RCRA-2002-0029 RCRA-2002-0029-0002

(20)

01-31-03P12:30 RCVD

FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT FOR QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES AND METHODOLOGY

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October 23, 1991

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1. INTRODUCTION AND RECAP OF PRE-1990 TREATMENT STANDARDS

The Hazardous and Solid Waste Amendments of 1984 (HSWA) imposed substantial new responsibilities on those who handle hazardous wastes, including stringent new restrictions on the land disposal of hazardous wastes and associated treatment residuals.

This document, prepared by the U.S. Environmental Protection Agency (EPA), Office of Solid Waste (OSW), provides EPA's approach for implementing the Land Disposal Restrictions (LDR) Program both in terms of how treatment standards were developed for earlier rules and, also, how EPA intends to collect and evaluate treatment data to develop treatment standards on future rules. Section 2 presents the Quality Assurance Project Plan used to evaluate treatment data collected past and present for the LDR Program. Section 3 presents the methodology used for establishing treatment standards. Section 4 summarizes the treatment standards calculated and promulgated for the Solvents and Dioxins Rule, the California List Rule, and the First Third, Second Third, and Third Third Rules.

1.1 General Requirements Under HSWA as Related to the LDR Program

The Hazardous and Solid Waste Amendments of 1984 (HSWA), enacted on November 8, 1984, amended the Resource Conservation and Recovery Act (RCRA) of 1976 in several ways. Among other initiatives, the amendments require the EPA to promulgate regulations restricting the land disposal of hazardous wastes according to a strict and detailed schedule. This effort is generally referred to as the Land Disposal Restrictions Program (LDR).

In its enactment of HSWA, Congress stated explicitly that "to avoid substantial risk to human health and the environment, reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous waste" (RCRA section 1002(b)(7)). Exceptions to the

restrictions are intended to be minimal; all waste must be treated unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous"--the so-called "no-migration" demonstration (RCRA section 3004(d)(1), (e)(1), (g)(5)).

Consistent with the comprehensive scope of this program, HSWA's definition of land disposal is broad. Land disposal includes but is not limited to "any placement of hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k)). The statute does, however, set different schedules for restricting various categories of waste from various types of land disposal.

HSWA grants the Agency substantial flexibility in designing treatment standards to implement the program. The standards can require the use of specific treatment "methods" (technologies), or they can be stated as numerical performance standards (i.e., required concentration-based levels of treatment), as long as they "substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1)). In exercising this flexibility, EPA prefers, wherever possible, to establish numerical performance standards based on the constituent concentration in the treatment residual rather than to require the use of specific treatment methods. The Agency believes that concentration-based treatment standards offer the regulated community greater flexibility to develop and implement compliance strategies. Such standards also provide an incentive to develop innovative technologies, whereas, if this standard is established as a method of treatment, the regulated community must apply for a variance to use an alternative treatment technology, such as a new and innovative technology that was not available when the rule for a specific waste code was promulgated.

EPA is not required to establish unique standards for each waste code. In some instances, variations in physical or chemical characteristics within a single waste code may require the establishment of multiple treatment standards for that single code. In many cases, similarities among wastes may allow the Agency to set a single treatment standard to cover multiple waste codes. RCRA requires the Agency to make a land disposal prohibition determination for any hazardous waste that is newly identified or listed in 40 CFR Part 261 after November 8, 1984, such as the mineral processing wastes removed from the Bevill Exclusion and the additional Toxicity Characteristic wastes (55 FR 11798), within 6 months of the date of identification or listing (RCRA section 3004(g)(4)).

Originally HSWA set a strict and detailed schedule for establishing treatment standards, based generally on priorities related to the volume and intrinsic hazards of different types of wastes. Two groups received early attention: (1) solvent and dioxin wastes, to be regulated within 24 months of HSWA's passage, and (2) the so-called "California List" wastes, to be regulated within 32 months. The solvent/dioxin waste group identified in HSWA includes those solvent wastes covered under waste codes F001, F002, F003, F004, and F005, as well as the dioxin-containing wastes covered under waste codes F020, F021, F022, and F023 (RCRA section 3004(3)).*

The California List wastes, a group of wastes originally listed by the State of California and adopted intact within HSWA, include liquid hazardous wastes containing metals, free cyanides, polychlorinated biphenyls (PCBs), corrosives (pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight.

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* The final dioxin regulation also established treatment standards for F026, F027, and F028.

Priorities for all other hazardous wastes listed under RCRA section 3001 were established separately, based on considerations of volume and intrinsic hazard, in a formal schedule submitted to Congress on November 8, 1986 (RCRA section 3004(g)(1)). This schedule required all LDR regulations for these listed wastes to be in place by May 8, 1990. Consistent with the requirements of HSWA, EPA divided all other listed hazardous wastes into three groups (the "Thirds"), to be regulated in successive stages over a period of 66 months from the passage of HSWA on November 8, 1984. Furthermore, if EPA failed to set a treatment standard in the first or second third of the schedule, the wastes could be disposed of only in accordance with the "soft hammer" provisions, such as the requirement for disposal in a landfill or surface impoundment unit that met the minimum technological requirements specified in RCRA section 3004(o) for new facilities (RCRA section 3004(g)(6)). If EPA failed to set a treatment standard for any scheduled hazardous waste by May 8, 1990, the soft hammer provisions would then be superseded by the hard hammer provisions, which automatically prohibited all forms of disposal on May 8, 1990, unless the wastes are the subject of a successful "no migration" demonstration (RCRA section 3004(g)(6)).

The overall completion schedule for the LDR Program for the wastes specifically listed in HSWA was as follows:

- Solvents and Dioxins: Final standards promulgated on November 7, 1986.
- California List wastes: Final standards promulgated on July 8, 1987.
- "First Third" scheduled wastes: Final standards promulgated on August 8, 1988.
- "Second Third" scheduled wastes: Final standards promulgated on June 8, 1989.
- "Third Third" scheduled wastes: Final standards promulgated on May 8, 1990.

Under the Third Third Rule, EPA granted an extension of the effective date until May 8, 1992, for certain First, Second, and Third Third contaminated soil and debris for which the

treatment standards are based on incineration, vitrification, or mercury retorting. EPA also granted a national capacity variance for inorganic solids debris contaminated with D004 through D011 wastes. In addition, EPA has granted a 2-year national capacity variance to all inorganic solids debris and to all soil and debris contaminated with RCRA/radioactive wastes (i.e., mixed wastes).

Factors that must be taken into account when granting any exceptions to this program reflect the basic rationale of the program itself. Before it can allow a waste to continue to be disposed of in or on the land, EPA must consider the following:

1. The long-term uncertainties associated with land disposal;
2. The goal of managing hazardous waste in an appropriate manner; and
3. The persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous wastes and their hazardous constituents.

1.2 Development of Quality Assurance Project Plan Used for Previous Collection of Data for BDAT Program

To collect data of known quality to generate the treatment standards, EPA has developed a generic quality assurance project plan for the collection of treatment data. Originally the *Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT")* was published in March 1987 (EPA/530-SW-87-011) and is referred to hereafter as the March 1987 generic quality assurance project plan. This document established specific quality assurance and quality control parameters for assessing the quality of the data collected specifically for the LDR Program, collected for other EPA programs, or submitted by industry for consideration in the development of the BDAT standards.

Section 2 of this Background Document replaces the March 1987 generic quality assurance project plan; it is being distributed separately in order to facilitate dissemination. For collection of data for contaminated soil and debris under the LDR Program, EPA developed a separate quality assurance project plan entitled *Quality Assurance Project Plan for Characterization Sampling and Treatment Tests Conducted for the Contaminated Soil and Debris (CSD) Program*, November 8, 1990.

1.2.1 EPA Data Collected from BDAT Sampling and Analysis Program

EPA's Office of Solid Waste (EPA/OSW) and Office of Research and Development (EPA/ORD) conducted treatment tests for the listed wastes at (1) the facilities of waste generators that also treat the waste; (2) commercial facilities (i.e., treatment, storage, and disposal facilities (TSDFs)) that treat the waste of interest; and (3) EPA or commercial facilities with pilot-scale treatment systems. The data were collected following the March 1987 generic quality assurance project plan and formed the basis for calculating the numerical treatment standards calculated in the First, Second, and Third Thirds rulemaking.

(1) <u>Data sources used to identify treatment facilities</u>. All available in-house data were assessed to identify waste codes for which inadequate treatment data existed. EPA used a number of sources to identify facilities that treat and/or generate these selected waste codes. The sources included the following:

- 1988 National Survey of Treatment, Storage, Disposal, and Recycling Facilities (TSDR Survey);
- Stanford Research Institute's (SRI) Directory of Chemical Procedures;
- 1986 National Screening Survey of TSDFs;
- Industry Studies Data Base; and

- Hazardous Waste Data Management System (HWDMS).

In addition, trade associations were contacted to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

(2) Facility selection. A hierarchy of types of plants to sample for collection of BDAT data collection was established that was consistent with the regulatory approach described in the preamble to the November 7, 1986, Land Disposal Restrictions Rule for Solvents and Dioxins. The hierarchy for facility selection was as follows:

1. Generator/treater. This facility type was the best choice. This type of facility would most likely treat the waste by itself or as a significant percentage component of a waste mixture and would most likely optimize treatment parameters for the waste of interest since it routinely treats the waste.

2. Commercial facility or TSDF. This facility type was second choice. This type of facility would be familiar with treatment of a particular waste type, and would be able to optimize treatment parameters and demonstrate the technology under "full-scale" conditions.

3. EPA or commercial pilot-scale treatment units. This was the last choice. This type of facility would be able to demonstrate the performance of the treatment system; however, it does not "routinely" treat the waste of concern or similar waste and, therefore, may have problems optimizing the treatment parameters. In addition, it is not a "full-scale" operation.

Final plant selection was affected by the type of treatment, if any, available at generator/treater facilities; the types of treatment technologies used at TSDFs; the composition of the waste stream at the facility (i.e., whether the waste of concern constitutes a significant portion of the waste stream); the design and operation of the technologies; whether the facility layout is conducive to sampling; whether the treatment system is full-scale or pilot-scale; and statutory time constraints.

(3) Treatment tests. The purpose of the treatment tests was to obtain data of known quality for listed waste codes for which inadequate treatment data existed. For these waste codes, all treatment technologies currently used by generators, as well as all applicable treatment technologies, were evaluated. Final selection of the treatment system to be tested was determined on the basis of which applicable treatment systems could be considered to be demonstrated for the waste of interest.

(4) Reports generated as part of sampling program. For each treatment test, a site-specific sampling and analysis plan (SAP) was prepared. The SAP provided the site-specific details concerning the sampling points, sampling procedures, frequency of collection, constituents of interest, analytical methods, quality control checks, operational parameters, and frequency of data collection.

Upon completion of the sampling and analysis activities, an onsite engineering report summarizing all data pertinent to the evaluation of the treatment system for the listed wastes was developed. The onsite engineering report included the following:

- Description of the waste;
- Description of the treatment system, including all pertinent design parameters;
- Summary of the operating data;
- Summary of the sample collection activities, especially any deviations or modifications from the SAP and the rationale for their implementation;
- Summary of all analytical data; and
- Summary of all pertinent quality control data, especially analytical results for precision and accuracy.

1.2.2 Other EPA Data

EPA obtained and evaluated data from other programs, especially from EPA's Industrial Technology Division, for setting the Best Available Technology Economically Achievable standards for point source discharges to receiving waters or publicly owned treatment works (POTWs). These data were used, if sufficient information was available, to determine that the waste or constituents of interest were substantially treated, the treatment system could be identified, and the treatment system could be determined to be well-operated. Available information on analytical methods and quality control indicators (e.g., matrix spikes, duplicates, blanks) were also evaluated.

1.2.3 Industry-Supplied Data

For the LDR Program, EPA solicited treatment data from facilities for consideration in the development of the BDAT standards. Facilities were requested to follow the procedures documented in Sections 3 and 4 of the March 1987 generic quality assurance project plan. Facilities were also requested to supply design, operating, and analytical data for both untreated waste and treatment residuals, which included quality control data that could be used to determine the precision and accuracy of the analytical data and the analytical procedures/methods used.

1.3 Development of Methodology to Calculate Previous Treatment Standards

The framework for the methodology used to calculate treatment standards for the LDR Program was published in the Solvents and Dioxins Rule promulgated on November 7, 1986.

1.3.1 Evaluation of Data

In the November 7, 1986, Solvents and Dioxins Rule, EPA stated, "The Agency will not establish treatment standards using performance data that are determined not to be representative of a well-designed and well-operated treatment system" (FR 40590). Ideally, for all treatment data, the associated design and operating data should be evaluated. However, because treatment performance data are limited, engineering judgment based on a comparison of constituent concentrations before and after treatment may be used to determine whether the data reflect a well-designed and well-operated treatment system.

EPA promulgated the use of a statistical outlier test (Appendix A) and an analysis of variance test (ANOVA) to provide a method to evaluate whether there is a statistical difference between the data sets, or whether the data sets are homogeneous and can be evaluated together (Appendix B). The analysis of variance is used to evaluate data from two or more treatment technologies where data from two or more different wastes with the same constituents need to be treated differently.

A comprehensive discussion of these statistical methods can be found in detail in many statistics texts, e.g., *Statistical Concepts and Methods*, Bhattacharyya and Johnson, (1977, John Wiley Publications, New York).

Based on the statistical evaluation of the data, the best demonstrated available technology (BDAT) could be determined.

1.3.2 Calculation of Treatment Standards

The treatment standards for each waste code are based on data from (1) actual performance data for the waste code; (2) transfer of performance data based on similar waste

characteristics; or (3) a specific treatment technology if sufficient data are not available to calculate a concentration-based standard.

Based on the data available for the selected BDAT, a treatment standard could be calculated. EPA also incorporated a method to account for process variability (including variability that may be attributed to sampling and analytical processes). The equation for the variability factor was proposed in the Notice of Availability for the Solvents and Dioxins Rule and promulgated in the November 7, 1986, rule. The equation has also been used to calculate variability factors for the development of numerous rules in the Effluent Guidelines Program under the Clean Water Act. The use of a variability factor was determined not to be a "relaxation" of the requirements in RCRA 3004(m), but rather a function of the normal variability of the treatment processes. A treatment facility would have to be designed to meet the mean achievable treatment performance level rather than the treatment standard to ensure that the performance level remains within the limits of the treatment standard.

To determine BDAT and to calculate the concentration-based standards, EPA used the approach discussed above. All available data were evaluated to determine whether they could be used in the rulemaking for each waste code.

It should be noted that under the Solvents and Dioxins Rule, EPA required the use of the Toxicity Characteristic Leaching Procedure (TCLP) to determine whether a waste requires treatment or whether a treated waste meets the applicable treatment standards. However, in subsequent rulemakings, EPA used a total constituent analysis as the basis for treatment standards if the BDAT was a destruction or removal technology, used TCLP only if the BDAT was an immobilization technology, and used both total constituent and TCLP analysis to measure performance if the BDAT was a recovery technology.

1.4 Data Collection and Evaluation of Post-1990 Treatment Standards

Section 2 is the second edition of the 1987 Generic Quality Assurance Project Plan for the land disposal restrictions program. These are the data requirements for newly listed wastes standards.

Section 3 presents the methodology used to calculate treatment standards for the LDR Program.

2. QUALITY ASSURANCE PROJECT PLAN FOR LAND DISPOSAL RESTRICTIONS PROGRAM

Under the Land Disposal Restrictions Program (LDR), a document entitled *Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT")* was developed and published in March 1987 (EPA/530-SW-87-011). A "Project Plan" describes the QA/QC activities in any single EPA data collection program such as developing LDRs. This document serves as the update to that project plan and provides additional clarification and guidance for collection of treatment test data for the LDR Program by EPA and by others such as industry or research organizations.

2.1 Overview of QA Concepts and Procedures Involved in Generating Data for Land Disposal Restrictions Standards

EPA is soliciting data on treatability of a variety of hazardous wastes as discussed in the May 30, 1991, Federal Register and subsequent notices. Although EPA will examine any waste treatment data submitted, data generated and presented according to the requirements of this Project Plan are less likely to be rejected for use in developing treatment standards because of data quality problems.

Quality assurance/quality control (QA/QC) is the body of administrative and technical procedures used to generate analytical chemical data which both accurately reflect the compositions of the waste streams involved and also include a subset of data verifying the validity of the results plus data characterizing the performance of the treatment system.

QA/QC requirements can be expressed in two different contexts: substantively as those procedures a laboratory must carry out to generate acceptable data or conceptually as data quality indicators (or objectives) which represent important factors to consider in planning for or evaluating data quality. The QA/QC Methodology Background Document (QMBD) discusses

conceptual QA/QC requirements at length: this handbook focuses on substantive QA/QC requirements such as laboratory procedures and documentation requirements.

The major substantive QA/QC requirements for generating data, which must be discussed in test-specific plans and reports, are the following:

Sample Handling

- Documentation of basis for selecting sample point.
- Documentation that SW-846 sample preservation procedures were followed.
- Documentation that chain-of-custody procedures were followed.

Sample Analysis

- Instrument calibration: documentation of instrument calibration procedures.
- Availability of calibration reagents.
- Blanks: results of analysis of field, laboratory, and trip blanks, clearly labeled.
- Matrix spike duplicates: results of matrix spike duplicate analyses performed on one sample from every set of samples from a single sampling point or one of every 20 samples.
- Detection limits: verified detection limits of 1 ppm in treatment residual matrices or documentation of attempts to reach these detection limits.
- Clear designation of analytical results on raw and untreated waste samples, including documentation of quantitative results of all method-specific QC procedures for each sample whose results are reported.

Data Reporting Format

- Documents for reporting results in a standard format: Sampling and Analysis Plan (SAP) and Onsite Engineering Report (OER).

QA/QC requirements for reporting on treatment technology operating conditions are to be developed on a treatment test by treatment test basis and defined in the SAP. The operating conditions and design parameters to report for each treatment process being tested depend on the type of technology and the various engineering refinements exhibited by the system being tested. EPA welcomes opportunities to evaluate draft SAPs or OERs from a commenter wishing to submit treatability data. A potential commenter's concerns about developing the appropriate format for treatment system design and operation data can be readily resolved once the commenter initiates contact with EPA by requesting review at any preliminary level of SAP or OER development.

One element of analytical QA/QC, which has assumed a new role in the post-Thirds BDAT program, is the analytical detection limit. As of the publication of the First Update to the Third Edition of SW-846, the definition of the detection limit in SW-846 is changing from the 1986 Third Edition (Zero Update) definition: this definition is becoming more quantitatively rigorous. Detection limits are important because they are frequently the basis of numerical standards; thus, the definition of the detection limit can profoundly affect the magnitude of the standard.

The 1986 Third Edition (Zero Update) definition in Chapter One, which sets baseline QA/QC requirements for all SW-846 procedures, that is, the method detection limit (MDL) is three times the standard deviation of the average noise level divided by the slope of the calibration line generated with solutions of known quantities of the analyte in question. The 1991 First Update to the Third Edition defines the MDL as the product of the standard deviation (from at least three analyses of a matrix spiked with the analyte of interest at a level believed

to be near the detection level) and the t-statistic (one-sided, 99 percent level of probability, chosen as a function of the number of analyses).

For both the 1986 and the 1991 versions, some of the methods themselves have more rigorous detection limits definitions which are spelled out in the QA/QC heading of the method chapter itself. The First Update changes to the Chapter One global QA/QC requirements for all SW-846 methods do not invalidate any of the method-specific requirements, but rather they make the chapter-specific QA/QC requirements more uniform among each other by bringing them up to a higher degree of rigor.

An acceptable data package will generally consist of two documents: the Sampling and Analysis Plan (SAP) and the Onsite Engineering Report (OER). The exception is the case where the data has already been generated; in this case the organization submitting the data will do well to study the contents of a good SAP as presented in Section 2.2, but their data must be arranged in the OER format presented in Section 2.3.

The SAP describes how the raw and treated waste will be sampled, preserved, shipped, and analyzed. It includes a table assigning a unique code to each sample, duplicate and blank, a description and justification of each sampling point, the preparations, spikes, replicates, and analyses to be performed plus provisions for documenting the chain of custody and for assembling documentation of these sampling and analytical procedures as they are actually performed.

The OER is the summary of these samplings and analyses results and is essentially documentation (both tabular and narrative) of how the activities planned in the SAP were carried out in reality. Listing and discussing deviations from the SAP, which occurred in the course of these activities, is an important part of the OER.

2.1.1 Data Quality Objectives

The overall objective for the BDAT Program's sampling and analysis efforts is to produce well-documented data of known quality that can be used to determine the best demonstrated available technologies for the various listed wastes and to develop BDAT treatment standards for these wastes.

The treatment data, i.e., data resulting from treatment tests, consist of the results of analytical tests results of the composition of the untreated wastes and the treatment residuals. The treatment data, which are the concentrations of hazardous constituents, can then be used to evaluate the performance of the technology on the listed hazardous waste.

The constituents to be quantified in the BDAT Program investigations are presented in Table 2-1. This list is updated periodically as additional information is obtained on the analytical procedures used to measure the hazardous constituents listed in Appendix VIII. The untreated wastes and treatment residual should be screened for most of the BDAT constituents to determine which constituents are present or were formed; which constituents were treated (or formed during treatment); and which constituents should be regulated.

The data quality for analytical measurements of the BDAT list constituents in raw waste and in treated waste residuals are primarily assessed by means of the following indicators: analytical method detection limits, precision, and accuracy; and special QA/QC documentation requirements apply. Each of these indicators is discussed in detail below.

(1) **Detection limits**. Matrix detection limits should be calculated for the untreated wastes and each treatment residual sample, following the procedures given in *Test Methods for Evaluating Solid Waste (SW-846), Third Edition (USEPA 1986)*, where applicable. If samples are diluted, the matrix detection limit should be calculated as the detection limit for the particular matrix times the dilution factor.

