDE to the MEI at 20 years in the Resident Farmer scenario, whereas the clearance limit for ^{234}U is based on the TEDE to the MEI at about 300 years in the Resident Farmer scenario). Copies of the graphic outputs for TEDE for each isotope at its clearance limit, in each scenario, are included in Appendices B and C.

RESRAD input parameters for the subject calculations, as well as their bases, are provided in Appendices D, E, and F, and include calculations using site specific material characteristics, as determined from the Hydrogeological Report for the Proposed Middle Point Sanitary Landfill Expansion, a copy of which is included as Appendix H. Where site specific information was not available, NRC recommended parameters, from PG-8-08, were utilized. Where neither site specific nor PG-8-08 recommendations were available, RESRAD default parameters were used.

4.2.2 Specific Disposal Model

Waste disposal at Middle Point Landfill is modeled from information obtained in Appendices G and I. The site specific information is used to model how surveyed materials would be disposed and mixed with other wastes.

BFI currently receives approximately 7,000 cubic yards of uncompacted waste per day for disposal at Middle Point Landfill. In order to prepare a disposal location for the waste, BFI constructs a series of cells with dimensions 125' long x 100' wide x 40' deep. Each of these cells is comprised of ten individual layers, or "lifts", consisting of 3.5 feet of compacted waste and 0.5 feet of material. Each cell is located immediately adjacent and tied into the next, creating a row of cells.

The cells are filled, one (1) layer at a time, to a depth of approximately four feet (4') after compaction, including a minimum six inch (6") cover of material. The next cell then begins the filling process. This process is repeated until all cells are filled to a four foot (4') level and then waste placement begins again in the first cell with a second four foot (4') level of waste. This process continues until all cells are filled to the 40' height.

As stated above, Middle Point Landfill receives approximately 7,000 cubic yards of waste per day for disposal. At 27 ft^3 per cubic yard and 20 work days per month, the landfill receives 3.78 $(10)^6$ ft^3 per month or 1.07 $(10)^5$ m^3 per month. Given the 6:1 compaction ratio, and the 1.63 g/cm^3 density for compacted material, this results in 2.91 $(10)^{10}$ g per month or 6.4 $(10)^7$ lbs. per month. Assuming, based upon landfill operations, that the 8 $(10)^5$ lbs./month of cleared material is mixed relatively evenly throughout the lift, then the resulting distribution factor equals 8 $(10)^5$ lbs. per month of cleared material divided by 6.40 $(10)^7$ lbs. per month of general waste, or 0.0125 (i.e., 1/80).

During the five (5) year period of time, during which clearance activities are modeled, the landfill will receive approximately 4.10 $(10)^7$ ft^3 (compacted) of industrial waste. Since the volume of each waste lift is approximately 44,000 cubic feet (125' x 100' x 3.5'), roughly 1,000 lifts will be filled. Assuming each cell consists of ten (10) lifts, the material will be disposed in a ten (10) cell by ten (10) cell area that is approximately 125,000 ft^2 in size (125' x 100' x 100).

These values are used in developing the inputs into the dose assessment models. Individual radionuclide concentrations were based upon a minimum factor of ten (i.e., the uniform contaminated zone concentration for each isotope was input as 0.10 times the clearance limit for that isotope). This provides an additional safety margin of a factor of eight (8) to account for other licensed clearance activities that could be sending material to the same landfill.

4.3 Short-Lived Isotope Exposure Scenarios

Short-lived isotopes (i.e., those with a half-life of less than six (6) months) are not a disposal scenario concern, and are not available to be modeled through the RESRAD computer code. Given the maximum half-life of six (6) months, and the minimum credited institutional control period of 20 years, the concentration of these isotopes would be reduced by 40 half-lives of decay (i.e., a factor of $9.09\ (10)^{-13}$) prior to the earliest modeled occupation by "Resident Farmer." Many short-lived isotopes could still present external and internal radiological hazards during interim handling and storage. Assessment of these hazards are presented herein.

4.3.1 External Dose Assessment

While not a long-term concern in the disposal scenario, there could be external radiation hazards due to transportation, as well as industrial storage and handling of materials with residual concentrations of short-lived isotopes. To safely bound this concern, Section 5.0 contains controls limiting allowable exposure-rate external to the conveyance to a level of ten microRoentgen (10 μR) per hour above ambient radiation levels. This includes the total contribution of: short-lived isotopes; long-lived isotopes modeled as described in Section 4.2; and NORM isotopes described in Section 4.4. Therefore, the total external dose hazard associated with interim storage and handling is bounded by the subject control.

Assuming a 2,000 hour work year and a conservative assumption that less than 5.0 % of the work-time is spent directly adjacent to the cleared material, then a nominal occupancy of 100 hours per year is established. This limits the MEI to less than one (1) mrem per year of exposure due to this pathway.

4.3.2 Internal Dose Assessment

In addition to the total external exposure controls described in Section 4.3.1, Appendix A, Table A-2, lists a limit for short-lived isotopes based upon the most conservative of either their ingestion or inhalation Annual Limits on Intake (ALIs) as listed in SRPAR 1200-2-5-.161, Schedule RHS 8-30, Table I, Column 1 or 2, respectively, as compared with long-lived isotopes with similar ALIs.

For example, ^{58}Co is a short-lived isotope with ALIs of 1,000 μCi and 700 μCi, respectively. The long-lived isotope ^{60}Co has ALIs of 200 μCi and 30μCi, respectively. Therefore, ^{60}Co presents a greater internal dose hazard during routine handling than ^{58}Co. Therefore, the Appendix A, Table 2, limit for ^{58}Co, as set at the ^{60}Co limit, is conservatively bounded for this exposure scenario.

4.4 Other Included Isotopes Not Specifically Assessed

As previously discussed, the NORM isotopes (e.g., ^{40}K, and those resulting from the Uranium (i.e., ^{226}Ra) and Thorium Series) exist in detectable quantities within most materials. The subject NORM isotopes are not specifically modeled herein, since they are generally governed under separate regulation. As such, separate regulation-based operational controls are implemented in Section 5.0 to govern handling and disposal of materials containing these NORM isotopes.

5.0 Controls

5.1 Sampling for Hard-To-Detect (HTD) Isotopes

Control: Each customer waste stream will be sampled for a gamma spectrometry analysis, as well as ^{3}H, ^{14}C, ^{55}Fe, ^{63}Ni, ^{90}Sr, ^{99}Tc, ^{129}I, and any other credible Hard-To-Detect (HTD) isotopes that customer process knowledge indicates might be present in the material in significant quantities (i.e., greater than 10% of the Appendix A values). Waste streams contaminated with only HTD isotopes will be sampled for the applicable HTD isotopes IAW the sampling methodology (e.g., number of sample points required) described in NUREG-1575 (MARSSIM).

Basis: The subject control ensures the adequacy of the bulk waste stream scaling factors used for each waste stream, allowing the HTD isotopes that are present to be scaled to the gamma emitting isotopes for each container, such that the HTD isotopic concentrations are bounded within their applicable Appendix A limits for each container. Where no gamma emitting isotopes are available, the MARSSIM sampling requirements ensure that an adequate number of samples are taken to demonstrate compliance with the clearance criteria.

5.2 Characterizing Gamma Emitting Isotopes

Control: Each container, or equivalent counting geometry, will be characterized for credible gamma emitting isotopes of concern IAW the requirements of Section 5.2 of the license application.

Basis: The subject control ensures adequate characterization of each gamma emitting isotope within candidate materials.

5.3 Allowable Activity per Container

Control: Prior to releasing each container, or equivalent counting geometry, the activity concentration in the container for each isotope will be divided by the associated activity concentration limit from Appendix A, Table A-1 and A-2, providing a dose fraction contribution value for each isotope.

For the purpose of this calculation, the detectable gamma emitting isotopes will be based on the characterization from Control 5.2, and the HTD isotopes will be scaled to the most accurate (i.e., combination of highest concentration, energy, and yield) gamma isotope present in that container, using the scaling factors verified in Control 5.1. For waste streams with no gamma emitting isotopes present, the results of the MARSSIM sampling protocol of Control 5.1 will be used.

The sum of each isotope's dose fraction contribution value will be added together. This total dose contribution value will not exceed 3.0 for containers of reasonable flowable materials (e.g., soil, resin, gravel, etc.), with individual isotopes not to exceed 1.5 times their individual dose fraction limits, and neither the sum of the dose fractions nor the individual isotopes will exceed 1.0 for containers of non-flowable materials.

The "Negligible" risk isotopes, as specified in Appendix A, Table A-1 and A-2, are not included in this control. However, "Negligible" risk isotopes are bound by the total specific activity per conveyance limit of Control 5.8.

Basis: The subject control establishes a maximum dose contribution to the model that each container can provide.

5.4 NORM

Control: The activity concentration for natural Radium (i.e., ^{226}Ra and ^{228}Ra) and Thorium (i.e., ^{230}Th and ^{232}Th) isotopes will not exceed 5 ρCi/g above normal concentrations within the subject materials (i.e., unaffected blanks) for the total activity for each element. Although not included in the calculation to demonstrate compliance, progeny isotopes associated with the ^{226}Ra (i.e., Uranium) and Thorium decay series are specifically bounded by this control. Candidate materials will not contain Potassium (K) that has been technically enhanced in the isotope ^{40}K.

Basis: The subject limits are conservatively based upon those provided in 40CFR192.12 and SECY 81-576 for Radium and Thorium, respectively. Potassium that has not been technically enhanced in the isotope ^{40}K is excluded from regulatory control.

5.5 Short-Lived Isotopes

Control: The activity concentration of any short-lived isotopes (i.e., with a half-life of six (6) months or less) within a container, or equivalent counting geometry, will be limited to the Appendix A, Table A-2, limits for that isotope. Table A-2 lists isotopes with half-lives between seven (7) days and six (6) months.

The primary demonstration of compliance with these limits will be through mathematically calculating the concentration based upon decay-time, with secondary verification through applicable analyses (i.e., less than the A-2 value or the detection limit for the analysis, whichever is greater).

Basis: The subject control establishes a maximum activity concentration to address the potential internal exposure hazards during transportation and handling due to short-lived isotopes, which will have decayed to less than $9.1\ (10)^{-11}$% of their original concentration in the disposal scenario by the end of the institutional control period. This control establishes a technical specification (i.e., Table A-2) for the clearance of materials that have "decayed to background levels" as currently authorized under Condition 19.C of the subject license.

5.6 Activity Concentration per Conveyance

Control: The total dose contribution value for each container, or equivalent counting geometry, from Control 5.3, which is included within the conveyance that will be used to transport the material to the landfill, will be averaged by mass. The total dose contribution value for each conveyance of material will not exceed 1.0. Furthermore, no greater than 10.0 wt.% of the container contents included within the conveyance will include materials that were cleared with total dose fractions greater than 1.0 as described in Control 5.3.

Basis: The subject control establishes a maximum dose contribution to the model that each conveyance can provide. If the entire model were loaded with the contents of any single conveyance, the resultant dose to the MEI will not exceed one (1) mrem per year.

5.7 Control of Conveyance to Disposal

Control: Materials that have been verified to meet the radiological clearance criteria contained herein will not be cleared from licensed radioactive material status until it has been approved by Middle Point Landfill as suitable material for disposal (e.g., satisfactory non-radiological sampling results, Special Waste approvals, etc.). While on site after clearance, the material will be handled as non-radioactive solid waste with appropriate prudent measures to prevent loss of control of the material while awaiting transport to the landfill.

Basis: The model assumes that the material will be buried in the subject landfill (i.e., not taken elsewhere).

5.8 Total Specific Activity per Conveyance

Control: Each container shipped to the landfill will not exceed 2,000 ρCi/g total activity concentration.

Basis: The subject control is based on DOT shipping regulations.

5.9 External Dose per Conveyance

Control: Cleared materials will not be intentionally shielded within the conveyance that will be used for transport to the landfill (e.g., the materials will not be preferentially loaded into the conveyance, placing higher concentration material in the center, etc.). Each conveyance of material will be surveyed with a μR meter or equivalent upon leaving the site for the landfill. On-contact μR meter readings will not exceed 10 μR per hour above background on average and 40 μR per hour above background for individual spots (i.e., less than one square foot ($< 1\ ft^2$)) with elevated on-contact radiation levels. Conveyances of material that fail to meet this criteria will have the offending material removed and that material's associated clearance status revoked (i.e., the offending material will no longer be considered cleared from licensed radioactive materials status).

