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FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT FOR

K099

(Non CBI Version)

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EXECUTIVE SUMMARY

BDAT Treatment Standards for K099

Pursuant to the Hazardous and Solid Waste Amendments (HSWA) enacted on November 8, 1984, the Environmental Protection Agency is establishing best demonstrated available technology (BDAT) treatment standards for the listed waste identified in 40 CFR 261.32 as K099. Compliance with these treatment standards is a prerequisite for placement of the waste in units designated as land disposal units according to 40 CFR Part 268. These treatment standards become effective as of August 8, 1988.

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in K099 waste and for developing treatment standards for those regulated constituents. The document also provides waste characterization information that serves as a basis for determining whether treatment variances may be warranted. EPA may grant a treatment variance in cases where the Agency determines that the waste in question is more difficult to treat than the waste upon which the treatment standards have been established.

The introductory section, which appears verbatim in all the First Third background documents, summarizes the Agency's legal authority and promulgated methodology for establishing treatment standards and discusses the petition process necessary for requesting a variance from the treatment standards. The remainder of the document presents waste-specific information--the number and locations of facilities

affected by the land disposal restrictions for K099 waste, the waste generating process, waste characterization data, the technologies used to treat the waste (or similar wastes), and available performance data, including data on which the treatment standards are based. The document also explains EPA's determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

K099 waste is defined as untreated wastewater from the production of 2,4-dichlorophenoxyacetic acid (2,4-D). The Agency has identified only one facility that produces 2,4-D. This facility is Dow Chemical USA, Midland, Michigan (EPA Region V).

The Agency is regulating seven organic constituents, 2,4-D and six chlorinated dioxins and furans, in both nonwastewater and wastewater forms of K099 waste. (For the purpose of determining the applicability of the BDAT treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition must comply with the treatment standards for nonwastewaters.) The wastewater treatment standards for 2,4-D are based on performance data from chemical oxidation using chlorine. Wastewater treatment standards for the chlorinated dioxins and furans are transferred from the treatment standards promulgated for dioxin-

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*The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by method 209C (Total Suspended Solids Dried at 103-105°C) in Standard Methods for the Examination of Water and Wastewater, Sixteenth Edition.

containing wastes (51 FR 40615, November 7, 1986). Nonwastewater treatment standards for all seven regulated constituents are transferred from the wastewater treatment standards.

The following table lists the specific BDAT standards for K099 wastewater and nonwastewater. The treatment standards reflect total constituent concentrations. The units for nonwastewater are mg/kg (parts per million on a weight-by-weight basis); the units for wastewater are mg/l (parts per million on a weight-by-volume basis). Note that if the concentrations of the regulated constituents in the waste, as generated, are lower than or equal to the treatment standards, then treatment is not required prior to land disposal.

Testing and analysis procedures are specifically identified and discussed in Appendix B (QA/QC Section) of this background document.

BDAT Treatment Standards for K099

Constituent	Maximum for any single grab sample		
	Nonwastewater		Wastewater
	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total concentration (mg/l)
Phenoxyocetic Acid Herbicides			
2,4-Dichlorophenoxyacetic acid	1.0	NA	1.0
Dioxins and Furans			
Hexachlorodibenzo-p-dioxins	0.001	NA	0.001
Hexachlorodibenzofuran	0.001	NA	0.001
Pentachlorodibenzo-p-dioxins	0.001	NA	0.001
Pentachlorodibenzofuran	0.001	NA	0.001
Tetrachlorodibenzo-p-dioxins	0.001	NA	0.001
Tetrachlorodibenzofurans	0.001	NA	0.001

NA = Not applicable.

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1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the best demonstrated available technology (BDAT) treatment standards were developed, a summary of EPA's promulgated methodology for developing the BDAT treatment standards, and, finally, a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), which were enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "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 wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal 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" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be 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), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which 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), 42 U.S.C. 6924 (m)(1)). Wastes that satisfy such levels or methods of treatment established by EPA, i.e., treatment standards, are not prohibited from being land disposed.

In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such

characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters. Alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, a particular constituent present in the wastes can be treated to the same concentration in all the wastes.

In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the amendments allow the Agency to grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set treatment standards by the statutory deadline for any hazardous waste in the First Third or Second Third waste groups (see Section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In

addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated, and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of landfills and surface impoundments applies until EPA sets treatment standards for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set treatment standards for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

1. Solvent and dioxin wastes by November 8, 1986;
2. The "California List" wastes by July 8, 1987;
3. At least one-third of all listed hazardous wastes by August 8, 1988 (First Third);

4. At least two-thirds of all listed hazardous wastes by June 8, 1989 (Second Third); and

5. All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a 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. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish treatment standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third land disposal restriction rules. This schedule is incorporated into 40 CFR 268.10, 268.11, and 268.12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m).

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under section 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards), rather than to require the use of specific treatment "methods." EPA believes that concentration-based treatment

levels offer the regulated community greater flexibility to develop and implement compliance strategies, as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that hazardous constituents in wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the wastes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one of the wastes in the group, the waste from which treatment standards are to be developed, is expected to be most difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are currently used on a full-scale basis to

treat the waste of interest or a waste judged to be similar (see 51 FR 40588, November 7, 1986). EPA also will consider as demonstrated treatment those technologies used to separate or otherwise process chemicals and other materials on a full-scale basis. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. (The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document.) If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration to be a demonstrated technology for many waste codes containing hazardous organic

constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no full-scale treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations, will not be considered in identifying demonstrated treatment technologies for a waste. Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under section 3004(m) be not only "demonstrated," but also "available." To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the

toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste. These criteria are discussed below.

1. Commercially available treatment. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is a commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

2. Substantial treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern (provided the nondetectable levels are low relative to the concentrations in the untreated waste). If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

   - Number and types of constituents treated;
   - Performance (concentration of the constituents in the treatment residuals); and
   - Percent of constituents removed.

EPA will only set treatment standards based on a technology that meets both availability criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If the best demonstrated technology is unavailable, the treatment standards will be based on the next best demonstrated treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become available.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are considered in determining BDAT. The data evaluation includes data already collected directly by

EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (1) the identification of facilities for site visits, (2) the engineering site visit, (3) the sampling and analysis plan, (4) the sampling visit, and (5) the onsite engineering report.

(1) Identification of facilities for site visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers; EPA's Hazardous Waste Data Management System (HWDMS); the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey; and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes together on site; (3) commercial treatment, storage, and disposal facilities (TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment

standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using full-scale treatment systems. If performance data from properly designed and operated full-scale systems treating a particular waste or a waste judged to be similar are not available, EPA may use data from research facility operations. Whenever research facility data are used, EPA will explain in the preamble and background document why such data were used and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering site visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to

ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste, as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and analysis plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific sampling and analysis plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency

of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific SAP within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of BDAT treatment standards. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well designed and well operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up onsite engineering report.

(5) Onsite engineering report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the onsite engineering report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes that appear in Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986.

After the OER is completed, the report is submitted to the waste generator and/or treater for review. This review provides a final opportunity for claiming any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT list. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendices VII and VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a

Table 1-1 BDAT Constituent List

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

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Volatile organics (continued)	
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4-Xylene	106-44-5
	Semivolatile organics	
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53.	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57.	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61.	Deleted	
62.	Benzo(a)pyrene	50-32-8
63.	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108-94-1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94.	p-Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98.	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3-Methylcholanthrene	56-49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01-6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	N-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137.	Pentachloroethane	76-01-7
138.	Pentachloronitrobenzene	82-68-8
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-3
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440-22-4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
	Inorganics other than metals	
169.	Cyanide	57-12-5
170.	Fluoride	16964-48-8
171.	Sulfide	8496-25-8
	Organochlorine pesticides	
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319-86-8

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Organochlorine pesticides (continued)	
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104 28-2
202.	Aroclor 1232	11141-16-5
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins.	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") in March 1987. Additional constituents are added to the BDAT constituent list as more key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, 18 additional constituents (hexavalent chromium, xylenes (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. A waste can be listed as a toxic waste on the basis that it contains a constituent in Appendix VIII.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex

waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT constituent list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are five major reasons that constituents were not included on the BDAT constituent list:

1. Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water, and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

2. EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

3. The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). 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. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituent list.

4. Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high performance liquid chromatography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is usually not an appropriate analytical procedure for complex samples containing unknown constituents.

5. Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics;
- Semivolatile organics;
- Metals;
- Other inorganics;
- Organochlorine pesticides;
- Phenoxyacetic acid herbicides;
- Organophosphorous insecticides;
- PCBs; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly during treatment and are also analyzed, with the exception of the metals and the other inorganics, by using the same analytical methods.

(2) Constituent selection analysis. The constituents that the Agency selects for regulation in each waste are, in general, those found in the untreated wastes at treatable concentrations. For certain waste

codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood that the constituent will be present.

In selecting constituents for regulation, the first step is to develop of list of potentially regulated constituents by summarizing all the constituents that are present or are likely to be present in the untreated waste at treatable concentrations. A constituent is considered present in a waste if the constituent (1) is detected in the untreated waste above the detection limit, (2) is detected in any of the treated residuals above the detection limit, or (3) is likely to be present based on the Agency's analyses of the waste-generating process. In case (2), the presence of other constituents in the untreated waste may interfere with the quantification of the constituent of concern, making the detection limit relatively high and resulting in a finding of "not detected" when, in fact, the constituent is present in the waste. Thus, the Agency reserves the right to regulate such constituents.

After developing a list of potential constituents for regulation. EPA reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents on the list. This indicator analysis is done for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 6 of this background document.

(3) Calculation of standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average accuracy-corrected treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of section 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard for each constituent of concern is calculated by first averaging the mean performance value for each technology and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the technologies used as the basis for the BDAT treatment standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

Usually the treatment standards reflect performance achieved by the best demonstrated available technology (BDAT). As such, compliance with these numerical standards requires only that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standards is prohibited, wastes that are generated in such a way as to naturally meet the standards can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal or that specify use of certain treatment methods, all established treatment standards are expressed as concentration levels.

EPA is using both the total constituent concentration and the concentration of the constituent in the TCLP extract of the treated waste as a measure of technology performance.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA is using this measurement because most technologies for treatment of organics destroy or remove organics compounds. Accordingly, the best measure of performance would be the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) use the TCLP extract value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, 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.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP extract concentration as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is that it reduces the amount of metal in a waste by separating the metal for recovery; total constituent concentration in the treated residual, therefore, is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP extract concentration as a measure of performance. It is important to note that for wastes for which treatment standards are based

on a metal recovery process, the facility has to comply with both the total and the TCLP extract constituent concentrations prior to land disposing the waste.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP value as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

BDAT for a waste must be the "best" of the demonstrated available technologies. EPA determines which technology constitutes "best" after screening the available data from each demonstrated technology, adjusting these data for accuracy, and comparing the performance of each demonstrated technology to that of the others. If only one technology is identified as demonstrated, it is considered "best"; if it is available, the technology is BDAT.

(1) Screening of treatment data. The first activity in determining which of the treatment technologies represent treatment by BDAT is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

1. Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for the waste code(s) of interest are discussed in Section 3.2 of this document.)

2. Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the true value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

3. The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP extract concentration for metals from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis as to whether to use the data as a basis for the treatment standards. The factors included in this case-by-case analysis will be the actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern.

(2) Comparison of treatment data. In cases in which EPA has treatment data from more than one demonstrated available technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better than the others. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If EPA finds that one technology performs significantly better (i.e., is "best"), BDAT treatment standards

are the level of performance achieved by that best technology multiplied by the corresponding variability factor for each regulated constituent. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the technologies.

(3) Quality assurance/quality control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011.

To calculate the treatment standards for the land disposal restriction rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking--which is the addition of a known amount of the constituent--minus the initial concentration in the samples, all divided by the spike amount added) for each spiked sample of the treated residual. Once the recovery values are 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 (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

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 available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spike 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 using the lowest average value.

4. If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is similar (e.g., if the data represent an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. 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 the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition methods, the

specific procedures and equipment used are documented. In addition, any deviations from the SW-846, Third Edition methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment standards presented in Section 7 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from treatment trains generating multiple residues. In a number of instances, the proposed BDAT consists of a series of operations, each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment--a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

1. All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

2. The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all derived-from wastes meeting the Agency definition of wastewater (less than 1 percent total organic carbon (TOC) and less than 1 percent total suspended solids) would have to meet the treatment standard for wastewaters. All residuals not meeting this definition would have to meet the treatment standard for nonwastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

3. The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and other derived-from residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR 261.3(c)(2)(i)) or the mixture rule (40 CFR 261.3(a)(2)(iii) and (iv)) or because the listed waste is contained in the matrix (see, for example, 40 CFR 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a

separate treatability subcategorization). For the most part, these residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a)). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from managing listed wastes or that contain listed wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the listed hazardous waste as originally generated. Residues from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR 261.3(c)(2) or, in some cases, from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions that address mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the original listed waste. Consequently, these residues are treated as the original listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are

covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain or from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology on the specific waste subject to the treatment standard. The Agency has determined that the constituents present in the untested waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance data for use in establishing treatment standards for untested wastes is technically valid in cases where the untested wastes are generated from similar industries or processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether constituents in the untested wastes can be treated to the same level of performance as in the tested waste. First, EPA reviews the available waste characterization data to identify those parameters that are

expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for the given waste(s) in Section 3.

Second, when analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste can be treated as well or better than the tested waste, the treatment standards can be transferred.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes on which the treatment standards are based because the subject waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the

requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

1. The petitioner's name and address.

2. A statement of the petitioner's interest in the proposed action.

3. The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.

4. The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.

5. A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)

6. If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)

7. A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question; and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP, where appropriate, for stabilized metals) that can be achieved by applying such treatment to the waste.

8. A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3 for a discussion of

waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

9. The dates of the sampling and testing.

10. A description of the methodologies and equipment used to obtain representative samples.

11. A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.

12. A description of analytical procedures used, including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are

appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the Federal Register, followed by a 30-day period for public comment. After review of the public comments, EPA will publish its final determination in the Federal Register as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

According to 40 CFR 261.32, the waste identified as K099 is listed as follows:

K099: Untreated wastewater from the production of 2,4-D.

The chemical 2,4-D is 2,4-dichlorophenoxyacetic acid.

This section provides a complete characterization of K099 waste by describing the industry that generates the waste, the process generating the waste, and waste characterization data.

2.1 Industry Affected and Process Description

K099 waste is generated by the manufactures of 2,4-D. The Agency has identified only one facility that produces 2,4-D - Dow Chemical USA, Midland, Michigan (EPA Region V).

The manufacturing process for 2,4-D involves the reaction of 2,4-dichlorophenol with chloroacetic acid in the presence of sodium hydroxide, hydrochloric acid, and a catalyst in a batch reactor to form 2,4-D. The 2,4-D is recovered using a proprietary solvent and is then water-washed to form the final product. The solvent is recovered by distillation and recycled. The solvent recovery still bottoms are sent to incineration. The recovery and water-wash processes generate wastewater, which is listed as K099. The K099 waste is treated by chemical oxidation using chlorine. A flow diagram of the process is presented in Figure 2-1.

2.2 Waste Characterization

This section presents the waste characterization data available to the Agency for K099 waste. Based on engineering judgment and analytical

[THIS FIGURE CONTAINS RCRA CONFIDENTIAL BUSINESS INFORMATION (CBI).]

