WASTE FORMS TECHNICAL BACKGROUND DOCUMENT

in support of the
Hazardous Waste Identification Rule

Office of Solid Waste
U.S. Environmental Protection Agency
October, 1999

EXECUTIVE SUMMARY

Due to the broad reach of the “derived-from” and “mixture” rules, many residuals generated from effective treatment that may be of low or minimal risk remain subject to the hazardous waste regulations under the Resource Conservation and Recovery Act (RCRA). There are avenues for revising this designation (e.g., delisting), however the process is time-consuming and expensive. In response to this issue, the Hazardous Waste Identification Division (HWID) of EPA's Office of Solid Waste is developing revisions to the existing regulations defining hazardous waste. One objective of these revisions is the discussion of risk-based exemption levels where wastes would no longer be regulated as hazardous waste. Under the Hazardous Waste Identification Rule (HWIR), wastes that contain toxic constituents below these levels could be disposed in ways currently used for non-hazardous waste.

As an adjunct to the HWIR approach, the Agency is exploring a Waste Forms initiative that evaluates a waste’s physical form in conjunction with common or expected management practices. The combination of these factors may provide a cost-effective method for identifying those wastes and management practices that are candidates for becoming exempt from RCRA without the need for the sampling, analysis, and reporting required under HWIR.

The Waste Forms Approach consists of the following steps:

- Develop baseline BRS data set,
- Develop screening criteria,
- Develop definitions for consistent application or criteria, and
- Conduct Screening.

Using the 1995 Biennial Reporting System data as a baseline for the hazardous waste universe, the Agency applied this methodology to identify 64 Form Code/System Type Code combinations as preliminary Waste Forms candidates. Of these 64 combinations, the Agency analyzed the available constituent data from the National Hazardous Waste Constituent Survey and the historic HWIR exemption levels for specific management units to identify those wastes that appear well-suited for the Waste Forms Approach. The following nine wastes were identified for more detailed consideration:

- Ash, Slag, or Other Residue from the Incineration of Wastes, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B303/M111)

- Other “Dry” Ash, Slag, or Thermal Residue, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B304/M111)

- “Dry” Lime or Metal Hydroxide Solids Chemically “Fixed”, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B305/M111)

- "Dry" Lime or Metal Hydroxide Solids Not "Fixed", Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B306/M111)

- Air Pollution Control Device Sludge (e.g., Fly Ash, Wet Scrubber Sludge), Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B511/M111)

- Untreated Plating Sludge without Cyanides, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B505/M111)

- Other Wastewater Treatment Sludge, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B504/M111)

- "Dry" Lime or Metal Hydroxide Solids Chemically "Fixed", Managed by Chemical Precipitation (B305/M077)

- "Dry" Lime or Metal Hydroxide Solids Chemically "Fixed", Managed in Landfills (B305/M132)

Of the remaining wastes, 23 wastes from the organic liquids and solids and sludges groups were determined not to be low risk and were not pursued; three wastes were not considered for other reasons; additional study and evaluation is required for the remaining 29 wastes. Therefore, monolithic cement or pozzolanic-stabilized wastes were selected as the initial basis for developing regulatory options under the Waste Forms Approach.

The Agency considered the following factors as part of the regulatory options development process:

- Which hazardous wastes are managed using this treatment,
- How the waste is generated,
- How the waste is managed and disposed, and
- Exposure pathways mitigated by waste form.

These evaluations resulted in the identification of several issues. Specifically these issues included:

- How should cement-stabilized wastes be defined?
- Should specific reagents be required or disclosed?
- Will tests for minimum physical properties be required?
- Are only specific wastes allowed?
- Will target constituents be identified?
- Will TCLP be required?
- Will disposal in landfills be required?

- If the wastes meets the requirements for Waste Forms Exemption, what assurance does the Agency have that the cement-stabilized wastes will not be used for construction applications?

EPA had neither the time nor the resources under the current effort to explore these many considerations associated with a waste form specific exemption. Most fundamentally, the Agency in conjunction with the broader technical community seeks to establish reasonable assumptions regarding potential releases from stabilized waste forms. Such current and future inquiries would also focus on the long term efficacy of reducing the mobility of hazardous constituents from these forms.

Contents

1.0 INTRODUCTION

The Hazardous Waste Identification Division (HWID) of EPA's Office of Solid Waste is developing revisions to the existing regulations defining hazardous waste. One objective of these revisions, known as the Hazardous Waste Identification Rule (HWIR), is to develop the framework for risk-based exemption levels where wastes, whose hazardous constituents are in concentrations below these exemption levels, would no longer be regulated as hazardous waste under Subtitle C of the Resource Conservation and Recovery Act (RCRA). Wastes that contain toxic constituents below these levels could be disposed in ways currently used for non-hazardous waste. EPA is also exploring conditions under which waste would still be able to become exempt from the Subtitle C "system" but the disposal of such waste might be limited to certain types of wastes and/or disposed at certain types of facilities meeting certain conditions -- a regulatory scheme known as contingent management. Such contingent management could be implemented through a federal model adopted by States or through federal reliance on State-developed contingent management programs.

Analytically, the Agency has chosen to identify certain low risk wastes as those wastes whose hazardous constituents are at concentrations below these risk-based exemption levels. Based on the analyses that have been conducted to date, the Agency believes that it is more cost effective to set levels for a group of toxic constituents rather than on an industry-by-industry basis. The Agency recognizes, however, that two wastes that contain the same toxic constituents are not necessarily the same wastes and that these wastes might possess different characteristics regarding the wastes' integrity, the wastes' ability to be disposed with other types of waste, and the ability of these constituents to migrate from the wastes. Furthermore, the compatibility of the waste with particular waste management units with consideration of the geological and other environmental conditions existing at those waste management unit could affect the migration of toxic constituents and thereby the protectiveness of disposing such waste in particular waste management units.

The purpose of this technical background document is to discuss EPA's efforts to develop viable strategies for structuring exemption mechanisms for specific low-risk hazardous wastes that merit regulatory relief -- by nature of their composition and common management practices -- beyond relief that would be provided through the nationally-based HWIR rulemaking based on exemption levels for individual constituents. EPA refers to this effort as its Waste Forms initiative; however, waste management is an integral part of the development of such exemption mechanisms.

This document presents the methodologies followed to support EPA's research efforts, identifies criteria evaluated in identifying candidate hazardous waste types for consideration, and discusses risk management conditions specific to waste management units that are likely to receive wastes becoming exempt from Subtitle C. This document has been prepared to assist EPA in laying the groundwork for exemptions based on conditions such as waste forms and waste management. This document also has been prepared to assist the HWIR Team in reaching agreement regarding the reasonableness of conducting additional work on the Waste Forms initiative, and how such work should proceed.

This background document includes the following main sections:

- *Regulatory Background* (Chapter 2) -- Provides background and explains the regulatory climate and issues that have led EPA to pursue the Waste Forms Approach under HWIR;

- *Waste Forms -- An Alternative Approach* (Chapter 3) -- Describes the Agency's rationale for pursuing the Waste Forms Approach and explains how the Waste Forms Approach might function;

- *Profile of the Hazardous Waste Universe* (Chapter 4) -- Uses data from the 1995 Biennial Report to describe the overall composition of the universe of hazardous wastes, including distinctions between waste generation and management, and trends associated with both;

- *Identification of Candidate Wastes* (Chapter 5) -- Describes the methodology used to identify waste form/management practice combinations that are candidates for exemption under the Waste Forms Approach, and identifies and describes those waste form/management practice combinations; and

- *Unit-Specific Risk Management* (Chapter 6) -- Reviews the primary waste management units associated with the Waste Forms Approach (i.e., landfills, monofills, surface impoundments, land application units, waste piles, and tanks) and describes the potential exposure pathways associated with each, the fate and transport mechanisms, design criteria, and associated requirements.

2.0 REGULATORY BACKGROUND

2.1 How Are Hazardous Wastes Classified under RCRA?

Hazardous wastes are regulated under the Solid Waste Disposal Act (SWDA), as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA). These statutes are commonly referred to as the Resource Conservation and Recovery Act (RCRA), and are codified at Volume 42 of the United States Code (U.S.C), Sections 6901 to 6992k. RCRA Section 3001(a) requires EPA to promulgate criteria for identifying characteristics of hazardous wastes and for listing hazardous wastes. These regulations are codified at volume 40 of the Code of Federal Regulations (CFR) Section 261.11 (40 CFR 261.11), and describe the criteria for identifying wastes that exhibit hazardous waste characteristics and for listing wastes as hazardous. There are two types of hazardous wastes: "characteristic" and "listed" hazardous wastes. Once classified as hazardous, wastes must be managed in accordance with the RCRA regulations.

Hazardous wastes may be classified as "characteristic" wastes if they have any of the properties described at 40 CFR 261.20. These properties are described as ignitability, corrosivity, reactivity, and toxicity. There are three definitions based on physical characteristics, and 40 definitions based on specific toxic chemical characteristics, and EPA assigns separate "D" codes to these wastes.

- Ignitable wastes are designated D001 and are assigned to wastes that burn easily.
- Corrosive wastes are designated D002 and are assigned to wastes with acidic or caustic wastes that demonstrate corrosive properties.
- Reactive wastes are designated D003 and are assigned to wastes that can explode or have reactions that create hazardous conditions.
- The remaining codes (D004 through D043) correspond with specific levels of toxic chemicals. If a waste contains any one of these chemicals that can leach out at or above the specified level, it is a characteristic waste for that constituent.

For example, wastes that exhibit the characteristic of reactivity are classified as D003 wastes; wastes that exhibit the characteristic of toxicity based on chromium are classified as D007 wastes. Characteristic wastes (or D wastes) are <u>not</u> eligible for exemption under HWIR, until they are de-characterized:

- Hazardous wastes that are ignitable (D001), corrosive (D002), or reactive (D003) are considered hazardous until they no longer exhibit the characteristic for which they were listed. These wastes can be treated to remove the characteristic.

- The risks associated with these wastes are not based solely on the presence of toxic constituents; the risks are associated with certain properties of the waste. (Physical properties for D001 through D003, and leaching properties for D004 through D043.)

- Wastes that exhibit the characteristic of toxicity (D004-D043) are considered hazardous because they contain leachable concentrations of specific chemicals above regulatory thresholds indicated in Table 1 of 40 CFR Section 261.24.

- Because, by definition, characteristically toxic wastes contain significant concentrations of toxic constituents, these wastes will not be expected to satisfy the HWIR exemption criteria (i.e., exemption levels). But they can be treated to make them less leachable.

Solid wastes also may be "listed" as hazardous if they contain any of the hazardous constituents identified in Appendix VIII of 40 CFR Part 261. The Agency considers eleven factors enumerated in 40 CFR Section 261.11(a)(3) to determine whether a waste is capable of posing a hazard to human health or the environment when improperly managed. In general, wastes meeting the specific descriptions are regulated as hazardous regardless of the concentrations and mobilities of the hazardous constituents contained in the waste. Listed hazardous wastes may fall under one of three categories:

- Non-specific waste sources (40 CFR Section 261.31). These are generic wastes commonly produced by manufacturing and industrial processes. Examples of hazardous wastes identified in this list include spent solvents from degreasing and wastewater treatment sludges from electroplating operations. EPA designates these wastes with "F" codes.

- Specific source waste (40 CFR Section 261.32). This list identifies wastes from specific industries and processes such as wood preserving, petroleum refining, and organic chemical manufacturing. These wastes typically include still bottoms, sludges, spent catalysts, and residues. EPA designates these wastes with "K" codes.

- Commercial chemical products (40 CFR Sections 261.33(e) and (f)). These lists identify specific commercial chemicals that are discarded, off-specification, container residues, or spills as listed hazardous wastes. These lists include chemicals such as chloroform, creosote, sulfuric acid, and pesticides such as DDT and kepone. EPA designates these wastes with "P" or "U" codes.

In addition to listing wastes as hazardous upon their generation, EPA also regulates residues that facilities generate during the treatment of hazardous wastes. Known as the "derived-from" rule, 40 CFR Section 261.3(c)(2)(i) indicates that

> "... any solid waste generated from the treatment, storage, or disposal of a hazardous waste, including any sludge, spill residue, ash, emission control dust, or leachate (but not including precipitation run-off) is a hazardous waste ...."

Thus, if a facility chooses to incinerate a benzene-laden waste classified as an F005 waste, the ash generated during the incineration process also carries the F005 classification and must be managed in accordance with EPA's hazardous waste regulations. The derived-from rule also applies to characteristic wastes; however, if the waste no longer exhibits the characteristic, it is no longer hazardous.

There is one final manner in which a waste may be classified as hazardous under RCRA. 40 CFR 261.3(a)(2)(iv), referred to as the "mixture" rule, defines any mixture of solid waste and hazardous waste (as listed in 40 CFR Part 261, Subpart D) as a hazardous waste unless the waste is otherwise excluded from hazardous waste regulation. Thus, if a facility combines sludges from a tank containing wastewater treatment sludges from wood preserving (K001) with cleanout sludges from a storage tank, the combined volume of sludge is considered to be a K001 hazardous waste, and must be managed as such.

Without these rules, the Agency was concerned that a hazardous waste treater (or generator) would provide minimal or ineffective treatment of the hazardous waste in order to avoid or remove the hazardous designation. For example, without the mixture rule, the K001 waste may be mixed with a nonhazardous tank sludge and the facility could claim that the combined waste does not meet the definition of K001. The mixture rule effectively prevents this practice.

2.2 How Have the "Mixture" and "Derived-from" Rules Affected Industry?

In response to the proposed HWIR rule several commenters provided anecdotal information on how the mixture and derived-from rules are creating problems. The following examples illustrate these cases:

- The mixture and derived-from rules has caused one facility to evaluate the segregation of hazardous and nonhazardous wastewaters from a large centralized wastewater treatment system. This segregation would require the construction of a second treatment facility and significant repiping, resulting in millions of dollars with no net change in the quality of treated wastewater discharged.

- One facility that generates several hazardous waste streams is seeking solutions for recycling these streams to usable materials. However the mixture and derived-from rules frequently render promising technologies economically impractical due to the high cost of RCRA management of treated materials.

- A facility developed a process that could remove sulfates and chlorides from K069 emission control dust to reduce the emission of sulfur dioxide when the dust is remelted. The derived from rule would apply to the generation of any residuals resulting from this treatment, subjecting chloride and sulfate materials to RCRA regulation. Thus the facility is generating two new wastes that they must manage as hazardous while reducing sulfur dioxide emissions.

- Treated wastes typically do not resemble the original waste. For example, ash from the incineration of organic hazardous wastes generally exist in different physical form than the incinerated residual.

In general, these examples illustrate that residuals from effective treatment are subject to the stringent and costly RCRA management requirements for hazardous wastes. Although there is a means for "delisting" these derived-from materials, the process is costly and time-consuming.

2.3 How Have the "Mixture" and "Derived-from" Rules Influenced the Development of HWIR?

EPA initially proposed its regulations for hazardous wastes in December 1978. In 1980, EPA finalized much of the proposed regulations; however, for various reasons, EPA was unable to finalize all of the proposed hazardous waste characteristics. In finalizing the Part 261 regulations, EPA included provisions to also regulate mixtures of hazardous wastes and residues generated during the treatment of hazardous wastes. EPA developed the "mixture" and "derived-from" rules based on Agency concerns that industry might attempt to evade regulation. In promulgating Part 261 regulations that included the "mixture" and "derived-from" rules, however, EPA did not provide industry with an opportunity to comment on these rules.

Industry sued EPA on this matter, and settlement negotiations were held. EPA amended its hazardous waste regulations. In 1991, the DC Circuit Court subsequently issued an opinion that vacated (i.e., voided) the "mixture" and "derived-from" rules, noting that EPA had violated the requirements for notice-and-comment. The Agency subsequently promulgated an emergency rule reinstating the "mixture" and "derived-from" as interim final rules. Under these interim final rules, industry remained obligated to manage wastes classified under the "mixture" and "derived-from" rules as hazardous.

In March of 1992, EPA promulgated a rule, which, at the request of OMB, included a one-year "sunset" provision. This sunset provision provided that the "mixture" and "derived-from" rules would remain in effect only until April 1993. In May of 1992, EPA published a proposed rule that identified options for revising the "mixture" and "derived-from" rules. The notion of risk-based levels was included in most of the proposed options. This 1992 proposal was, perhaps, the first time EPA proposed the concept of a concentration-based exemption.

In October of 1992, EPA removed the sunset provision and withdrew its May 1992 proposed rule. Congress established an enforceable deadline to cover the "mixture" and "derived-from" rules until October 1994. Again, under this enforceable deadline, industry remained obligated to manage wastes classified under the "mixture" and "derived-from" rules as hazardous.

EPA missed its October 1994 deadline and, in response, three lawsuits were filed. As a result, the Court entered a consent decree requiring EPA to sign a proposal and amend the "mixture" and "derived-from" rules by November 13, 1995, and publish a notice of final rulemaking by December 15, 1996.

In December 1995, EPA published a proposed rule that established risk-based exemption levels for hazardous wastes and described a number of options for implementing the HWIR exemption mechanism. Included in this proposed rule was an option to provide relief to industry from the Land Disposal Restrictions (LDR) requirements. EPA received substantial comments on its December 1995 proposal, particularly on the technical merits of the risk assessment models used in developing the HWIR exemption levels. In part due to stakeholder concerns regarding the Agency's risk assessment, EPA approached the litigants for an extension of its 1996 deadline. Through early 1997, EPA participated in negotiations with the litigants for over six months and signed a consent decree in April 1997. EPA currently has an October 31, 1999 deadline to re-propose HWIR. EPA is tasked to publish a final rule by April 30, 2001. This final rule must take action with respect to revisions to the "mixture" and "derived-from" rule currently codified in 40 CFR §261.3.

2.4 What Are the Current Exemption Options Available to Industry for These Wastes?

EPA exploring whether its hazardous waste identification process has inadvertently classified some low-risk wastes as hazardous. Cases are presumed to exist where wastes, under current regulations, are classified as hazardous; yet, due to low concentrations of hazardous constituents, these wastes pose no or minimal threat to human health and the environment. For example, any treatment regime that is used to immobilize, recover, or destroy hazardous contaminants may generate a residue that contains very low concentrations of hazardous constituents. Thermal processes such as incineration have been demonstrated to be successful in destroying organic constituents in wastes, resulting in an ash residue that is made up of inorganic material. However, because of the "derived-from" rule, this ash residue will carry the same hazardous waste designation as the hazardous waste that was originally burned.

Other factors may also contribute to low concentrations of hazardous constituents. A manufacturing process, which was reviewed in conjunction with EPA's listing determination process, may be modified by one facility such that the concentrations of hazardous constituents in the waste are drastically reduced or eliminated. For example, F006 wastes are sludges generated from the treatment of electroplating wastewaters. Electroplating encompasses a wide variety of different processes, using many different types of coatings. In the original listing determination, the Agency collected information on these wastes and determined that, as generated and in the manner that the wastes were being managed, electroplating sludges posed a risk to human health and the environment. Technologies now exist where electroplating can be done without using these same hazardous constituents (e.g., cyanide). As a result, wastewater treatment sludges from these processes now may contain insignificant or very low concentrations of hazardous constituents, and, therefore, these wastes may pose relatively low risk. However, because these sludges meet the hazardous waste description for F006 wastes, they must be managed as hazardous waste.

Currently, industry has few options available for removing the "hazardous waste" label from wastes listed as hazardous. In the case of the F006 waste described above, the Agency has since recognized that there are electroplating operations that do not generate wastes with high concentrations of hazardous constituents. Consequently, EPA promulgated an interpretive rule to the original F006 listing to include specific descriptions of those electroplating processes that are now excluded from the F006 listing (see December 2, 1986; 51 FR 43350).

Facilities may also find regulatory relief if they seek a formal, waste-specific exclusion from the list of hazardous wastes. This approach is referred to as the "delisting" process. This process involves submitting a petition to the Agency demonstrating that the waste does not meet any of the criteria under which the waste was listed as a hazardous waste and does not otherwise exhibit any properties of a hazardous waste. The procedures and requirements for such a petition are presented in 40 CFR Sections 260.20 and 260.22. These exclusions apply only to specific wastes at a specific facility. Historically, the delisting of a hazardous waste has been a time- and resource-intensive process typically requiring sampling and analysis, submission and evaluation of groundwater monitoring data, publication of notices in the Federal Register, and revisions to 40 CFR 261. Because EPA is required to take public comment on its delisting decisions, a facility often did not a receive an exclusion from the hazardous waste regulations for up to two and a half years after submittal of a complete petition. The majority of wastes excluded under EPA Headquarter's delisting process have been metal-bearing wastes such as electroplating sludges (F006) and treated electric arc furnace dusts (K061). In general, residuals generated from the treatment of hazardous wastes that meet current LDR treatment levels are good candidates for delisting.[1]

Facilities also have the option to minimize the impact of EPA's hazardous waste regulations by taking advantage of the solid waste variances. If a waste is not a solid waste, it cannot be a hazardous waste. Thus, if a facility can demonstrate that it does not generate a solid waste, it no longer is required to meet RCRA Subtitle C requirements. The standards and criteria for these classification variances are found in 40 CFR Section 260.31. In most cases, the candidate wastes must be destined for some type of recycling or reuse.

Although facilities may, and do, pursue these existing exemption options, industry has requested an exemption mechanism that minimizes the burdens and costs associated with re-classifying a hazardous waste as non-hazardous, particularly for wastes that present little threat to human health and the environment. EPA's development of a self-implementing exemption such as HWIR is, in part, an effort to provide regulatory relief to industry for low-risk hazardous wastes. Under the "generic" HWIR approach, EPA is structuring a relief mechanism that will be all encompassing of the hazardous waste universe. As such, EPA acknowledges that implementation burdens and costs may be unacceptable to some generators as EPA sets in place sampling,

[1] U.S. EPA. Environmental Fact Sheet. Delisting Petitions and the Petition Review Process

analysis, and reporting conditions that will provide assurance that wastes becoming exempt under HWIR will not cause harm to human health and the environment in the future. However, EPA is also exploring ways in which to reduce these implementation burdens and costs. The Waste Forms Approach developed in this technical background document uses an alternative methodology than the "generic" HWIR approach. Section 3, which follows, describes efforts to structure an HWIR exemption option that is linked to the physical form of a waste and the waste management options associated with that physical form.

3.0 WASTE FORMS -- AN ALTERNATE HWIR APPROACH

3.1 What Does EPA Mean by "Waste Form", and What is the Waste Forms Approach?

The term "waste form" refers simply to the physical nature of the waste. The physical properties of a waste impart certain characteristics to that waste, just as the chemical properties of a waste impart certain characteristics. Some waste forms are familiar and used by most individuals. For example, water is a waste form in the truest sense, while "liquid" is a waste form that most individuals could identify yet not completely define. EPA commonly uses the terms "solid", "sludge", "organic liquid", and "wastewater". These are waste forms, yet EPA's use of these terms is often challenged because different EPA program offices assign different meanings and definitions to these terms -- definitions that are essential to the implementation of regulations published by those offices.[2] For example, under 40 CFR Section 268.2 of the Land Disposal Restrictions (LDR), "wastewaters" are those wastes that contain less than 1 percent by weight total organic carbon and less than 1 percent by weight total suspended solids. Yet, under 40 CFR Section 258.28, the solid waste disposal facility criteria (for determining compliance with the prohibition of liquids in municipal solid waste landfills) define a liquid waste as any waste containing free liquids as determined using SW-846 Method 9095. Thus, additional complexity is encountered when exact definitions are required. Regardless of the difficulties or ambiguities associated with various terms, EPA considers any term that refers to the matrix of a waste to be a "waste form".

