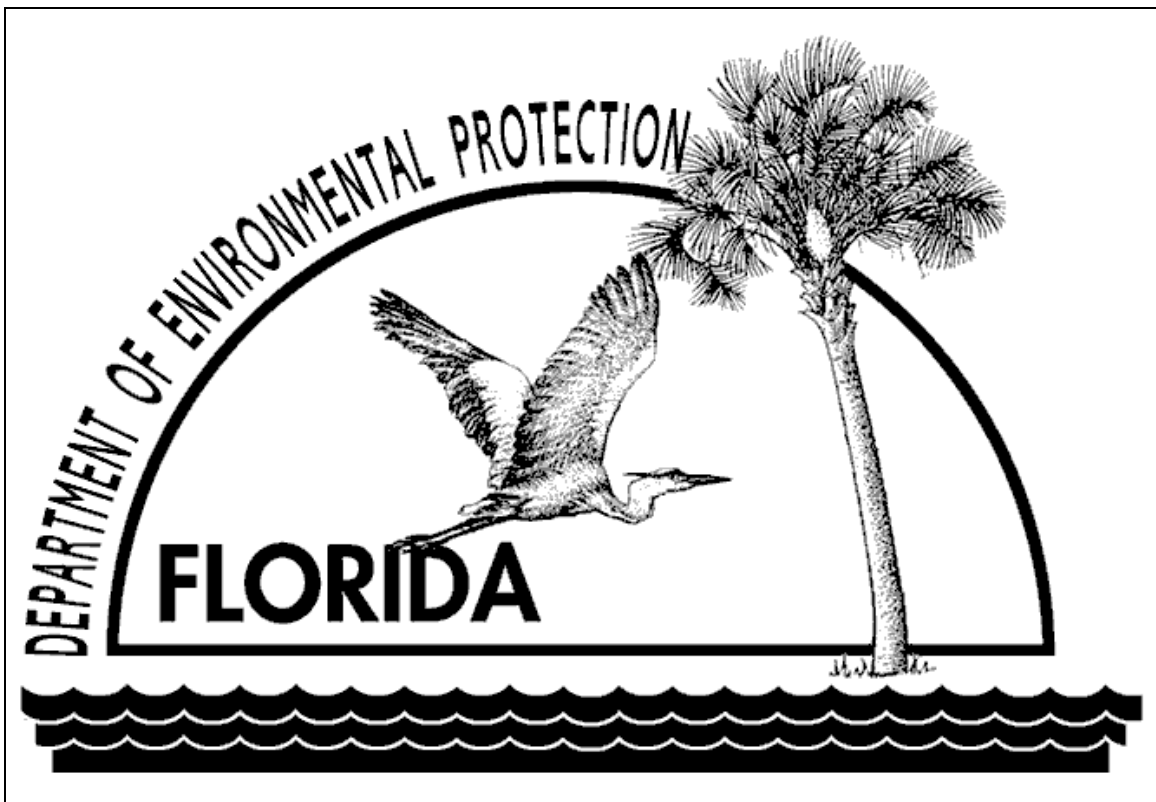


**GUIDANCE FOR PREPARING
MUNICIPAL WASTE-TO-ENERGY ASH
BENEFICIAL USE DEMONSTRATIONS**

**FINAL
REVISION No. 1**

February 27, 2001



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DISCLAIMER

The information contained in this document is intended for guidance only. It is not a rule and does not create any standards or criteria which must be followed by the regulated community. While the use of waste-to-energy (WTE) ash or WTE ash products in accordance with this guidance is not expected to result in contamination of ground water or surface water, compliance with this document does not relieve the owner or operator from the responsibility for complying with the Department's rules nor from any liability for environmental damages caused by the use of the ash or ash product.

PREFACE

This document was originally finalized on August 21, 2000. The primary purpose of this revision, Revision No. 1, is to include reuse target levels (RTLs) in this document for assistance to the regulated community. The use of the August 21, 2000 document should be discontinued. An applicant preparing a Beneficial Use Demonstration for waste-to-energy ash should follow the guidance contained in this revised document.

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LIST OF ACRONYMS

- APA - Administrative Procedure Act
- ATL - Alternate Target Level
- BUD - Beneficial Use Demonstration
- COCs - Chemicals of Concern
- CompQAP - Comprehensive Quality Assurance Plan
- CFR - Code of Federal Regulations
- EPA - U. S. Environmental Protection Agency
- F.A.C. - Florida Administrative Code
- F.R. - Federal Register
- F.S. - Florida Statutes
- HRA - Health Risk Assessment
- NELAP - National Environmental Laboratory Accreditation Program
- RCRA - Resource Conservation and Recovery Act
- RME - Reasonable Maximum Exposure
- RTL - Reuse Target Level
- SOP - Standard Operating Procedures
- SPLP - Synthetic Precipitation Leaching Procedure
- SWANA - Solid Waste Association of North America
- TC - Toxicity Characteristic
- TCDD - Tetrachlorodibenzo-p-dioxin
- TCLP - Toxicity Characteristic Leaching Procedure
- TDS - Total Dissolved Solids
- VOC - Volatile Organic Compound
- WTE - Waste-to-Energy

1.0 BACKGROUND

1.1 RCRA Issues

Prior to 1994, it was generally believed that the ash residue (ash) from municipal waste-to-energy (WTE) facilities was exempt from regulation under Subtitle C of the Resource Conservation and Recovery Act (RCRA). This changed on May 2, 1994, when the U.S. Supreme Court issued a decision in the City of Chicago v. Environmental Defense Fund, Inc., 114 S.Ct. 1588 (1994). In this case, the Court held that municipal WTE facilities could burn household waste alone or in combination with industrial or commercial wastes and not be regulated under Subtitle C of RCRA, but the ash generated by these facilities was not exempt from regulation. Consequently, owner/operators of WTE facilities had to determine if their ash was a hazardous waste. This decision placed a cloud of uncertainty on the prospects of using WTE ash as a product rather than disposing of it as a solid waste.

In response to this decision, on May 27, 1994, the U.S. Environmental Protection Agency (EPA) issued an implementation strategy which directed generators of ash from WTE facilities to conduct an initial hazardous waste characterization of their ash within 90 days of the effective date of the Supreme Court decision.¹ On June 23, 1994 (59 FR 32427), the EPA released a draft guidance document² to assist these generators in determining whether their ash exhibited the Toxicity Characteristic (TC). This draft guidance was entitled, "Sampling and Analysis of Municipal Refuse Incineration Ash." By September 1994, all WTE facilities in Florida had characterized their ash in accordance with EPA's draft protocol and determined that the ash was not a characteristic hazardous waste. However, the issue of sampling point location, or point of generation, for WTE ash had not yet been resolved, which left the initial characterizations in doubt.

On February 3, 1995, the EPA published its determination in the Federal Register (60 FR 6666) that the point of generation at which RCRA Subtitle C jurisdiction began for WTE ash was when the ash exited the combustion building following the combustion and air pollution control processes. This determination allowed WTE facilities to combine the fly ash and bottom ash inside the combustion building prior to sampling. It also allowed the

¹ The Supreme Court decision became effective on June 1, 1994.

² On July 24, 1995 (60 FR 37896), this document became final and was entitled, "Guidance for the Sampling and Analysis of Municipal Waste Combustion Ash for the Toxicity Characteristic."

treatment or conditioning of the ash inside the combustion building prior to sampling. As a result of this determination, the Florida Department of Environmental Protection (Department) concluded that the initial ash characterizations for the Florida WTE facilities were acceptable. In addition, on October 5, 1995, the Department determined it would not require additional characterizations of the WTE ash prior to disposal because, in accordance with 40 CFR 262.11, these decisions are the responsibility of the generator and all the ash was being disposed of in lined landfills. Nonetheless, the Department continues to expect the generator to recharacterize its ash if there are changes in the WTE facility process, feed stream composition or other factors which could be reasonably expected to adversely affect the leachability of the ash.

1.2 State Issues

For many years, WTE plant owner/operators and third party recyclers have been investigating the possibility of using WTE ash as a product or as a raw material in the formulation of other products rather than disposing of this ash as a solid waste. It is estimated that the 13 WTE facilities currently operating in Florida burn approximately 5 million tons of waste per year and generate approximately 1.4 million tons per year of ash. Currently, this ash is disposed of in landfills located throughout the State which are lined and meet or exceed the RCRA Subtitle D requirements. To develop a uniform review process, the Solid Waste Association of North America (SWANA), the owner/operators of WTE facilities and ash recyclers asked the Department to develop guidelines for obtaining approvals to use WTE ash.

While considering this request, questions were raised about the Department's authority to approve the use of ash. In 1988, the Legislature adopted Section 403.7045(5), Florida Statutes (F.S.), which encouraged the Department to develop methods for recycling and reuse of ash. However, Section 403.7045(5), F.S. also clearly stated that "ash shall be disposed of in a properly designed solid waste disposal area that complies with standards developed by the department." This statute did not give specific authority to the Department to approve ash use projects or to adopt rules approving ash use projects. Furthermore, in 1996 the Legislature amended the Florida Administrative Procedure Act (APA) to restrict the rulemaking authority of all state agencies. In light of these changes to the APA, the Department became reluctant to consider or approve proposals for ash use projects.

In order to resolve this difficulty, in 1998 the Florida Legislature amended Section 403.7045(5), F.S. to read as follows:

(5) Ash residue generated by a solid waste management facility from the burning of solid waste must be disposed of in a properly designed solid waste disposal area that complies with standards developed by the department for the disposal of such ash residue. The department shall work with solid waste management facilities that burn solid waste to identify and develop methods for recycling and reuse of ash residue or treated ash residue, and the department may allow such recycling or reuse by an applicant who demonstrates that no significant threat to public health will result and that applicable department standards and criteria will not be violated. The Division of Waste Management shall direct the district offices and bureaus on matters relating to the interpretation and applicability of this subsection. The department may adopt rules necessary for administering this subsection, but the department is not required to amend its existing rules.

This new language granted the Department clear authority for approving WTE ash use projects, provided public health is protected and applicable Department standards and criteria are not violated. WTE facility owner/operators or third party recyclers or operators who wish to beneficially use WTE ash rather than dispose of it must demonstrate to the Department that the proposed use will satisfy these requirements.

2.0 PURPOSE

The purpose of this document is to implement the provisions of Section 403.7045(5), F.S. by providing guidance to the regulated community and the Department for the preparation of acceptable Beneficial Use Demonstrations (BUDs) which establish the basis for using WTE ash either as a product or as a raw material in the formulation of other products. While additional rulemaking is authorized by statute and is being considered by the Department, this document is not a rule and does not create any standards or criteria which must be followed by the regulated community.

3.0 GOALS FOR BENEFICIAL USE DEMONSTRATIONS

Consistent with Sections 403.7045(5), F.S. and 403.704(6), F.S., it is the Legislature's and the Department's policy to promote the recycling of WTE ash in a cost-effective manner, provided the recycling is protective of human health and applicable Department standards and criteria will not be violated. In order for a project to be approved by the Department, the BUD for WTE ash must provide reasonable assurance³ that the proposed use will satisfy Section 403.7045(5), F.S. The main goals for applicants seeking approvals for the beneficial use of ash or ash-derived products are summarized as follows:

- (a) The ash must be managed and used so that it will not cause violations of applicable Department air standards or ground water or surface water standards and criteria.
- (b) The use of the ash must not pose a significant threat to human health, which, for the purposes of this document, means an incremental risk of no greater than 1×10^{-6} for carcinogens and a hazard index of no greater than one (1.0) for non-carcinogens. When providing this demonstration, the BUD must consider human exposure pathways such as inhalation, ingestion, and dermal contact with the ash in its proposed use.
- (c) In order to qualify as a product or raw material, the use of the ash must be beneficial, i.e., the ash must have chemical or physical properties similar to the raw material it is replacing or its use must have enhancing qualities to the final product which would distinguish that use from disposal.
- (d) The use of the ash must not create a public nuisance.

³ The Department requires "reasonable assurance" but not "absolute guarantees that a project will not under any circumstances cause pollution." See J.T. McCormick, et al. v. City of Jacksonville and Department of Environmental Regulation, 12 F.A.L.R. 960 (Final Order dated January 22, 1989). The reasonable assurance standard has been applied to a wide range of cases, including cases involving landfills, and the same standard would apply to the Department's review of BUDs.

4.0 GENERAL BUD REQUIREMENTS

4.1 General Format and Process

The BUD should have text printed on 8 1/2 inch by 11 inch consecutively numbered pages with a cover sheet stating the project title, date and applicant's name and address. It should also include a table of contents describing the body of the report and the appendices. The BUD should be a complete document containing process descriptions for generation, handling and treatment of the ash, and all supporting calculations, figures, laboratory analytical data, risk assessments or other information required in this document or provided by the applicant supporting each proposed use of the WTE ash.

The BUD must show that the goals of Section 3.0 will be achieved for each proposed ash use. To evaluate potential human health risks, the requirements of Section 4.2 should be followed. In order to determine the potential of ash to contaminate ground or surface water, the applicant should normally compare the results of the Synthetic Precipitation Leaching Procedure⁴ (SPLP) testing, EPA Method 1312, required in Section 6.2 to the Department's ground water and surface water standards and criteria.

To begin the Department's review process, two copies of the BUD should be submitted to the Administrator of the Department's Solid Waste Section in Tallahassee, Florida. In addition, two copies of the BUD should be submitted to the Department's District office in the District where the WTE facility generating the ash, or the ash recycling facility, addressed in the BUD is located. A list of contacts and addresses for the Tallahassee and District offices is provided in APPENDIX A.

Submittal of a BUD, by itself, does not constitute a request to modify a permit or site certification. However, a BUD may be used as supporting documentation for any such request. A single BUD may be appropriate for requests to use ash in a product, while separate BUDs (or separate elements within a single BUD)

⁴ This document assumes that an applicant will choose to use the results of the SPLP tests to evaluate leaching potential of the ash and is written from that perspective. However, potential ground water or surface water impacts can also be evaluated using column leaching tests (lysimeters). Also ground water impact evaluations can be supplemented using computerized ground water modeling or longer term studies of smaller demonstration projects constructed in the field under controlled conditions with approved ground water monitoring plans. The BUD should thoroughly explain these alternatives if they are proposed. In addition, potential ground water and surface water impacts can be evaluated by comparing the concentrations of chemicals detected in the ash to the RTL leachability values in APPENDIX D.

may be appropriate for different use projects. Depending upon the nature of the proposed use, Department approval may take the form of a permit or certification modification (for specific projects located within a Department District) or a generic statewide approval (for products using ash). A permit or certification modification may also be needed if the ash is specially managed on-site as part of a project. For off-site uses of ash that require Department approval under Section 10.0, separate Department approvals will be required for each proposed use specified in Section 10.0, although a single BUD may be used to support each request for approval. Denial of a proposal in a BUD does not constitute a denial of any previously approved activity at a WTE facility or landfill.

4.2 Human Health Risks From Direct Exposure

In order to demonstrate that no significant threat to human health is expected from direct exposure to the ash or ash products, the BUD should either: (1) compare the results of the baseline total analysis of the ash or ash-derived product required in Section 6.2 to the Department's Reuse Target Levels⁵ (RTLs) contained in APPENDIX D, and show that the Department's RTLs will not be exceeded for the proposed use; or (2) provide a satisfactory independent human health risk assessment (HRA) which demonstrates that the risk goals in Section 3.0(b) will be achieved with the proposed ash use and develops Alternate Target Levels⁶ (ATLs) for that use; or (3) show that human exposure pathways are negligible or significantly reduced for the proposed ash use so that the risk goals of Section 3.0(b) will not be exceeded; or (4) show that the chemical concentrations in the ash or ash product are at or below the naturally occurring background concentrations at sites destined for ash use.

The Department recognizes that ash which is used in encapsulation technologies⁷ or as protected structural fill⁸ or

⁵ The RTLs only apply to the upper two feet of soil where the ash or proposed ash product is applied.

⁶ While the goal of the HRA will be to show that the health risk goals of Section 3.0(b) are achieved for use of the ash or ash-derived product, the concentrations of chemicals used as input values in a Department approved HRA may be considered "alternate target levels" for the purposes of determining chemicals of concern in Section 6.2. ATLs are further defined in Section 6.2.