Basis: The subject control limits external radiation exposure to the MEI during transport and handling until the material is covered in the landfill, as well as external dose due to short-lived isotopes during the institutional control period.

5.10 Mass Limit per Period of Time

Control: The mass of material that can be sent to the subject landfill will be limited to 400 tons (i.e., $8\ (10)^5$ lbs.) per month.

Basis: The subject control limits source term loading (i.e., maximum total activity) for the model, maintaining a minimum factor of eight (8) safety margin.

5.11 Periodic Surveillance

Control: Annual independent (e.g., Quality Assurance (QA)) surveillances of the activity will be conducted, including a physical visit to the Middle Point Landfill. Additional independent sampling of randomly chosen client waste streams (i.e., validating associated scaling factors) will be included in this surveillance activity. The subject surveillance will ensure that the actual characterization and landfill activities are bounded by assumed model parameters such that the primary standard is met.

Basis: The subject control limits source term loading (i.e., maximum total activity) and mixing for the model, maintaining an adequate safety margin.

5.12 Periodic Reporting

Control: By the last business day of the month following each calendar quarter, a written report will be submitted to TDRH, providing the following information regarding materials sent to the landfill for disposal during the subject calendar quarter:

- the total mass of material sent to the Middle Point Landfill for disposal during the subject calendar quarter IAW the subject process;
- a value bounding the total activity of each isotope identified to be present in significant concentrations (i.e., greater than 10% of the Appendix A limits per conveyance) in the subject materials;
- the resultant average concentration of the subject materials; and
- the isotopic concentration of each container, or equivalent counting geometry, of flowable materials cleared with a total dose contribution value greater than 1.0, as described in Control 5.3, as well as a brief description of the flowable materials.

Basis: The subject control provides a periodic notification to the regulator on process performance.

5.13 Authorized Disposal Period

Control: The subject activity will terminate (i.e., the last conveyance of material will be shipped off-site) on or before 2400 on July 31, 2006.

Basis: The subject control limits the number of cells filled with the subject material to approximately 100 cells over a time period of five (5) years.

6.0 Conclusion

This assessment clearly demonstrates that the process controls contained herein will prevent the subject clearance activities from resulting in a TEDE of one (1) mrem per year or greater to the MEI.

7.0 Appendices

Appendix A: Isotopic Concentration Limits for Clearance

Appendix B: RESRAD Graphic Output for Industrial Disposal Scenario

Appendix C: RESRAD Graphic Output for Resident Farmer Disposal Scenario

Appendix D: RESRAD Report of Input Parameters and Resultant TEDE for Industrial Disposal Scenario

Appendix E: RESRAD Report of Input Parameters and Resultant TEDE for Resident Farmer Disposal Scenario

Appendix F: Technical Bases for RESRAD Input Parameters

Appendix G: Closure/Post-Closure Plan for Middle Point Sanitary Landfill

Appendix H: Hydrogeological Report for the Proposed Middle Point Sanitary Landfill Expansion

Appendix I: Operations Manual and Permit Application Documents for the Proposed Middle Point Sanitary Landfill

Appendix J: NRC Policy and Guidance Directive PG-8-08, "Scenarios for Assessing Potential Doses Associated with Residual Radioactivity"

APPENDIX A

Isotopic Concentration Limits for Clearance

Table A-1

Long-Lived Isotopic Limits for Clearance
(Listed Alphabetically)

Isotope	Risk Category	Dose Fraction Limit (ρCi/g)
Ac-227	Moderate	0.44
Ag-108m	Low	13
Ag-110m	Minimal	740
Al-26	Low	10
Am-241	Moderate	0.15
Am-243	Moderate	0.13
Au-195	Negligible	Not Applicable
Ba-133	Low	49
Bi-207	Low	51
C-14	Low	2,000
Ca-41	Low	130
Cd-109	Negligible	Not Applicable
Ce-144	Negligible	Not Applicable
Cf-252	Low	2,000
Cl-36	Low	2.7
Cm-243	Low	32
Cm-244	Low	94

[1] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.
[2] NORM limitations are defined in Control 5.4.

Table A-1

Long-Lived Isotopic Limits for Clearance
(Listed Alphabetically)

Isotope	Risk Category	Dose Fraction Limit (ρCi/g)
Cm-245	Moderate	0.37
Cm-246	Low	20
Cm-247	Low	2.6
Cm-248	Low	2.4
Co-57	Negligible	Not Applicable
Co-60	Low	22
Cs-134	Minimal	1,200
Cs-135	Low	120
Cs-137	Low	8.5
Eu-152	Low	10
Eu-154	Low	17
Eu-155	Minimal	2,400[1]
Fe-55	Negligible	Not Applicable
Gd-152	Low	60
Gd-153	Negligible	Not Applicable
Ge-68	Minimal	3,900[1]
H-3	Negligible	Not Applicable

[1] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.
[2] NORM limitations are defined in Control 5.4.

Table A-1

Long-Lived Isotopic Limits for Clearance
(Listed Alphabetically)

Isotope	Risk Category	Dose Fraction Limit (ρCi/g)
I-129	Moderate	0.23
K-40	NORM	K not technically enhanced in K-40[2]
Mn-54	Minimal	2,200[1]
Na-22	Low	400
Nb-93m	Minimal	1,200
Nb-94	Low	26
Ni-59	Minimal	3,900[1]
Ni-63	Minimal	1,600
Np-237	Moderate	0.6
Pa-231	Moderate	0.026
Pb-210	Low	2.7
Pm-147	Negligible	Not Applicable
Pu-238	Low	31
Pu-239	Low	16
Pu-240	Low	24
Pu-241	Low	5
Pu-242	Low	12

[1] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.
[2] NORM limitations are defined in Control 5.4.

Table A-1

Long-Lived Isotopic Limits for Clearance
(Listed Alphabetically)

Isotope	Risk Category	Dose Fraction Limit (ρCi/g)
Pu-244	Low	2.5
Ra-226	NORM	< 5 ρCi/g of Ra > ambient concentrations[2]
Ra-228	NORM	< 5 ρCi/g of Ra > ambient concentrations[2]
Ru-106	Negligible	Not Applicable
Sb-125	Low	2,000
Se-79	Low	5.7
Sm-147	Low	74
Sm-151	Low	2,000
Sr-90	Low	2.7
Tc-99	Low	12
Th-228	Low	470
Th-229	Low	7.8
Th-230	NORM	< 5 ρCi/g of Th > ambient concentrations[2]
Th-232	NORM	< 5 ρCi/g of Th > ambient concentrations[2]
Tl-204	Low	310
U-232	Low	2.7
U-233	Low	4.6

[1] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.
[2] NORM limitations are defined in Control 5.4.

Table A-1

Long-Lived Isotopic Limits for Clearance
(Listed Alphabetically)

Isotope	Risk Category	Dose Fraction Limit (ρCi/g)
U-234	Low	4.7
U-235	Low	1.9
U-236	Low	4.9
U-238	Low	4.8
Zn-65	Minimal	3,000[1]
Zr-93	Low	46

[1] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.
[2] NORM limitations are defined in Control 5.4.

Table A-2

Short-Lived Isotopic Limits for Clearance
(Listed by Atomic Number and Mass)

Isotope	Half-Life (days)	Comparison Isotope[1]	Clearance Limit (ρCi/g)[2]
Be-7	53.44	Fe-55	2,000
P-32	14.29	Co-60	22
P-33	25.4	Co-60	22
S-35	87.44	Co-60	22
Ar-37	35.02	Negligible Risk	Not Applicable
Ca-45	162.7	Co-60	22
Sc-46	83.83	Sr-90	2.7
V-48	15.971	Sr-90	2.7
Cr-51	27.704	Fe-55	2,000
Co-56	78.76	Sr-90	2.7
Ni-56	6.10	Co-60	22
Co-58	70.80	Co-60	22
Fe-59	44.63	Sr-90	2.7
Cu-67	61.88	Sr-90	2.7
Ge-71	11.8	Negligible Risk	Not Applicable
As-73	80.30	Fe-55	2,000
As-74	17.77	Co-60	22

[1] These comparisons bound internal dose risk. Control 5.9 bounds external dose risk.
[2] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.

Table A-2

Short-Lived Isotopic Limits for Clearance
(Listed by Atomic Number and Mass)

Isotope	Half-Life (days)	Comparison Isotope[1]	Clearance Limit (ρCi/g)[2]
Se-75	119.78	Co-60	22
Rb-83	86.2	Co-60	22
Rb-84	32.9	Co-60	22
Sr-85	64.84	Co-60	22
Rb-86	18.66	Co-60	22
Y-88	106.60	Sr-90	2.7
Zr-88	83.4	Co-60	22
Sr-89	50.55	Sr-90	2.7
Y-91	58.51	Co-60	22
Zr-95	64.02	Sr-90	2.7
Nb-95	35.06	Co-60	22
Ru-103	39.35	Co-60	22
Pd-103	16.961	Co-60	22
Ag-106m	8.46	Co-60	22
Ag-111	7.46	Co-60	22
Sn-113	115.1	Co-60	22
In-114m	49.51	Sr-90	2.7

[1] These comparisons bound internal dose risk. Control 5.9 bounds external dose risk.
[2] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.

Table A-2

Short-Lived Isotopic Limits for Clearance
(Listed by Atomic Number and Mass)

Isotope	Half-Life (days)	Comparison Isotope[1]	Clearance Limit (ρCi/g)[2]
Cd-115m	44.6	Co-60	22
Sn-117m	13.6	Co-60	22
Sn-123	129.2	Co-60	22
Sn-125	9.64	Cs-137	8.5
Te-125m	58	Co-60	22
I-125	60.14	I-129	0.23
Sb-126	12.4	Co-60	22
I-126	12.93	I-129	0.23
Te-127m	109	Co-60	22
Xe-127	36.406	Sr-90	2.7
Te-129m	33.6	Co-60	22
Xe-129m	8.89	Negligible Risk	Not Applicable
I-131	8.040	I-129	0.23
Xe-131m	11.8	Negligible Risk	Not Applicable
Ba-131	11.8	Co-60	22
Cs-132	6.475	Co-60	22
Cs-136	13.16	Sr-90	2.7

[1] These comparisons bound internal dose risk. Control 5.9 bounds external dose risk.
[2] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.

000025

Table A-2

Short-Lived Isotopic Limits for Clearance
(Listed by Atomic Number and Mass)

Isotope	Half-Life (days)	Comparison Isotope[1]	Clearance Limit (ρCi/g)[2]
Ba-140	12.789	Co-60	22
Ce-141	32.50	Co-60	22
Pr-143	13.56	Co-60	22
Pm-148m	41.3	Cs-137	8.5
Eu-156	15.19	Co-60	22
Tb-160	72.3	Sr-90	2.7
Er-169	9.4	Co-60	22
Yb-169	31.97	Co-60	22
Tm-170	128.6	Co-60	22
Lu-177m	160.10	Sr-90	2.7
Hf-181	42.39	Co-60	22
W-181	120.95	Fe-55	2,000
Ta-182	114.74	Sr-90	2.7
W-185	75.1	Co-60	22
Os-185	93.6	Sr-90	2.7
W-188	69.4	Cs-137	8.5
Ir-190	11.78	Co-60	22

1 These comparisons bound internal dose risk. Control 5.9 bounds external dose risk.
2 Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.

000026

Table A-2

Short-Lived Isotopic Limits for Clearance
(Listed by Atomic Number and Mass)

Isotope	Half-Life (days)	Comparison Isotope[1]	Clearance Limit (ρCi/g)[2]
Os-191	15.4	Co-60	22
Ir-192	74.02	Sr-90	2.7
Ir-194m	171	Co-60	22
Tl-202	12.23	Co-60	22
Hg-203	46.60	Co-60	22

[1] These comparisons bound internal dose risk. Control 5.9 bounds external dose risk.
[2] Not to exceed a total specific activity per conveyance of 2 ηCi/g IAW Control 5.8.

5) Groundwater Pathway Model

The 60 mil. high density polyethylene liner and leachate collection system incorporated in the design and construction of the Middle Point disposal facility will mitigate the movement of any liquid in waste to groundwater. However, for purposes of this evaluation no credit is given for the HDPE liner or the leachate collection system.