Table 2-1 BDAT Constituent List

Constituent	CAS no.	BDAT reference no.
Volatile organics		
Acetone	67-64-1	222
Acetonitrile	75-05-8	1
Acrolein	107-02-8	2
Acrylonitrile	107-13-1	3
Benzene	71-43-2	4
Bromodichloromethane	75-27-4	5
Bromomethane	74-83-9	6
n-Butyl alcohol	71-36-3	223
Carbon tetrachloride	56-23-5	7
Carbon disulfide	75-15-0	8
Chlorobenzene	108-90-7	9
2-Chloro-1,3-butadiene*	126-99-8	10
Chlorodibromomethane	124-48-1	11
Chloroethane	75-00-3	12
2-Chloroethyl vinyl ether	110-75-8	13
Chloroform	67-66-3	14
Chloromethane	74-87-3	15
3-Chloropropene	107-05-1	16
1,2-Dibromo-3-chloropropane	96-12-8	17
1,2-Dibromoethane	106-93-4	18
Dibromomethane	74-95-3	19
*trans-1,4-Dichloro-2-butene	110-57-6	20
Dichlorodifluoromethane	75-71-8	21
1,1-Dichloroethane	75-34-3	22
1,2-Dichloroethane	107-06-2	23
1,1-Dichloroethylene	75-35-4	24
trans-1,2-Dichloroethene	156-60-5	25
1,2-Dichloropropane	78-87-5	26
trans-1,3-Dichloropropene	10061-02-6	27
cis-1,3-Dichloropropene	10061-01-5	28
1,4-Dioxane	123-91-1	29
(Deleted-2-ethoxyethanol)	110-80-5	224
Ethyl acetate	141-78-6	225
Ethyl benzene	100-41-4	226
Ethyl cyanide	107-12-0	30
Ethyl ether	60-29-7	227
Ethyl methacrylate	97-63-2	31
Ethylene oxide	75-21-8	214
Iodomethane	74-88-4	32

Table 2-1 (Continued)

Constituent	CAS no.	BDAT reference no.
Volatile Organics (continued)		
Isobutyl alcohol	78-83-1	33
Methanol*	67-56-1	228
Methyl ethyl ketone	78-93-3	34
Methyl isobutyl ketone	108-10-1	229
Methyl methacrylate	80-62-6	35
Methacrylonitrile	126-98-7	37
Methylene chloride	75-09-2	38
(Deleted-2-Nitropropane)	79-46-9	230
Pyridine	110-86-1	39
1,1,1,2-Tetrachloroethane	630-26-6	40
1,1,2,2-Tetrachloroethane	79-34-6	41
Tetrachloroethene	127-18-4	42
Toluene	108-88-3	43
Tribromomethane (Bromoform)	75-25-2	44
1,1,1-Trichloroethane	71-55-6	45
1,1,2-Trichloroethane	79-00-5	46
Trichloroethene	79-01-6	47
Trichloromonofluoromethane	75-69-4	48
1,2,3-Trichloropropane	96-18-4	49
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	231
Vinyl chloride	75-01-4	50
1,2-Xylene	97-47-6	215
1,3-Xylene	108-38-3	216
1,4-Xylene	106-44-5	217
Semivolatile Organics		
Acenapthalene	208-96-8	51
Acenaphthene	83-32-9	52
Acetophenone	96-86-2	53
Acrylamide*	79-06-1	233
2-Acetylaminofluorene	53-96-3	54
4-Aminobiphenyl	92-67-1	55
Aniline	62-53-3	56
Anthracene	120-12-7	57
Aramite*	140-57-8	58
Benz(a)anthracene	56-55-3	59
Benzal chloride*	98-87-3	218
Benzenethiol*	108-98-5	60

Table 2-1 (Continued)

Constituent	CAS no.	BDAT reference no.
Semivolatile Organics (continued)		
(Deleted-Benzidine)	92-87-5	61
Benzo(a)pyrene	50-32-8	62
Benzo(b)fluoranthene	205-99-2	63
Benzo(ghi)perylene	191-24-2	64
Benzo(k)fluoranthene	207-08-9	65
p-Benzoquinone*	106-51-4	66
Bis(2-chloroethyoxy)methane	111-91-1	67
Bis(2-chloroethyl)ether	111-44-4	68
Bis(2-chloroisopropyl)ether	39638-32-9	69
Bis(2-ethylhexyl)phthalate	117-81-7	70
4-Bromophenyl phenyl ether	101-55-3	71
Butyl benzyl phthalate	85-68-7	72
2-sec-Butyl-4,6-dinitrophenol	88-85-7	73
p-Chloroaniline	106-47-8	74
Chlorobenzilate*	510-15-6	75
p-Chloro-m-cresol	59-50-7	76
2-Chloronapthalene	91-58-7	77
2-Chlorophenol	95-57-8	78
(Deleted-3-chloropropionitrile)	542-76-7	79
Chrysene	218-01-9	80
o-Cresol	95-48-7	81
p-Cresol	106-44-5	82
Cyclohexanone*	108-94-1	232
Dibenz(a,h)anthracene	53-70-3	83
Dibenzo(a,e)pyrene*	192-65-4	84
(Deleted-Dibenzo(a,i)pyrene)	189-55-9	85
m-Dichlorobenzene	541-73-1	86
o-Dichlorobenzene	95-50-1	87
p-Dichlorobenzene	106-46-7	88
3,3'-Dichlorobenzidine*	91-94-1	89
cis-1,4-Dichloro-2-butene*	1476-11-5	234
2,4-Dichlorophenol	120-83-2	90
2,6-Dichlorophenol	87-65-0	91
Diethyl phthalate	84-66-2	92
3,3'-Dimethoxybenzidine*	119-90-4	93
p-Dimethylaminoazobenzene*	60-11-7	94
3,3'-Dimethylbenzidine*	119-93-7	95
2,4-Dimethylphenol	105-67-9	96
Dimethyl phthalate	131-11-3	97

Table 2-1 (Continued)

Constituent	CAS no.	BDAT reference no.
Semivolatile Organics (continued)		
Di-n-butyl phthalate	84-74-2	98
1,4-Dinitrobenzene	100-25-4	99
4,6-Dinitro-o-cresol	534-52-1	100
2,4-Dinitrophenol	51-28-5	101
2,4-Dinitrotoluene	121-14-2	102
2,6-Dinitrotoluene	606-20-2	103
Di-n-octyl phthalate	117-84-0	104
Di-n-propylnitrosamine	621-67-7	105
Diphenylamine	122-39-4	106
Diphenylnitrosamine	86-30-6	219
1,2-Diphenylhydrazine	122-66-7	107
Fluoranthene	206-44-0	108
Fluorene	86-73-7	109
Hexachlorobenzene	118-74-1	110
Hexachlorobutadine	87-68-3	111
Hexachlorocyclopentadiene*	77-47-4	112
Hexachloroethane	67-72-1	113
Hexachlorphene*	70-30-4	114
Hexachloropropene	1888-71-7	115
Indeno(1,2,3-cd)pyrene	193-39-5	116
Isosafrole	120-58-1	117
Methapyrilene	91-80-5	118
3-Methylcholanthrene	56-49-5	119
4,4'-Methylenebis(2-chloroaniline)	101-14-4	120
Methyl methanesulfonate	66-27-3	36
Naphthalene	91-20-3	121
1,4-Naphthoquinone*	130-15-4	122
1-Napthylamine*	134-32-7	123
2-Napthylamine*	91-59-8	124
p-Nitroaniline	100-01-6	125
Nitrobenzene	98-95-3	126
4-Nitrophenol	100-02-7	127
N-Nitrosodi-n-butylamine	924-16-3	128
N-Nitrosodiethylamine	55-18-5	129
*N-Nitrosodimethylamine	62-75-9	130
N-Nitrosomethylethylamine	10595-95-6	131
N-Nitrosomorpholine	59-98-2	132
N-Nitrosopiperidine	100-75-4	133
N-Nitrosopyrrolidine	930-55-2	134

Table 2-1 (Continued)

Constituent	CAS no.	BDAT reference no.
Semivolatile Organics (continued)		
5-Nitro-o-toluidine	99-65-8	135
Pentachlorobenzene	608-93-5	136
Pentachloroethane*	76-01-7	137
Pentachloronitrobenzene	82-68-8	138
Pentachlorophenol	87-86-5	139
Phenacetin	62-44-2	140
Phenanthrene	85-01-8	141
Phenol	108-95-2	142
Phthalic anhydride*	85-44-9	220
(Deleted-2-Picoline)	109-06-8	143
Pronamide	23950-58-5	144
Pyrene	129-00-0	145
Resorcinol*	108-46-3	146
Safrole	94-59-7	147
1,2,4,5-Tetrachlorobenzene	95-94-3	148
2,3,4,6-Tetrachlorophenol	58-90-2	149
1,2,4-Trichlorobenzene	120-82-1	150
2,4,5-Trichlorophenol	95-95-4	151
2,4,6-Trichlorophenol	88-06-2	152
Tris(2,3-dibromopropyl) phosphate*	126-72-7	153
Metals		
Antimony	7440-36-0	154
Arsenic	7440-38-2	155
Barium	7440-39-3	156
Beryllium	7440-41-7	157
Cadmium	7440-43-9	158
Chromium (total)	7440-47-3	159
Chromium (hexavalent)	--	221
Copper	7440-50-8	160
Lead	7439-92-1	161
Mercury	7439-97-6	162
Nickel	7440-02-0	163
Selenium	7782-49-2	164
Silver	7440-22-4	165
Thallium	7440-28-0	166
Vanadium	7440-62-2	167
Zinc	7440-66-6	168

Table 2-1 (Continued)

Constituent	CAS no.	BDAT reference no.
Inorganics Other Than Metals		
Cyanide	57-12-5	169
Fluoride	16964-48-8	170
Sulfide	8496-25-8	171
Organochlorine Pesticides		
Aldrin	309-00-2	172
alpha-BHC	319-84-6	173
beta-BHC	319-85-7	174
delta-BHC	319-86-6	175
gamma-BHC	58-89-9	176
Chlordane	57-74-9	177
p,p'-DDD	72-54-8	178
o,p'-DDD	53-19-0	235
p,p'-DDE	72-55-9	179
o,p'-DDE	3424-82-6	236
p,p'-DDT	50-29-3	180
o,p'-DDT	789-02-6	237
Dieldrin	60-57-1	181
Endosulfan I	939-98-8	182
Endosulfan II	33213-6-5	183
Endosulfan sulfate	1031-07-8	238
Endrin	72-20-8	184
Endrin aldehyde	7421-93-4	185
Heptachlor	76-44-8	186
Heptachlor epoxide	1024-57-3	187
Isodrin	465-73-6	188
Kepone	143-50-0	189
Methoxychlor	72-43-5	190
Toxaphene	8001-35-2	191
Phenoxyacetic Acid Herbicides		
2,4-Dichlorophenoxyacetic acid	94-75-7	192
Silvex	93-72-1	193
2,4,5-Trichlorophenoxyacetic acid	93-76-5	194

Table 2-1 (Continued)

Constituent	CAS no.	BDAT reference no.
Organophosphorous Insecticides		
Disulfton	298-04-4	195
Famphur	52-85-7	196
Methyl parathion	298-00-0	197
Parathion	56-38-2	198
Phorate	298-02-2	199
PCBs		
Aroclor 1016	12674-11-2	200
Aroclor 1221	11104-28-2	201
Aroclor 1232	11141-16-5	202
Aroclor 1242	53469-21-9	203
Aroclor 1248	12672-29-6	204
Aroclor 1254	11097-69-1	205
Aroclor 1260	11096-82-5	206
Dioxins and Furans		
Hexachlorodibenzo-p-dioxins	--	207
Hexachlorodibenzofurans	--	208
Pentachlorodibenzo-p-dioxins	--	209
Pentachlorodibenzofurans	--	210
Tetrachlorodibenzo-p-dioxins	--	211
Tetrachlorodibenzofurans	--	212
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	213

*Because of the analytical problems associated with these constituents, their analysis should be undertaken only if they are suspected to be present in the matrix of interest. For EPA projects, approval for analyzing the specific constituents should be obtained from the EPA Project Manager and the designated QA Officer.

For the constituents of interest, the detection limit should be at a maximum 1 ppm in the matrix to be analyzed. For multicomponent target analysis such as PCDDs and PCDFs, the detection limit should be reported in terms of a single isomer. The laboratory should try to achieve the lowest detection limit possible for all constituents of interest. Figure 2-1 provides a decision tree diagram of the steps that the laboratory must take if a 1-ppm or lower detection limit cannot be achieved for all constituents.

For EPA tests, if a detection limit of 1 ppm or lower cannot be obtained based on the amount of sample that will be used for sample extraction, digestion, or other sample preparation step, the laboratory is to stop work and immediately contact the Contractor Project Manager or his/her designee. At this time, the laboratory should make recommendations on how to proceed with the analysis, including recommendations on any additional cleanup methods that could be used to eliminate the interference or matrix problems that are preventing the laboratory from achieving this data quality objective. The Contractor Project Manager must then immediately notify the EPA Project Manager or his/her designee of the problem. The EPA Project Manager will then evaluate the recommendations and determine whether (1) the laboratory should proceed even though a 1-ppm or lower detection limit cannot be achieved; (2) the laboratory should implement the additional cleanup techniques to achieve better detection limits; or (3) the work should be discontinued since the expected detection limits are not adequate to evaluate treatment performance. Note, the laboratory must obtain approval for exceeding the 1-ppm detection limit requirement if it has determined by a review of historical data or by a screening technique that to achieve better analytical results, the amount of sample to be extracted or digested should be reduced from the sample quantity recommended for samples with low constituent concentrations.

If sufficient sample is extracted or digested such that a detection limit of 1 ppm or lower is expected to be achieved for the constituents of interest in the sample, but some constituents are present at concentrations greater than the linear range of the calibration curve, then the laboratory is authorized to quantify the diluted sample results following each method's procedures without first notifying the Contractor Project Manager that a 1-ppm detection limit

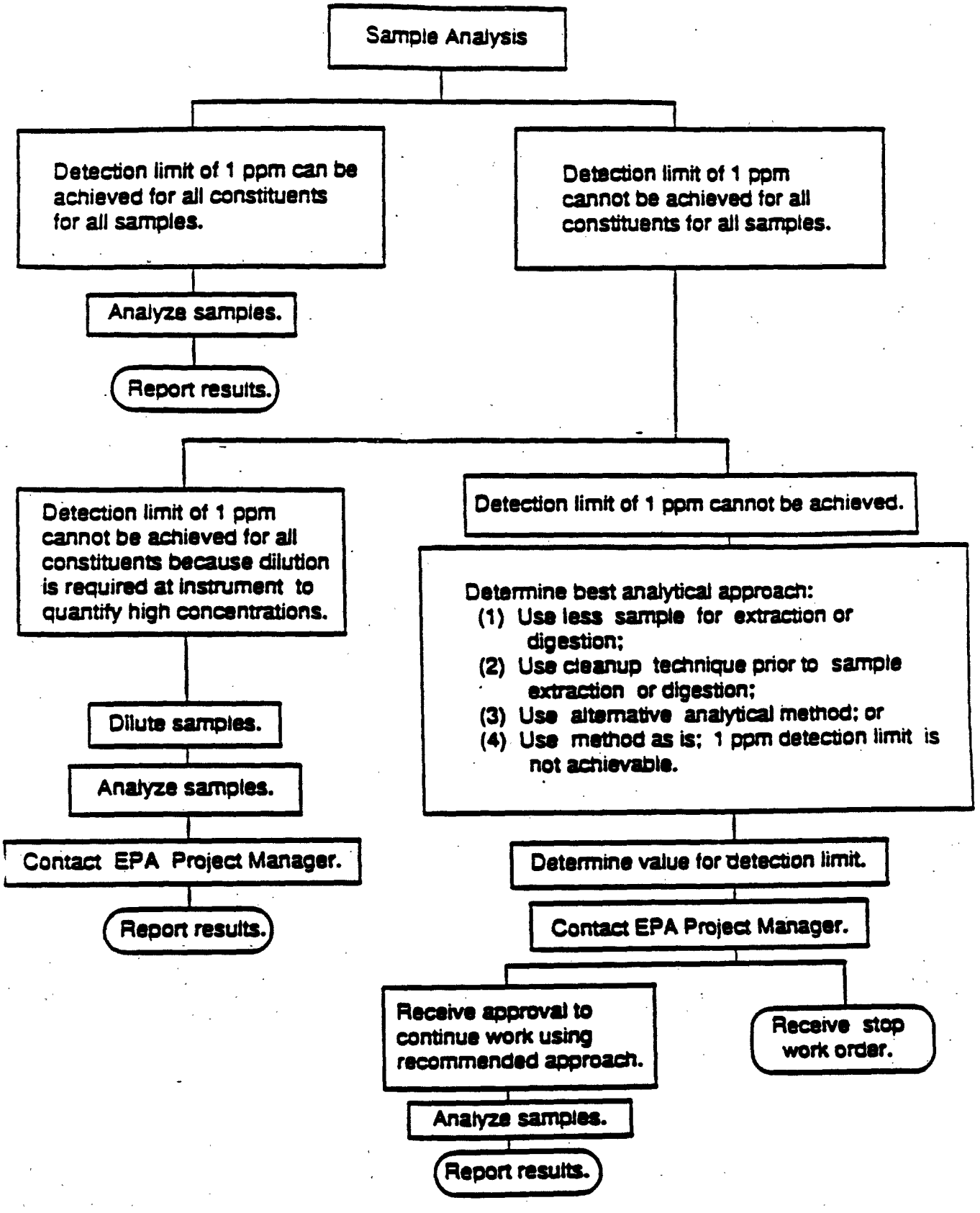

Figure 2-1. Decision Tree Diagram for Achieving Detection Limit

may not be achieved for all constituents in that sample. The laboratory, however, must then notify the Contractor Project Manager and EPA Project Manager that the concentration levels of some constituents were high, impacting the detection limits of other constituents. The laboratory should make recommendations on additional sample cleanup techniques that may be used to achieve better detection limits for these other constituents.

The matrix detection limit is to be calculated following the procedures given in each analytical method. The method detection limit should be calculated following the procedures given in the revised Section 1 of SW-846. The method detection limit is calculated using the following equation:

$$\text{Method Detection Limit} = 6.9s$$

where s = the standard deviation calculated from three replicates.

(2) **Precision and accuracy**. Precision is defined in terms of the relative percent difference of the matrix spike and the matrix spike duplicate, where applicable. The site-specific SAP for each treatment test should specify the samples designated for this analysis.

Precision will be calculated using the following equation for relative percent difference:

$$RPD\ (\%) = \frac{(C_1 - C_2) \times 100}{[(C_1 + C_2)/2]}$$

where:

RPD = relative percent difference,
C_1 = the larger of the two values for matrix spike duplicates or laboratory duplicates, and
C_2 = The smaller of the two values for matrix spike duplicates or laboratory duplicates.

Although EPA is not yet specifying acceptable limits for precision, a RPD result should be reported in the data packages received from the laboratory and in the ensuing OERs.

Percent recovery of laboratory matrix spikes is the quantitative measure of accuracy. For the treatment test analysis, a matrix spike and a matrix spike duplicate will be completed, at a minimum, on one sample of each type of treatment residual.

The spike constituents should be determined on a site-specific basis for each sampling activity and should be presented in the SAP together with the code numbers for each sample to be taken. Spiking should be completed at the laboratory prior to extraction or digestion of the sample. (If less than 1 liter of sample is required for the matrix spike and matrix spike duplicate, then one sample container will be filled in the field, and the laboratory will take the sample aliquots for the matrix spike and the matrix spike duplicate from the same container. If more than 1 liter of sample is required, then multiple sample containers are required and the matrix spike and matrix spike duplicate will be taken from different containers.) The spike concentration levels should be within five times the initial concentration level prior to spiking or at five times the expected matrix detection limit for constituents expected to be at the nondetect level. If the sample was not spiked within these ranges, the impact on the quality of the data should be assessed, and the EPA Project Manager should be notified. If necessary, the samples may be respiked and reanalyzed.

When the March 1987 generic quality assurance project plan was published, no limits for accuracy were specified. Subsequently, it was determined that the recoveries for the matrix spike and matrix spike duplicate should be between 20 and 200 percent. If recoveries are less than 20 percent, the EPA Project Manager must be notified. The EPA Project Manager will determine whether any additional work is required to achieve spike recoveries of at least 20 percent. If recoveries are greater than 200 percent, the data must be flagged; review on a case-by-case basis will determine whether the results are usable.

The following equation should be used to calculate recoveries:

$$\textit{Percent Recovery } (\%) = \frac{(C_i - C_o)}{C_t} \times 100$$

where:

C_i = concentration of spiked aliquot,
C_o = concentration of unspiked aliquot, and
C_t = concentration of spike added.

(3) Completeness. Completeness is defined as the number of activities initiated that are actually finished. For this project, the first activity is acquiring the samples; the final activity is reporting the analytical data. The degree of completeness is the number of samples for which acceptable analytical data are generated divided by the total number of samples collected times 100. The QA objective for completeness in the contaminated soil and debris (CSD) sampling and analysis efforts is 100 percent. If the completeness is less than 100 percent, documentation must be provided to explain why the QA objective was not met in terms of sample handling, analysis, and documentation and to describe the impact on the project of these failures to achieve 100 percent completeness.

(4) Representativeness. For this project, representativeness is addressed through selection of appropriate sampling locations and procedures. For the treatment tests, the goal is to obtain samples representative of the untreated matrix and treatment residuals such that the performance of the treatment could be evaluated. One way this can be accomplished is by obtaining matched in and out sample pairs (or sets) of the untreated matrix and treatment residuals. (Note, residence times must be taken into account.)

(5) Comparability. For this project, comparability for each treatment test will be addressed through use of the same analytical procedures to analyze the samples. The analytical data should be reported in the same units for each test.

2.1.2 Project Organization

The EPA Program Manager will have the overall quality assurance (QA) responsibility for all sampling and analysis data collected for the BDAT program. All SAPs must be approved by the EPA Program QA Coordinator or his/her designees. Figure 2-2 presents a general organization chart. A test-specific organization chart should be prepared for each SAP. Responsibilities of the various positions are described below.

EPA Project Manager:	Overall responsibility for all sampling and analysis data and for ensuring data compliance with the program's data quality objective.
EPA QA Officer:	Responsible for ensuring data compliance with the program's data quality objectives; approving site-specific SAPs and OERs, and conducting audits, if necessary.
Contractor Program Manager:	Responsible for all work performed by the contractor.
Contractor Project Manager:	Responsible for budgets and scheduling; project technical oversight and coordination; and project staff (principal engineers, sampling staff, and laboratory staff).
Contractor QA Officer:	Responsible for ensuring that the sampling and analysis data meet the project's data quality objectives and reviewing all data management activities.
Principal Engineer:	Responsible for obtaining background information on the waste to be treated and on the applicable treatment technologies; scheduling the treatment tests; and preparing the site-specific SAPs and OERs.

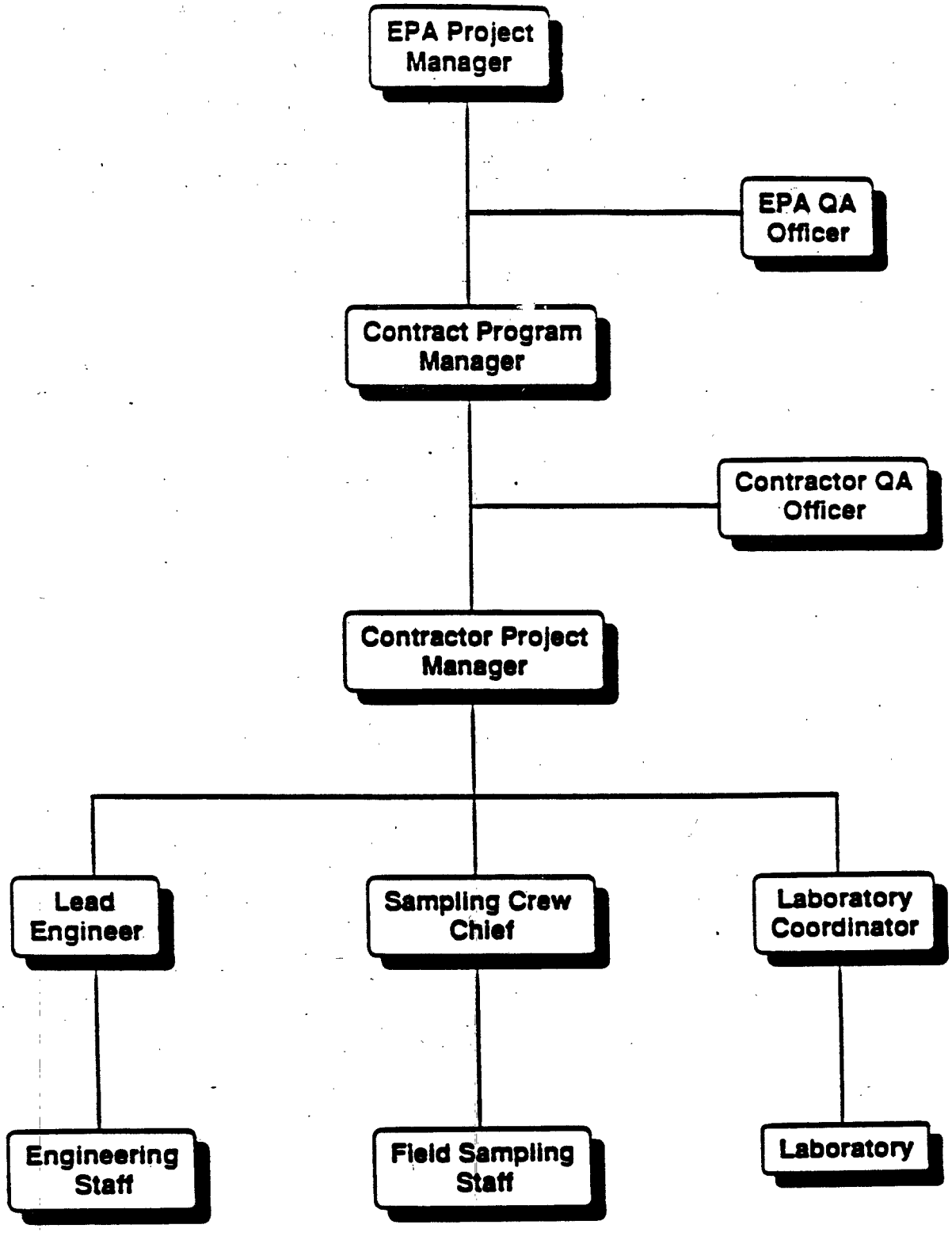

Figure 2-2. Project Organization

Sampling Crew Chief:	Responsible for ensuring that all samples and data required by the site-specific SAP are collected in accordance with the project's QAPjP; ensuring that the field staff members have adequate training; and ensuring onsite compliance with the appropriate health and safety requirements.
Laboratory Coordinator:	Responsible for scheduling the analytical work and ensuring compliance with the analytical requirements of the QAPjP and SAP.

2.1.3 Collection Plan for Field Samples and Design and Operating Parameters

To determine the quality of data with respect to the characterization of the waste being treated and the treated residual, the site-specific sampling and analysis plan must contain the following information. Note, these bulleted items are appropriate section heading.

- Sampling point descriptions. Describe the sampling points and provide the justification for their selection. All sampling points must be identified on the schematic diagram for the waste treatment system.

- Sample collection method. All samples should be collected as grab samples. Sample collection procedures must be described for each sample location.

- Sampling scheduling. Frequency of sample collection will vary depending on the treatment system. The frequency of sample collection at each sampling location must be specified in the SAP and should be selected to best characterize the variability in (1) the waste stream, (2) the treatment process, and (3) the analytical results.

- Constituents to be analyzed. For all sampling points, specify which of the compounds shown in Table 2-1 (BDAT Constituents List) will be analyzed. All analyses should be performed using SW-846 (Third Edition). Deviations from this list of compounds should be justified. (For example, if one sample of the untreated waste is analyzed and the data show that particular compounds are not present, then further analysis of these compounds may not be required for the other samples from the plant.) Table 2-2 provides an example table that can be used to summarize planned analysis and quality control samples.

Table 2-2 Example Summary of Planned Analyses and Quality Control Samples

Analytical procedure	Number of samples collected		
	Characterization sample	Untreated waste	Treatment residual
Semivolatiles			
Primary samples	1	6	6
Matrix spikes[a]	1	1	1
Matrix spike duplicates[a]	0	1	1
Field sampling blank	1	0	1
Equipment blank	0	0	1
Metals			
Primary samples	1	6	6
Matrix spikes[a]	1	1	1
Matrix spike duplicates[a]	0	1	1
Field sampling blank	1	1	1
Equipment blank	1	1	1

[a]Analyses of the matrix spike and matrix spike duplicate samples are to be completed for the third set of matched samples collected for the untreated soil and the treatment residuals. Note, sufficient sample aliquot amounts must be collected for this set of samples to complete these analyses.