⁷ For example, use of ash as part of the aggregate feed in the production of Portland cement, concrete or asphalt.

⁸ For the purposes of this document, "protected structural fill" means fill which will be used in construction projects but, through use of engineering controls such as barriers like concrete or asphalt, will not be exposed at its surface when the construction is complete and thus human exposure to the fill will be prevented. Examples of this use would include fill used underneath a building, below a paved parking lot, as subbase for a paved road or behind a solid retaining wall.

which is covered with at least two feet of clean fill⁹ can significantly reduce the likelihood of direct human exposure. To ensure that the human exposure pathways are negligible for use in encapsulation technologies, the BUD should provide details of the technology to be used including percentage of ash in the final product and an estimate of the long-term durability of the product. To ensure that the human exposure pathways are negligible for use as protected structural fill, the BUD should provide assurance, normally in the form of a legally enforceable institutional control, that the engineering controls of this use, such as retaining walls, concrete slabs or paved surfaces, will be maintained. To ensure that the human exposure pathways are negligible for use under two feet of clean fill, the BUD should provide assurance, normally in the form of a legally enforceable institutional control, that the two feet of cover will be maintained. Baseline analysis to characterize the ash or ash products in Section 6.2 will still be required even if the ash use provides negligible human exposure pathways. Weekly analysis for some constituents will not be required (see Sections 7.1(a) and 8.0(b)).

In some cases, ash use may be planned for a particular site in which the naturally occurring background conditions are known, or can be readily determined. When evaluating proposed ash uses, the Department will consider naturally occurring background conditions at a site provided: (1) the site is not planned for residential use; (2) naturally occurring background chemical concentrations have been properly determined; and (3) the concentrations of chemicals in the ash or ash product as determined by baseline analysis in Section 6.2 are at or below naturally occurring background concentrations.

An applicant may choose to use the Department's RTLs for human health risk evaluations of proposed ash uses. However, as was stated in Section 2.0, this document is not a rule and does not create any standards or criteria which must be followed by the regulated community. Thus, it should be remembered that the Department's RTLs are intended for guidance only and their use is not required.

An applicant may also evaluate the potential for direct human exposure to the ash or ash products by conducting a separate human HRA for each proposed ash use. This HRA must be prepared by a toxicologist, or other qualified professional with experience in the preparation of health risk assessments, and

⁹ For the purposes of this document, "clean fill" means soil which has not become contaminated by human activity or soil which meets the "cleaned soil" criteria of Chapter 62-713, F.A.C. Soil may include other similar materials if approved by the Department.

must conform to standard guidelines and practices for risk assessments. It should be based on an estimate of the reasonable maximum exposure (RME) expected to occur under both proposed and reasonably anticipated future land uses. The Department considers the RME to be the highest exposure reasonably expected to occur at a site where ash is used, rather than the "worst possible case"¹⁰. The HRA should include basic elements such as a description of the project and the contaminants of concern, an exposure assessment, a toxicity assessment and a risk characterization. The HRA should show that the goals of Section 3.0 will be achieved. If any ATLS are proposed to justify use of the ash or ash-derived products, then the HRA should provide the derivation and documentation for these ATLS. Baseline analysis in Section 6.2 will still be required to characterize the ash or ash-derived products.

5.0 BENEFICIAL USE AND PROCESS DESCRIPTION

5.1 Description of Ash and Proposed Use

The BUD should include a detailed description of the ash or ash-derived product that will be used and the proposed use or uses for that ash or ash-derived product. Since project approvals are given on a use-specific basis, the Department recommends that each proposed ash use or product, from the point at which it is generated to final use, be addressed separately in the BUD. The BUD should consider both the proposed uses and reasonably anticipated future uses of the ash or ash-derived product in its evaluation.¹¹

5.2 Usefulness as Raw Material or Product

The BUD should show that a proposed ash use is beneficial rather than solely an alternate means of disposal. An ash use is beneficial if the ash has chemical or physical properties similar to the raw material it is replacing, or if its use has enhancing qualities to the final product which would distinguish the proposed use from disposal. For example, if an ash is to be used as a protected structural fill¹² such as road subbase, then the BUD could include documentation that the structural properties of the ash are similar to other materials normally used in road

¹⁰ U.S. EPA, 1991, Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, p.2.

¹¹ While the Department does not require a "life cycle analysis" of the ash, the BUD should consider future, reasonably anticipated land use changes which could result in additional impacts to human health and the environment from the ash in its proposed use.

¹² Protected structural fill is defined in Section 4.2.

subbase applications. Or if an ash is proposed as an aggregate feed in cement manufacturing, then data could be provided to show this use is similar to other raw materials typically used in this process. To the extent possible, a BUD should also include use approval letters from other agencies which would regulate these applications such as the Florida Department of Transportation¹³ or agencies in other states that have reviewed the same or similar proposals.

5.3 Process Operation Plan

The BUD should include a Process Operation Plan which will describe the following:

- (a) A description of how the ash will be generated and processed into the final product including (if necessary) any treatment of the ash;
- (b) Procedures for routine analysis of the ash (Section 7.0) to ensure that the ash's composition or proposed product's composition have not changed significantly from the results of the baseline analysis (Section 6.2) so as to require another characterization (Section 6.4);
- (c) Procedures for ensuring that the Quarterly Reports (Section 7.4) will be completed and submitted to the Department in a timely manner each quarter;
- (d) Procedures for ensuring that fugitive dust emissions from the ash or proposed product will be controlled during transportation and off-site storage; and
- (e) Procedures for ensuring that any off-site storage of the ash or proposed ash-derived product will not result in violations of the Department's ground water or surface water standards. In place of proposing leachate and stormwater controls, the BUD could include a demonstration that the leachability of the ash or ash-derived product will be at or below ground water and surface water standards and criteria before leaving the WTE facility or ash recycling facility where it is generated. This testing could include evaluations of

¹³ While the BUD must provide information that the proposed ash uses are beneficial, the Department will rely upon determinations made by other Florida agencies on the aspects of ash use proposals which are within the regulatory authority of those agencies and outside of the jurisdiction of the Department.

the ash in its raw form, in a conditioned form or as formulated in the proposed product.

6.0 ASH AND PRODUCT CHARACTERIZATIONS

6.1 Hazardous Waste Characterization

In order to be approved, a BUD proposed for WTE ash should include a demonstration that the ash to be used is not a hazardous waste. Several options are available to the applicant for providing this information.

First, as was stated in Section 1.0, by September 1995 all active WTE facilities in Florida had determined their ash waste streams were not characteristic hazardous wastes. This testing was considered the "initial characterization" of the ash. In most cases, prior to this sampling and analysis the fly ash and bottom ash streams were combined inside the combustion building following the combustion and air pollution control processes. In addition, some WTE facilities conditioned the ash prior to sampling. Both combining the fly ash with bottom ash and conditioning of the ash prior to sampling were allowed by EPA if this was conducted within the combustion building. Consequently, if the ash waste stream that was tested in 1995 is the same proposed for use in the BUD, then the information from that initial characterization can be used and should be submitted to support a non-hazardous waste determination for the ash. However, if the ash in the proposed BUD is not the same waste stream as that which was tested in September 1995, i.e., is a new waste stream, then a separate hazardous waste characterization will be required for the ash proposed in the BUD. Some reasons why an ash stream would be considered new and not the same as the ash tested in the initial characterization are as follows:

- (a) The ash in the initial characterization consisted of combined fly ash and bottom ash, but the ash proposed in the BUD is not combined;
- (b) Ash conditioning was conducted during the initial characterization but is either not proposed or a different treatment technology is proposed for the ash in the BUD;
- (c) The current or proposed composition of the waste stream to the WTE facility for the BUD is significantly different from the waste stream during the initial characterization; or

- (d) The WTE facility has implemented significant process changes since the initial characterization which would reasonably be expected to adversely affect the leachability of the ash.

Any new ash waste stream¹⁴ proposed in the BUD should be sampled and analyzed in accordance with EPA's June 1995 protocol called, "Guidance For The Sampling And Analysis Of Municipal Waste Combustion Ash For The Toxicity Characteristic" (EPA, 1995). The results of this testing should be included in the BUD.

6.2 Baseline Analysis

Baseline analysis refers to a chemical characterization required of the ash or the product using ash which is proposed in the BUD. The goals of baseline analysis are: (1) to determine total and leachable concentrations of chemicals in the ash or proposed product for use as, or confirmation of, input parameters in a HRA (i.e., ATLS) or to determine concentrations of chemicals in the ash or proposed product for comparison to the Department's RTLs; (2) to determine if the ash or product will leach constituents at concentrations greater than the Department's ground water or surface water standards or criteria; and (3) to identify the chemicals of concern (COCs) or other chemicals, i.e. potential COCs, that should be monitored during routine analysis. Available, relevant data on ash or proposed product chemical characteristics from a WTE facility can be used to supplement the information needed for baseline analysis provided this data can be reasonably shown to be properly obtained and representative of the ash being evaluated. The decision to allow the use of available ash data will be made by the Department on a case-by-case basis.

Chemicals are considered COCs if they could create a potential human health risk from direct exposure or if they have the potential to contaminate ground water or surface water, i.e., leachability concerns. In this document, "**COCs for direct human exposure**" are defined as any chemicals detected in the baseline

¹⁴ While outside the scope of this guidance document, it is important to remember that WTE ash management changes implemented to accommodate a BUD may also result in changes to the residual ash stream (if not all the ash stream is proposed for use in the BUD). Since this residual ash would normally be disposed of at a landfill, the generator is also responsible for ensuring that the residual ash is not a hazardous waste. This determination may require a characterization of the residual ash using EPA's June 1995 sampling and analysis protocol.

analyses where the upper 95 percent confidence level¹⁵ for the mean concentrations are: (1) greater than the Department's residential RTLs for direct exposure contained in APPENDIX D; or (2) greater than the ATLs for direct human exposure¹⁶ as determined by a Department approved HRA.

Chemicals detected in baseline analysis are considered "**COCs for leachability**" when any of the following three conditions occur. In the first condition, detected chemicals are considered COCs for leachability when the upper 95 percent confidence level for the mean of their total concentrations in the baseline analyses exceed the corresponding RTL leachability values contained in APPENDIX D. If the total concentration of a chemical exceeds its RTL leachability value, the applicant may choose to conduct SPLP testing for that chemical to further evaluate its leachability. In that case, the chemical is considered a COC for leachability when the upper 95 percent confidence level for its mean concentration in the SPLP¹⁷ results is: (1) above the Department's ground water or surface water standards¹⁸ or criteria; or (2) above the ATL for leachability if determined by a HRA. If a chemical's leachability values in APPENDIX D are exceeded in the total analysis but the SPLP results do not indicate that the ATL for leachability or the appropriate Department standards or criteria will be violated, then the SPLP test shall be the determining factor.

¹⁵ Procedures for calculating upper confidence levels are contained in APPENDIX C.

¹⁶ This document considers two types of ATLs which may be proposed in a HRA: (1) ATL for direct human exposure; and (2) ATL for leachability. The "ATLs for direct human exposure" would be functionally comparable to the Department's residential RTLs. The "ATLs for leachability" are proposed allowable ground water concentrations which, based on a ground water model, are not expected to result in violations of the Department's water quality standards or criteria at a designated point of compliance.

¹⁷ The Department will also allow the use of Toxicity Characteristic Leaching Procedure (TCLP), EPA Method 1311, results to evaluate leachability of ash if these results are available.

¹⁸ Many of the surface water standards for metals contained in Chapter 62-302, F.A.C. are a function of the total hardness (not alkalinity) of the receiving surface water body. This total hardness is expressed as mg/L of CaCO₃. Some of these metals would likely be COCs in ash such as: cadmium, chromium (trivalent), copper, lead, nickel and zinc. When determining surface water metals criteria, Chapter 62-302, F.A.C. allows a total hardness range from 25 mg/L to 400 mg/L, i.e., from soft water to very hard water, in the receiving body of water. Since ash uses can be statewide, the Department recommends the metals criteria for these parameters be based on a total hardness value of 100 mg/L as CaCO₃ unless site-specific data on total hardness is available. Also, the SPLP results should be compared to the Department's Class III surface water quality standards contained in Chapter 62-302, F.A.C.

For the second condition, there are some parameters in the ash or ash product that do not have a corresponding RTL for leachability values¹⁹ and must be evaluated using the SPLP test. They will be considered a COC for leachability when the upper 95 percent confidence level for their mean concentrations in the SPLP results is: (1) above the Department's ground water or surface water standards or criteria; or (2) above the ATL for leachability if determined by a HRA.

Finally, for the third condition, a chemical detected in baseline analysis is considered a COC for leachability when more than ten percent of: (1) its individual total concentrations exceed the corresponding RTL for leachability; or (2) its individual SPLP test results exceed the Department's corresponding ground water or surface water standard or criteria (or exceed the ATL for leachability).

Should this third condition occur, the applicant may attempt to remedy it in two ways. First, additional representative samples of the ash or product may be collected and subjected to total analysis or the SPLP analysis, as needed. These new results may then be combined with the original baseline total analyses or SPLP results for the chemical. If, when all of these results are used, the 10 percent threshold is no longer exceeded, then the condition has been remedied.

Second, a sample of ash or product which resulted in a chemical having elevated test results may be further analyzed, to confirm or reject the initial result, by conducting total or SPLP testing on three additional aliquots from the original sample, as needed. If none of the total concentrations for the chemical from analyzing the three additional aliquots exceed the corresponding RTL for leachability, then the initial total test result for that sample may be rejected. Or, if none of the SPLP results from analyzing the three additional aliquots for the chemical exceed the Department's corresponding ground water or surface water standard or criteria (or exceed the ATL for leachability), then the initial SPLP test result for that sample may be rejected.

In addition to identifying COCs, baseline analysis can also be used to evaluate potential COCs. In this document, **"potential COCs for direct human exposure"** occur when the upper 95 percent confidence level of the mean concentration for any chemical detected during the baseline analysis is less than the Department's corresponding residential RTL (or ATL for direct

¹⁹ These parameters include at least pH, chloride, sulfate, total dissolved solids, manganese, iron, aluminum, copper, fluoride and lead.

human exposure) but greater than or equal to 50 percent of that value. Also, "**potential COCs for leachability**" occur when the upper 95 percent confidence level of the mean concentration for the total analysis or SPLP results of any chemical detected during baseline analysis is less than the corresponding RTL for leachability or ground water or surface water standard or criteria (or ATL for leachability) but greater than or equal to 50 percent of those respective values, standards or criteria.

To characterize newly generated ash or proposed products, a minimum of fourteen, representative 8-hour composite samples should be collected over seven to fourteen consecutive days of operation. In addition, seven grab samples shall be collected for analysis of volatile organic compounds. The samples must be collected from ash or ash-derived product that is representative of the material to be utilized. The samples should be collected and handled according to the procedures described in the Department's approved Standard Operating Procedures (SOP) contained in APPENDIX B.

For on-site ash stockpiles at existing facilities, the number of samples needed to characterize each stockpile should be determined from the procedures described in EPA publication SW-846, Chapter Nine (1982)²⁰. However, a minimum of fourteen representative composite samples are needed to characterize existing ash stockpiles. In addition, seven grab samples shall be collected for analysis of volatile organic compounds. The locations of the samples for these stockpiles shall be randomly selected using a grid pattern, as described in EPA publication SW-846, Chapter Nine. The samples should be collected and handled according to the procedures described in the Department's approved SOP contained in APPENDIX B.

The Department recognizes that for some WTE facilities or ash recycling facilities attempting to characterize their proposed product using WTE ash, it may not be practical or appropriate to collect fourteen separate 8-hour composite samples over a two week period. In some cases, time periods longer than two weeks may be needed. In others, the proposed ash product may not be generated continuously during an 8-hour shift or may not be generated continuously during the two week period. For some WTE or ash recycling facilities, it may be more appropriate to stockpile fresh proposed product for a period of time, and then sample the stockpile using the procedures described in EPA publication SW-846. Consequently, the Department is willing to consider revisions to this baseline sampling protocol provided a

²⁰ This document can be ordered through the U.S. Government Printing Office in Jacksonville, Florida at 904/353-0569.

reasonable justification for an alternate protocol is provided and the alternate protocol is approved by the Department. The Department will review requests for alternate baseline sampling on a case-by-case basis. In all cases, however, a minimum of fourteen representative composite samples will be required.