From a waste perspective, "waste forms" can be defined in a number of ways. Three classification systems commonly used include:

- Classification according to waste origin -- Wastes may be classified based on the process that generates the waste. In this system, a waste is linked to the process unit that generates the waste. Examples include: ash generated from an incinerator, still bottoms retrieved from a distillation column, slag generated from a high temperature metals recovery unit, sediment generated from a chemical precipitation process, waters discharged from a non-contact cooling system. EPA has used this classification system in its listing determination process for wastes identified under 40 CFR Section 261.31 (wastes from non-specific sources) and 40 CFR Section 261.32 (wastes from specific

---

[2] In addition, different Federal agencies assign different definitions to some waste forms. For example, Department of Transportation (DOT) regulations, under 40 CFR Section 171.8, define a solid waste as "a material which has a vertical flow of two inches (50 mm) or less within a three-minute period, or a separation of one gram (1 g) or less of liquid when determined in accordance with the procedures specified in ASTM D4359-84 'Standard Test Method for Determining Whether a Material is a Liquid or a Solid'". EPA's definition of a solid waste is much more complex, and begins with " a solid waste is any discarded material that is not excluded by Section 261.4(a) or that is not excluded by variance granted under Sections 260.30 and 260.21". EPA's definition of a solid waste includes wastes that are in liquid form.

sources). In fact, EPA's use of K codes and F codes is a specialized use of this classification system.

- Classification as defined by an analytical or test method -- Wastes may be classified based on the results of an analytical or test procedure. The results of the procedure provide, in some cases, quantitative information about the chemical or physical properties of a waste. In other cases, the results of the procedure may describe a waste in terms of whether it passes or fails the performance criteria of the method. Examples include: wastes that pass the Paint Filter Liquids Test[3], wastes that can withstand repeated blows with a hammer, and wastes that have a certain durability index as determined using ASTM D3744. EPA's LDR Program uses this classification system to identify "debris". Under the LDR Program, "debris" refers to solid material that exceeds a 60 mm particle size (in addition to other criteria).

- Classification according to waste matrix -- Wastes may be classified based on the visual appearance or day-to-day handling of the waste. In this system, a waste is typically defined by the individual most responsible for the waste. Examples include: friable wastes, solvents, lagoon sediments, contaminated media, oily sludges, and tars.

EPA sought to classify the full spectrum of "waste forms", particularly in standardizing multiple-choice answers to surveys and questionnaires administered to the regulated community. The Biennial Reporting System (BRS) relies on such terms, as do surveys issued under the authority of RCRA Section 3001 and EPA's recently issued Hazardous Waste Constituent Survey. In general, it appears that these survey instruments rely on the use of "waste forms" that cross over each of the classification systems described above. For these cases, such a waste form "list" seems to be effective in that the list helps to reduce the seemingly infinite number of waste descriptions that survey respondents could provide, yet ensures a level of detail that goes beyond more generalized categories such as solids, sludges, wastewaters, inorganic liquids, and organic liquids.

EPA's initial intention under the Waste Forms effort was to subdivide and classify the hazardous waste universe according to specific waste forms. EPA envisioned that, once it identified these waste forms, the Agency could proceed with identifying scenarios typically used to manage these types of wastes and exposure pathways common to these management units. EPA found that identification of the whole universe of waste forms was difficult, yet important to circumscribe the universe of hazardous wastes and to bring understanding to the types of waste that will be encompassed under the national "generic" HWIR option. EPA also recognized that the challenges presented seemed to be based upon the variety of classification systems in use. Although presented with this dilemma, EPA continued its efforts to identify the universe of waste forms and eligible waste forms for which exemptions could be structured under the Waste Forms Approach. Section 4 of this technical background document presents a profile of the universe of

[3] The protocol for conducting the Paint Filter Liquids Test is set forth in Method 9095 of SW-846.

hazardous wastes, as developed by the Agency. Section 5 presents descriptive information on waste forms determined to be eligible for the development of an exemption mechanism.

The Waste Forms Approach

The Waste Forms Approach is a supplemental effort to the discussion and development of concentration-based exemption based on the generic and landfill only options. As conceived, the Waste Forms Approach could provide specialized relief mechanisms for certain wastes based on EPA's belief that the physical nature of some wastes (and resultant management of these wastes) provide additional certainty that the management of these wastes will adequately protect human and ecological receptors from potential harm.

EPA could seek to rely on waste- and, as appropriate, management-specific information, to develop exemption levels specific to a certain waste and use these exemption levels as criteria. EPA may use waste- and management-specific information directly as inputs to its risk assessment models, or EPA may simply use such information to reduce the number of exposure pathways modeled in the risk assessment effort. In doing this, EPA envisions that it could provide facilities with a more tailored set of exemption levels, which will likely differ from the exemption levels established under the national "generic" HWIR program. In addition, EPA may establish other criteria as part of a Waste Forms exemption that might be specific to the waste. Such criteria might include specialized requirements related to waste sampling and analysis, reporting, notification, and recordkeeping. EPA could also establish other criteria that are associated with waste management.

3.2 Why is the Waste Forms Approach Being Developed?

For many years, EPA has pursued development of an exemption for low-risk hazardous wastes by working to develop criteria that would define whether a waste contains contaminants at concentrations that could potentially present threats to human health and the environment. EPA has proceeded to develop and apply scientific models to estimate contaminant transport over various pathways, keying on contaminant properties, mobility in the environment, and uptake by human and ecological receptors. In its modeling efforts, EPA has considered all types of hazardous wastes, regardless of how a waste is generated, treated, managed, or disposed. Thus, EPA's modeling efforts have supported the development of HWIR exemption levels that will be protective of receptors over plausible exposure pathways. EPA's intention has been to establish a single set of HWIR exemption levels that are protective, and to integrate the use of these HWIR exemption levels into a self-implementing exemption mechanism for any facility seeking relief from the hazardous waste regulations. EPA acknowledges that this approach, referred to as the national "generic" HWIR approach, although protective, holds each facility to the same standard of protectiveness regardless of obvious discerning factors (e.g., waste matrix, waste management). However, in order for EPA to promulgate a self-implementing mechanism that could be potentially useful to all facilities, EPA has continued its development of a national "generic" HWIR approach.

EPA and stakeholders perceive that some wastes, by nature of their physical makeup or industry's selection of waste management options, could present minimal threat to human health or the environment as currently managed and could present the same minimal threat if managed under Subtitle D regulations. Therefore, EPA continues to explore regulatory alternatives for structuring relief mechanisms comparable to the national "generic" HWIR approach.

3.3 Will the Waste Forms Approach Be Protective, and How Will the Approach Be Structured?

EPA believes that the level of protectiveness for any type of waste exemption is defined by the criteria that must be satisfied to qualify for the exemption. Thus, EPA believes that the level of protectiveness that will be afforded by the Waste Forms Approach will be related to the requirements the waste will have to meet. EPA expects that these criteria will be similar to the criteria established for the national "generic" HWIR approach, including concentration thresholds that limit the amount of contaminant present in a waste or its extract. For wastes qualifying for a Waste Forms exemption, it will be the properties of the waste and the ability of these properties to limit or exclude contaminant releases that will ensure protectiveness under a Waste Forms approach. For example, if the Agency develops a Waste Forms exemption for a waste that could not contain volatile organic constituents, then it is this property (albeit a chemical property) that will ensure that human health and the environment will not be adversely impacted by releases of toxic volatile organic constituents.

In general, EPA does not believe that an exemption under the Waste Forms Approach will provide a lesser level of protectiveness than the national "generic" HWIR approach. The exemption levels established under the Waste Forms Approach could be developed using the same risk assessment model(s) used to establish the exemption criteria for the national "generic" HWIR approach; albeit based on the assumption that a waste will be managed in a particular type of unit or managed in a unit meeting certain design requirements.

3.4 Who Will Benefit from the Waste Forms Approach?

Facilities that generate wastes with specific physical properties will benefit from the Waste Forms Approach. These physical properties may be imparted through the design of the manufacturing process, treatment steps undertaken by the facility to reduce waste volume or immobilize waste contaminants, or by waste segregation practices. In other cases, facilities that generate wastes with specific physical properties and that commit to managing their wastes in a certain manner may benefit from the Waste Forms Approach. Whether directed by the nature of the waste or the employed management practice, EPA is exploring exemptions specific to such wastes that will be protective of human health and the environment.

EPA could develop exemptions under the Waste Forms Approach for wastes that do not meet the criteria established under the national "generic" HWIR approach, yet do meet criteria that indicate that these wastes would present minimal threat to human and ecological receptors. Facilities that generate these wastes will benefit most from the Waste Forms Approach because, with no likelihood of becoming exempt under the national "generic" HWIR approach (which establishes contaminant concentrations protective of all wastes) these wastes would essentially have only the delisting process as an exclusion mechanism. Waste Form exemptions might also provide tangible benefits to industry if the implementation requirements of the exemption are less burdensome than the requirements established for the national "generic" HWIR approach. For example, the Agency may be able to establish specialized requirements related to waste sampling and analysis, reporting, notification, and recordkeeping. If these specialized requirements eliminate certain notification requirements or enable the facility to conduct waste analyses on a smaller target analyte list, then the facility will save money.

Regulatory agencies will likely benefit from the Waste Forms Approach. Since the promulgation of RCRA regulations, facilities that generate low-risk wastes have consistently sought relief from the hazardous waste regulations through the existing variance and exemption mechanisms. EPA's promulgation of Waste Forms exemptions may decrease the current burden placed on regulatory agencies, for example to process delisting petitions, thus allowing agency staff to direct their efforts to other pressing activities. This decrease in burden may also enable regulatory agencies to process variances and exemptions that are more complex, rather then to expend resources and staff time on cases that easily meet HWIR exemption criteria. In addition, regulatory agencies, particularly State and Regional offices, will benefit from the Waste Forms Approach if such agencies choose not to adopt the national "generic" HWIR approach and do adopt the Waste Forms exemptions. These agencies might have increased confidence that the protective measures of the Waste Forms exemptions will be adequate to ensure that declassified hazardous wastes will not be mismanaged. EPA also believes that, if these agencies embrace the Waste Forms Approach through the implementation of waste-specific exemptions, eventually these agencies might embrace the benefits that the national "generic" HWIR approach could provide. In a similar way, if Waste Forms exemptions are implemented and used by industry, regulatory agencies could likely monitor the success and limitations of these "test-case" exemptions and apply such knowledge to the development of other contingent management approaches.

The public will likely benefit from the Waste Forms Approach. A key advantage of the Waste Forms Approach is that the exemption will be structured around a waste and the types of facilities generating that waste. Information will be readily available to the public on the nature of these wastes, which will benefit the public as it seeks to understand the regulation and assess the impact of the regulation on the interested community.

The waste management industry will benefit from the Waste Forms Approach. Waste-specific exemptions will be developed under the Waste Forms Approach. These exemptions will provide industry with target thresholds and management conditions that must be met in order to benefit from the exemption mechanism. Some companies may choose to expand their capabilities to ensure that these conditions are consistently met. In doing so, these companies could expand their client base. In addition, similar to benefits provided to State and Regional regulatory agencies, landfill owners/ operators might have increased confidence in accepting a declassified hazardous waste knowing that EPA carefully studied the waste and industry covered by the Waste Forms exemption. Such confidence might later be expanded to declassified hazardous wastes meeting the exemption criteria developed under the national “generic” HWIR approach.

3.5 Will EPA Be Developing Waste Form Exemptions for Wastes That Are Likely to Meet the Exemption Criteria Established Under the “Generic” Option?

At present, EPA has not completely excluded from consideration under the Waste Forms Approach wastes that otherwise meet the criteria developed for the national “generic” HWIR approach. EPA believes that to exclude such wastes from consideration would be premature, as the Agency has no way to predict, at present, how the national “generic” approach HWIR approach will look. Thus, for now, EPA is tracking all wastes, even though some of these wastes may meet the more stringent exemption levels developed for the national “generic” HWIR approach. In the future, EPA could choose to focus its attention for the Waste Forms Approach on only those wastes that do not meet the criteria developed for the national “generic” HWIR approach. In addition, our targeted efforts seeking to improve hazardous waste regulations for specific waste forms remains under consideration.

4.0 PROFILE OF THE HAZARDOUS WASTE UNIVERSE

4.1 What is the Source of the Data?

The hazardous waste universe is profiled here using data for hazardous wastes generated or managed in 1995. These data were collected from generators and treatment, storage, and disposal (TSD) facilities by the U.S. EPA, in cooperation with States[4], through the Biennial Report. The Biennial Report is completed by generators and TSDs, and it includes information on the "generation, management, and final disposition of hazardous wastes regulated" under RCRA (U.S. EPA, 1997, ES-1).

4.2 What Caveats Exist for the Data?

4.2.1 Large Quantity Generators

The data used in this section include only hazardous waste generated by large quantity generators (LQGs) subject to federal RCRA regulations. Facilities filing the Biennial Report determine whether they are LQGs using the following criteria:

- Generating 1,000 kilogram or more of RCRA hazardous wastes in a single month,
- Generating or accumulating 1 kilogram of acutely hazardous waste in a single month, or
- Generating or accumulating more that 100 kilograms of spill cleanup material contaminated with RCRA acutely hazardous waste at any time.

Generally, the data reflect federally-regulated hazardous wastes generated or managed by large quantity generators in units subject to federal RCRA requirements. However, some amount of wastes generated by small quantity or conditionally exempt small quantity generators may have been included. This could occur because some States require all generators, regardless of size, to complete the Biennial Report forms. In these instances, all non-LQG reporters are excluded from the data reported here. However, in some instances a reporter may have incorrectly identified itself as an LQG due to the inclusion of wastes exempt from RCRA regulation or wastes regulated only by a State. In such instances, the facility is included in the data reported here (U.S. EPA, 1997, ES-2). Further, commercial hazardous waste treatment, storage, and disposal facilities (TSDFs) receive wastes from generators of all sizes (large, small, and conditionally exempt) and may have included in their Biennial Reports some quantities of wastes received from non-LQG facilities.

---

[4] States include the 50 States as well as the District of Columbia, Puerto Rico, Guam, the Navajo Nation, the Trust Territories, and the Virgin Islands.

4.2.2 Exempt Units

Hazardous wastes managed in units exempt from RCRA permitting requirements, such as wastewater treatment units subject to permitting under the National Pollutant Discharge Elimination System (NPDES) are not included in the totals presented here (U.S. EPA, 1997, ES-2). However, all shipments sent off-site are included, even if the eventual disposition of the waste includes management in a RCRA exempt unit.

4.2.3 Definitions of Wastewaters

In the *National Analysis: The National Biennial RCRA Hazardous Waste Report*, wastewaters are defined by one of two criteria. They either match a specific hazardous waste form code or they are treated in a specific unit type. The hazardous waste form codes deemed to be wastewaters include (U.S. EPA, 1997, 2-5):

- B101: Aqueous waste with low solvents,
- B102: Aqueous waste with low other toxic organics,
- B105: Acidic aqueous waste,
- B110: Caustic aqueous waste,
- B111: Aqueous waste with reactive sulfides,
- B112: Aqueous waste with other reactives (e.g., explosives),
- B113: Other aqueous waste with high dissolved solids,
- B114: Other aqueous waste with low dissolved solids,
- B115: Scrubber water, and
- B116: Leachate.

The system type codes that are deemed wastewater treatment include all aqueous inorganic treatment (codes M071-M078), all aqueous organic treatment (codes M081-M089), all aqueous organic and inorganic treatment (M091-M099), all "other treatment" (codes M121-M129)[5], deepwell/underground injection (code M134), direct discharge to sewer/POTW with no prior treatment (code M135), direct discharge to surface water under NPDES with no prior treatment (code M136), and other disposal as specified in comments (code M137) (U.S. EPA, 1997, 2-5).

4.2.4 Comparing Management Quantities

The quantities reportedly generated by LQGs do not match the quantity of hazardous waste reportedly managed by TSDs. This difference has been attributed to importation of hazardous wastes from foreign countries and management of wastes generated at the end of a calendar year but managed in the next year (U.S. EPA, 1997, ES-4). Within this Section of the

[5] This includes neutralization only (M121), evaporation only (M122), settling/clarification only (M123), phase separation only (M124), other treatment as specified in comments (M125), and other treatment of a type unknown.

report, only quantities managed are discussed.[6] This methodology is consistent with the Waste Forms Approach—to identify specific waste management methods being used with respect to the physical characteristics of the wastes. Because the Biennial Report System (BRS) separately categorizes (1) wastes generated and (2) wastes managed, this focus on wastes managed eliminates the potential for double counting of waste quantities.

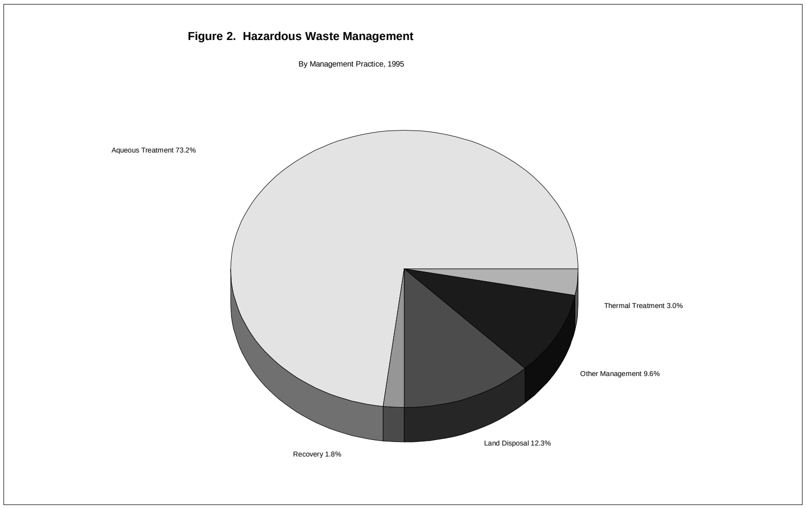
4.3 How Much Hazardous Waste was Managed in 1995, and How Does That Compare to 1993?

In 1995, 1,983 TSDs reported managing 208 million tons of hazardous waste, including 198 million tons of wastewater and 10 million tons of nonwastewater. In comparison, in 1993, 2,584 TSDs reported managing 235 million tons of hazardous waste, including 220 million tons of wastewater and 15 million tons of nonwastewater. Between 1993 and 1995, the number of TSDs reporting dropped by 23.3 percent and the amount of hazardous waste managed dropped by 18.7 percent (U.S. EPA, 1997, 2-1 and 2-5). The wastewater totals reported in the National Report are based on combinations of waste Form Codes and Management Codes that are determined to represent "wastewater treatment." However, wastes disposed in surface impoundments, applied in land application units, or incinerated may be wastewaters or nonwastewaters. Similarly, some nonwastewaters may be managed as if they were wastewaters (i.e., sludges managed by phase separation). When comparing total reported quantities of wastewaters *managed* (as reported in this Section) to total reported wastes managed by aqueous treatment (as reported in Section 4.4), the numbers will not add properly due to the difference between the type of waste—wastewater or nonwastewater—and the type of waste *management*.

---

[6] In 1995, 20,783 LQGs reported generating a total of 214 million tons of hazardous waste, of which 202 million tons was wastewater and 11 million tons was nonwastewater. (These numbers do not total due to rounding.) In comparison, in 1993 24,272 LQGs reported managing a total of 258 million tons of hazardous waste, including 237 million tons of wastewater and 22 million tons of nonwastewater. (These numbers do not total due to rounding.) Between 1993 and 1995, the number of LQGs dropped by 14.4 percent, and the amount of hazardous waste generated dropped by 17.1 percent (U.S. EPA, 1997, 1-1 and 1-10).

4.4 How Were Hazardous Wastes Managed in 1995, and What Kind of Management Practices Were Used?



Source: U.S. EPA, 1997, page 2-12.

As Figure 2 shows, almost three-quarters of the hazardous wastes managed in 1995, or 153 million tons, were treated by some type of aqueous treatment of organics, inorganics, or organic/metallic mixtures. This is expected, since over 95 percent of all hazardous wastes managed were wastewaters (U.S. EPA, 1997, 2-12 and 2-13).

Land disposal was the second most prevalent management practice, with just under 26 million tons managed in land-based units. The majority of these wastes (92 percent) were managed in a deepwell or underground injection unit, and one million tons were managed in landfills. Other reported land disposal practices include land treatment, land application, or land farming (11,000 tons) and disposal in surface impoundments (575,000 tons). (U.S. EPA, 1997, 2-12). The latter category does not include all wastes managed in surface impoundments, which would be a much larger quantity. Rather, these wastes are disposed in surface impoundments that are to be closed as landfills. Surface impoundments that are not to be closed as landfills are treatment units that usually are part of a wastewater treatment system, such as holding ponds, treatment basins, or polishing ponds.

Six million tons of hazardous waste were managed by thermal treatment, including 4 million tons incinerated and 2 million tons burned for energy recovery or reused as fuel. Recovery accounted for 3.4 million tons of wastes managed, including fuel blending (2 million tons), recovery of metals (610,000 tons), recovery of solvents (356,000 tons), and other recovery (422,000 tons) (U.S. EPA, 1997, 2-12).

Finally, just over 20 million tons of hazardous waste were managed by other practices. The greatest amount, 18 million tons, were wastewaters managed by neutralization, evaporation, settling/clarification, phase separation, or other treatment. Additionally, 1 million tons of hazardous waste was stabilized, 663,000 tons were disposed by practices not listed elsewhere in the Biennial Report codes, and 481,000 tons were sludges that were treated (U.S. EPA, 1997, 2-13).

4.4.1 Data-Based Mapping of Form Codes (Bxxx) to Management Codes (Mxxx)

As part of the analysis to characterize the relationship between waste form and waste management, the BRS data was evaluated by mapping the Form Codes to the reported Management Codes. Two analyses were conducted: highest quantity and highest frequency. The summaries are presented in Appendix A. In most cases, the summaries show that the Form Codes with the highest quantities did not correspond with the Form Codes occurring most frequently for a given Management Code. For example, the Form Code with the largest quantities for M111 (stabilization/chemical fixation using cementitious and/or pozzolanic materials) was B511 (air pollution control device sludge such as fly ash or scrubber sludge), whereas the most frequently occurring (highest number of different waste streams) Form Code was B319 (other waste inorganic solids). These results suggest that for stabilization, hazardous air pollution control dusts are the largest volume, but are generated by relatively few facilities. Because the most frequently-occurring stream is "other organic solids," there are more facilities generating this category of waste than APC dusts. This may be significant when assessing potential impacts of any regulations for these combinations -- target highest volume wastes or most number facilities.

4.5 What Types of Wastes Were Managed?

To further analyze the universe of hazardous wastes managed, the universe was subdivided into five major Waste Types according to the Form Code reported by the management facility on the Biennial Report form. This subdivision of the universe was undertaken because "wastewaters" as defined in the *National Report* dominate the quantities reportedly managed. In order to further elucidate the types of wastes managed, and to see beyond the large quantity of wastewaters discussed in the *National Report*, the hazardous waste universe was separated into the following Waste Type subcategories—wastewaters, organic liquids, inorganic liquids, solids, and other wastes—as shown in Table 4-1.

Because the only criterion for inclusion in one of the five Waste Type subcategories was the reported Form Code for a waste stream, the quantity of waste reported to be managed is lower than that in the *National Report*. This is due to missing or inaccurate Form Codes in the Biennial Reporting System. In most cases the Form Codes were not reported. Inaccurate codes included incomplete codes (e.g., only two or three digits where four is required) or the Form Code did not match with the anecdotal description of the waste. No attempt was made to identify the correct Form Codes, due to the high resource requirements of such an undertaking. Rather, waste streams with missing or inaccurate Form Codes were excluded in the subsequent analyses.