The non-dispersion model (ND) is appropriate for use in this assessment. The ND model appropriately matches the Middle Point Landfill characteristics for the saturated and unsaturated zones and the size of the contaminated area. In particular the ND model is recommended for contaminated areas larger than 1,000 m^2. (ANL/EAD/LD-2, Page 207)

C. Unsaturated Zone Parameters

Data concerning the unsaturated zone is principally taken from Appendix H. The unsaturated zone is the thirteen foot (13') thick zone of soil below the HDPE liner and above the limestone bedrock. Characteristics of this soil are contained on Pages 4 and 5 of Liner Evaluation located in Appendix H. It should be noted that the modeling of the unsaturated zone does not consider:

- the 60 mil thick HDPE liner;
- leachate collection system; and
- the depth of in-situ soils beneath the three feet (3') of compacted clay and ten feet (10') of compacted soil which forms the bottom of the disposal facility. This soil depth can be as great as 175' (Page 21, Appendix H).

The unsaturated zone was modeled as two (2) layers as depicted in the Middle Point Liner Evaluation. These are a three foot (3') thick compacted clay layer and a ten foot (10') thick compacted soil layer.

For zone 1:

1) Zone Thickness

$$\text{Thickness} = 3 \text{ ft. x } \frac{1\text{m}}{3.28\text{ft}} = 0.915\text{m.}$$

Bulk Survey for Release (BSFR) Waste Materials

Material Handling Procedures BFI

Solid Waste Advisory Committee Meeting
Nashville, Tennessee

16 August 2007

Bulk Survey for Release BSFR Waste Materials

Acceptance and Handling Procedures

- Organization
  - Material Acceptance Procedures
  - Handling and Placement Procedures
  - Monitoring Procedures

Material Acceptance Procedures Prior to Shipment

- Generator must submit information regarding specific waste stream to Division of Solid Waste Management (DSWM). This information may include analytical test results
- Information is reviewed by the Division
- The Division issues Approval Letter and sends copy to the Generator and the Landfill
- A profile of the waste and a copy of the Approval Letter from Solid Waste Management is reviewed by our Internal Approval Group
- Once this process is completed,the waste is assigned a specific waste ID number

Material Acceptance Procedures Receipt of BSFR Waste at Landfill

- Waste must be manifested and include the approved Specific ID Number
- Manifest must accompany load and include:
  - waste description
  - name of approved Landfill
  - identifying physical characteristics (e.g., color, size, consistency, etc.)
  - signed by authorized representative of the Generator
- <u>All waste</u> accepted at the Landfill pulls up to the Scale House and goes though the radiation monitor

Handling and Placement Procedures

- Landfill Scale House
  - Check manifest for completeness
  - Compare manifest and ID with Approval Letter and profile of the waste (located on file in Scale House)
  - Notifies Operator at working face of incoming BSFR waste

Handling and Placement Procedures

- Landfill Operator
  - Awaits delivery of the BSFR waste after notification from Scale House
  - Visually inspects load as it is off-loaded to confirm load
  - Once contents confirmed, BSFR waste is mixed, and covered with other waste
  - For anything unusual, Operator contacts the Environmental Compliance Manger for verification

Monitoring Procedures

- After passing Scale House, additional monitoring is not required
  - All waste received at Landfill passes radiation monitors before transportation to working face
  - Approved BSFR is effectively "covered" or mixed with MSW
  - All waste is covered <u>daily</u>

Performance Records

- Records are maintained at the landfill of BSFR Waste for inspection by the State of Tennessee Division of Solid Waste Management and Radiological Health.

Bulk Survey for Release (BSFR) Waste Materials

Potential Impacts to Landfill Liners

Solid Waste Advisory Committee Meeting
Nashville, Tennessee

16 August 2007

Bulk Survey for Release (BSFR) Waste Materials

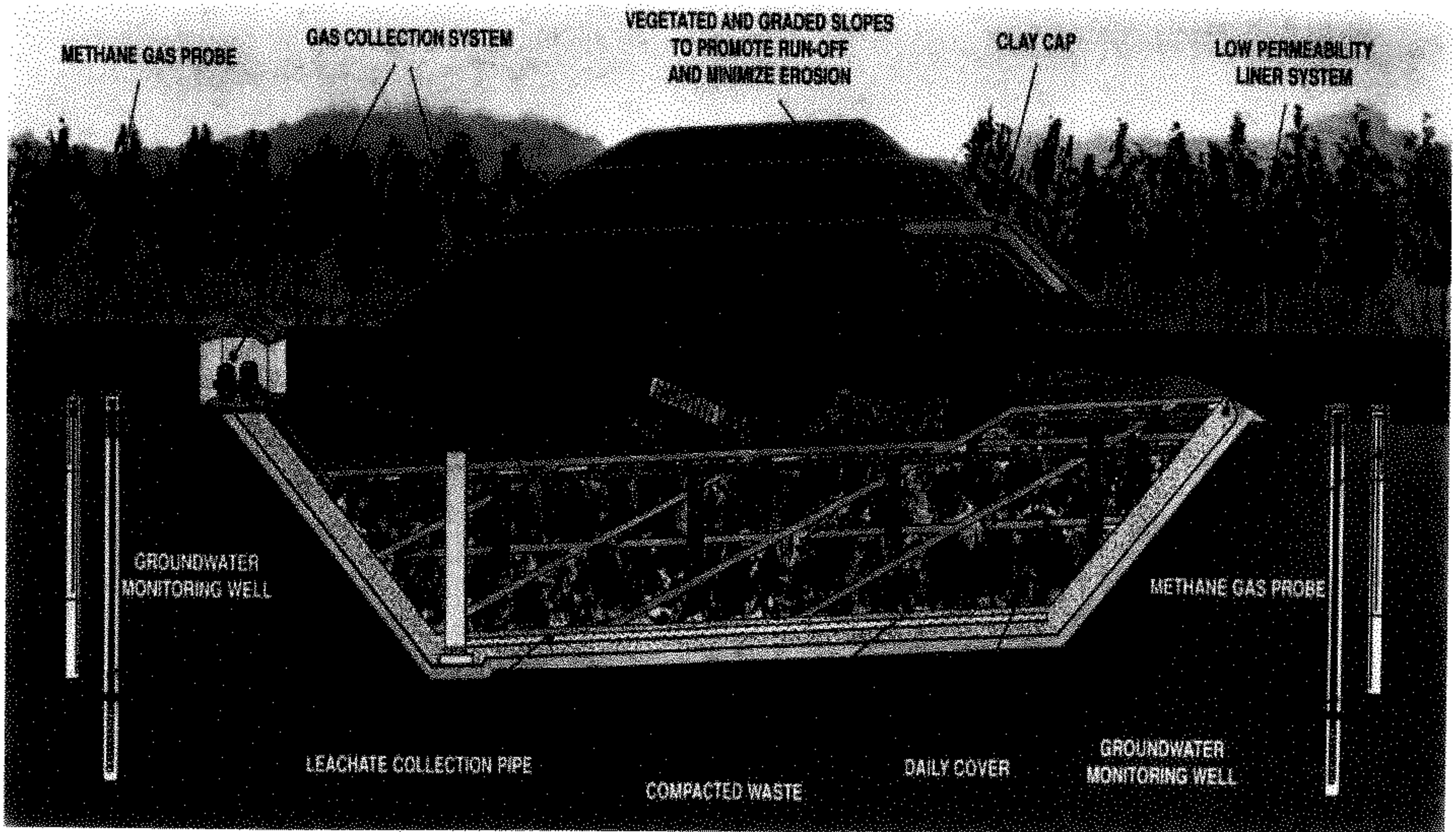
Potential Impacts to Landfill Liners

- Organization
  - Design of Modern Landfills
  - Construction Inspection of Modern Landfills
  - Impact of Radiation on Liners
  - Liner Systems for Waste Streams Containing Radioactive Isotopes

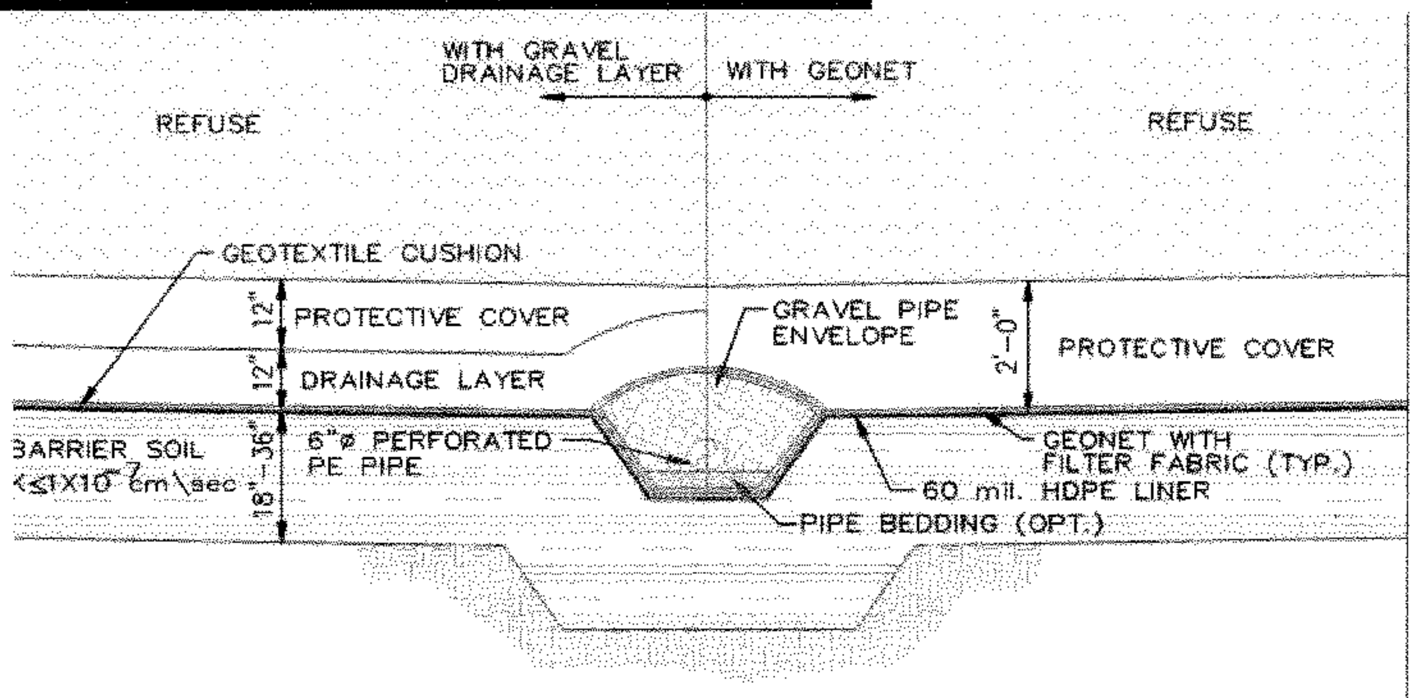
Design of Modern Landfills

- ☐ Modern Landfills are engineered systems that provide long-term containment of constituents that are potentially harmful to human health and the environment
- ☐ Design and Construction governed by Federal and State regulations (Subtitle D)
- ☐ Regulations also require collection of liquids and gas from facility during operations, as well as post-construction monitoring of groundwater, surface water, and air