The fourteen representative baseline 8-hour composite samples should be analyzed as follows:

- (a) Total analysis should be conducted on all the composite samples for dioxin²¹ using EPA Method 8290, and for the eight RCRA metals²² and aluminum, copper, fluoride, iron, manganese and zinc using the approved EPA Methods.
- (b) Total analysis should be conducted on seven²³ of the fourteen composite samples for the following organic compounds: semi-volatile organic compounds using EPA Method 8270C, and pesticides using EPA Method 8081A.
- (c) To further evaluate leaching potential²⁴ of the ash or proposed product, all composite samples should also be prepared using the SPLP²⁵. Using the approved EPA methods, all of the extracts prepared from this procedure should be analyzed for pH, chloride, sulfates²⁶, total dissolved solids (TDS), manganese, iron, aluminum, copper, fluoride, lead and any other parameters that would be considered COCs for leachability on the basis of their total analyses. Seven²⁷ of the extracts prepared from the composite

²¹ For the purposes of this document, all references to "dioxin" shall mean 2,3,7,8-tetrachlorodibenzo-p-dioxin, i.e. 2,3,7,8-TCDD.

²² These metals are: arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver.

²³ Due to the nature of the combustion process at WTE facilities, organic compounds are not expected to be a contamination problem in the ash. However, the Department will require analyses of seven ash composite samples to confirm this assumption. Should these analyses indicate organic compounds may be present at unacceptable concentrations in the ash, additional testing may be required to complete the baseline analysis.

²⁴ Comparing total concentrations to the Department's RTL leachability value is the first step in evaluating this potential.

²⁵ The Department will also allow the use of the TCLP, EPA Method 1311, to evaluate the leaching potential of ash or products using ash.

²⁶ When analyzing for sulfates and TDS, it is likely that de-ionized water will need to be used as the extraction fluid in the SPLP test rather than the extraction fluid specified in the method itself.

²⁷ Due to the nature of the combustion process at WTE facilities, organic compounds are not expected to be a contamination problem in the ash. However, the Department will require seven set of analyses of the ash extracts to confirm this assumption. Should these analyses indicate organic compounds may

samples should be analyzed for semi-volatile organic compounds using EPA Method 8270C, and for pesticides using EPA Method 8081A.

- (d) Laboratories conducting the analyses must have a Department approved Comprehensive Quality Assurance Plan (CompQAP) in accordance with the requirements of Chapter 62-160, Florida Administrative Code (F.A.C.) or be certified by an accrediting authority recognized by the National Environmental Laboratory Accreditation Program (NELAP). Analysis of the SPLP extracts must be conducted using detection limits at or below the Department's ground water standards and criteria. The laboratory shall supply the sample containers, appropriately cleaned, for the analyses required.

The baseline seven grab samples for volatile organic compounds should be analyzed as follows:

- (a) Total analysis for volatile organic compounds using EPA Method 8260B on all the grab samples.
- (b) To further evaluate leaching potential²⁸, SPLP extracts should be prepared from the seven grab samples and analyzed for the individual volatile organic compounds using EPA Method 8260B that either had no RTL for leachability or would be considered a COC for leachability based on their total analyses.
- (c) Laboratories conducting the analyses must have a Department approved Comprehensive Quality Assurance Plan (CompQAP) in accordance with the requirements of Chapter 62-160, Florida Administrative Code (F.A.C.) or be certified by an accrediting authority recognized by the National Environmental Laboratory Accreditation Program (NELAP). Analysis of the SPLP extracts must be conducted using detection limits at or below the Department's ground water standards and criteria. The laboratory shall supply the sample containers, appropriately cleaned, for the analyses required.

6.3 Baseline Report

The BUD should include a Baseline Report summarizing the results of the ash or proposed product baseline sampling and

leach out at unacceptable concentrations in the ash, additional testing may be required to complete the baseline analysis.

²⁸ Comparing total concentrations to the Department's RTL leachability value is the first step in evaluating this potential.

analysis. This should include a complete set of all laboratory reports showing results of the baseline composite sampling, results of the total analyses and leaching tests, and a summary of the data. The summary of the baseline analysis data should include at least the following:

- (a) The summary should be in a table format and should list all chemicals detected in both total and SPLP analyses for each sample analyzed with their corresponding analytical results. The table should also include information showing the Department's RTLs, and ATLS if determined by a HRA, for each chemical that is detected in the total analyses and the Department's ground water or surface water standards for each chemical that is detected in the SPLP analyses.
- (b) If the data for a detected chemical are normally distributed, then the arithmetic means and the upper 95 percent confidence levels for the means should be calculated using the calculation method in APPENDIX C.
- (c) If the data for a chemical are not normally distributed, then a lognormal transformation of the data is allowed using the calculation method provided in APPENDIX C. If the log transformed data are normally distributed, then the transformed data can be used to calculate the geometric mean and the upper 95 percent confidence level value for the chemical. The procedures in APPENDIX C should be followed for this transformation.

6.4 Repeating Characterizations

If a significant change occurs in the operation of the WTE facility or ash recycling facility, in the composition of the waste stream processed by the facility, or in the method of producing the proposed product and the change may adversely affect the quality of ash or the proposed product, then the baseline analysis of the ash or proposed product from the facility should be repeated under these new conditions.

7.0 ROUTINE ANALYSIS

The BUD should propose a routine sampling and analysis protocol for ensuring that the chemical composition of the ash or proposed ash-derived product is consistent with the results of the baseline analysis. Routine analysis will primarily monitor

the COCs for direct human exposure and potential COCs²⁹ that were identified in the baseline report. When calculating mean concentrations, if the data are normally distributed then the arithmetic mean can be used. If the data are not normally distributed, but a lognormal transformation of the data results in them being normally distributed, then the geometric mean can be used. Appendix C contains the methods and procedures for these calculations.

7.1 Weekly Analysis

One 8-hour composite sample of ash or proposed product generated at the facility or processed at an ash recycling facility should be collected at least once per week using the Department's SOP in APPENDIX B. Also, if volatile organic compounds are identified as COCs for direct human exposure or potential COCs for leachability, then a single grab sample shall be collected during the 8-hour composite sample using the Department's SOP in APPENDIX B. Using the approved EPA method, each weekly sample should be analyzed as follows:

- (a) COCs for Direct Human Exposure - The weekly sample(s) should be analyzed for total concentrations of each COC(s) for direct human exposure identified in the baseline analysis in Section 6.2. For ash which is allowed use under Section 10.0(a), this weekly sampling is not required.
- (b) Potential COCs for Leachability - The weekly samples(s) should be analyzed for total concentrations of potential COC(s) for leachability which were identified in the baseline analysis in Section 6.2 on the basis of their total concentrations. An SPLP extract, EPA Method 1312, for the weekly sample(s) should be prepared and analyzed for each potential COC for leachability identified in the baseline analysis in Section 6.2 on the basis of their SPLP analyses.

7.2 Quarterly Analysis

At a frequency of every three months, four 8-hour composite samples, and four grab samples for volatile organic compounds³⁰, of the ash or proposed ash product should be collected using the Department's approved SOP in APPENDIX B and transported to the laboratory for analysis. Using the approved EPA method, each

²⁹ COCs and potential COCs are defined in Section 6.2.

³⁰ If no VOCs are identified as potential COCs for direct human exposure, then it is not necessary to collect the four grab samples for VOCs.

sample should be analyzed for total concentrations of each potential COC(s) for direct human exposure identified in the baseline analysis.

7.3 General Requirements

- (a) Samples can be collected by an operator from the WTE facility or an ash recycling facility trained in accordance with Rule 62-701.320(14), F.A.C., or by personnel from a Department approved laboratory. In either case, sample collection procedures shall follow the Department's approved SOP in APPENDIX B.
- (b) Laboratories conducting the analysis must have a Department approved Comprehensive Quality Assurance Plan (CompQAP) in accordance with the requirements of Chapter 62-160, F.A.C or be certified by an accrediting authority recognized by the National Environmental Laboratory Accreditation Program (NELAP). Analysis of the SPLP extracts must be conducted using detection limits at or below the Department's ground water standards and criteria. The laboratory shall supply the sample containers, appropriately cleaned, for the analyses required.

7.4 Quarterly Report

The BUD should propose a format for a Quarterly Report which will summarize the results of the ash or proposed product weekly and quarterly analysis. This should include a complete set of all laboratory reports showing the analytical results. The quarterly report should also provide a summary of the weekly and quarterly data which should include at least the following:

- (a) The summary should include a table listing the analytical results for the COCs and/or potential COCs evaluated in each weekly and quarterly sample analyzed during the quarter. The table should also include information showing the Department's RTLs, or ATLS if determined by a Department approved HRA, whichever is applicable, and ground water and surface water standards corresponding to each COC or potential COC.
- (b) If the data for a COC or potential COC are normally distributed, then the arithmetic mean and the upper 95 percent confidence level for the mean should be calculated using the calculation method in APPENDIX C.

- (c) If the data for a COC or potential COC are not normally distributed, then a lognormal transformation of the data is allowed using the calculation method provided in APPENDIX C. If the log transformed data are normally distributed, then the transformed data can be used to calculate the geometric mean and the upper 95 percent confidence level value for the COC. The procedures in APPENDIX C should be followed for this transformation.

8.0 BUD EVALUATIONS

The Department will review the BUD submittals and determine if the applicant has provided reasonable assurance that the proposed uses of the ash or ash products satisfy the requirements of Section 403.7045(5), F.S. Requests for additional information, if necessary, will be made in writing to the applicant. The use(s) of ash or ash-derived products is not authorized until the Department approves the use(s) and determines, from the results of the baseline analysis, HRA or other relevant data, which chemicals should be monitored during routine analysis. When making its determination whether to approve the use(s) of ash or ash-derived products proposed by the applicant, the Department will review the baseline report, the HRA (if provided) and other relevant information contained in the BUD or provided to the Department by the applicant.

- (a) For proposed ash uses which do not qualify for use in Section 10.0(a), any chemical detected during the baseline analysis which meets the definition of a COC for direct human exposure contained in Section 6.2, shall be added to the parameters required for weekly analysis.
- (b) If the proposed ash use does qualify for use in Section 10.0(a), then weekly analysis for COCs for direct human exposure is not required.
- (c) Any chemical detected during baseline analysis which meets the definition of a potential COC for direct human exposure contained in Section 6.2, shall be added to the parameters required for quarterly analysis.
- (d) Any chemical detected during baseline analysis which meets the definition of a potential COC for leachability contained in Section 6.2, shall be added to the parameters required for weekly analysis.

9.0 OPERATIONAL EVALUATIONS

The Department will review the Quarterly Reports and, depending on the results, may require or allow changes to the sampling procedures and ash uses. Also, during the collection and evaluation of the weekly samples, the WTE facility or ash recycling facility may notice changes in the analytical results for the ash which require notification to the Department and possible further action. Reporting or notification requirements will be specified in the permit or statewide approval on a case-by-case basis, and will be based primarily on any significant changes from the baseline analysis that could affect public health or the environment.

After one year of routine analysis of the ash or product using ash from a WTE facility, the owner/operator of the WTE facility or ash recycling facility may request a reduction in the sampling parameters and/or frequencies. The Department's evaluation of this request will be based upon the results contained in the quarterly reports and other relevant data for the facility.

10.0 OFF-SITE USE REQUIREMENTS

This BUD document does not apply to the use of WTE ash or ash-derived products in jurisdictional surface waters or wetlands, in land application as a soil amendment or for agricultural purposes. However, WTE ash or ash-derived products may be used as fill material in jurisdictional surface waters or wetlands if a permit specifically authorizing this use of ash has been issued by the Department. In addition, use of ash or ash-derived products should comply with one of the following:

- (a) Use of ash or products containing ash is allowed in any of the following circumstances, if:
 1. The ash or product is covered by at least two feet of clean fill or is used as protected structural fill³¹, the leaching tests or characterization data do not indicate that the use of the ash or product will result in violations of the Department's ground water standards or criteria, and the BUD demonstrates that the barrier of the protected structural fill or the two feet of cover will be maintained.

³¹ Protected structural fill is defined in Section 4.2.

2. The ash or product is used at a permitted Class I or II landfill as subsurface construction material or as intermediate cover³² provided it also meets the criteria of Rule 62-701.200(55), F.A.C and provided the leaching tests or characterization data do not indicate that the use of the ash or product will result in violations of the Department's ground water or surface water standards or criteria. These uses of ash or product may require approval by the Department as part of the landfill permit.
3. The ash or product is used in encapsulation technologies, for example as part of the aggregate feed in the production of Portland cement, concrete or asphalt, provided the BUD demonstrates the proposed use achieves the risk goals of Section 3.0(b) and will not leach constituents so as to cause a violation of Department ground water standards or criteria.
 - (b) Use of ash or ash-derived product is allowed in accordance with the uses described in a BUD if the BUD, and a Department approved HRA, demonstrate that the goals of Section 3.0 will be achieved for those uses.
 - (c) Use of ash or products containing ash as fill is allowed in residential settings if: (1) the upper 95 percent confidence level for the mean of all chemicals detected in the ash is less than or equal to the Department's RTLs for residential settings corresponding to those chemicals; (2) neither the leaching tests nor characterization data indicate that the use of the ash will result in violations of the Department's ground water or surface water standards or criteria; and (3) notification to the land owner is provided which explains the approved uses of ash. The notification to the land owner should contain the following language:

This material contains ash from the combustion of municipal solid waste. The Florida Department of Environmental Protection has approved the use of this material as fill in land. Its use has not been approved as fill material in surface waters or wetlands unless a permit specifically authorizing the use

³² Use of WTE ash as initial cover at permitted, lined landfills is already allowed in accordance with the requirements of Rule 62-702.570(6), F.A.C.

of this material as fill in surface waters or wetlands has been issued by the Department.

- (d) Use of ash or ash-derived product is allowed in industrial settings if: (1) the upper 95 percent confidence level for the mean of all chemicals detected in the ash or product is either at or below naturally occurring background total concentrations for the chemicals at the site selected for use or is less than or equal to the Department's RTLs for industrial settings corresponding to those chemicals; (2) neither the leaching tests nor characterization data indicate that the use of the ash will result in violations of the Department's ground water or surface water standards or criteria; and (3) institutional controls, such as property deed restrictions or access controls, will be used at each site receiving ash.
- (e) Permission may be granted for ash or ash-derived product to be used in commercial areas under the same conditions as use in industrial settings on a case-by-case basis if the BUD demonstrates that the exposure potential from the proposed use is comparable to an industrial land use.
- (f) Permission may be granted for ash or ash-derived product to be used in other applications on a case-by-case basis provided the applicant can demonstrate that the proposed use will meet the risk goals of Section 3.0. The Department may also require institutional controls for each site where the ash is to be used.

REFERENCES

- DEP (Florida Department of Environmental Protection), 1992, Standard Operating Procedures For Laboratory Operations And Sample Collection Activities, DEP-QA-001/92, Quality Assurance Section, Tallahassee, Florida, September.
- DEP (Florida Department of Environmental Protection), 1993, Quality Assurance Standard Operating Procedures Manual for Sampling of Ash Residue from Solid Waste Combustors, Solid Waste Section, Tallahassee, Florida, December.
- DEP (Florida Department of Environmental Protection), 1994, Ground Water Guidance Concentrations, Bureau of Drinking Water and Ground Water Resources, Tallahassee, Florida, June.
- DEP (Florida Department of Environmental Protection), 1999, Solid Waste Management in Florida, Bureau of Solid and Hazardous Waste, Tallahassee, Florida, July.
- EPA (U.S. Environmental Protection Agency), 1982, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA Publication SW-846, Third Edition, Revised May 1997.
- EPA (U.S. Environmental Protection Agency), 1991, Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, NTIS PB91-921314, Office of Solid Waste and Emergency Response, Washington, D.C., November.
- EPA (U.S. Environmental Protection Agency), 1995, Guidance For the Sampling and Analysis of Municipal Waste Combustion Ash For the Toxicity Characteristic, EPA 530-R-95-036, Office of Solid Waste, Washington, D.C., June.