Finally, the management of wastes in the five subcategories was subdivided to present the quantities managed in units that are located on site (as reported on the Form GM-General Management) and units that are located off-site (as reported on the Form WR-Wastes Received

Table 4-1: Definition of Waste Types

Waste Type	Form Code	Form Code Description
Wastewater	B101	Aqueous waste with low solvents
	B102	Aqueous waste with low other toxic organics
	B105	Acidic aqueous waste
	B110	Caustic aqueous waste
	B111	Aqueous waste with reactive sulfides (e.g., explosives)
	B112	Aqueous waste with other reactives
	B113	Other aqueous wastes with high dissolved solids
	B114	Other aqueous waste with low dissolved solids
	B115	Scrubber water
	B116	Leachate
Organic Liquid	B201	Concentrated solvent-water solution
	B202	Halogenated (e.g., chlorinated) solvent
	B203	Nonhalogenated solvent
	B204	Halogenated/nonhalogenated solvent mixture
	B205	Oil-water emulsion or mixture
	B206	Waste oil
	B207	Concentrated aqueous solution of other organics[7]
	B208	Concentrated phenolics
	B209	Organic paint, ink, lacquer, or varnish
	B210	Adhesives or epoxies
	B211	Paint thinner or petroleum distillates
	B212	Reactive or polymerizable organic liquid
	B219	Other organic liquids (specified in comments)
Inorganic Liquid	B103	Spent acid with metals
	B104	Spent acid without metals
	B106	Caustic solution with metals but no cyanides
	B107	Caustic solution with metals and cyanides
	B108	Caustic solution with cyanides but no metals
	B109	Spent caustic
Solid	B301-B316	Inorganic Solids
	B401-B409	Organic Solids
	B501-B519	Inorganic Sludges
	B601-B609	Organic Sludges
Other	B001-B009	Lab Packs
	B117	Waste liquid mercury[8]
	B119	Other inorganic liquids (specified in comments)
	B701	Inorganic gases
	B801	Organic gases

[7] By definition, inclusion in the organic liquid category definition indicates that this Form Code includes wastes that are primarily organic and highly fluid, with low inorganic content and low to moderate water content.

[8] Liquid mercury waste is included in this category because it is expected that this waste will be managed in a manner significantly different than a liquid, solid, or wastewater.

from Off-site). Table 4-2 presents the types of wastes managed in on-site and off-site RCRA-regulated by Waste Type.

The data in Table 4-2 also indicate that relatively modest amounts of hazardous waste are managed in off-site units. Excluding wastewaters, 14.8% of all remaining wastes (e.g., inorganic and organic liquids, solids, and other wastes) are managed in RCRA-regulated off-site units. When wastewaters are considered, only 4.3% of all hazardous wastes are managed in RCRA-regulated off-site units. The bulk of hazardous waste treatment appears to occur on-site.

Table 4-2: Quantities of Waste Types Managed

Waste Type	Tons Managed in RCRA Units		
	On-Site	Off-Site	Total*
Inorganic Liquids	2,790,749	774,038	3,564,787
Organic Liquids	35,156,701	3,326,376	38,483,076
Solids	2,256,331	3,576,266	5,832,597
Other Wastes	4,293,905	71,017	4,364,921
SUBTOTAL	**44,497,686**	**7,747,697**	**52,245,381**
Wastewaters	147,445,506	858,481	148,303,987
TOTAL	**191,943,192**	**8,606,178**	**200,549,368**

*Totals do not match quantity reported in *National Report* due to inaccurate or missing Form Codes.

High Volume Management Practices

The data were analyzed to determine which management practices handled the highest quantity of RCRA-regulated wastes. The data were arrayed first by Waste Type. Within each Waste Type, management practices were ranked according to the quantity of waste managed by that particular practice (both on- and off-site), from lowest to highest. The highest volume management practices were then determined for each Waste Type. The results of this analysis are discussed in the following subsections.

Common Management

The data also were analyzed to determine which management practices were most commonly used to manage RCRA-regulated wastes, as indicated by the number of facilities sending its waste to a specific management. The data were arrayed first by Waste Type. Within each Waste Type category, management practices were listed in order by management code. Based on this array, waste management codes were grouped by type (e.g., codes M011-M019 were grouped as *Metals Recovery (for Reuse)*). Then the most commonly-used management types were determined by the number of facilities reporting this management. The results of this analysis are discussed in the following subsections.

4.5.1 Wastewaters

Wastewaters were managed by two primary practices; biological treatment accounted for 85.5 million tons (57.7% of wastewaters managed) and deepwell/underground injection accounted for 16.3 million tons (11.0% of wastewaters managed). Eleven additional practices were used to managed over one million tons each, ranging from 6.6% to 0.7% of the total wastewaters managed.

Because the Waste Type encompasses only wastewaters (which are primarily aqueous wastes), wastewater management practices are most commonly employed. Collectively, Aqueous Organic Treatment (M081-M089) accounted for 62.3% of all wastewaters managed. Aqueous Organic and Inorganic Treatment (M091-M099) accounted for 11.3%, Deepwell Injection accounted for 11.0%, and Aqueous Inorganic Treatment accounted for 4.2% of wastewaters managed.

4.5.2 Inorganic Liquids

Neutralization only was the highest volume waste management practice, at 1.6 million tons or 44.9% of inorganic liquids managed. The second highest volume of inorganic liquids was managed by chemical precipitation, totaling nearly one million tons or 28.0% of all inorganic liquids managed.

Little difference was seen between high volume and common management practices. Neutralization remained dominant at 44.9%. Aqueous Organic Treatment (M071-M079) accounted for 39.3% of inorganic liquids managed and deepwell injection accounted for 9.8% of inorganic liquids managed.

4.5.3 Organic Liquids

Biological treatment was the highest volume management practice for organic liquids, at nearly 21 million tons, or 53.9% of organic liquids managed. Other high volume management practices include deepwell injection (16.4% of organic liquid management) and other treatment (as specified in comments on the BR form) (15.1% of organic liquid management). These practices, due to their high volume, are the most common management practices for organic liquids.

4.5.4 Solids

Landfilling was the highest volume management practice for solids, with approximately one million tons (17.52%) of solids managed in this manner. Stabilization/chemical fixation using cementitious and/or pozzolanic materials accounted for 14.2% of solids management. Other treatment (as specified in comments on the BR Form) accounted for 14.1% of solids management and fuel blending accounted for 12.1% of solids management.

No common management practice truly dominates for solids. It is possible to presume that wastes being stabilized (M111-M119) are destined for landfilling. Combining stabilization and landfilling (M132) into a common "Landfill" management practice accounts for 32.9% of all solids managed. Technologies that result in burning of the solids (e.g., incineration (M041-M049), energy recovery (M051-M059), and fuel blending (M061)) account for 26.9% of solids managed. Other treatment (as specified in comments on the BR form) accounts for 14.1% of solids managed, and metals recovery (M011-M019) accounted for 8.9%.

4.5.5 Other Wastes

Biological treatment was the highest volume management practice for the "other" waste type, at approximately 3.2 million tons, or 73.82% of other wastes managed. The next two highest volumes were in the hundreds of thousands of tons range. Chrome reduction followed by chemical precipitation accounted for 12.0% of other wastes managed and management in a surface impoundment that is to be closed as a landfill accounted for 8.1% of other wastes managed. If one assumes "other wastes" to be lab packs and gasses, it is counterintuitive to find 8.1%, or approximately 2.7 million tons, managed in sites to be closed as landfills. Because of the high quantity of wastes managed by the high volume practices, these practices also are the common practices.

4.5.6 How Do These Categories of Waste Form Compare to Other Waste Form Categories Used by the RCRA Program?

There are two programs under RCRA that define wastewaters: Land Disposal Restrictions (LDR) and Biennial Reporting System (BRS). The waste forms definition for wastewaters is based on the BRS Form Codes listed in Table 4-1. The definition for BRS wastewaters is discussed in Section 2.4.3, and differ from the waste forms definition in that management in wastewater treatment units are considered. Wastewaters under LDR are defined as having less than 1% total organic carbon (TOC) and less than 1% total suspended solids (TSS). An analysis of the various wastewaters definitions indicated the following:

- There are cases where wastewaters that meet the waste forms definition will not meet the LDR definition. The Form Code descriptions do not have any numerical values for TOC or TSS to compare with the LDR definition. However, based on engineering judgement and standard texts, TOC for industrial wastewaters (Kirk-

Othmer, 1984) may be has high as 16%. However there is very limited available data to estimate volumes.

- Based on engineering judgment, it is unlikely that there are many LDR wastewaters that would not meet the waste forms definitions. The waste forms definition is based on wastes with "low suspended inorganic solid and low organic content." Qualitatively, this definition corresponds with the LDR definition. This assertion is supported by the fact that wastewaters with greater than 1% TOC and 1% TSS are routinely treated in conventional wastewater treatment systems.

- The BRS definition incorporates wastewater treatment units (M codes) in its wastewater analyses. An analysis of BRS data for nonwastewater F-codes managed in the wastewater treatment codes listed in Section 4.2.3 indicated that there were many types of wastes managed in these wastewater treatment units. Qualitatively, many of these wastes do not appear to be wastewaters by its descriptions. Two explanations were offered:

    - The treatment unit is not being utilized for wastewater treatment. For example, phase separation is used as a stand-alone treatment for oily sludges from the petroleum industry to recover oil, and these units are not part of the wastewater treatment system.

    - Reporting error. The BRS relies on the respondent to categorize the wastes and treatment, however little guidance is given on the definitions. For example, "sludge dewatering" (M101) may closely resemble "phase separation (e.g., emulsion breaking, filtration) only" (M124).

4.6 What EPA Hazardous Waste Codes are Associated with Waste Types?

As discussed in Section 2.1, hazardous wastes may either be listed (e.g., F-code, K-code, U-code, and P-code) or they may exhibit a characteristic of hazardous waste (i.e., D-Code). An analysis was conducted to determine whether certain Waste Types were commonly associated with specific hazardous waste codes.

Using the Waste Type definitions arrayed in Table 4-1, the universe of hazardous wastes managed in RCRA-regulated units was further subdivided based on the EPA Hazardous Waste Codes associated with the waste stream. The data source used, EPA's Waste File, contains fields that indicate, in a "yes" or "no" format, whether the waste stream carries one of the five Waste Codes (e.g., F, K, U, P, and/or D). One important caveat is that some waste streams carry multiple codes. Those that do are accounted for in each appropriate category. Thus, a waste stream bearing the codes F001 and D001 would be counted twice, once as an F-code waste and once as a D-code waste. No attempt was made at this stage to delineate the waste streams into unique categories. In addition, some reporters to the BRS may have incorrectly indicated more than one management code associated with a particular waste stream, instead of apportioning the waste stream to each management code. Therefore, within each Waste Type/ Waste Code some wastes may be counted twice, according to management. Table 4-3 presents the tons of waste managed for each Waste Type for each Waste Code.

Two analyses were performed. First, the data were arrayed by EPA Hazardous Waste Code grouping and Waste Type and then by RCRA-regulated management practice. This allowed examination of the management practices receiving the highest quantity of waste by Waste Code/Waste Type pairing. Second, the data were arrayed by EPA Hazardous Waste Code grouping, by Form Code, and then by management practice. This allowed an examination of the management practices receiving the highest quantity of waste by Waste Code/Form Code pairing. Detailed data are presented in Appendix B and summarized below.

The totals in Table 4-3, separated by waste code, were based upon reports generated to describe the quantity of waste handled by RCRA units separated by Management Code instead of Form Code. Due to the fact that a facility can report more than one management code for any given waste, the totals summed from these lists will contain duplicate volumes. Ideally, the quantity calculated would equal the quantity reported by the Form Code report, but facilities often incorrectly report management. Facilities will frequently list multiple management codes in an effort to characterize a treatment train. Facilities will also split a waste for treatment and then list the full waste quantity in each waste stream instead of splitting the volume. This added multiple counting created the discrepancy in the quantities reported.

Table 4-3: Tons of Waste Managed In RCRA Units, by Waste Type and Hazardous Waste Code

Waste Type	F-Code	K-Code	U-Code	P-Code	D-Code	Total*
Wastewater	63,816,174	22,943,745	15,540,009	3,174,325	73,464,715	178,938,968
Organic Liquid	5,105,116	4,042,591	2,829,908	2,283,126	34,513,682	48,774,423
Inorganic Liquid	152,329	208,570	1,533	905	2,718,550	3,081,887
Solid	2,616,709	1,544,063	621,849	345,481	3,688,841	8,816,943
Other Wastes	261,488	32,085	144,272	138,256	4,193,259	4,769,360
TOTAL*	71,951,816	28,771,054	19,137,571	5,942,093	118,579,047	

*The totals are not additive.

4.6.1 Hazardous Waste from Non-Specific Sources (F-waste Codes)

Management of Specific Waste Types

By far, the wastewaters Waste Type dominates F-codes wastes, with 88.7% of all F-code wastes reported to be wastewaters. Not surprisingly, aqueous organic treatment (M081 to M089) topped the management practices receiving the highest quantity of wastewater, with 55 million tons (or 76.5%) of F-code wastes being managed in this manner. Within that category, biological treatment was the preferred practice, receiving 79.1% of all F-code wastewaters. Other aqueous treatment technologies (M071-M079 and M091-M099) accounted for an additional 3.4 million tons managed (or 5.3% of wastewater management). Deepwell injection accounted for 4.3 million tons (or 6.7% of wastewater management). Collectively, these practices account for 97.9% of wastewaters managed.

Organic liquids are the next most common Waste Type, accounting for 7.1% of all F-code wastes. Two management practices dominate. Deepwell injection of F-code organic liquids accounts for 41.6% of organic liquids management (2.1 million tons) and fuel blending accounts for 21.3% (1.1 million tons). Other management practices include energy recovery of liquids, 12.2% (0.6 million tons), unspecified treatment, 5.2% (0.3 million tons), and liquids incineration, 4.2% (0.2 million tons).

Solids are the third most common F-code Waste Type, accounting for 3.6% of all F-code wastes managed. Two management practices account for nearly 50% of all F-code solids management—fuel blending, at 0.64 million tons (24.4%) and landfilling at 0.63 million tons (23.9%). Together, recovery, incineration (of a type unknown), stabilization/chemical fixation, and unspecified treatment account for 27.2% or 0.71 million tons of F-code solids.

F-code wastes tend not to be found as frequently in the inorganic liquid or other waste categories, which account for 0.2% and 0.3%, respectively, of all F-code wastes managed. Most inorganic liquids are managed by cyanide destruction followed by chemical precipitation (79.7%). A significant amount of F-code other wastes (41.0%) are managed by biological treatment, which is presumed to be biological treatment of gases.

Management of Specific Form Codes

An analysis of the most common Form Codes associated with F-code wastes was conducted. As expected, wastewater Form Codes dominated. A total of 42.6 million tons of F-code waste (59.5%) was defined as aqueous waste with low solvents (B101) and 13.0 million tons (18.2%) was defined as aqueous waste with low other toxic organics (B102). Other form codes representing greater than one percent of the total universe of F-code wastes include B115-scrubber water (4.8%), B219-other organic liquids (3.6%), B114-other aqueous waste with low dissolved solids (2.9%), B116-leachate (1.9%), B204-halogenated/nonhalogenated solvent mixtures (1.8%), B113-other aqueous waste with high dissolved solids (1.2%), and B603-oily sludge (1.0%). Together, these Form Codes account for 94.9% of the F-Code universe.

Aqueous treatment technologies are used heavily for F-codes within these categories of wastes. Deepwell injection is used less often, but still accounts for a significant amount (9.1%)

of F-code waste management for the Form Codes just discussed. Analysis of the data indicate that for combinations of F-Code and Form Code, a few management practices tend to predominate. For example, biological treatment was the preferred management practice for B101 F-codes, receiving 37.9 million tons (or 89.1%) of such wastes. Similarly, for B102 F-code wastes, biological treatment received 11.7 million tons (of 89.9%) of B102 F-code wastes. For B115 F-codes, 60.2% were managed by chemical oxidation followed by chemical precipitation and 21.3% by biological treatment. Deepwell injection received 83.3% of all B219 F-codes, 79.6% of all B114 F-codes, and 97.6% of all B113 F-codes. For B204 F-codes, 61.2% were managed by fuel blending and 30.1% by energy recovery of liquids. For B603 F-codes, 79.4% were managed by fuel blending.

4.6.2 Hazardous Waste from Specific Sources (K-Waste Codes)

<u>Management of Specific Waste Types</u>

Wastewaters once again topped the Waste Type with the highest quantity of waste, with 79.7% of all K-Code wastes falling into the wastewater category. Of the wastewaters, 90.8% of the wastes were managed by four practices: biological treatment (44.8%), deepwell injection (25.3%), storage prior to off-site shipment (14.5%), and other treatment (6.2%), as specified on the BR form.

Organic liquids accounted for 14.0% of all K-Codes , and three management practices received 94.4% of all organic liquids: deepwell injection (76.8%), fuel blending (10.7%), and energy recovery of liquids (6.9%). Solids accounted for 5.4% of all K-Code wastes, and showed much more diversity in the management practices used, with eight practices receiving 90.7% of the solids. Landfilling accounted for 32.2% of solids management and stabilization/chemical fixation using cementitious and/or pozzolanic materials—presumably prior to landfilling—accounted for 14.3%. Thermal treatment, including sludge incineration, solids, incineration, and energy recovery of liquids, accounted for 16.1% of solids managed. Three other management practices accounted for 28.1% of solids management—other recovery (9.7%), other treatment (8.9%), and sludge dewatering (9.5%).

Only much smaller amounts of K-Code wastes fell into the inorganic liquid (0.7%) or other waste (0.1%) categories.

<u>Management of Specific Form Codes</u>

An analysis of the most common Form Codes associated with K-code wastes was conducted. Wastewaters and organic liquids were most common. A total of 13.8 million tons of K-code waste (54.4%) was defined as aqueous waste with low other toxic organics (B102). Other form codes representing greater than one percent of the total universe of K-code wastes include B219-other organic liquids (8.9%), B114-other aqueous waste with low dissolved solids (8.4%), B113-other aqueous waste with high dissolved solids (7.5%), B115-scrubber water (5.0%), B207-concentrated aqueous solution of other organics (3.9%), B206-waste oil (1.5%), B105-acidic aqueous waste (1.5%), and B603-oily sludge (1.2%). Together, these Form Codes account for 92.3% of the K-Code universe.

Analysis of the data indicate that for specific combinations of K-Code and Form Code, a few management practices tend to predominate. For B102 K-Codes, 71.6% are managed by biological treatment and 20.0% by underground injection. Deepwell injection was used heavily in the management of B219 K-Codes (93.0%), B113 K-Codes (72.3%), B207 K-Codes (99.5%), and B114 K-Codes (69.2%). The remaining B114 K-Codes were managed by chemical precipitation. Nearly all (99.8%) of B206 K-Codes were managed by fuel blending. B115 K-Codes were managed by neutralization (31.9%), biological treatment (25.8%), sludge dewatering (25.7%), and deepwell injection (12.6%). B105 K-Codes were managed by carbon adsorption (67.5%) or neutralization (30.2%). B603 K-Codes were managed by miscellaneous recovery processes (45.3%), sludge dewatering (31.2%), or fuel blending (11.0%).

4.6.3 Hazardous Waste from Discarded Chemicals (U-Waste Codes)

Management of Specific Waste Types

Wastewaters accounted for 81.2% of all U-Code Waste Types.

Organic liquids accounted for an additional 14.8%, with three management practices receiving the 91.1% of these wastes—deepwell injection (77.9%), energy recovery of liquids (8.3%), and biological treatment (4.9%). Solids accounted for 3.2% of K-Code wastes. As seen with F-codes, management was highly diverse, with six management practices receiving 92.8% of these wastes—landfill (48.3%), carbon adsorption (10.8%), stabilization/chemical fixation using cementitious and/or pozzolanic materials (9.5%), incineration of solids (9.2%), incineration of sludges (7.8%), and energy recovery of liquids (7.2%).

Inorganic liquids (0%) and other wastes (0.8%) accounted for relatively little of the total K-Code wastes managed.

Management of Specific Form Codes

An analysis of the most common Form Codes associated with U-code wastes was conducted. Wastewaters and organic liquids predominated. A total of 9.6 million tons of U-code waste (50.4%) was defined as aqueous waste with low other toxic organics (B102). Other form codes representing greater than one percent of the total universe of U-code wastes include B115-scrubber water (14.9%), B219-other organic liquids (13.0%), B114-other aqueous waste with low dissolved solids (8.6%), B113-other aqueous waste with high dissolved solids (4.5%), B101-aqueous waste with low solvents (1.7%), B204-halogenated/nonhalogenated solvent mixture (1.4%), and B105-acidic aqueous waste (1.2%). Together, these Form Codes account for 95.7% of the U-Code universe.

Analysis of the data indicate that for specific combinations of U-Code and Form Code, a few management practices tend to predominate. For B102 U-Codes, 78.4% are managed by biological treatment and 18.7% by underground injection. Deepwell injection was used heavily in the management of B219 U-Codes (88.6%), B114 U-Codes (90.4%), B113 U-Codes (99.8%), and B105 U-Codes (99.4%). Incineration of liquids predominated for B115 U-Codes (65.2%) and B101 U-Codes (64.3%) The remaining B115 U-Codes were managed by neutralization (14.1%) or biological treatment (13.4%). The remaining B101 U-Codes were managed by air/steam stripping (21.0%) or biological treatment (12.5%). For B204 U-Codes, preferred management practices included energy recovery of liquids (71.8%), fuel blending (14.8%) or incineration of liquids (12.8%).

4.6.4 Acutely Hazardous Waste from Discarded Chemicals (P-Waste Codes)

Management of Specific Waste Types

Wastewaters had a less clear majority within the P-Codes, accounting for 53.4% of all P-Code wastes managed. Two management practices accounted for 89% of wastewaters managed: deepwell injection (73.4%) and biological treatment (15.6%). Organic liquids accounted for 38.4% of P-Code waste managed, and 92.6% of organic liquids were managed by deepwell injection.

Solids accounted for 5.8% of all P-code waste managed. Three management practices accounted for 93% of all solids managed—landfill (77.5%), stabilization/chemical fixation using cementitious and/or pozzolanic materials (9.9%), and incineration of solids (5.6%).

Inorganic liquids (0%) and other wastes (2.3%) account for relatively little P-code waste managed.

Management of Specific Form Codes

An analysis of the most common Form Codes associated with P-Code wastes was conducted. No specific type of waste dominated—organic liquids, wastewaters, solids, and other wastes were all noted. A total of 2.2 million tons of P-Code waste (38.0%) was defined as other organic liquids (B219) and 1.2 million tons (20.1%) were defined as aqueous waste with low other toxic organics (B102). Other form codes representing greater than one percent of the total universe of P-Code wastes include B113-other aqueous waste with high dissolved solids (14.5%), B115-scrubber water (11.7%), B105-acidic aqueous waste (3.8%), B114-other aqueous waste with low dissolved solids (2.7%), B119-other organic liquids (1.9%), B305-“dry” lime or metal hydroxide solids that have been chemically fixed (1.9%), B319-other waste inorganic solids (1.9%), and B303-ash, slag, or other residue from incineration of wastes (1.2%). Together, these Form Codes account for 97.7% of the P-Code universe.

The data indicate that for specific combinations of P-Code and Form Code, a specific management practice tends to predominate in the waste code and Form Code pairing. Deepwell injection was used heavily in the management of B219 P-Codes (93.9%), B102 P-Codes (91.9%), B113 P-Codes (99.8%), B105 P-Codes (~100.0%), and B115 P-Codes (22.8%). The other B115 P-Codes were managed by biological treatment (55.0%) or neutralization (14.9%). B114 P-Codes were managed by other disposal (87.1%), and B119 P-Codes were managed by biological treatment (93.7%). Landfilling was the selected management practice for B305 P-Codes (100%), B319 P-Codes (95.6%), and B303 P-Codes (57.6%). The remaining B303 P-Codes were managed by stabilization/chemical fixation using cementitious and/or pozzolanic materials (37.8%).