Design of Modern Landfills



Design of Modern Landfills



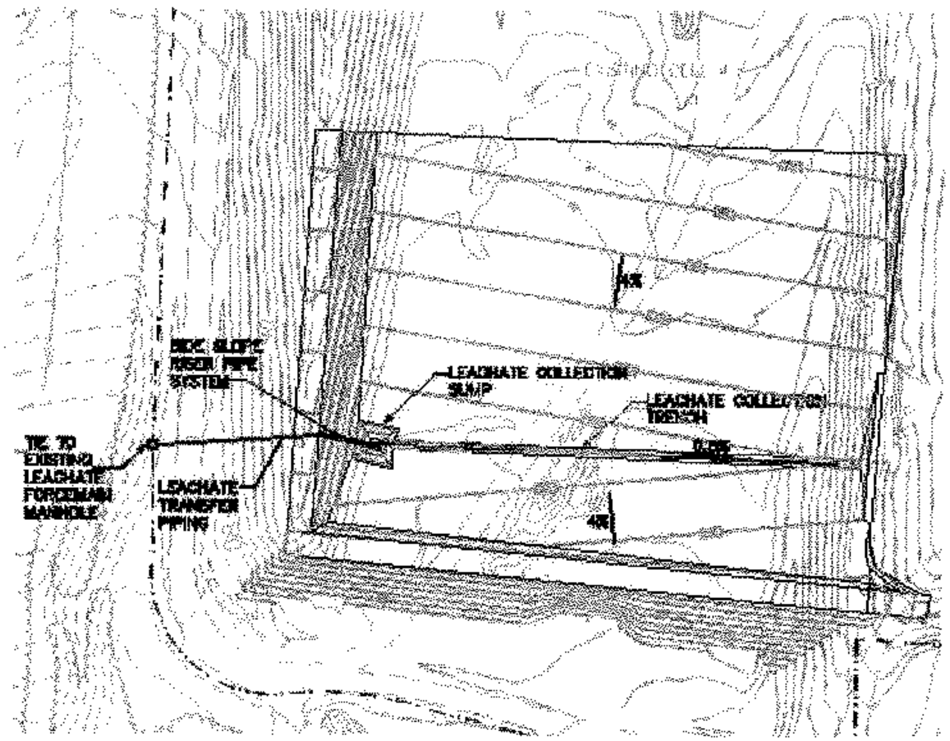
Heart of design is a "composite" lining system, comprised of:
Geomembrane
in intimate contact with
Compacted Clay

Construction Inspection of Modern Landfills

- Construction inspection (CQA) required at all modern landfills by independent engineering firm
- Testing of soil and geosynthetic materials required before and during construction
- Final Certification Report by Professional Engineer confirming construction in accordance with design and regulations

Cell Design and Construction Monitoring

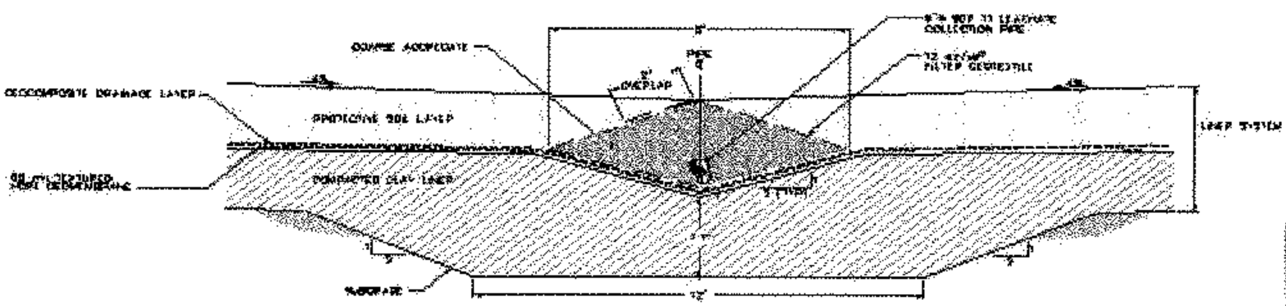
Example Cell Construction and Monitoring



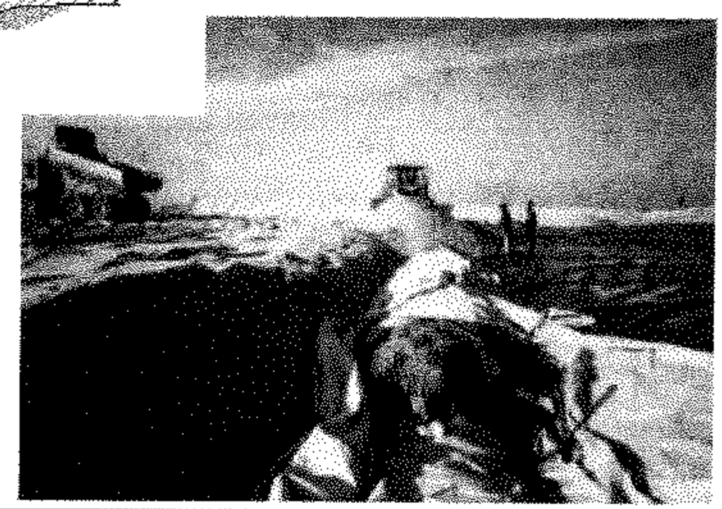
Example Cell Design Grading

Leachate Collection and Construction Monitoring

Example Liner System Design



Example Liner System Construction and Monitoring



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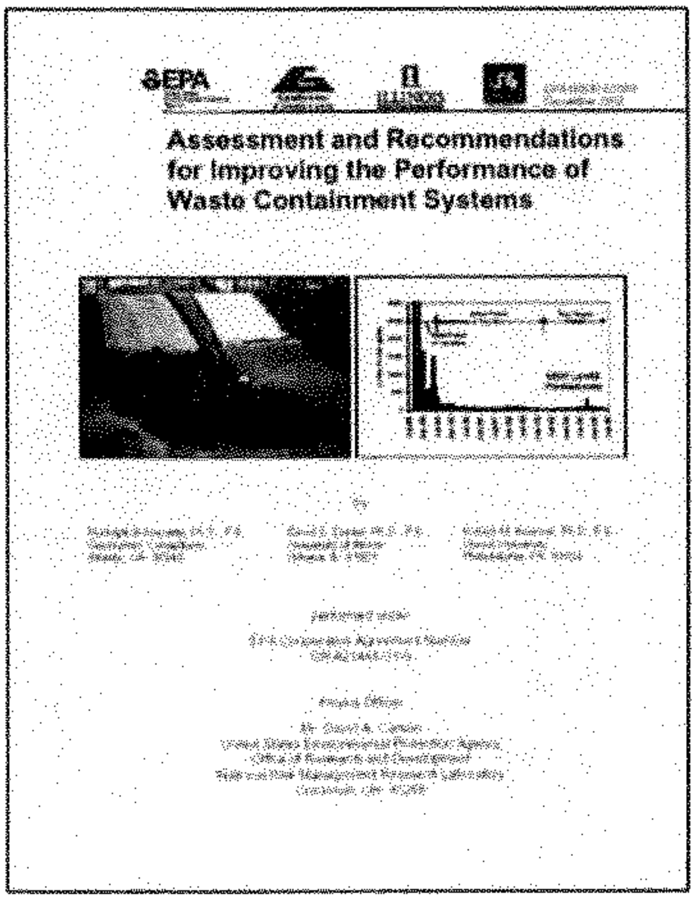
Landfill Performance Assessment



1. Historical performance of modern landfills has been assessed under contract to USEPA

2. Lessons learned from 10+ years of experience at operating facilities across the US was presented in 2002 report

3. Performance of landfill liners has been excellent and has exceeded expectations

Impact of Radiation on Liners

- ☐ Testing performed using radioactive isotopes in liquid in liquids at DOE LLRW disposal site (USEPA 9090 test)
  - Results confirm no impact on geosynthetic and natural materials
  - Liner life predicted to exceed 200 (and likely now 300) years... due to test extrapolation limits

Liner Systems for Waste Streams Containing Radioactive Isotopes

- Lessons from DOE projects regarding liner compatibility and liner design for radioactive waste disposal facilities
  - Facilities designed and constructed for long-term containment
  - Liner systems almost exclusively use natural soils and not geosynthetics
  - Tests indicate little impact to soil or geosynthetic materials
  - Results reported to indicate service life exceeding 11,000 years

Conclusions

- ☐ Modern landfills are designed and constructed to be highly protective of human health and the environment
- ☐ Landfill lining systems incorporating soil alone provide sufficient containment for radioactive waste
- ☐ Tests and performance records confirm liner compatibility with radioactive waste
- ☐ Soil and geosynthetic materials provide adequate protection at DOE sites, which contain waste at a much higher radioactive dosage than BSFR waste

City of MURFREESBORO TENNESSEE

. . . creating a better quality of life

MEMORANDUM

TO: Solid Waste Advisory Committee **DATE:** August 14, 2007

FROM: Joe Kirchner, Director

SUBJECT: Department of Environment and Conservation, Division of Radiological Health, Meeting of the Solid Waste Advisory Committee, August 16, 2007.

At the request from staff of the Tennessee Department of Environment and Conservation I appear before the Solid Waste Advisory Committee to present facts and answer questions regarding the Murfreesboro water and sewer system; its source of drinking water supply, drinking water quality, and wastewater discharge as they relate to the Middle Point Landfill Operation.

The Murfreesboro City Council has approved and sent to the Committee Resolution 07-R-26 concerning the landfill safety and Tennessee's Bulk Survey for Release Program. This resolution requests the State to "carefully review the existing BSFR regulations and if necessary modify them to ensure the long term health of both persons and waters and lands of the State. Health should be the paramount goal of such review. In the absence of clear, scientific evidence the BSFR program, with or without modification, does not endanger public health, the placement of such waste in the Middle Point Landfill should cease." The City is calling for continuing the moratorium until these issues can be clarified. A copy of the Resolution is attached.

The following is factual information that may be pertinent to your deliberations.

Water Supply

Murfreesboro has two sources of water supply. The primary supply is on the East Fork of the Stones River at approximate river mile 10.0 upstream of the Walter Hill Dam (river mile 8.0) and the Middle point Landfill (river mile 9.1). See Illustration 1. The second water supply is from an auxiliary intake on the East Fork of the Stones River at river mile 2.5 just east of the bridge on SR 840 crossing the East Fork of the Stones River. See Illustration 2.

Although not a regulatory requirement the Water and Sewer Department has analyzed the raw drinking water supply at Walter Hill Dam annually since 1988. These analyses have included Gross Alpha and Gross Beta testing. Alpha and beta particles are emitted during the decay of certain radioactive elements. National Primary Drinking Water regulations of the Federal Safe Drinking Water Act establish Maximum Contaminate Levels (MCL) of 15pCi/L and 4

Water and Sewer Department
300 NW Broad Street * P.O. Box 1477 * Murfreesboro, TN 37133-1477 * Office: 615 890 0862 * Fax: 615 896 4259
TTY 615 848 3214 * www.murfreesborotn.gov

mrem/year respectively. The regulations also specify the testing methods. All results have been below the detectable limit (BDL) of the test protocol specified by the regulations except two. The detectable limit for the test method for alpha particles is 3 pCi/L and for beta particles 4 pCi/L. In 1988 a Gross Alpha of 9.0 pCi/L was reported and in 1993 a Gross Beta of 4.7 was reported. Although raw water is analyzed the results have been compared to drinking water regulation Maximum Contaminate Levels. All results were well below the Maximum Contaminate Levels (MCL) for drinking water. Attached is a History of Radionuclide Testing at the Stones River Water Plant (Raw Water).

Drinking Water Radionuclide Testing

Since 1984 the drinking water has been analyzed on intervals dictated by the drinking water regulations for Gross Alpha. In 2003 Radium 226 and 228 testing was required by the regulations. All results have been below the detectable limit of the test protocol specified by the drinking water regulations. In 2003 the water was tested three times with results all below detectable limits. The Division of Water Supply granted the Murfreesboro water system a waiver from further radionuclide testing through December 31, 2007. Attached is a History of Radionuclide Testing at the Stones River Water Plant (Distribution system).

Water Treatment

The present plant is a lime softening plant with conventional sand filters. It is currently being expanded to 20 million gallon per day capacity. A lime softening basin is being added to the four existing basins which are being refitted with new mechanical equipment. The sand filters will be replaced with membrane filters (micro filtration) followed by granular activated carbon filters. The micro membrane filter technology will provide an absolute barrier to any particle greater than 0.1 microns in size. The present sand filters provide only a probable barrier to particles without regard to size. This is significant for the removal of pathogens. The cost of the plant expansion is $40,123, 370.

Wastewater Discharge

The wastewater treatment plant discharges into the West Fork of the Stones at river mile 10.5. See Illustration 3. It is authorized by NPDES Permit TN0022586. The permit specifies sampling, testing and reporting requirements of the effluent limitations. There is not a requirement to test for radionuclides in the current permit. The West Fork of the Stones River converges with the East Fork of the Stones River below both Murfreesboro water supply intakes.