APPENDIX A

Department Solid Waste Contacts and Addresses

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APPENDIX B

Department Standard Operating Procedures (SOP)
for Sampling WTE Ash as Part of
a Beneficial Use Demonstration

APPENDIX B
DEP Ash Use Guidance
February 27, 2001

QUALITY ASSURANCE
STANDARD OPERATION PROCEDURES MANUAL
FOR
SAMPLING WASTE-TO-ENERGY (WTE) ASH
AS PART OF A
BENEFICIAL USE DEMONSTRATION

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I. INTRODUCTION

The Department of Environmental Protection has compiled this Standard Operating Procedures (SOP) Manual to establish consistent sampling procedures for sampling Waste-to-Energy (WTE) ash residue, or products using WTE ash residue. The use of this document and procedures will support the development of a Beneficial Use Demonstration (BUD) for use of the ash³³. Section 403.7045, Florida Statutes (F.S.), requires that in order to recycle or reuse WTE ash the applicant must demonstrate that "no significant threat to public health will result and that applicable department standards and criteria will not be violated." Part of this demonstration requires sample collection and the analysis of both the chemical and leaching characteristics of the ash.

This document addresses the proper collection of WTE ash samples. These procedures have been developed in cooperation with the Bureau of Laboratories, Environmental Assessment Section, and reflect current solid waste rules governing ash. All parties conducting ash sampling for the purposes of developing a BUD for WTE ash must follow this SOP. The sampled ash shall be representative of the material that is proposed for use in the BUD. Subsequent analysis of collected samples must be performed by a laboratory having an approved Comprehensive Quality Assurance Plan (CompQAP) in accordance with the requirements of Chapter 62-160, F.A.C. or certified by an accrediting authority recognized by the National Environmental Laboratory Accreditation Program. The Department is willing to consider revisions to the procedures in this APPENDIX on a case-by-case basis if a reasonable justification for an alternate protocol is provided to and approved by the Department.

II. GENERAL DESCRIPTION

The Department's guidance for preparing a WTE ash BUD requires the collection of composite samples and grab samples of ash during both baseline and routine analysis. These samples will be analyzed for concentrations of metals, inorganic chemicals and organic compounds³⁴ in the ash.

³³ For the purposes of this APPENDIX, all references to "ash" shall refer to both WTE ash residue or to products made from WTE ash residue.

³⁴ The groups of organic compounds are: volatile and semi-volatile organic compounds, pesticides and dioxin. In this APPENDIX, all references to "dioxin" shall mean 2,3,7,8-tetrachlorodibenzo-p-dioxin, i.e. 2,3,7,8-TCDD. The concentrations of volatile organic compounds shall be determined from grab

For composite sampling, baseline analysis generally requires a minimum of 14 separate 8-hour composite samples, while routine analysis requires at least one 8-hour composite sample. For existing stockpiles, the 14 composite sample locations are selected by a grid system and collected at one time rather than over an 8 hour period. These composite samples may be analyzed for total concentrations of metals, other inorganic chemicals and non-volatile organic compounds and can be used for the SPLP (or TCLP) leaching tests for these same parameters.

Each 8-hour composite sample of the ash shall consist of eight subsamples, or separate grab samples. These shall be collected once every hour for eight consecutive hours with each individual subsample weighing approximately three pounds. At the end of the 8-hour sampling event, approximately 24 pounds of ash will have been collected which shall be mixed together and a single 8-hour composite sample will be obtained from this mixture.

The Department's guidance for preparing a WTE ash BUD also requires the collection of grab samples to be analyzed for total and leachable concentrations of volatile organic compounds (VOCs) during both baseline and routine analysis. Due to the nature of the combustion process at WTE facilities, organic compounds generally are not expected to be a contamination problem in the ash. However, the Department will still require some testing for VOCs during baseline and routine analyses for these chemicals (DEP, 1998). For baseline analysis, seven grab samples will be required, while routine analysis will require at least one grab sample. Each grab sample may be collected at any time during an 8-hour composite sampling event for ash from a conveyance mechanism or new stockpile or at one of the random sample locations determined by a grid system for existing stockpiles.

Samples may be collected by an operator from the WTE facility generating the ash, or from the ash recycling facility, provided the operator is experienced in proper sampling procedures. The sample collection procedures for the ash shall follow the procedures contained in this APPENDIX. Laboratories conducting the analyses shall provide precleaned sample containers, and appropriate preservatives.

samples of the ash. The concentrations of all other organic compounds shall be determined from composite samples.

The remainder of this APPENDIX describes how to collect both the grab samples to be analyzed for VOCs and the 8-hour or grid located composite samples to be analyzed for metals and other chemicals. It will describe procedures for sampling ash from a conveyance mechanism, from a new stockpile, or from an existing stockpile. It will also describe the cleaning procedures and sample custody and documentation needed for this sampling.

III. LABORATORY CREDENTIALS AND RESPONSIBILITIES

The laboratory analyzing the ash samples must have an approved Comprehensive Quality Assurance Plan (CompQAP) on file with the Department, or be certified by an accrediting authority recognized by the National Environmental Laboratory Accreditation Program. In all cases, the laboratory must be certified or approved for the specific matrix and analytical tests required for the ash analyses.

The laboratory must be approved or certified for the latest versions of at least the following tests:

- EPA Method 8260 for volatile organic compounds;
- EPA Method 8270 for semi-volatile organic compounds;
- EPA Method 8081 for pesticides;
- EPA Methods 8290 for dioxin (as 2,3,7,8-TCDD);
- EPA Method 1312, Synthetic Precipitation Leaching Procedure;
- EPA Methods 7060, 7061, 7062, 6010 for arsenic;
- EPA Methods 7080, 7081, 6010 for barium;
- EPA Methods 7130, 7131, 6010 for cadmium;
- EPA Methods 7190, 7191, 6010 for chromium;
- EPA Methods 7420, 7421, 6010 for lead;
- EPA Method 7471 for mercury (solid sample) and EPA Method 7470 for mercury (liquid sample);
- EPA Methods 7740, 7741, 7742, 6010 for selenium;
- EPA Methods 7760, 7761, 6010 for silver;
- EPA Methods 7020, 6010 for aluminum;
- EPA Methods 7210, 7211, 6010 for copper;
- EPA Methods 9056, 9214 for fluoride;
- EPA Methods 7380, 7381, 6010 for iron;
- EPA Methods 7460, 7461, 6010 for manganese;
- EPA Methods 7950, 7951, 6010 for zinc;
- EPA Methods 9040 for pH of liquid by meter;

- EPA Methods 9035, 9036, 9038, 9056 for sulfate (liquid sample);
- EPA Method 9056, 9250, 9251, 9253, 9212 for chloride (liquid sample); and
- Methods 160.1, 2540C for total dissolved solids (liquid sample).

The laboratory shall supply precleaned sample containers appropriate to the requested tests. At a minimum, these shall include glass containers for volatile organic samples with teflon lined septa, and glass jars for the remaining samples that have cap liners composed of teflon. Additional supplies, such as preservatives, shall also be provided by the laboratory.

IV. SAMPLING PROCEDURES - CONVEYANCE SYSTEM

A. Sample Location

For subsamples collected from a conveyance mechanism, each subsample shall be collected at a fixed point over the entire width and depth of the conveyor.

B. For Collecting Volatile Organic Samples

This subsection describes the procedures for collecting a single grab sample of ash for VOCs. The sample collector shall use a laboratory-supplied cleaned glass sample container(s) sealed with a teflon-lined septum. The sample shall be analyzed for total and leachable VOCs and may be collected at any time during an 8-hour composite sampling event.

(1) The sample of ash must represent a cross section of the material on the conveyance mechanism and must be collected with a cleaned stainless steel (not plastic) trowel, spoon or scoop. There should be sufficient sample to fill the sample container(s) provided by the laboratory.

(2) Place the sample into a cleaned stainless steel or glass tray to cool until the material can be safely handled.

(3) After cooling, fill the sample container(s) provided by the laboratory with the ash. Lightly tamp the ash into the container(s) with a stainless steel, glass, or Teflon rod to reduce headspace in the container(s). Add more ash as needed to fill the container(s) until no headspace exists. Do not allow anything to enter the container(s) except ash and the tamping

device. Use a clean disposable wipe (such as Kimwipes) to remove ash from the rim of the container(s). Seal the container(s) with the cap **immediately** after cleaning.

(4) Identify the container(s), with unique field identification codes, place it into a zip lock bag and seal the bag. Place the bag in wet ice immediately.

(5) Discard any remaining ash sample.

C. For Collecting Composite Samples

This subsection describes the procedures for collecting an 8-hour composite sample in a cleaned sample container(s) provided by the laboratory. This composite sample can then be analyzed for total and leachable extractable organic compounds, metals and other inorganic chemicals. The 8-hour composite sample consists of eight subsamples that are collected at 60 minute intervals.

(1) At each 60 minute interval, collect a subsample of ash with a cleaned stainless steel trowel, spoon or scoop. Take a cross section of the entire conveyance system. The total amount of ash collected should weigh approximately three pounds.

(2) Place the subsample into a stainless steel or glass tray until the subsample has reached ambient air temperature.

(3) Place the ambient temperature subsample into a cleaned 1-gallon glass wide-mouthed container with a teflon lined lid and seal tightly. Store the 1-gallon container at 4 degrees Centigrade.

(4) Repeat steps (1) through (3) until a total of eight subsamples of ash, each in separate 1-gallon containers, have been collected during the 8-hour period.

(5) At the end of the 8-hour sampling period, screen the contents of the eight subsamples (a total of approximately 24 pounds of ash) through a 3/8-inch stainless steel screen. Place the screened portion of the eight subsamples, i.e. the < 3/8-inch fraction, into a cleaned stainless steel tray or mixing bowl.

(6) Remove the > 3/8-inch non-crushable ash from the screen (e.g. wheels, batteries, rebar, metal frames, etc.), weigh it and discard it. Record the weight, type and approximate size of the discarded material.

(7) Place the > 3/8-inch crushable ash from the screen in step (5) into a cleaned stainless steel tray. Crush the ash by applying approximately five to six blows to the material with a cleaned stainless steel hammer. Pass this crushed ash through a 3/8-inch stainless steel screen. Combine the crushed ash which passes through the screen with the < 3/8-inch ash in step (5). Any ash remaining on the 3/8-inch screen after crushing may be discarded. Record the weight of the discarded material.

(8) Next, the entire screened sample in the stainless steel tray or bowl shall be thoroughly blended with a cleaned stainless steel spoon by mixing, dividing into sections and mixing the sections, then recombining all mixed sections and mixing thoroughly. This process shall be continued until the screened ash subsamples are thoroughly blended.

(9) Remove the mixed sample in step (8) from the stainless steel tray or bowl mixer with a clean stainless steel spoon or scoop and fill and cap the glass sample container(s) provided by the laboratory. Seal the container(s) with a teflon-lined cap. This will be the 8-hour composite sample. Any remaining ash sample may be discarded.

(10) Identify the container(s) with unique field identification codes and place it in wet ice or a refrigerator that is maintained at 4 degrees Centigrade.

D. Quality Control Blanks

Quality Control (QC) blanks shall be collected in the field during each sampling event. If no equipment is cleaned on-site, the blank(s) may be collected at any time during the sampling day. If equipment is cleaned in the field, the blank(s) must be collected from a set of **field-cleaned** equipment.

(1) Set aside one of each type of sample container used during the day.

(2) If using field-cleaned equipment, thoroughly clean all equipment (other than precleaned sample containers provided by the laboratory) used during the day for sampling (see Section VIII).

(3) Use analyte-free water and rinse the sampling utensils and interim sampling containers into the tray or mixing bowl used for preparing the composite samples.

(4) With rinse water from the tray or mixing bowl, carefully fill the type of container used to collect the single grab sample for VOCs. Pour the water gently down the side of the container and create a convex meniscus at the top. Cap the container tightly.

Invert the container and tap gently looking for bubbles inside the container. If bubbles are present, uncap the container, carefully add more water from the tray or mixing bowl, cap the container and check again for bubbles. After three attempts, start with a new container. Continue until a bubble free container is produced.

Do not fill the lid of the container or allow anything but sample water to enter the container.

(5) Fill the type of container used to collect the 8-hour composite sample with the rinse water leaving a small headspace. Cap the container tightly.

(6) Identify the containers with unique field identification codes. Place the VOC blank into a separate zip lock bag and seal the bag. Store the bag containing the VOC blank and the QC blank container associated with the 8-hour composite with the rest of the samples that were collected during the day. This should be on wet ice, or in a refrigerated unit maintained at 4 degrees Centigrade.

(7) When all precleaned equipment is used, omit step (2) of the above procedure.

V. SAMPLING PROCEDURES - NEW STOCKPILES

A. Sample Location

If subsamples are collected off a fresh WTE ash stockpile while it is being generated, then the sampling location generally should be midway up the vertical height of the pile at a surface depth of approximately 6 to 12 inches into the ash.

B. For Collecting Volatile Organic Samples

This subsection describes the procedures for collecting a single grab sample of ash for VOCs. The sample collector shall use a laboratory-supplied cleaned glass sample container(s) sealed with a teflon-lined septum. The sample shall be analyzed for total and leachable VOCs and may be collected at any time during an 8-hour composite sampling event.

(1) The ash sample must be collected by taking a grab sample midway up the vertical height of the pile and at a surface depth of approximately 6 to 12 inches into the ash. Collect the sample with a cleaned stainless steel device such as a trowel, spoon or scoop. There should be sufficient sample to fill the cleaned sample container(s) provided by the laboratory.

(2) To complete the sampling procedure, follow (2) through (5) of Section IV.B.

C. For Collecting Composite Samples

This subsection describes the procedures for collecting an 8-hour composite sample in a cleaned sample container(s) provided by the laboratory. This composite sample can then be analyzed for total and leachable extractable organic compounds, metals and other inorganic chemicals. The 8-hour composite sample consists of eight subsamples that are collected at 60 minute intervals.

(1) At each 60 minute interval, collect a subsample of the ash with a cleaned stainless steel trowel, spoon or scoop. Collect the sample by taking a grab sample midway up the vertical height of the pile at a surface depth of approximately 6 to 12 inches into the ash. The total amount of ash collected for each interval should weigh approximately three pounds.

(2) Complete the sampling process by following steps (2) through (10) of Section IV.C.

D. Quality Control Blanks

Quality Control blanks shall be collected **in the field** at the end of each sampling day by following steps (1) through (7) of Section IV.D.

VI. SAMPLING PROCEDURES - EXISTING STOCKPILES

The Department recognizes that there may be occasions where baseline samples or routine samples must be collected from existing ash stockpiles. In these cases, the number of composite samples needed to characterize a stockpile shall be determined from the procedures described in Chapter Nine of EPA publication SW-846 but no less than 14 samples shall be allowed for baseline analyses. The locations of the composite samples must be randomly selected using a grid pattern which is described in Chapter Nine of SW-846. After both the number of composite samples and their sample locations have been determined, the

composite samples and a single grab sample for VOCs must then be collected using the following procedures:

A. Preparation of the Sample Location

Each sample location in the stockpile identified by the grid method must be prepared before the composite samples can be collected. This preparation includes the following steps:

(1) Leaves, grass, and other surface debris shall be removed from the area where the sample is to be collected using a clean stainless steel spoon or shovel.

(2) The top 6 to 12 inches of ash should be removed using a stainless steel shovel. A minimum surface area of approximately 4 square feet should be exposed for collecting the samples.

(3) On existing stockpiles, where the ash has become hardened, it may be necessary to use a backhoe or excavator to penetrate the ash matrix and remove the top 6 to 12 inches of ash. After the surface ash has been removed in this manner, the backhoe or excavator can be used to obtain additional buckets of ash in the exposed location. Samples of newly exposed ash can then be collected from the interior portions of the bucket.

B. For Collecting Volatile Organic Samples

This subsection describes the procedures for collecting a single grab sample of ash for VOCs. The sample collector shall use a laboratory-supplied cleaned glass sample container(s) sealed with a teflon-lined septum. The sample shall be analyzed for total and leachable VOCs. This sample shall be collected at one of the composite sampling locations identified by the grid pattern. The single VOC sample location shall be randomly selected from the fourteen or more sampling locations of the grid pattern.