4.6.5 Analysis of Listed Waste Streams of Concern

The Agency used a crosswalk between the characteristic and listed waste codes (D, F and K RCRA hazardous waste codes) and each of following five categories of wastes:

- Oily wastes
- Dioxin-bearing wastes
- Cyanide-bearing wastes
- Metal-bearing wastes
- LNAPL/DNAPL-bearing wastes

This crosswalk was used in conjunction with 1995 BRS data to estimate the number of facilities and volume of waste potentially impacted by a waste forms approach. Table 4-4 presents a summary of the results for the national totals.

Waste Category	Number of Streams	Total (tons)
Oily Waste	1713	1,571,253.52
Dioxin-bearing Wastes	1,116	269,605.10
Cyanide-bearing Wastes	11,595	11,210,135.51
Metal-bearing Wastes	124,592	24,762,813.35
LNAPL/DNAPL-bearing Wastes	88,444	73913278.61

For these analyses, there is some double counting of the number of streams and waste volumes due to an artifact of the BRS data reporting.[9] Based on these estimates, LNAPL/DNAPL-bearing wastes constitute the highest volume, and metal-bearing wastes are

[9] BRS allows the respondent to report more than one RCRA waste code for a stream. Thus, for a waste that was reported with D018 and F037, that stream would be included in every category where D018 or F005. For this analysis 153 RCRA waste codes were crosswalked with the five waste categories. Due to the high number of potential waste code combinations that are possible, no attempt was made to eliminate double counting.

generated by the greatest number of facilities. Dioxin-bearing wastes are demonstrated to be the lowest volume and generated by the fewest number of facilities.

4.6.6 Characteristic Waste (D-Waste Codes)

Management of Specific Waste Types

Wastewaters again were the highest quantity Waste Type, accounting for 62.0% of all D-Codes. Diversity in the choice of management practice was seen, with eight practices receiving 91.8% of the wastewaters. Aqueous organic and/or inorganic treatment accounted for 69.7% of management (including biological treatment (49.3%), other organic/inorganic aqueous treatment (8.6%), air/steam stripping (5.8%), chemical precipitation in combination with biological treatment (3.6%), and wet air oxidation (2.4%). Other management practices include deepwell injection (14.9%), storage prior to off-site shipment (3.9%), and neutralization only (3.3%).

Also accounting for a significant portion of the D-Codes were organic liquids (29.1%). Three management practices accounted for 91.6% of the organic liquids managed—biological treatment (60.0%), other treatment (as specified in comments on the BR form) (16.5%), and deepwell injection (15.1%).

All other Waste Types also are represented. Inorganic liquids accounted for 2.3% of D-Codes, with 47.0% managed by neutralization only and 30.0% managed by chemical precipitation. Other wastes accounted for 3.5% of the D-Codes, with 74.3% managed by biological treatment, 12.2% by chrome reduction followed by chemical precipitation, and 8.5% managed in a surface impoundment that is to be closed as a landfill. Solids accounted for 3.1%, with nine management practices accounting for 86.6% of D-Code solids management. Solids were managed by fuel blending (17.1%), other treatment (as specified on the BR form) (15.7%), stabilization/chemical fixation using cementitious and/or pozzolanic materials (15.6%), secondary smelting (12.1%), landfill (10.0%), surface impoundment to be closed as a landfill (5.2%), other recovery (specified on the BR form) (4.4%), incineration of solids (3.9%), and sludge dewatering (2.6%).

Management of Specific Form Codes

An analysis of the most common Form Codes associated with D-code wastes was conducted. Once again, wastewaters and organic liquids were most common, although inorganic liquids and other wastes are seen. In addition, rather than 5 or 6 specific form codes accounting for greater than 90% of the universe, much more diversity is seen in D-code wastes. A total of 45.3 million tons of D-code waste (39.3%) was defined as aqueous waste with low other toxic organics (B102) and 20.6 million tons (17.9%) was defined as an oil-water emulsion or mixture. Other form codes representing greater than one percent of the total universe of D-code wastes include B114-other aqueous waste with low dissolved solids (6.8%), B219-other organic liquids (6.7%), B101-aqueous waste with low solvents (5.1%), B119-other inorganic liquids (3.6%), B105-acidic aqueous waste (3.6%), B110-caustic aqueous waste (2.7%), B207-concentrated aqueous solution of other organics (2.1%), B113-other aqueous waste with high dissolved solids

(2.0%), B208-concentrated phenolics (1.8%), B103- spent acid with metals (1.5%), and B115-scrubber water (1.1%). Together, these Form Codes account for 94.2% of the D-Code universe.

Analysis of the data indicate that for specific combinations of D-Code and Form Code, a few management practices tend to predominate, although there appears to be more diversity in the management of D-Code wastes than with the listed hazardous wastes (e.g., F-, K-, U-, and P-Code wastes). Deepwell injection was used heavily in the management of B208 D-Codes (99.0%). For other D-Code/Form Code combinations, two or more management practices tend be used most often:

- B102 D-Codes were managed by biological treatment (69.4%) and by other organic/inorganic treatment (13.9%).
- B205 D-Codes were managed by biological treatment (76%) and by other treatment (as specified on the BR form) (23.7%).
- B114 D-Codes were managed by biological treatment (47.3%), deepwell injection (23.8%), and chrome reduction followed by chemical precipitation (11.7%).
- B219 D-Codes were managed by biological treatment (55.8%), deepwell injection (27.5%), or other treatment (as specified in comments on the BR form) (10.0%).
- B101 D-Codes were managed by air/steam stripping (40.1%), wet air oxidation (30.1%), or deepwell injection (10.9%).
- B119 D-Codes were managed by biological treatment (75.1%) or chrome reduction followed by chemical precipitation (12.4%).
- B105 D-Codes were managed by deepwell injection (73.1%) or chemical precipitation in combination with biological treatment (25.4%)
- B110 D-Codes were managed by neutralization only (75.2%) or biological treatment (23.8%).
- B207 D-Codes were managed by deepwell injection (41.7%), biological treatment (30.4%), or phase separation (16.2%).
- B113 D-Codes were managed by deepwell injection (59.4%), other treatment (as specified in comments on the BR form) (22.5%), or chemical precipitation (16.9%).
- B103 D-Codes were managed by neutralization only (71.3%), chrome reduction followed by chemical precipitation (11.1%), or chemical precipitation (9.5%).
- B115 D-Codes were managed by chemical precipitation (59.4%), settling/clarification only (16.5%), deepwell injection (9.3%), or neutralization only (9.0%).

References for Chapter 4

U.S. EPA, August 1997. *National Analysis: The National Biennial RCRA Hazardous Waste Report (Based on 1995 Data*)

5.0 IDENTIFICATION OF CANDIDATE WASTES

5.1 How Did EPA Identify Wastes That Might Be Good Candidates for the Waste Forms Approach?

EPA devised and followed a methodical strategy in identifying hazardous wastes that would be eligible for the Waste Forms Approach. EPA's strategy involved four steps. First, EPA set out to define the hazardous waste universe. EPA began by utilizing the information compiled in the Biennial Reporting System (BRS) . EPA then eliminated all BRS information for characteristically hazardous wastes (as discussed in Section 4).

Second, EPA identified criteria that could be used to screen whether a waste should be considered as a candidate[10] for an exemption that would be developed under the Waste Forms Approach. EPA established such criteria to help focus its efforts in prioritizing wastes for consideration under the Waste Forms Approach. In particular, prior to expending resources on a comprehensive Waste Forms Approach that attempts to address all low-risk hazardous wastes, EPA wished to first apply the Waste Forms Approach on one or more candidate wastes in order to quantify or semi-quantify the benefits.

Once EPA identified its screening criteria, the Agency established "definitions" so that individuals applying the criteria would apply such criteria consistently. For some criteria, EPA established definitions that involved determining whether a question should be answered "yes" or "no". For other criteria, EPA established definitions that prompted an individual to collectively consider a number of factors prior to determining whether the specific criterion was met or not.

Lastly, EPA applied these defined criteria to each waste in the hazardous waste universe. Through this effort, EPA gathered readily available information and conducted studies of the wastes in support of these screening criteria. Using this strategy, EPA was able to assess, albeit in general terms, all wastes in the hazardous waste universe. Furthermore, EPA was able to prioritize its research efforts on wastes that would be most eligible for the Waste Forms Approach. EPA documented the results of this screening effort on standardized data management forms. A copy of a blank form, which EPA refers to as a Waste Form Profile, is included in Appendix C to this technical background document.

5.2 What Information in the Biennial Reporting System (BRS) Did EPA Use to Identify Candidate Waste Forms?

---

[10] Candidate wastes are wastes that would be eligible for exemption from the Subtitle C system under the Waste Forms Approach. These wastes could be low-risk hazardous wastes by nature of their composition and/or common management practice.

To identify candidate waste forms that meet the screening criteria, EPA used data from the BRS. Facilities that are either large quantity generators or treat, store, or dispose of RCRA hazardous waste are required to file a Hazardous Waste Report under the BRS. Facilities generating hazardous waste must submit a Waste Generation and Management Form (GM Form), while facilities receiving hazardous waste must submit a Waste Received from Offsite Form (WR Form). Information provided through the GM Form includes data related to waste generation and management; information related to the WR Form includes waste characterization and management data. Facilities describe the type of waste generated using BRS's Form Codes. These codes, which describe the physical or chemical composition of the waste, are denoted with the letter "B". For example, B101 represents "aqueous waste with low solvents". The management of a waste is described using BRS's System Type Codes, denoted by the letter "M". For example, M011 designates "high temperature metals recovery". These M-codes are used to describe either the operation from which the waste is generated, if the waste is a residual, or the on- or off-site process system type used to manage the waste. The source of waste generation is described using BRS's A-codes. For example, A07 is "vapor degreasing". A list of A-codes, B-codes, and M-codes is provided in Appendix D to this technical background document.

Below is a list of mandatory and non-mandatory reporting elements for both the GM and WR forms of the BRS, which were used for analysis conducted in this chapter:

GM Form, Mandatory
- Waste description
- EPA hazardous waste code
- Quantity generated in reporting year
- On-site process system
- Quantity TDR on site during reporting year
- Total quantity shipped during reporting year

GM Form, Non-mandatory
- Form code
- Origin code
- System type code
- Source code
- SIC code
- System type shipped to
- Comments

WR Form, Mandatory
- Description of hazardous waste
- EPA hazardous waste code
- Quantity received in reporting year
- System type

WR Form, Non-mandatory
- Form code

This chapter discusses waste in terms of tons managed. The BRS Waste File has been designed so that tons managed are approximately equal to tons generated on site plus tons received off site.

5.3 Did EPA Establish Different Screening Criteria for Different Types of Wastes (i.e., Wastes Having Different Physical Natures)?

In analyses conducted to date, EPA has, in most cases, applied a given screening criterion consistently, regardless of different types of wastes. The exception to this is EPA's application of the Large Waste Volume/Large Number of Facilities criterion. Based on its review of initial analyses conducted using BRS information, EPA recognized that certain wastes were being eliminated from further consideration based on this criterion. In particular, the large volumes of liquid wastes were overshadowing the smaller volumes of non-liquid wastes. Thus, EPA sought to minimize the chances that certain wastes would be removed from consideration because the waste type tends to be generated in smaller volumes than other waste types. EPA decided to take into account the general form of a waste in its analysis of BRS information. Specifically, prior to applying the screening criteria, the Agency divided the hazardous waste universe -- as defined by BRS information -- into the following five groupings:

- Solids and sludges -- Wastes classified in the BRS using the following B codes: B301-B316, B319, B401-B409, B501-B516, B519, and B601-B609

- Organic Liquids -- Wastes classified in the BRS using the following B codes: B201-B212, and B219

- Inorganic Liquids -- Wastes classified in the BRS using the following B codes: B103, B104, and B106-B109

- Wastewaters -- Wastes classified in the BRS using the following B codes: B101, B102, B105, and B110-B116

- Other Wastes -- Wastes classified in the BRS using the following B codes: B001-B004, B009, B701, B801, B117, and B119. This set of wastes includes lab packs, waste liquid mercury, other inorganic liquids, and gases. This set of waste includes those wastes that are not in any of the above four groupings.

EPA found that, in addition to addressing the elimination of small (but significant) volumes of solid wastes from further consideration under the Waste Forms effort, its decision to subdivide the hazardous waste universe into these groupings supported the Agency's evaluation of the results of the screening analysis. First, EPA found that, by subdividing the universe into the above groupings, EPA could better track the impacts of a certain screening criterion on wastes of a specific form and modify screening criteria, as appropriate. Second, EPA found that it had an improved perspective on the results of the screening analysis because the results for "like" wastes could be compared with each other. Third, EPA acknowledged that the Waste Forms Approach is structured on the premise that the physical nature of some wastes (and resultant management of these wastes) might provide additional certainty that the management of these wastes will adequately protect human and ecological receptors from potential harm. Thus, EPA found that subdividing the hazardous waste universe into the above groupings enabled the Agency to more efficiently investigate the link between waste form and waste management.

As part of its decision to develop the above groupings, EPA chose to eliminate from further consideration under the Waste Forms Approach, all wastes classified as "Other Wastes". As defined, this set of wastes includes those wastes that are not solids or sludges, organic liquids, inorganic liquids, or wastewaters. For various reasons, EPA does not believe that wastes classified as "Other Wastes" are candidates for the Waste Forms Approach.

For example, "lab packs" are commonly used in the disposal of laboratory wastes. A lab pack, as specified by DOT regulations, is a drum of 55-gallon capacity that is filled with waste materials in their purchased or stored packages (e.g., cans, bottles, ampules). Lab packs of smaller capacity are also used. Inert packing material is used to surround each smaller package within a lab pack, and the volume of this packing material must be sufficient to absorb any liquid that would be released from the smaller package upon breaking or leaking. Lab packs typically contain a broad range of hazardous constituents, and often are used for the disposal of unused or unusable quantities of chemicals. Because lab pack wastes are a collection of many smaller volume wastes, EPA believes that it would be difficult (if not impossible) to quantify contaminant concentrations in these wastes for the purposes of determining whether HWIR exemption levels have been met. Accordingly, EPA believes that it would not be possible to develop an implementable Waste Forms exemption for lab pack wastes.

5.4 What Criteria Did EPA Use in Identifying Wastes for Further Study?

EPA used the following screening criteria to identify wastes that would be eligible for consideration for an exemption under the Waste Forms Approach. Each is discussed, in turn, in the remainder of this section.

- Large Waste Volume/ Large Number of Facilities
- "Definable" Waste Form
- Management other than Transfer Facility Storage
- Management Under Subtitle C other than Part 266
- Management Under Subtitle C other than Deepwell Injection

- No Coverage Under Other EPA Rules

- High Cost Savings Streams

These criteria were used as a screening mechanism to determine whether a waste would be a candidate for becoming exempt from the RCRA system using the Waste Forms Approach. Wastes that did not meet the screening criteria were eliminated from further consideration.

These screening criteria were applied to each waste type within the hazardous waste universe, as defined by every unique combination of Form Code and System Type Code reported in the BRS. In the discussions presented in the following section, "waste form" refers to these Form Code/System Type Code combinations (e.g., B202-M021) unless otherwise indicated. Because waste form and mangement are intrinsically linked, this combination was examined together. The level of threat a waste form presents to human health and the environment is related to management controls placed on the waste form. In addition, because a given waste form is not typically managed exclusively by one management practice, none of its potential exposure pathways can be eliminated from concern.

Large Waste Volume / Large Number of Facilities

EPA established this criterion as a qualitative measure of the amount of waste (or number of facilities) that might be provided with regulatory relief should a Waste Forms exemption be developed. EPA believed that it is appropriate to give a higher priority to wastes that are generated at high volumes or to wastes that are produced by a large number of facilities. If facilities generating these wastes were to meet the conditions of a Waste Forms exemption, then more benefits would be realized by the regulated community. EPA believes that it is less appropriate to expend Agency resources to structure an exemption mechanism for wastes that are generated at relatively small volumes or to wastes that are produced by only a small number of facilities. EPA recognizes, however, that a Waste Forms exemption might be beneficial to a small number of facilities that generate a significant volume of waste. For this reason, EPA established this criterion as an "or" condition. That is, EPA retained for consideration wastes that either were generated at relatively high volumes or that were generated by a large number of facilities. This criterion effectively eliminated from further consideration wastes that were generated at low volumes and that were generated by a small number of facilities.

In establishing a "definition" for this criterion, EPA conducted an assessment of BRS information to determine whether waste volume data were distributed in a manner that would naturally identify a point that would distinguish between a "large" volume of waste and a "small" volume of waste. In this assessment, EPA extracted waste quantity information from the BRS for each waste form (i.e., Form Code/System Type combination) within each waste grouping (e.g., wastewaters). For example, EPA determined the quantity of waste reported for each waste form within the Wastewaters grouping (e.g., B101-M081, B102-M081, B101-M083). EPA next determined the total quantity of all wastewaters. EPA then calculated the percentage of the total quantity of wastewaters that each waste form represented and arrayed this information from the waste form with the largest volume to the waste form with the smallest volume. EPA examined this distribution and determined that there was no specific cut-off that could be used to "define" a small volume wastewater or a large volume wastewater. EPA thus choose to retain, for further consideration, wastewaters representing 90 percent of the total quantity of wastewaters. The remaining 10 percent of the total quantity of wastewaters represent numerous waste forms generated in small quantities. Any regulatory relief potentially granted for these waste forms would not justify the resources that would be expended to further analyze them. EPA repeated this distribution analysis for the remaining three waste groupings, and drew similar conclusions with regards to the lack of a natural cut-off point. A cut-off point of 90 percent of the total quanitity was chosen for organic liquids, inorganic liquids, and solids as well.

EPA conducted a similar assessment of BRS information to determine whether information regarding the number of facilities were distributed in a manner that would naturally identify a "large" number of facilities versus a "small" number of facilities. Based on this analysis, EPA choose a value of 100 to identify a large number of facilities.

The Large Waste Volume Criterion for each of the four waste groups is identified below. Wastes generated in volumes less than the Large Waste Volume Criterion were eliminated from further consideration.

	Large Waste Volume Criterion
Solids/Sludges	9,015 tons
Organic Liquids	41,949 tons
Inorganic Liquids	7,417 tons
Wastewaters	902,995 tons

As noted previously in this Section, EPA's primary objective in establishing the screening criteria was to focus its efforts by prioritizing wastes for further consideration. EPA recognizes that the above two cutoffs could be considered arbitrary. However, EPA has analyzed BRS information characterizing waste volume and the number of facilities in a number of different ways and believes that the selected screening approach does not eliminate waste forms that are viable candidates.

In using this criterion, EPA relied exclusively on information contained in the BRS. EPA applied this criterion by setting up a query that identified waste volume and number of facilities (i.e., BRS records) associated with a reported waste type and its reported management. The BRS identifies reported waste types using standardized Form Codes (also referred to as B-codes). The BRS identifies reported management using standardized System Type Codes (also referred to as M-codes). A listing of the standardized BRS Form Codes and System Type Codes are presented in Appendix D to this technical background document.

The following exhibit identifies the number of wastes that were eliminated from consideration due to this criterion.

	Number of Wastes Excluded Because of Large Waste Volume/ Large Number of Facilities Criterion
Solids/ Sludges	882
Organic Liquids	402
Inorganic Liquids	151
Wastewaters	263

"Definable" Waste Form

EPA established this criterion as it is essential to the underlying premise of the Waste Forms Approach --that the physical properties of a waste (which relate to or "define" the waste's form) may provide additional certainty that the management of these wastes will adequately protect human and ecological receptors from potential harm. EPA recognizes that it is critical to be consistent and clear in structuring a Waste Forms exemption that is, in part, based on the form of a waste. The "definition" of a waste form is important for a number of reasons. First, EPA's assessment of risk in support of a Waste Forms exemption will likely be based on waste-specific information. Second, regulatory agencies must be provided with assurance that facilities will not inappropriately use a Waste Forms exemption, which has been tailored to a specific waste. Thus, regulatory agencies must be provided with information that will allow them to identify whether a facility's waste is the waste for which the Waste Forms exemption was developed. Third, a facility must be able to defend its decision that its waste is the waste for which the Waste Forms exemption was developed. Finally, EPA must be able to collect data descriptive of a waste as it seeks to best model potential risks and develop a Waste Forms exemption. If EPA is unable to sample and analyze waste samples or conduct tests that provide information such as contaminant mobility, the Agency might find itself severely constrained in developing necessary information to support promulgation of a Waste Forms exemption. Similarly, if industry is unable to sample and analyze waste samples or otherwise conduct tests prescribed as part of a Waste Forms exemption, facilities could find themselves unable to satisfy the conditions of the Waste Forms exemption. Thus, in summary, a "definable" waste is essential to structuring an exemption under the Waste Forms Approach as well as implementing the exemption once it has been structured.

In establishing a "definition" for this criterion, EPA developed a number of questions to assist individuals in collecting information about the waste which could be used in determining whether the waste was definable. For example, EPA documented whether facilities reporting to the BRS described the waste in a similar manner. EPA also documented whether the waste was a solid or liquid, or whether it was not possible to identify the waste as either a solid or liquid. EPA also documented whether the waste was generated from a single type of process or treatment unit, and whether the waste was stabilized or not. A complete listing of the questions EPA used to determine whether a waste is definable is included in the Waste Forms Profile, which was developed to document EPA's research efforts. A copy of a blank Waste Forms Profile is included in Appendix C to this technical background document.

To use this criterion, EPA set up a query that screened out any wastes that were identified with the following BRS Codes:

B119 - Other inorganic liquids (specify)
B219 - Other organic liquids (specify)
B315 - Other reactive salts/ chemicals
B316 - Other metal salts/ chemicals
B319 - Other waste inorganic solids (specify)
B407 - Other halogenated organic solids (specify)
B409 - Other nonhalogenated organic solids (specify)
B519 - Other inorganic sludges (specify)
B609 - Other organic sludges (specify)
M078 - Other aqueous inorganic treatment
M079 - Aqueous inorganic treatment - type unknown
M085 - Other aqueous organic treatment (specify)
M089 - Aqueous organic treatment - type unknown
M094 - Other organic/inorganic treatment (specify)
M099 - Aqueous organic and inorganic treatment (type unknown)
M109 - Sludge treatment (type unknown)
M119 - Stabilization (type unknown)
M125 - Other treatment (specify)
M129 - Other treatment (type unknown)
M137 - Other disposal (specify)

EPA recognized these waste description codes to be miscellaneous, catch-all terms. EPA further believed that, if facilities reporting to the BRS could provide no further distinction of the physical nature of their wastes than the above waste descriptions, the Agency would not likely be able to adequately define these wastes in developing a Waste Forms exemption. The Agency reviewed BRS information reported in the waste description and comment field for a sample of these codes to verify that reporting for these codes is extremely diversified, and found this to be the case. EPA decided to keep both B113 - Other aqueous waste with high dissolved solids and B114 - Other aqueous waste with low dissolved solids as they are further defined by their solids content.

The following exhibit identifies the number of wastes that were eliminated from consideration due to this criterion:

	Number of Wastes Excluded on the Basis of Specific B Codes*
Solids/Sludges	43
Organic Liquids	18
Inorganic Liquids	1
Wastewaters	2

*These numbers are based on this criterion being applied as a second screen and, as a result, are lower than if this was the sole criterion applied.

Management Other Than Transfer Facility Stored Wastes

Wastes that are reported to be managed by transfer facility storage are those wastes that are shipped off site with no on-site treatment, disposal or recycling (TDR) activity. EPA has determined not enough information is known about these wastes to make a determination about them.

The following exhibit identifies the number of wastes that were eliminated from consideration due to this criterion:

	Number of Wastes Excluded on the Basis of Transfer Facility Storage*
Solids/Sludges	22
Organic Liquids	11
Inorganic Liquids	4
Wastewaters	5

*These numbers are based on this criterion being applied as a third screen and, as a result, are lower than if this was the sole criterion applied.