- Total composition and TCLP extracts. For the treated residuals, analysis will be completed on both the total composition sample for organics and inorganics and the TCLP extracts for inorganics only. For all other samples collected, analysis will be completed only for total composition. (It should be noted that in the March 1987 generic quality assurance project plan, TCLP analysis was required for both organic and inorganic constituents in the treated residuals since at the time it was not determined whether the treatment standards were to be developed using total composition or TCLP data. Subsequently, EPA decided to use total composition data to develop the treatment standards for organics.)

- Sample containerization and preservation. Procedures for sample containerization and preservation presented in SW-846 (Third Edition, Table 2-16) should be followed The specific types of containers and the required sample preservation should be specified in the SAP. All sampling vessels and containers will be cleaned prior to the sample collection. The procedures used should be specified in the site-specific SAP. Table 2-3 provides examples of sample containers, sizes, holding times, and preservation requirements.

- Design and operating data collection. To evaluate the treatment design and operation, the SAP must contain (1) all design and operating data to be collected, the method of collecting these data, and the reason for collecting these data; (2) the specific frequency for collecting the operating data; and (3) identified locations for collecting operating data on the treatment system schematic.

Sampling procedures, locations, and frequencies must be documented in the site-specific SAP. Sampling times for the untreated and treated samples must take into account the residence time of the treatment system. The untreated and treated samples should be corresponding matched pairs so that waste characteristics can be evaluated. Any deviations from obtaining matched pairs must be documented in the SAP and approved by the EPA Project Manager. If possible, six sets of untreated and treated samples should be collected. However, the final selection of the number of sampling sets needed to evaluate the treatment system must be approved by the EPA Project Manager and presented in the treatment test SAP.

Table 2-3 Example of Sample Containers, Sizes, Holding Times, and Preservation Requirements

Parameter	Container	Sample size	Holding time	Preservation[a]
Wastewaters				
Total metals	P,G	1 one-liter jar	6 months (except mercury at 28 days)	pH <2 with HNO_3
TCLP (metals only)[b]	P,G	1 one-liter jar	6 months (except mercury at 28 days)	Cool ≤4°C
pH	-	-	Immediately	-
Chloride) Sulfate) Total solids)	P,G	1 500-ml jar	28 days 28 days 7 days	Cool ≤4°C
Total organic carbons	G	2 40-ml VOA vials	28 days	pH <2 with H_2SO_4, cool ≤4°C
Volatile organics	G	2 40-ml VOA vials	14 day	Cool ≤4°C
Semivolatile organics[c]	G	2 one-liter jars	7 days to extraction 40 days to analysis	Cool ≤4°C
Dioxins and furans[c]	G	2 one-liter jars	30 days to extraction 45 days to analysis from collection	Cool ≤4°C
Solids				
Total metals) TCLP (metals only)[b])	P,G	1 500-ml wide-mouth jar	6 months (except mercury at 28 days 6 months to TCLP extraction, 6 months to analysis (except mercury at 28 days and 28 days, respectively)	Cool ≤4°C
Chloride) Sulfate) Total organic carbon)	G	1 250-ml jar	28 days	Cool ≤4°C
Volatile organics	G	1 120-ml jar	14 days	Cool ≤4°C
Semivolatile organics[c]	G	1 250-ml jar	14 days to extraction 40 days to analysis	Cool ≤4°C
Dioxins and furans[c]	G	1 120-ml jar	30 days to extraction, 45 days to analysis from collection	Cool ≤4°C

Table 2-3 (Continued)

Parameter	Container	Sample size	Holding time	Preservation[a]
Sludges				
Total metals) TCLP (metals only)[b])	P,G	2 one-liter wide-mouth jars	6 months (except mercury at 28 days)	Cool ≤4°C
Chloride)	G	1 500-ml wide-mouth jar	28 days	Cool ≤4°C
Sulfate)			28 days	
Total organic carbon)			28 days	
Total solids)			7 days	
Volatile organics	G	2 40-ml VOA vials	14 days	Cool ≤4°C
Semivolatile organics[b]	G	2 one-liter wide-mouth jars	14 days to extraction, 40 days to analysis	Cool ≤4°C
Dioxins and furans[c]	G	2 one-liter wide-mouth jars	30 days to extraction 45 days to analysis from collection	Cool ≤4°C

Footnotes:

P - Plastic
G - Glass

[a]Field samples will be packed on ice for shipment. Upon receipt at the laboratory, the samples will be stored at ≤4°C.

[b]If TCLP extracts are to be analyzed for organics, holding times are as follows: volatiles, 14 days to TCLP extraction and 14 days to analysis (28 days total); semivolatiles, 7 days to TCLP extraction, 7 days to preparative extraction, and 40 days to analysis (54 days total).

[c]For samples requiring QA analyses (MS and MSD), collect twice the amount.

Note: Sample containers must be filled to ensure that adequate sample is available for analysis.

2.1.4 Sample Custody and Transport

Field chain of custody must be maintained for all samples collected for the LDR Program. Documentation of all field activities is required to provide backup for any deviations from the SAP. All samples collected should be labeled and identified using a multi-part label; an example of a three-part label is shown in Figure 2-3. The labels have a preprinted number that becomes the field sample number. One portion will be completed and affixed to the sample bottle; another portion will be entered into the field notebook with pertinent information entered alongside the label. At a minimum, all replicate volumes for a particular sample/parameter should have the same field sample number assigned to them.

Sample custody seals (see Figure 2-4) will be placed around all shipping container lids to detect unauthorized tampering with samples following collection and prior to the time of analysis. (This includes any untreated waste or treatment residuals that are being shipped for the purpose of being used in a treatment test.) The seal must be attached in such a way that it is necessary to break it in order to open the container. Seals must be affixed at the time of packaging by the sampling crew chief or his/her designee. The seal should include the signature of the sampling crew chief and the date.

Sample custody will begin at the time of sample collection by placing the sample in an ice chest, or other appropriate container, in the possession of the sampling crew chief or his/her designee. The chain of custody record form (see Figure 2-5) should be filled out immediately and signed by the sampling crew chief or his/her designee. The chain of custody record must be filled out completely and accurately since this form provides documentation for what was collected in the field and the analysis to be completed in the laboratory. The chain of custody record form should include the following information:

- Project name/code;
- Site/facility name;

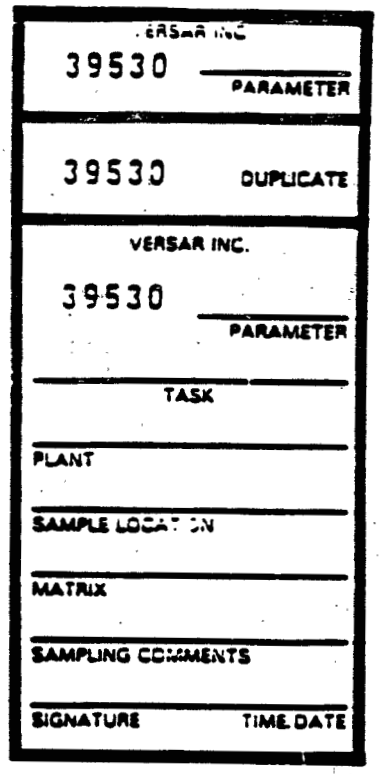

Figure 2-3. Example of Three-Part Label

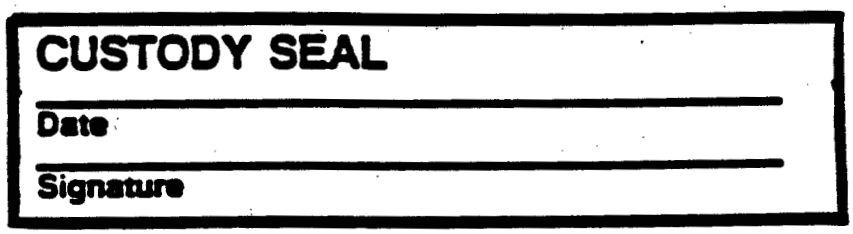

Figure 2-4. Example of Custody Seal

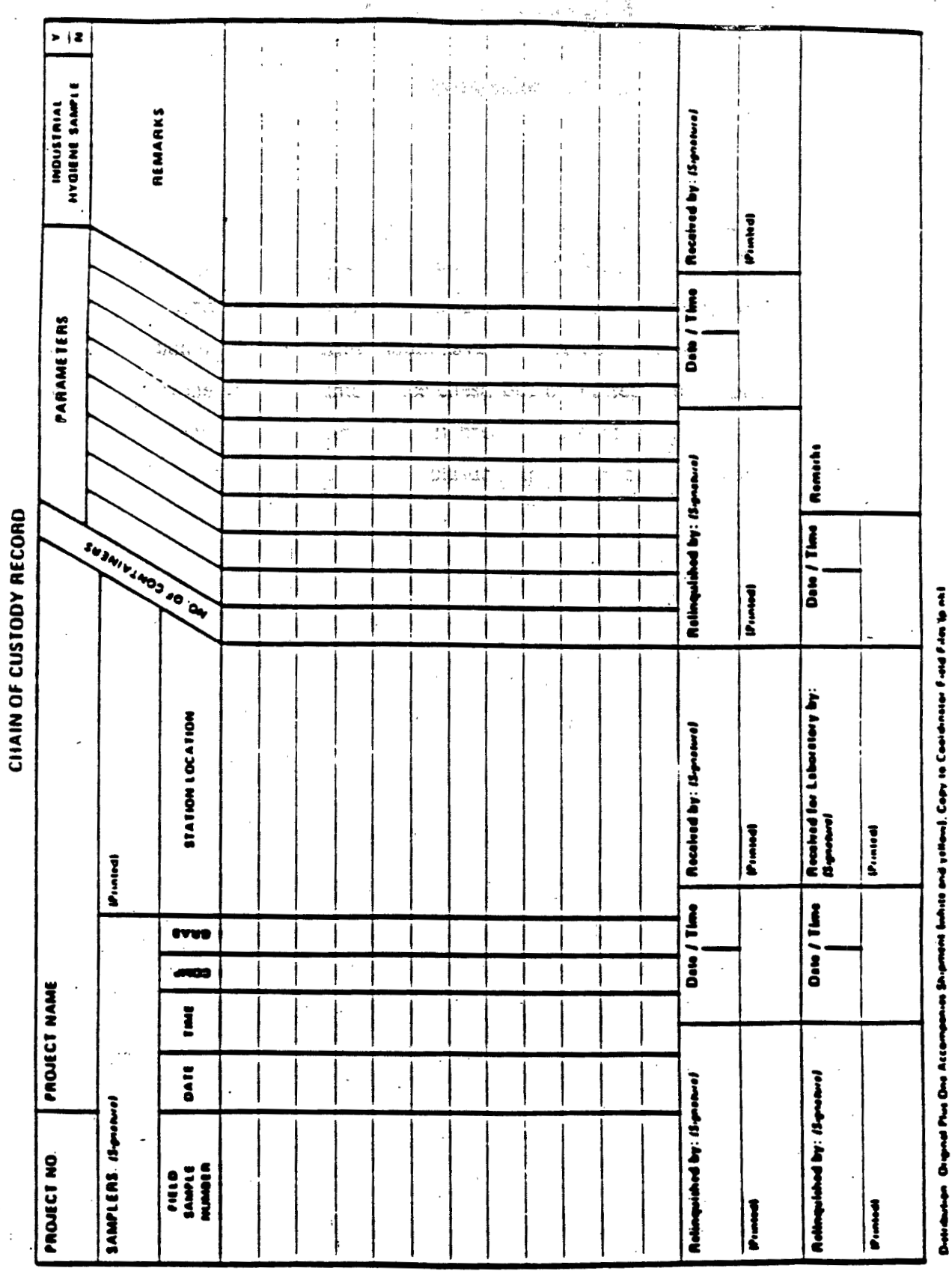

Figure 2-5. Example of Chain-of-Custody Record

- Sample location;
- Sample type or matrix;
- Sample date and time;
- Signature of sampling crew chief or his/her designee; and
- Analysis required.

Any additional pertinent remarks concerning the samples, e.g., sample preservative used, should also be included.

Upon completion of the form, the sampling crew chief or his/her designee will sign, date, enter the time, and confirm completeness of all descriptive information contained on the chain of custody record. Each individual who subsequently assumes responsibility for the sample will sign the chain of custody record and indicate the reason for assuming custody. The field chain of custody record will terminate upon laboratory receipt of samples. The field sample custodian should retain a copy of the chain of custody record for the program files.

Samples must be packaged and labeled for shipment in compliance with current U.S. Department of Transportation (DOT) and International Air Transport Association (IATA) dangerous goods regulations. Any additional requirements stipulated by the overnight carrier must be followed. The packaging and labeling requirements should be documented in the site-specific SAP. In addition to the complete mailing address, each ice chest must be clearly marked with "this end up" arrows on all four sides, a label on each side of the container indicating the proper shipping description of the samples, and the originator's address.

A metal or plastic ice chest should be used as the outside shipping container for hazardous waste samples, unless otherwise specified by the shipping regulations. The outside container must be able to withstand a 4-foot drop on solid concrete in the position most likely to cause damage. Each ice chest should be lined with two 6-mil thick plastic bags. Styrofoam

or bubble wrap will be used to absorb shock. When sample containers are placed in an ice chest for shipment, all samples from a single sampling location (except for replicate field samples, if collected) will be kept together as a set, unless the SAP specifies otherwise. Replicate samples will be packaged and shipped in a separate ice chest. Since the replicate sample containers are collected only to ensure that a sufficient sample quantity is available should a problem occur during sample transport, the chain of custody forms should have these samples marked as "hold for analysis." When more than one set can fit into an ice chest, one of the sets will be placed in a separate plastic bag to prevent cross-contamination if breakage should occur. Volatile Organic Analysis (VOA) vials will be packaged inside a plastic "ziplock" bag. Styrofoam or bubble wrap can be used to prevent bottle breakage. The outside of the VOA package will be labeled with the appropriate sample identification number. VOA vials should be shipped with appropriate sample sets from a given sample location.

After sample containers are sufficiently packaged, the 6-mil thick plastic bags should be sealed around the samples by twisting the top and securely taping the bag closed to prevent leakage. The custody seal will be placed around the neck of the bag. When preservation requirements dictate, ice will be placed between the inner and outer plastic bags, with the latter taped shut.

Chain of custody records and any other shipping/sample documentation accompanying the shipment will be enclosed in a waterproof plastic bag and taped to the underside of the ice chest lid.

Each ice chest prepared for shipment will be securely taped shut. Custody seals will be affixed across the joint between the top and bottom (both in front and in back) of each ice chest prepared for shipment.

The actual transportation mode should be selected based on holding times for individual analytes. All samples should be either delivered by the sampling crew or shipped via a commercial overnight carrier.

Upon receipt of the samples in the laboratory, the ice chests will be checked for intact custody seals. The samples will then be unpackaged, and the information on the accompanying chain of custody records examined. If the samples shipped match those described on the chain of custody record, the laboratory sample custodian will sign the form and assume responsibility for the samples. If problems are noted with the sample shipment, the laboratory custodian will sign the form and record problems in the "Remarks" box. The appropriate Project Manager (for EPA projects, the contractor and EPA Project Manager) should be notified of any problems.

All samples will then be logged into a sample logbook and/or computerized information system. The following information will be documented:

- Date and time of sample receipt;
- Project number;
- Field sample number;
- Laboratory sample number (assigned during log-in procedure);
- Sample matrix;
- Sample parameters;
- Storage location; and
- Log-in person's initials.

All information relevant to the samples will be secured at the end of each business day. All samples will be stored in a designated sample storage refrigerator, access to which will be limited to laboratory employees.

2.1.5 Selection of Analytical Methods

Analytical methods will be selected, whenever possible, from EPA/OSW-approved methods, most of which appear in *Test Methods for Evaluating Solid Waste* (SW-846), Third Edition (USEPA 1986). Exceptions to the requirement will be allowed for cases in which the EPA/OSW-approved methods are not appropriate for the preparation or analysis of a specific sample matrix or are not available for a particular constituent or other parameter of interest.

References to be used for selecting alternatives to the approved methods include the following:

1. *Methods for the Chemical Analysis of Water and Wastes* (MCAWW), EPA 600/4-79-020 (USEPA 1983);

2. Other available EPA methods, e.g., methods described in the Statement of Work (SOW) for EPA's Contract Laboratory Program (CLP);

3. *Standard Methods for the Examination of Water and Wastewater* (SM), 16th Edition (American Public Health Association, American Water Works Association, and Water Pollution Control Federation 1985); and

4. Methods published annually by the American Society of Testing and Materials (ASTM).

If appropriate methods to analyze specific waste matrices or to analyze specific other parameters for waste characterization are not available in the aforementioned references, then a literature search may be completed to obtain an appropriate method to complete the analysis.

All SAPs should specify the exact analytical methods to be used for the samples collected during the treatment test. Since the SAPs are site-specific, they should include any cleanup or preparation steps that may be required to analyze the samples. Table 2-4 presents recommended SW-846 methods and other methods that may be used to analyze BDAT constituents and waste characteristics affecting performance.

Table 2-4 Recommended Analytical Methods

Parameter	Preparation method[a]	Analysis method[a]
Solids		
BDAT list constituents:		
Volatile organics	5030	8240
Methanol	5040	8015
Semivolatile organics	3540/3550	8270
TCLP for organics	1311 followed by methods for organics in wastewaters	Follow methods for organics in wastewaters
Metals, total		
ICP metals	3050	6010
Arsenic	3050	7060
Chromium (hexavalent)	TCLP-51 FR 40643	7197
Lead	3050	7421
Mercury		7471
Selenium	3050	7740
Thallium	3050	7841
Metals, TCLP	1311 followed by:	
ICP metals	3010	6010
Arsenic		7060
Chromium (hexavalent)		7197
Lead	3020	7421
Mercury		7470
Selenium		7740
Thallium	3020	7841
Cyanides		9012
Fluorides		MCAWW 340.2
Sulfides		9030
Organochlorine pesticides		8080
Phenoxyacetic acid herbicides		8150

Table 2-4 (continued)

Parameter	Preparation method[a]	Analysis method[a]
Organophosphorous insecticides		8140
PCBs		8080
Dioxins and furans		8280
Other parameters:		
Ash content		ASTM D3174
Ash fusibility		ASTM E953
Chloride		9250
Corrosivity		1110
Heating value		ASTM D2015
Moisture content		ASTM D2216
Oil and grease		9071
pH		9045
Sulfate		9036
Sulfur content		ASTM D4239
Total halogens		ASTM D808
Total organic carbon (TOC)		Lloyd Kahn
Total organic halides		9020
Wastewaters		
BDAT list parameters:		
Volatile organics		8240
Semivolatile organics	3510/3520	8270
Metals		
ICP metals	3010	6010
Arsenic		7060
Chromium (hexavalent)		7197
Lead	3020	7421
Mercury		7471
Selenium		7740
Thallium	3020	7841
Cyanides		9012
Fluorides		MCAWW 340.2
Sulfides		9030
Organochlorine pesticides		8080

Table 2-4 (continued)

Parameter	Preparation method[a]	Analysis method[a]
Phenoxyacetic acid herbicides		8150
Organophosphorous insecticides		8140
PCBs		8080
Dioxins and furans		8280
Other parameters		
Acidity		MCAWW 305.1
Alkalinity		MCAWW 310.1
Bromide		MCAWW 320.1
Chemical oxygen demand (COD)		MCAWW 410.1-.4
Chloride		9250-52
Color		MCAWW 110.1-.3
Conductance		MCAWW 120.1
Corrosivity		1110
Hardness, total		MCAWW 130.1-.2
Heat value		ASTM E711
Iodide		MCAWW 345.1
Nitrogen		
Ammonia		MCAWW 350.1-.3
Kjeldahl, total		MCAWW 351.1-.4
Nitrate		MCAWW 352.1
Nitrate-nitrite		MCAWW 353.1-.3
Nitrite		MCAWW 354.1]
Oil and grease		9070
pH		MCAWW 365.1-.4
Solids		
Filterable, gravimetric		MCAWW 160.1
Nonfilterable, gravimetric		MCAWW 160.2
Total, gravimetric		MCAWW 160.3
Volatile gravimetric		MCAWW 160.4
Settleable matter		MCAWW 160.5
Sulfate		9035/9036/9038
Total organic carbon (TOC)		9060
Total organic halides (TOX)		9020/9022
Viscosity		ASTM D445

[a]All methods are SW-846 methods unless otherwise specified.

Whether an EPA-approved or other method is used for the constituent parameter of interest, the laboratory must provide documentation concerning the methods used and any modifications or deviations required to analyze the various samples. If feasible, the laboratory should obtain approval from the EPA Project Manager or his/her designee for method modifications or deviations prior to implementation. This information must be included in the OER completed for the treatment test.

2.1.6 Quality Assurance/Quality Control Procedures

The overall effectiveness of a quality control program depends on operating in the field and laboratory in accordance with a program that systematically ensures the precision and accuracy of analyses by detecting errors and preventing their recurrence or measuring the degree of error inherent in the methods applied.

Most of the analytical methods to be used give guidelines for number and frequency of replicates, matrix spikes, and calibration standards. The matrix spikes, replicates, calibration standards, etc., are analyzed in the same way as the field samples and are interspersed with the field samples. The analytical results are used to document the validity and control of data.

- Spikes: A matrix spike and matrix spike duplicate analysis should be performed on at least one sample of each treatment residual taken during a treatment test. The SAPs should specify which samples are to be spiked and identify the spiking components. Samples should be spiked with constituents of interest expected to be present in the waste. The matrix spike and matrix spike duplicate should meet the requirements for precision and accuracy as specified in Section 2.1.1.

- Laboratory duplicate analysis: One laboratory duplicate analysis of the spiked sample extract should be performed for each group of the treated residual samples taken from the same sampling point. The laboratory duplicate analysis should also be completed on the TCLP extract. Analytical results of the duplicate injection must be within ±20 percent of each other for values greater than 200 ppb. For values less than or equal to 200 ppb, analytical results for the duplicate injection should be within ±100 percent of each other. (The precision results of the matrix spike and matrix spike duplicate can be substituted for the laboratory duplicate analysis.) If

these criteria are not met, the data should be flagged and reviewed on a case-by-case basis to determine usability.

- **Surrogates:** For GC/MS and GC methods, surrogates (i.e., chemically inert compounds not expected to occur in an environmental sample) will be spiked into each sample to provide matrix recovery values. Surrogates should be used if specified in the analytical method. (Because of limited experience in analyzing each of the waste matrices, precision and accuracy requirements are not being specified.)

- **Calibration standards:** Calibration standards will be prepared in accordance with the specifications provided in the methods. Calibration standards will be analyzed at a frequency specified in the methods. Reagent grade compounds that conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society should be used if possible.

- **QC check standards:** For the metal analytes, a QC check standard will be analyzed with each batch of samples. This standard is prepared by spiking laboratory pure water with a stock solution of the analyte that was obtained from a source independent of the source used to obtain standards for the calibration curve.

- **Calibration check samples:** For GC/MS analysis, calibration check samples should be prepared and analyzed as specified in the appropriate methods.

- **Method blank:** A minimum of one method blank will be prepared per set of samples of similar matrix collected during the same sampling episode or a set of 20 samples of similar matrix, whichever is smaller. In cases where the concentration detected in any of the compounds detected in the blank is 10 percent or greater than the concentration detected in any of the samples in the batch, the laboratory must take corrective actions, as specified in Section 2.1.8.

- **Internal standards:** Internal standards should be used where feasible to monitor for the consistency of GC/MS response factors and relative response times. The internal standards projected to be used are specified in the methods, e.g., SW-846 Methods 8240 and 8270. If the internal standards are not specified in the analytical method, they should be specified in the site-specific SAP.

- **System performance check compounds:** For GC/MS analysis, system performance check samples should be prepared and analyzed as specified in the appropriate methods (e.g., SW-846 Methods 8240 and 8270).

- **Laboratory pure water:** Laboratory water should be prepared by particulate filtration, carbon filtration, reverse osmosis, and deionization, or by an equivalent procedure.

Quality control checks to be taken during field activities will include calibration of any field monitoring equipment as well as collection of the blanks discussed below.

- One trip blank that is not opened in the field should be collected to check for sample contamination originating from sample transport, shipping, or site conditions. The parameters for analysis should be specified in the SAP.

- Equipment blanks should be taken as needed. Collection and frequency must be specified in the SAP. To prepare an equipment blank, laboratory pure water or solvents are brought to the field in a sealed container and then opened in the field. The contents are poured over or through the sample collection device and then collected in the sample container. The parameters for analysis will be specified in the SAP. If contamination in the equipment blank is detected, the effect of the contamination on the samples collected should be presented in the OER for the treatment system.

- If samples are to be collected for analysis of volatile organic compounds, a volatile organic blank should be collected once a day. This blank consists of laboratory pure water taken to the field and poured into a sample container in the area where the treatment system is located. The volatile organic blank should be analyzed for the volatile compounds specified in the SAP. If volatile organic compounds are measured in this blank, the effect of the contamination on the samples collected should be presented in the OER for the treatment system.

2.1.7 Quality Assurance Performance and System Audits

Field activities of each contractor should be audited at least once by a representative designated by EPA to ensure that required equipment and procedures for sample collection, preservation, shipping, handling, laboratory, and documentation were used. In lieu of a third party auditor, the field activities could be evaluated by the EPA Project Manager.