Since the BSFR came into question the effluent, discharge to the stream, has been tested by the Water and Sewer Department for gross alpha, gross beta, Uranium, Radium 226 and Radium 228. All results were below detectable limit of the test protocol except for gross beta which was 22 pCi/l. The test method detectable limit for gross beta is 0.8 pCi/L.

The Tennessee Division of Radiological Health also sampled and tested the effluent as well as the biosolids. They reported in a letter dated June 28, 2007 "None of the radionuclide concentrations measured exceeded the limits in our regulations for effluent releases to surface waters."

Biosolids removed from the wastewater are dewatered and returned by truck to the landfill.

Leachate
The Middle Point Landfill has an industrial user permit to discharge leachate into the Murfreesboro sanitary sewerage system. Leachate is the liquid that is collected from under the landfill. During dry weather, there are periods where no discharge occurs. Leachate discharged to the sanitary sewer is limited to 130,000 gallons per day. Excess leachate is trucked by the landfill operator to a processor in Nashville.

During periods of discharge, flow proportional composite samples are collected and analyzed for ammonia, biochemical oxygen demand, suspended solids, pH and metals. The landfill has a pretreatment facility in which ammonia is reduced through break-point chlorination, utilizing bleach.

Since the BSFR came into question the Water and Sewer Department tested samples of the wastewater entering the Murfreesboro plant and leachate for Gross Alpha, Gross Beta, Uranium, and Radium 226 and 228. The results for the wastewater entering the plant are 5.8pCi/L for Gross Alpha, 34 pCi/L Gross Beta, below detectable limit (BDL) for Uranium, and BDL for Radium 226 and 228. The results for the leachate are BDL for Gross Alpha, 1,600 pCi/L Gross Beta, 1.4 micrograms per liter for Uranium, 1.9 pCi/L for Radium 226 and BDL for Radium 228.

Attachments

RESOLUTION 07-R-26 concerning landfill safety and Tennessee's Bulk Survey For Release Program.

WHEREAS, the City of Murfreesboro has become aware that waste regulated under Tennessee's Bulk Survey For Release ("BSFR") program has been placed in the Middle Point Landfill in Rutherford County; and,

WHEREAS, this information is of great concern to the City because the Middle Point Landfill is located upstream and in the vicinity of the raw water intake for the City's water treatment plant and because the leachate for the Middle Point Landfill is piped to, and treated in, the City's wastewater treatment plant; and,

WHEREAS, the short and long term implications of the BSFR program for the health and well-being of the City's residents and the City's water and wastewater systems is of high importance to the City Council; and,

WHEREAS, the adequacy and wisdom of the State's BSFR program and regulations are currently being reviewed by the Municipal Solid Waste Advisory Committee pursuant to Chapter 584 of the Public Acts of 2007 and may be the subject of rulemaking by the Solid Waste Disposal Control Board.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF MURFREESBORO, TENNESSEE, AS FOLLOWS:

SECTION 1. The State of Tennessee should continue the moratorium on placing BSFR waste in the Middle Point Landfill beyond the legislatively mandated date to ensure that all aspects of such program are thoroughly reviewed, analyzed, and explained to the residents of the City, County and State.

SECTION 2. The State of Tennessee should carefully review the existing BSFR regulations and if necessary modify them to ensure the long-term health of both persons and the waters and lands of the State. Health should be the paramount goal of such review. In the absence of clear, scientific evidence that the BSFR program, with or without modification, does not endanger public health, the placement of such waste in the Middle Point Landfill should cease.

SECTION 3. The City Recorder shall send copies of this Resolution to the Governor, the Commissioner for the Tennessee Department of Environment and Conservation, the Solid Waste Disposal Control Board, the Municipal Solid Waste Advisory Committee, the Rutherford County Delegation of the Tennessee General Assembly, the Rutherford County Mayor and Allied Waste Services.

SECTION 4. This Resolution shall be effective immediately upon its passage and adoption, the public welfare and the welfare of the City requiring it.

Passed: August 2, 2007

Tommy Bragg, Mayor

ATTEST:

James B. Penner
City Recorder

APPROVED AS TO FORM:

Susan Emery McGannon
City Attorney

State of Tennessee)
: SS
Rutherford County)

I, the undersigned, **James B. Penner**, do hereby certify that I as the duly appointed City Recorder of the City of Murfreesboro, Rutherford County, Tennessee, and as such official I further certify that attached hereto is a true and correct copy of RESOLUTION 07-R-26 adopted by the City Council of said City at its meeting held on August 2, 2007.

IN WITNESS WHEREOF, I have hereunto subscribed by official signature and affixed the Corporate Seal of said City this 6th day of August, 2007.

James B. Penner
City Recorder

(SEAL)

History of Radionuclide Testing at Stones River Water Treatment Plant (Raw Water)

Date Of Testing	Sample Point	Test Run	Test Results	Det. Limit	MCL
4/19/1988	Walter Hill Dam	Gross Alpha	9.0 pCi/L		
		Gross Beta	<3 pCi/L		
10/25/1989	Walter Hill Dam	Gross Alpha	0.0 pCi/L		
		Gross Beta	3.6 pCi/L		
9/6/1990	Walter Hill Dam	Gross Alpha	0.0 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	0.6 pCi/L	4 pCi/L	4 mrem/yr
10/7/1991	Walter Hill Dam	Gross Alpha	0.8 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	3.6 pCi/L	4 pCi/L	4 mrem/yr
10/1/1992	Walter Hill Dam	Gross Alpha	1.2 pCi/L	3 pCi/L	15 pCi/L
10/29/1993	Walter Hill Dam	Gross Alpha	0.78 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	4.7 pCi/L	4 pCi/L	4 mrem/yr
10/7/1994	Walter Hill Dam	Gross Alpha	1.8 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	2.0 pCi/L	4 pCi/L	4 mrem/yr
11/1/1995	Walter Hill Dam	Gross Alpha	0.81 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	0.98 pCi/L	4 pCi/L	4 mrem/yr
11/6/1996	Walter Hill Dam	Gross Alpha	0.97 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	1.6 pCi/L	4 pCi/L	4 mrem/yr
10/21/1997	Walter Hill Dam	Gross Alpha	1.2 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	2.81 pCi/L	4 pCi/L	4 mrem/yr

History of Radionuclide Testing at Stones River Water Treatment Plant (Raw Water)

Date Of Testing	Sample Point	Test Run	Test Results	Det. Limit	MCL
10/23/1998	Walter Hill Dam	Gross Alpha	0.53 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	2.5 pCi/L	4 pCi/L	4 mrem/yr
11/22/1999	Walter Hill Dam	Gross Alpha	0.15 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	2.0 pCi/L	4 pCi/L	4 mrem/yr
10/13/2005	Walter Hill Dam	Gross Alpha	<1.5 pCi/L	3 pCi/L	15 pCi/L
		Gross Beta	2.6 pCi/L	4 pCi/L	4 mrem/yr
12/19/2006	Walter Hill Dam	Gross Alpha	BDL	3 pCi/L	15 pCi/L
		Gross Beta	1.7 pCi/L	4 pCi/L	4 mrem/yr
5/14/2007	River Intake	Gross Alpha	1.4 pCi/L	3pCi/L	15 pCi/L
		Gross Beta	1.8 pCi/L	4 pCi/L	4 mrem/yr
		Uranium	BDL	1.0 µg/L	30 µg/L
		Radium 226	BDL	1.0 pCi/L	5 pCi/L
		Radium 228	BDL	1.0 pCi/L	

History of Radionuclide Testing at Stones River Water Treatment Plant (Distribution System)

Date Of Testing	Sample Point	Test Run	Test Results	Det. Limit	MCL
4/2/1984	Distribution System	Gross Alpha	0.4 pCi/L	3 pCi/L	15 pCi/L
4/16/1987	Received Waiver for June 24, 1988 due date.				
4/23/1991	Distribution System	Gross Alpha	0.75 pCi/L	3 pCi/L	15 pCi/L
5/25/1995	Distribution System	Gross Alpha	1.3 pCi/L	3 pCi/L	15 pCi/L
6/8/1998	Distribution System	Gross Alpha	0.22 pCi/L	3 pCi/L	15 pCi/L
3/5/2002	Distribution System	Gross Alpha	<1.4 pCi/L	3 pCi/L	15 pCi/L
2/24/2003	Entry Point to Distribution System	Gross Alpha	BDL	3 pCi/L	15 pCi/L
		Radium 226	BDL	1 pCi/L	5 pCi/L
		Radium 228	BDL	1 pCi/L	
4/16/2003	Entry Point to Distribution System	Gross Alpha	BDL	3 pCi/L	15 pCi/L
		Radium 226	0.30 pCi/L	1 pCi/L	5 pCi/L
		Radium 228	BDL	1 pCi/L	
7/16/2003	Entry Point to Distribution System	Gross Apha	BDL	3 pCi/L	15 pCi/L
		Radium 226	0.30 pCi/L	1 pCi/L	5 pCi/L
		Radium 228	BDL	1 pCi/L	
2/14/2005	Received Waiver Jan 1, 2005 through December 31, 2007 Compliance Period				


Walter Hill Dam
Approx. River Mile 8.0
EAST FORK STONES RIVER

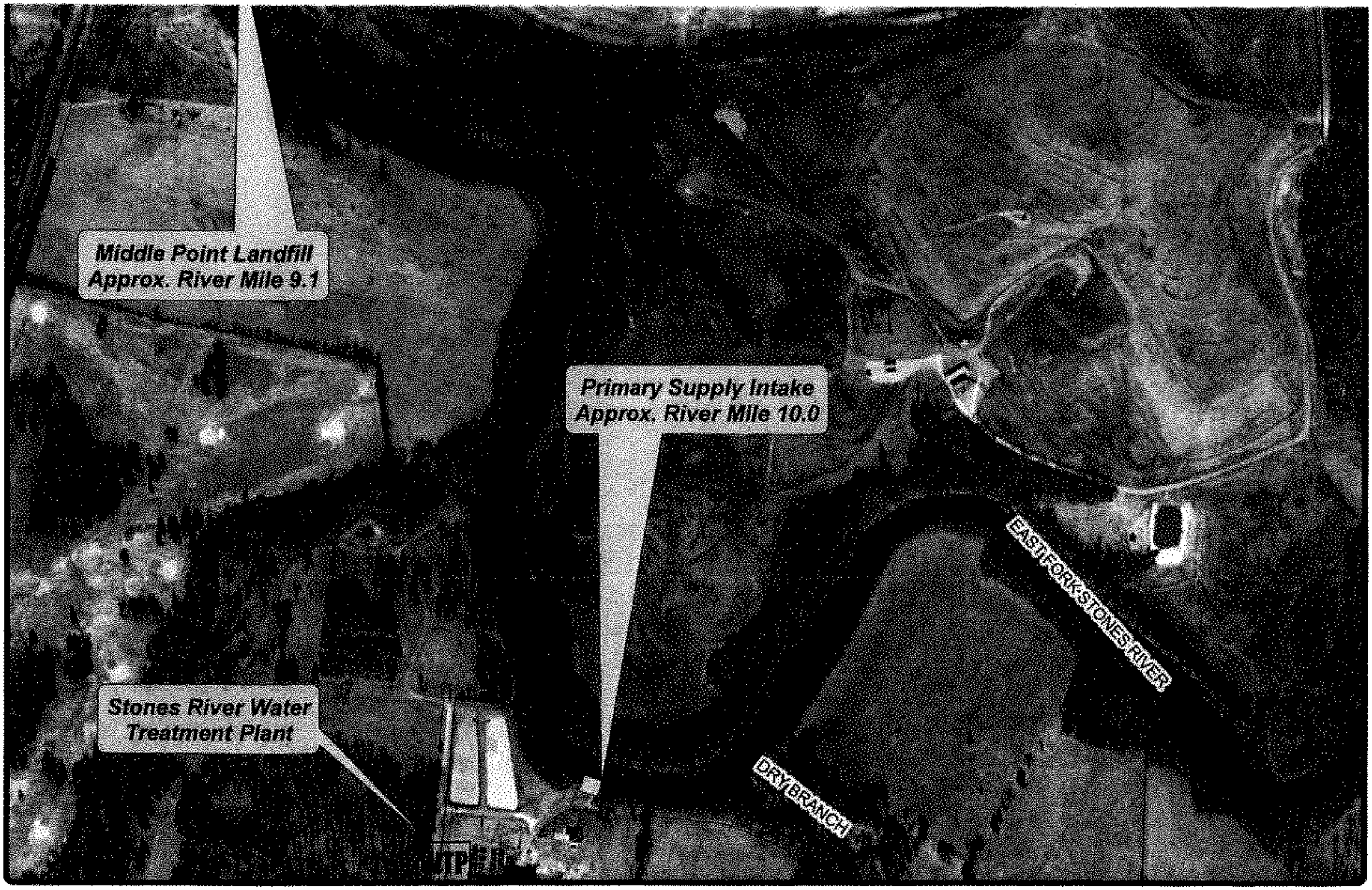


Illustration 1.mxd

MURFREESBORO WATER AND SEWER DEPARTMENT

Illustration 1
Primary Water Supply Intake

SCALE : 1" = 600'