Management Under Subtitle C Other Than Part 266

EPA established this criterion recognizing that industry currently has the option to recycle materials, providing the conditions of 40 CFR Part 266 are met. Part 266 sets forth standards for the management of specific hazardous wastes and specific types of hazardous waste management facilities. For a number of reasons, EPA believes that consideration of wastes which are typically destined for recovery or reuse should be a low priority in its Waste Forms effort. First, EPA believes that Part 266 presents viable options for regulatory relief. At this time, EPA does not wish to supersede such an existing option by promoting a Waste Forms exemption. EPA also does not wish to expend its resources developing a Waste Forms exemption that might not be used by facilities because of the existence of the Part 266 regulations. Finally, EPA has not yet made a final determination whether it should consider developing exemptions under the Waste Forms Approach that are linked to a non-management options such as reuse or recovery.

In establishing a “definition” for this criterion, EPA developed a list of the various types of reuse and recovery practices in which industry engages. EPA relied on the System Type Codes used in the BRS in developing this list. EPA then set up a query to screen out wastes that are sent for reuse or recovery using the following System Type Codes:

M011 - High temperature metals recovery
M012 - Retorting

M013 - Secondary smelting
M014 - Other metals recovery for reuse
M019 - Metals recovery (type unknown)
M021 - Fractionation/ distillation
M022 - Thin film evaporation
M023 - Solvent extraction
M024 - Other solvent recovery (specify)
M029 - Solvents recovery (type unknown)
M031 - Acid regeneration
M032 - Other recovery
M039 - Other recovery (type unknown)
M051 - Energy recovery - liquids
M052 - Energy recovery - sludges
M053 - Energy recovery - solids
M059 - Energy recovery (type unknown)
M061 - Fuel blending

The following exhibit identifies the number of wastes that were eliminated from consideration due to this criterion.

	Number of Wastes Excluded Because of the Management Under Part 266 Criterion*
Solids/ Sludges	19
Organic Liquids	33
Inorganic Liquids	1
Wastewaters	2

*These numbers are based on this criterion being applied as a fourth screen and, as a result, are lower than if this was the sole crtierion applied.

Management Under Subtitle C Other Than Deepwell

EPA also set up a query to screen out wastes that were reported to be injected into deep wells. It is the Agency's belief that the management practice of deepwell injection, which typically occurs on site, is unlikely to change if a facility were to be given a waste forms exemption option for wastes that are currently deepwell injected. This belief is based on economics and capacity of deepwell injection. EPA relied on the System Type Code M134 - Deepwell/underground injection used in the BRS in identifying these wastes.

	Number of Wastes Excluded Because of the Deepwell Injection Criterion*
Solids/ Sludges	0
Organic Liquids	0
Inorganic Liquids	1
Wastewaters	4

*These numbers are based on this criterion being applied as a fifth screen and, as a result, may be lower than if this was the sole crtierion applied.

No Coverage Under Other EPA Rules

EPA choose to eliminate certain wastes from further consideration because the Agency is currently addressing the regulation of these wastes under other initiatives. EPA relied on the Form Codes used in the BRS. Specifically, EPA identified that wastes covered under other EPA rules have the following BRS Form Codes: B301 - Soil contaminated with organics, B302 - Soil contaminated with inorganics only, B309 - Batteries or battery parts, casings, cores, B311 - Asbestos solids and debris, and B515 - Asbestos slurry or sludge. For example, EPA will be promulgating standards for contaminated soils under the HWIR Media rule in the future.

The following exhibit identifies the number of wastes that were eliminated from consideration due to this criterion.

	Number of Wastes Excluded Because of Existing Coverage Under Other EPA Programs*
Solids/ Sludges	6
Organic Liquids	0
Inorganic Liquids	0
Wastewaters	0

*These numbers are based on this criterion being applied as a sixth screen and, as a result, may be lower than if this was the sole crtierion applied.

High Cost Savings Streams

As determined in HWIR's RIA, streams having a high cost savings impact are not necessarily high volume streams. These streams have been identifed as those requiring deactivation or incineration. EPA has not included these streams as a part of this analysis because of the large number of such streams. EPA may consider investigating these streams further in the future.

Appendix E diagrams the number of Form Code/System Type Code combinations, tons of waste managed, and number of streams after each screening criterion is applied, by waste category.

5.5 Why Does EPA Believe that the Screening Criteria Used are Appropriate?

From the onset, EPA recognized that it was establishing its screening criteria while relying primarily on its general knowledge of hazardous wastes and their management. EPA has focused on an approach that resulted in a manageable number of waste forms that will have an impact. In addition, these are waste forms for which EPA is able to identify and craft regulatory provisions for and which are expected to be eligible for HWIR exemption. EPA's secondary reason for establishing "definitions" for each of the criteria was to allow EPA to re-visit any particular criteria that was significantly impacting the screening process. Throughout EPA's application of the screening criteria, the Agency paused to reflect upon its findings. As a result of this reflection, EPA did improve upon the "definitions" for some of the screening criteria. Currently, EPA believes that the screening criteria that it has developed are appropriate and that the criteria support the general objectives of the Waste Forms effort.

5.6 What Waste Form Candidates Emerged from the Screening of the BRS?

Application of the seven screening criteria produced a list of 64 Form Code/System Type Code combinations -- sixteen combinations for organic liquids, three combinations for inorganic liquids, nine combinations for wastewaters, and 36 combinations for solids. EPA obtained additional information from the BRS Waste File and completed a Waste Form Profile for each of these 64 wastes. Additional information collected included the volume of waste generated, the number of facilities generating the waste, the primary industries (based on SIC codes) generating the waste, the source of waste generation, a geographical profile of the facilities generating the waste, information regarding whether the waste is managed onsite or offsite, EPA listed waste codes, and waste characteristics (e.g., ignitable, reactive, corrosive).

The following table lists the 64 Form Code/System Type Code combinations by chemical grouping.

Wastewaters
Aqueous Waste with Low Solvents, Managed by Biological Treatment
Aqueous Waste with Low Solvents, Managed by Air/Steam Stripping
Aqueous Waste with Low Solvents, Managed by Wet Air Oxidation
Aqueous Waste with Low Other Toxic Organics, Managed by Biological Treatment
Scrubber Water, Managed by Chemical Oxidation Followed by Chemical Precipitation
Aqueous Waste with Low Solvents, Managed by Liquids Incineration
Aqueous Waste with Low Other Toxic Organics, Managed by Liquids Incineration
Scrubber Water, Managed by Liquids Incineration
Aqueous Waste With Low Solvents, Managed by Sludges Incineration
Inorganic Liquids
Spent Acid with Metals, Managed by Chrome Reduction Followed by Chemical Precipitation
Spent Acid with Metals, Managed by Chemical Precipitation
Caustic Solution with Metals and Cyanides, Managed by Cyanide Destruction Followed by Chemical Precipitation
Organic Liquids
Concentrated Aqueous Solution of Other Organics, Managed by Settling/Clarification Only
Concentrated Aqueous Solution of Other Organics, Managed by Phase Separation (e.g., Emulsion Breaking, Filtration) Only
Organic Paint, Ink, Lacquer or Varnish, Managed in Landfills
Halogenated/nonhalogenated Solvent Mixture, Managed by Solids Incineration
Concentrated Solvent-Water Solution, Managed by Liquids Incineration

Halogenated (e.g., Chlorinated) Solvent, Managed by Liquids Incineration
Nonhalogenated Solvent, Managed by Liquids Incineration
Halogenated/Nonhalogenated Solvent Mixture, Managed by Liquids Incineration
Waste Oil, Managed by Liquids Incineration
Oil-Water Emulsion or Mixture, Managed by Liquids Incineration
Concentrated Aqueous Solution of Other Organics, Managed by Liquids Incineration
Organic Paint, Ink Lacquer, or Varnish, Managed by Liquids Incineration
Organic Paint, Ink, Lacquer, or Varnish, Managed by Solids Incineration
Organic Paint, Ink Lacquer, or Varnish, Managed by Sludges Incineration
Reactive or Polymerizable Organic Liquid, Managed by Liquids Incineration
Paint Thinner or Petroleum Distillates, Managed by Liquids Incineration
Solids/Sludges
Ash, Slag or Other Residue from the Incineration of Wastes, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials
Ash, Slag, or Other Residue from the Incineration of Wastes, Managed in Landfills
Other “Dry” Ash, Slag, or Thermal Residue, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials
Other “Dry” Ash, Slag, or Thermal Residue, Managed in Landfills
“Dry” Lime or metal Hydroxide Solids Chemically “Fixed”, Managed by Chemical Precipitation
“Dry” Lime or Metal Hydroxide Solids Chemically “Fixed”, Managed by Stabilization/Chemical Fixation Using Cementitous and/or Pozzolanic Materials
“Dry” Lime or Metal Hydroxide Solids Chemically “Fixed”, Managed in Landfills
“Dry” Lime or Metal Hydroxide Solids Not “Fixed”, Managed by Wet Air Oxidation
“Dry” Lime or Metal Hydroxide Solids Not “Fixed”, Managed by Stabilization/Chemical Fixation Using Cementitous and/or Pozzolanic Materials
“Dry” Lime or Metal Hydroxide Solids Not “Fixed”, Managed in Landfills
Metal-Cyanide Salts/Chemical, Managed in Landfills
Spent Carbon, Managed by Carbon Adsorption
Lime Sludge with Metals/Metal Hydroxide Sludge, Managed by Chrome Reduction Followed by Chemical Precipitation
Lime Sludge with Metals/Metal Hydroxide Sludge, Managed by Surfcae Impoundment (to be Closed as a Landfill)
Wastewater Treatment Sludge with Toxic Organics, Managed in Landfills

Other Wastewater Treatment Sludge, Managed by Chemical Precipitation
Other Wastewater Treatment Sludge, Managed by Sludge Dewatering
Other Wastewater Treatment Sludge, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials
Other Wastewater Treatment Sludge, Managed by Landfills
Untreated Plating Sludge Without Cyanides, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials
Air Pollution Control Device Sludge, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials
Oily Sludge, Managed by Sludge Dewatering
Oily Sludge, Managed by Phase Separation (e.g., emulsion breaking, filtration) Only
Oily Sludge, Managed by Surface Impoundment (to be closed as a landfill)
Biological Treatment Sludge, Managed in Landfills
Wastewater Treatment Sludge with Toxic Organics, Managed by Incineration (Type Unknown)
Still Bottoms of Nonhalogenated Solvents or Other Organic Liquids, Managed by Liquids Incineration
Still Bottoms of Halogenated Solvents or Other Organic Liquids, Managed by Sludges Incineration
Reactive Organic Solid, Managed by Solids Incineration
Nonhalogenated Pesticide Solid, Managed by Solids Incineration
Spent Solid Filters or Adsorbents by Solids Incineration
Solid Resins or Polymerized Organics by Solids Incineration
Other Wastewater Treatment Sludge, Managed by Sludges Incineration
Halogenated Pesticide Solid, Managed by Solids Incineration
Biological Treatment Sludge, Managed by Sludges Incineration
Spent Carbon, Managed by Solids Incineration

To obtain information on chemical composition, the Agency accessed the 1993 National Hazardous Waste Constituent Survey (NHWCS) for constituent data for the 64 Form Code/System Type Code combinations. The National Hazardous Waste Constituent Survey provides data on constituents commonly present in wastes. The NHWCS is a sample of facilities; whereas, the BRS is a census of Large Quantity Generators and Treatment, Storage, and Disposal Sites. The NHWCS considered only the largest waste streams produced by sites selected to participate. In addition, because participation in the NHWCS survey was completely voluntary, in many cases the respondents left out vital information about their wastes and processes. EPA ran a query accessing both GM and WR Forms, as very little constituent data is provided by the GM

Form alone due to the sampling strategy employed by the NHWCS. Constituent data were available for 28 of the 64 combinations.

Using the constituent data from the NHWCS, EPA compared the constituent concentrations to the proposed exemption levels for the "Generic" HWIR (toxicity benchmark option) for wastewater (totals) and nonwastewater (both totals and leach). EPA determined which waste forms contain constituents having concentrations above the proposed exemption levels and which waste forms contain constituents having concentrations below the proposed exemption levels. EPA has developed and proposed unit-specific exemption levels for land applications, ash monofills, waste piles, surface impoundments, and aerated tanks. Where applicable, EPA also compared constituent concentrations to the unit specific exemption levels. Constituent concentrations for waste forms managed by M131- Land treatment/application/farming were compared to exemption levels for land application. Constituent concentrations for waste forms managed by M132 - Landfill were compared to exemption levels for ash monofills. Constituent concentrations for waste forms managed by M133 - Surface impoundment were compared to exemption levels for surface impoundments. Waste form constituent concentrations managed by M081 - Biological treatment were compared to exemption levels for aerated tanks. It should be noted that the constituent concentrations from the NHWCS are pre-treatment levels. Therefore, waste constituent levels would probably result in lower levels due to the wastes having been treated.

EPA evaluated the 64 Form Code/System Type combinations to determine if the reported management practice was suitable in treating the waste form. Where constituent data were available, EPA took this into consideration (e.g., if chromium was present, was chrome reduction practiced?). Where constituent data were unavailable, an assessment was made based on the waste form description (e.g., caustic solutions with metals and cyanides). To aid in evaluating suitable management practices, EPA created a table showing what treatment technologies are applicable to what wastes. This table is in Appendix F called "Waste Treatment Applicability to Waste Forms."

5.7 What Additional Judgements Did EPA Apply in Selecting Waste Form Candidates to Explore for the 1999 HWIR Proposal?

EPA considered whether or not constituents contained in the waste were likely to persist or bioaccumulate if released into the environment. EPA then considered whether or not the corresponding management of the waste was likely to treat these constituents or prevent their release into the environment.

Waste form/system type combinations are low risk if waste forms are managed in a way that treats the constituents in the waste and/or prevents them from being released into the environment. Waste forms/system types that are not managed in this manner are not suited for HWIR exemption.

5.8 What Wastes Appear Well-Suited for the Wastes Forms Approach?

In the following discussion, whenever referring to a "waste," EPA intends the waste to which the B code corresponds, not the waste following treatment by the M code.

<u>Ash, Slag, or Other Residue from the Incineration of Wastes, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B303/M111)</u>

A total of 87,517 tons of ash, slag, or other residue from the incineration of wastes managed by stabilization/chemical fixation using cementitious and/or pozzolanic materials (39,428 tons are treated onsite, and 48,089 tons are treated offsite) was reported in the BRS as being managed by 12 facilities (3 that treat onsite and 9 that treat offsite). Eleven facilities generate this waste; it is primarily generated by the refuse systems industry and nonclassifiable establishments as a result of incineration/thermal treatment operations. Each of the waste streams carries a large number of listed waste codes; the most common listed waste codes are F001-F005. Constituent data were available for this Form Code/System Type Code combination from both the GM and the WR Forms. These data indicate that the waste contains numerous metals, organics, and inorganics with arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc, 1,1-dichloroethylene, 1,2-dichloroethane, 2-nitropropane, aldrin, benzo(a)pyrene, bis(2-chloroethyl)ether, chlordan, dieldrin, dimethyl phthalate, pentachlorophenol, phenanthrene, and toxaphene present at concentrations above the December 1995 proposed HWIR exemption levels. Although all of these metals are persistent if released into the environment, the management practice of stabilization/chemical fixation is likely to treat these metals contained in the waste preventing them from leaching into the environment; however, the presence of organic constituents interferes with the hydration process and may reduce the strength of the matrix if present at a total organic carbon (TOC) content of about 1-2%.

<u>Other "Dry" Ash, Slag, or Thermal Residue, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B304/M111)</u>

A total of 20,430 tons of other dry ash, slag, or thermal residue managed by stabilization/chemical fixation using cementitious and/or pozzolanic materials (17 tons are treated onsite and 20,413 tons are treated offsite) was reported in the BRS as being managed by 7 facilities (1 that treats onsite and 6 that treat offsite). Eight facilities generate this waste; it is primarily generated by blast furnaces and steel mills and the air, water, and solid waste management industries as a result of cleaning out process equipment and air pollution control operations. Approximately 7 percent of the wastes are ignitable, 11 percent are corrosive, and 4 percent are reactive. The most common listed waste code associated with this waste is K061. Constituent data were available for this Form Code/System Type Code combination from both the GM and the WR Forms. These data indicate that the waste corresponding to the Form code contains several metals (including selenium, chromium, cadmium, barium, arsenic, silver, lead, copper, beryllium, antimony, zinc, thallium, nickel, and mercury) and some organic constituents (including trichloroethylene, tetrachloroethylene, carbon disulfide, p,p´-DDT, and toxaphene). Most of these constituents are present at concentrations above the December 1995 proposed HWIR exemption levels. Although all of these metals are persistent if released into the environment, the management practice of stabilization/chemical fixation is likely to treat these metals contained in the waste, preventing them from leaching into the environment; however, the presence of organic constituents interferes with the hydration process and may reduce the strength of the matrix. Also air pollution control ash is often acidic -- if due to hydrochloric acid, it would make a poor stabilized solid matrix because the salt, calcium chloride, makes a poor concrete.

"Dry" Lime or Metal Hydroxide Solids Chemically "Fixed", Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B305/M111)

A total of 17,407 tons of dry lime or metal hydroxide solids chemically fixed managed by stabilization/chemical fixation using cementitious and/or pozzolanic materials (16,651 tons are treated onsite, and 756 tons are treated offsite) was reported in the BRS as being managed by 10 facilities (1 that treats onsite and 9 that treat offsite). Ten facilities generate this waste; it is primarily generated by the refuse systems industry as a result of stabilization operations. Approximately 11 percent of the wastes are ignitable, and 13 percent are corrosive. The most common listed waste codes associated with this waste are F001-F005, F006, and F019. Constituent data were available for this Form Code/System Type Code combination; however, constituent levels were below the HWIR exemption levels. This Form Code/System Type Code combination would be exempt under the Generic HWIR Approach. However, it should be noted that the constituent data applied in this analysis constitutes a very limited data set due to the limitations of the NHWCS noted in Section 5.6 of this technical background document. The management practice of stabilization/chemical fixation, if accomplished using sulfuric or phosphoric acid, is likely to treat the metal compounds present in waste and prevent them from being released into the environment.

"Dry" Lime or Metal Hydroxide Solids Not "Fixed", Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B306/M111)

A total of 9,561 tons of dry lime or metal hydroxide solids not fixed managed by stabilization/chemical fixation using cementitious and/or pozzolanic materials (less than 1 ton is treated onsite, and 9,560 tons are treated offsite) was reported in the BRS as being managed by 16 facilities (1 that treats onsite and 15 that treat offsite). Twenty-three facilities generate this waste; it is primarily generated by the plating and polishing, guided missiles and space vehicles, and refuse systems industries as a result of wastewater treatment operations. Approximately two percent of the wastes are ignitable and four percent are corrosive. The most common listed waste codes associated with this waste are F006, F007, F008, F009, and F019. Constituent data were available for this Form Code/System Type Code combination; however, constituent levels were below the HWIR exemption levels. This Form Code/System Type Code combination would be exempt under the Generic HWIR Approach. However, it should be noted that the constituent data applied in this analysis constitutes a very limited data set due to the limitations of the NHWCS noted in Section 5.6 of this technical background document. The management practice of stabilization/chemical fixation is likely to treat the metal compounds present in waste and prevent them from being released into the environment.

Air Pollution Control Device Sludge (e.g., Fly Ash, Wet Scrubber Sludge), Managed by
Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B511/M111)

A total of 99,197 tons of air pollution control device sludge (e.g., fly ash, wet scrubber sludge) managed by stabilization/chemical fixation using cementitious and/or pozzolanic materials (61,145 tons are treated onsite, and 38,052 tons are treated offsite) was reported in the BRS as being managed by two facilities (one that treats onsite and one that treats offsite). Two facilities generate this waste; it is generated by the blast furnaces and steel mills industry as a result of air pollution control processes. None of the wastes are ignitable, corrosive, or reactive. The listed waste codes associated with this waste are F003, F005, and K061. Constituent data were available for this Form Code/System Type Code combination from both the GM and the WR Forms. These data indicate that the waste contains several metals with chromium, lead, zinc, selenium, silver, cadmium, arsenic present at concentrations above the proposed HWIR levels and numerous organics with 2-nitropropane, carbon tetrachloride, chlorobenzene, cresols (mixed isomers), nitrobenzene, pyridine, and trichloroethylene present at concentrations above the proposed HWIR levels. The management practice of stabilization/chemical fixation using cementitious and/or pozzolanic materials is typically used to treat metals preventing them from being released into the environment; however, the presence of organic constituents interferes with the hydration process and may reduce the strength of the matrix.

Untreated Plating Sludge without Cyanides, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B505/M111)

A total of 4,939 tons of untreated plating sludge without cyanides managed by stabilization/chemical fixation using cementitious and/or pozzolanic materials (18 tons are treated onsite, and 4,921 tons are treated offsite) was reported in the BRS as being managed by 17 facilities (1 that treats onsite and 16 that treat offsite). This waste is generated by 13 facilities; it is primarily generated by the refuse systems industry as a result of electroplating and other operations. Approximately 2 percent of the wastes are ignitable, and 12 percent are corrosive. The most common listed waste codes associated with this waste are F006, F007, and F019. No constituent data were available for this Form Code/System Type Code combination. Sludge generated as a result of plating operations commonly contains metals. The management practice of stabilization/chemical fixation using cementitious and/or pozzolanic materials is likely to treat any metals, preventing them from being released into the environment.

Other Wastewater Treatment Sludge, Managed by Stabilization/Chemical Fixation Using Cementitious and/or Pozzolanic Materials (B504/M111)

A total of 29,293 tons of other wastewater treatment sludge managed by stabilization/chemical fixation using cementitious and/or pozzolanic materials (17,266 tons are treated onsite, and 12,027 tons are treated offsite) was reported in the BRS as being managed by 19 facilities (3 that treat onsite and 16 that treat offsite). This waste is generated by 30 facilities; it is primarily generated by the refuse systems industry as a result of wastewater treatment operations. Approximately 35 percent of the wastes are ignitable, 41 percent are corrosive, and 2 percent are reactive. The most common listed waste codes associated with this waste are F001-F005, F006, and F019. Constituent data were available for this Form Code/System Type Code combination; however, constituent levels were below the HWIR exemption levels. At these constituent levels, this combination would be exempt under the Generic HWIR Approach. However, it should be noted that the constituent data applied in this analysis constitutes a very limited data set due to the limitations of the NHWCS noted in Section 5.6 of this technical background document.

"Dry" Lime or Metal Hydroxide Solids Chemically "Fixed", Managed by Chemical Precipitation (B305/M077)

A total of 30,568 tons of this waste (30,546 tons are treated onsite and 22 tons are treated offsite) was reported in the BRS as being managed by two facilities (one that treats onsite and one that treats offsite). Two facilities generate this waste; it is generated by the plating and polishing industry as a result of electroplating operations. There were no waste streams with ignitable, corrosive, or reactive waste codes. The listed waste codes associated with this waste are F006 and F019. No constituent data were available for this Form Code/System Type Code combination. The management practice of chemical precipitation is typically applicable to aqueous waste streams.

"Dry" Lime or Metal Hydroxide Solids Chemically "Fixed", Managed in Landfills (B305/M132)

A total of 158,017 tons of dry lime or metal hydroxide solids chemically fixed managed in landfills (86,860 tons are managed onsite, and 71,157 tons are managed offsite) was reported in the BRS as being managed by 16 facilities (6 that manage onsite and 10 that manage offsite). This waste is generated by 20 facilities; it is primarily generated by the refuse systems and air, water, and solid waste management industries as a result of stabilization. Approximately 8 percent of the wastes are ignitable, 7 percent are corrosive; and 10 percent are reactive. The most common listed waste codes associated with this waste are F006, F007, F008, F009, and F019. No constituent data were available for this Form Code/System Type Code combination, however, because approximately 25 percent are ignitable, corrosive or reactive, the stability of these wastes is questionable.