For most treatment test studies (and on at least one conducted by each contractor) for the scheduled Thirds waste codes, the EPA Project Manager was present. He could observe that the procedures for sample collection, preservation, shipping, handling, and documentation (e.g., field notebooks and chain of custody) were performed in accordance with the site-specific

sampling and analysis plans. Performance samples for organics and/or metals were completed by the laboratory quarterly. The results of the performance samples indicated that the laboratory could complete the analysis for the BDAT constituents satisfactorily. A formal system audit of the laboratory was not conducted; however, the laboratory was audited for other EPA projects during the period that samples were analyzed for the various treatment tests.

2.1.8 Corrective Actions

Data generated as part of the analytical quality control program were received by the QA Officer and the project's lead engineer to ensure the absence of systematic bias or trends. Corrective actions were taken upon identification of any problems with the project that affected the product quality. If problems occurred, the cause was determined, the effect of the problem on the project was evaluated, and a solution was developed to prevent a subsequent occurrence of the problem.

The following corrective actions were taken if the program's data quality objectives for blank contamination, duplicate injection (or analysis), or matrix spike recovery were not achieved:

1. Calculations were reviewed for mathematical or transcription error.
2. The laboratory/field documentation were reviewed to determine whether procedural errors were made.
3. Equipment and reagents were examined to determine whether there was any malfunctioning equipment or reagent contamination.
4. Instrument documentation was examined to determine whether the signal response met the acceptance criteria and whether the calibration check standards agreed with the calibration curve as specified by the analytical method to determine whether the instruments were still within calibration.

If these steps did not correct the problem, the EPA Project Manager was contacted to discuss the source of the problem and its impact on the data and to determine whether any additional corrective actions, such as reanalysis of the samples, should be taken to try to obtain data that could meet the data quality objectives.

2.1.9 Calibration Procedures

2.1.9.1 Laboratory Analyses

All instruments should be calibrated each day that analyses are performed. The calibration standards should include the constituents of concern for the project. The calibration procedures described in the appropriate analytical methods will be followed.

All calibration information should be documented. If the calibration check standard does not meet the criteria specified in the method, the instrument should be recalibrated, and the samples analyzed after the last calibration check standard meeting the calibration specifications should be reanalyzed. If deviations from or modifications to these procedures are necessary, approval should be obtained from EPA prior to implementation of the deviation/modification. Documentation of these deviations/modifications and the reason for their implementation must be presented in the final analytical data report.

Calibration standards must be prepared using pure standard materials or purchased as certified solutions. If the standards are made from pure standard materials, the materials must be assayed and the purity of the standard must be known. When compound purity is assayed to be 96 percent or greater, the weight may be used without correction to calculate the concentration of the stock solution unless otherwise specified in the analytical material. Commercially prepared stock standards may be used at any concentration if they are certified by the manufacturer or by an independent source. The name of the manufacturer and the

information regarding purity of the standard or the concentration of the stock solution, if commercially prepared, must be available upon request.

Below is an overview of the calibration procedures for the analytical instruments that may be used. The concentrations of the calibration standards for each method will be determined by the detection limit and the linear curve of the range. For example, for a three-point calibration or curve, one standard would be selected near the detection limit, one at the midpoint of the linear range, and one at the upper end of the curve.

Instrument	Procedure
Flame AA	Daily four-point calibration with blank, 1, 5, and 10 mg/l standards. Check standard and blank analysis after every 10 samples.
Furnace AA	Daily five-point calibration with blank, 5, 10, 20, and 50 μl standards. Check standard and blank analysis after every 10 samples.
ICP	Daily two-point calibration with blank and 1 mg/l standards. Interference check sample analysis every 8 hours. Check standard and blank analysis after every 10 samples.
GC	Meet chromatographic acceptance criteria (such as degradation, peak shape, sensitivity signal to noise ratio, and retention time stability). Then do three-point initial calibration with 0.2, 0.25, and 1.0 μl standards, followed by daily chromatographic check and calibration check.
GC/MS	Meet MS tuning criteria followed by chromatographic acceptance criteria. Then do three-point initial calibration with 20, 50, and 100 ng/ml standards, followed by daily chromatographic check and calibration check.
Analytical balance	Prior calibration check with class S weights in the gram and milligran range. Other checks as appropriate in expected weighing range.

Instrument	Procedure
HPLC	Meet chromatographic acceptance criteria (such as degradation, peak shape, sensitivity, signal to noise ratio, and retention time stability). Then do multipoint initial calibration, followed by daily chromographic check and calibration check.
pH meter	Three-point calibration at pH 5, 7, and 10. Calibration check after every 10 samples.
Conductivity meter	Calibration check daily and every 20 samples.
UV spectrometer	Daily multipoint calibration. Check standard every 20 samples.
Technicon	Daily multipoint calibration. Check standard every 20 samples.
TOC	Daily single-point calibration in triplicate. Check standard every 20 samples.
TOX	Daily calibration check. Check standard every 20 samples.
IC	Daily multipoint calibration. Check standard every 20 samples.
Thermometers	Check against NBS thermometer every 6 months.
Hg analyzer	Daily four-point calibration. Check standard and blank analysis after every 10 samples.

2.1.9.2 Field Calibration

All instruments should be calibrated each day that analyses are performed in the field. The calibration standards should include the constituents of concern for the project. The calibration procedures described in the appropriate Standard Operating Procedures (SOPs) written for the field team and provided in the SAP should be followed. If the calibration check

standard does not meet the criteria specified in the method, the use of the instrument will be discontinued until the unit can be recalibrated. Data collected after the last calibration check standard meeting the calibration specifications should be reanalyzed with a calibrated instrument, if possible. In addition, calibration checks should be made by the crew chief at time intervals specified in the SAP.

2.1.10 Data Reduction, Validation, and Reporting

For data to be scientifically valid, legally defensible, and comparable, valid procedures must be used to prepare those data. The following sections describe the data reduction, validation, and reporting procedures to be used for field and laboratory data.

2.1.10.1 Data Reduction

The analytical laboratory should specify its data reduction methods. Wherever possible, the initial data reduction should be computerized. This reduces the frequency of transcription errors and calculation errors. Where data reduction is not computerized, calculations should be performed in permanently bound laboratory notebooks with carbon copy pages or on preprinted data reduction pages. The data reduction for some analyses includes analysts' interpretations of the raw data and manual calculations. When this is required, the analysts' decisions will be written in ink on the raw data sheets. Any corrections to data sheets will be made by lining out inaccurate information, initialing the line-out, and adding the revised information next to the line-out.

2.1.10.2 Data Validation

Data validation begins with the analyst and continues until the data are reported. The individual analyst should verify the completion of the appropriate data forms to ensure the completeness and correctness of data acquisition and reduction. The Laboratory Supervisor or

the data reduction staff should review computer and manual data reduction results and should inspect laboratory notebooks and data sheets to verify data reduction correctness and completeness and to ensure close adherence to the specified analytical method procotols. Calibration and QC data should be examined by the individual analyst and the Laboratory Supervisor or the data reduction staff to verify that all instrument systems were in control and that QA objectives for precision, accuracy, completeness, and method detection limit were met for the project.

Project data that are outside specified acceptance limits established for the data quality indicators (e.g., data points with detection limits above 1 ppm) or that are associated with QC outlier data should be flagged or otherwise identified in the laboratory's final data package.

2.1.10.3 Reporting

All reports and documentation required, including chromatograms and mass spectra, calibration records, and QC results, should be clearly labeled with the laboratory sample number and associated field sample number. A flow chart depicting the overall data handling and reporting scheme is provided in Figure 2.6.

The final data package submitted by the analytical laboratory should include a summary of the analytical results for each sample as well as all reports and documentation generated as required by the analytical methods (e.g., chromatograms, extraction notes, and chain of custody forms).

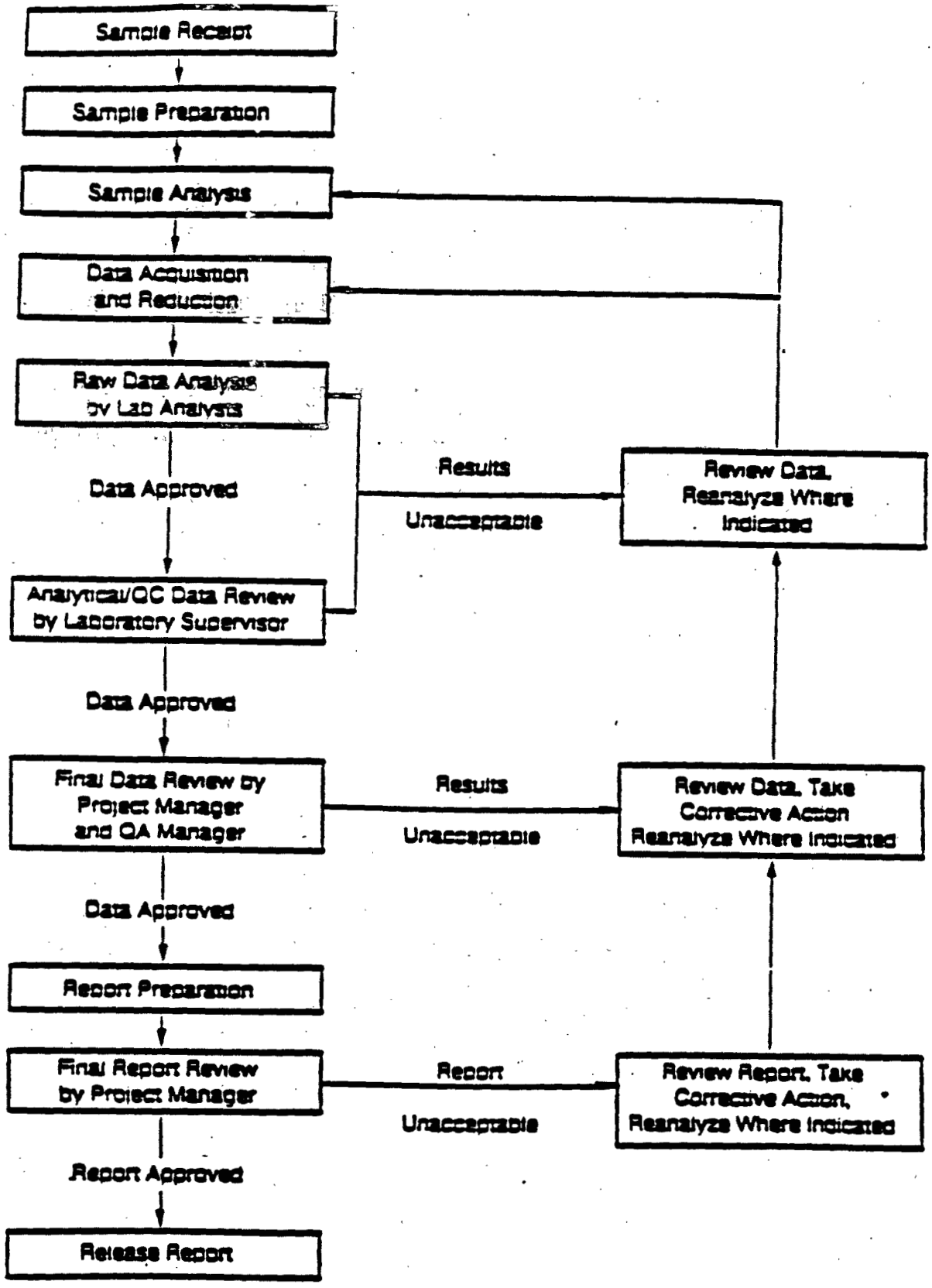

Figure 2-6. Data Reduction, Validation, and Reporting Scheme

2.1.11 Preventive Maintenance

2.1.11.1 Field Preventive Maintenance

All field equipment should be maintained following procedures outlined by the manufacturer. Prior to a sampling project, the field equipment to be used should be inspected and calibrated to ensure that it is working properly. Spare parts should be available and should be taken on the sampling trip, if appropriate. Following its use, equipment should be decontaminated using the appropriate cleaning procedures required for the project.

2.1.11.2 Laboratory Preventive Maintenance

All laboratory instrumentation will be maintained following procedures outlined by the instrument manufacturers. Instrument maintenance logbooks should be kept with each instrument and updated by the operator whenever routine or nonroutine maintenance procedures are performed.

2.1.12 Quality Assurance Reports to Management

The Contractor Project Manager, in conjunction with the Contractor QA Officer, should identify critical areas of the project that will be subject to inspection. These inspections should be performed by qualified staff members who are not performing or supervising the activity. The areas inspected may include the following:

- Staff qualifications;
- Equipment maintenance records;
- Equipment calibration records;
- Protocol adherence;
- Documentation practices;
- Sample traceability and control;
- Data traceability and document control;

- Recordkeeping practices;
- Review and validation practices;
- Computation practices;
- QC data and practices; and
- QC compliance.

2.2 Sampling and Analysis Plan

The following format presents prospective sampling and analysis activities in a rational and identifiable manner. "Organization" is presented here as a shorthand for the name of the industrial facility, corporation, consortium, or other entity intending to submit this data.

- Title Page

- Approval Page: Names, organizational addresses, and titles of the individuals serving as Project Manager and Quality Assurance Officer in generating the data.

- Introductory Pages: Table of contents, list of tables, and list of figures.

- Section One: Introduction.

  1.1 Short description of the Organization's participation in generating data for the LDR program.

  1.2 Discussion of the objective of this treatment test in terms of the waste being treated and the technology being evaluated.

  1.3 Introductory description of the waste being treated, summarizing available analytical and other test results already performed. (Data tables can go into an appendix.)

  1.4 Names, telephone numbers, and addresses of the Project Manager, Analytical Laboratory Manager, and Quality Assurance Officer with responsibility in this project.

  1.5 Description of the treatment system under evaluation. How much detail?

  1.6 Outline and schedule of the major sampling and analysis events as anticipated.

- Section Two: Project Organization.

  2.1 Organizational Chart. (See Figure 2-2.)

  2.2 Addresses and telephone numbers of key individuals.

  2.3 Summaries of key individuals' responsibilities.

- Section Three: Waste and Treatment System Description.

  3.1 Qualitative discussion of waste: process generating it, regulatory history, previous management practices, and discussion of results of earlier analytical investigations of this waste.

  3.2 Summary of existing data characterizing the waste in tabular form.

  3.3 Qualitative discussion of treatment system: how it works, whether it is an established or innovative technology, whether the system is part of the generating plant's existing onsite waste management system or an offsite system or a mobile unit, dimensions and capacities of process units, and key design and operating parameters.

- Section Four: Sampling and Analysis Activities.

  4.1 Table of each sample, blank, and duplicate to be taken, each numbered with a unique alphanumeric code indicating whether it is a field or equipment blank, raw or treated residual, single sample, or one of a duplicate-sample pair and indicating to what category of residual it belongs (i.e., scrubber water vs. ash for incinerator residuals) to be explained in the footnotes to this table. This table should state at which point each sample will be taken.

  4.2 Schedule for sampling visit, accounting for collection, preservation, and transport of each numbered sample, duplicate or blank by identification code.

  4.3 Description of proposed sampling procedure for each coded sample plus the number of samples to be collected at each site.

  4.4 List of the analytes and parameters to be analyzed in each sample, the sample preparation (digestion, extraction, cleanup, etc.), and analytical methods to be used for each sample, all presented with unique sample code.

  4.5 Narrative discussion of why these analytes and not others were selected from the BDAT list.

4.6 Specifications for sample aliquot size, preservation, and acceptable holding times.

- Section Five: Site-Specific QA/QC Procedures.

5.1 Description of field QA/QC activities including calibration of field monitoring equipment, preparing sampling, travel, and field blanks, ensuring that appropriate duplicates are taken and decontamination and disposal of field sampling equipment.

5.2 Specify the sample aliquots upon which matrix spike analyses are to be completed and specify the spike constituents and their concentration levels.

5.3 Specify the number of trip, field, or equipment blanks to be collected and the procedures to be used. Also, specify the analyses/methods to be performed on the blanks, noting that in most cases the blanks will be marked "Hold for Analysis." Also specify procedures to be performed with reagent blanks.

5.4 List the surrogate determinations to be performed for organic analyses; if methods other than 8240 or 8270 are being used, described a surrogate use procedure similar to 8240 or 8270s to be employed.

5.5 List the QC check standards to be run for metals analyses.

5.6 List provisions for documenting all method-specific internal standards for GC and GC/MS procedures.

- Section Six: Sample Custody and Transport.

6.1 Description of sample custody procedures and for transporting waste from generation facility to treatment facility if planned.

6.2 Relevant information on sample packing and shipment: Shipping category for samples and any transported waste; DOT regulations and the carrier's requirements for these materials; carrier name and address of the local shipping station; address of the laboratory to which the samples will be sent; and name and telephone number of the designated contact at this laboratory.

- Section Seven: Health and Safety.

7.1 Summary of health and safety procedures to be followed onsite during sampling and treatment operations. Use the facility's existing health and safety plan if one is available.

- Section Eight: References.

2.3 Onsite Engineering Report

The following format assembles the results from sampling and analysis activities in a rational and identifiable discussion of the performance of the treatment system in terms of its measured design and operating parameters and the concentration of contaminants in the raw and treated waste streams.

- Title Page
- Approval Page: Names, organizational addresses, and titles of the individuals serving as Project Manager and Quality Assurance Officer in generating the data.
- Introductory Pages: Table of contents, list of tables, and list of figures.
- Section One: Introduction.

  1.1 Short description of the Organization's participation in generating data for the Land Disposal Restrictions program.

  1.2 Discussion of the goals of this treatment test, in terms of the waste being treated and the technology being evaluated, and how these goals were achieved.

  1.3 Preliminary discussion of significant deviations from the SAP.

  1.4 Brief introduction of the sections of the OER to follow.

  1.5 Table summarizing the test site and personnel: Name and address of treatment site; site contact names with addresses and telephone numbers; treatment test dates; names, titles, and addresses of EPA personnel involved in onsite activities; names, titles, and addresses of those responsible for preparing the OER; and the name, address, and telephone number of the laboratory coordinator.

- Section Two: Waste Being Treated.

  2.1 Qualitative discussion of waste: process generating it, regulatory history, previous management and disposal problems unique to this waste, existing management practices, and discussion of results of earlier analytical investigations of this waste.

  2.2 Summary of data taken previous to this test characterizing the waste in tabular form.

  2.3 Summary of analytical results on untreated waste samples in tabular form.

- Section Three: Treatment System Being Evaluated.

  3.1 Qualitative discussion of treatment system: how it worked, whether it is an established or innovative technology, whether the system was part of the generating plant's existing onsite waste management system or an offsite system or a mobile unit, dimensions and capacities of process units, and key design and operating parameters.

  3.2 Tabular summary of design and operating parameters measured during the test.

  3.3 Process diagram of treatment system showing key units associated with design and operating parameters and sampling points.

- Section Four: Sampling and Analysis Activities and Results.

  4.1 Summary schedule of treatment test events and activities.

  4.2 Deviations from planned sampling and analysis operations.

  4.3 Tabular summary of all analytical results, each referenced by sample code number and including the analytical method used.

  NOTE: Report on all items listed in Section four of the SAP, explicitly referencing it whenever appropriate.

- Section Five: QA/QC Measures Taken.

  5.1 Tabulate collection, sample preparation, and analysis dates and (for preparation and analyses, the procedures) for each uniquely coded sample.

5.2 List of the BDAT List constituents analyzed for in each sample for the raw waste and the treated waste residuals plus the analytical method used for each constituent.

5.3 Narrative summary of analytical problems, deviations from SW-846, alternatives or equivalent to SW-846 and options chosen among SW-846 alternatives.

5.4 Tabulation and explanation of any detection limits exceeding 1 ppm for BDAT List constituents.

5.6 Data Quality Indicators:

Precision and accuracy data for the treatment test sample analytical results: spiking data (matrix and injection extracts, samples, and duplicates).

Instrument and matrix detection limits, together with analytical method involved.

5.7 Instrument and Procedure Verification:

Results of surrogate determinations performed for organic analyses.

Results of QC check standards to be run for metals analyses.

Results of all method-specific internal standards for GC and GC/MS procedures.

- Section Six: Correspondence.

Critical correspondence with EPA, generating facility and treatment facility.

- Appendix:

Complete SAP

Laboratory instrument calibration results.

Laboratory QC checks (e.g., results for laboratory blanks, QC check samples, reference samples.

3. METHODOLOGY FOR ESTABLISHING TREATMENT STANDARDS

RCRA section 3004(m) specifies that treatment standards must minimize long- and short-term threats to human health and the environment arising from land disposal of hazardous wastes. EPA's general approach for complying with this requirement was promulgated as part of the November 7, 1986, rule.

The legislative history accompanying HSWA states that a technical method used for treating hazardous waste should be "the best that has been demonstrated to be achievable," but it notes that Congress' intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily edition, July 25, 1984)). The word "achievable," therefore, does not require the use of experimental or emerging technologies in developing treatment standards. Rather, the intent of the statute is to base treatment standards on the best technologies commonly in use and thus reasonably available to any generator.

Accordingly, EPA's treatment standards are set in one of the following three modes: (1) concentrations of hazardous constituents in wastewater and nonwastewater treatment residues, (2) specific treatment technologies for the waste, or (3) a combination of a specific treatment technology for a type of residue and constituent concentrations. The treatment standards are generally based on the performance of the "best demonstrated available technology," or BDAT. This approach involves the identification of applicable treatment systems for individual wastes or for groups of wastes; determination of whether these systems are "demonstrated" to achieve acceptably low effluent contaminant concentrations and "available" commercially; selection of the "best" of those that are demonstrated and available; and, if possible, collection of treatment data for the waste code of interest from representative well-designed and well-operated systems to serve as the basis for concentration-based or technology-based performance standards.

In the case of numerical or concentration-based standards, EPA does not mandate the use of a particular technology. Waste treaters are free to use any method they choose, as long as the results achieve compliance with the numerical treatment standard. Numerical standards also allow waste treaters to use new and innovative technologies as they become available so long as the numerical standards are achieved.

In cases where analytical methods were not available to measure and ensure compliance for the constituents of concern in the treatment matrix or where sufficient performance data were not available to establish numerical standards, a method of treatment was established as the BDAT treatment standard. Treaters are required to use the established technology to treat the waste. For these cases, concentration-based standards may be established in the future should an analytical method be developed to measure the constituents of concern or should an adequate surrogate or indicator constituent be identified to measure treatment and ensure compliance. However, to use new technologies as they are developed, treaters must apply for a variance and must be able to demonstrate that the performance of the new technology is equal to that of the established technology.

3.1 Waste Treatability Groups

To determine the applicable treatment technologies, wastes may be clustered into "treatability groups" that are similar with respect to various parameters that affect the success of treatment. A single waste code can be divided into one or more waste treatability groups if the waste stream manifests itself in several well defined categories. These parameters can include such factors as physical state, water content, presence of similar hazardous and nonhazardous contaminants, organic content, heat content, pH, and so forth. As noted, waste treatability groups can include multiple waste codes, single waste codes, or subcategories of a single waste code, in any combination. Information on the waste characteristics of the "treatability" group are used to determine the applicable treatment technologies and to determine whether sufficient data are available to evaluate each of the applicable technologies.

3.2 Determining BDAT for Individual Waste Treatability Groups

For any particular waste treatability group, EPA first identifies applicable technologies through literature reviews or on the basis of information provided by facilities currently treating the waste or similar wastes. In some instances, technologies used to separate or process chemicals or other materials, such as retorting, may potentially provide waste treatment in cases where the wastes are similar to the raw materials processed, even though these technologies were not originally designed to treat hazardous waste.

From among the applicable technologies, EPA then identifies those that are "demonstrated" for the particular treatability group. These technologies must be used in a full-scale operation for treatment of the waste, a similar waste, or raw materials similar to the waste. Where the Agency does not identify any facilities treating specific wastes from a particular group, it may "transfer" a finding of demonstrated treatment by comparing the parameters that affect treatment of the target waste group to parameters of other waste groups for which demonstrated treatments are known. For example, on the basis of technical literature and data collected by the Agency, EPA considers rotary kiln incineration to be a demonstrated technology for wastes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating specific hazardous waste codes using this type of incineration.

The next step is to determine which of the demonstrated technologies is "best" for the purposes of establishing BDAT. In defining "best," EPA considers only the effectiveness of treatment--the degree to which hazardous constituents in the waste are removed or destroyed. RCRA treatment technology evaluations do not consider economic factors.

If only one technology is demonstrated for a particular waste group, then that technology is automatically "best." If two or more technologies are available, but acceptable data exist for only one of them, then the Agency decides whether to develop new data or to use engineering

judgment to determine whether the performance of the documented technology is likely to be equal to, or better than, that of the others. If several technologies are available, each with acceptable performance data, then the Agency compares the performance of these technologies using available data.

The data comparisons among several available technologies with acceptable performance data must be statistically defensible to the extent that sample sizes and other technical factors permit. Before performing statistical tests, the Agency first adjusts the measured results to account for the accuracy of the laboratory procedure used to generate the data. EPA then compares the adjusted performance levels using the statistical "analysis of variance" (ANOVA) technique to confirm that the technology selected as "best" does indeed perform statistically better than the others. (See Appendix B, F Value Determination for ANOVA Test.) If the differences among the available data sets are not statistically significant, then two or more technologies can both be considered "best demonstrated."

Next, the Agency determines whether the best demonstrated technology or technologies are "available." "Available" technologies must be both commercially available and provide "substantial treatment." To be considered commercially available, the technology may be either a common technology in universal use (such as neutralization or incineration) or a proprietary or patented process that can be purchased or licensed from the proprietor or that is commercially available at a facility offering use of the technology for a fee.