Figure 2-1 Schematic Diagram of 2,4-Dichlorophenoxyacetic Acid (2,4-D) Process

results, it was concluded that the major constituents composing K099 waste are water and dissolved solids (approximately 95 percent) and sodium salts (approximately 5 percent). These data are presented in Table 2-1. The analytical data available for K099 waste further indicate that BDAT constituents are present in concentrations of less than 0.01 percent, with 2,4-D present at the greatest concentration (26.9 ppm). The ranges of BDAT constituents present in the waste are shown in Table 2-2.

Table 2-1 Major Constituent Composition of K099 Waste

Constituent	Concentration (percent)
Water and dissolved solids	< 95[a]
Sodium salts	> 5
BDAT constituents	< 0.01
	100

[a]Engineering estimate.

Reference: USEPA 1987a.

Table 2-2 BDAT Constituent Composition and Other Data

Parameter	Untreated waste concentration
BDAT volatile organics (mg/l)	
Chloroform	[UNTREATED WASTE CONCENTRATIONS ARE RCRA CBI.]
Tetrachloroethene	
BDAT semivolatile organics (mg/l)	
Phenol	
2-Chlorophenol	
2,4-Dichlorophenol	
2,6-Dichlorophenol	
2,4,6-Trichlorophenol	
Phenoxyacetic acid herbicides (mg/l)	
2,4-D	
BDAT chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans (ug/l)	
Tetrachlorodibenzo-p-dioxins	
Hexachlorodibenzo-p-dioxins	
BDAT metals (mg/l)	
Zinc	
Non-BDAT metals (mg/l)	
Calcium	
Iron	
Magnesium	
Manganese	
Sodium	
Strontium	
Non-BDAT chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans (ug/l)	
Total octachlorodibenzofurans	

Reference: USEPA 1987a.

3. APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES

This section describes the applicable and demonstrated treatment technologies for K099 waste. The demonstrated technology is discussed in detail in Section 3.2.1.

3.1 Applicable Treatment Technologies

The waste characterization data in Section 2 indicate that untreated K099 waste contains low concentrations of BDAT organic constituents, high water content, and significant dissolved solids (as indicated by the sodium content of the waste).

The Agency has identified the following treatment technologies as applicable for such waste: chemical oxidation, wet air oxidation (a specialized form of chemical oxidation), biological treatment followed by incineration of the biological sludge, and carbon adsorption followed by incineration of the carbon. The oxidation technologies are designed to chemically destroy the organic constituents in the waste by reacting them with an oxidizing agent such as oxygen, chlorine, or hydrogen peroxide. Biological treatment uses naturally occurring, acclimated microorganisms to degrade the organic contaminants in the waste. Carbon adsorption is designed to adsorb hazardous constituents from the waste by surface attraction within the internal pores of the carbon granules. Incineration technologies are designed to destroy the toxic organics that would be present in the biological sludge generated during biological treatment or the spent carbon from the carbon adsorption system.

3.2 Demonstrated Treatment Technologies

Of the applicable treatment technologies, only chemical oxidation using chlorine has been identified as demonstrated. This technology is used by the one facility that generates this waste. EPA has not identified other applicable technologies as demonstrated either on this waste or on a similar waste. Therefore, the Agency does not believe that wet air oxidation, biological treatment followed by incineration of the sludge, or carbon adsorption followed by incineration of the spent carbon are demonstrated for K099 waste.

A detailed discussion of chemical oxidation is presented below.

3.2.1 Chemical Oxidation

(1) Applicability and use of chemical oxidation. Chemical oxidation processes are used to oxidize a number of BDAT list organic compounds including phenol and some substituted phenols. In addition, this process is used to treat sulfide wastes by converting the sulfide to the essentially insoluble sulfate form. The parameters that affect selection of this technology include water content, filterable solids, and total organic carbon content. The term chemical oxidation, as used in this report, refers to the technology that is applicable only when treatment can be conducted at ambient or near ambient pressure and temperature conditions. When chemical oxidation is conducted at higher temperatures and pressures, the process is referred to as wet air oxidation. This latter technology is discussed separately. The processes described in this section also do not include the oxidation of cyanides by similar chemicals, which is also discussed separately.

(2) Underlying principles of operation. Some dissolved organic compounds or sulfides can be chemically oxidized to yield carbon dioxide, water, salts, or acids, and, in the case of sulfides, sulfates. The principal oxidants are hypochlorate or free chlorine, hydrogen peroxide, and chlorine dioxide. The reaction chemistry for each of these oxidants is discussed below.

(a) Oxidation with hypochlorite or free chlorine. This type of oxidation is carried out using either sodium hypochlorite or free chlorine. The reaction is normally conducted under slightly alkaline conditions. Example reactions for the oxidation of phenol and sulfide are shown below.

$$C_6H_5OH + 14NaOCl \rightarrow 6CO_2 + 3H_2O + 14NaCl$$

$$S^{=} + 4NaOCl \rightarrow SO_4^{=} + 4NaCl.$$

(b) Peroxide oxidation. Peroxide also oxidizes the same constituents (intermediate) under similar conditions. The relevant reactions are:

$$S^{=} + 4H_2O_2 \rightarrow SO_4^{=} + 4H_2O$$

$$C_6H_5OH + 14H_2O_2 \rightarrow 6CO_2 + 17H_2O.$$

(c) Chlorine dioxide oxidation. Chlorine dioxide also oxidizes the same pollutants under identical conditions. Chlorine dioxide first hydrolyzes to form a mixture of chlorous ($HClO_2$) and chloric acids ($HClO_3$). These acids act as the oxidants, as shown in the equations below.

$$2ClO_2 + H_2O \rightarrow HClO_2 + HClO_3$$

$$C_6H_5OH + 7HClO_2 \rightarrow 6CO_2 + 3H_2O + 7HCl$$

$$3C_6H_5OH + 14HClO_3 \rightarrow 8CO_2 + 9H_2O + 14HCl.$$

(3) Technology description. Chemical oxidation can be accomplished by either a batch or a continuous process. For batch treatment, the wastewater is transferred to a reaction tank where the pH is adjusted and the oxidizing agent is added. In some cases, the tank may be heated to increase the reaction rate. For most operations, a slightly alkaline pH is used. It is important that the wastewater in the tank be well mixed for effective treatment to occur. After treatment, the wastewater is either directly discharged or transferred to another process for further treatment.

In the continuous process, automatic instrumentation may be used to control pH levels, reagent oxidation, and temperature. In both types of processes, typical retention times are in the 60- to 120-minute range.

(4) Waste characteristics affecting performance. In determining whether performance standards can be transferred from a previously tested waste to an untested waste, EPA will examine the following waste characteristics: (1) the concentration of other oxidizable contaminants and (2) the presence of metal salts.

(a) Concentration of organic oxidizable compounds. The presence of other oxidizable compounds in addition to the BDAT constituents of concern will increase the demand for oxidizing agents and hence will potentially reduce the effectiveness of the treatment process. As a

surrogate for the amount of oxidizable organics present, EPA will analyze for total organic carbon (TOC).

(b) Concentrations of metal salts (oxidizable compounds). Metal salts, especially lead and silver salts, will react with the oxidizing agent(s) to form metal peroxides, chlorides, hypochlorites, and/or chlorates. Formation of these compounds can cause excessive consumption of oxidizing agents and potentially interfere with the effectiveness of treatment. Lead and silver salts can be analyzed by EPA Method 3050.

(5) Design and operating parameters. In assessing the effectiveness of the design and operation of a chemical oxidation system, the parameters that the Agency will examine are:

1. Retention time;
2. Type of oxidizing agent;
3. Mixing;
4. pH; and
5. Temperature.

(a) Retention time. The system must be designed to provide enough retention time to ensure complete oxidation. For a batch system, adequate retention time is provided by holding the treated batch until the reaction nears completion prior to discharge. The reaction typically requires from 1 to 2 hours to approach completion. The rate may be increased somewhat by increasing the temperature if the reaction tank is equipped with heating units. The tank size is determined by the amount of waste treated per batch and the amount of oxidizing agent added. For continuous systems, retention time is determined by the size of the tank

and the process flow rates of the waste treated. To ensure that the system is operated at the design retention time, EPA will monitor the waste feed rate.