August 2007
TAB

City of MURFREESBORO TENNESSEE

SCALE : 1" = 2,500'

MURFREESBORO WATE

Illustration 2 - Auxili

Illustration 2.mxd
August 2007
TAB

ID SEWER DEPARTMENT

Water Supply Intake

City of MURFREESBORO TENNESSEE

SCALE : 1" = 5,000'

MURFREESBORO WATEF

Illustration 3 - Wastewate

Illustration 3.mxd

ID SEWER DEPARTMENT

August 2007
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'reatment Plant Discharge

City of MURFREESBORO TENNESSEE

Responses to SWAC Questions 1 through 10

Submitted by Lisa Stetar
August 16, 2007

SWAC Question #1

Do you believe the Bulk Survey for Release Program implemented by the TN Department of Environment and Conservation effectively monitors the processing and the disposal of solid wastes with residual levels of radioactivity at Class 1 Landfills in Tennessee? Please explain your answer in regards to waste tracking, waste characterization, compliance with licensing requirements and potential hazard this material presents to public health and the environment.

Response:

There has not been sufficient time available to conduct a rigorous review of TDEC's implementation of the Bulk Survey for Release Program, and the results reported here are general observations. My review has included discussions with personnel in TDEC's Division of Radiological Health (DRH), review of the most recent licensing and technical support documents related to the BSFR program, review of the most recent inspection reports for the BSFR processors, and a phone conversation pertaining to waste characterization with Mr. Mark McHugh. Mr. McHugh has performed the dose assessments and developed the waste characterization programs for the two processors, Impact and Toxco, that are currently approved to send materials to the Middlepoint landfill. I will be visiting the Impact facility on August 17 to talk further with Mr. McHugh and to observe Impact's waste characterization program.

My general impression is that DRH staff are making a diligent effort to thoroughly evaluate BSFR proposals and oversee the processors that implement this process as part of their overall inspection program. However, I believe there is room for a number of improvements that could result in more effective management of the program.

It should be noted that a number of the issues discussed below have been previously identified by DRH staff and would be addressed under their proposed *Licensing Requirements for Evaluation and Acceptance of Licensee Requests for the Disposal of Materials with Extremely Low Levels of Contamination in Class I (Subtitle D) Landfill.* DRH issued this document as a draft in 2006. This document specifies the RESRAD modeling requirements, including the addition of a scenario specific to workers involved in the daily landfill operations, and establishes the minimum sampling requirements for waste characterization.

My specific recommendations for changes in the BSFR management and oversight program include:

1. **Define and document staff roles and responsibilities for evaluation and oversight of the BSFR program**. Oversight responsibilities for the BSFR program are shared among the licensing section, inspection section and the individual who provides

review of the technical basis documents and RESRAD model evaluations submitted as part of requests for BSFR approvals. This overlap is necessary, but without clearly defined and documented responsibilities, it can cause confusion and result in gaps in the oversight process especially when personnel changes occur. For example, waste tracking information (waste volumes and activities) reported by the licensees has not always been consistently compiled and evaluated.

2. **Develop a single set of clearly defined BSFR related requirements for all licensees**. The BSFR program has evolved over time resulting in requirements that vary among the four processors and the five landfills involved. Examples include differences in:
    a. reporting requirements for waste tracking information
    b. approaches to limiting total volumes of waste sent to the landfill
    c. extent to which processors must perform sampling to verify generator scaling factors before applying them in the bulk survey methods used for waste characterization
    d. Administrative controls such as limits on the external dose rates that can be present on conveyance surfaces and adherence to DOT concentration limits that are more restrictive for some radionuclides than the BSFR condition release criteria.

    The concern is not that the requirements are not adequate, but rather that the variations in requirements complicate DRH efforts to manage the program and to evaluate processor compliance with BSFR license conditions. The situation is further complicated by a cumbersome filing system. The specific requirements for the individual processors have generally changed over time and are frequently spelled out over a number of documents and letters some of which date back several years. These BSFR related documents are maintained as part of the overall license file for the processor and are, therefore, interspersed among numerous other letters and documents pertaining to other aspects of the licensee's program. The records are maintained in a single location because it is important that the inspectors have access to all of the licensee records in one location to ensure the program is evaluated in a comprehensive manner. However, improvements are needed in the way in which the information is organized even if this requires duplication of some records that pertain to more than one license condition or aspect of the licensee's program.

    The varying BSFR related requirements coupled with the fact that the supporting documentation cannot be easily compiled for review are obstacles to the consistent and effective oversight of the BSFR program.

3. **Conduct further evaluations to verify that doses to workers involved in current landfill operations are negligible**. There are a number of factors that limit potential exposures to landfill workers from disposals of BSFR materials. These factors include the presence of radiation detectors at the landfill scales, limits on the overall volumes of BSFR wastes that can be disposed of in the landfills on an annual basis, the limited time in which landfill workers would be in proximity to BSFR materials.

    However, the current, BSFR dose modeling does not specifically address doses to workers during active landfill operations. The required modeling evaluates potential doses to workers during the 30-year post closure maintenance period and to the resident farmer, from 20 years post closure to 1000 years in the future. Additional modeling is recommended to verify doses for workers involved in active landfill operations are negligible especially for shorter-lived radionuclides that would not factor into the residential farmer analysis. TDEC's proposed changes to the BSFR program would make this analysis a requirement of the BSFR program.

4. **Develop a standardized, electronic format for recording and reporting waste tracking information.** Requiring the processors to use a common, electronic format for reporting BSFR waste volumes and activities would streamline DRH efforts to compile data and would ensure more consistent and detailed information is available for tracking BSFR waste disposals.

5. **Limit the extent to which processors identify BSFR related records as proprietary (i.e., unavailable for public review).** The concentration limits used to control BSFR related disposals as well as the summary information that provides specific isotopes and total quantities of material shipped to the landfills for disposal on an annual basis should be available for public review. DRH should challenge the processors to be more judicious about the types and quantities of information contained in BSFR submittals that is designated as "proprietary" or "business sensitive."

SWAC Question # 2

How does Tennessee's BSFR waste disposal process compare with the NRC practices for disposal of this waste as described in 10 CFR 20.2002, Alternate Methods of Disposal?

Response:

According to the NRC website, "10 CFR 20.2002 is available for use by licensees for wastes that typically are a small fraction of the Class A limits contained in Part 61, and for which the extensive controls in Part 61 are not needed to ensure protection of public health and safety and the environment. Thus, 10 CFR 20.2002 provides an alternative, safe, risk-informed disposal method for these materials, which are frequently called "low-activity waste." The Class A limits mentioned here refer to a specific class of low level radioactive waste. Part 61 specifies the licensing requirements for land disposal of radioactive waste.

Tennessee's BSFR process is consistent with the process implemented under 10 CFR 20.2002. Both approaches require dose based analysis to demonstrate compliance with the dose limit. In the case of the BSFR program, the specified limit is 1 mrem/year. NRC limits doses to "a few mrem" according to the NRC website. Regulation 20.2002 does not specify a dose limit for these types of disposals, but requires that they meet the overall dose limits specified in Part 20 which for members of the public is 100 mrem/year. Under Part 20 licensees must not only meet the dose limits, but must also be maintained "as low as reasonably achievable."

In the previous SWAC meeting, a representative of one of the processors stated that "a few mrem" is defined by the NRC as 5 mrem in the supporting documentation for alternate disposals (a NUREG document). I have not been able to verify this information, but assume it is valid. The bottom line is that the Tennessee dose limit is either a little more restrictive, or at least as restrictive, as that used by the NRC. In a 2002 report, the National Academy of Sciences made recommendations to the NRC that included the use of a 1 mrem/yr dose limit as "a reasonable starting point for the process of considering options for a dose-base standard for clearance or conditional clearance of slightly radioactive solid material."

NRC and TDEC both require radiological dose assessments to demonstrate compliance with the dose limits as part of the approvals process. At present, TDEC only requires two scenarios: worker during the post closure period for the landfill and a resident farmer scenario. Proposed changes to the TDEC program (see response to SWAC Question #1), would add an additional scenario to address potential doses to workers during active landfill operations. For offsite disposals under 20.2002, the NRC typically requires analysis of three scenarios: transport worker, worker at the disposal facility and resident farmer.

The following is the NRC regulation pertaining to alternate disposal methods:

20.2002 Method for obtaining approval of proposed disposal procedures.

A licensee or applicant for a license may apply to the Commission for approval of proposed procedures, not otherwise authorized in the regulations in this chapter, to dispose of licensed material generated in the licensee's activities. Each application shall include:

(a) A description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk evaluation, and the proposed manner an conditions of waste disposal; and
(b) An analysis and evaluation of pertinent information on the nature of the environment; and
(c) The nature and location of other potentially affected licensed and unlicensed facilities; and
(d) Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in this part.

Sources:
http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-2002.html

The Disposition Dilemma: Controlling the Release of Solid Materials from Nuclear Regulatory Commission-Licensed Facilities, National Academy of Sciences. 2002. Available at: http://www.nap.edu/catalog.php?record_id=10326

SWAC Question #3

How many other states allow waste equivalent to BSFR waste to be disposed at Class I landfills, or equivalent. Please list the states that allow this practice and waste acceptance criteria the waste must meet to be accepted at Class 1 landfills or their equivalent. Is the disposal of BSFR waste implemented in other states following the NRC process or in a manner similar to Tennessee?

Question Deferred: There was insufficient time available to attempt to address this question. It would likely take several months to compile this information from the various state radiation control programs through surveys, phone calls, and site visits.

SWAC Question # 4

Please compare the leachate sample results generated from leachate sampling at Class I landfills by TDEC. Of particular interest are the levels of radioactivity in the samples (by isotope) and whether there is any indication that radiation levels in leachate from landfills accepting BSFR waste is greater than that in leachate from landfills that do not accept BSFR waste. Have elevated levels of tritium been detected in the leachate from the Middlepoint Landfill or other landfills, and if detected are the tritium levels greater than EPA standards

Response:

There are insufficient data to perform meaningful data comparisons among the landfills. The only isotope specific data available for the leachate samples are tritium and K-40 (except for low detections of naturally occurring Pb-212 and Bi-214 in a few of the samples). The tritium concentrations are comparable to those seen in other states and the levels in the BSFR landfills are comparable to, and no higher than, the concentrations in the comparison landfills. The average tritium concentrations observed in the nine Tennessee landfills are comparable to average levels seen from landfills in other states (further discussion provided below).

K-40 is a naturally occurring, beta/gamma emitting radionuclide that is prevalent throughout the environment. The K-40 concentrations in the leachate samples varied significantly (from 190 to 3400 pCi/L). For comparison, concentrations of K-40 in milk average around 1500 pCi/L.

The other analyses performed were gross alpha and gross beta which are not isotope specific and are of limited value except as screening tools to determine the need for additional analyses. The counting errors for the majority of the gross alpha data are very high (>100%) making these data essentially meaningless. These high errors are indicative of a high concentration of solids within the leachate samples.

The gross beta concentrations vary widely and indicate the need for additional sampling and more specific analyses as discussed in more detail below. (See also the response to SWAC Question #7 for further discussion of the beta concentration measurements.)

Discussion:

Landfills Sampled: Leachate samples were collected from the five landfills that receive BSFR wastes and from four landfills that do not receive BSFR wastes and were considered to be the best available "comparisons" based on location, similar soil types, etc. The BSFR landfills (in bold) and the corresponding comparison landfills (in parenthesis) are as follows: **Middlepoint** (Clarksville Bi County), **Chestnut Ridge** (Bount County), **Carters Valley** (Iris Glen), **North Shelby County** (Jackson), **South Shelby County** (Jackson). One grab sample was collected from each location.