Technologies provide "substantial treatment" when they "substantially diminish the toxicity" of a waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste (consistent with the language of HSWA section 3004m). By establishing that treatment is "substantial," the Agency ensures compliance with statutory objectives and eliminates treatment methods providing little or no environmental benefit. Treatment will be considered to be substantial if the available data from a well-operated treatment system show statistically significant reductions in concentrations resulting from

treatment. This process involves the use of the statistical analysis of variance (ANOVA) test as described in Appendix B.

For organic constituents, EPA measures performance based on the total constituent concentration found in the treated waste with the exception of the wastes regulated under the Solvents and Dioxins Rule. This is because technologies exist to destroy various organic compounds in waste, making the total amount of constituent left in the treated waste the more logical measure of performance.*

For all metal constituents, EPA measures performance based on total constituent concentration and/or the constituent concentration in the TCLP extract. When the BDAT involves a metals recovery operation, EPA may use both total and TCLP analyses to measure performance because it is important to establish both the effectiveness of recovery (measured by changes in total concentration) and the stability of any treated residuals that may be sent to land disposal (measured by TCLP analysis of the residuals). When the BDAT for metals involves only immobilization, such as stabilization treatment, the appropriate measure of performance is the constituent concentration in the TLCP extract.

3.3 Establishing Numerical Performance Standards on the Basis of BDAT

Once the BDAT is determined for a particular waste code, EPA prefers, wherever possible, to define numerical performance standards in terms of concentrations of hazardous constituents in the nonwastewater and wastewater residuals that are produced during the treatment of the hazardous waste.

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*EPA's LDR for solvent waste codes F001-F005 and dioxin waste codes F020-F023 and F026-F028 (51 FR 40572) use the TCLP value as a measure of performance. At the time that EPA promulgated the treatment standards for these wastes, useful data were not available on total constituent concentrations in treated residuals, and, as a result, the TCLP data were considered to be the best measure of performance.

EPA develops numerical treatment standards using performance data gathered from representative facilities. Only data from well-designed and well-operated facilities are acceptable as usable--a judgment made on a case-by-base basis for each set of potentially usable data. Data need not be generated only by EPA; the Agency may use data submitted by industry, provided these data are shown to be from a well-designed and well-operated facility and were generated using adequate QA/QC procedures for laboratory data.

3.3.1 Evaluating the Adequacy of Existing Data

All valid data available to the Agency may be used to establish BDAT-based performance standards. All data either collected by EPA or submitted by industry, research organizations, etc. for a specific waste code are published in the Administrative Record either during proposal or promulgation (depending on the date of submission) of the rulemaking for the specific waste code. Whatever the information source, however, the data underlying the performance standards must meet QA/QC standards. If the available data for a given technology/waste group combination are not of adequate quality, then data can be "transferred" from another standard if they meet certain conditions. These issues are discussed separately below.

(1) Criteria for accepting existing data. EPA considers a number of factors in evaluating data sets as the possible bases for BDAT standards:

1. Data must come from technologies that are demonstrated and available.

2. The facility from which the data were generated must be well-designed and well-operated. Design adequacy is determined through review of facility specifications; the essential requirement is that the facility include all processes needed to handle the hazardous constituents in the target waste group, as well as all nonhazardous constituents that could affect the system's performance in treating the hazardous constituents. Operations adequacy is determined based on a review of the performance range operating parameters used during the treatment test versus the design operating specifications. Engineering judgment is used to review available performance data to determine whether the treatment system was well-operated and well-designed.

3. EPA reviews the adequacy of the QA/QC protocols followed in generating the laboratory analytical data. If these protocols are substandard or nonexistent, the data may be discarded. Engineering judgment may be used to determine the quality of the available data.

4. All candidate data sets for the treatment residuals must use measures of performance consistent with those being used to set the standard (e.g., total constituent analysis for all hazardous (organic and inorganic) parameters for destruction or removal technologies and analysis in the TCLP extract for immobilization technologies).

5. For a data set to be accepted in whole or in part, the data must show substantial treatment on a constituent-by-constituent basis. Data should be provided for both untreated and treated concentrations. Treated concentrations must be lower than untreated concentrations. Statistical tests can be used to determine whether substantial treatment occurred.

6. Data on concentrations in treated waste must be adjusted for accuracy using recovery factors specific to the laboratory tests. (See Appendix C.)

In situations where the available data show substantial treatment for one class of constituents but not for another, the Agency may conclude that the standard should be based on a treatment "train" of multiple BDAT technologies operating as a system. This may be the case, for instance, in treating wastes that include both organics and metals. Incineration may show substantial treatment of the organics, but not of the metals, which would require another form of treatment, such as stabilization.

(2) <u>Transfer of treatment data or standards</u>. In some instances, EPA is proposing and has promulgated treatment standards that are not based on a treatment test of the waste in question by the selected BDAT technology. However, the constituents present in the subject waste were determined to be treatable to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes such transfers are technically valid in cases where the untested wastes are generated from similar industries or from similar processing steps, or have similar waste characteristics affecting performance and treatment selection.

Transfer of treatment standards to similar wastes or to wastes from similar processing steps requires a detailed comparison of the constituents of concern in the untested waste to those in the tested waste. If the parameters that affect treatment performance for these constituents indicate that the untreated waste is equally as easy or easier to treat than the tested waste, then the transfer can be made.

3.3.2 Hazardous Constituents Considered for Regulation

The list of hazardous constituents for which BDAT performance standards may be established is known as the BDAT Constituent List. The current list, provided in Table 2-1, is a subset of the constituents listed in 40 CFR 261, Appendix VIII; it also includes several ignitable constituents used as the basis for listing wastes for F003 and F005. Chemicals are listed in Appendix VIII if they have been shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life forms; for instance, they include such substances as those identified by EPA's Carcinogen Assessment Group as being carcinogenic.

There are three major reasons why not all Appendix VIII constituents or the F003 and F005 ignitables are included on the BDAT Constituent List:

1. <u>EPA-approved or verified analytical methods are not available.</u> Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately, or even detected, using EPA's analytical methods such as those published in SW-846 Third Edition. EPA may choose to regulate a surrogate or indicator such as a decomposition or ionization product, if appropriate.

2. <u>The constituent is a member of a chemical group designated in Appendix VIII as "not otherwise specified" (N.O.S.).</u> Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. For each N.O.S. group, constituents that can be readily analyzed are included in the BDAT Constituent List.

3. <u>Available analytical procedures are not appropriate for a complex waste matrix.</u> Some compounds, such as auramine, can be analyzed as a pure constituent, but the

recommended analytical method may not positively identify the constituent in the presence of other constituents or in a complex waste matrix.

The BDAT Constituent List is updated periodically and does not preclude the addition of new constituents as the problems above are resolved or deletion of constituents if the available analytical methods are determined not to be valid for analyzing the constituent in residual matrices. The initial list was published in EPA's *Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT")* (EPA/530-SW-87-011); since then constituents have been added, deleted, and annotated to note the possibility of analytical problems, especially in solid matrices.

3.3.3 Selecting Constituents for Inclusion in the Standard

A performance standard for treating a particular waste group will list acceptable concentrations of BDAT list constituents in treated residuals. The standard will not necessarily include all BDAT list constituents analyzed in a particular waste stream, and may, in some instances, include one or more BDAT list constituents that have not been detected in the waste stream. The rationale for selecting constituents for inclusion in a standard is as follows.

The constituents considered for regulation in each waste code are, in general, those for which available data show statistically significant reductions in concentrations resulting from treatment. This process involves the use of the statistical analysis of the ANOVA test described in Appendix B. EPA interprets a statistically significant reduction in concentration as evidence that the technology actually "treats" the waste.

In some instances, EPA may regulate constituents that are "not detected" in the untreated waste but are detected in the analyzed residual (ash, sludge, etc.). This may happen, for instance, where the presence of other constituents in the untreated waste matrix interferes with quantification of the constituent of concern. The result may be a finding of "not detected" when

in fact the constituent is present in the waste. EPA may also choose to consider a constituent not found in a particular sampled untreated waste if it believes that the constituent is likely to be present in the same hazardous waste generated by another source. For example, EPA may choose to regulate all conceivable hazardous solvents that might be used in paint or ink manufacture, even if the available performance data do not include them all. This is done to preclude generators from using alternative materials that are hazardous to meet the regulation for the waste code instead of treating the waste material.

EPA then reviews the candidate constituents list to determine whether any can be excluded from regulation because they would be indirectly controlled by regulation of other constituents. For instance, an incineration regulation might regulate only the least combustible organic compounds present in the waste since achievement of a standard for these compounds would ensure achievement of adequate treatment for the others. This approach is intended to reduce analytical cost burdens on the treater and also to facilitate implementation of the compliance and enforcement program.

3.3.4 Calculation of Numerical Performance Standards

The final step in setting a performance standard is to define the maximum acceptable constituent levels in treatment residuals for the selected BDAT list constituents for a particular waste treatability group, based on the performance of the BDAT technology. This is done by multiplying the average treatment value observed in the acceptable available data by a factor known as the "variability factor."

Only data obtained from treatment systems determined to be well-designed and well-operated are used to calculate performance standards. Parts or all of the available data for a treatment test may be discarded on a case-by-case basis. For example, if the residence time for a waste during a particular test run was substantially shorter than the planned value, EPA might

conclude that the system was not properly operated during that run and would discard the associated treatment results in calculating average treatment efficiencies.

The variability factor used to calculate performance standards takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. These fluctuations may result from inherent mechanical limitations in treatment control systems, treatability variations caused by changing influent loads, unavoidable variations in procedures for collecting treated samples, or variations in sample analysis. Setting treatment standards using a variability factor should, therefore, not be viewed as a relaxation of the requirements of section 3004(m), but rather as a response to normal variations in treatment processes. As a practical matter, facilities will have to incorporate variability factors into process design to ensure performance that is more stringent than the standard in order to ensure continuous compliance with the standard.

EPA calculates the variability factor for each selected constituent of concern using the statistical methods described in Appendix D. The equation is the same as that used for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. It sets the standard at the upper 99th percentile value concentration of the constituent expected in the treatment residual, using the mean and standard deviation calculated from the acceptable available data, and assuming that performance varies lognormally.

An additional step in the calculation of the treatment standards occurs when the ANOVA test shows that more than one technology achieves a level of performance that represents BDAT. In such an instance, EPA first averages the mean performance value for each technology for each constituent of concern and then multiplies that value by the highest variability factor among the technologies considered. This ensures that all BDAT technologies used as the basis of the standard will achieve full compliance.

3.3.5 Recovery/Recycle

In developing treatment standards for the LDR program, the Agency has at times chosen to modify the BDAT methodology that was presented in the 1989 Methodology Document. This occurred when treatment performance data from recycling/recovery technologies were being considered as a basis for standards development together with data from destruction and removal technologies. Part of the rationale for modifying the methodology where recycling/recovery technologies are being considered is the fact that the RCRA favors use of recycling and recovery technologies. (See, e.g., H.R. Rep. No.198, 98th Cong. 1st Sess. 31.) Therefore, the Agency may choose to modify the standard BDAT approach for setting treatment standards in those situations where recycle/recovery technologies are being considered along with other technologies that involve destruction and removal. EPA may then determine that it may not be appropriate to set treatment standards based on the technology that is determined to be "best" (as determined by statistical comparison).

The Agency recognizes that not basing treatment standards on the "best" technology (as determined by statistical comparison) may result in treatment residues that may not be minimized in mobility or toxicity to the maximum extent. However, the Agency believes that a modified methodology (where the recycling/recovery technology may be given preference) may be appropriate if the recycling/recovery technology is well-designed and well-operated and represents significant reduction in the mobility and or the toxicity of a waste of concern.

Further, the Agency believes that such a modified approach to developing treatment standards where recycling/recovery technologies are given preference is consistent with the language of RCRA section 3004(m) and with the overall statutory goals of encouraging material reuse and waste minimization. (See e.g., RCRA section 1003 (a)(6).)

EPA used modified approaches in developing treatment standards in at least two rulemakings for the LDR program (i.e., the amendment to the K048-K052 rule in the Third

Third final rule, and in the recent final rule for K061 high zinc subcategory nonwastewaters). In both rules, the Agency notes that the treatment standards are based on treatment technologies that may not achieve complete destruction or removal but, nevertheless, achieve substantial reduction in the mobility and or toxicity of the waste of concern.

The following discussion of the modified BDAT methodologies used for developing the final amended treatment standards for K048-K052 wastes and the final treatment standards for K061 high zinc subcategory nonwastewaters illuminates how EPA has included recycling and recovery considerations in earlier decisions to set treatment standards.

First, it must be noted that the Agency determined in the final First Third rule for K048-K052 that both incineration and solvent extraction are BDAT for the organic constituents in K048-K052 nonwastewaters. EPA noted that in selecting both solvent extraction and incineration as BDAT for K048-K052 it has included a technology that does not destroy or remove the organic constituents of concern as well as incineration. EPA believed this was a permissible and rational choice given that solvent extraction is a recovery technology and because of RCRA's strong preference for use of such technologies.

In the development of the amended treatment standards for K048-K052, the Agency was concerned with setting realistic and achievable treatment standards. The Agency adopted a modified methodology in determining treatment standards to account for the variability in K048-K052 wastes generated from different refineries. The Agency had a wide range of constituent concentration data for untreated K048-K052. The most difficult to treat wastes in K048-K052 were typically those containing the highest concentrations of constituents in the untreated waste of the constituents of concern. The Agency attempted to account for variations in the feed in assessing the performance of the BDAT technologies (i.e., solvent extraction and incineration). This was particularly important since treatment performance data available to the Agency indicated that solvent extraction technologies are to some extent matrix dependent (only data from solvent extraction were used to develop the final amended standards for K048-K052).

The Agency had treatment data from the following four sources:

1. Five-pass solvent extraction followed by centrifugation (from plant Q);
2. Three-pass solvent extraction (from plant R);
3. Three-pass solvent extraction (plant T); and,
4. Fluidized-bed incineration (from plant A).

It should be noted that although the data from incineration were determined to provide the best treatment (the organic constituent removal efficiency for solvent extraction was 98 percent on average compared to 99 percent for incineration), the constituent removal efficiency of solvent extraction was comparable to incineration. However, the data from incineration were not used to develop the treatment standards (for organic constituents) because it would have resulted in standards that were technology-forcing.

Moreover, due to the resource recovery potential associated with solvent extraction, it was given preferential consideration and was designated the best technology. Incineration was not designated as best as would have been the case if the standard BDAT methodology had been used.

The treatment standard for each organic constituent in K048-K052 nonwastewaters was calculated as follows:

1. The four available data sources from Plant Q, R, T, and A were reviewed to determine the sample set with the most difficult to treat waste, typically the one with the highest concentration value (including detection limit values) for the constituent in the untreated waste. The Agency assumed that high detection limit values in the untreated waste for several data sets indicated high concentrations of a constituent if other data (untreated waste data or the presence of the constituent in the treated waste) indicated that the constituent was indeed present in the untreated waste but was not detected because of matrix interferences.

2. The concentration of the constituent in the treated waste that corresponded to the untreated waste concentration representing the most difficult to treat waste was then multiplied by a variability factor of 2.8 to derive the treatment standard for the constituent. The variability factor of 2.8 is used by the Agency to account for

treatment standards. The Agency then compared the four sets of treatment standards and selected the highest standard as the treatment standard for each regulated metal.

In development of the treatment standards, the specific calculations were dependent on the different scenarios that the data presented, as explained below. All data were corrected for accuracy before calculating treatment standards:

1. If the data consisted of all detected values, then the standard BDAT formula was used to calculate the treatment standard, i.e., Treatment Standard (TS)= Exponent (EXP) (mean of the logtransformed data + 2.33 (the standard deviation of the logtransformed data)).

2. If the data consisted of detected values and nondetected values (i.e., detection limit), the highest detection limit was identified. If any of the detected values were below but not above the highest detection limit, the highest detection limit was multiplied by a variability factor of 2.8 to derive the treatment standard.

3. If the data consisted of both detected values and nondetected values and the detected values were both above and below the highest detection limit identified in the data set, the standard BDAT formula was used, i.e., TS = Exp (mean logtransformed data +2.33 (the standard deviation of the logtransformed data)).

4. If the data consisted of all nondetected values (detection limit), the highest detection (not the mean of the detection limit) was multiplied by a variability factor of 2.8 to derive the treatment standard.

5. If the data consisted of just one datum point, the datum point was multiplied by a variability factor of 2.8 to derive the treatment standard.

3.4 Technology as a Method of Treatment Standards

In some circumstances, it is not possible to develop concentration-based performance standards, in which case the Agency has set a performance standard based on a specific treatment method. This may happen when an analytical procedure is not available to measure the constituent of concern or an appropriate surrogate or indicator constituent cannot be identified to measure the treatment performance.

variability when only one data point is used in a treatment standard calculation. (Note 2.8 is also used when all the values are below the detection limit.)

Further, EPA did not believe that it would be technically valid to develop a variability factor for each constituent by pooling all the available treatment performance data for solvent extraction, because the data were obtained from several different types of solvent extraction technologies, and each treatment test generating data was conducted under different conditions. Therefore, the result of pooling the data would have been an artificially high variability factor leading to unrealistically high treatment standards.

The Agency believes that this methodology in determining treatment standards accounts for refinery variability in K048-K052. The Agency also accounted for the variability inherent in performance of treatment systems as well as in the collection and analysis of treated waste samples by using a variability factor in the calculation of the revised treatment standards.

In the development of treatment standards for K061 high zinc subcategory nonwastewaters, the Agency was concerned with setting achievable treatment standards for all the well-designed and well-operated High Temperature Metals Recovery (HTMR) processes. (HTMR was BDAT for K061.) The Agency was concerned with the variability of treatment from the different HTMR processes and with potential detection limit problems that could result from analytical equipment variability and TCLP digestion problems for the slag matrix.

As a result of these concerns, EPA used a slight modification to the BDAT methodology for calculating the treatment standards detailed as follows. In summary, four separate sets of treatment standards (for the metal constituents) were calculated from four individual sets of HTMR treatment data representing different HTMR processes. It is important to note that the Agency used only data that were determined to be from well-designed and well-operated HTMR processes. This is an important consideration because data processes that were not well-operated, in some cases, indicated wide variability that would yield very high and unrealistic

The Agency sets method-of-treatment standards in two cases. First, for ignitable, reactive, and otherwise unstable wastes, EPA specifies a deactivation process. For relatively stable wastes which are difficult to analyze chemically, EPA sets as a method of treatment that technology demonstrated to treat a similar waste, or waste component, to acceptably low levels.

4. TREATMENT STANDARDS CALCULATED AND PROMULGATED UNDER THE LDR PROGRAM

As of May 8, 1990, treatment standards had been promulgated for the following:

- Solvents and Dioxins Rule - November 7, 1986;
- California Rule - July 8, 1987;
- First Third Scheduled Wastes - August 8, 1988;
- Second Third Scheduled Wastes - June 8, 1989; and
- Third Third Scheduled Wastes - May 8, 1990.

This Background Document tabulates all of these standards.

All treatment standards promulgated under the LDR Program were based on the best data available at the time of promulgation.

It should be noted that the treatment standards in the Solvents and Dioxins Rule are based on the TCLP, whereas, for subsequent rules, the treatment standards are based on total waste analysis for organics and inorganics for destruction or removal technologies (such as incineration or solvent extraction) and TCLP for inorganics for immobilization technologies (such as stabilization or vitrification).

Table 4-1 summarizes the information on how the standards were calculated for each waste code. Table 4-1 includes the following:

- The technology;
- The type of treatment data, i.e., whether data were based on the actual waste code or on a similar waste code; and
- The type of QC data used to adjust the standard.

Appendix E summarizes the standards by BDAT constituent.

Table 4-1 Treatment Standards for Scheduled Wastes

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer)	Accuracy correction calculations
SDR	F001-F005	Carbon adsorption, distillation, biological treatment, incineration, wet air oxidation, air stripping, and fuel substitution (WW and NW standards set on TCLP)	EPA data from various sources	Transfer	NA	NA
3/3	F002, F005	Biological Treatment, Steam Stripping, Carbon Adsorption (WW)	EPA data from various sources	Transfer	EPA data from various sources	No calculated recoveries over 100%
		Incineration (NW)	EPA data from various sources	Transfer	EPA data from various sources	No calculated recoveries over 100%
1/3	F006	Stabilization, High Temperature Metals Recovery (Metals) (NW)	Industry submitted	Data	Submitted with data	Calculated recoveries over 100%
2/3	F006-F012, F019 (F006-cyanide)	Electrolytic Oxidation, Alkaline Chlorination (NW) for cyanide	CyanoKEM	Data	Submitted with data	Calculated recoveries over 100%
3/3	F006	Alkaline Chlorination for cyanide, chromium reduction, chemical precipitation (WW)	K062	Transfer	Transfer from K062	No calculated recoveries over 100%
3/3	F019	Alkaline Chlorination, Stabilization (Metals)	F006-F012	Transfer	Transfer from F006-F012	No calculated recoveries over 100%
SDR	F020-F023, F026-F028	Incineration (WW and NW standards set on TCLP)	EPA data	Transfer	NA	NA

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer)	Accuracy correction calculations
2/3	F024	Rotary Kiln Incineration (Organics-NW)	EPA test	Data	Data	No calculated recoveries over 100%
		Lime and Sulfide Precipitation (Metals-WW)	K062	Transfer	Submitted with data transfer from K062	Calculated recoveries over 100%
3/3	F024	Stabilization (Metals-NW)	EPA test	Data	EPA data	No calculated recoveries over 100%
		Incineration (Organics)	EPA test	Data	EPA data	No calculated recoveries over 100%
3/3	F025	Incineration (NW)	K019, K011	Transfer	Transfer from K019, K001	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
1/3	K001	Incineration (Organics-WW and NW)	EPA test K001 (Organics)	Data for organics	EPA data for organics	Calculated recoveries over 100%
		Stabilization (Metals-NW)	EPA data	Data transfer	EPA data transfer from F006	Calculated recoveries over 100%
		Chemical Precipitation (WW)	EPA transfer from F006	Data transfer	EPA data transfer from F006	No recoveries over 100%
3/3	K001, U051	Stabilization (Metals-NW)	EPA test	Data	EPA data	No calculated recoveries over 100%
		Incineration (Organics-WW and NW)	EPA test	Data	Data	No calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
1/3	K002-K008	No Land Disposal Based On No Generation	NA	NA	NA	NA
2/3	K005, K007	No Land Disposal Based On No Generation	NA	NA	NA	NA
3/3	K002-K008	Stabilization, Chromium Reduction, Chemical Precipitation, Sludge Dewatering (NW)	K062, F006	Data transfer from industry	Data transfer from industry	No calculated recoveries over 100%
2/3	K009, K010	Chemical Precipitation, Alkaline Chlorination, Chromium Reduction (WW)	EPA data	Data transfer	Data transfer	No calculated recoveries over 100%
		Incineration (NW)	K019	Data transfer	Transfer from K019	Calculated recoveries over 100%
		Steam Stripping, Biological Treatment (WW)	Industry submitted	Data	Submitted with data	Calculated recoveries over 100%
2/3	K011, K013, K014	Rotary Kiln Incineration (NW)	EPA test	Data	EPA data	Calculated recoveries over 100%
3/3	K011, K013, K014	Wet Air Oxidation (WW)	Industry	Data	Submitted with data	No calculated recoveries over 100%
1/3	K015	No Land Disposal (NW)	K015	EPA data	EPA data	Calculated recoveries over over 100%
		Incineration (Organics-WW) Chemical Precipitation (NW)	EPA data	Data transfer	Data transfer	Calculated recoveries over 100%
3/3	K015	Incineration (Organics), Stabilization (Metals)	K048-52, K087	Transfer	Transfer from K087, F019, K048-52	No calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
3/3	K017	Incineration (NW)	F024	Transfer	Transfer from F024	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
1/3	K016, K019, K020, K030	Rotary Kiln Incineration (Organics-NW and WW)	EPA test	Data	EPA data	Calculated recoveries over 100%
1/3	K021	No Land Disposal Based On No Generation	NA		NA	NA
3/3	K021	Incineration (Organics-NW)	K019, K087	Transfer	Transfer from K019, K087	No calculated recoveries over 100%
		Stabilization (Metals-NW)	K048-52	Transfer	Transfer from K048-52	No recoveries over over 100%
		Biotreatment, Steam Stripping Carbon Adsorption, Liquid Extraction	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
1/3	K022	Fuel Substitution (Organics)	EPA test	Data	Submitted with data	Calculated recoveries over 100%
		Stabilization (Metals)	Transfer from F006	Transfer	Transfer from F006	
		No Land Disposal for Wastewaters	NA	NA	NA	NA

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
3/3	K022	Biological Treatment, Steam Stripping, Carbon Adsorption, Liquid Extraction, etc. (Organics-WW) Chemical Precipitation, Filtration (Metals-NW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No recoveries over 100%
3/3	K025, K026	Incineration (Nonwastewaters) Incineration or Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	Method of treatment Method of treatment	NA NA	NA NA	NA NA
2/3	K023	Incineration	K024	Transfer	Transfer from K024	Calculated recoveries over 100%
1/3	K024	Incineration (Organics-NW and WW)	EPA test	Data	EPA data	Calculated recoveries over 100%
1/3	K025	No Land Disposal Based On No Generation	NA	NA	NA	NA
2/3	K027	Incineration or Fuel Substitution Carbon Adsorption Followed by Incineration or Fuel Substitution of Spent Carbon (WW)	Method of treatment	NA	NA	NA