(b) Type of oxidizing agent. Several factors govern the choice of oxidizing agents. The amount of oxidizing agent required to treat a given amount of reducing compound will vary with the agent chosen. Enough oxidant must be added to ensure complete oxidation; the specific amount will depend on the type and chemistry of the reducing compounds in the waste. Theoretically, the amount of oxidizing agent to be added can be computed from process stoichiometry; in practice, a small excess of oxidant should be used. In assessing the effectiveness of any chemical oxidation system, EPA would want to know how a facility determines the amount of oxidant to be added, as well as how the facility ensures that the particular addition rate is maintained.

(c) Mixing. Process tanks must be equipped with mixers to ensure that there is maximum contact between the reducing solution and the oxidizing agent. Proper mixing also limits the production of any solid precipitates from side reactions that may resist oxidation. In addition, mixing provides an even distribution of the tank contents and a homogeneous pH throughout the waste, thereby improving oxidation of wastewater constituents. The quantifiable degree of mixing is a complex assessment that includes, the energy supplied, the time the material is mixed, and the related turbulence effects of the specific size and shape of the tank. EPA will, however, evaluate the degree of mixing

qualitatively by considering whether mixing is provided and whether the type of mixing device is one that could be expected to achieve uniform mixing.

(d) pH. Operation at the optimal pH will maximize the chemical oxidation by keeping the ions in solution and limiting the formation of undesirable precipitates. The pH in batch processes should be monitored at regular intervals during the reaction. The pH is controlled by the addition of caustic, lime, or acid to the solution. In most cases, a slightly alkaline pH is used. In a few cases involving the use of free chlorine, slightly acidic pH values may be selected. In order to ensure that the proper pH is maintained during treatment, EPA will continuously monitor the pH.

(e) Temperature. Temperature is important because it affects the rate of reaction and the solubility of the oxidizing agent. As the temperature is increased, the required reaction time is reduced and the solubility of the oxidizing agent will, in most instances, be increased. EPA will monitor temperature during the treatment period to ensure that the design value is achieved.

4. PERFORMANCE DATA BASE

This section discusses the available performance data associated with the demonstrated technology for K099 waste. Performance data include the constituent concentrations in untreated and treated waste samples, the operating data collected during treatment of the sampled waste, design values for the treatment technology, and data on waste characteristics that affect performance. EPA has presented all such data to the extent that they are available.

EPA's use of these data in determining the technology that represents BDAT, and for developing treatment standards, is described in Sections 5 and 7, respectively.

The Agency collected two untreated and treated waste samples at Dow Chemical's Midland Plant in order to characterize the treatment of K099 waste by chemical oxidation using chlorine. While design and operating data for the treatment system were not collected at the time of treatment, data were subsequently obtained from the facility for the nominal operating ranges. Table 4-1 presents the untreated and treated data and the limited data available for the nominal operation of the treatment system.

Dow Chemical submitted data showing 2,4-D concentrations for 31 additional treated samples from its Midland Plant. These analytical data are presented in Table 4-2. Dow did not provide data on the untreated waste or information on design and operation of the system at the time of treatment.

Table 4-1 Performance Data Collected by EPA for Treatment of K099 Waste by Chemical Oxidation Using Chlorine

Parameter	Concentration (μg/l)			
	Untreated K099		Treated K099	
	Sample 1	Sample 2	Sample 1	Sample 2
BDAT volatiles				
Choloroform	[UNTREATED CONCENTRATIONS		1560	2190
Tetrachloroethene	ARE RCRA CBI.]	3	<2	
Bromodichloromethane			9	9
BDAT semivolatiles				
Phenol			<15	<15
2-chlorophenol			<15	<15
2,4-dichlorophenol			34	33
2,6-dichlorophenol			<20	<20
2,4,6-trichlorophenol			80	73
BDAT phenoxyacetic acid herbicides				
2,4-Dichlorophenoxyacetic acid (2,4-D)			61	42
BDAT dioxins and furans				
Hexachlorodibenzo-p-dioxins			0.007	0.007
Hexachlorodibenzofurans			0.068	0.053
Pentachlorodibenzo-p-dioxins			0.004	0.005
Pentachlorodibenzofurans			0.041	0.065
Tetrachlorodibenzo-p-dioxins			0.008	0.009
Tetrachlorodibenzofurans			0.035	0.045
BDAT metals				
Zinc			285	330
Other parameters				
Non-BDAT dioxins and furans				
Octachlorodibenzo-p-dioxins			0.022	0.021
Octachlorodibenzofurans			0.782	0.826
Heptachlorodibenzo-p-dioxins			<0.002	0.004
Heptachlorodibenzofurans			0.013	0.014

Table 4-1 (Continued)

Parameter	Concentration (µg/l)			
	Untreated K099		Treated K099	
	Sample 1	Sample 2	Sample 1	Sample 2
Non-BDAT metals				
Calcium			3,320	7,380
Iron			1,710	3,350
Magnesium			945	1,950
Manganese			< 100	< 100
Sodium			31,000,000	49,800,000
Strontium			295	655

Nominal operating parameters for the chlorinator at the Dow 2,4-D Plant were as follows:

1. pH in the chlorinator:
   - control 6.0 - 6.2
   - acceptable range 5.3 - 6.5

2. Chlorine feed quantity:
   - 4 lb/hr chlorine per gallon/minute of water to be treated
   - The chlorine feed is typically varied to maintain approximately 450 ppm of chlorine in the chlorinator.

3. Reaction time:
   - Reaction time is 40 minutes per vessel or approximately 80 minutes total.

References: USEPA 1987a and letter from W. I. Delaney, Dow Chemical, to J. Carra, USEPA, 1987, concerning operating information for treatment of 2,4-D wastewater.

Table 4-2 Chemical Oxidation Performance Data Submitted by Dow Chemical USA Showing 2,4-D Concentrations in the Treated Wastewater

Sample no.	Wastewater 2,4-D concentration (ppb)	Sampling date
1	81.94	05/11/87
2	40.89	05/26/87
3	103.14	06/09/87
4	117.10	06/22/87
5	36.19	07/07/87
6	116.35	07/27/87
7	244.62	08/10/87
8	141.76	08/24/87
9	68.28	09/08/87
10	530.83	09/21/87
11	1031.46	10/05/87
12	8.39	10/12/87
13	4.42	10/14/87
14	41	10/26/87
15	31.31	10/19/87
16	393.66	12/03/07
17	302.79	12/06/87
18	54.04	12/13/87
19	157.44	12/25/87
20	55.74	12/28/87
21	1638.45	01/21/88
22	93.07	01/25/88
23	25.61	01/31/88
24	59.08	02/02/88
25	105.29	02/03/88
26	<4	02/25/88
27	152.38	02/29/88
28	18.87	03/24/88
29	32.89	03/28/88
30	33.65	04/24/88
31	272.98	04/26/88

Reference: Dow Chemical Company 1988 (LDR8-00036) and personal communications with Reid Tait, Dow Chemical, on July 20, 1988.

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section explains EPA's determination of the best demonstrated available technology (BDAT) for K099 waste. As discussed in Section 1, the BDAT for a waste must be the "best" of the "demonstrated" technologies; the BDAT must also be "available." In general, the technology that constitutes "best" is determined after screening the available data from each demonstrated technology, adjusting these data for accuracy, and comparing the performance of each technology to that of the others. If only one technology is identified as demonstrated, this technology is considered "best." To be "available," a technology (1) must be commercially available and (2) must provide substantial treatment.

Chemical oxidation using chlorine is the only technology identified as being demonstrated for K099 waste. Accordingly, EPA considers this technology "best."