There are insufficient data to perform meaningful data comparisons among the landfills. A cursory review of the data follows:

Analyses performed: The analyses performed are gross alpha and gross beta (which are not isotope specific), tritium, and gamma spectroscopy (which is isotope specific, but only identifies gamma emitters above certain energies). The only radionuclides reported for the gamma spec analysis are K-40, Pb-212, and Bi-214 which are all naturally occurring. Pb-212 was identified in only 3 samples and Bi-214 was reported for only one sample. The concentrations of these radionuclides were low and are not discussed further.

Gross alpha results: The gross alpha data are not useful because the associated counting errors for most of the samples are exceedingly high (6 out of 9 samples had errors above 100%). Because the reported concentrations are well above the detection limits for the method used, the high counting errors lead me to believe that the levels of solids in these samples were very high. The method used (EPA Method 900.0 Gross Alpha and Gross Beta Radioactivity in Drinking Water) involves evaporation of a small portion of the sample and counting of the residue. EPA states that for gross alpha analysis "the solids concentration is very much a limiting factor." For samples with high solids, EPA recommends Method 900.1 which involves co-precipitation to chemically separate the activity from the solids.

Gross beta results: It is not possible to draw any meaningful conclusions from the gross beta data, and these data should be followed up with further sampling, isotope specific analyses.

The gross beta concentrations varied widely (Figure 1), and the highest gross beta concentrations among the nine landfills sampled (BSFR and comparison) were measured in the leachate from the Carters Valley and Middlepoint landfills. The lowest gross beta concentrations among the nine landfills were measured at the South Shelby County and North Shelby County landfills. After correction for the contribution of betas from naturally occurring K-40, the remaining beta concentrations ranged from a few picocuries per liter to a maximum of 1600 pCi/L. This maximum concentration is substantially higher than the maximum beta concentrations measured in leachate from California and Pennsylvania landfills and warrants further investigation. (See also the response to

SWAC Question #7 for further discussion of the beta concentration measurements in comparison to data from other states).

Gamma specstroscopy results: Potassium-40 is a naturally occurring beta/gamma emitter. The concentrations of K-40 measured in the leachate samples generally varied with the gross beta concentrations (i.e., samples with higher gross beta concentrations had proportionally higher K-40 concentrations) see Figure 1.

Tritium results: Tritium was measured in leachate from all of the landfills sampled. The concentrations range from 330 to 56,000 pCi/L with an average of 23,000 pCi/L (see Figure x below). The average for the BSFR landfills is 20,090 pCi/L and the average for the comparisons landfills is 27,000 pCi/L. The Clarksville sample has the highest concentration, followed closely by Middlepoint and Iris Glen which have comparable concentrations. The concentration in the Jackson landfill leachate is slightly higher than the Carters Valley, North Shelby and South Shelby concentrations.

The average tritium concentrations in Tennessee landfills are comparable to those measured in other states. For example, the average concentration reported for Pennsylvania landfills is 24, 400 pCi/L with a range of 0 to 182,000 pCi/L The average concentration reported for landfills in New York and New Jersey is 33,800 pCi/L with a maximum level of 192,000 pCi/L.

Source for Pennsylvania data: *Environmental Research and Education Bulletin*, Vol.5, No. 2, Spring 2007(www.erefdn.org.).
Source for NY and NJ data: *A Study of Tritium In Municipal Solid Waste Leachate and Gas*. Robert D. Mutch, Jr., John D. Mahony, Paul R. Paquin, and Joseph Cleary. HydroQual, Inc. (www.hydroqual.com).

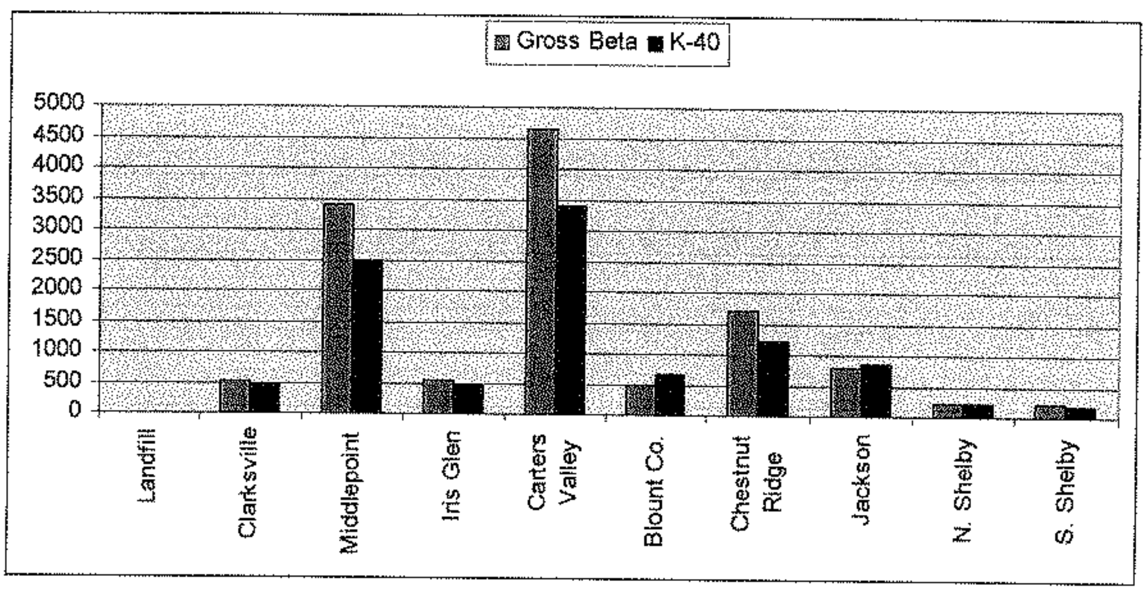

Figure 1: Gross beta and potassium-40 (K-40) concentrations in leachate from nine Tennessee landfills.

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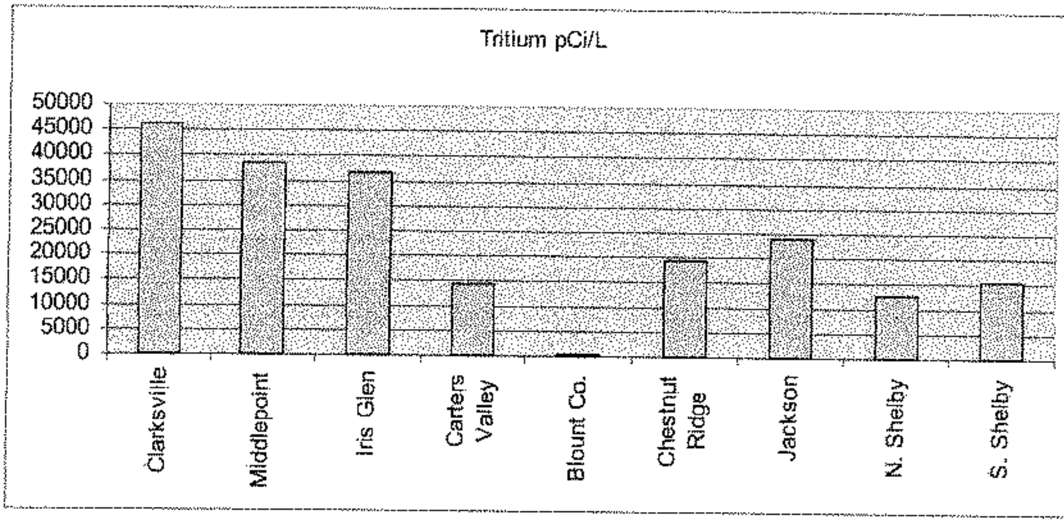

Figure 2. Tritium concentrations in leachate from nine Tennessee landfills.

SWAC Question #5

Have the current NRC requirements for managing waste materials that have radiation levels below the levels for disposal at a secure low level radioactive waste landfill changed over the last 20 years? If so, please describe the change.

Response:

There are no regulations that specifically define the radiation levels below which wastes from licensed operations do not require disposal at a radioactive waste disposal facility. NRC *Regulatory Guide* 1.86 provides the criteria under which materials with only surface contamination can be released from regulatory control and has been in use for about 30 years. Releases of materials that *contain* low levels of radioactive material (volumetrically contaminated materials) can only be released from regulatory control on a case-by-case basis in accordance with 10 CFR 20.2002 (see response to SWAC Question #2). The NRC has been unsuccessful in its attempts over the last 20 to 30 years to develop a new policy, one that would not require case-by-case review.

One change that has occurred in recent years is that prior to 2000 the majority of 10.2002 authorizations pertained to onsite disposals. Since 2000, the NRC has received 17 requests for offsite disposals.

SWAC Question #6

Does the RESRAD Model used by Tennessee accurately predict the level of exposure to radioactivity that occurs when BSFR waste is disposed at Class 1 Landfills? Please confirm that the site conditions and assumptions made in utilization of the RESRAD Model confirm that the exposure of a person at the landfill would be subject to 1 *millirem/year of exposure to radioactivity even if the landfill synthetic liner and clay liners failed.*

Response:

Sufficient time was not available to perform detailed assessments to address potential impacts of liner failure. However, my review of the RESRAD analysis (including site-specific parameter values) that was performed by DRH to establish limits for the Middlepoint landfill and the additional RESRAD evaluations that I performed showed the following:

- No credit is taken for the geomembrane (synthetic liner) in the DRH RESRAD analysis for Middlepoint
- Credit is taken in the DRH analysis for the clay liner and a soil buffer thickness of 10 feet below the liner, (the geologic buffer at Middlepoint is estimated to range from 5 to 75 feet below the waste in the landfill)
- Removal of the clay layer from the model does not increase the estimated dose for the eight radionuclides I evaluated: Co-60, Cs-137, Sr-90, Th-232, U-234, U-235, U-238, and Pu-238
- Radionuclides evaluated were chosen because they represent a wide range of Kd values (i.e., leach rates) (30 to 60,000 cm^3/g) and different predominant pathways of exposure
- Limited evaluation indicates that failure of the clay liner would not result in dose above 1 mrem/year.

It must be kept in mind that this review does not address other landfills or other radionuclides that are involved in the BSFR process.

Discussion:

Environmental transport models, such as the ones implemented in the RESRAD computer code, are simplifications of complex systems and processes. Therefore, there are inherent uncertainties associated with the output from these models. Because the model results are uncertain, conservative assumptions are used to ensure the calculated dose represents an upper bound estimate.

For example, for the BSFR program the RESRAD code is used to calculate the dose to a hypothetical, resident farmer who is assumed to move onto the landfill 20 years post closure. The individual is assumed to consume produce (grown in the waste), to eat meat and milk from the site, and to drink untreated groundwater from a well located down-gradient at the edge of the landfill.

A review of the RESRAD evaluation performed for the Middlepoint landfill, confirmed that no credit was taken for the synthetic liner (geomembrane) or leachate collection system. The model does assume that the unsaturated zone (the zone between the bottom of the waste and the water table) consists of two layers, a 3-foot layer of clay underlain by 10 feet of soil with hydraulic conductivities of 1×10^{-7} and 5.2×10^{-4}, respectively. These assumptions are based on a liner analysis that was performed as part of a hydrogeological report that was prepared for the Middlepoint landfill in 1990.

To evaluate the effects of a failure of the clay liner, I completely removed the clay layer from the model and re-ran the code with only 10 feet of soil between the bottom of the waste and the water table. There was no increase in the maximum dose estimated for the eight radionuclides chosen for the evaluation. However, the time of the maximum dose did change slightly for some. The radionuclides evaluated and their respective Kd values are as follows: Sr-90 (30 cm^3/g), Uranium isotopes (50 cm^3/g), Co-60 (1000 cm^3/g), Pu-238 (2000 cm^3/g), Cs-137 (4600 cm^3/g), and Th-232 (60,000 cm^3/g). These radionuclides were selected because they represent a wide range of leach rates and different predominant exposure pathways (e.g., external, drinking water, and plant ingestion).