(1) A sample of ash must be collected by taking grab sample of the undisturbed, newly exposed ash after the top 6 to 12 inches have been removed. Use a precleaned stainless steel spoon to clear away ash that came in contact with the excavation device. Use a second precleaned stainless steel spoon to collect the sample. The total volume of sample should be enough ash to fill the sample container(s) provided by the laboratory.

(2) Complete the sampling process by following steps (2) through (5) of Section IV.B. Step (2) of Section VI.B. may be eliminated if the ash is already at ambient temperature.

C. For Collecting Composite Samples

This subsection describes the procedures for collecting a composite sample in a cleaned sample container(s) provided by the laboratory. This composite sample can then be analyzed for total and leachable extractable organic compounds, metals and other inorganic chemicals. One composite sample shall be collected at each of the sample locations identified by the grid pattern.

(1) Collect a subsample from each quadrant of the undisturbed, newly exposed ash after the top 6 to 12 inches have been removed (for a total of four subsamples). The subsample in each quadrant shall first be exposed by using one precleaned stainless steel spoon to clear away ash that came in contact with the excavation device. Collect the sample with a second precleaned stainless steel spoon. The four subsamples should have a total combined weight of approximately three pounds. This ash shall be placed in a cleaned 1-gallon glass wide-mouthed container with a teflon lined lid.

(2) Complete the sampling process by following steps (5) through (10) of Section IV.C.

D. Quality Control Blanks

Quality Control blanks shall be collected **in the field** at the end of each sampling day by following steps (1) through (7) of Section IV.D.

VII. **SAMPLING CONTAINERS, SAMPLING AND CLEANING EQUIPMENT**

The following materials are needed to properly collect samples of ash:

A. Sample Containers

Obtain precleaned sample containers from the laboratory that will perform the chemical analyses (see Section III).

B. Sampling Equipment

- (1) Stainless steel, glass or Teflon trowels, spoons, scoops, spatulas and augers;

- (2) 1-gallon wide-mouthed glass jars with teflon lined lids;
- (3) 3/8 inch stainless steel screen;
- (4) Stainless steel hammer;
- (5) Ice chest or refrigeration unit capable of holding a temperature of 4 degrees Centigrade or cooler;
- (6) Ice;
- (7) Stainless steel mixing pans, trays or bowls;
- (8) Field sheets;
- (9) Chain of Custody Forms;
- (10) Water proof ink pen;
- (11) Latex powder free gloves;
- (12) Zip lock bags;
- (13) Labels.

C. Cleaning Equipment

- (1) Liquinox soap;
- (2) Nylon brushes;
- (3) Isopropyl alcohol, pesticide grade, in a Teflon squeeze bottle;
- (4) Tap water in glass, polypropylene, or high density polypropylene containers;
- (5) Deionized water in glass or high density polypropylene containers;
- (6) Analyte-free water in glass or Teflon containers;
- (7) Aluminum foil or untreated butcher paper.

VIII. CLEANING PROCEDURES

Before each daily sampling event, all equipment used for sampling (except for pre-cleaned sample containers provided by the laboratory) must be cleaned in a controlled environment before transporting to the facility. Rinse all sampling equipment with tap water immediately after use. Sampling equipment that is used but not cleaned in the field must be tagged with the sample location, returned to the cleaning facility and cleaned in a controlled environment.

The following procedures shall be used to clean equipment either on-site or in a controlled environment, however decontamination equipment at the facility **is not recommended**. When cleaning under controlled conditions, hot water must be used in steps A and B below.

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- A. Clean with tap water and Liquinox or equivalent soap using a brush, if necessary, to remove particulate matter or surface film.
- B. Rinse thoroughly with tap water.
- C. If cleaning glass or Teflon sampling equipment, rinse with 10 to 15 percent reagent grade nitric acid. **DO NOT USE** acid on stainless steel equipment.
- D. Rinse thoroughly with de-ionized water. Sufficient de-ionized water shall be used to ensure that all equipment surfaces are flushed with water.
- E. Rinse with enough pesticide grade isopropanol so that all equipment surfaces are thoroughly wetted with free flowing isopropanol.
- F. Rinse thoroughly with analyte-free water and allow to air dry as long as possible.
- G. The cleaned sampling equipment shall be wrapped in aluminum foil or untreated butcher paper.
- H. All cleaning rinse water must be collected and disposed of in the sanitary sewer in accordance with any local pretreatment requirements.

IX. SAMPLE CUSTODY AND DOCUMENTATION

A. Sample Labeling

All sample containers must be labeled. Each sample label shall bear a unique field identification code, preservation type, sampler's name and date the sample was collected.

B. Field Records

Records of the field collection activities shall be maintained on the field sheets shown in ATTACHMENT 1, or equivalent. All areas of the field sheets must be completed including the data control blocks. The original field sheets must be maintained by the owner/operator of the ash facility. Copies of the field sheets must be included with the samples to the laboratory.

C. Chain of Custody Record

(1) A chain of custody record must be completed for every sample collected. All parties accepting custody of the samples including the collector, coordinator, laboratory custodian, etc., must provide signatures on the chain of custody forms. The Chain of Custody Form shown in ATTACHMENT 2, or equivalent, shall be used.

(2) A binder containing copies of chain of custody records must be maintained by the party collecting the samples. The original Chain of Custody Form must accompany the samples to the laboratory. The laboratory shall complete the form, indicate the date of receipt or delivery and retain the original copy on file with all other records.

X. SAMPLE STORAGE AND TRANSPORTATION

- A. All samples shall be stored and shipped to the laboratory for analysis on wet ice in an ice chest at 4 degrees Centigrade. The samples should be transported to the laboratory for analysis as soon as possible after collection since the allowed sample holding time, prior to analysis, for organic compounds is only 14 days. The allowed sample holding time for total metal analysis is 6 months.
- B. Transportation may be provided by the sampler by direct delivery to laboratory.
- C. Shipping of the samples may be by courier, bus, or other responsible means.
- D. All field sheets and chain of custody sheets must be completed and accompany the samples.
- E. Ice chests must be adequately sealed and secured to protect the samples.
- F. Glass jars must be bubble wrapped and zip lock sealed for shipping.
- G. Be sure the laboratory address is complete and all forms are included.

REFERENCES

- DEP (Florida Department of Environmental Protection), 1992, Standard Operating Procedures For Laboratory Operations And Sample Collection Activities, DEP-QA-001/92, Quality Assurance Section, Tallahassee, Florida, September.
- DEP (Florida Department of Environmental Protection), 1998, "New Soil Sampling Procedures and Recommended EPA Analytical Methods (per changes to USEPA SW-846) and other Quality Assurance Issues for the Division of Waste Management," Memorandum from John Ruddell and Sylvia Labie to Interested Parties, Tallahassee, Florida, July 15.
- EPA (U.S. Environmental Protection Agency), 1982, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA Publication SW-846, Third Edition, Revised May 1997.

ATTACHMENT 1

FIELD SHEET

WTE ASH FIELD SAMPLING SHEET

WTE Facility Name: _____

Sampler's Name: _____

WTE Facility Address: _____

Sampler's Employer: _____

Employer Address: _____

Other Observers/Personnel		
Name	Affiliation	Role/Responsibility

Weather Conditions: _____

Description: (Include Locations of Pile(s) and Conveyance Mechanisms): _____

Equipment: _____

ATTACHMENT 2
CHAIN OF CUSTODY FORM

APPENDIX C

Data Calculations

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I. INTRODUCTION

In the Department's Ash Use Guidance, several mathematical calculations are either required or allowed when evaluating analytical data on ash. These include calculations of mean values, lognormal transformations, confidence levels and checking for normality. In addition, there may be questions on how to calculate ash blend concentrations should it be necessary to blend separate stockpiles of ash or ash with other materials to achieve Alternate Target Levels (ATLs) or the guideline concentrations in the Department's Reuse Target Levels (RTLs). The Department of Environmental Protection has prepared this APPENDIX for owners and operators of Waste-to-Energy (WTE) facilities to explain how to perform these calculations³⁵.

II. DESCRIPTION OF EQUATIONS

Many equations are needed to perform the calculations described in this APPENDIX. For clarity, each one will be described separately in this subsection and numbered. Sample calculations used in this APPENDIX will refer to these equations by their reference number.

Equation 1 - Arithmetic Mean of the Sample

$$X_A = \frac{\sum_{i=1}^n x_i}{n}$$

Where:

- X_A = Arithmetic mean of the n samples
- x_i = Single sample value
- n = Number of samples

³⁵ Examples in this APPENDIX assume all values are above the laboratory detection limit. When performing calculations on data sets which have one or more values below the detection level, i.e., BDL, the Department recommends that one half the detection limit be used as the sample value for those BDL results in the calculations.

Equation 2 - Arithmetic Variance of the Sample

$$S_A^2 = \frac{\sum_{i=1}^n (x_i - X_A)^2}{n - 1}$$

Where:

- S_A^2 = Arithmetic variance of the n samples
- x_i = Single sample value
- X_A = Arithmetic mean of the n samples (from Eq. 1)
- n = Number of samples

Equation 3 - Lognormal Mean of the Sample

$$X_L = \frac{\sum_{i=1}^n \log_e(x_i)}{n}$$

Where:

- X_L = Lognormal mean of the n samples
- $\log_e(x_i)$ = Natural log of the single sample value
- n = Number of samples

Equation 4 - Geometric Mean of the Sample

$$X_G = \exp(X_L)$$

Where:

- X_G = Geometric mean of the n samples
- $\exp(X_L)$ = Exponential of the lognormal mean (from Eq. 3)

Equation 5 - Lognormal Variance of the Sample

$$S_L^2 = \frac{\sum_{i=1}^n (\log_e(x_i) - X_L)^2}{n - 1}$$

Where:

- S_L^2 = Lognormal variance of the n samples
- $\log_e(x_i)$ = Natural log of the single sample value
- X_L = Lognormal mean of the n samples (from Eq. 3)
- n = Number of samples

Equation 6 - Standard Deviation of the Sample

$$S = \sqrt{S^2}$$

Where:

- S = Standard deviation of the sample
- S² = Variance of the sample (from Equations 2 or 5)

Equation 7 - Standard Error of the Sample

$$S_x = \frac{S}{\sqrt{n}}$$

Where:

- S_x = Standard error of the sample
- S = Standard deviation of the sample (from Eq. 6)
- n = Number of samples

Equation 8 - 95 Percent Upper Confidence Level for the Mean

$$CL = X + (t_{0.05})(S_x)$$

Where:

- CL = 95 percent upper confidence level
- X = Mean of the sample (from Equations 1 or 3)
- t_{0.05} = t value for one-tailed limit and a probability of 0.05
- S_x = standard error of the sample (from Equation 7)

Equation 9 - Blended Ash Concentrations

$$F_f = F_o \left[\frac{x_o - x_{COC}}{x_{COC} - x_f} \right]$$

Where:

- F_f = Fresh Ash stockpile, tons
- F_o = Old Ash stockpile, tons
- x_f = Concentration for COC in fresh Ash, mg/kg
- x_o = Concentration for COC in old Ash, mg/kg
- x_{COC} = Soil Cleanup Target Level for COC, mg/kg.

III. CALCULATING ASH MEAN VALUES

This APPENDIX describes two methods for calculating the mean. They are the arithmetic mean (X_A), using Equation 1, or the lognormal mean (X_L), using Equation 3. The lognormal mean for ash should not be used unless the raw data do not appear to be normally distributed. Simple tests for checking for normally distributed data will be described in Section IV. This section will illustrate how to calculate both means, however.

Suppose the Contaminant of Concern (COC) for an ash from Facility A is arsenic³⁶ only, and Facility A needs to determine the mean of 12 weekly sampling events. Also, assume the arsenic concentrations of the 12 weekly samples are: 2.4 mg/kg, 1.6 mg/kg, 3.3 mg/kg, 3.4 mg/kg, 3.1 mg/kg, 2.1 mg/kg, 1.4 mg/kg, 2.0 mg/kg, 4.7 mg/kg, 2.3 mg/kg, 1.2 mg/kg and 2.0 mg/kg. What are the arithmetic and lognormal mean values for these 12 samples?

To calculate the arithmetic mean, Equation 1 should be used. The 12 sample values should be added together and divided by the number of samples, i.e. 12. The resulting arithmetic mean is 2.5 mg/kg. This calculation is illustrated in Table C-1.

To calculate the lognormal mean of the data from Facility A, Equation 3 should be used. This equation is the same as Equation 1 except the "natural log" values³⁷ of the 12 samples are used rather than the original raw data. When the natural log values are used in statistical calculations, this is often referred to as a "log transformation" of the data. The natural logs of the 12 sample values should be added together and divided by the number of samples, i.e. 12. The resulting lognormal mean is 0.83 mg/kg. This calculation is illustrated in Table C-2.

³⁶ The arsenic concentrations chosen for examples in this APPENDIX were originally derived from a media other than WTE ash and are used to illustrate the calculation methods only. They are not realistic concentrations for Florida WTE ash. The actual, average arsenic concentration for WTE ash reported to the Department is approximately 40 mg/kg.

³⁷ The natural log is a logarithm to the base e. It is often expressed as $\log_e(x)$ or $\ln(x)$. Often in pocket calculators the natural log is expressed as $\ln(x)$ or just \ln . For example, the natural log of 2.1 is 0.74 or $\ln(2.1) = 0.74$.

IV. CHECKING FOR NORMAL DISTRIBUTIONS

The accuracy of using the arithmetic mean (X_A) and arithmetic standard deviation (S_A) to calculate the upper confidence limit for the true mean of an ash pile is based upon the assumption that the raw data used to calculate X_A and S_A are normally distributed. Unfortunately, mathematical methods to test for normality are only valid if a "large number" of samples are collected from the ash, (EPA, 1982).

In spite of this limitation, EPA suggests two simple tests can be used to superficially examine the data for departure from normality, (EPA, 1982 and 1989). These tests are as follows:

First Test: Is the sample mean greater than the sample variance?

Second Test: Is the sample standard deviation divided by the sample mean³⁸ less than one, i.e., is the standard deviation less than the mean?

If the answer to either or both of these questions is "No", then it is likely that the raw ash data are not normally distributed. In order to calculate an upper confidence limit, the data will have to be transformed.

For the purposes of this APPENDIX, if either or both of the two EPA tests suggest the data is not normally distributed, then a lognormal transformation of the data should be performed using the procedures in this APPENDIX. All subsequent statistical evaluations must use the transformed data. If the log transformation does not adequately normalize the data, then the assistance of a professional statistician should be obtained to determine an appropriate statistical procedure to follow and the Department must be notified.

To check for normality, the variance and the standard deviation must be calculated. First, the arithmetic variance (S_A^2) and standard deviation (S_A) will be calculated using the Facility A data. From Section III, the arithmetic mean (X_A) of the Facility A data was 2.5 mg/kg. Using Equation 2, the arithmetic variance is then equal to the sum of the squared

³⁸ The standard deviation divided by the mean is often identified as the "Coefficient of Variation" or Cv. The Cv is a measure of data variability.

differences of each value with the mean all divided by the number of samples less one. The resulting variance (S_A^2) is 1.01. This calculation for the Facility A data is shown in Table C-3.

Next, Equation 6 can be used to calculate the arithmetic standard deviation for Facility A. In this case, the standard deviation (S_A) is just the square root of the arithmetic variance and is equal to 1.0, or:

$$S_A = \sqrt{S_A^2} = \sqrt{1.01} = 1.0$$

Thus, for the Facility A arsenic data, the arithmetic variance and standard deviation are 1.01 and 1.0, respectively. From Section III, the arithmetic mean was 2.5 mg/kg. Using EPA's simple tests we can now check for normality. The first test was is the mean greater than the variance? Since 2.5 is greater than 1.01, the answer is "Yes." The second test was is the standard deviation less than the mean? Again since 1.0 is less than 2.5 the answer is "Yes." Since neither test resulted in a "No" answer, it is likely that the arsenic values for Facility A are normally distributed and a lognormal transformation of those values is not necessary. Consequently, the 95 percent confidence limits for Facility A (to be described in Section V) should be calculated using the arithmetic mean and arithmetic standard deviation.