EPA believes that chemical oxidation using chlorine represents BDAT because it is commercially available and provides substantial treatment. Having screened the data and eliminated four data points, EPA determined that substantial treatment is provided, based on the observation that untreated concentrations of 2,4-D as high as [CBI] ug/l were reduced to 64 and 44 ug/l in samples collected by the Agency, and moreover, in the data submitted by Dow, expectedly similar untreated concentrations of 2,4-D were reduced to less than 4 to 456 ug/l. The treated residual concentrations reported here have been corrected for accuracy using the associated QA/QC information on recoveries.

The analytical data recoveries and accuracy-corrected 2,4-D concentrations are presented in Table 5-1. (Accuracy correction is discussed in Appendix B.) Table 5-1 also indicates which data points were eliminated during screening. The data point from sample number 26 in the Dow-submitted data was discarded because the recovery was less than 20 percent, the minimum requirement for usable data. Three more data points from the Dow-submitted data were discarded because they were statistical outliers, an indication of poor operation. In cases where no associated design and operating data are available, the Agency uses a statistical outlier analysis to determine whether the data meet the well-designed and well-operated criteria (51 FR 40590, November 7, 1986).

Table 5-1 Accuracy-Corrected Performance Data for 2,4-D in Treated K099 Wastewater

Data source	Sample no.	2,4-D concentration (ug/l)	3,4-D spike concentration (ug/l)	Recovery[a]	Accuracy-corrected 2,4-D concentration[b] (ug/l)
EPA (Table 4-1)	1	61	-	0.96	64
	2	42	-	0.96	44
Dow (Table 4-2)	1	81.94	29.37	0.59	139.4961
	2	40.89	16.24	0.32	125.8929
	3	103.14	53.18	1.06	96.9725
	4	117.10	35.90	0.72	163.0919
	5	36.19	15.32	0.31	118.1136
	6	116.35	43.85	0.88	132.6682
	7	244.62	35.68	0.71	342.7971
	8	141.76	41.11	0.82	172.4155
	9	68.28	23.14	0.46	147.5367
	10	530.83	17.20	0.34	1543.11
	11	1031.46	38.93	0.78	1324.26
	12	8.39	43.89	0.88	9.5584
	13	4.42	67.75	1.36	3.2618
	14	41.00	26.46	0.53	77.4754
	15	31.31	48.58	0.97	32.2252
	16	393.66	43.19	0.86	455.7305
	17	302.79	49.64	0.99	304.9859
	18	54.04	25.88	0.52	104.4049
	19	157.44	60.61	1.21	129.8796
	20	55.74	44.14	0.88	63.1400
	21	1638.45	27.01	0.54	3033.04
	22	93.07	35.91	0.72	129.5879
	23	25.61	45.39	0.91	28.2111
	24	59.08	53.68	1.07	55.0298
	25	105.29	45.29	0.91	116.2398
	26	<4	0	0	-
	27	152.38	40.86	0.82	186.4477
	28	18.87	56.20	1.12	16.7883
	29	32.89	40.04	0.80	41.0714
	30	33.65	48.14	0.96	34.9501
	31	272.98	47.14	0.94	289.5418

[a]Recovery = 3,4-D spike concentration in ppb/50 ppb for Dow-submitted data. (Samples were spiked with 50 ppb of 3,4-D.) See Appendix B for recovery information on EPA-collected samples.

[b]Accuracy-corrected 2,4-D concentration = 2,4-D concentration/recovery.

6. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a list of hazardous constituents (Table 1-1) from which the constituents to be regulated are selected. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous pesticides, PCBs, and dioxins and furans.

This section describes the process used to select the constituents to be regulated. The process involves developing a list of potential regulated constituents and then eliminating those constituents that would not be treated by the chosen BDAT or that would be controlled by regulation of the remaining constituents.

6.1 Identification of BDAT List Constituents in the Untreated Waste

As discussed in Sections 2 and 4, the Agency has characterization data as well as performance data from treatment of K099 waste by chemical oxidation using chlorine. These data, along with information on the waste generating process, have been used to determine which BDAT list constituents may be present in the waste and thus which are potential candidates for regulation in the nonwastewater and wastewater.

Table 6-1 indicates, for the untreated waste, which constituents were analyzed, which constituents were detected, and which constituents the Agency believes could be present though not detected. For those constituents detected, concentrations are shown.

Under the column "Believed to be present," constituents other than those detected in the untreated waste are marked with X or Y if EPA believes they are likely to be present in the untreated waste. For those constituents marked with X, an engineering analysis of the waste generating process indicates that they are likely to be present (e.g., the engineering analysis shows that a particular constituent is a major raw material). Those constituents marked with Y have been detected in the treated residual(s) and thus EPA believes they are present in the untreated waste. Constituents may not have been detected in the untreated waste for one of several reasons: (1) none of the untreated waste samples were analyzed for those constituents, (2) masking or interference by other constituents prevented detection, or (3) the constituent indeed was not present. (With regard to Reason (3), it is important to note that some wastes are defined as being generated from a process. The process may utilize variable starting materials composed of different constituents; therefore, all potentially regulated constituents would not necessarily be present in any given sample.)

In samples collected by EPA at the Dow facility, EPA analyzed for 51 of the 231 BDAT list constituents. EPA believes that the compounds not analyzed are unlikely to be present in the waste because there is no in-process source for these compounds. Of the 45 analyzed constituents, 11 were detected in the untreated waste and an additional 5 were detected in the treated residual wastewater. These 16 constituents are potential candidates for regulation in K099 waste.

6.2 Constituent Selection

EPA is regulating 7 of the 16 candidate constituents. These are 2,4-D, hexachlorodibenzo-p-dioxins, hexachlorodibenzofurans, pentachlorodibenzo-p-dioxins, pentachlorodibenzofurans, tetrachlorodibenzo-p-dioxins, and tetrachlorodibenzofurans. The 2,4-D is clearly treated by the BDAT. Levels of the chlorinated dioxins and dibenzofurans in the untreated waste samples were relatively low (see Table 4-1); thus, the data do not show treatment for these compounds. The Agency believes, however, that in some cases these compounds may be present in the waste at levels significantly higher.

The performance data presented in Table 4-1 indicate that the tetrachloroethene concentration is reduced by treatment. It is unclear to the Agency, however, how chemical oxidation using chlorine would destroy this constituent; therefore, the Agency has chosen not to regulate it.

The performance data also show that phenol, 2-chlorophenol, 2,4-dichlorophenol, 2,6-dichlorophenol, and 2,4,6-trichlorophenol concentrations are reduced by the BDAT treatment. Because the recovery data associated with these compounds show zero percent recoveries, the analytical data are not reliable. Nevertheless, the Agency could regulate these constituents if other data were available for transfer. EPA is choosing not to regulate these constituents because it believes they will be controlled by regulation of 2,4-D and the chlorinated dioxins and furans.