SWAC Question # 7

Please provide your thoughts on the comments offered by Dr. Dan Hirsch, the former University of California at Santa Cruz Professor regarding the disposal of BSFR wastes at Class 1 Landfills in Tennessee.

Response:

Based on my review I have identified two primary issues in Mr. Hirsch's comments which are dated July 24, 2007:

Issue 1: Concerns about radionuclides in landfills. Specific issues identified are potential for organics in municipal waste to increase radionuclide migration rates and lack of radiological monitoring requirements for landfills.

Issue Deferred. Insufficient time is available in which to address this issue. However, it does warrant further evaluation. My recommended approach would be to use information contained in the document, *Assessing the Impact of Hazardous Constituents on the Mobilization, Transport, and Fate of Radionuclides in RCRA Waste Disposal Units* (ANL/EAD/TM-93) to assess the impact of potential increases in leach rates through probabilistic analysis and bounding calculations. The results of this assessment could be used to evaluate the adequacy of the current concentration limits on a radionuclide-by-radionuclide basis.

Issue 2. Elevated beta concentrations were measured in leachate from the Middlepoint landfill. The measured value exceeds the EPA drinking water MCL of 50 pCi/L. Measurements for 42 of 50 California leachate samples were below this MCL.

Response:

Mr. Hirsch points out that the gross beta concentrations reported for the Middlepoint landfill leachate sample are 3395 ± 286 pCi/L and contrasts it with the EPA drinking water MCL (maximum contaminant level) of 50 pCi/L. Mr. Hirsch also states that 42 of 50 landfills sampled in California had leachate concentrations below this MCL. He points out that not all of the beta activity in the Middlepoint sample can be attributed to K-40.

I agree with Mr. Hirsch that the Middlepoint landfill leachate sample is substantially higher than the EPA MCL for gross beta and the values reported for the California landfills—even after correction for K-40 at the measured value of 2480 ± 31 pCi/L of K-40 present in the sample. Potassium-40 is a naturally occurring beta/gamma emitting nuclide that is present throughout the environment. There are 0.893 pCi/L of betas activity per pCi/L K-40. If the contribution of betas from K-40 in the Middlepoint sample is subtracted from the gross beta activity measured for that sample, the remaining beta concentration would be approximately 1200 pCi/L. The maximum beta concentration measured in the nine Tennessee landfills sampled, after correction for K-40, is 1600 pCi/L (Carters Valley landfill.) Both of these values are significantly higher than the EPA MCL of 50 pCi/L referenced by Mr. Hirsch.

It should be kept in mind that, although the EPA drinking water standards provide useful points of comparison for radionuclide measurements, they would not be directly applicable to samples of landfill leachates. Also, the gross beta MCL of 50 pCi/L is a screening value above which more isotope specific analyses are needed. The isotopic results are then compared to concentration values, for individual beta/gamma emitting radionuclides, that are derived on the basis of the EPA drinking water dose limit of 4 mrem/year. These derived concentration values range from one to several thousands of pCi/L with typical values on the order of a few hundred pCi/L, depending on the nuclides involved.

The most appropriate way to address the questions raised by the gross beta results for the Tennessee landfill leachate samples would be to perform additional sampling and isotopic specific analyses. The primary purpose of gross analyses, such as gross alpha and beta, is to screen samples to identify which, if any, specific analyses are needed.

One factor that I believe may be contributing slightly to the discrepancies between the Tennessee results and the California results reference by Mr. Hirsch is that the California samples were filtered prior to analysis. Although I have not identified a report that provides data for all 50 of the California landfills mentioned by Mr. Hirsch, I have reviewed two reports that discuss sampling of leachates in California. This sampling was conducted in response to requests from the California State Water Resources Control Board and Regional Water Quality Control Board. In both of these reports it is stated that prior to analysis the samples were filtered through a 0.45 μm filter.

In contrast to the California results approximately 90% of gross beta measurements for leachates from Pennsylvania landfills exceeded the EPA MCL of 50 pCi/L. Pennsylvania initially tried to filter their samples, but found it too difficult because of the high solids concentrations present in the samples. It should be noted that the maximum gross beta concentration measured for 81 Pennsylvania landfills was less than half of the value measured for the Middlepoint landfill in Tennessee.

Sources:

Radiological Investigation Results for Pennsylvania Landfill Leachate, Pennsylvania Department of Environmental Protection and Bureau of Waste Management, Project No. 040-195, October 3, 2005.

Results and Evaluation of Radiochemical Sampling at Six Waste Management, Inc. California Landfills, prepared by GeoChem Applications for the California State Water Resources Control Board. January 2003.

Calabassas Landfill Radioactivity Sampling Report, County Sanitation Districts of Los Angeles County, File: 31R-106.10A. January 23 2003.

SWAC Question #8

Please compare the amount of exposure to radiation for the BSFR waste going to the Middlepoint Landfill with radiation exposure in daily life; i.e. drinking water limits, radon in home limits, exposure during x-rays, exposure to granite, Fiesta dinnerware, etc. Compare the level of exposure at the Middlepoint Landfill with the allowable limits for workers, children and pregnant women.

Under the BSFR program, a dose limit of 1 mrem/year is used to establish concentration limits for landfill disposals. The individual for whom the dose is calculated is a resident farmer who is assumed to live on the landfill starting 20 years post closure. The individual eats food produced on the site including fish from an onsite pond and to drinking untreated groundwater from a down-gradient well located at the edge of the landfill. Both external and internal doses are calculated. External dose comes from radionuclides located outside the body, and internal dose is from radionuclides that are taken into the body through inhalation, ingestion of food, ingestion of drinking water, and inadvertent ingestion of soil. The BSFR concentration limits are based on limiting the dose to the resident farmer to a maximum of 1 mrem/year.

The NRC limits radiation doses to adult workers to 5000 mrem/year. Doses to pregnant women (during pregnancy) are limited to 500 mrem. There is not a dose limit for children, but the NRC dose limit for the general public is 100 mrem/year.

Comparison doses are provided in the table below. This information is taken from the EPA website.

Source	mrem
Chest x-ray	10
Mammogram	30
Cosmic rays	31 annually
Human body	39 annually
Household radon	200
Cross-country airline flight (round trip)	5 mrem

A 1 mrem dose corresponds to an estimated cancer risk (both cancer incidence and cancer deaths) of one in a million (BEIR VII). The NRC website lists the following examples of common activities that correspond to a one in a million risk of dying:

- Smoking 1.4 cigarettes (lung cancer)
- Eating 40 tablespoons of peanut butter
- Spending 2 days in New York City (air pollution)
- Driving 40 miles in a car (accident)
- Flying 2500 miles in a jet (accident)
- Receiving 1 mrem of radiation (cancer)

Assuming 70 years of exposure at a dose rate of 1 mrem/year the estimated lifetime risk would be 7 in 100,000. For comparison, this risk is less than 0.6% of the lifetime risk from natural background radiation and falls within EPA's acceptable risk range for Superfund activities which is 1 in 1,000,000 to 1 in 10,000.

Sources:
www.epa.gov.radiation/rert/radfacts.htm

http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html (risk comparisons are adapted from DOE Radiation Worker Training, based on work by B.L Cohen, Sc.D.)

Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2. www.nap.edu. National Research Council of the National Academies. The National Academies Press. Washington, D.C. 2006

SWAC Question #9

Please provide type and physical description of the BSFR wastes that are disposed at the Middlepoint Landfill. Does the BSFR waste have greater levels of radioactivity than typical Tennessee soils?

Deferred: This question was deferred because there was insufficient time to address it.

However, I can offer the following:

BSFR approved materials include soils, resins, concrete, wood, asphalt, paper, plastic and clothing.

BSFR concentrations differ for different landfills. In some cases the levels of radioactivity in BSFR wastes would be less than typical background levels in soils. However, in other cases they would be higher. Because there are different types of radionuclides involved, dose assessments would be needed to provide meaningful comparisons between the BSFR materials and background soils.

SWAC Question #10

If the Middlepoint Landfill continues to receive BSFR waste will the additional waste increase the exposure hazard (>1 millirem/year), as more waste is disposed at the landfill? Please explain your answer.

The BSFR concentration limits are based on limiting the dose to a resident farmer to a maximum of 1 mrem/year. For the BSFR dose analysis it is assumed that 10% of the total volume of waste in the landfill at the time of closure is BSFR material. The annual disposal rates are controlled such that this percentage is not exceeded on an annual basis. At Middlepoint the annual BSFR waste volumes are held to 5% of the total expected waste volumes. Therefore, the maximum dose rate calculated for the resident farmer for 20 to 1000 years post closure would not exceed 1 mrem/year.

Response to End It's Concern about Tritium in Drinking Water

"Questions and Comments To the Solid Waste Advisory Committee From Citizens to End Nuclear Dumping in TN," Our Concerns About Radiation

13th Bulleted Item: One of the test of Murfreesboro's drinking water has shown an elevated tritium, a radioactive isotope of hydrogen, which, if inhaled or ingested, is known to increase risk of cancer, birth defects, miscarriages, and genetic abnormalities. According to the EPA website, "Its (tritium's) most significant use is as a component in the triggering mechanism in thermonuclear (fusion) weapons capabilities.

Response:

I am not aware of any tritium measurements in Murfreesboro drinking water. I believe the sample in question may actually be effluent from the **wastewater** treatment plant. The concentration of tritium measured in the wastewater treatment plant effluent which is discharged into the river is less than 1% of the EPA drinking water standard for tritium.

The EPA considers all elements that emit ionizing radiation to be Class A carcinogens. However, because tritium is a low-energy, pure beta emitter it is not considered a particularly effective carcinogen. Tritium is only a concern when taken into the body, and according to the EPA "for a given amount of activity ingested, tritium is one of the least dangerous radionuclides."

Discussion:

Sample data: I am not aware of any data that shows elevated levels of tritium in the Murfreesboro drinking water supply. Under the EPA drinking water standards, Murfreesboro is not required to perform tritium analysis. No tritium data have been reported to TDEC by Murfreesboro based on TDEC records going back as far as 1988.

Tritium was detected in an effluent sample from the Murfreesboro **wastewater** treatment plant. It is possible that this data has been mistakenly assumed to be a water treatment plant sample. The wastewater treatment plant receives leachate from the Middlepoint landfill which has been shown to contain elevated levels of tritium and is the most likely source.

The **wastewater** treatment plant effluent sample was collected by TDEC on 6/8/07 in conjunction with their leachate sampling effort. The tritium level in this effluent sample was 167 ± 98 pCi/l which is less than 1% of the EPA maximum contaminant level (MCL) for tritium (i.e., the drinking water standard). The MCL is based on a dose limit of 1 mrem/year* and a water ingestion rate of 2 liters per day. Therefore, consumption of the wastewater treatment plant effluent for an entire year would result in a dose of approximately 0.008 mrem which is about 0.003% of the average annual background radiation dose. Drinking this water over a 70-year lifespan would result in a dose of about 0.6 mrem which equates to a lifetime cancer risk of less than 6×10^{-7}.

Health effects of tritium. Because it emits ionizing radiation, tritium is classified by the EPA as a Class A carcinogen. On its website EPA states "As with all ionizing radiation, exposure to tritium increases the risk of developing cancer. However, because it emits very low energy radiation and leaves the body relatively quickly, for a given amount of activity ingested, tritium is one of the least dangerous radionuclides." <<http://www.epa.gov/radiation/radionuclides/tritium.htm#inthebody >>

The California Environmental Protection Agency states the following in its document, *Public Health Goal for Tritium in Drinking Water,* which was issued in March 2006:

> For tritium, the experimental evidence for carcinogenicity is rather weak. Many animal studies show no increased incidences of tumors over controls, or the evidence is debatable. To optimize the possibility to observe tritium induced tumors, investigators have focused their efforts by administering tritium in utero or shortly after birth, yet this approach did not always result in increased tumor incidence. Life-span shortening seen at high doses of tritium described by Balonov et al. (1993) and Cahill et al. (1975) were associated with decreased tumor incidence when compared with lower doses of tritium exposure. Apparently, animals were not dying from tumors associated with tritium exposure.
>
> We found no human data that specifically address the carcinogenic effects of tritium. There is a wealth of human cancer information on ionizing radiation in general. Hence, U.S. EPA classifies all emitters of ionizing radiation as Group A carcinogens based on sufficient epidemiological evidence.