To illustrate data that is not normally distributed, consider the following. Suppose Facility B has arsenic data from 12 weekly sampling events and needs to determine if the data is normally distributed. Also, assume the arsenic concentrations of the 12 weekly samples are: 1.4 mg/kg, 3.6 mg/kg, 8.2 mg/kg, 1.8 mg/kg, 1.6 mg/kg, 2.2 mg/kg, 11.6 mg/kg, 2.0 mg/kg, 2.4 mg/kg, 1.8 mg/kg, 2.0 mg/kg and 1.7 mg/kg. Are these data normally distributed? If not, does a lognormal transformation of the data result in them being normally distributed?

Using Equation 1 with Facility B data and the procedure previously shown in Table C-1, the arithmetic mean (X_A) is 3.4 mg/kg. With this mean and using Equation 2 with the procedure shown in Table C-3, the arithmetic variance (S_A^2) is calculated to be 10.2. Finally with Equation 6, the arithmetic standard deviation (S_A) is 3.2. Using EPA's first simple test, the mean value of 3.4 mg/kg is not greater than the variance of 10.2. This suggests the data is not normally distributed. Using EPA's

second test, the standard deviation of 3.2 is less than the mean value of 3.4. For the purposes of this APPENDIX, if the answer to one or both of EPA's simple tests is "No", then it should be assumed that the data is not normally distributed and a log transformation of the data should be performed. Thus, for Facility B, we can assume the data is not normal since the answer to the first test was "No."

The first step in log transforming the data is to calculate the lognormal mean. Using Equation 3 with Facility B data and the procedure previously shown in Table C-2, the lognormal mean (X_L) is 0.95. Next, using Equation 5, the lognormal variance (S_L^2) is calculated to be 0.45. This procedure is shown in Table C-4.

With the lognormal variance, Equation 6 can be used to calculate the lognormal standard deviation for Facility B. As in the data for Facility A, the standard deviation (S_L) is just the square root of the lognormal variance and is equal to 0.67, or:

$$S_L = \sqrt{S_L^2} = \sqrt{0.45} = 0.67$$

Thus for the Facility B arsenic data, the lognormal mean (X_L), variance (S_L^2) and standard deviation (S_L) are 0.95, 0.45 and 0.67, respectively. Using EPA's first test, the mean is greater than the variance. Also, using EPA's second test, the standard deviation is less than the mean. Thus, the transformed data appear to be normally distributed, and the upper 95 percent confidence limit can be calculated using the log transformed data.

V. CALCULATING 95 PERCENT UPPER CONFIDENCE LEVELS

In order to calculate the upper 95 percent confidence level of the mean, both Equations 7 and 8 have to be used. Equation 7 is used to calculate the standard error of the sample. The standard error term is used in Equation 8 with the mean and $t_{0.05}$ value to estimate the confidence limit. The confidence limits for data from both Facility A and Facility B will be calculated.

In Section IV, the arithmetic standard deviation (S_A) for Facility A was calculated to be 1.0. Since the number of samples (n) is equal to 12, using Equation 7 the standard error (S_X) is 0.29, or:

$$S_X = \frac{S_A}{\sqrt{n}} = \frac{1.0}{\sqrt{12}} = 0.29$$

Now using Equation 8, the upper 95 percent confidence limit for the mean, CL, can be calculated with the data from Facility A. The $t_{0.05}$ value for Equation 8 must be obtained from Table C-5 and is a function of the degrees of freedom for the data. The tabulated $t_{0.05}$ values in Table C-5 are for a one-tailed confidence limit with a probability of 0.05. The degrees of freedom are equal to the number of samples (n) less one, i.e. n-1. Since for the examples used in this APPENDIX, n is equal to 12, then the degrees of freedom for both Facility A and B are 11. Thus, in Table C-5, with the degrees of freedom equal to 11, the $t_{0.05}$ value is 1.796. And for Facility A data with the arithmetic mean equal to 2.5 and the standard error equal to 0.29, the upper 95 percent confidence limit for the mean is 3.02, or from Equation 8:

$$CL = X_A + (t_{0.05})(S_X) = 2.5 + (1.796)(0.29) = 3.02$$

For Facility B, the data was not normally distributed so a log transformation of the data was performed. The confidence limit must first be calculated using the transformed data and the result can be untransformed by taking the antilog of the resulting confidence limit. This untransformed value will be the value which is compared to the Department's Reuse Target Levels or RTLs.

From Section IV, the lognormal standard deviation (S_L) for Facility B data was 0.67. With the number of samples equal to 12, using Equation 7 the standard error for Facility B is 0.19, or:

$$S_X = \frac{S_L}{\sqrt{n}} = \frac{0.67}{\sqrt{12}} = 0.19$$

Now using Equation 8, the upper 95 percent confidence limit for the mean (CL) can be calculated with the data from Facility B. As in the case of Facility A, the degrees of freedom are equal to 11 resulting in a $t_{0.05}$ value of 1.796. With a standard error of 0.19, using Equation 8 the lognormal value for the upper 95 percent confidence limit of the mean is 1.29, or:

$$\text{Lognormal CL} = X_L + (t_{0.05})(S_X) = 0.95 + (1.796)(0.19) = 1.29$$

It is important to remember that this value for CL is based on the transformed data. Before comparing this to the Department's cleanup goals, the value must be untransformed by taking the antilog or exponential of the lognormal value for the CL. The resulting untransformed value for the confidence limit is 3.63. This can be calculated as follows:

$$CL = \exp(\text{lognormal CL}) = \exp(1.29) = 3.63$$

VI. CALCULATING BLENDED ASH CONCENTRATIONS

Assume Facility B has two stockpiles of ash³⁹, old and fresh, with arsenic as the primary contaminant of concern. Based upon test results, the mean concentration for arsenic is 2.2 mg/kg for the fresh stockpile and 4.8 mg/kg for the old stockpile. Facility B has also determined that the 95 percent confidence limits for the mean concentration of arsenic are 2.83 mg/kg for the fresh stockpile and 7.12 mg/kg for the old stockpile. Facility B would like to use this ash in an industrial setting by blending the stockpiles so the resulting mean concentration of the blended stockpile is at or below 3.7 mg/kg with a 95 percent confidence limit. Equation 9 should be used to calculate the appropriate ash blend ratios.

It is important to note that to achieve a blend with a 95 percent confidence limit for the mean the 95 percent confidence limits for the mean of the individual stockpiles must be used rather than their mean values. Equation 9 can be used to estimate the amount of fresh ash that must be blended with the old ash to achieve the target concentration.

Assume the basis for the blend is one ton of old ash, i.e., how much fresh ash must be added to one ton of old ash to achieve

³⁹ This example assumes two WTE ash stockpiles will be blended. It is probably more realistic to assume that ash will be blended with another media such as soil. Equation 9 can still be used by substituting concentrations of the COC in the soil for one of the ash concentrations in the equation, i.e. either the old or fresh ash.

the target concentration? In this case, the values for the terms in Equation 9 should be:

$$\begin{aligned} F_o &= 1.0 \text{ tons of old ash} \\ x_f &= 2.83 \text{ mg/kg} \\ x_o &= 7.12 \text{ mg/kg} \\ x_{COC} &= 3.7 \text{ mg/kg} \end{aligned}$$

Using these values in Equation 9:

$$F_f = F_o \left[\frac{x_o - x_{COC}}{x_{COC} - x_f} \right] = 1.0 \left[\frac{7.12 - 3.7}{3.7 - 2.83} \right] = 3.93 \text{ tons of fresh Ash}$$

Thus, for every ton of old ash, Facility B must blend 3.93 tons of the fresh ash with the old ash. Provided the resulting ash is well mixed, the 95 percent upper confidence limit for the mean of the mixture will have an arsenic concentration value of 3.7 mg/kg.

TABLE C-1: Arithmetic Mean for Facility A

Sample	Arsenic Conc., x_i , mg/kg
1	2.4
2	1.6
3	3.3
4	3.4
5	3.1
6	2.1
7	1.4
8	2.0
9	4.7
10	2.3
11	1.2
12	2.0
$\sum_{i=1}^n x_i =$	29.5
$X_A =$	2.5

TABLE C-2: Lognormal Mean for Facility A

Sample	Arsenic Conc., x_i , mg/kg	Natural Log, $\log_e(x_i)$, mg/kg
1	2.4	0.88
2	1.6	0.47
3	3.3	1.19
4	3.4	1.22
5	3.1	1.13
6	2.1	0.74
7	1.4	0.34
8	2.0	0.69
9	4.7	1.55
10	2.3	0.83
11	1.2	0.18
12	2.0	0.69
	$\sum_{i=1}^n \log_e(x_i) =$	9.91
	$X_L =$	0.83

TABLE C-3: Arithmetic Variance for Facility A

Sample	Arsenic Conc., x_i , mg/kg	$(x_i - X_A)^2$
1	2.4	0.01
2	1.6	0.81
3	3.3	0.64
4	3.4	0.81
5	3.1	0.36
6	2.1	0.16
7	1.4	1.21
8	2.0	0.25
9	4.7	4.84
10	2.3	0.04
11	1.2	1.69
12	2.0	0.25
	$\sum_{i=1}^n (x_i - X_A)^2 =$	11.07
	$S_A^2 =$	1.01

TABLE C-4: Lognormal Variance for Facility B

Sample	Arsenic Conc., x_i , mg/kg	$\log_e(x_i)$	$(\log_e(x_i) - X_L)^2$
1	1.4	0.34	0.37
2	3.6	1.28	0.11
3	8.2	2.10	1.32
4	1.8	0.59	0.13
5	1.6	0.47	0.23
6	2.2	0.79	0.03
7	11.6	2.45	2.25
8	2.0	0.69	0.07
9	2.4	0.88	0.005
10	1.8	0.59	0.13
11	2.0	0.69	0.07
12	1.7	0.53	0.18
		$\sum_{i=1}^n (\log_e(x_i) - X_L)^2 =$	4.895
		$S_L^2 =$	0.45

TABLE C-5: Tabulated Values For Student t Test

Degrees of freedom (n-1) ^a	Tabulated $t_{0.05}$ value ^b
1	6.314
2	2.920
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812
11	1.796
12	1.782
13	1.771
14	1.761
15	1.753
16	1.746
17	1.740
18	1.734
19	1.729
20	1.725
21	1.721
22	1.717
23	1.714
24	1.711
25	1.708
26	1.706
27	1.703
28	1.701
29	1.699
30	1.697
40	1.684
60	1.671
120	1.658
∞	1.645

^a Degrees of freedom are equal to the number of samples, n, less one, i.e. n-1.

^b Tabulated values are for a one-tailed confidence limit and a probability of 0.05.

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APPENDIX D

Reuse Target Levels

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Acenaphthene	83-32-9	1900	18000	2.1	0.7	0.7	21	-Liver
Acenaphthylene	208-96-8	1100	11000	27	0.7	0.7	270	-Body Weight -Liver
Acephate	30560-19-1	64	130	0.03	0.8	0.8	0.3	-Carcinogen -Neurological
Acetone	67-64-1	780	5500	2.8	6.8	6.8	28	-Kidney -Liver -Neurological
Acetonitrile	75-05-8	120	960	2	80	80	20	-Blood -Liver
Acetophenone	98-86-2	2700	24000	3.9	44	44	39	-None Specified
Acrolein	107-02-8	0.04	0.3	0.06	0.002	0.002	0.6	-Nasal
Acrylamide	79-06-1	0.1	0.3	0.004	0.02	0.02	0.04	-Carcinogen -Neurological
Acrylonitrile	107-13-1	0.3	0.5	0.004	0.2	0.2	0.04	-Carcinogen -Nasal -Reproductive
Alachlor	15972-60-8	12	36	0.02	0.006	0.006	0.2	-Blood -Carcinogen
Aldicarb [or Temik]	116-06-3	56	760	0.03	0.004	0.004	0.3	-Neurological
Aldrin	309-00-2	0.07	0.3	0.5	0.01	0.01	5	-Carcinogen -Liver
Allyl alcohol	107-18-6	62	460	1	0.02	0.02	10	-Kidney -Liver
Aluminum	7429-90-5	72000	*	***	***	***	***	-Body Weight
Aluminum phosphide	20859-73-8	31	730	***	***	***	***	-Body Weight
Ametryn	834-12-8	590	9300	0.8	0.08	0.08	8	-Liver
Ammonia	7664-41-7	550	3700	570	4	NA	5700	-Respiratory
Aniline	62-53-3	14	100	0.03	0.02	0.02	0.3	-Blood -Carcinogen
Anthracene	120-12-7	18000	260000	2500	0.7	0.7	25000	-None Specified
Antimony	7440-36-0	26	240	5	***	***	50	-Blood -Mortality
Arsenic	7440-38-2	0.8	3.7	29	***	***	290	-Carcinogen -Cardiovascular -Skin
Atrazine	1912-24-9	4	12	0.06	0.04	0.04	0.6	-Body Weight -Carcinogen
Azobenzene	103-33-3	8.2	24	0.4	0.06	0.06	4	-Carcinogen
Barium	7440-39-3	110**	87000	1600	***	***	16000	-Cardiovascular
Bayleton	43121-43-3	2000	29000	4.8	11	11	48	-Blood -Body Weight
Benomyl	17804-35-2	3600	64000	3.1	0.03	0.03	31	-Developmental
Bentazon	25057-89-0	1500	18000	1.2	NA	NA	12	-Blood
Benzaldehyde	100-52-7	2200	18000	4.8	0.4	0.4	48	-Gastrointestinal -Kidney
Benzene	71-43-2	1.1	1.6	0.007	0.5	0.5	0.07	-Carcinogen
Benzenethiol	108-98-5	0.1	1	0.3	NA	NA	3	-Liver
Benzo(a)anthracene	56-55-3	1.4	5	3.2	0.7	0.7	32	-Carcinogen
Benzo(a)pyrene	50-32-8	0.1	0.5	8	1.2	1.2	80	-Carcinogen
Benzo(b)fluoranthene	205-99-2	1.4	4.8	10	1.6	1.6	100	-Carcinogen
Benzo(g,h,i)perylene	191-24-2	2300	41000	32000	4.8	4.8	320000	-Neurological
Benzo(k)fluoranthene	207-08-9	15	52	25	1.6	1.6	250	-Carcinogen
Benzoic acid	65-85-0	150000	*	110	36	36	1100	-None Specified
Benzotrichloride	98-08-7	0.04	0.07	0.003	0.0002	0.0002	0.03	-Carcinogen
Benzyl alcohol	100-51-6	23000	610000	9.5	2.3	2.3	95	-Gastrointestinal
Benzyl chloride	100-44-7	0.8	1.2	0.006	0.03	0.03	0.06	-Carcinogen
Beryllium	7440-41-7	120	800	63	***	***	630	-Carcinogen -Gastrointestinal -Respiratory