Table 6-1 Status of BDAT List Constituent Presence in Untreated K099 Waste

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Volatile organics		
222.	Acetone	NA	
1.	Acetonitrile	NA	
2.	Acrolein	NA	
3.	Acrylonitrile	NA	
4.	Benzene	ND	
5.	Bromodichloromethane	ND	
6.	Bromomethane	NA	
223.	n-Butyl alcohol	NA	
7.	Carbon tetrachloride	ND	
8.	Carbon disulfide	NA	
9.	Chlorobenzene	NA	
10.	2-Chloro-1,3-butadiene	NA	
11.	Chlorodibromomethane	ND	
12.	Chloroethane	NA	
13.	2-Chloroethyl vinyl ether	NA	
14.	Chloroform	D (CBI)	
15.	Chloromethane	NA	
16.	3-Chloropropene	NA	
17.	1,2-Dibromo-3-chloropropane	NA	
18.	1,2-Dibromoethane	NA	
19.	Dibromomethane	NA	
20.	trans-1,4-Dichloro-2-butene	NA	
21.	Dichlorodifluoromethane	NA	
22.	1,1-Dichloroethane	NA	
23.	1,2-Dichloroethane	NA	
24.	1,1-Dichloroethylene	NA	
25.	trans-1,2-Dichloroethene	NA	
26.	1,2-Dichloropropane	NA	
27.	trans-1,3-Dichloropropene	NA	
28.	cis-1,3-Dichloropropene	NA	
29.	1,4-Dioxane	NA	
224.	2-Ethoxyethanol	NA	
225.	Ethyl acetate	NA	
226.	Ethyl benzene	ND	
30.	Ethyl cyanide	NA	
227.	Ethyl ether	NA	
31.	Ethyl methacrylate	NA	
214.	Ethylene oxide	NA	
32.	Iodomethane	NA	
33.	Isobutyl alcohol	NA	
228.	Methanol	NA	
34.	Methyl ethyl ketone	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Volatile organics (continued)		
229.	Methyl isobutyl ketone	NA	
35.	Methyl methacrylate	NA	
37.	Methacrylonitrile	NA	
38.	Methylene chloride	NA	
230.	2-Nitropropane	NA	
39.	Pyridine	NA	
40.	1,1,1,2-Tetrachloroethane	NA	
41.	1,1,2,2-Tetrachloroethane	NA	
42.	Tetrachloroethene	D (CBI)	
43.	Toluene	ND	
44.	Tribromomethane	NA	
45.	1,1,1-Trichloroethane	NA	
46.	1,1,2-Trichloroethane	NA	
47.	Trichloroethene	ND	
48.	Trichloromonofluoromethane	NA	
49.	1,2,3-Trichloropropane	NA	
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	NA	
50.	Vinyl chloride	NA	
215.	1,2-Xylene	ND	
216.	1,3-Xylene	ND	
217.	1,4-Xylene	ND	
	Semivolatile organics		
51.	Acenaphthalene	NA	
52.	Acenaphthene	NA	
53.	Acetophenone	NA	
54.	2-Acetylaminofluorene	NA	
55.	4-Aminobiphenyl	NA	
56.	Aniline	NA	
57.	Anthracene	NA	
58.	Aramite	NA	
59.	Benz(a)anthracene	NA	
218.	Benzal chloride	NA	
60.	Benzenethiol	NA	
61.	Deleted	NA	
62.	Benzo(a)pyrene	NA	
63.	Benzo(b)fluoranthene	NA	
64.	Benzo(ghi)perylene	NA	
65.	Benzo(k)fluoranthene	NA	
66.	p-Benzoquinone	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
67.	Bis(2-chloroethoxy)methane	NA	
68.	Bis(2-chloroethyl)ether	NA	
69.	Bis(2-chloroisopropyl)ether	NA	
70.	Bis(2-ethylhexyl)phthalate	NA	
71.	4-Bromophenyl phenyl ether	NA	
72.	Butyl benzyl phthalate	NA	
73.	2-sec-Butyl-4,6-dinitrophenol	NA	
74.	p-Chloroaniline	NA	
75.	Chlorobenzilate	NA	
76.	p-Chloro-m-cresol	ND	
77.	2-Chloronaphthalene	NA	
78.	2-Chlorophenol	D (CBI)	
79.	3-Chloropropionitrile	NA	
80.	Chrysene	NA	
81.	ortho-Cresol	ND	
82.	para-Cresol	ND	
232.	Cyclohexanone	NA	
83.	Dibenz(a,h)anthracene	NA	
84.	Dibenzo(a,e)pyrene	NA	
85.	Dibenzo(a,i)pyrene	NA	
86.	m-Dichlorobenzene	NA	
87.	o-Dichlorobenzene	NA	
88.	p-Dichlorobenzene	NA	
89.	3,3'-Dichlorobenzidine	NA	
90.	2,4-Dichlorophenol	D (CBI)	
91.	2,6-Dichlorophenol	D (CBI)	
92.	Diethyl phthalate	NA	
93.	3,3'-Dimethoxybenzidine	NA	
94.	p-Dimethylaminoazobenzene	NA	
95.	3,3'-Dimethylbenzidine	NA	
96.	2,4-Dimethylphenol	ND	
97.	Dimethyl phthalate	NA	
98.	Di-n-butyl phthalate	NA	
99.	1,4-Dinitrobenzene	NA	
100.	4,6-Dinitro-o-cresol	ND	
101.	2,4-Dinitrophenol	ND	
102.	2,4-Dinitrotoluene	NA	
103.	2,6-Dinitrotoluene	NA	
104.	Di-n-octyl phthalate	NA	
105.	Di-n-propylnitrosamine	NA	
106.	Diphenylamine	NA	
219.	Diphenylnitrosamine	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
107.	1,2-Diphenylhydrazine	NA	
108.	Fluoranthene	NA	
109.	Fluorene	NA	
110.	Hexachlorobenzene	NA	
111.	Hexachlorobutadiene	NA	
112.	Hexachlorocyclopentadiene	NA	
113.	Hexachloroethane	NA	
114.	Hexachlorophene	NA	
115.	Hexachloropropene	NA	
116.	Indeno(1,2,3-cd)pyrene	NA	
117.	Isosafrole	NA	
118.	Methapyrilene	NA	
119.	3-Methylcholanthrene	NA	
120.	4,4'-Methylenebis (2-chloroaniline)	NA	
36.	Methyl methanesulfonate	NA	
121.	Naphthalene	NA	
122.	1,4-Naphthoquinone	NA	
123.	1-Naphthylamine	NA	
124.	2-Naphthylamine	NA	
125.	p-Nitroaniline	NA	
126.	Nitrobenzene	NA	
127.	4-Nitrophenol	ND	
128.	N-Nitrosodi-n-butylamine	NA	
129.	N-Nitrosodiethylamine	NA	
130.	N-Nitrosodimethylamine	NA	
131.	N-Nitrosomethylethylamine	NA	
132.	N-Nitrosomorpholine	NA	
133.	N-Nitrosopiperidine	NA	
134.	n-Nitrosopyrrolidine	NA	
135.	5-Nitro-o-toluidine	NA	
136.	Pentachlorobenzene	NA	
137.	Pentachloroethane	NA	
138.	Pentachloronitrobenzene	NA	
139.	Pentachlorophenol	ND	
140.	Phenacetin	NA	
141.	Phenanthrene	NA	
142.	Phenol	D (CBI)	
220.	Phthalic anhydride	NA	
143.	2-Picoline	NA	
144.	Pronamide	NA	
145.	Pyrene	NA	
146.	Resorcinol	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
147.	Safrole	NA	
148.	1,2,4,5-Tetrachlorobenzene	NA	
149.	2,3,4,6-Tetrachlorophenol	ND	
150.	1,2,4-Trichlorobenzene	NA	
151.	2,4,5-Trichlorophenol	ND	
152.	2,4,6-Trichlorophenol	D (CBI)	
153.	Tris(2,3-dibromopropyl) phosphate	NA	
	Metals		
154.	Antimony	NA	
155.	Arsenic	NA	
156.	Barium	ND	
157.	Beryllium	ND	
158.	Cadmium	ND	
159.	Chromium (total)	ND	
221.	Chromium (hexavalent)	NA	
160.	Copper	ND	
161.	Lead	ND	
162.	Mercury	NA	
163.	Nickel	ND	
164.	Selenium	NA	
165.	Silver	ND	
166.	Thallium	NA	
167.	Vanadium	ND	
168.	Zinc	D (CBI)	
	Inorganics other than metals		
169.	Cyanide	NA	
170.	Fluoride	NA	
171.	Sulfide	NA	
	Organochlorine pesticides		
172.	Aldrin	NA	
173.	alpha-BHC	NA	
174.	beta-BHC	NA	
175.	delta-BHC	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Organochlorine pesticides (continued)		
176.	gamma-BHC	NA	
177.	Chlordane	NA	
178.	DDD	NA	
179.	DDE	NA	
180.	DDT	NA	
181.	Dieldrin	NA	
182.	Endosulfan I	NA	
183.	Endosulfan II	NA	
184.	Endrin	NA	
185.	Endrin aldehyde	NA	
186.	Heptachlor	NA	
187.	Heptachlor epoxide	NA	
188.	Isodrin	NA	
189.	Kepone	NA	
190.	Methoxyclor	NA	
191.	Toxaphene	NA	
	Phenoxyacetic acid herbicides		
192.	2,4-Dichlorophenoxyacetic acid	D (CBI)	
193.	Silvex	NA	
194.	2,4,5-T	NA	
	Organophosphorous insecticides		
195.	Disulfoton	NA	
196.	Famphur	NA	
197.	Methyl parathion	NA	
198.	Parathion	NA	
199.	Phorate	NA	
	PCBs		
200.	Aroclor 1016	NA	
201.	Aroclor 1221	NA	
202.	Aroclor 1232	NA	
203.	Aroclor 1242	NA	
204.	Aroclor 1248	NA	
205.	Aroclor 1254	NA	
206.	Aroclor 1260	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Dioxins and furans		
207.	Hexachlorodibenzo-p-dioxins	D (CBI)	
208.	Hexachlorodibenzofurans	ND	Y
209.	Pentachlorodibenzo-p-dioxins	ND	Y
210.	Pentachlorodibenzofurans	ND	Y
211.	Tetrachlorodibenzo-p-dioxins	D (CBI)	
212.	Tetrachlorodibenzofurans	ND	Y
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND	