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
2/3	K028, K029 (NW only for K029)	Incineration (Organics-NW)	F024, K019	Transfer	Transfer from F024, K019	Calculated recoveries over 100%
		Stabilization (Metals-NW)	K048-K052	Transfer	Transfer from K048-52	Calculated recoveries over 100%
		Chemical Precipitation (Metals-WW)	K062	Transfer	Transfer from K062	Calculated recoveries over 100%
3/3	K028	Stabilization (Metals-NW only revised)	F024	Transfer	Transfer from F024	No recoveries over 100%
3/3	K029	Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
		Stabilization (NW)	F024	Transfer	Transfer from F024	No recoveries over 100%
3/3	K032, K033, K034	Incineration (NW)	EPA test	Data	EPA data	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
3/3	K035	Incineration (Nonwastewaters)	K086	Transfer	Transfer	No recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (Organic-WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
		Chemical Precipitation, Filtration (Metals-NW)				

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
1/3	K036	No Land Disposal Based On No Generation	NA	NA	NA	NA
2/3	K036	Biological Treatment	Industry submitted	Data	Industry submitted	Calculated recoveries over 100%
3/3	K036	Incineration (Nonwastewaters for Disulfoton)	K037	Transfer	Transfer from K037	No calculated recoveries over 100%
1/3	K037	Incineration (Organics-WW and NW)	EPA test	Data	EPA data	Calculated recoveries over 100%
3/3	K037	Biological Treatment (WW)	EPA test	Data	EPA data	No calculated recoveries over 100%
2/3	K038, K040	Incineration (NW)	K037	Transfer from K037	Transfer from K037	Calculated recoveries over 100%
		Biological Treatment (WW)	Industry submitted	Data	Industry submitted	Calculated recoveries over 100%
3/3	K041	Incineration (NW)	EPA test	Data	EPA data	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
3/3	K042	Incineration (NW)	EPA test	Data	EPA data	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume a	No calculated recoveries over 100%
2/3	K043	Incineration	EPA test	Data	Data	No calculated recoveries over 100%
1/3	K044, K045, K047	No Land Disposal	NA	NA	NA	NA
3/3	K044, K045, K047	Deactivation	NA	NA	NA	NA
1/3	K046 (Nonreactive)	Stabilization (Metals-WW)	EPA test	Data	EPA data	Calculated recoveries over 100%
3/3	K046 (Reactives)	Deactivation, Stabilization (Nonwastewaters)	Industry	Data	Industry	No calculated recoveries over 100%
		Alkaline Precipitation, Settling, Filtration (WW-Reactive and Nonreactives)	K062	Transfer	Transfer from K062	No calculated recoveries over 100%
1/3	K048-K052	Fluidized Bed Incineration, Solvent Extraction, Thermal Drying	EPA test and industry submitted	Data	Submitted with data	Calculated recoveries over 100%
3/3	K048-K052	Incineration, Solvent Extraction (Organic-NW)	EPA test and industry data	Data	Data	No recoveries over 100%
		Stabilization (Metals-NW)	Industry data	Data	Data	No recoveries over 100%
		Alkaline Chlorination (NW-WW)	Transfer	Transfer	Transfer	No recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
1/3	K060	No Land Disposal Based On No Generation	NA	NA	NA	NA
3/3	K060	Biological Treatment (Wastewaters)	EPA data	Transfer	EPA data	No calculated recoveries over 100%
		Incineration (Nonwastewaters)	K087	Transfer	K087	No calculated recoveries over 100%
1/3	K061 (Low Zinc)	High Temperature Metals Recovery, Stabilization	EPA test	Data	EPA data	Calculated recoveries over 100%
1/3	K061 (High Zinc)	Recycling	NA	NA	NA	NA
3/3	K061	Chemical Reduction (WW)	K062 transfer	Transfer	K062 transfer	No calculated recoveries over 100%
		Chemical Precipitation (WW)	Industry data	Data for lead	Industry data	No calculated recoveries over 100%
1/3	K062	Chromium Reduction, Chemical Precipitation	EPA test	Data	Transferred	Calculated recoveries over 100%
1/3	K069	No Land Disposal Based on Recycling	NA	NA	NA	NA
3/3	K069	Chemical Precipitation (WW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Stabilization, Vitrification (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
1/3	K071	Acid Leaching, Chemical Oxidation	EPA test	Data	Submitted with data	Calculated recoveries over 100%
3/3	K071	Thermal Processing, Acid Leaching, Stabilization (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Chemical Precipitation (WW)	K071	Data	Transfer from K071	No calculated recoveries over 100%
1/3	K073	No Land Disposal Based On No Generation	NA	NA	NA	NA
3/3	K073	Incineration (Nonwastewaters)	K019	Transfer	Transfer from K019	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
1/3	K083	No Land Disposal Based On No Ash	NA	NA	NA	NA
3/3	K083	Incineration (Nonwastewaters)	K086	Transfer	Transfer	No recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (Organics-WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No recoveries over 100%
		Chemical Precipitation, Filtration (Metals-WW)				

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
3/3	K085	Incineration (NW)	EPA test	Data	EPA data	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction	F039, Volume A	Transfer	Transfer from F039, Volume a	No calculated recoveries over 100%
1/3	K086 (Solvent wastes)	Incineration	EPA test	Data	EPA data	Calculated recoveries over 100%
		Chemical Precipitation (Metals-WW)	Transfer from K062	Transfer	Transfer	Calculated recoveries over 100%
3/3	K086	Incineration (NW)	F039, Volume A	Data transfer	EPA data	No recoveries over 100%
		Alkaline Chlorination (Cyanides)	F006-F012	Transfer	F006-F012	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
1/3	K087	Incineration	EPA test	Data	EPA data	Calculated recoveries over 100%
2/3	K093	Incineration	K024	Transfer	Transfer from K024	Calculated recoveries over 100%
2/3	K094	Incineration	K024	Transfer	Transfer from K024	Calculated recoveries over 100%
2/3	K095, K096 (NW only)	Incineration (Organics)	F024, K019	Transfer	Transfer from F024, K019	Calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
3/3	K095, K096	Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No recoveries over 100%
		Stabilization (NW)	F024	Transfer	Transfer from F024	No recoveries over 100%
3/3	K097, K098	Incineration (NW)	EPA test	Data	EPA data	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume A	No calculated recoveries over 100%
1/3	K099	Chemical Oxidation	EPA data and industry submitted	Data	EPA data	Calculated recoveries over 100%
1/3	K100	No Land Disposal Based On No Generation	NA	NA	NA	NA
3/3	K100	Chemical Precipitation (WW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Stabilization, Vitrification (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
1/3	K101, K102	Incineration (Organics-NW and WW)	EPA test	Data	EPA data	Calculated recoveries over 100%
		Stabilization (Metals-NW)	Transfer	Transfer	Data	No calculated recoveries over 100%
		Chemical Precipitation (Metals-WW)	Transfer	Transfer	Transfer	No calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
3/3	K101, K102	Incineration (Organics)	EPA test	Data	EPA data	Calculated recoveries over 100%
		Stabilization Technologies (Metals-NW)	Industry submitted	Data	Data	Calculated recoveries over 100%
		Chemical Precipitation (WW)	EPA data	Data	Data	No recoveries over 100%
1/3	K104, K105	Liquid/Liquid Extraction, Steam Stripping, Carbon Adsorption	EPA test	Data	Data	Calculated recoveries over 100%
3/3	K105	Incineration (NW)	EPA test	Data	EPA data	No calculated recoveries over 100%
		Biotreatment, Steam Stripping, Carbon Adsorption, Liquid Extraction (WW)	F039, Volume A	Transfer	Transfer from F039, Volume a	No calculated recoveries over 100%
3/3	K106	Thermal Processing, Acid Leaching, Stabilization (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Chemical Precipitation (WW)	K071	Data	Transfer from K071	No calculated recoveries over 100%
2/3	K113, K114, K115 K116	Incineration or Fuel Substitution (NW)	NA	NA	NA	NA
		Stabilization (Metals-NW)	Transfer	Transfer from F006	Data	Calculated recoveries over 100%
		Carbon Adsorption Followed by Incineration or Fuel Substitution of Spent Carbon (WW)	Method of treatment	NA	NA	NA

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
2/3	K221	Incineration	K015, K086	Transfer	Transfer from K015, K085	Calculated recoveries over 100%
3/3	D001	Deactivation to Remove Ignitability or Incineration/Fuel Substitution for High TOC D001	EPA, Industry	Data	NA	NA
3/3	D002	Deactivation to Remove Corrosivity	EPA, Industry	Data	NA	NA
3/3	D003	Deactivation to Remove Reactivity Except for Cyanides	NA	NA	NA	NA
		Alkaline Chlorination (Cyanides)	EPA data	Transfer	Transfer from F007	No recoveries over 100%
3/3	Arsenic (D004)	Vitrification (NW)	Industry	Data	Industry data	No recoveries over 100%
		Chemical Precipitation (WW)	Industry	Data	Industry data	No recoveries over 100%
3/3	Arsenic (K031, K084, P010, P012, P036, P038, U136)	Vitrification (NW)	Industry	Data	Industry data	No recoveries over 100%
		Chemical Precipitation (WW)	Industry	Industry data	Industry data	No recoveries over 100%
3/3	Barium (D005, P013)	Chemical Precipitation (WW)	EPA data	Data	EPA data	No calculated recoveries over 100%
		Stabilization (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
3/3	Cadmium (D006)	Chemical Precipitation (WW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Stabilization (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Thermal Recovery (Cadmium Batteries)	Industry submitted	NA	NA	NA
3/3	Chromium (D007, U032)	Chemical Precipitation (WW)	EPA data	Data	EPA data	No calculated recoveries over 100%
		Stabilization (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Recovery (Refractory Bricks)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
3/3	Lead (D008, D110, U144-U146)	Chemical Precipitation (WW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Stabilization, Vitrification (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
3/3	Mercury (D009, P065, P092, U151)	Thermal Processing, Acid Leaching, Stabilization (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Chemical Precipitation (WW)	K071	Transfer	Transfer from K071	No calculated recoveries over 100%
3/3	Selenium (D010, P103, P114, U204, U205)	Chemical Precipitation (WW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%
		Stabilization, Vitrification (NW)	Industry submitted	Data	Industry submitted	No calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
3/3	Silver (D011, P099, P104)	Chemical Precipitation, Ion Exchange (WW)	Industry submitted, EPA data	Data, transfer	Industry submitted, EPA data	No calculated recoveries over 100%
		Recovery, Stabilization (NW)	Industry submitted, EPA data	Data	Industry submitted, EPA data	No calculated recoveries over 100%
3/3	Thallium (P113, P114, P115, U214 U215, U216, U217)	Recovery, Stabilization (NW)	Industry	Data	Industry	No calculated recoveries over 100%
		Chemical Oxidation, Chemical Precipitation (WW)	EPA data	Data	EPA data	No calculated recoveries over 100%
3/3	Vanadium (P119, P120	Recovery, Chemical Precipitation (WW)	Industry	Data	Industry	No calculated recoveries over 100%
		Recovery, Stabilization (NW)	Industry	Data	Industry	No calculated recoveries over 100%
3/3	D012, D013, D014 D015, D016, D017	Incineration (NW)	Method of treatment	NA	NA	NA
		Incineration (All), Biodegradation (D012, D015, D016) Carbon Adsorption (D013), Wet Air Oxidation (D014), Chemical Oxidation (D016, D017)				
2/3	P039, P040, P041, P043, P044, P062, P071, P085, P089, P094, P097, P109, P111, U058, U087, U235	Incineration (NW)	K037	Transfer	Transfer from K037	Calculated recoveries over 100%
		Biological Treatment (WW)	Industry submitted	Data	Industry data	Calculated recoveries over 100%

Table 4-1 (Continued)

Promulgated regulation in specific third	Waste code(s)	BDAT technology	Source of performance data	Type of data (actual data vs. transfer)	QC data (actual data vs. transfer	Accuracy correction calculations
2/3	Cyanide U&P Wastes (P013, P021, P029, P030, P063, P074, P098, P099, P104, P106, P121)	Electrolytic Oxidation, Alkaline Chlorination	Industry submitted F006-F012, F019	Data, transfer	Submitted with data Transfer from F006-F012, F019	Calculated recoveries over 100%
2/3	U028, U069, U088, U102, U107, U190	Incineration	K024	Transfer	Transfer from K024	Calculated recoveries over 100%
2/3	U221, U223	Incineration or Fuel Substitution (NW) Carbon Adsorption Followed by Incineration or Fuel Substitution of Spent Carbon (WW)	Method of treatment	NA	NA	NA
3/3	U & P wastes not previously regulated	Incineration (NW) Biological Treatment, etc. (WW)	EPA data EPA data	Transfer Transfer	Transfer Transfer	No recoveries over 100% No recoveries over 100%

5.0 REFERENCES

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APPENDIX A

Outlier Procedure

An outlier in a data set is an observation (or data point) that is significantly different from the other data. The measure of difference is determined by the statistical methods known as a Z-score. Because the outlier test assumes data to be normally distributed, it is necessary to transform the data by computing the logarithm of each data point before performing the outlier test. The Z-score is calculated by dividing the difference between the data point and the average of the data set by the standard deviation. For data, this is normally distributed, 99.5 percent (or two standard deviations) of the measurements will have a Z-score between -2.0 and 2.0. A data point outside this range is not considered to be representative of the population from which the data are drawn.

EPA uses this statistical method to confirm that certain data do not represent treatment by a well-operated system. The Agency uses this method only in cases where data on the design and operation of a treatment system were limited. This method is a commonly used technique for evaluating data sets.

APPENDIX B

ANOVA Test

F Value Determination for ANOVA Test

EPA is using the statistical method known as analysis of variance (ANOVA) to determine the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets.

If the Agency finds that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA then averages the long-term performance values achieved by each technology and multiplies this value by the largest variability factor associated with any of the acceptable technologies. If EPA finds that one technology performs significantly better (i.e., the data sets are not homogeneous), the "best" technology would be the technology that achieves the best level of performance, i.e., the technology with the lowest mean value.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table B-1.) These critical values are available in most statistics texts (see, for example, *Statistical Concepts and Methods* by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

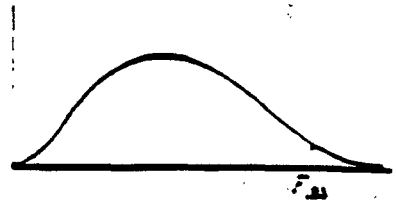
Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine whether any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

95th PERCENTILE VALUES FOR THE *F* DISTRIBUTION

n_1 = degrees of freedom for numerator

n_2 = degrees of freedom for denominator

(shaded area = .95)



$n_1 = k-1 \qquad n_2 = N-k$

n_2 \ n_1	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.22	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.45	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.22	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.35	1.24	1.00

Table B-7 95th Percentile Values for the F Distribution

The F value is calculated as follows:

(i) All data are natural logtransformed.
(ii) The sum of the data points for each data set is computed (T_i).
(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left(\frac{\left[\sum_{i=1}^{k} T_i \right]^2}{N} \right)$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtrnasformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_1} x^2 i\, j \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

where:

$x_{i,j}$ = The natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

MSB = SSB/(k-1) and
MSW = SSW/(N-k).

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F
Between	k-1	SSB	MSB = SSB/k-1	
MSB/MSW				
Within	N-k	SSW	MSW = SSW/N-k	

Following are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case where one technology is significantly better treatment than the other technology.

Example 1
Methylene Chloride

Steam stripping				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]²	Influent (µg/l)	Effluent (µg/l	ln(effluent)	[ln(effluent)]²
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640.00	10.00	2.30	5.29	1817.00	10.00	2.30	5.29
5100.00	12.00	2.48	6.15	1640.00	26.00	3.26	10.63
1450.00	10.00	2.30	5.29	3907.00	10.00	2.30	5.29
4600.00	10.00	2.30	5.29				
1760.00	10.00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum:							
-	-	23.18	53.76	-	-	12.46	31.79
Sample Size:							
10	10	10	-	5	5	5	-
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328.67	.63	.06	-	923.04	7.15	.43	-
Variability Factor:							
-	1.15	-	-	-	2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)\right] - \left[\frac{\left(\sum_{i=1}^{k} T_i\right)^2}{N}\right]$$

$$SSW = \left[\sum_{i=1}^{k}\sum_{j=1}^{n_i} x^2_{i,j}\right] - \sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

Example 1 (continued)

F = MSB/MSW

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} = the nat. logtransformed observations (j) for treatment technology (i)

$n_1 = 10, n_2 = 5, N = 15, k = 2, T_1 = 23.18, T_2 = 12.46, T = 35.46, T^2 = 1270.21$

$T_1^2 = 537.31 \quad T_2^2 = 155.25$

$$SSB = \left(\frac{537.31}{10} + \frac{155.25}{5} \right) - \frac{1270.21}{15} = 0.10$$

$$SSW = (53.76 + 31.79) - \left(\frac{537.31}{10} + \frac{155.25}{5} \right) = 0.77$$

MSB = 0.10/1 = 0.10

MSW = 0.77/13 = 0.06

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.10	0.10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

NOTE: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculation.

Example 2
Trichloroethylene

Activated sludge followed by adsorption				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]²	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]²
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10.00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10.00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10.00	2.30	5.29	163.00	10.00	2.30	5.29
210.00	10.00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.89				
204.00	85.00	4.44	19.71				
160.00	10.00	2.30	5.29				
Sum:							
-	-	26.14	72.92	-	-	16.59	39.52
Sample Size:							
10	10	10	-	7	7	7	-
Mean:							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation:							
3209.6	23.7	.71	-	120.5	2.36	.19	-
Variability Factor:							
-	3.70	-	-	-	1.53	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)\right] - \left[\frac{\left(\sum_{i=1}^{k} T_i\right)^2}{N}\right]$$

$$SSW = \left[\sum_{i=1}^{k}\sum_{j=1}^{n_i} x^2_{i,j}\right] - \sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

F = MSB/MSW

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} = the nat. logtransformed observations (j) for treatment technology (i)

$N_1 = 10, N_2 = 7, N = 17, k = 2, T_1 = 26.14, T_2 = 16.59, T = 42.73, T^2 = 1825.85, T_1^2 = 683.30, T_2^2 = 275.23$

$$SSB = \left(\frac{683.30}{10} + \frac{275.23}{7}\right) - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left(\frac{683.30}{10} + \frac{275.23}{7}\right) = 4.79$$

MSB = 0.25/1 = 0.25

MSW = 4.79/15 = 0.32

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

NOTE: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculation.

Example 3
Chlorobenzene

Steam stripping				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]²	Influent (µg/l)	Effluent (µg/l	ln(effluent)	[ln(effluent)]²
7200.00	80.00	4.38	19.18	9206.00	1083.00	6.99	48.86
6500.00	70.00	4.25	18.06	16646.00	709.50	6.56	43.03
6075.00	35.00	3.56	12.67	49775.00	460.00	6.13	37.58
3040.00	10.00	2.30	5.29	14731.00	142.00	4.96	24.60
				3159.00	603.00	6.40	40.96
				6756.00	153.00	5.03	25.30
				3040.00	17.00	2.83	8.01
Sum:							
-	-	14.49	55.20	-	-	38.90	228.34
Sample Size:							
4	4	4	-	7	7	7	-
Mean:							
5703	49	3.62	-	14759	452.5	5.56	-
Standard Deviation:							
1835.4	32.24	.95	-	16311.86	379.04	1.42	-
Variability Factor:							
-	7.00	-	-	-	15.79	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

Example 3 (continued)

F = MSB/MSW

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} = the nat. logtransformed observations (j) for treatment technology (i)

$N_1 = 4, N_2 = 7, N = 11, k = 2, T_1 = 14.49, T_2 = 38.90, T = 53.39, T^2 = 2850.49, T_1^2 = 209.96, T_2^2 = 1513.21$

$$SSB = \left(\frac{209.96}{4} + \frac{1513.21}{7} \right) - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left(\frac{209.96}{4} + \frac{1513.21}{7} \right) = 14.88$$

MSB = 9.52/1 = 9.52

MSW = 14.88/9 = 1.65

F = 9.52/1.65 = 5.77

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is less than the critical value, the means are significantly different (i.e., they are heterogeneous). Activated sludge followed by carbon adsorption is "best" in this example because the mean of the long-term performance value, i.e., the effluent concentration, is lower

NOTE: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculation.

APPENDIX C

Accuracy Correction Procedure

Accuracy Correction Procedure

To calculate treatment standards, it is first necessary to adjust laboratory results for accuracy, based on the laboratory test's "recovery value" for each constituent it analyzes.* The recovery value measures the amount of constituent recovered after "spiking"--the addition to the waste sample of a known amount of constituent. The recovery value is equal to the amount of constituent recovered after spiking, minus the initial concentration in the sample, divided by the amount recovered.

Once the recovery value is determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

1. If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value--the value that will yield the most conservative estimate of treatment achieved. (If a spike recovery value of less than 20 percent is reported for a specific constituent, however, the data cannot be used to set a national treatment standard and are discarded.)

2. If data are not available for a specific constituent, but are available for an isomer, then the spike recovery data are transferred from the isomer, and the data are adjusted using the percent recovery selected, according to the procedure described in (1) above.

3. If data are not avaiable for a specific constituent, but are available for a similar class of constituents, then spike recovery values for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spiked sample are averaged, and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by the lowest average value.

4. If spike recovery data are not available for the waste matrix, then spike recovery values are transferred from a waste that the Agency believes is a similar matrix. For instance, if the data are for an ash resulting from incineration, then data from other incinerator

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*It may also be necessary to estimate recovery values in order to perform the ANOVA test discussed in Section 3.2 to determine which demonstrated technologies are "best."

ashes could be used. This is not an exact analysis, but it is considered the best practical approach. In assessing the recovery data to be transferred, the procedures outlined in (1), (2), and (3) above are followed.

The analytical procedures employed to generate the data used to calculate each treatment standard for tested wastes are provided in the background document prepared for that waste. Any alternatives or equivalent procedures and/or equipment allowed by the approved methods will also be documented in EPA's SW-846, Third Edition (November 1986). NOTE: The Agency will use the methods and procedures presented in each background document to enforce the treatment standards. Facilities should, therefore, use these procedures in assessing the performance of their treatment systems.

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APPENDIX D

Variability Factor

Variability Factor

$$VF = \frac{C_{99}}{Mean} \tag{1}$$

Where:

VF = estimate of the daily maximum variability factor determined from a sample population of daily data.

C_{99} = Estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = Exp(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data.

Mean = Average of the individual performance values.

EPA is establishing this figure as a maximum, because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered to be unknown and, hence, cannot be used to estimate the variability factor of the analytical results. The following is a description of EPA's approach for calculating the variability factor for cases in which all concentrations are below the detection limit.

It has been postulated that a lognormal distribution adequately describes the variation among concentrations. Agency data shows that the treatment residual concentrations are often distributed approximately lognormally. Therefore, the lognormal model has been used routinely in EPA's development of numerous regulations in the Effluent Guidelines Program and is being

used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean).

$$VF = \frac{C_{99}}{Mean} \tag{1}$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally distributed concentrations can be found in most mathematical statistics texts. (See, for example, Volume 1, by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp}\ (\mu + 2.33\ ) \tag{2}$$

$$\text{Mean} = \text{Exp}\ (\mu + 0.5\sigma^2) \tag{3}$$

By substitution (2) and (3) in (1), the VF can then be expressed in terms of σ as follows:

$$\text{VF} = \text{Exp}\ (2.33\sigma - 0.5\sigma^2) \tag{4}$$

$(.494)^2$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and, accordingly, the VF can be estimated using equation (1). For residuals with concentations that are below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a VF:

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is equal to one-tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally fall within one order of magnitude.

- Assumption 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).

- Assumption 3: The standard deviation (σ) of the normal distribution is approximated by:

$$\sigma = [(\ln(UL) - \ln(LL)] / [(2)(2.33)] = [\ln(UL/LL)] / 4.\cancel{55}\ 652 \qquad (5)$$

(Note that when LL = (0.1)(UL) as in Assumption 1, then $\sigma = (\ln 10) / 4.\cancel{66}\ 652 = 0.494$.)

Substitution of the σ values from equation (5) into equation (4) yields the VF.

$$VF = 2.8$$

For concentration data with only two data points, a reliable estimate of the variability of the data and, hence, the VF cannot be obtained. Nevertheless, the following procedure assumes that the population of concentration data from which these two samples were drawn is lognormally distributed. It is also assumed that the values of these two samples represent an estimate of the range (min and max) of population data.

The standard deviation σ of the corresponding normal distribution can be estimated using the ratio of the two available data points, R, (larger value/smaller value) as

$$\sigma = [\log(R)] / (2*2.33) = \log R/4.66 \qquad (6)$$

For several values of R (10, 20,...100)), the value of VF was obtained and tabulated in Table C-1. To use the table to find the VF (as calculated using (4)), the ratio of the larger value to the smaller value is obtained and rounded to the nearest R value in the Table. Alternatively, VF can be calculated by combining equations (4) and (6). The treatment standard is then calculated as:

$$C^{99} = (VF)\ (mean) \tag{7}$$

The mean is the average of the two treatment values.