5.9 What Wastes Were Not Pursued Under the Wastes Forms Approach?

5.9.1 Wastes Not Likely to be Low Risk – Organic Liquids

The following waste forms are not likely to be low risk. Note, however, that most are treated by incineration. If the ash were then stabilized by Portland Cement or lime-pozzolan, the final form would be B303/M111, a well-suited final form.

Organic Paint, Ink, Lacquer, or Varnish, Managed in Landfills (B209/M132)

A total of less than 0.5 tons of organic paint, ink, lacquer, or varnish managed in landfills was reported in the BRS as being managed by one facility, which manages the waste offsite. Eight facilities generate this waste; it is primarily generated by the refuse systems industry as a result of painting operations. Approximately 82 percent of the wastes are ignitable, and 1 percent are corrosive. The most common listed waste codes associated with this waste are F001, F002, F003, and F005. Constituent data were available for this Form Code/System Type Code combination from the WR Forms; however, constituent levels were below the December 1995 proposed HWIR exemption levels. This Form Code/System Type Code combination waste would be exempt under the Generic HWIR Approach. However, it should be noted that the constituent data applied in this analysis constitutes a very limited data set due to the limitations noted in Section 5.6 of this technical background document.

Concentrated Solvent-Water Solution, Managed by Liquids Incineration (B201/M041)

A total of 43,858 tons of concentrated solvent-water solution managed by liquids incineration (38,183 tons are treated onsite and 5,675 tons are treated offsite) was reported in BRS as being managed by 40 facilities (19 that treat onsite and 21 that treat offsite). Twenty-one facilities generate this waste; it is primarily generated in the following industries: refuse systems, industrial organic chemicals, national security, and commercial physical and biological research. The waste streams were generated as a result of cleaning and degreasing processes, laboratory wastes, other processes, and product rinsing. Approximately 71 percent of the wastes are ignitable, 17 percent are corrosive, and 5 percent are reactive. In addition, 86 percent of the waste streams carry the F- listed waste code, 3 percent carry the K- listed waste code, 5 percent carry the P-listed waste code and 24 percent carry the U-listed waste code. Constituent data were available for this Form Code/System Type Code combination from the GM Form. These data indicate that the waste contains organic constituents including but not limited to: acetone, methanol, methyl ethyl ketone, methyl isobutyl ketone, methylene chloride, 2-picoline, ethyl acetate, and toluene. Acetone, 2-picoline, methanol, methylene chloride, and toluene are present at concentrations above the December 1995 proposed HWIR exemption levels.

Concentrated Aqueous Solution of Other Organics, Managed by Liquids Incineration (B207/M041)

A total of 10,509 tons of concentrated aqueous solution of other organics managed by liquids incineration (3,781 tons are treated onsite, and 6,728 tons are treated offsite) was reported in BRS as being managed by 21 facilities (7 that treat onsite and 14 that treat offsite). Fourteen facilities generate this waste; it is primarily generated in the following industries: refuse systems and industrial organic chemicals. The waste streams were generated as a result of laboratory activities and other processes. Approximately 71 percent of the wastes are ignitable, 23 percent are corrosive, and less than 1 percent are reactive. In addition, 73 percent of the waste streams carry the F- listed waste code, 3 percent carry the K-listed waste code, 5 percent carry the P-listed waste code and 38 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Halogenated (e.g., Chlorinated) Solvent, Managed by Liquids Incineration (B202/M041)

A total of 34,719 tons of halogenated solvent managed by liquids incineration (23,780 tons are treated onsite, and 10,939 tons are treated offsite) was reported in BRS to be managed by 35 facilities (14 that treat onsite and 21 that treat offsite). Twenty-one facilities generate this waste; it is primarily generated in the following industries: refuse systems, national security, industrial organic chemicals, and plastics materials and resins. The waste streams were generated as a result of laboratory wastes, discarding of out of date products or chemicals, cleaning and degreasing processes, and other processes. Approximately 56 percent of the wastes are ignitable, 10 percent are corrosive and 1 percent are reactive. In addition, 85 percent of the waste streams carry the F- listed waste code, 2 percent carry the K- listed waste code, 3 percent carry the P-listed waste code and 15 percent carry the U-listed waste code. Constituent data were available for this Form Code/System Type Code combination from the GM Form. These data indicate that the waste contains organic constituents including but not limited to: 2-picoline, methylene chloride, toluene, carbon tetrachloride, hexachlorobenzene, hexachloroethane and tetrachloroethylene. The majority of the constituents listed are present at concentrations above the December 1995 proposed HWIR exemption levels.

Nonhalogenated Solvent, Managed by Liquids Incineration (B203/M041)

A total of 28,000 tons of nonhalogenated solvent managed by liquids incineration (13,664 tons are treated onsite and 14,336 tons are treated offsite) was reported in the BRS as being managed by 50 facilities (25 that treat onsite, and 26 that treat offsite). One hundred eighty-four facilities generate this waste; it is primarily generated in the following industries: industrial organic chemicals, refuse systems, national security, and plastics materials and resins. The wastes were generated as a result of laboratory wastes, discarding of out of date products of chemicals, and clean out process equipment processes. Approximately 85 percent of the wastes are ignitable, 5 percent are corrosive, and 2 percent are reactive. In addition 86 percent of the waste streams carry the F- listed waste code, 0.4 percent carry the K-listed waste code, 1.5 percent carry the P-listed waste code and 17 percent carry the U-listed waste code. Constituent data were available for this Form Code/System Type Code combination from the GM Form. These data indicate that the waste contains organic constituents including but not limited to pentane, 1,4-dichlorobutene, toluene, heptane, hexane, toluene, methyl ethyl ketone, and xylenes. Methanol, butanol, acetone, 1,4-dichlorobutene, toluene, methyl ethyl ketone, xylenes, and chloromethane are present at concentrations above the December 1995 proposed HWIR exemption levels.

<u>Halogenated/Nonhalogenated Solvent Mixture, Managed by Liquids Incineration (B204/M041)</u>

A total of 70,250 tons of halogenated/nonhalogenated solvent mixture managed by liquids incineration (32,846 tons are treated onsite, and 37,404 tons are treated offsite) was reported in the BRS to be managed by 40 facilities (15 that treat onsite and 25 that treat offsite). One hundred and seventy-one facilities generate this waste (16 facilities reported a quantity); it is primarily generated in the following industries: refuse systems, national security, and colleges and universities. The waste streams were generated as a result of cleaning and degreasing processes, laboratory wastes, and other processes. Approximately 83 percent of the waste are ignitable, 18 percent are corrosive, and 2 percent are reactive. In addition 95 percent of the waste streams carried the F- listed waste code, 2 percent carry the K- listed waste code, 2 percent carry the P-listed waste code and 17 percent carry the U- listed waste code. Constituent data were available for this Form Code/System Type Code combination from the GM Form. These data indicate that the waste contains inorganic and organic constituents including but not limited to: trichloroethylene, tetrachloroethylene, trichlorofluoromethane, barium, benzene, methylene chloride, chloroform, methanol, silver, lead, and toluene. The majority of the constituents listed are present at concentrations above the December 1995 proposed HWIR exemption levels.

Halogenated/nonhalogenated Solvent Mixturem Managed by Solids Incineration (B204/M043)

A total of 237 tons of halogenated/nonhalogenated solvent mixture managed by solids incineration (59 tons are treated onsite, and 178 are treated offsite) was reported in the BRS to be managed by 13 facilities (3 that treat onsite and 10 that treat offsite). Ten facilities generate this waste; it is primarily generated in the following industries: refuse systems, photographic equipment and supplies, and pesticides and agricultural chemicals. The waste streams were generated as a result of the production laboratory wastes, discarding of out of date products or chemicals, and cleaning and degreasing processes. Approximately 74 percent of the wastes are ignitable, 9 percent are corrosive, and 4 percent are reactive. In addition, 85 percent of the waste streams carry the F- listed waste code, 1 percent carry the K-listed waste code, 5 percent carry the P-listed waste code and 32 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Paint Thinner or Petroleum Distillates, Managed by Liquids Incineration (B211/M041)

A total of 1,675 tons of paint thinner of petroleum distillates managed by liquids incineration (527 tons are treated onsite, and 1,148 tons are treated offsite) was reported in the BRS as being managed by 20 facilities (5 that treat onsite and 15 that treat offsite). Seventy-three facilities generate this waste; it is primarily generated by the national security and refuse systems industries as a result of painting and other operations. Approximately 94 percent of the wastes are ignitable. In addition, 98 percent of the waste streams carry a F- listed waste code. Few streams are corrosive or reactive, or carry a K-, P-, or U- listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Organic Paint, Ink Lacquer, or Varnish, Managed by Liquids Incineration (B209/M041)

A total of 2,237 tons of organic paint, ink lacquer, or varnish managed by liquids incineration (48 tons are treated onsite, and 2,189 tons are treated offsite) was reported in the BRS to be managed by 19 facilities (4 that treat onsite and 15 that treat offsite). Seventy-six facilities generate the waste; it is primarily generated in the following industries: refuse systems, industrial organic chemicals, national security, and aircraft parts and equipment. The waste streams were generated as a result of painting processes, discarding out of date products of chemicals, and other processes. Approximately 87 percent of the wastes are ignitable, 8 percent are corrosive, and 3 percent are reactive. In addition 96 percent of the waste streams carry the F-listed waste code, 2 percent carry the K-listed waste code, 2 percent carry the P-listed waste code and 13 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Organic Paint, Ink, Lacquer, or Varnish, Managed by Solids Incineration (B209/M043)

A total of 272 tons of organic paint, ink, lacquer, or varnish managed by solids incineration (35 tons are treated onsite, and 237 tons are treated offsite) was reported in the BRS as being managed by 11 facilities (3 that treat onsite and 8 that treat offsite). Thirty-three facilities generate this waste; it is primarily generated in the following industries: refuse systems and industrial organic chemicals. The waste streams were generated as a result of painting processes and other processes. Approximately 82 percent of the wastes are ignitable, 3 percent are corrosive and 4 percent are reactive. In addition, 91 percent of the waste streams carry the F-listed waste code, less than 1 percent carry the K-listed waste code, less than 1 percent carry the P-listed waste code and 12 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Organic Paint, Ink Lacquer, or varnish, Managed by Sludges Incineration (B209/M042)

A total 5 tons of organic paint, ink, lacquer, or varnish managed by sludges incineration (all treated offsite) was reported in the BRS to be managed by two facilities, both of which treat the waste offsite. Seventeen facilities generate this waste; it is primarily generated in the following industries: refuse systems and aircraft engines and engine parts. The waste streams were generated as a result of painting processes and other processes. Approximately 68 percent of the wastes are ignitable, and 17 percent are corrosive. In addition, 98 percent of the waste streams carry the F- listed waste code, 1 percent carry the K-listed waste code, 2 percent carry the P-listed waste code and 17 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Waste Oil, Managed by Liquids Incineration (B206/M041)

A total of 7,712 tons of waste oil managed by liquids incineration (5,462 tons treated onsite, and 2,250 tons treated offsite) was reported in the BRS to be managed by 18 facilities (6 that treat onsite and 12 that treat offsite). Sixty facilities generate this waste; it is primarily generated in the following industries: refuse systems, national security, industrial organic chemicals, and colleges and universities. The wastes were generated as a result of cleaning and degreasing processes, oil changes, and other processes. Approximately 31 percent of the wastes were ignitable, 3 percent corrosive, and 1 percent reactive. In addition 92 percent of the waste streams carry the F-listed waste code, 5 percent carry the K-listed waste code, 2 percent carry the P-listed waste code and 11 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Oil-Water Emulsion or Mixture, Managed by Liquids Incineration (B205/M041)

A total of 1,531 tons of oil-water emulsion or mixture managed by liquids incineration (377 tons treated onsite and 1,154 tons treated offsite) was reported in the BRS as being managed by 15 facilities (4 that treat onsite and 11 that treat offsite). Eleven facilities generate this waste; it is primarily generated in the following industries: refuse systems, industrial organic chemicals, and petroleum refining. The waste streams were generated as a result of process equipment clean out processes, wastewater treatment processes, and other processes. Approximately 34 percent of the wastes are ignitable, 10 percent are corrosive, and less than 1 percent are reactive.   In addition, 84 percent of the waste streams carry the F- listed waste code, 12 percent carry the K-listed waste code, less than 1 percent carry the P-listed waste code and 12 percent carry the U-listed waste code.   Constituent data were available for this Form Code/System Type Code combination from the GM Form. These data indicate that the waste contains organic constituents including but not limited to: trichloroethylene, tetrachloroethylene, trichlorofluoromethane, carbon tetrachloride, ethylbenzene, acetone, benzene, chloroform and toluene. 1,1,2- Trichloroethane, 1,2-dichloroethane, benzene, carbon tetrachloride, chloromethane and methylene chloride are present at concentrations above the December 1995 proposed HWIR exemption levels.

Reactive or Polymerizable Organic Liquid, Managed by Liquids Incineration (B212/M041)

A total of 14,813 tons of reactive or polymerizable organic liquid managed by liquids incineration (10,280 tons treated onsite and 4,533 tons treated offsite) was reported in the BRS as being managed by 16 facilities (6 that treat onsite and 10 that treat offsite). Thirty-six facilities generate this waste; it is primarily generated in the following industries: refuse systems, and industrial organic chemicals. The waste streams were as a result of discarding of off-spec material, product distillation, laboratory practices, and other processes. Approximately 71 percent of the wastes are ignitable, 20 percent are corrosive, and 48 percent are reactive. In addition, 52 percent of the waste streams carry the F- listed waste code, 13 percent carry the K-listed waste code, less than 1 percent carry the P-listed waste code and 61 percent carry the U-listed waste code. Constituent data were available for this Form Code/System Type Code combination from the GM Form. These data indicate that the waste contains organic constituents including but not limited to: 1,4 Dichloro 2 butene, 2-chloro-1,3-butadiene, toluene, methanol, acrylonitrile. 1,4- Dichloro-2- butane, 2-chloro-1,3-butadiene, toluene, acrylonitrile, and methanol are present at concentrations above the December 1995 proposed HWIR exemption levels.

5.9.2 Wastes Not Likely to be Low Risk - Solids and Sludges

As with the non-low-risk organic liquids in subsection 5.9.1, if the residues from incineration are stabilized by M111 (a cementitious or lime-pozzolan method), a good final form would be obtained.

Oily Sludge, Managed by Sludge Dewatering (B603/M101)

A total of 95,002 tons of oily sludge managed by sludge dewatering was reported in the BRS as being managed by five facilities, all of whom treat the waste onsite. All five facilities are in the petroleum refining industry. The waste is primarily generated as a result of wastewater treatment and routine cleanup operations. None of the wastes are ignitable, corrosive, or reactive. The listed waste codes associated with this waste are F037, F038, K048, K049, K050, and K051. No constituent data were available for this Form Code/System Type Code combination.

Oily Sludge, Managed by Surface Impoundment (to be Closed as a Landfill) (B603/M133)

A total of 39,350 tons of oily sludge managed by surface impoundment (to be closed as a landfill) was reported in the BRS as being managed by one facility, which treated the waste onsite. This waste is generated by a facility in the petroleum refining industry as a result of the RCRA closure of a hazardous waste management unit. None of the wastes are ignitable, corrosive, or reactive. The listed waste codes associated with this waste are F037 and F038. Constituent data were available for this Form Code/System Type Code combination from both the GM Forms. These data indicate that the waste contains phenol, arochlor-1248, xylene - mixed isomers, pyrene, toluene, ethylbenzene, fluorene, di-n-butyl phthalate, naphthalene, nickel, and barium at concentrations below the proposed levels for HWIR, and chrysene, phenanthrene, benzo(a)pyrene, lead, arsenic, and chromium present at concentrations above the December 1995 proposed HWIR exemption levels. Arsenic, bis(2-ethylhexyl)phthalate, benzo(a)pyrene, and benzene are present at levels above the proposed media specific levels for HWIR. No treatment of the oil or constituents is reported prior to placing the waste in a surface impoundment.

Still Bottoms of Nonhalogenated Solvents or Other Organic Liquids, Managed by Liquids Incineration (B602/M041)

A total of 13,140 tons of still bottoms of nonhalogenated solvents or other organic liquids managed by liquids incineration (6,616 tons are treated onsite, and 6,524 tons are treated offsite) was reported in the BRS as being managed by eight facilities (three facilities that treat onsite and five that treat offsite). Eleven facilities generate this waste; it is primarily generated by the industrial organic chemicals industry. The wastes are generated as a result of product distillation, and solvents recovery processes. Approximately 50 percent of the wastes are ignitable and approximately 13 percent of the waste is corrosive. In addition, 88 percent of the waste streams carry the F-listed waste code, 25 percent carry the K-listed waste code, and 6 percent carry the P-listed waste code. Constituent data were available for this Form Code/System Type Code combination from the GM Form. These data indicate that the waste contains inorganic and organic constituents including but not limited to nickel, antimony, aniline, benzene, cyclohexanone, nitrobenzene, and phenol. Aniline, benzene, and nitrobenzene are present at concentrations above the December 1995 proposed HWIR exemption levels.

Still Bottoms of Halogenated Solvents or Other Organic Liquids, Managed by Sludges Incineration (B601/M042)

A total 300 tons of still bottoms of halogenated solvents or other organic liquids managed by sludges incineration (229 tons treated onsite and 271 tons treated offsite) was reported in the BRS as being managed by seven facilities (two that treat onsite and five that treat offsite). Fifteen facilities generate this waste; it is primarily generated in the following industries: national security, refuse systems, and alkalies and chlorine. The wastes were generated as a result of solvents recovery, tank sludge removal, and other processes. Approximately 21 percent of the wastes are ignitable, and 4 percent are corrosive. In addition, the waste streams carried F-, K-, and U-listed codes; 93 percent carried F-listed waste codes, 4 percent carried K-listed waste codes and 5 percent carried U-listed waste codes.

Reactive Organic Solid, Managed by Solids Incineration (B405/M043)

A total 2,509 tons of reactive organic solid managed by solids incineration (nearly all treated offsite) was reported in the BRS as being managed by twelve facilities (one that treats onsite and eleven that treat offsite). Nine facilities generate this waste; it is primarily generated in the following industries: refuse systems and photographic equipment and supplies. The waste streams were generated as a result of miscellaneous processes. Approximately 64 percent of the wastes are ignitable, 22 percent are corrosive, and 27 percent are reactive. In addition, the waste streams carried F-, K-, P-, and U-listed codes; 56 percent carried the F-listed waste code, 4 percent carried the K- listed waste code, 10 percent carried the P-listed waste code and 50 percent carried the U-listed waste code.

Nonhalogenated Pesticide Solid, Managed by Solids Incineration (B402/M043)

A total 230 tons of nonhalogenated pesticide solid managed by solids incineration (all treated offsite) was reported in the BRS as being managed by twelve facilities, all of which treat the wastes offsite. Twenty-one facilities generate this waste; it is primarily generated in the following industries: refuse systems, national security, and pesticides and agricultural chemicals. The waste streams are generated as a result of production derived one time and intermittent processes, as well as other processes. Approximately 16 percent of the wastes are ignitable, 8 percent are corrosive, and less then one percent are reactive. In addition, 35 percent of the waste streams carried F-listed waste code, four percent carried the K-listed waste code, 39 percent carried the P-listed waste code and 36 percent carried the U-listed waste code.

Halogenated Pesticide Solid, Managed by Solids Incineration (B401/M043)

A total 15,068 tons of halogenated pesticide solid managed by solids incineration (all treated offsite) was reported in the BRS as being managed by 12 facilities, which treat the wastes offsite. Thirty-three facilities generated this waste. The waste streams were generated as a result of discarding out of date products or chemicals. Approximately 35 to 40 percent of the wastes are ignitable, less than 1 percent are corrosive, and less than 1 percent are reactive. In addition, the waste streams often carry the F-, K-, U-, and P-listed waste codes. No constituent data were available for this Form Code/System Type Code combination.

Solid Resins or Polymerized Organics, Managed by Solids Incineration (B403/M043)

A total of 6,382 tons of solid resins or polymerized organics by solids incineration (411 tons treated onsite, and 5,971 tons treated offsite) was reported in the BRS as being managed by 20 facilities (6 that treat onsite and 14 that treat offsite). Sixty-two facilities generated this waste; it is primarily generated by the following industries: plastics materials and resins, industrial organic chemicals, and refuse systems. The wastes were generated as a result of discarding off-specification and out-of-date products and chemicals, cleaning out process equipment, production-derived one-time and intermittent processes, painting, and other operations. Approximately 52 percent of the wastes are ignitable, 7 percent are corrosive, and 11 percent are reactive. In addition, 84 percent of the waste streams carry the F-listed waste code, 18 percent carry the K-listed waste code, 12 percent carry the P-listed waste code and 43 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Spent Carbon, Managed by Solids Incineration (B404/M043)

A total of 1,088 tons of spent carbon managed by solids incineration (237 tons treated onsite, and 851 tons treated offsite) was reported in the BRS as being managed by 22 facilities (8 that treat onsite and 14 that treat offsite). Sixty-six facilities generate this waste; it is primarily generated by the following industries: industrial organic chemicals, refuse systems, and other nonclassifiable establishments. The wastes were generated as a result of cleaning out process equipment, other remediation, wastewater treatment, air pollution control devices, and other processes. Approximately 35 percent of the wastes are ignitable, 8 percent are corrosive, and 14 percent are reactive. In addition, 35 percent of the waste streams carry the F-listed waste code, 26 percent carry the K-listed waste code, 12 percent carry the P-listed waste code, and 37 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

5.9.3 Wastes Not Pursued for Other Reasons

Aqueous Waste with Low Solvents, Managed by Biological Treatment (B101/M081)

A total of 37,986,592 tons of aqueous waste with low solvents managed by biological treatment (37,986,421 tons are treated onsite, and 171 tons are treated offsite) was reported in the Biennial Reporting System, BRS as being managed by six facilities (four that treat the waste onsite and two that treat the waste offsite). Twelve facilities generate this waste; it is primarily generated by the business services industry as a result of processes other than surface operations. Approximately 20 percent of the wastes are ignitable, 20 percent are corrosive, and 20 percent are reactive. The listed waste codes associated with this waste are F001-F005, F037, F039, U002, U044, U154, U159, and U359. No constituent data were available for this Form Code/System

Type Code combination. The management practice of biological treatment likely will treat the solvent compounds in the waste.

Aqueous Waste with Low Other Toxic Organics, Managed by Biological Treatment (B102/M081)

A total of 11,819,620 tons of aqueous waste with low other toxic organics managed by biological treatment (11,819,613 tons are treated onsite, and 7 tons are treated offsite) was reported in the BRS as being managed by six facilities (five that treat onsite and one that treats offsite). Six facilities generate this waste; it is primarily generated by the industrial organic chemicals industry as a result of the following operations: product distillation, processes other than surface preparation, wastewater treatment, air pollution control, and spent process liquids removal. Approximately 8 percent of the wastes are ignitable, 20 percent are corrosive, and 8 percent are reactive. The most common listed waste codes associated with this waste are F001, F005, F039, K009, and K010. Constituent data were available for this Form Code/System Type Code combination from the GM Forms. These data indicate the waste contains numerous organic constituents with benzene, n-butyl alcohol, 1,4-dioxane, 1,2-dichloroethane, acrolein, formaldehyde, hexachlorobenzene, carbon tetrachloride, chloroform, methylene chloride, aldrin, pentachlorophenol, 1,1-dichloroethylene, heptachlor, vinyl chloride, toxaphene, dieldrin, acetone, 2,4-dinitrotoluene, and arsenic present at concentrations above the December 1995 proposed HWIR exemption levels. This Form Code/System Type Code combination would be difficult to analyze because it is generated by numerous operations. The management practice of biological treatment likely will treat the toxic organic constituents in the waste; however, this practice may not treat the arsenic (biological treatment may result in microbial absorption of some or all of the arsenic).