CBI = Confidential Business Information
D = Detected
ND = Not detected.
NA = Not analyzed.
X = Believed to be present based on engineering analysis of waste generating process.
Y = Believed to be present based on detection in treated residuals.

[a]If detected, concentration is shown, units are mg/l.

7. CALCULATION OF THE BDAT TREATMENT STANDARDS

This section discusses the determination of the treatment standards for the regulated constituents in K099 waste. EPA is establishing treatment standards for 2,4-D based on performance data from chemical oxidation using chlorine. The chlorinated dioxin and furan treatment standards are being transferred from the promulgated rule for dioxin-containing wastes (40 CFR 268.41).

As discussed in the introduction, the following steps are taken to derive the BDAT treatment standards:

1. The Agency screens the available data to determine whether any of the data fail to meet QA/QC requirements or represent poor design or poor operation of the treatment system.

2. Accuracy-corrected constituent concentrations are calculated.

3. The mean (arithmetic average) and variability factor for the accuracy-corrected data are calculated (See Appendix A for a discussion on the variability factor).

4. The treatment standard is computed by multiplying the mean by the variability factor.

For 2,4-D, EPA has 33 wastewater data points from one facility (2 collected by EPA and 31 submitted by Dow) from the BDAT treatment of K099 waste. In Section 5, EPA eliminated 4 data points (for reasons given in Step 1) and corrected the remaining 29 data points for accuracy. The 29 data points, their recoveries, and the accuracy-corrected data are presented in Table 7-1, along with the variability factor and the treatment standard.

The Agency cannot calculate wastewater treatment standards for the chlorinated dioxins and furans using the available performance data because these constituents were not present at treatable levels in the

untreated waste sampled by EPA. The Agency, instead, is transferring treatment standards established for the dioxin-containing wastes (see 51 FR 40615, November 7, 1986).

EPA has identified a nonwastewater waste that would be classified as K099 under the "derived-from" rule. This waste could be generated from the collection of clarification sludges from biological treatment or from the spent carbon from carbon adsorption treatment. Because EPA has no data on treatment of this waste, or on a waste believed to be similar, the Agency is establishing standards for the nonwastewater that are equal to the wastewater standards.

Table 7-2 summarizes the treatment standards established for K099 waste.

Table 7-1 Calculation of Wastewater Treatment Standard for 2,4-D

Data source	Sample no.	2,4-D concentration (ug/l)	3,4-D spike concentration (ug/l)	Recovery[a]	Accuracy-corrected 2,4-D concentration[b] (ug/l)	Mean (ug/l)	Variability factor	Treatment standard (mg/l)
EPA (Table 4-1)	1	61	-	0.96	64	125	8.27	1.0
	2	42	-	0.96	44			
Dow (Table 4-2)	1	81.94	29.37	0.59	139.4961			
	2	40.89	16.24	0.32	125.8929			
	3	103.14	53.18	1.06	96.9725			
	4	117.10	35.90	0.72	163.0919			
	5	36.19	15.32	0.31	118.1136			
	6	116.35	43.85	0.88	132.6682			
	7	244.62	35.68	0.71	342.7971			
	8	141.76	41.11	0.82	172.4155			
	9	68.28	23.14	0.46	147.5367			
	10	530.83	17.20	0.34	1543.11			
	11	1031.46	38.93	0.78	1324.26			
	12	8.39	43.89	0.88	9.5584			
	13	4.42	67.75	1.36	3.2618			
	14	41.00	26.46	0.53	77.4754			
	15	31.31	48.58	0.97	32.2252			
	16	393.66	43.19	0.86	455.7305			
	17	302.79	49.64	0.99	304.9859			
	18	54.04	25.88	0.52	104.4049			
	19	157.44	60.61	1.21	129.8796			
	20	55.74	44.14	0.88	63.1400			
	21	1638.45	27.01	0.54	3033.04			
	22	93.07	35.91	0.72	129.5879			
	23	25.61	45.39	0.91	28.2111			
	24	59.08	53.68	1.07	55.0298			
	25	105.29	45.29	0.91	116.2398			
	26	<4	0	0	-			
	27	152.38	40.86	0.82	186.4477			
	28	18.87	56.20	1.12	16.7883			
	29	32.89	40.04	0.80	41.0714			
	30	33.65	48.14	0.96	34.9501			
	31	272.98	47.14	0.94	289.5418			

[a]Recovery = (3,4-D spike concentration in ppb)/50 ppb for Dow-submitted data. (Samples were spiked with 50 ppb of 3,4-D.) See Appendix B for recovery information on EPA collected data.

[b]Accuracy-corrected 2,4-D concentration = 2,4-D concentration/recovery.

Table 7-2 BDAT Treatment Standards for K099

Constituent	Total concentration	
	Nonwastewater (mg/kg)	Wastewater (mg/l)
2,4-Dichlorophenoxyacetic acid	1.0	1.0
Hexachlorodibenzo-p-dioxins	0.001	0.001
Hexachlorodibenzofurans	0.001	0.001
Pentachlorodibenzo-p-dioxins	0.001	0.001
Pentachlorodibenzofurans	0.001	0.001
Tetrachlorodibenzo-p-dioxins	0.001	0.001
Tetrachlorodibenzofurans	0.001	0.001

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Versar personnel involved in the preparation of this document included Mr. Jerome Strauss, Program Manager; Mr. David Pepson, Senior Technical Reviewer; Ms. Justine Alchowiak, Quality Assurance Officer; Ms. Olenna Truskett, Technical Reviewer; Ms. Barbara Malczak, Technical Editor; and the Versar secretarial staff, Ms. Linda Gardiner and Ms. Mary Burton.

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APPENDIX A

STATISTICAL METHODS

A.1 F Value Determination for ANOVA Test

As noted in Section 1.2, 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 found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long-term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found 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 A-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).

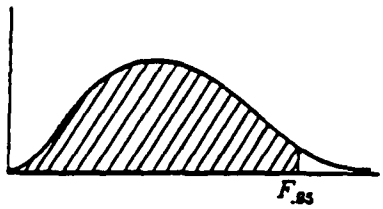
Table A-1

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_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	4.23	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	2.23	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	1.32	1.24	1.00

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 if 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.

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 logtransformed data points for each technology.