Table D-1. Variability Factors When only Two Data Points Are Available

Ration of larger value to smaller value (order of magnitude)	Variability Factor
5	2.11
10	2.80
20	3.64
30	4.20
40	4.62
50	4.97
60	5.27
70	5.52
80	5.75
90	5.95
100	6.14

APPENDIX E

Calculation of Variability Factor When All Treated Residual Concentrations are Below the Detection Limit

Calculation of Variability Factor When All Treated Soil Concentrations are Below the Detection Limit

Agency data show that the treatment residual concentrations are often distributed approximately lognormally. Therefore, the lognormal model has been used routinely in EPA's development of numerous regulations in the Effluent Guidelines Program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean).

$$VF = \frac{C_{99}}{Mean} \tag{1}$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution, created by taking the natural logarithms of the lognormally distributed concentrations, can be found in most mathematical statistics texts. (See, for example, Volume 1, Johnson and Kotz, 1970.) The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (s) of the normal distribution as follows:

$$C_{99} = Exp\ (\mu + 2.33\ s) \tag{2}$$

$$Mean = Exp\ (\mu + 0.5\ s^2) \tag{3}$$

By substitution (2) and (3) in (1), the VF can then be expressed in terms of (s) as follows:

$$VF = Exp\ (2.33\ s - 0.5s^2) \tag{4}$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and, accordingly, the VF can be estimated using equation 1. For residuals with concentrations below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a VF.

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is equal to one-tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally fall within one order of magnitude.

- Assumption 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).

- Assumption 3: The standard deviation of the normal distribution is approximated by:

$$s = [(\ln (UL) - \ln (LL)] / [(2)(2.33)] = [\ln(UL/LL)] / 4.66 \quad (5)$$

(Note, when LL = (0.1)(UL) as in Assumption 1, then s = (ln10) / 4.66 = 0.494.)

Substitution of the s values from equation (5) into equation (4) yields the VF.

$$VF = 2.8 \quad (6)$$

For concentration data with only two data points, the following procedure can be used to estimate the variability of the data. This procedure assumes that the population of concentration data from which these two samples were drawn is lognormally distributed. It is also assumed that the values of these two samples represent an estimate of the range (min. and max.) of population data.

The standard deviation (s) of the corresponding normal distribution can be estimated using the ratio of the two available data points, R, (larger value/smaller value) as:

$$s = [\ln(R)] / (2*2.33) = \ln R/4.66 \quad (7)$$

For several values of R (10, 20,...100), the value of VF was obtained and tabulated in Table F-1. To use Table F-1 to find the VF (as calculated using (4)), the ratio of the larger value to the smaller value is obtained and rounded to the nearest R value. Alternatively, VF can be calculated by combining equations (4) and (7). The treatment standard is then calculated as:

$$C^{99} = (VF)\ (mean) \tag{8}$$

The mean is the average of the two treatment values.

Table F-1 Variability Factors When only Two Data Points Are Available

Ratio of larger value to smaller value (order of magnitude)	Variability Factor
5	2.11
10	2.80
20	3.64
30	4.20
40	4.62
50	4.97
60	5.27
70	5.52
80	5.75
90	5.95
100	6.14

APPENDIX F

Regulatory Standards for BDAT List Constituents

REGULATORY STANDARDS FOR BDAT LIST CONSTITUENTS

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FOOTNOTES

1. Wet air/carbon for salts.

2. Based on EP leachate analysis but this does not preclude the use of TCLP analysis.

3. Sum of diphenylamine and diphenylnitrosamine.

4. High mercury subcategory ≥260 mg/kg total mercury.

5. High mercury subcategory ≥260 mg/kg total mercury - contains mercury and organics (and are not incinerator residues).

6. High mercury subcategory ≥260 mg/kg total mercury - inorganics (including incineration residues and residues from retorting of mercury).

7. Low mercury subcategory <260 mg/kg total mercury.

8. Low mercury subcategory <260 mg/kg total mercury - residues from retorting of mercury.

9. Low mercury subcategory <260 mg/kg total mercury - that are not residues from retorting of mercury.

10. Light ends subcategory.

11. Spent filters/aids and desiccants subcategory.

12. High Zn subcategory.

13. Low Zn subcategory.

14. In TCLP extract.

15. Radioactive hazardous mixed waste.

NR Not regulated.

SDR Regulated by solvent/dioxin rule.

TS Treatment technology specified.

• Not on BDAT list but regulated.

() Numbers in parenthesis refer to thirds.

Regulatory Standards for BDAT List Waste Constituents
Volatile Organics

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
222.	Acetone	K086	0.28	(3)	160	(3)
		U002	0.28	(3)	160	(3)
		SDR	0.05		0.59(1)	
1.	Acetonitrile	K011	38	(3)	1.8	(2)
		K013	38	(3)	1.8	(2)
		K014	38	(3)	1.8	(2)
		U003	0.17	(3)	0.17	(3)
2.	Acrolein	P003	NR	(3)	TS	(3)
3.	Acrylonitrile	K011	0.06	(3)	1.4	(2)
		K013	0.06	(3)	1.4	(2)
		K014	0.06	(3)	1.4	(2)
		U009	0.24	(3)	84	(3)
4.	Benzene	F005	0.07	(3)	3.7	(3)
		K011	0.02	(3)	0.03	(2)
		K013	0.02	(3)	0.03	(2)
		K014	0.02	(3)	0.03	(2)
		K048	0.011	(1)	14	(3)
		K049	0.011	(1)	14	(3)
		K051	0.011	(1)	14	(3)
		K052	0.011	(1)	14	(3)
		K060	0.17	(3)	0.071	(3)
		K083	0.14	(3)	6.6	(3)
		K085	0.14	(3)	4.4	(3)
		K087	0.014	(1)	0.071	(1)
		K103	0.15	(1)	6.0	(1)
		K104	0.15	(1)	6.0	(1)
		K105	0.14	(3)	4.4	(3)
		U019	0.14	(3)	36	(3)
5.	Bromodichloromethane	NR				
6.	Bromomethane	U029	0.11	(3)	15	(3)

Regulatory Standards for BDAT List Waste Constituents
Volatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
223.	n-Butyl alcohol	K086	5.6	(3)	2.6	(3)
		U031	5.6	(3)	2.6	(3)
		SDR	5.0		5.0[13]	
7.	Carbon tetrachloride	F025[9]	0.057	(3)	6.2	(3)
		F025[9]	0.057	(3)	6.2	(3)
		K021	0.057	(3)	6.2	(3)
		K073	0.057	(3)	6.2	(3)
		U211	0.057	(3)	5.6	(3)
		SDR	0.05		0.96[13]	
8.	Carbon disulfide	K049	0.011	(1)	NR	
		SDR	1.05		4.81[13]	
9.	Chlorobenzene	K019	0.006	(1)	6.0	(1)
		K085	0.057	(3)	4.4	(3)
		K105	0.057	(3)	4.4	(3)
		U037	0.057	(3)	5.7	(3)
		SDR	0.15		0.15[13]	
10.	2-Chloro-1,3-butadiene	F024	0.28	(2)	0.28	(2)
11.	Chlorodibromomethane	NR				
12.	Chloroethane	K018	0.007	(1)	6.0	(1)
13.	2-Chloroethylvinylether	NR				
14.	Chloroform	F025[9]	0.046	(3)	6.2	(3)
		F025[9]	0.046	(3)	6.2	(3)
		K009	0.10	(2)	6.0	(2)
		K010	0.10	(2)	6.0	(2)
		K019	0.007	(1)	6.0	(1)
		K021	0.046	(3)	6.2	(3)
		K029	0.046	(3)	6.0	(2)
		K073	0.046	(3)	6.2	(3)
		U044	0.046	(3)	5.6	(3)

Regulatory Standards for BDAT List Waste Constituents
Volatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
15.	Chloromethane	K018	0.007	(1)	NR	
		U045	0.19	(3)	33	(3)
16.	3-Chloropropene	F024	0.28	(2)	0.28	(2)
17.	1,2-Dibromo-3-chloropropene	U066	0.11	(3)	15	(3)
18.	1,2-Dibromoethane	U067	0.028	(3)	15	(3)
19.	Dibromoethane	U068	0.11	(3)	15	(3)
20.	Trans-1,4 Dichloro-2-butene	U074	TS	(3)	TS	(3)
21.	2 Dichlorodifluoromethane	U075	0.23	(3)	7.2	(3)
22.	1,1-Dichloroethane	F024	0.014	(2)	0.014	(2)
		K018	0.007	(1)	6.0	(1)
		K028	0.007	(2)	6.0	(2)
		U076	0.059	(3)	7.2	(3)
23.	1,2-Dichloroethane	F024	0.014	(2)	0.014	(2)
		F025[a]	0.21	(3)	6.2	(3)
		K018	0.007	(1)	6.0	(1)
		K019	0.007	(1)	6.0	(1)
		K020	0.007	(1)	6.0	(1)
		K029	0.21	(3)	6.0	(2)
		U077	0.21	(3)	7.2	(3)
24.	1,1-Dichloroethylene	F025[a]	0.025	(3)	6.2	(3)
		K029	0.025	(3)	6.0	(2)
		U078	0.025	(3)	33	(3)
25.	Trans-1,2 Dichloroethene	U079	0.054	(3)	33	(3)

Regulatory Standards for BDAT List Waste Constituents
Volatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
26.	1,2-Dichloropropane	F024	0.014	(2)	0.014	(2)
		K017	0.85	(3)	18	(3)
		U083	0.85	(3)	18	(3)
27.	Trans-1,3-Dichloropropene	F024	0.014	(2)	0.014	(2)
		U084	0.036	(3)	18	(3)
28.	Cis-1,3-Dichloropropene	F024	0.014	(2)	0.014	(2)
		U084	0.036	(3)	18	(3)
29.	1,4 Dioxane	U108	0.12	(3)	170	(3)
	2-Ethoxyethenol	F005	TS	(3)	TS	(3)
225.	Ethyl acetate	K086	0.34	(3)	33	(3)
		U112	0.34	(3)	33	(3)
		SDR	0.05		0.75[(1)]	
226.	Ethyl benzene	K048	0.011	(1)	14	(3)
		K049	0.011	(1)	14	(3)
		K051	0.011	(1)	14	(3)
		K052	0.011	(1)	14	(3)
		K086	0.057	(3)	6.0	(3)
		SDR	0.05		0.053[(1)]	
30.	Ethyl cyanide	P101	0.24	(3)	360	(3)
227.	Ethyl ether	U117	0.12	(3)	160	(3)
		SDR	0.05		0.75[(1)]	
31.	Ethyl methacrylate	U118	0.14	(3)	160	(3)
214.	Ethylene oxide	NR				
32.	Iodomethane	U138	0.19	(3)	65	(3)
33.	Isobutyl alcohol	U140	5.6	(3)	170	(3)
		SDR	5.0		5.0[(1)]	

Regulatory Standards for BDAT List Waste Constituents
Volatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
228.	Methanol	K086	5.6	(3)	NR	(3)
		U154	5.6	(3)	TS	(3)
		SDR	0.25		0.75[13]	
34.	Methyl ethyl ketone	K086	0.28	(3)	36	(3)
		U159	0.28	(3)	36	(3)
		SDR	0.05		0.75[13]	
229.	Methyl isobutyl ketone	K086	0.14	(3)	33	(3)
		U161	0.14	(3)	33	(3)
		SDR	0.05		0.33[13]	
35.	Methyl methacrylate	U162	0.14	(3)	160	(3)
37.	Methacrylonitrile	U152	0.24	(3)	84	(3)
38.	Methylene Chloride	F001	0.44	(1)	NR	
		F002	0.44	(1)	NR	
		F003	0.44	(1)	NR	
		F004	0.44	(1)	NR	
		F005	0.44	(1)	NR	
		F025[9]	0.089	(3)	31	(3)
		F025[9]	0.089	(3)	31	(3)
		K086	0.089	(3)	33	(3)
		U080	0.089	(3)	33	(3)
		SDR	0.20		0.96[13]	
	2-Nitropropane	F005	TS	(3)	TS	(3)
39.	Pyridine	K026	TS	(3)	TS	(3)
		U196	0.014	(3)	16	(3)
		SDR	1.12		0.33[13]	
40.	1,1,1,2-Tetrachloroethane	K028	0.007	(2)	5.6	(2)
		K095	0.057	(3)	5.6	(2)
		K096	0.057	(3)	5.6	(2)
		U208	0.057	(3)	42	(3)

Regulatory Standards for BDAT List Waste Constituents
Volatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
41.	1,1,2,2-Tetrachloroethane	K020	0.007	(1)	5.6	(1)
		K028	0.007	(2)	5.6	(2)
		K095	0.057	(3)	5.6	(2)
		K096	0.057	(3)	5.6	(2)
		U209	0.057	(3)	42	(3)
42.	Tetrachloroethene	K016	0.007	(1)	6.0	(1)
		K019	0.007	(1)	6.0	(1)
		K020	0.007	(1)	6.0	(1)
		K028	0.007	(2)	6.0	(2)
		K030	0.007	(1)	6.0	(1)
		K043	0.006	(2)	1.7	(2)
		K073	0.056	(3)	6.2	(3)
		K095	0.056	(3)	6.0	(2)
		K096	0.056	(3)	6.0	(2)
		U210	0.056	(3)	5.6	(3)
		SDR	0.079		0.05(1)	
43.	Toluene	K001	0.028	(3)	28	(3)
		K015	.15	(1)	6.0	(3)
		K022	0.080	(3)	0.034	(1)
		K037	0.080	(3)	28	(1)
		K048	0.011	(1)	14	(3)
		K049	0.011	(1)	14	(3)
		K051	0.011	(1)	14	(3)
		K052	0.011	(1)	14	(3)
		K086	0.080	(3)	28	(3)
		K087	0.008	(1)	0.65	(1)
		U051	0.028	(3)	28	(3)
		U220	0.080	(3)	28	(3)
		SDR	1.12		0.33(1)	
44.	Tribromomethane (Bromoform)	U225	0.63	(3)	15	(3)
45.	1,1,1-Trichloroethane	K018	0.007	(1)	6.0	(1)
		K019	0.007	(1)	6.0	(1)
		K028	0.007	(2)	6.0	(2)

Regulatory Standards for BDAT List Waste Constituents
Volatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
45.	1,1,1-Trichloroethane (continued)	K029	0.054	(3)	6.0	(2)
		K073	0.054	(3)	6.2	(3)
		K086	0.054	(3)	5.6	(3)
		U226	0.054	(3)	5.6	(3)
		SDR	1.05		0.41[13]	
46.	1,1,2-Trichloroethane	F001	0.030	(3)	7.6	(3)
		F002	0.030	(3)	7.6	(3)
		F003	0.030	(3)	7.6	(3)
		F004	0.030	(3)	7.6	(3)
		F005	0.030	(3)	7.6	(3)
		F025[9]	0.054	(3)	6.2	(3)
		F025[9]	0.054	(3)	6.2	(3)
		K028	0.007	(2)	6.0	(2)
		K095	0.054	(3)	6.0	(2)
		K096	0.054	(3)	6.0	(2)
		U227	0.054	(3)	5.6	(3)
47.	Trichloroethene	F025[9]	0.054	(3)	5.6	(3)
		F025[9]	0.054	(3)	5.6	(3)
		K086	0.054	(3)	5.6	(3)
		K095	0.054	(3)	5.6	(2)
		K096	0.054	(3)	5.6	(2)
		U228	0.054	(3)	5.6	(3)
		SDR	0.062		0.091[13]	
48.	Trichloromonofluoromethane	U121	0.020	(3)	33	(3)
		SDR	0.05		0.96[13]	
49.	1,2,3-Trichloropropane	K017	0.85	(3)	28	(3)
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	SDR	1.05		0.96[13]	
50.	Vinyl chloride	F025[9]	0.27	(3)	33	(3)
		F025[9]	0.27	(3)	33	(3)
		K029	0.27	(3)	6.0	(2)
		U043	0.27	(3)	33	(3)

Regulatory Standards for BDAT List Waste Constituents
Volatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
215.	1,2-Xylene	K001	0.032	(3)	33	(3)
	1,3-Xylene	K048	0.011	(1)	22	(3)
	1,4-Xylene (total)	K049	0.011	(1)	22	(3)
		K051	0.011	(1)	22	(3)
		K052	0.011	(1)	22	(3)
		K086	0.32	(3)	28	(3)
		K087	0.014	(1)	0.070	(1)
		U051	0.032	(3)	33	(3)
		U239	0.032	(3)	28	(3)
		SDR	0.05		0.15[13]	

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
51.	Acenaphthalene	K087	0.028	(1)	3.4	(1)
52.	Acenaphthene	K035	NR		3.4	(3)
		K051	0.050	(1)	3.4	
53.	Acetophenone	K022	0.010	(3)	19	(1)
		K086	0.010	(3)	9.7	(3)
		U004	0.010	(3)	9.7	(3)
233.	Acrylamide	K011	19	(3)	23	(2)
		K013	19	(3)	23	(2)
		K014	19	(3)	23	(2)
54.	2-Acetylaminofluorene	U005	0.059	(3)	140	(3)
55.	4-Aminobiphenyl	NR				
56.	Aniline	K083	0.81	(3)	14	(3)
		K013	4.5	(1)	5.6	(1)
		K104	4.5	(1)	5.6	(1)
		U012	0.81	(3)	14	(3)
57.	Anthracene	K015	1.0	(1)	3.4	(3)
		K035	NR		3.4	(3)
		K049	0.039	(1)	28	(3)
		K051	0.039	(1)	28	(3)
58.	Aramite	NR				
59.	Benz(a)anthracene	K035	0.059	(3)	3.4	(3)
		K051	0.043	(1)	20	(1)
		U018	0.059	(3)	8.2	(3)

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
60.	Benzenethiol	NR				
62.	Benzo(a)pyrene	K035	NR		3.4	(3)
		K048	0.047	(1)	12	(3)
		K049	0.047	(1)	12	(3)
		K050	0.047	(1)	12	(3)
		K051	0.047	(1)	12	(3)
		K052	0.047	(1)	12	(3)
		K060	0.035	(3)	3.6	(3)
		U022	0.061	(3)	8.2	(3)
63.	Benzo(b)fluoranthene	K015	.29	(1)	3.4	(3)
64.	Benzo-(ghi)perylene	NR				
65.	Benzo(k)fluoroanthene	K015	.29	(1)	3.4	(3)
66.	p-Benzoquinone	U197	TS	(3)	TS	(3)
67.	Bis(2-chloroethoxy)-methane	U024	0.036	(3)	7.2	(3)
68.	Bis(2-chloroethyl)-ether	K017	0.033	(3)	7.2	(3)
		K019	0.007	(1)	5.6	(1)
		U025	0.033	(3)	7.2	(3)
69.	Bis(2-chloroisopropyl) ether	U027	0.055	(3)	7.2	(3)
70.	Bis(2-ethylhexyl)-phthalate	F024	0.036	(2)	1.8	(2)
		K048	0.043	(1)	7.3	(3)
		K049	0.043	(1)	7.3	(3)
		K051	0.043	(1)	7.3	(3)
		K086	0.28	(1)	28	(1)
		U028	0.54	(2)	28	(2)

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
71.	4-Bromophenyl phenyl ether	U030	0.055	(3)	15	(3)
72.	Butylbenzyl phthalate	K086	0.017	(3)	7.9	(3)
73.	2-sec-Butyl-4,6-dinitrophenol	P020	0.066	(3)	2.5	(3)
74.	p-Chloroaniline	P024	0.46	(3)	16	(3)
75.	Chlorobenzilate	U038	0.10	(3)	TS	(3)
76.	p-Chloro m-cresol	U039	0.018	(3)	14	(3)
77.	2-Chloronaphthalene	U047	0.055	(3)	5.6	(3)
78.	2-Chlorophenol	K105	0.044	(3)	4.4	(3)
		U048	0.044	(3)	5.7	(3)
80.	Chrysene	K035	0.059	(3)	3.4	(3)
		K048	0.043	(1)	15	(3)
		K049	0.043	(1)	15	(3)
		K051	0.043	(1)	15	(3)
		K087	0.028	(1)	3.4	(1)
		U050	0.059	(3)	8.2	(3)
81.	Ortho-Cresol	K035	0.11	(3)	NR	
		K052	0.011	(1)	6.2	(3)
		U052	0.11	(3)	5.6	(3)
		SDR	2.82		0.75(**)	
82.	Para-Cresol	K035	0.77	(3)	NR	
		K052	0.011	(1)	6.2	(3)
		U052	0.77	(3)	3.2	(3)
		SDR	2.82		0.75(**)	

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
232.	Cyclohexanone	K083	0.36	(3)	NR	(3)
		K086	0.36	(3)	NR	(3)
		U057	0.36	(3)	TS	(3)
		SDR	0.125		0.75[1]	
83.	Dibenz(a,h)-anthracene	K035	NR		3.4	(3)
		U063	0.055	(3)	8.2	(3)
84.	Dibenzo(a,e)-pyrene	NR				
86.	m-Dichlorobenzene	K085	0.036	(3)	4.4	(3)
		K096	0.036	(3)	5.6	(2)
		U071	0.036	(3)	6.2	(3)
87.	o-Dichlorobenzene	K030	0.008	(1)	NR	
		K042	0.088	(3)	4.4	(3)
		K085	0.088	(3)	4.4	(3)
		K086	0.088	(3)	6.2	(3)
		K105	0.088	(3)	4.4	(3)
		U070	0.088	(3)	6.2	(3)
88.	p-Dichlorobenzene	K019	0.008	(1)	NR	
		K030	0.008	(1)	NR	
		K042	0.090	(3)	4.4	(3)
		K085	0.090	(3)	4.4	(3)
		K105	0.090	(3)	4.4	(3)
		U072	0.090	(3)	6.2	(3)
		SDR	0.65		0.125[1]	
89.	3,3'-Dichlorobenzidine	U073	TS	(3)	TS	(3)
234.	Cis-1,4-Dichloro-2-butene	U074	TS	(3)	TS	(3)
90.	2,4-Dichlorophenol	K043	0.049	(2)	0.38	(2)
		U081	0.044	(3)	14	(3)
91.	2,6-Dichlorophenol	K043	0.013	(2)	0.34	(2)
		U082	0.044	(3)	14	(3)

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
92.	Diethyl phthalate	K086	0.20	(3)	28	(3)
		U088	0.54	(2)	28	(2)
93.	3,3'-Dimethoxybenzidine	U091	TS	(3)	TS	(3)
94.	p-Dimethylaminoazobenzene	U093	0.13	(3)	TS	(3)
95.	3,3'-Dimethylbenzidine	U095	TS	(3)	TS	(3)
96.	2,4-Dimethyl phenol	K049	0.033	(1)	NR	
		K052	0.033	(1)	NR	
		U101	0.036	(3)	14	(3)
97.	Dimethyl phthalate	K086	0.047	(3)	28	(3)
		U102	0.54	(2)	28	(2)
98.	Di-n-butyl phthalate	K048	0.060	(1)	3.6	(3)
		K051	0.060	(1)	3.6	(3)
		K086	0.057	(3)	28	(3)
		U069	0.54	(2)	28	(2)
99.	1,4-Dinitrobenzene	NR				
100.	4,6-Dinitro-o-cresol	P047	0.28[1]	(3)	160[1]	(3)
101.	2,4-Dinitrophenol	K103	0.61	(1)	5.6	(1)
		K104	0.61	(1)	5.6	(1)
		P048	0.12	(3)	160	(3)
102.	2,4-Dinitrotoluene	K025	TS	(3)	TS	(3)
		U105	0.32	(3)	140	(3)
103.	2,6-Dinitrotoluene	U106	0.55	(3)	28	(3)
104.	Di-n-octyl phthalate	K086	0.017	(3)	28	(3)
		U107	0.54	(2)	28	(2)

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
105.	Di-n-propylnitrosamine	U111	0.40	(3)	14	(3)
106.	Diphenylamine	K022	0.52[3]	(3)	NR	
		K083	0.52[3]	(3)	NR	
219.	Diphenylnitrosamine	K022	0.40[3]	(3)	NR	
		K083	0.40[3]	(3)	NR	
107.	1,2-Diphenylhydrazine	U109	TS	(3)	TS	(3)
108.	Fluoranthene	K035	0.068	(3)	3.4	(3)
		K087	0.028	(1)	3.4	(1)
		U120	0.068	(3)	8.2	(3)
109.	Fluorene	K019	0.007	(1)	NR	
		K035	NR		3.4	(3)
		K048	0.050	(1)	NR	
		K051	0.050	(1)	NR	
110.	Hexachlorobenzene	F025[9]	0.055	(3)	37	(3)
		K016	0.033	(1)	28	(1)
		K018	0.033	(1)	28	(1)
		K085	0.055	(3)	4.4	(3)
		U127	0.055	(3)	37	(3)
111.	Hexachlorobutadiene	F025[9]	0.055	(3)	28	(3)
		K016	0.007	(1)	5.6	(1)
		K018	0.007	(1)	5.6	(1)
		K028	0.007	(2)	5.6	(2)
		K030	0.007	(1)	5.6	(1)
		U128	0.055	(3)	28	(3)
112.	Hexachlorocyclopentadiene	K016	0.007	(1)	5.6	(1)
		K032	0.057	(3)	2.4	(3)
		K033	0.057	(3)	2.4	(3)
		K034	0.057	(3)	2.4	(3)
		K097	0.057	(3)	2.4	(3)
		U130	0.057	(3)	3.6	(3)