Metal-Cyanide Salts/Chemicals, Managed in Landfills (B312/M132)

A total of 68,216 tons of metal-cyanide salts/chemicals managed in landfills was reported in the BRS as being managed by four facilities, all of whom manage the waste offsite. Four facilities generate this waste; it is primarily generated by the motor vehicle parts and accessories and refuse systems industries as a result of wastewater treatment operations and the discontinued use of process equipment. Approximately three percent of the wastes are corrosive, and three percent are reactive. The most common listed waste codes associated with this waste are F006, F007, F008, and F019. Constituent data were available for this Form Code/System Type Code combination from the WR Forms. These data indicate that the waste contains cyanides at concentrations above the levels proposed for HWIR. This Form Code/System Type Code combination would be difficult to analyze due to the nature of the processes generating the waste. In addition, it is difficult to prove that the combination is low-risk because the waste form is not reported to be managed in a way that would prevent the metal cyanides from being released into the environment. Metals are known to be persistent when released into the environment.

5.10 What Wastes Require Further Study and Evaluation?

EPA identified a number of waste form/management combinations for which the Agency was unable to draw the conculsion that the forms are/are not suitable for the waste forms approach without further analysis. EPA is not currently contemplating undertaking this additional analysis.

5.10.1 Wastewaters

Aqueous Waste with Low Solvents, Managed by Air/Steam Stripping (B101/M083)

A total of 2,369,793 tons of aqueous waste with low solvents managed by air/steam stripping (2,369,792 tons are treated onsite, and 1 ton is treated offsite) was reported in the BRS as being managed by seven facilities (six that treat onsite and one that treats offsite). Nine facilities generate this waste; it is primarily generated by the following industries: space propulsion units and parts, ordnance and accessories, refuse systems, and nonclassifiable establishments. The wastes were generated as a result of pollution control or waste treatment, Superfund Remedial Action, and other operations. Approximately 28 percent of the wastes are ignitable and approximately 15 percent are corrosive. The listed waste codes associated with this waste are F001-F005, U123, U133, U210, and U228. Constituent data were available for this Form Code/System Type Code combination from the Generation and Management, (GM) Forms. These data indicate that the waste contains numerous organic constituents with trichloroethylene, 1,1-dichloroethane, 1,1-dichloroethylene, and chloroform present at concentrations above the December 1995 proposed exemption levels for Hazardous Waste Identification Rule, HWIR. The management practice of air/steam stripping is likely to remove the organic constituents from the waste.

Aqueous Waste with Low Solvents, Managed by Wet Air Oxidation (B101/M084)

A total of 1,762,324 tons of aqueous waste with low solvents managed by wet air oxidation was reported in the BRS as being managed by one facility, which treats its waste onsite. This waste is generated by a facility in the space propulsion units and parts industry as a result of remediation operations. The waste is not ignitable, corrosive, or reactive; however, the waste carries the following listed waste codes: F001-F003 and F005. No constituent data were available for this Form Code/System Type Code combination. The management practice of wet air oxidation likely will treat the solvent compounds in the waste.

Scrubber Water, Managed by Chemical Oxidation Followed by Chemical Precipitation (B115/M074)

A total of 2,083,978 tons of scrubber water managed by chemical oxidation followed by chemical precipitation was reported in the BRS as being managed by one facility, which treats the waste onsite. This waste is generated by a facility in the refuse systems industry as a result of air pollution control operations. This waste is not ignitable, corrosive, or reactive. However, the waste does carry the listed waste codes F001-F004. No constituent data were available for this Form Code/System Type Code combination.

Aqueous Waste with Low Solvents, Managed by Liquids Incineration (B101/M041)

A total of 316,740 tons of aqueous waste with low solvents managed by liquids incineration (304,262 tons are treated onsite, and 12,478 tons are treated offsite) was reported in the BRS as being managed by 38 facilities (19 that treat onsite and 19 that treat offsite). One hundred thirty-four facilities generate this waste; it is primarily generated in the pesticides and agricultural chemicals industry. The wastes were generated as a result of spent process liquids removal. Approximately 37 percent of the wastes are ignitable, 12 percent are corrosive, and 1 percent are reactive. In addition, 87 percent of the waste streams carry the F- listed waste code, 4 percent carry the K- listed waste code, 3.5 percent carry the P- listed waste code and 21.5 percent carry the U- listed waste code. Constituent data were available for this Form Code/System Type Code combination from the GM Form. These data indicate that the waste contains organic constituents including but not limited to 1,2-dichloroethane, methanol, methyl isobutyl ketone, methylene chloride, phorate, toluene, and xylenes. The majority of these constituents are present at concentrations above the December 1995 proposed HWIR exemption levels.

Aqueous Waste with Low Other Toxic Organics, Managed by Liquids Incineration (B102/M041)

A total of 263,229 tons of aqueous waste with low other toxic organics managed by liquids incineration (261,338 tons are treated onsite, and 1,891 tons are treated offsite) was reported in the BRS as being managed by 20 facilities (10 that treat onsite, and 10 that treat offsite). Forty-nine facilities generate this waste; it is primarily generated in the following industries: national security, refuse system, steel works, blast furnaces, rolling mills, and pesticides and agricultural chemicals. The wastes were generated as a result of laboratory activities and other processes. Approximately 20 percent of the wastes are ignitable, 10 percent are corrosive, and 2 percent are reactive. In addition, the waste streams often carry the F-, K-, P-, and U- listed waste codes. No constituent data were available for this Form Code/System Type Code combination.

Scrubber Water, Managed by Liquids Incineration (B115/M041)

A total of 1,856,330 tons of scrubber water managed by liquids incineration (all treated onsite) was reported in the BRS as being managed by three facilities, which treat the waste onsite. Three facilities generate this waste; it is primarily generated in the refuse systems industry. The waste streams were generated as a result of air pollution control devices and other pollution control or waste treatment processes. Approximately 35 percent of the wastes are ignitable, 35 percent are corrosive and 35 percent are reactive. In addition, the waste streams often carry the F-, K-, P-, and U- listed waste codes. No constituent data were available for this Form Code/System Type Code combination.

Aqueous Waste With Low Solvents, Managed by Sludges Incineration (B101/M042)

A total of 0.07 tons of aqueous waste with low solvents managed by sludges incineration (all treated offsite) was reported in the BRS as being managed by one facility, which treats its waste offsite. Two facilities generate this waste; it is primarily generated in the refuse systems, and scrap and waste materials industries. The waste streams were generated as a result of cleaning and degreasing processes, by-product processing, spent process liquids removal, and other surface coating/preparation processes. Approximately 65 to 70 percent of the wastes are ignitable, and 1 percent are corrosive. In addition, the waste streams often carry the F-, P-, and U- listed waste codes. No constituent data were available for this Form Code/System Type Code combination.

5.10.2 Acids and Bases

Spent Acid with Metals, Managed by Chrome Reduction Followed by Chemical Precipitation (B103/M071)

A total of 24,238 tons of spent acid with metals managed by chrome reduction followed by chemical precipitation (14,982 tons are treated onsite, and 9,256 tons are treated offsite) was reported in the BRS as being managed by 9 facilities (2 that treat onsite and 7 that treat offsite). Four facilities generate this waste; it is generated by the following industries: blast furnaces and steel mills, aluminum extruded products, guided missiles and space vehicles, and special warehousing and storage. The waste was generated as a result of painting, electroplating, other surface coating/preparation processes, and other operations. Approximately 8 percent of the wastes are ignitable, 84 percent are corrosive and 4 percent are reactive. The listed waste codes associated with this waste are F001-F005, F006, F007, F008, F009, F019, and K062. No constituent data were available for this Form Code/System Type Code combination. Although this waste contains metals that are persistent if released into the environment, the management practice of chrome reduction followed by chemical precipitation is likely to treat these metals.

Spent Acid with Metals, Managed by Chemical Precipitation (B103/M077)

A total of 78,345 tons of spent acid with metals managed by chemical precipitation (11 tons are treated onsite, and 78,334 tons are treated offsite) was reported in the BRS as being managed by 18 facilities (3 that treat onsite and 15 that treat offsite). Fourteen facilities generate this waste; it is primarily generated by the blast furnaces and steel mills industry as a result of electroplating and pickling operations. Approximately 3 percent of the wastes are ignitable, and 40 percent are corrosive. The listed waste codes associated with this waste are F002-F005, F006, F007, F008, F009, F019, K062, U133, and U134. Constituent data were available for this Form Code/System Type Code combination from the Waste Received, WR Forms. These data indicate that the waste contains several metals (including zinc, copper, chromium, cadmium, nickel, lead, barium, arsenic, and silver), with chromium, copper, and zinc present in the waste at concentrations above the December 1995 proposed HWIR exemption levels. Although all of these metals are persistent if released into the environment, the management practice of chemical precipitation likely will treat these metals.

Caustic Solution with Metals and Cyanides, Managed by Cyanide Destruction Followed by Chemical Precipitation (B107/M072)

A total of 121,289 tons of caustic solution with metals and cyanides managed by cyanide destruction followed by chemical precipitation (112,343 tons are treated onsite, and 8,946 tons are treated offsite) was reported in the BRS as being managed by 22 facilities (11 that treat onsite and 11 that treat offsite). This waste is generated by 43 facilities; it is primarily generated by the plating and polishing and refuse systems industries as a result of electroplating and other operations, and discarding out-of-date products/chemicals. Approximately 1 percent of the wastes are ignitable, 40 percent are corrosive, and 28 percent are reactive. The most common listed waste codes are F006, F007, F008, and F009. Constituent data were available for this Form Code/System Type Code combination from the GM Forms. These data indicate that the waste contains cyanides and several metals (including chromium, cadmium, silver, nickel, and lead). Lead and cyanide are present at concentrations above the December 1995 proposed HWIR exemption levels. Although all of these metals are persistent if released into the environment, the management practice of chemical precipitation likely will treat these metals. In addition, the cyanide destruction would treat the cyanides preventing this contaminant from leaching into the environment.

5.10.3 Organic Liquids

Concentrated Aqueous Solution of Other Organics, Managed by Settling/ Clarification Only (B207/M123)

A total of 183,400 tons of concentrated aqueous solution of other organics managed by settling/clarification only was reported in the BRS as being managed by one facility, which treats its waste onsite. Two facilities report generating this waste; it is generated by facilities in the plastics materials and resins and industrial organic chemicals industries as a result of spent process liquids removal and wastewater treatment operations. Both of the wastes are ignitable. The listed waste codes associated with this waste are F002, F003, F005, U002, U031, U112, U140, and U359. Constituent data were available for this Form Code/System Type Code combination from the GM Forms. These data indicate that the waste contains several organics; however, they are all present in the waste at concentrations below the December 1995 proposed HWIR exemption levels. This Form Code/System Type Code combination waste would be exempt under the Generic HWIR Approach. However, it should be noted that the constituent data applied in this analysis constitutes a very limited data set due to the limitations of the National Hazardous Waste Constituent Survey, NHWCS noted in Section 5.6 of this technical background document.

Concentrated Aqueous Solution of Other Organics, Managed by Phase Separation (e.g., Emulsion Breaking, Filtration) Only (B207/M124)

A total of 1,610 tons of concentrated aqueous solution of other organics managed by phase separation only this waste (64 tons are treated, onsite and 1,546 tons are treated offsite) was reported in the BRS as being managed by four facilities (one that treats onsite and three that treat offsite). Three facilities generate this waste; it is primarily generated by the industrial organic chemicals and chemical preparations industries as a result of cleaning out process equipment and pollution control or waste treatment operations. Approximately 64 percent of the wastes are ignitable; 5 percent are corrosive; and 1 percent are reactive. The most common listed waste codes associated with this waste are F001, F002, F003, and F005.

5.10.4 Solids and Sludges

Many of the residues from incineration might be expected to generate a good final form if stabilized by a cementitious or lime-pozzolan method (M111).

Ash, Slag, or Other Residue from the Incineration of Wastes, Managed in Landfills (B303/M132)

A total of 74,338 tons of ash, slag, or other residue from the incineration of wastes managed in landfills this waste (14,262 tons are managed onsite and 60,076 tons are managed offsite) was reported in the BRS as being managed by 16 facilities (6 that manage onsite and 10 that manage offsite). This waste is generated by 58 facilities; it is primarily generated by the refuse systems, industrial organic chemicals, and pesticides and agricultural chemicals industries. The wastes are often generated as a result of incineration/thermal treatment operations. Approximately 17 percent of the wastes are ignitable; 13 percent are corrosive; and 9 percent are reactive. Each of the waste streams carry a large number of listed waste codes; the most common listed waste codes associated with this waste are F002, F003, and F005. Constituent data were available for this Form Code/System Type Code combination from both the GM and the WR Forms. These data indicate that the waste contains numerous metals, organics, and inorganics with antimony, arsenic, barium, cadmium, chromium, lead, mercury, benzene, selenium, thallium, tin, carbon tetrachloride, chlordane, chlorobenzene, hexachlorobenzene, endrin, endrin aldehyde, chloroform, m-cresol, o-cresol, p-cresol, silvex (2,4,5-TP), and toxaphene present at concentrations above the December 1995 proposed HWIR exemption levels. Arsenic is present at a level above the proposed media- specific level for HWIR.

Other “Dry” Ash, Slag, or Thermal Residue, Managed in Landfills (B304/M132)

A total of 29,662 tons of other dry ash, slag, or thermal residue managed in landfills (260 tons are managed onsite, and 29,402 tons are managed offsite) was reported in the BRS as being managed by 10 facilities (2 that manage onsite and 8 that manage offsite). This waste is generated by 19 facilities; it is primarily generated by the refuse systems industry and blast furnaces and steel mills as a result of incineration/thermal treatment, air pollution control, and other operations. Approximately 2 percent of the wastes are ignitable, 7 percent are corrosive, and 2 percent are reactive. The most common listed waste codes associated with this waste are F001-F005, K048-K051, and K061. Constituent data were available for this Form Code/System Type Code combination from the WR Forms. These data indicate that the waste contains several metals (including zinc, copper, chromium, arsenic, nickel, barium, selenium, and lead) and cyanides. Most of the metals and cyanides are present at concentrations above the December 1995 proposed HWIR exemption levels.

“Dry” Lime or Metal Hydroxide Solids Not “Fixed”, Managed by Wet Air Oxidation (B306/M076)

A total of 88,104 tons of dry lime or metal hydroxide solids not fixed managed by wet air oxidation was reported in the BRS as being managed by one facility, which treats its waste onsite. This waste is generated by a facility in the plating and polishing industry as a result of electroplating operations. The waste has a listed waste code of F006. No constituent data were available for this Form Code/System Type Code combination. The management practice of wet air oxidation is typically applicable to aqueous waste streams. This may be a code selection error in completing the BRS form.

“Dry” Lime or Metal Hydroxide Solids Not “Fixed”, Managed in Landfills (B306/M132)

A total of 18,150 tons of dry lime or metal hydroxide solids not fixed managed in landfills (213 tons are managed onsite, and 17,937 tons are managed offsite) was reported in the BRS as being managed by eight facilities (one that manages onsite and seven that manage offsite). This waste is generated by 22 facilities; it is primarily generated by the refuse systems industry as a result of wastewater treatment and other operations. Approximately one percent of the wastes are ignitable, three percent are corrosive, and one percent are reactive. The most common listed waste codes associated with this waste are F006, F007, F008, F019, and K046. No constituent data were available for this Form Code/System Type Code combination. This Form Code/System Type Code combination would be difficult to analyze due to the nature of the processes generating the waste. In addition, it is difficult to prove that the combination is low-risk because the waste form is not reported to be managed in a way that would prevent the metals from the metal hydroxides from being released into the environment. Metals are known to be persistent when released into the environment.

Spent Carbon, Managed by Carbon Adsorption (B404/M082)

A total of 67,094 tons of spent carbon managed by carbon adsorption (67,093 tons are treated onsite, and 1 ton is treated offsite) was reported in the BRS as being managed by three facilities (two that treat onsite and one that treats offsite). Three facilities generate this waste; it is primarily generated by the blankbooks and looseleaf binders, explosives, and photographic equipment and supplies industries as a result of remediation, air pollution control, and other operations. None of the wastes carry ignitable, corrosive, or reactive waste codes. The listed waste codes associated with this waste are F001, K045, and U228. No constituent data were available for this Form Code/System Type Code combination. This Form Code/System Type Code combination would be difficult to analyze due to the numerous industries generating the waste and the nature of the processes generating the waste. In addition, there appears to be a reporting error in how the waste is managed. Spent carbon is typically generated as a result of carbon adsorption, not managed by this practice.

Lime Sludge with Metals/Metal Hydroxide Sludge, Managed by Chrome Reduction Followed by Chemical Precipitation (B502/M071)

A total of 9,333 tons of lime sludge with metals/metal hydroxide sludge managed by chrome reduction followed by chemical precipitation was reported in the BRS as being managed by three facilities, all of whom treat the waste offsite. One facility generates this waste; it is generated by a facility in the trucking (except local) industry as a result of unknown operations. Approximately 25 percent of the wastes are ignitable and 25 percent are corrosive. The listed waste codes associated with this waste are F003, F019, K062, and U122. Constituent data were available for this Form Code/System Type Code combination from the WR Forms. These data indicate that the waste contains several metals with chromium and nickel present at concentrations above the levels proposed for HWIR. The management practice of chrome reduction would treat the chromium and the management practice of chemical precipitation would treat the nickel.

Lime Sludge with Metals/Metal Hydroxide Sludge, Managed by Surface Impoundment (to be Closed as a Landfill) (B502/M133)

A total of 25,000 tons of lime sludge with metals/metal hydroxide sludge managed by surface impoundment (to be closed as a landfill) was reported in the BRS as being managed by one facility, which treats the waste onsite. This waste is generated from a facility in the aluminum extruded products industry as a result of RCRA Corrective Action at a solid waste management unit. The waste has only one listed waste codes of F019. No constituent data were available for this Form Code/System Type Code combination. This waste form is not reported to be managed in a way that would prevent the metals from the metal hydroxides from being released into the environment. Metals are known to be persistent when released into the environment.

Wastewater Treatment Sludge with Toxic Organics, Managed in Landfills (B503/M132)

A total of 9,719 tons of wastewater treatment sludge with toxic organics managed in landfills (9,562 tons are managed onsite, and 157 tons are managed offsite) was reported in the BRS as being managed by five facilities (two that manage onsite and three that manage offsite). This waste is generated by 13 facilities; it is primarily generated by the petroleum refining industry as a result of wastewater treatment operations. Approximately five percent of the wastes are reactive. The most common listed waste codes associated with this waste are F006, F008, F037, and F038. No constituent data were available for this Form Code/System Type Code combination. This waste form is not reported to be managed in a way that would prevent toxic organics from being released into the environment.

Other Wastewater Treatment Sludge, Managed by Chemical Precipitation (B504/M077)

A total of 13,885 tons of other wastewater treatment sludge managed by chemical precipitation (446 tons are treated onsite, and 13,439 tons are treated offsite) was reported in the BRS as being managed by two facilities (one that treats onsite and one that treats offsite). Six facilities generate this waste; it is was generated by the following industries: explosives, plating and polishing, motor vehicles and car bodies, aircraft engines and engine parts, and refuse systems. The waste was generated as a result of electroplating and wastewater treatment operations. Approximately one percent of the wastes are ignitable, five percent are corrosive, and three percent are reactive. The listed waste codes associated with this waste are F003, F005, F006, F008, F012, F019, K044, K046, and K062. No constituent data were available for this Form Code/System Type Code combination. This Form Code/System Type Code combination would be difficult to analyze due to the numerous industries generating the waste. The management practice of chemical precipitation is typically used to treat aqueous waste streams. Possibly, the sludge may be dewatered, and the resulting aqueous stream may be treated by chemical precipitation.

Other Wastewater Treatment Sludge, Managed by Sludge Dewatering (B504/M101)

A total of 52,997 tons of other wastewater treatment sludge managed by sludge dewatering (52,796 tons are treated onsite, and 201 tons are treated offsite) was reported in the BRS as being managed by three facilities (one that treats onsite and two that treat offsite). One facility generates this waste; the waste is generated by a facility in the petroleum refining industry as a result of wastewater treatment operations. None of the wastes are ignitable, corrosive, or reactive. The listed waste codes associated with this waste are F006, F007, F008, F009, K048, and K051. Constituent data were available for this Form Code/System Type Code combination from both the GM and the WR Forms. These data indicate that the waste contains several metals including mercury, barium, cadmium, lead, and cyanides with chromium, nickel, silver, and arsenic present at concentrations above the levels proposed for HWIR and some organics including chrysene, ethylbenzene, pyrene, phenol, toluene, phenanthrene, di-n-butyl phthalate, naphthalene, and bis(2-ethylhexyl)phthalate with benzo(a)pyrene present at a concentration above the level proposed for HWIR. The reported management practice of sludge dewatering would be unlikely to treat the metals and organics contained in the waste.

Other Wastewater Treatment Sludge, Managed by Landfills (B504/M132)

A total of 10,717 tons of other wastewater treatment sludge managed by landfills (2,784 tons are managed onsite, and 7,933 tons are managed offsite) was reported in the BRS as being managed by 12 facilities (4 that manage onsite and 8 that manage offsite). This waste is generated by 27 facilities; it is primarily generated by the refuse systems industry as a result of wastewater treatment operations. Approximately four percent of the wastes are ignitable; seven percent are corrosive, and four percent are reactive. The most common listed waste codes associated with this waste are F006 and F019. Constituent data were available for this Form Code/System Type Code combination; however, constituent levels were below the HWIR exemption levels. This combination would be exempt under the Generic HWIR Approach. However, it should be noted that the constituent data applied in this analysis constitutes a very limited data set due to the limitations of the NHWCS noted in Section 5.6 of this technical background document.

Oily Sludge, Managed by Phase Separation (e.g., Emulsion Breaking, Filtration) Only (B603/M124)

A total of 10,593 tons of oily sludge managed by phase separation (e.g., emulsion breaking, filtration) only was reported in the BRS as being managed by one facility, which treated the waste onsite. This waste is generated from a facility in the petroleum refining industry as a result of wastewater treatment operations. None of the wastes are ignitable, corrosive, or reactive. The listed waste codes associated with this waste are F037, K048, and K051. No constituent data were available for this Form Code/System Type Code combination. The management practice of phase separation is likely to separate the oil from the sludge.

Biological Treatment Sludge, Managed in Landfills (B607/M132)

A total of 47,550 tons of biological treatment sludge managed in landfills (46,734 tons are managed onsite, and 816 tons are managed offsite) was reported in the BRS as being managed by four facilities (two that manage onsite and two that manage offsite). Five facilities generate this waste; it is primarily generated by the explosives and the medicinals and botanicals industries as a result of wastewater treatment and sludge dewatering operations. None of the wastes are ignitable, corrosive, or reactive. The most common listed waste codes associated with this waste are F002, F003, F005, and K044. Constituent data were available for this Form Code/System Type Code combination from both the GM and WR Forms. These data indicate that the waste contains numerous organics and metals, all at concentrations below the proposed generic and media specific levels for HWIR. At these levels, this combination would be exempt under the Generic HWIR Approach. However, it should be noted that the constituent data applied in this analysis constitutes a very limited data set due to the limitations of the NHWCS noted in Section 5.6 of this technical background document.

Wastewater Treatment Sludge with Toxic Organics, Managed by Incineration (Type Unknown) (B503/M049)

A total of 188,029 tons of wastewater treatment sludge with toxic organics managed by incineration (type unknown) (all treated onsite) was reported in the BRS as being managed by two facilities, which treat the waste onsite. Three facilities generate this waste; it is primarily generated in the following industries: man-made organic fibers, except cellulosic, and pesticides and agricultural chemicals. The waste streams were generated as a result of wastewater treatment processes. The waste streams are not typically ignitable, corrosive, or reactive. In addition, the waste streams often carry the F- and P-listed waste codes. No constituent data were available for this Form Code/System Type Code combination.