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Bidrin [or Dicrotophos]	141-66-2	5.5	67	0.005	0.1	0.1	0.05	-Developmental
Biphenyl, 1,1- [or Diphenyl]	92-52-4	2300	26000	0.2	5.8	5.8	2	-Kidney
Bis(2-chloroethyl)ether	111-44-4	0.3	0.4	0.02	0.05	0.05	0.2	-Carcinogen
Bis(2-chloroisopropyl)ether	108-60-1	4.4	7.3	0.07	0.003	0.003	0.7	-Blood -Carcinogen
Bis(2-ethylhexyl)phthalate [or DEHP]	117-81-7	76	280	3600	12	12	36000	-Carcinogen -Liver
Bisphenol A	80-05-7	3300	51000	11	1.7	1.7	110	-Body Weight
Boron	7440-42-8	7000	160000	***	NA	NA	***	-Reproductive -Respiratory
Bromacil	314-40-9	5700	72000	0.6	0.6	0.6	6	-Body Weight
Bromochloromethane	74-97-5	57	390	0.6	NA	NA	6	-None Specified
Bromodichloromethane	75-27-4	1.4	2	0.004	0.1	0.1	0.04	-Carcinogen -Kidney
Bromoform	75-25-2	48	84	0.03	2.7	2.7	0.3	-Carcinogen -Liver
Bromomethane [or Methyl bromide]	74-83-9	2.2	15	0.05	0.2	0.2	0.5	-Gastrointestinal
Butanol, 1-	71-36-3	1300	10000	3	110	110	30	-Neurological
Butanone, 2- [or MEK]	78-93-3	3100	21000	17	490	490	170	-Developmental
Butyl benzyl phthalate, n-	85-68-7	15000	320000	310	56	56	3100	-Liver
Butylate	2008-41-5	2100	22000	5.2	0.2	0.2	52	-Liver
Butylphthalyl butylglycolate	85-70-1	74000	*	4200	NA	NA	42000	-None Specified
Cadmium	7440-43-9	75**	1300	8	***	***	80	-Carcinogen -Kidney
Calcium cyanide	592-01-8	3100	73000	***	NA	NA	***	-Body Weight -Neurological -Thyroid
Captan	133-06-2	190	410	3.6	0.03	0.03	36	-Body Weight -Carcinogen
Carbaryl [or Sevin]	63-25-2	6800	120000	8.7	0.0007	0.0007	87	-Kidney -Liver
Carbazole	86-74-8	53	190	0.6	6.5	6.5	6	-Carcinogen
Carbofuran	1563-66-2	58	430	0.2	0.0006	0.0006	2	-Neurological -Reproductive
Carbon disulfide	75-15-0	200	1400	5.6	0.8	0.8	56	-Developmental -Neurological
Carbon tetrachloride	56-23-5	0.4	0.6	0.04	0.06	0.06	0.4	-Carcinogen -Liver
Carbophenothion [or Trithion]	786-19-6	9.8	180	13	1.5	1.5	130	-Neurological
Chlordane	57-74-9	3.1	12	9.6	0.003	0.003	96	-Carcinogen -Liver
Chlorine	7782-50-5	7800	200000	***	***	***	***	-Body Weight
Chlorine cyanide [or Cyanogen chloride]	506-77-4	910	7200	71	0.3	0.3	710	-Body Weight -Neurological -Thyroid
Chloro-1,3-butadiene [or Chloroprene]	126-99-8	2.6	17	1.5	NA	NA	15	-Body Weight -Hair Loss -Nasal
Chloroacetic acid	79-11-8	87	920	0.07	NA	NA	0.7	-Cardiovascular
Chloroaniline, 4-	106-47-8	190	2000	0.2	0.02	0.02	2	-Spleen
Chlorobenzene	108-90-7	30	200	1.3	0.2	0.2	13	-Liver
Chlorobenzilate	510-15-6	3.9	14	0.08	0.07	0.07	0.8	-Body Weight -Carcinogen
Chloroform	67-66-3	0.4	0.5	0.03	2.8	2.8	0.3	-Carcinogen -Liver
Chloro-m-cresol, p- [or 4-chloro-3-methylphenol]	59-50-7	410	4400	0.4	0.6	0.6	4	-Body Weight
Chloromethane	74-87-3	1.7	2.3	0.01	2.3	2.3	0.1	-Carcinogen
Chloronaphthalene, beta-	91-58-7	4000	49000	260	NA	NA	2600	-Liver -Respiratory
Chloronitrobenzene, p-	100-00-5	28	55	3.7	1.6	1.6	37	-Carcinogen

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Chlorophenol, 2-	95-57-8	82	640	0.7	2.5	2.5	7	-Reproductive
Chlorophenol, 3-	108-43-0	280	3400	0.2	3.1	3.1	2	-None Specified
Chlorophenol, 4-	106-48-9	220	2400	0.04	1.2	1.2	0.4	-None Specified
Chlorothalonil [or Bravo]	1897-45-6	88	280	0.2	0.06	0.06	2	-Carcinogen -Kidney
Chlorotoluene, o-	95-49-8	120	850	2.8	7.7	7.7	28	-Body Weight
Chlorotoluene, p-	106-43-4	100	730	2.5	NA	NA	25	-None Specified
Chlorpropham	101-21-3	13000	200000	51	7	7	510	-Bone Marrow -Kidney -Liver -Spleen
Chlorpyrifos	2921-88-2	220	4200	15	0.001	0.001	150	-Neurological
Chromium (hexavalent)	18540-29-9	210	420	38	***	***	380	-Carcinogen -Respiratory
Chrysene	218-01-9	140	450	77	0.7	0.7	770	-Carcinogen
Cobalt	7440-48-4	4700	110000	***	NA	NA	***	-Cardiovascular -Immunological -Neurological - Reproductive
Copper	7440-50-8	110**	76000	***	***	***	***	-Gastrointestinal
Coumaphos	56-72-4	18	300	0.3	0.0007	0.0007	3	-Neurological
Crotonaldehyde	123-73-9	0.07	0.1	17	NA	NA	170	-Carcinogen
Cumene [or Isopropyl benzene]	98-82-8	160	1100	0.2	56	56	2	-Adrenals -Kidney
Cyanide (potassium salt)	57-12-5	30**	39000	40	***	***	400	-Body Weight -Neurological -Thyroid
Cyanogen	460-19-5	340	2500	2000	NA	NA	20000	-None Specified
Cycloate	1134-23-2	240	2600	0.7	2.5	2.5	7	-Neurological
Cyclohexanone	108-94-1	68000	510000	150	110	110	1500	-Body Weight
Cypermethrin	52315-07-8	750	14000	70	0.005	0.005	700	-Gastrointestinal
DDD, 4,4'-	72-54-8	4.6	18	4	0.1	0.1	40	-Carcinogen
DDE, 4,4'-	72-55-9	3.3	13	18	0.1	0.1	180	-Carcinogen
DDT, 4,4'-	50-29-3	3.3	13	11	0.06	0.06	110	-Carcinogen -Liver
Diallate	2303-16-4	17	56	0.6	NA	NA	6	-Carcinogen
Diazinon	333-41-5	55	760	0.02	0.00005	0.00005	0.2	-Neurological
Dibenz(a,h)anthracene	53-70-3	0.1	0.5	30	4.7	4.7	300	-Carcinogen
Dibenzofuran	132-64-9	280	5000	15	36	36	150	-None Specified
Dibromo-3-chloropropane, 1,2- [or DBCP]	96-12-8	0.8	2.7	0.001	NA	NA	0.01	-Carcinogen -Reproductive
Dibromochloromethane	124-48-1	1.4	2.1	0.003	0.2	0.2	0.03	-Carcinogen -Liver
Dibromoethane, 1,2- [or EDB]	106-93-4	0.01	0.04	0.0001	0.07	0.07	0.001	-Carcinogen -Reproductive
Dicamba	1918-00-9	1800	24000	2.6	2.4	2.4	26	-Developmental
Dichloroacetic acid	79-43-6	200	2300	0.2	8.1	8.1	2	-None Specified
Dichloroacetonitrile	3018-12-0	170	1400	0.03	NA	NA	0.3	-None Specified
Dichlorobenzene, 1,2-	95-50-1	650	4600	17	2.8	2.8	170	-Body Weight
Dichlorobenzene, 1,3-	541-73-1	27	180	0.3	2.8	2.8	3	-None Specified
Dichlorobenzene, 1,4-	106-46-7	6	9	2.2	2.9	2.9	22	-Carcinogen -Liver
Dichlorobenzidine, 3,3'-	91-94-1	2.1	6.3	0.4	0.002	0.002	4	-Carcinogen
Dichlorodifluoromethane	75-71-8	56	370	44	NA	NA	440	-Body Weight -Liver
Dichloroethane, 1,1-	75-34-3	290	2000	0.4	NA	NA	4	-Kidney

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Dichloroethane, 1,2- [or EDC]	107-06-2	0.5	0.7	0.01	0.02	0.02	0.1	-Carcinogen
Dichloroethene, 1,1-	75-35-4	0.09	0.1	0.06	0.03	0.03	0.6	-Carcinogen -Liver
Dichloroethene, cis-1,2-	156-59-2	19	130	0.4	NA	NA	4	-Blood
Dichloroethene, trans-1,2-	156-60-5	31	210	0.7	75	75	7	-Blood -Liver
Dichlorophenol, 2,3-	576-24-9	180	2500	0.2	1.2	1.2	2	-None Specified
Dichlorophenol, 2,4-	120-83-2	130	1300	0.005	0.1	0.1	0.05	-Immunological
Dichlorophenol, 2,5-	583-78-8	200	3000	0.5	4.3	4.3	5	-None Specified
Dichlorophenol, 2,6-	87-65-0	170	2200	0.1	2.5	2.5	1	-None Specified
Dichlorophenol, 3,4-	95-77-2	200	3100	0.03	3.9	3.9	0.3	-None Specified
Dichlorophenoxy acetic acid, 2,4-	94-75-7	670	11000	0.7	0.9	0.9	7	-Kidney -Liver
Dichloropropane, 1,2-	78-87-5	0.6	0.8	0.03	15	15	0.3	-Carcinogen -Nasal
Dichloropropene, 1,3-	542-75-6	0.2	0.2	0.001	0.09	0.09	0.01	-Carcinogen -Kidney -Nasal
Dichlorprop	120-36-5	270	3300	0.3	0.3	0.3	3	-None Specified
Dichlorvos	62-73-7	0.2	0.3	0.0005	0.00002	0.00002	0.005	-Carcinogen -Neurological
Dicofol [or Kelthane]	115-32-2	2.3	7.6	0.05	0.0004	0.0004	0.5	-Adrenals -Carcinogen
Dieldrin	60-57-1	0.07	0.3	0.004	0.0001	0.0001	0.04	-Carcinogen -Liver
Diethylphthalate	84-66-2	54000	920000	86	5.9	5.9	860	-Body Weight
Dimethoate	60-51-5	8.4	86	0.0004	0.0004	0.0004	0.004	-Neurological
Dimethrin	70-38-2	19000	270000	2500	1.3	1.3	25000	-Liver
Dimethylformamide, N,N-	68-12-2	1100	7800	3	210	210	30	-Gastrointestinal -Liver
Dimethylphenol, 2,4-	105-67-9	910	9800	1.7	3.2	3.2	17	-Blood -Neurological
Dimethylphthalate	131-11-3	590000	*	380	7.8	7.8	3800	-Kidney
Di-n-butylphthalate	84-74-2	7300	140000	47	1.5	1.5	470	-Mortality
Dinitrobenzene, 1,2- (o)	528-29-0	13	130	1	0.2	0.2	10	-Spleen
Dinitrobenzene, 1,3- (m)	99-65-0	3.5	33	0.04	0.4	0.4	0.4	-Spleen
Dinitrophenol, 2,4-	51-28-5	66	620	0.06	0.01	0.01	0.6	-Eye
Dinitrotoluene, 2,4-	121-14-2	1.3	3.7	0.0008	0.07	0.07	0.008	-Carcinogen -Liver -Neurological
Dinitrotoluene, 2,6-	606-20-2	1	2.1	0.0007	0.03	0.03	0.007	-Blood -Carcinogen -Kidney -Mortality -Neurological
Di-n-octylphthalate	117-84-0	1500	27000	480000	NA	NA	4800000	-Kidney -Liver
Dinoseb	88-85-7	55	740	0.03	0.03	0.03	0.3	-Developmental
Dioxane, 1,4-	123-91-1	12	18	0.02	1	1	0.2	-Carcinogen
Dioxin [or 2,3,7,8-TCDD]	1746-01-6	0.000007	0.00003	0.003	0.000001	0.000001	0.03	-Carcinogen
Diphenamid	957-51-7	1800	25000	2.6	20	20	26	-Liver
Diphenylhydrazine, 1,2-	122-66-7	1.2	3.7	0.4	0.01	0.01	4	-Carcinogen
Disulfoton	298-04-4	2.9	56	0.1	0.1	0.1	1	-Neurological
Diuron	330-54-1	130	2000	0.3	0.2	0.2	3	-Blood
Endosulfan	115-29-7	410	6700	3.8	0.005	0.0008	38	-Body Weight -Cardiovascular -Kidney
Endothall	145-73-3	780	7800	0.4	0.4	0.4	4	-Gastrointestinal
Endrin	72-20-8	21	340	1	0.001	0.001	10	-Liver
Epichlorohydrin	106-89-8	11	74	0.03	2.4	2.4	0.3	-Carcinogen -Kidney -Nasal
Ethion	563-12-2	38	780	1.7	0.003	0.003	17	-Neurological

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Ethoprop	13194-48-4	5.5	69	0.005	0.002	0.002	0.05	-Neurological
Ethoxyethanol, 2-	110-80-5	8100	65000	120	NA	NA	1200	-Body Weight -Reproductive
Ethyl acetate	141-78-6	5500	39000	26	26	26	260	-Body Weight -Mortality
Ethyl acrylate	140-88-5	1.6	2.2	25	0.6	0.6	250	-Carcinogen
Ethyl chloride [or Chloroethane]	75-00-3	2.9	4	0.06	NA	NA	0.6	-Carcinogen -Developmental
Ethyl dipropylthiocarbamate, S- [or EPTC]	759-94-4	1100	13000	11	15	15	110	-Cardiovascular
Ethyl ether	60-29-7	150	1000	5	850	850	50	-Body Weight
Ethyl methacrylate	97-63-2	380	2600	3.5	NA	NA	35	-Kidney
Ethyl p-nitrophenyl phenylphosphorothioate [or EPN]	2104-64-5	0.7	15	0.04	0.003	0.003	0.4	-Neurological
Ethylbenzene	100-41-4	1100	8400	0.6	12	12	6	-Developmental -Kidney -Liver
Ethylene diamine	107-15-3	610	5500	40	3.2	3.2	400	-Blood -Cardiovascular
Ethylene glycol	107-21-1	24000	180000	56	65	65	560	-Kidney
Ethylene oxide	75-21-8	0.3	0.4	0.05	20	20	0.5	-Carcinogen
Fenamiphos	22224-92-6	15	210	0.02	0.003	0.003	0.2	-Neurological
Fensulfothion	115-90-2	14	180	0.01	0.004	0.004	0.1	-Neurological
Fluometuron	2164-17-2	750	9700	0.9	1.8	1.8	9	-None Specified
Fluoranthene	206-44-0	2900	48000	1200	1.3	1.3	12000	-Blood -Kidney -Liver
Fluorene	86-73-7	2200	28000	160	17	17	1600	-Blood
Fluoride	7782-41-4	500**	120000	***	***	***	***	-Teeth
Fonofos	944-22-9	120	1800	0.4	0.003	0.003	4	-Liver -Neurological
Formaldehyde	50-00-0	21	29	2.4	0.4	0.4	24	-Body Weight -Carcinogen -Gastrointestinal
Furfural	98-01-1	160	2000	1	2.7	2.7	10	-Liver -Nasal
Guthion [or Azinphos, methyl]	86-50-0	110	2000	0.2	0.0002	0.0002	2	-Neurological
Heptachlor	76-44-8	0.2	0.9	23	0.1	0.1	230	-Carcinogen -Liver
Heptachlor epoxide	1024-57-3	0.1	0.4	0.6	0.006	0.006	6	-Carcinogen -Liver
Hexachloro-1,3-butadiene	87-68-3	6.3	12	1.1	110	110	11	-Carcinogen -Kidney
Hexachlorobenzene	118-74-1	0.5	1.1	2.2	0.0008	0.0008	22	-Carcinogen -Liver
Hexachlorocyclohexane, alpha-	319-84-6	0.2	0.5	0.0003	0.0006	0.0006	0.003	-Carcinogen
Hexachlorocyclohexane, beta-	319-85-7	0.6	2.1	0.001	0.003	0.003	0.01	-Carcinogen
Hexachlorocyclohexane, delta-	319-86-8	22	420	0.2	NA	NA	2	-Kidney -Liver
Hexachlorocyclohexane, gamma- [or Lindane]	58-89-9	0.7	2.2	0.009	0.003	0.003	0.09	-Carcinogen -Kidney -Liver
Hexachlorocyclopentadiene	77-47-4	2.4	16	400	24	24	4000	-Gastrointestinal
Hexachloroethane	67-72-1	34	78	0.2	0.08	0.08	2	-Carcinogen -Kidney
Hexahydro-1,3,5-trinitro-1,3,5-triazine [or RDX]	121-82-4	6.7	16	0.007	1.3	1.3	0.07	-Carcinogen -Reproductive
Hexane, n-	110-54-3	500	3600	3.5	1200	1200	35	-Neurological
Hexanone, 2- [or Methyl butyl ketone]	591-78-6	5.1	34	1.4	NA	NA	14	-None Specified
Hexazinone	51235-04-2	1600	18000	1.1	5	5	11	-Body Weight