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
113.	Hexachloroethane	F024	0.036	(2)	1.8	(2)
		F025[9]	0.055	(3)	30	(3)
		K016	0.033	(1)	28	(1)
		K018	NR		28	(1)
		K019	0.033	(1)	28	(1)
		K028	0.033	(2)	28	(2)
		K030	0.033	(1)	28	(1)
		K073	0.055	(3)	30	(3)
		K095	0.055	(3)	28	(2)
		U131	0.055	(3)	28	(3)
114.	Hexachlorophene	U132	TS	(3)	TS	(3)
115.	Hexachloropropene	K030	NR		19	(1)
		U243	0.035	(3)	28	(3)
116.	Ideno-(1,2,3-cd)pyrene	K035	NR		3.4	(3)
		K087	0.028	(1)	3.4	(1)
		U137	0.0055	(3)	8.2	(3)
117.	Isosafrole	U141	0.081	(3)	2.6	(3)
118.	Methapyrilene	U155	0.081	(3)	1.5	(3)
119.	3-Methylcholanthrene	U157	0.0055	(3)	15	(3)
120.	4,4'-Methylenebis-(2-chloro-aniline)	U158	0.50	(3)	35	(3)
36.	Methyl methane-sulfonate		NR			
121.	Napthalene	K001	0.031	(3)	1.5	(3)
		K019	0.007	(1)	5.6	(1)
		K035	0.059	(3)	3.4	(3)
		K048	0.033	(1)	42	(3)
		K049	0.033	(1)	42	(3)
		K051	0.033	(1)	42	(3)
		K052	0.033	(1)	42	(3)

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
121.	Napthalene (continued)	K060	0.028	(3)	3.4	(3)
		K086	0.059	(3)	3.1	(3)
		K087	0.028	(1)	3.4	(3)
		U051	0.031	(3)	1.5	(3)
		U165	0.059	(3)	3.1	(3)
122.	1,4-Napththoquinone	U166	TS	(3)	TS	(3)
123.	1-Napthylamine	U167	TS	(3)	TS	(3)
124.	2-Naphthylamine	U168	0.52	(3)	TS	(3)
	O-Nitroaniline	K101	0.27	(1)	14	(1)
125.	p-Nitroaniline	P077	0.028	(3)	28	(3)
126.	Nitrobenzene	K025	TS	(3)	TS	(3)
		K083	0.068	(3)	14	(3)
		K086	0.068	(3)	14	(3)
		K103	0.073	(1)	5.6	(1)
		K104	0.073	(1)	5.6	(1)
		U169	0.068	(3)	14	(3)
		SDR	0.66		0.125[13]	
127.	4-Nitrophenol	K025	TS	(3)	TS	(3)
		U170	0.12	(3)	29	(3)
	O-Nitrophenol	K102	0.028	(1)	13	(1)
128.	N-Nitrosodi-n-butylamine	U172	0.40	(3)	17	(3)
129.	N-Nitrosodiethylamine	U174	0.40	(3)	28	(3)
130.	N-Nitrosodimethylamine	P082	0.40	(3)	TS	(3)
131.	N-Nitrosomethylethylamine		NR			

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
132.	N-Nitrosomorpholine	NR				
133.	N-Nitrosopiperidine	U179	0.013	(3)	35	(3)
134.	N-Nitrosopyrrolidine	U180	0.013	(3)	35	(3)
135.	5-Nitro-o-toluidine	U181	0.32	(3)	28	(3)
136.	Pentachlorobenzene	K030	NR		28	(1)
		K042	0.055	(3)	4.4	(3)
		K085	0.055	(3)	4.4	(3)
		U183	0.055	(3)	37	(3)
137.	Pentachloroethane	K018	0.007	(1)	5.6	(1)
		K028	0.033	(2)	5.6	(2)
		K030	0.007	(1)	5.6	(1)
		K095	0.055	(3)	5.6	(2)
		K096	0.055	(3)	5.6	(2)
		U184	TS	(3)	TS	(3)
138.	Pentachloronitrobenzene	U185	0.055	(3)	4.8	(3)
139.	Pentachlorophenol	K001	0.18	(3)	7.4	(3)
		K043	0.22	(2)	1.9	(2)
		U051	0.18	(3)	7.4	(3)
		SDR	0.01		0.01[(1)]	
140.	Phenacetin	U187	0.081	(3)	16	(3)
141.	Phenanthrene	K001	0.031	(3)	1.5	(3)
		K015	0.27	(1)	3.4	(3)
		K019	0.007	(1)	5.6	(1)
		K035	0.059	(3)	3.4	(3)
		K048	0.039	(1)	34	(3)
		K049	0.039	(1)	34	(3)
		K051	0.039	(1)	34	(3)
		K052	0.039	(1)	34	(3)

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
141.	Phenanthrene (continued)	K087	0.028	(1)	3.4	(1)
		U051	0.031	(3)	1.5	(3)
142	Phenol	K022	0.039	(3)	12	
		K035	0.039	(3)	NR	
		K048	0.047	(1)	3.6	(3)
		K049	0.047	(1)	3.6	(3)
		K050	0.047	(1)	3.6	(3)
		K051	0.047	(1)	3.6	(3)
		K052	0.047	(1)	3.6	(3)
		K060	0.042	(3)	3.4	(3)
		K083	0.039	(3)	5.6	(3)
		K103	1.4	(1)	5.6	(1)
		K104	1.4	(1)	5.6	(1)
		K105	0.039	(3)	4.4	(3)
		U188	0.039	(3)	6.2	(3)
220.	Phthalic anhydride	K023	0.54	(2)	28	(2)
		K024	0.54	(2)	28	(2)
		K093	0.54	(2)	28	(2)
		K094	0.54	(2)	28	(2)
		U190	0.54	(2)	28	(2)
144.	Pronamide	U192	0.093	(3)	1.5	(3)
145.	Pyrene	K001	0.028	(3)	1.5	(3)
		K035	0.067	(3)	8.2	(3)
		K048	0.045	(1)	36	(3)
		K049	0.045	(1)	36	(3)
		K051	0.045	(1)	36	(3)
		U051	0.028	(3)	1.5	(3)
146.	Resorcinol	U201	TS	(3)	TS	(3)
147.	Safrole	U203	0.081	(3)	22	(3)

Regulatory Standards for BDAT List Waste Constituents
Semivolatile Organics (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
148.	1,2,4,5-Tetrachlorobenzene	K019	0.017	(1)	NR	
		K030	0.017	(1)	14	(1)
		K042	0.055	(3)	4.4	(3)
		K085	0.055	(3)	4.4	(3)
		U207	0.055	(3)	19	(3)
149.	Total-Tetrachlorophenol	K043	0.018	(2)	0.68	(2)
		SDR	0.01		0.01[13]	
150.	1,2,4-Trichlorobenzene	K019	0.023	(1)	19	(1)
		K030	0.023	(1)	19	(1)
		K042	0.055	(3)	4.4	(3)
		K085	0.055	(3)	4.4	(3)
		K096	0.055	(3)	19	(2)
151.	2,4,5-Trichlorophenol	D017	TS	(3)	7.9	(3)
		K043	0.016	(2)	8.2	(2)
		K105	0.18	(3)	4.4	(3)
		SDR	0.05		0.05[13]	
152.	2,4,6-Trichlorophenol	K043	0.039	(2)	7.6	(2)
		K105	0.035	(3)	4.4	(3)
		SDR	0.05		0.15[13]	
153.	Tris(2,3-dibromo-propyl)-phosphate	U235	0.025	(2)	0.1	(2)

Regulatory Standards for BDAT List Waste Constituents

Metals

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/l) (TCLP values, otherwise noted)	
154.	Antimony	K021	0.60	(3)	0.23	(3)
155.	Arsenic	D004	5.0	(3)	5.0[2]	(3)
		D004[1,2]	NA		TS	(3)
		K031	0.79	(3)	5.6[2]	(3)
		K048	NR		0.004	(1)
		K049	NR		0.004	(1)
		K050	NR		0.004	(1)
		K051	NR		0.004	(1)
		K052	NR		0.004	(1)
		K084	0.79	(3)	5.6[2]	(3)
		K101	0.79	(3)	5.6[2]	(3)
		K102	0.79	(3)	5.6[2]	(3)
		P010	0.79	(3)	5.6[2]	(3)
		P011	0.79	(3)	5.6[2]	(3)
		P012	0.79	(3)	5.6[2]	(3)
		P036	0.79	(3)	5.6[2]	(3)
		P038	0.79	(3)	5.6[2]	(3)
		U136	0.79	(3)	5.6[2]	(3)
156.	Barium	D005	100	(3)	100	(3)
		D005[1,2]	NA		TS	(3)
		P013	NR		52[2]	(3)
157.	Beryllium	P015	TS	(3)	TS	(3)
158.	Cadmium	D006	1.0	(3)	1.0	(3)
		D006[1,2]	NA		TS	(3)
		F006	1.6	(3)	0.066	(2)
		F007	NR		0.066	(2)
		F008	NR		0.066	(2)
		F009	NR		0.066	(2)
		F011	NR		0.066	(2)
		F012	NR		0.066	(2)

Regulatory Standards for BDAT List Waste Constituents

Metals (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/l) (TCLP values, otherwise noted)	
158.	Cadmium (continued)	K028	6.4	(2)	NR	(2)
		K061[12]	1.61	(3)	0.14	(1)
		K061[13]	1.61	(3)	0.14	(1)
		K069	1.6	(3)	0.14	(3)
		K100	1.6	(3)	0.066	(3)
		K101	0.24	(3)	0.066	(1)
		K102	0.24	(3)	0.066	(1)
159.	Chromium (total)	D007	5.0	(3)	5.0	(3)
		D007[15]	NA		TS	(3)
		F006	0.32	(3)	5.2	(1)
		F007	0.32	(2)	5.2	(2)
		F008	0.32	(2)	5.2	(2)
		F009	0.32	(2)	5.2	(2)
		F011	0.32	(2)	5.2	(2)
		F012	0.32	(2)	5.2	(2)
		F019	0.32	(3)	5.2	(3)
		F024	0.35	(2)	0.073	(3)
		K002	2.9	(3)	0.094	(3)
		K003	2.9	(3)	0.094	(3)
		K004	2.9	(3)	0.094	(3)
		K005	2.9	(3)	0.094	(3)
		K006 (anhydrous)	2.9	(3)	0.094	(3)
		K006 (hydrated)	2.9	(3)	5.2	(3)
		K007	2.9	(3)	0.094	(3)
		K008	2.9	(3)	0.094	(3)
		K015	0.32	(1)	1.7	(3)
		K022	0.35	(3)	5.2	(1)
		K028	0.35	(2)	0.073	(3)
		K048	0.20	(1)	1.7	(1)
		K049	0.20	(1)	1.7	(1)
		K050	0.20	(1)	1.7	(1)
		K051	0.20	(1)	1.7	(1)
		K052	0.20	(1)	1.7	(1)
		K061[12]	0.32	(3)	5.2	(1)

Regulatory Standards for BDAT List Waste Constituents

Metals (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/l) (TCLP values, otherwise noted)	
159.	Chromium (total) (continued)	K061[(1)]	0.32	(3)	5.2	(1)
		K062	0.32	(1)	0.094	(1)
		K086	0.32	(1)	0.094	(3)
		K100	0.32	(3)	5.2	(3)
		K101	NR		5.2	(1)
		K102	NR		5.2	(1)
		U032	0.32	(3)	0.094	(3)
221.	Chromium (hexavalent)	NR				
160.	Copper	NR				
161.	Lead	D008	5.0	(3)	5.0[(2)]	(3)
	Lead acid batteries	D008	TS	(3)	TS	(3)
		D008[(5)]	NA		TS	(3)
		F006	0.040	(3)	0.51	(1)
		F007	0.040	(2)	0.51	(2)
		F008	0.040	(2)	0.51	(2)
		F009	0.040	(2)	0.51	(2)
		F011	0.040	(2)	0.51	(2)
		F012	0.040	(2)	0.51	(2)
		F024	NR	(2)	Reserved	(3)
		K001	0.037	(1)	0.51	(3)
		K002	3.4	(3)	0.37	(3)
		K003	3.4	(3)	0.37	(3)
		K004	3.4	(3)	0.37	(3)
		K005	3.4	(3)	0.37	(3)
		K006 (anhydrous)	3.4	(3)	0.37	(3)
		K006 (hydrated)	3.4	(3)	5.2	(3)
		K007	3.4	(3)	0.37	(3)
		K008	3.4	(3)	0.37	(3)
		K028	0.037	(2)	0.021	(3)
		K044	TS	(3)	TS	(3)
		K045	TS	(3)	TS	(3)

Regulatory Standards for BDAT List Waste Constituents

Metals (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/l) (TCLP values, otherwise noted)	
161.	Lead (continued)	K046	0.037	(3)	0.18	(3)
		K047	TS	(3)	TS	(3)
		K048	0.037	(1)	NR	
		K049	0.037	(1)	NR	
		K050	0.037	(1)	NR	
		K051	0.037	(1)	NR	
		K052	0.037	(1)	NR	
		K061	0.51	(3)	0.24	(1)
		K062	0.04	(1)	0.37	(1)
		K069	0.51	(3)	0.24	(3)
		K086	0.037	(3)	0.37	(3)
		K087	0.037	(1)	0.51	(1)
		K100	0.51	(3)	0.51	(3)
		K101	0.17	(3)	0.51	(1)
		K102	0.17	(3)	0.51	(1)
		P110	0.040	(3)	0.51	(3)
		U051	0.037	(3)	0.51	(3)
		U144	0.040	(3)	0.51	(3)
		U145	0.040	(3)	0.51	(3)
		U146	0.040	(3)	0.51	(3)
162.	Mercury	D009[5]	0.20	(3)	TS[6]	(3)
		D009[5]	0.20	(3)	TS[6]	(3)
		D009[6]	0.20	(3)	0.20[7]	(3)
		D009[10]	NA		TS	(3)
		K071	0.030	(1)	0.025	(3)
		K101	0.082	(3)	NR	
		K102	0.082	(3)	NR	
		K106[5]	0.030	(3)	TS	(3)
		K106[6]	0.030	(3)	0.20[8]	(3)
		K106[6]	0.030	(3)	0.025[9]	(3)
		P065[5]	0.030	(3)	TS	(3)
		P065[6]	0.030	(3)	0.20[8]	(3)

Regulatory Standards for BDAT List Waste Constituents

Metals (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/l) (TCLP values, otherwise noted)	
162.	Mercury (continued)	P065[6]	0.030	(3)	0.025[9]	(3)
		P065	0.030	(3)	TS	(3)
		P092	0.030	(3)	TS	(3)
		U151[9]	0.030	(3)	TS	(3)
		U151[6]	0.030	(3)	0.20[8]	(3)
		U151[6]	0.030	(3)	0.025[9]	(3)
		U151[10]	NA		TS	(3)
163.	Nickel	F006	0.44	(3)	0.32	(1)
		F007	0.44	(2)	0.32	(2)
		F008	0.44	(2)	0.32	(2)
		F009	0.44	(2)	0.32	(2)
		F011	0.44	(2)	0.32	(2)
		F012	0.44	(2)	0.32	(2)
		F024	0.47	(2)	0.088	(3)
		K015	0.44	(1)	0.20	(3)
		K022	0.47	(3)	0.032	(1)
		K028	0.47	(2)	0.088	(3)
		K048	NR		0.20	(1)
		K049	NR		0.20	(1)
		K050	NR		0.20	(1)
		K051	NR		0.20	(1)
		K052	NR		0.20	(1)
		K061[11]	0.44	(3)	0.32	(1)
		K061[10]	0.44	(3)	0.32	(1)
		K062	0.44	(1)	NR	
		K083	0.47	(3)	0.088	(3)
		K101	NR		0.32	(1)
		K102	NR		0.32	(1)
		K115	0.47	(2)	0.32	(2)
		P073	0.32	(3)	0.32	(3)
		P074	0.44	(2)	0.32	(2)

Regulatory Standards for BDAT List Waste Constituents

Metals (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/l) (TCLP values, otherwise noted)	
164.	Selenium	D010	1.0	(3)	5.7	(3)
		D010[(1)]	NA		TS	(3)
		K048	NR		0.025	(1)
		K049	NR		0.025	(1)
		K050	NR		0.025	(1)
		K051	NR		0.025	(1)
		K052	NR		0.025	(1)
		P103	1.0	(3)	5.7	(3)
		P114	1.0	(3)	5.7	(3)
		U204	1.0	(3)	5.7	(3)
		U205	1.0	(3)	5.7	(3)
165.	Silver	D011	5.0	(3)	5.0	(3)
		D011[(1)]	NA		TS	(3)
		F006	NR		0.072	(1)
		F011	NR		0.072	(2)
		F012	NR		0.072	(2)
		P099	0.29	(3)	0.072	(2)
		P104	0.29	(3)	0.072	(2)
166.	Thallium	P113	0.14	(3)	TS	(3)
		P114	NR		NR	
		P115	0.14	(3)	TS	
		U214	0.14	(3)	TS	
		U215	0.14	(3)	TS	
		U216	0.14	(3)	TS	
		U217	0.14	(3)	TS	
167.	Vandadium	P119	28	(3)	TS	(3)
		P120	28	(3)	TS	(3)
168.	Zinc	P122	TS	(3)	TS	(3)
		U249	TS	(3)	TS	(3)

Regulatory Standards for BDAT List Waste Constituents
Inorganics Other Than Metals

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
169.	Cyanides (total)	D003	Reserved	(3)	590	(3)
		F006	1.2	(3)	590	(2)
		F007	1.9	(2)	590	(2)
		F008	1.9	(2)	590	(2)
		F009	1.9	(2)	590	(2)
		F010	1.9	(2)	1.5	(2)
		F011	1.9	(2)	110	(2)
		F012	1.9	(2)	110	(2)
		F019	1.2	(3)	590	(3)
		K005	0.74	(3)	Reserved	(3)
		K007	0.74	(3)	Reserved	(3)
		K011	21	(3)	57	(2)
		K013	21	(3)	57	(2)
		K014	21	(3)	57	(2)
		K048	0.028	(3)	1.8	(1)
		K049	0.028	(3)	1.8	(1)
		K050	0.028	(3)	1.8	(1)
		K051	0.028	(3)	1.8	(1)
		K052	0.028	(3)	1.8	(1)
		K060	1.9	(3)	1.2	(3)
		K086	1.9	(3)	1.5	(3)
		K104	2.7	(1)	1.8	(3)
		P013	1.9	(2)	110	(2)
		P021	1.9	(2)	110	(2)
		P029	1.9	(2)	110	(2)
		P030	1.9	(2)	110	(2)
		P063	1.9	(2)	110	(2)
		P074	1.9	(2)	110	(2)
		P098	1.9	(2)	110	(2)
		P099	1.9	(2)	110	(2)
		P104	1.9	(2)	110	(2)
		P106	1.9	(2)	110	(2)
		P121	1.9	(2)	110	(2)
169.	Cyanide (amenable)	D003	0.86	(3)	30	(3)
		F006	0.86	(3)	30	(2)
		F007	0.10	(2)	30	(2)
		F008	0.10	(2)	30	(2)

Regulatory Standards for BDAT List Waste Constituents
Inorganics Other Than Metals (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
169.	Cyanide (amenable) (continued)	F009	0.10	(2)	30	(2)
		F010	0.10	(2)	NR	
		F011	0.10	(2)	9.1	(2)
		F012	0.10	(2)	9.1	(2)
		F019	0.86	(3)	30	(3)
		K011	Reserved		Reserved	
		K013	Reserved		Reserved	
		K014	Reserved		Reserved	
		P013	0.1	(2)	9.1	(2)
		P021	0.1	(2)	9.1	(2)
		P029	0.1	(2)	9.1	(2)
		P030	0.1	(2)	9.1	(2)
		P063	0.1	(2)	9.1	(2)
		P074	0.2	(2)	9.1	(2)
		P098	0.1	(2)	9.1	(2)
		P099	0.1	(2)	9.1	(2)
		P104	0.1	(2)	9.1	(2)
		P106	0.1	(2)	9.1	(2)
		P121	0.1	(2)	9.1	(2)
170.	Fluoride	P056	35	(3)	TS	(3)
		U134	35	(3)	TS	(3)
171.	Sulfide	NR				
		Pesticides				
		Organochlorine Pesticides				
172.	Aldrin	P004	0.021	(3)	0.066	(3)
173.	alpha-BHC	U129	0.00014	(3)	0.066	(3)
174.	beta-BHC	U129	0.00014	(3)	0.066	(3)
175.	delta-BHC	U129	0.023	(3)	0.066	(3)
176.	gamma-BHC (Lindane)	D013	TS	(3)	0.066	(3)
		U129	0.0017	(3)	0.066	(3)

Regulatory Standards for BDAT List Waste Constituents
Organochlorine Pesticides (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
177.	Chlordane	K032	0.0033	(3)	0.26	(3)
		K097	0.0033	(3)	0.26	(3)
		U036	0.0033	(3)	0.13	(3)
178.	p,p'DDD	U060	0.023	(3)	0.087	(3)
		U061	0.023	(3)	0.087	(3)
235.	o,p'DDD	U060	0.023	(3)	0.087	(3)
		U061	0.023	(3)	0.087	(3)
179.	p,p'DDE	U061	0.031	(3)	0.087	(3)
236.	o,p'DDE	U061	0.031	(3)	0.087	(3)
180.	p,p'DDT	U061	0.0039	(3)	0.087	(3)
237.	o,p'DDT	U061	0.0039	(3)	0.087	(3)
181.	Dieldrin	P037	0.017	(3)	0.13	(3)
182.	Endosulfan I	P050	0.023	(3)	0.066	(3)
183.	Endosulfan II	P050	0.029	(3)	0.13	(3)
238.	Endosulfan sulfate	P050	0.029	(3)	0.13	(3)
184.	Endrin	D012	TS	(3)	0.13	(3)
		P051	0.0028	(3)	0.13	(3)
185.	Endrin aldehyde	P051	0.025	(3)	0.13	(3)
186.	Heptachlor	K032	0.0012	(3)	0.066	(3)
		K097	0.0012	(3)	0.066	(3)
		P059	0.0012	(3)	0.066	(3)
187.	Heptachlor epoxide	K032	0.016	(3)	0.066	(3)
		K097	0.016	(3)	0.066	(3)
		P059	0.016	(3)	0.066	(3)

Regulatory Standards for BDAT List Waste Constituents
Organochlorine Pesticides (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
188.	Isodrin	P060	0.021	(3)	0.066	(3)
189.	Kepone	U142	0.0011	(3)	0.13	(3)
190.	Methoxyclor	D014	TS	(3)	0.18	(3)
		U247	0.25	(3)	0.18	(3)
191.	Toxaphene	D015	TS	(3)	1.3	(3)
		K041	0.0095	(3)	2.6	(3)
		K098	0.0095	(3)	2.6	(3)
		P123	0.0095	(3)	1.3	(3)
		Phenoxyacetic Acid Herbicides				
192.	2,4-Dichlorophenoxyacetic acid	D016	TS	(3)	10	(3)
		K099	1.0	(1)	1.0	(1)
		U240	0.72	(3)	10	(3)
193.	Silvex	NR				
194.	2,4,5-T	D017	TS	(3)	7.9	(3)
		Organophosphorous Insecticides				
195.	Disulfoton	K036	0.025	(2)	0.1	(3)
		K037	0.025	(3)	0.1	(1)
		P039	0.017	(2)	0.1	(2)
196.	Famphur	P097	0.025	(2)	0.1	(2)
197.	Methyl parathion	P071	0.025	(2)	0.1	(2)
198.	Parathion	P089	0.025	(2)	0.1	(2)
199.	Phorate	K038	0.025	(2)	0.1	(2)
		K040	0.025	(2)	0.1	(2)
		P094	0.025	(2)	0.1	(2)

Regulatory Standards for BDAT List Waste Constituents

PCBs

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
200.	Aroclor 1016	K085	0.013	(3)	0.92	(3)
201.	Aroclor 1221	K085	0.014	(3)	0.92	(3)
202.	Aroclor 1232	K085	0.013	(3)	0.92	(3)
203.	Aroclor 1242	K085	0.017	(3)	0.92	(3)
204.	Aroclor 1248	K085	0.013	(3)	0.92	(3)
205.	Aroclor 1254	K085	0.014	(3)	1.8	(3)
206.	Aroclor 1260	K085	0.014	(3)	1.8	(3)
		Dioxins and Furans				
207.	Hexachlorodibenzo-p-dioxin	F024	0.001	(2)	0.001	(2)
		K043	0.001	(2)	0.001	(2)
		K099	0.001	(1)	0.001	(1)
		SDR	0.001		0.001(**)	
208.	Hexachlordibenzo-furans	F024	0.001	(2)	0.001	(2)
		K043	0.001	(2)	0.001	(2)
		K099	0.001	(1)	0.001	(1)
		SDR	0.001		0.001(**)	
209.	Pentachlorodibenzo-p-dioxin	F024	0.001	(2)	0.001	(2)
		K043	0.001	(2)	0.001	(2)
		K099	0.001	(1)	0.001	(1)
		SDR	0.001		0.001(**)	
210.	Pentachlorodibenzo-furans	F024	0.001	(2)	0.001	(2)
		K043	0.001	(2)	0.001	(2)
		K099	0.001	(1)	0.001	(1)
		SDR	0.001		0.001(**)	

Regulatory Standards for BDAT List Waste Constituents
Dioxins and Furans (continued)

BDAT list number	Constituent name	Codes in which constituent is regulated	Wastewater standard (mg/l)		Non-wastewater standard (mg/kg)	
211.	Tetrachlorodibenzo-p-dioxin	K043	0.011	(2)	0.001	(2)
		K099	0.001	(1)	0.001	(1)
		SDR	0.001		0.001[14]	
211.	Tetrachlorodibenzo-furans	F024	0.001	(2)	0.001	(2)
		K043	0.001	(2)	0.001	(2)
		K099	0.001	(1)	0.001	(1)
		SDR	0.001		0.001[14]	
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	SDR	0.001		0.001[14]	