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

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

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 value
Between	k-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below 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 in which one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

Steam stripping				Biological treatment			
Influent (μg/l)	Effluent (μg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent (μg/l)	Effluent (μg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$
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)

$n_1 = 10,\ n_2 = 5,\ N = 15,\ k = 2,\ T_1 = 23.18,\ T_2 = 12.46,\ T = 35.64,\ T^2 = 1270.21$

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

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

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

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 calculations.

Example 2
Trichloroethylene

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
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)

Example 2 (Continued)

$F = MSB/MSW$

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 logtransformed data points for each technology

X_{ij} = the natural 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 calculations.

Example 3
Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent (μg/l)	Effluent (μg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent (μg/l)	Effluent (μg/l)	ln(effluent)	$\ln[(\text{effluent})]^2$
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:

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

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

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

$$F = MSB/MSW$$

Example 3 (Continued)

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 logtransformed data points for each technology

X_{ij} = the natural 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 larger 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 calculations.

A.2 Variability Factor

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

where:

VF	=	estimate of 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; and
Mean	=	average of the individual performance values.

EPA is establishing this figure as an instantaneous 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 unknown and, hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data show that the treatment residual concentrations are

distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA 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), as follows:

$$VF = \frac{C_{99}}{Mean}. \qquad (1)$$

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, Distribution in Statistics-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:

$$C_{99} = Exp\ (\mu + 2.33\sigma) \qquad (2)$$

$$Mean = Exp\ (\mu + 0.5\sigma^2). \qquad (3)$$

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

$$VF = Exp\ (2.33\ \sigma - 0.5\sigma^2). \qquad (4)$$

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 variability factor (VF) can be estimated using equation (1). For residuals with concentrations

that are below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a variability factor.

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be 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:

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

(Note that when LL = (0.1)(UL) as in Assumption 1, then $\sigma = (\ln 10) / 4.66 = 0.494$.)

Substitution of the σ value from equation (5) into equation (4) yields the variability factor, VF, as shown:

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

APPENDIX B

ANALYTICAL QA/QC

The analytical methods used for analysis of the regulated constituents identified in Section 6 are listed in Table B-1. SW-846 methods (EPA's Test Methods for Evaluation Solid Waste: Physical/ Chemical Methods, SW-846, Third Edition, November 1986) are used in most cases for determining total constituent concentrations.

The accuracy determination for a constituent is based on the matrix spike recovery values. Table B-2 presents the matrix spike recoveries for 2,4-dichlorophenoxyacetic acid total constituent analyses for K099 residuals for the EPA-collected data.

For the data collected by EPA, the accuracy correction factor for 2,4-dichlorophenoxyacetic acid was determined in accordance with the general methodology discussed in the Introduction and is presented in Table B-2. For 2,4-dichlorophenoxyacetic acid, actual spike recovery data were obtained for analysis of wastewaters, and the lowest percent recovery value was used to calculate the accuracy correction factor. The calculation of a corrected concentration value for 2,4-D is shown below.

Analytical value	% Recovery	Correction factor	Corrected value
0.052	96	$\frac{100}{96} = 1.04$	1.04 x 0.052 = 0.054 ppm

Table B-1 Analytical Methods for Regulated Constituents

Regulated constituent	Extraction method	Analytical method
Total Composition		
2,4-Dichlorophenoxyacetic acid	Specified in analytical method	8150[a]
Total Hexachlorodibenzo-p-dioxins	Specified in analytical method	8280
Total Hexachlorodibenzofurans	Specified in analytical method	8280
Total Pentachlorodibenzo-p-dioxins	Specified in analytical method	8280
Total Pentachlorodibenzofurans	Specified in analytical method	8280
Total Tetrachlorodibenzo-p-dioxins	Specified in analytical method	8280
Total Tetrachlorodibenzofurans	Specified in analytical method	8280

[a]Samples analyzed by GC/MS rather than GC/ECD as specified in the method.

Source: USEPA 1986. U.S. Environmental Protection Agency. Test methods for evaluating solid waste: Physical/chemical methods. SW-846. Washington, D.C.: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, November 1986.

Table B-2 Matrix Spike Recoveries for K099 Treated Wastewater-EPA-Collected Data

BDAT constituent	Original amount found (mg/l)	Matrix spike			Matrix spike duplicate			Accuracy-correction factor[c]
		Spike added (mg/l)	Spike result (mg/l)	Percent recovery[a]	Spike added (mg/l)	Spike result (mg/l)	Percent recovery[a]	
2,4-Dichlorophenoxy-acetic acid	0.0516	0.050	0.0549	6.6[b]	0.05	0.148	193[b]	1.04
Bromodichloromethane	0.009	10	10.4	104	10	10.8	108	0.96
Chloroform	1.88	1	2.80	92	1	2.84	96	1.09
Tetrachloroethene	1.3	10	9.5	95	10	9.88	99	1.05
2-Chlorophenol	ND	0.05	ND	0	0.05	ND	0	0
2,4-Dichlorophenol	0.033	0.05	0.03	0	0.05	0.03	0	0
Phenol	ND	0.05	ND	0	50	ND	0	0
2,4,6-Trichlorophenol	0.08	0.15	0.096	13	0.15	0.08	0	0
Zinc	0.308	2.0	2.3	101	NA	NA	NA	0.99

NC = Not calculable because the only values available were the spike amount and the percent recovery.

[a]Percent recovery = [(spike result - original amount)/spike added].

[b]The OER documents that, for the matrix spike, the 2,4-dichlorophenoxyacetic acid (2,4-D) was apparently not added to the sample, and for the matrix spike duplicate, the sample was accurately spiked with twice the amount. Based on a review of the data, EPA believes that the matrix spike duplicate was spiked with 0.1 mg/l of 2,4-D and the recovery value is 96 percent. Therefore, 96 percent is used to calculate the accuracy-correction factor.

[c]Accuracy-correction factor = 100/percent recovery (using the lowest percent recovery value).

Note: For the chlorinated dioxins and furans, the samples were spiked with 2,3,7,8-TCDD; however, because of the dilution required to quantify the other chlorinated dioxin and furan values, the spike value was not measurable.

Reference: USEPA 1987a. U.S. Environmental Protection Agency, Office of Solid Waste. Draft final report, Sampling and analysis of the 2,4-D production process at the Dow Chemical USA Midland, Michigan, Plant. May 29, 1987. EPA Contract No. 68-01-7287. Prepared by Midwest Research Institute, Kansas City, Mo.

APPENDIX C

DETECTION LIMITS FOR K099 WASTE SAMPLES

Table C-1 presents detection limits for the analyzed constituents in untreated and treated waste sample data.

Table C-1 Detection Limits for K099 Untreated and Treated Samples

BDAT reference no.	BDAT list constituent	Untreated waste (ug/l)	Treated waste (ug/l)
5	Bromodichloromethane	[UNTREATED WASTE	2
14	Chloroform	CONCENTRATIONS	2
42	Tetrachloroethene	ARE RCRA CBI.]	2
78	2-Chlorophenol		15
90	2,4-Dichlorophenol		15
91	2,6-Dichlorophenol		20
142	Phenol		15
152	2,4,6-Trichlorophenol		45
160	Zinc		NA
192	2,4-Dichlorophenoxyacetic acid (2-4-D)		20, 4[a]
207	Total Hexachlorodibenzo-p-dioxins		0.002
208	Total Hexachlorodibenzofurans		0.002
209	Total Pentachlorodibenzo-p-dioxins		0.002
210	Total Pentachlorodibenzofurans		0.002
211	Total Tetrachlorodibenzo-p-dioxins		0.002
212	Total Tetrachlorodibenzofurans		0.002

NA - Not available

Reference: USEPA 1987a and Dow Chemical 1988 (LDR7-00036).

[a] Detection limit for 2,4-D is 20 μg/l in EPA-collected data and 4 μg/l in Dow-submitted data.