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Hydroquinone	123-31-9	1800	19000	1.4	0.02	0.02	14	-Blood
Indeno(1,2,3-cd)pyrene	193-39-5	1.5	5.3	28	4.3	4.3	280	-Carcinogen
Iron	7439-89-6	23000	480000	***	***	***	***	-Blood -Gastrointestinal
Isobutyl alcohol	78-83-1	4100	31000	8.9	200	200	89	-Neurological
Isophorone	78-59-1	340	580	0.2	3.8	3.8	2	-Carcinogen
Lead	7439-92-1	400	920	***	***	***	***	-Neurological
Linuron	330-55-2	130	2000	0.04	1.4	1.4	0.4	-Blood
Lithium	7439-93-32	1600	40000	***	NA	NA	***	-None Specified
Malathion	121-75-5	1300	20000	4.2	0.003	0.003	42	-Neurological
Maneb	12427-38-2	350	5500	6.3	0.5	0.5	63	-Thyroid
Manganese	7439-96-5	1600	22000	***	NA	NA	***	-Neurological
Mercury	7439-97-6	3.4	26	2.1	0.01	0.01	21	-Neurological
Mercury, methyl	22967-92-6	0.8	5.4	0.002	NA	NA	0.02	-Neurological
Merphos	150-50-5	2.2	41	0.5	NA	NA	5	-Body Weight -Neurological
Methacrylonitrile	126-98-7	0.8	5.4	0.02	NA	NA	0.2	-Liver
Methamidophos	10265-92-6	1.9	19	0.02	0	0	0.2	-Neurological
Methanol	67-56-1	5800	43000	20	180	180	200	-Liver -Neurological
Methidathion	950-37-8	47	530	0.003	0.0001	0.0001	0.03	-Liver
Methomyl	16752-77-5	22	150	1.2	0.007	0.007	12	-Kidney -Spleen
Methoxy-5-nitroaniline, 2-	99-59-2	17	41	0.4	NA	NA	4	-Carcinogen
Methoxychlor	72-43-5	370	7500	160	0.1	0.1	1600	-Developmental -Reproductive
Methyl acetate	79-20-9	4100	28000	26	NA	NA	260	-Liver
Methyl acrylate	96-33-3	99	680	0.9	NA	NA	9	-None Specified
Methyl isobutyl ketone [or MIBK]	108-10-1	220	1500	2.6	110	110	26	-Kidney -Liver
Methyl methacrylate	80-62-6	1400	9400	0.1	32	32	1	-Nasal
Methyl parathion [or Parathion, methyl]	298-00-0	18	310	0.06	0.0003	0.0003	0.6	-Blood -Neurological
Methyl tert-butyl ether [or MTBE]	1634-04-4	3200	22000	0.2	150	150	2	-Eye -Kidney -Liver
Methyl-4-chlorophenoxy acetic acid, 2-	94-74-6	30	440	0.02	0.4	0.4	0.2	-Kidney -Liver
Methylaniline, 2-	95-53-4	1.8	3.3	0.3	0.2	0.2	3	-Carcinogen
Methylene bis(2-chloroaniline), 4,4-	101-14-4	6.4	17	0.2	NA	NA	2	-Carcinogen -Liver -Bladder
Methylene bromide	74-95-3	58	400	0.3	NA	NA	3	-Blood
Methylene chloride	75-09-2	16	23	0.02	7.3	7.3	0.2	-Carcinogen -Liver
Methylnaphthalene, 1-	90-12-0	68	470	2.2	10	10	22	-Body Weight -Nasal
Methylnaphthalene, 2-	91-57-6	80	560	6.1	9.1	9.1	61	-Body Weight -Nasal
Methylphenol, 2- [or o-Cresol]	95-48-7	2400	28000	0.3	1.9	1.9	3	-Body Weight -Neurological
Methylphenol, 3- [or m-Cresol]	108-39-4	2500	29000	0.3	3.3	3.3	3	-Body Weight -Neurological
Methylphenol, 4- [or p-Cresol]	106-44-5	250	3000	0.03	0.5	0.5	0.3	-Maternal Death -Neurological -Respiratory
Metolachlor	51218-45-2	9100	120000	1.2	0.01	0.01	12	-Body Weight
Metribuzin	21087-64-9	32	210	2.2	0.8	0.8	22	-Body Weight -Kidney -Liver -Mortality
Mevinphos	7786-34-7	16	240	0.01	0.0003	0.0003	0.1	-Neurological
Molinate	2212-67-1	100	1200	0.1	0.1	0.1	1	-Reproductive

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Molybdenum	7439-98-7	390	9700	***	NA	NA	***	-Gout
Naled	300-76-5	130	2100	0.1	0.0002	0.0002	1	-Neurological
Naphthalene	91-20-3	40	270	1.7	2.2	2.2	17	-Body Weight -Nasal
Nickel	7440-02-0	110**	28000	130	***	***	1300	-Body Weight
Nitrate	14797-55-8	120000	*	***	***	***	***	-Blood
Nitrite	14797-65-0	7800	180000	***	***	***	***	-Blood
Nitroaniline, o-	88-74-4	5.7	66	0.3	NA	NA	3	-Blood
Nitroaniline, p-	100-01-6	5.2	56	0.1	5.9	5.9	1	-None Specified
Nitrobenzene	98-95-3	14	120	0.03	0.6	0.6	0.3	-Adrenals -Blood -Kidney -Liver
Nitrophenol, 4-	100-02-7	390	4400	0.3	0.3	0.3	3	-None Specified
Nitroso-di-ethylamine, N-	55-18-5	0.003	0.005	0.02	0.0007	0.0007	0.2	-Carcinogen
Nitroso-dimethylamine, N-	62-75-9	0.009	0.02	0.008	0.002	0.002	0.08	-Carcinogen
Nitroso-di-n-butylamine, N-	924-16-3	0.05	0.07	0.05	0.002	0.002	0.5	-Carcinogen
Nitroso-di-n-propylamine, N-	621-64-7	0.09	0.2	0.04	0.008	0.008	0.4	-Carcinogen
Nitroso-diphenylamine, N-	86-30-6	170	440	0.4	2.5	2.5	4	-Carcinogen
Nitroso-N-methylethylamine, N-	10595-95-6	0.01	0.02	0.03	0.005	0.005	0.3	-Carcinogen
Nitrotoluene, m-	99-08-1	210	1800	2.4	3.6	3.6	24	-Spleen
Nitrotoluene, o-	88-72-2	280	2500	3.3	7.3	7.3	33	-Spleen
Nitrotoluene, p-	99-99-0	640	9700	3.3	7.3	7.3	33	-Spleen
Octamethylpyrophosphoramidate	152-16-9	83	860	4	NA	NA	40	-Neurological
Oxamyl	23135-22-0	1100	12000	0.9	0.04	0.04	9	-Body Weight
Paraquat	1910-42-5	310	4000	160	230	230	1600	-Respiratory
Parathion	56-38-2	450	9100	10	0.01	0.01	100	-Neurological
PCBs [Aroclor mixture]	1336-36-3	0.5	2.1	17	0.002	0.002	170	-Carcinogen -Immunological
Pebulate	1114-71-2	1600	15000	8.5	7.4	7.4	85	-Blood
Pendimethalin	40487-42-1	2500	36000	28	1	1	280	-Liver
Pentachlorobenzene	608-93-5	27	250	3.9	1.2	1.2	39	-Kidney -Liver
Pentachloronitrobenzene	82-68-8	3	7.7	0.7	0.06	0.06	7	-Carcinogen -Liver
Pentachlorophenol	87-86-5	7.7	23	0.03	0.2	0.2	0.3	-Carcinogen -Kidney -Liver
Permethrin	52645-53-1	3700	67000	880	0.003	0.003	8800	-Liver
Phenanthrene	85-01-8	2000	30000	250	0.7	0.7	2500	-Kidney
Phenol	108-95-2	900**	390000	0.05	0.03	0.03	0.5	-Developmental
Phenylenediamine, p-	106-50-3	8000	83000	6.2	NA	NA	62	-Whole Body
Phenylphenol, 2-	90-43-7	460	1300	0.4	0.8	0.8	4	-Carcinogen
Phorate	298-02-2	14	280	0.3	0.001	0.001	3	-Neurological
Phosmet	732-11-6	1400	21000	5	0.004	0.004	50	-Body Weight -Liver -Neurological
Phthalic anhydride	85-44-9	8300	57000	76	NA	NA	760	-Kidney -Nasal -Respiratory
Prometon	1610-18-0	980	14000	2.4	14	14	24	-None Specified
Prometryn	7287-19-6	260	3900	0.7	0.5	0.5	7	-Bone Marrow -Kidney -Liver
Propachlor	1918-16-7	770	10000	1.1	0.1	0.1	11	-Body Weight -Liver
Propanil	709-98-8	300	4100	0.4	0.2	0.2	4	-Spleen

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Propazine	139-40-2	1200	17000	0.2	2.7	2.7	2	-Body Weight
Propylene glycol	57-55-6	710000	*	560	140	140	5600	-Blood -Bone Marrow
Propylene oxide	75-56-9	3.2	8.1	22	NA	NA	220	-Carcinogen -Nasal -Respiratory
Pydrin [or Fenvalerate]	51630-58-1	1800	32000	700	0.0001	0.0001	7000	-Neurological
Pyrene	129-00-0	2200	37000	880	1.3	1.3	8800	-Kidney
Pyridine	110-86-1	13	95	0.03	5.4	5.4	0.3	-Liver
Resmethrin	10453-86-8	2200	39000	1200	0.01	0.01	12000	-Reproductive
Ronnel	299-84-3	3600	59000	1300	0.2	0.2	13000	-Liver
Selenium	7782-49-2	390	10000	5	***	***	50	-Hair Loss -Neurological -Skin
Silver	7440-22-4	390	9100	17	***	***	170	-Skin
Simazine	122-34-9	7.4	21	0.08	0.1	0.1	0.8	-Blood -Body Weight -Carcinogen
Strontium	7440-24-6	47000	*	***	NA	NA	***	-Bone
Strychnine	57-24-9	17	210	0.7	0.3	0.3	7	-Mortality
Styrene	100-42-5	2700	21000	3.6	16	16	36	-Blood -Liver -Neurological
Terbacil	5902-51-2	660	7700	0.5	14	14	5	-Liver -Thyroid
Terbufos	13071-79-9	1.4	17	0.02	0.001	0.001	0.2	-Neurological
Tetrachlorobenzene, 1,2,4,5-	95-94-3	6.3	51	0.5	0.5	0.5	5	-Kidney
Tetrachloroethane, 1,1,1,2-	630-20-6	4	5.7	0.01	NA	NA	0.1	-Carcinogen -Kidney -Liver
Tetrachloroethane, 1,1,2,2-	79-34-5	0.7	1.1	0.002	0.08	0.08	0.02	-Carcinogen
Tetrachloroethene [or PCE]	127-18-4	8.9	17	0.03	0.1	0.1	0.3	-Body Weight -Carcinogen -Liver
Tetrachlorophenol, 2,3,4,6-	58-90-2	1500	17000	3.2	0.07	0.07	32	-Liver
Tetraethyl dithiopyrophosphate	3689-24-5	31	420	0.1	0.0004	0.0004	1	-Bone Marrow -Neurological
Thiram	137-26-8	330	4900	1.1	0.005	0.005	11	-Neurological
Tin	7440-31-5	44000	660000	***	NA	NA	***	-Kidney -Liver
Toluene	108-88-3	380	2600	0.5	5.6	5.6	5	-Kidney -Liver -Neurological
Toluidine, p-	106-49-0	1.4	2.2	0.7	NA	NA	7	-Carcinogen
Toxaphene	8001-35-2	1	3.7	31	0.002	0.002	310	-Carcinogen -Developmental
Triallate	2303-17-5	740	9500	8.4	6	6	84	-Liver -Spleen
Tributyltin oxide	56-35-9	22	400	36	0.2	0.2	360	-Immunological
Trichloro-1,2,2-trifluoroethane, 1,1,2-[or CFC 113]	76-13-1	13000	88000	27000	NA	NA	270000	-Body Weight -Neurological
Trichloroacetic acid	76-03-9	480	4600	1.2	400	400	12	-None Specified
Trichlorobenzene, 1,2,3-	87-61-6	560	7400	4.6	5.6	5.6	46	-Adrenals -Body Weight
Trichlorobenzene, 1,2,4-	120-82-1	560	7500	5.3	1.7	1.7	53	-Adrenals -Body Weight
Trichlorobenzene, 1,3,5-	108-70-3	190	1800	16	NA	NA	160	-None Specified
Trichloroethane, 1,1,1- [or Methyl chloroform]	71-55-6	400	3300	1.9	2.6	2.6	19	-None Specified
Trichloroethane, 1,1,2-	79-00-5	1.3	1.8	0.03	0.2	0.2	0.3	-Carcinogen -Liver
Trichloroethene [or TCE]	79-01-6	6	8.5	0.03	0.9	0.9	0.3	-Carcinogen
Trichlorofluoromethane	75-69-4	200	1300	33	NA	NA	330	-Cardiovascular -Kidney -Mortality -Respiratory
Trichlorophenol, 2,4,5-	95-95-4	6000	82000	0.3	1.5	1.5	3	-Kidney -Liver

APPENDIX D - REUSE TARGET LEVELS

Contaminant Name	CAS#	Direct Exposure Residential	Direct Exposure Industrial	Leachability Based on Groundwater Criteria	Leachability Based on Freshwater Surface Water Criteria	Leachability Based on Marine Surface Water Criteria	Leachability Based on Groundwater of Low Yield/Poor Quality	Target Organ/System or Effect
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Trichlorophenol, 2,4,6-	88-06-2	72	180	0.06	0.1	0.1	0.6	-Carcinogen
Trichlorophenoxy acetic acid, 2,4,5-	93-76-5	590	8300	0.4	0.8	0.8	4	-Kidney
Trichlorophenoxy propionic acid [or Silvex]	93-72-1	590	12000	5.4	NA	NA	54	-Liver
Trichloropropane, 1,2,3-	96-18-4	0.01	0.02	0.001	0.002	0.002	0.01	-Body Weight -Carcinogen -Kidney -Liver -Mortality
Trifluralin	1582-09-8	94	220	3.5	0.6	0.6	35	-Blood -Carcinogen -Liver
Trimethyl phosphate	512-56-1	15	30	0.2	NA	NA	2	-Carcinogen
Trimethylbenzene, 1,2,3-	526-73-8	13	89	0.3	NA	NA	3	-None Specified
Trimethylbenzene, 1,2,4-	95-63-6	13	88	0.3	7.2	7.2	3	-None Specified
Trimethylbenzene, 1,3,5-	108-67-8	11	74	0.3	6.7	6.7	3	-None Specified
Trinitrobenzene, 1,3,5-	99-35-4	1300	14000	1	0.09	0.09	10	-Blood -Spleen
Trinitrotoluene, 2,4,6-	118-96-7	24	55	0.06	0.3	0.3	0.6	-Carcinogen -Liver
TRPH	NOCAS#	340	2500	340	340	340	3400	-Multiple Endpoints Mixed Contaminants
Uranium, natural	7440-61-1	120	470	***	NA	NA	***	-None Specified
Vanadium	7440-62-2	15**	7400	980	NA	NA	9800	-None Specified
Vernam	1929-77-7	29	260	0.1	0.2	0.2	1	-Body Weight
Vinyl acetate	108-05-4	230	1600	0.4	3	3	4	-Body Weight -Kidney -Nasal
Vinyl chloride	75-01-4	0.03	0.04	0.007	NA	NA	0.07	-Carcinogen
Xylenes, total	1330-20-7	5900	40000	0.2	3.9	3.9	2	-Body Weight -Mortality -Neurological
Zinc	7440-66-6	23000	560000	6000	***	***	60000	-Blood
Zinc phosphide	1314-84-7	23	550	***	NA	NA	***	-Body Weight
Zineb	12122-67-7	3400	53000	19	0.7	0.7	190	-Thyroid

* Contaminant is not a health concern for this default exposure scenario.

** Direct exposure value based on acute toxicity considerations.

*** Leachability values may be derived using the SPLP test to calculate site-specific RTLs or may be determined using TCLP in the event oily wastes are present.

NA = Not available.