Spent Solid Filters or Adsorbents, Managed by Solids Incineration (B310/M043)

A total of 1,440 tons of spent solid filters or adsorbents by solids incineration (375 tons are treated onsite, and 1,065 are treated offsite) was reported in the BRS as being managed by 18 facilities (11 that treat onsite and 15 that treat offsite). One hundred twenty-five facilities generated this waste; it is primarily generated by the following industries: industrial organic chemicals and refuse systems. The waste were generated as a result of other operations. Approximately 42 percent of the waste are ignitable, 12 percent are corrosive and 12 percent are reactive. In addition, 10 percent of the waste streams carry the F-listed waste code, 2 percent carry the K-listed waste code, 5 percent carry the P-listed waste code, and 6 percent carry the U-listed waste code. No constituent data were available for this Form Code/System Type Code combination.

Other Wastewater Treatment Sludge, Managed by Sludges Incineration (B504/M042)

A total of 21,040 tons of other wastewater treatment sludge managed by sludges incineration (all treated onsite) was reported in the BRS as being managed by two facilities, which treat the wastes onsite. Sixteen facilities generated this waste; it is primarily generated in the following industries: petroleum refining and cyclic organic crudes, intermediates, dyes and pigments. The waste streams were generated as a result of wastewater treatment processes. Approximately 6 percent of the wastes are ignitable, 6 percent are corrosive and 25 percent are reactive. In addition, the waste streams often carry the F-, K-, P-, and U-listed waste codes. No constituent data were available for this Form Code/System Type Code combination.

Biological Treatment Sludge, Managed by Sludges Incineration (B607/M042)

A total of 45,443 tons of biological treatment sludge managed by sludges incineration (45,424 treated onsite, and 19 tons are treated offsite) was reported in the BRS as being managed by 3 facilities (two facilities that treat onsite and one that treats offsite). Four facilities generated this waste; it is primarily generated in the following industries: industrial organic chemicals and pesticides and agricultural chemicals. The waste streams were generated as a result of wastewater treatment processes. The waste streams are not typically ignitable, corrosive, or reactive. In addition, the waste streams often carry the F-, K-, P-, and U-listed waste codes. No constituent data were available for this Form Code/System Type Code combination.

6.0 CREATING REGULATORY OPTIONS UNDER THE WASTE FORM APPROACH

6.1 What Kind of Contingent Management Options Could EPA Develop Under the Waste Forms Approach?

A Waste Forms exemption could be structured in any number of ways. To be meaningful, the exemption must be different than the national "generic" HWIR option. As a result, a Waste Forms exemption must either contain additional conditions that must be met or must include restrictions.

An exemption under the national "generic" HWIR approach is premised on the belief that a waste will not present significant risks under typical management scenarios. In developing exemption levels for the national "generic" HWIR option, the Agency has identified typical management scenarios for the universe of hazardous wastes. The Agency has modeled the potential release of contaminants under these management scenarios and developed levels that will be protective regardless of the ultimate disposition of the waste. However, no "credit" is given to a waste if particular types of units provide additional protective measures, or if particular types of units are not used by industry to manage these wastes, or if the physical properties of the waste prevent or protect against the release of contaminants.

Under the HWIR Waste Forms Effort, EPA has investigated waste form-waste management combinations that, by their very nature, would enable the Agency to reduce the number of management scenarios (i.e., exposure pathways) that must be considered in developing exemption levels that are still protective. In reducing the number of exposure pathways, EPA may be able to exclude the more sensitive pathways from its modeling efforts. This, in turn, may enable EPA to develop exemption levels that are less stringent than the exemption levels developed for the national "generic" HWIR option. Although not all facilities would be able to use this set of exemption levels for all wastes, some facilities would be able to use this set of exemption levels for some wastes.

Because the key to reducing the number of management scenarios (i.e., exposure pathways) is linked to both waste form and waste management, the Agency envisions that a Waste Forms option could be structured to look like any of the following:

1. A particular waste could be required to be disposed of in a particular type of waste management unit (e.g., landfill) provided it met a tailored set of exemption levels.

2. A particular waste could be required to be disposed of in a particular type of waste management unit that has particular management controls (e.g., presence of a certain type of landfill liner) provided it met a tailored set of exemption levels.

3. A particular waste could be required to be disposed of in a particular type of waste management unit that is influenced by certain environmental factors provided it met a tailored set of exemption levels.

4. A particular waste could be required to be disposed of in a particular type of waste management unit provided it were managed in a waste management unit adhering to the requirements of a State solid waste management program and provided it met a tailored set of exemption levels.

5. A particular waste could be required to meet a tailored set of sampling and analysis conditions that are less burdensome than the criteria established under the national "generic" HWIR option provided it was disposed of in a particular type of waste management unit and provided it met the national "generic" exemption levels.

6. A particular waste could be prohibited from being disposed of in a particular type of unit, and could be disposed of in any other unit regardless of constituent levels.

7. A waste in a particular form (e.g., oily wastes) could be prohibited from becoming exempt under the national "generic" HWIR option.

8. A particular waste could be prohibited from being disposed of in a particular type of unit that is strongly influenced by certain environmental factors (e.g., distance to water body).

In addition, consistent with EPA's goals to minimize waste generation and promote resource recovery, EPA could develop Waste Forms options that encourage desirable management approaches (e.g., recycling) over less environmentally desirable approaches.

6.2 For Which Waste Forms Did EPA Develop Contingent Management Options Under the 1999 HWIR Proposal?

EPA's methodology for prioritizing its research efforts on wastes that would be eligible for the Waste Forms effort was presented in Section 5. From these research efforts, EPA identified numerous wastes that showed promise for further study. Specifically, EPA identified 64 wastes, which included wastes classified as organic liquids (16 wastes), inorganic liquids (3 wastes), solid or sludge wastes (36 wastes), and wastewaters (9 wastes). Each of these 64 wastes satisfied a set of screening criteria developed by EPA. Each of these wastes are identifiable using the Form Codes of the Biennial Reporting System (BRS), and were briefly described in Section 5 of this technical background document.

To develop an HWIR regulatory exemption mechanism for a less-mobile waste form, one needs to identify a waste that has special characteristics that support setting different exemption levels for the waste.[11] An example of a less-mobile waste form might be solidified material that is generated from a treatment process (e.g., pozzolanic stabilization of a metal-bearing waste, thermal treatment of a waste that produces a slag). The physical and chemical characteristics of a solidified material intuitively should lessen the release and transport of contaminants from the waste. Obviously, even solidified materials encompass a range of characteristics. Some solidified materials might hold up well in direct contact with the weather or other wastes; other solidified materials might not. Some solidified materials might be durable when stressed, compacted, or subjected to other types of physical impacts; other materials might break down at lower thresholds. However, in all cases (or hopefully most), solidified materials -- if the material remains in this form -- will have no or minimal contaminant releases to certain receptors.

EPA reviewed the types of wastes that met the screening criteria, and selected monolithic cement or pozzolanic stabilized wastes for more detailed consideration.

EPA chose only this limited number of wastes for more detailed consideration with the goal of focusing efforts on developing viable contingent management options for the 1999 HWIR proposed rule, if such options seem to show merit. EPA acknowledges that there may be other wastes that could be added to this list; however, EPA presumes that, if a contingent management option can be created for at least one waste form, HWIR stakeholders will identify these other wastes in time.

6.3 How Might the Agency Establish Exemption levels for Monolithic Cement-based Wastes Meeting Certain Criteria (e.g., Compressive Strength, Dusting)?

Solidified materials are not expected to release particulate matter, and thus are not expected to pose an inhalation risk. The absence of risk from contaminant releases to certain receptors means that the waste itself "protects" against these releases. Not all wastes can provide this protection on their own merits. Monolithic cement or pozzolanic-wastes are not expected to release particulates. Other wastes, such as sludges, must rely on management controls if the potential exposure to particulates via inhalation is to be eliminated or reduced. It is for this reason that monolithic cement and pozzolanic-wastes could be considered as candidates for an exemption mechanism under HWIR for less-mobile waste forms.

---

11 Presumably, these different exemption levels will be higher (i.e., less stringent) than the exemption levels established for the national generic HWIR approach based, in part, on waste-specific factors, treatment strategies, etc. Developing an exemption mechanism with <u>equal</u> exemption levels seems to be an unnecessary expenditure of Agency resources without additional benefits to the regulated community. Developing an exemption with <u>more</u> stringent exemption levels seems to be more appropriate to one of EPA's other Waste Form Effort objectives, namely to "justify the exclusion of particular waste forms, if appropriate, from becoming exempt under HWIR".

In developing exemption levels for monolithic cement-based wastes, EPA recognized the importance of first characterizing how these wastes are generated, what types of hazardous waste are treated using cement stabilization, and how cement-stabilized wastes are managed. With information regarding the range of cement-stabilized wastes being generated and the types of hazardous waste that are currently being treated using this technology, EPA can assess whether all or only a discrete subset of cement-stabilized wastes should be included in a Waste Forms exemption. Sections 6.3.1 and 6.3.2 discuss how this waste form is generated and the types of hazardous wastes that are currently treated using cement stabilization. With information regarding the management of cement-stabilized wastes, EPA can make appropriate decisions regarding the number of exposure pathways that must be considered in developing exemption levels that are still protective. Likewise, waste management information will influence EPA's decision to exclude certain pathways from its modeling efforts. Sections 6.3.3 and 6.3.4 discuss how cement-stabilized wastes are managed and the exposure pathways associated with common management practices.

Once the units and pathways of concern for cement-stabilized wastes are identified, efforts to conduct modeling analyses can proceed. Modeling results, once available, will provide exemption levels for this less-mobile waste form, and will provide "realness" to EPA's less-mobile waste form concept. The generation of modeled exemption levels, however, is just one necessary input to crafting an exemption mechanism for monolithic cement-stabilized wastes. Section 6.3.5 discusses considerations that EPA must assess to support the development of regulatory options for this waste under the Waste Forms Approach.

6.3.1 How is This Waste Form Generated?

Waste solidification and stabilization processes were developed to improve the chemical and physical properties of hazardous wastes, and used to treat free liquids until approximately 1988. Under EPA's Land Disposal Restrictions (LDR) Program, solidification and stabilization were identified as a "best demonstrated available technology". Solidification and stabilization were particularly used as a means to treat metal-bearing wastes. Solidification refers more to the physical properties of the material being treated, and is a technology that "treats" a waste by reducing the exposed surface area thus reducing the transport of contaminants from the waste. Stabilization refers more to the chemical properties of the material being treated, and is a technology that "treats" a waste by promoting a reaction between the waste constituents and the reagents specific to the selected stabilization technology. Stabilization and solidification often are both used to treat a waste to prevent contaminant release (Channell, 1996). *For ease in preparing and reading this document, the term stabilization will be used; however, admittedly, solidification may also be a key or the key process.*

Stabilization processes used in the treatment of hazardous wastes typically involve cementing reactions or pozzolanic reactions, which respectively rely on Portland cement or some type of lime-pozzolan combination as the basic reagents. Portland cement is widely available, economical, and well known. Pozzolans are siliceous materials. When pozzolans are combined with lime, cementation occurs, but at a lower rate than with Portland cement. Common pozzolans include fly ash, blast furnace slags, and kiln dust. These three materials also happen to be waste materials (Channell, 1996). Other stabilization processes have also been developed that rely on clays, polymers, thermoplastics, or proprietary sorbent materials (Channell, 1996; Stegemann, 1988).[12] In addition, the properties of a stabilization technology are often enhanced by using small quantities of "admixtures", which are incorporated to achieve specific effects. Admixtures that are routinely used for the treatment of soils include soluble silicates, organophilic clays, and activated carbon (Channell, 1996). *For ease in preparing and reading this document, the term cement will be used; however, admittedly, a lime-pozzolan may be the basic binding reagent or the binding reagent might include both cement and a pozzolan material.*

The process of waste stabilization follows a small number of steps, with the initial steps focusing on initial screening of the adequacy of the selected reagents with the waste. Once initial screening has been completed, batches of waste are stabilized and subjected to physical property testing. Stabilized batches may also be subjected to tests to measure contaminant release, depending on the objectives of the investigation or application.

During initial screening, the following steps may be conducted: analysis of the waste, determination of the water-to-waste ratio[13], and determination of the reagent-to-waste ratio. A physical property test is typically selected in determining the water-to-waste and reagent-to-waste ratio. For example, in a 1991 study to evaluate stabilization technologies appropriate for certain contaminated soils, the U.S. Army Corps of Engineers relied on the results of the cone index (CI) test to select appropriate water and reagent ratios (Fleming, 1991). Various specimens of selected ratios were prepared, allowed to cure for 48 hours, and then subjected to the CI test. The CI test "measures the resistance of a material to the penetration of a 30-deg right circular cone", and is specified in Technical Manual 5-530 issued by the Department of the Army. The CI test is reported as force per unit surface area, in pounds per square inch, of the cone base required to push the cone through a test material. It is one of several tests to determine hardness or physical strength of a stabilized specimen.

Once initial screening is completed, waste batches are prepared by mixing waste with the determined ratios of water and selected reagents. The combined mixture is typically poured into molds and allowed to cure prior to additional testing. A physical property test is then selected and conducted to assess the success of the stabilization. In the case of the U.S. Army Corps of Engineers 1991 study previously discussed, waste was removed from the molds when the material had developed sufficient strength to be free-standing (Fleming, 1991). The waste was then

---

12 Still other process have been developed to support actual cement manufacturing operations. For example, some wastes are suitable replacements for a material or materials otherwise used to manufacture cement. For example, Gulf Chemical & Metallurgical Corporation reclaims an alumina silica material from a spent catalyst. This reclaimed material is used by the Arizona Portland Cement Company as an alternative source of alumina in its cement manufacturing operations (CPCC, 1996).

13 It may be necessary to add water to hydrate the waste so that stabilization can occur.

allowed to cure for a number of days. Samples were collected at 7, 14, 21, and 28 days and tested for unconfined compressive strength (UCS) using ASTM Method C109-86. UCS results are reported as pounds per square inch required to fracture a sample of stabilized material. Other physical property tests, or chemical tests, can also be used to assess the success of stabilization. A 1996 study conducted by the U.S. Army Corps of Engineers used eight physical tests and one chemical test to evaluate the results of its stabilization studies (Channell, 1996). Physical tests were conducted to determine: unconfined compressive strength, set time, slump, bulk density, bleed water, cracking, moisture content, and specific gravity. The chemical test was the Agency's Toxicity Characteristic Leaching Procedure (TCLP).

The best assessment of the quality of a stabilized specimen includes both one or more strength and durability (i.e., resistance to abrasion) tests, as well as one or more chemical stability (i.e., resistance to leaching) tests. Also, the optimum stabilized waste form should be based on simultaneous consideration of strength/durability, leachability, and cost due to stabilizing binder (e.g., cement, lime-pozzolan) content.

6.3.2 What Hazardous Wastes Are Treated Using Cement-Stabilization?

According to information contained in the Biennial Reporting System (BRS), a number of different wastes are reportedly treated using cement or pozzolanic technologies. Those BRS wastes treated using cement or pozzolanic technologies include:

- Ash, slag, or other residue from the incineration of wastes, which includes wastes listed as EPA Hazardous Waste Nos. F001 through F005 among other classifications

- Other "dry" ash, slag, or thermal residue, which most commonly includes wastes listed as EPA Hazardous Waste No. K061

- Untreated plating sludge without cyanides, which includes most commonly wastes listed as EPA Hazardous Waste Nos. F006, F007, and F019

- Air pollution control device sludge (e.g., fly ash, wet scrubber sludge), which includes wastes listed as EPA Hazardous Waste Nos. F003, F005, and K061

- "Dry" lime or metal hydroxide solids, which most commonly includes wastes listed as EPA Hazardous Waste Nos. F001 through F005, F006, and F019

- "Dry" lime or metal hydroxide solids not "fixed", which most commonly includes wastes listed as EPA Hazardous Waste Nos. F006 through F009, and F019

- Other wastewater treatment sludge, which includes most commonly wastes listed as EPA Hazardous Waste Nos. F001 through F005, F006, and F019.

It should be noted that, based on preliminary studies conducted under the Waste Forms Effort (including the assessment of limited waste composition data obtained from responses to the Hazardous Waste Constituent Survey), the last three wastes may contain constituents at concentrations that meet the exemption levels presented in the December 1995 proposed HWIR Rule. More detailed descriptions of all of these wastes were presented in Section 5 of this technical background document.

6.3.3 How is this Waste Form Managed?

In assessing the potential risks of a less-mobile waste form, one must understand the conditions under which these wastes are managed, used, and disposed. Currently, EPA's HWIR effort is not considering beneficial use of HWIR exempt materials.[14] Thus, the ultimate disposition of HWIR exempt wastes is limited to waste management and disposal. Waste management and disposal options, in turn, are limited to those available for any solid or hazardous waste.[15]

Facilities/ units, which manage wastes, must meet certain Federal and State requirements prior to receiving waste. These requirements are in place to ensure the protection of human health and the environment. Protection of human health, in part, is addressed by minimizing the actual exposure of humans to the wastes and waste contaminants.[16] Exposure can be minimized in a number of ways, including the use of engineering controls to monitor, prevent, and address contaminant releases; the consideration of factors during unit design (e.g., siting considerations); and the adoption of on-site practices (e.g., employee education, spill prevention plans, waste acceptance criteria).

The modeling effort being conducted to support the national "generic" HWIR option is being structured around five types of waste management units, namely, landfills, land application units, waste piles, surface impoundments, and aerated tanks. Appendix G of this technical background document presents an overview of pathways, routes of exposure, and receptors for these five waste management units (Note: this table does not necessarily reflect the pathways represented in the current 3MRA model for HWIR99. The table is for purposes of illustration only). Of these five waste management units, monolithic cement-stabilized wastes are most likely

---

[14] Generators of hazardous waste continue to have the regulatory options of recycling their wastes (under 40 CFR Section 261.2) or using their wastes in a manner constituting disposal (under 40 CFR Section 261.2).

[15] It may be important to consider that generators of some HWIR exempt waste might choose to manage their waste in Subtitle C units.

[16] If EPA decides to consider beneficial use of HWIR-exempt wastes, a number of issues will need to be addressed. For example, different assumptions regarding exposure would be needed. Modeling waste use is expected to be much more complex than the modeling of waste management and disposal options.

to be disposed of in landfills, as obviously the physical properties of these wastes would preclude disposal in land application units, surface impoundments, and tanks. Waste piles are considered to be units for temporary storage and, thus, would not truly be a disposal option for cement-stabilized wastes. The remainder of this section describes design and operating requirements for non-hazardous waste landfills, the ability of the design and operating controls to protect human health and the environment from releases through various exposure pathways, and the effectiveness of current Federal and State requirements in ensuring that landfills will protect against contaminant releases.

Landfill Operation

A landfill is a disposal facility, not classified as a land treatment facility, waste pile, underground injection well, or surface impoundment, where solid waste is disposed on or into the land by spreading the waste in layers and covering it with a layer of earth or other approved material as required. Slightly more than one percent of the total non-hazardous industrial waste volume in the United States is managed in landfills.

A municipal solid waste landfill (MSWLF) can receive solid waste, including garbage, trash, and septic tank waste, derived from houses, apartments, hotels, motels, campgrounds, and picnic grounds. A MSWLF unit also may receive commercial solid waste, non-hazardous sludge, small quantity generator hazardous waste, and industrial solid waste. Newly constructed MSWLFs are subject to more stringent design, construction, and monitoring requirements than older facilities. Exemptions from Federal requirements exist for small MSWLFs that receive less than 20 tons of waste per day (averaged yearly), receive less than 25 inches of rainfall per year, have no other practical alternative, and show no evidence of ground-water contamination from the landfill. Extremely remote communities that have no ready access to other disposal sites for extended periods of time also are eligible for an exemption. Non-hazardous industrial wastes also may be managed in Industrial Subtitle D landfills that do not accept municipal wastes. Industrial landfills and older MSWLFs may be unlined and may lack leachate collection, landfill gas collection, and ground-water monitoring systems.

Potential Exposure Pathways Through Which Contaminants May Be Released

The potential routes of exposure from landfills are from releases of landfill leachate to the ground water via the subsurface portion of the landfill; to surface waters via runon and runoff; through air emissions of volatile chemicals and particulates. The resulting direct exposures include ingestion of surface water, ground water, or soils; inhalation of vapors or airborne particles; or dermal contact with surface or ground water. Indirect pathways include consumption of animal products or food crops. It is expected that certain pathways can result in higher exposures that others. For example, direct ingestion of contaminated ground water can result in a higher and more prolonged exposure to a contaminant than ingestion of contaminated ground water through bathing.

Ground-water Releases

Contaminated leachate from the landfill may be released into the subsurface soils. Natural attenuation of the leachate contaminants can occur in the soil through six primary mechanisms:

- Mechanical filtration results in the removal of suspended solids and pathogens.
- Chemical precipitation can occur due to changes in pH, temperature, and solution composition such that contaminants are converted to insoluble compounds.
- Adsorption occurs when contaminants are adsorbed to clay, soil, or hydrous oxides.
- Dilution and dispersion reduces the concentration of the contaminants, but not the total loading to the ground water.
- Microbes in the soil can utilize and remove contaminants in the soil.
- Contaminants with low vapor pressures can be volatilized if they move above the water table.

These mechanisms are site-specific, and the transport of contaminants can vary depending upon the number of different soil types present. The extent to which natural attenuation occurs depends on the soil type. Contaminants are not equally removed or reduced (O'Leary, July 1991).

The extent to which landfill leachate can reach ground water depends on whether or not the landfill is lined, the integrity of the liner, and the porosity and permeability of the underlying soils. Porosity is the "proportion of material that is void space where water can collect" while permeability is the "ability of the medium to transport water (Baily, 1990)." Clay soils have very low permeability and may be used in landfill construction if the natural underlying soil is sandy or gravelly.

Once contamination has occurred and the contaminant plume has reached the ground water, transport of the contaminant will depend upon the velocity at which the aquifer moves, as well as the chemical and physical properties of the contaminant.

Air Releases

Exposure to airborne contaminants may result from the release and emission of volatile chemicals and contaminated particulates. For both types of air releases, local meteorological factors will affect the amount and extent of airborne releases. The key weather influences that will impact fate and transport are precipitation and wind speed. Rainfall may transfer the airborne or volatilized constituents to the soil or surface waters, and wind will carry airborne contaminants to areas outside the facility and/or unit.

For airborne volatile constituents, chemical-specific parameters will influence releases from landfills. The solids properties of the material disposed in the landfill -- such as adsorption characteristics, moisture content, liquid-vapor equilibrium (Henry's Law), and chemical concentrations -- will determine the constituent loading that volatilizes into the air. Furthermore, local conditions (e.g., air temperature, humidity, and wind) and operational activities (e.g., landfill loading, covering, other disturbances) will affect diffusion and/or evaporative rates of the chemicals from the waste into the air. Once volatilized, the concentrations of the volatile chemicals may be attenuated by natural processes such as chemical transformation, biodegradation, photolysis, and hydrolysis.

For airborne contaminated particulates, factors that affect particulate dispersion and deposition are the major influences on fate and transport. For dispersion, waste characteristics such as moisture content, particle size, and particle density will impact the amount of particulates that are carried into the air and how far they may be transported. Design aspects such as landfill height, terrain characteristics, and cover activities will influence emissions associated with wind erosion, and operational activities such as vehicle traffic, unloading, spreading, compacting will suspend particulates into the air. Furthermore, the chemical interactions associated with volatile emissions can occur on the particulate-air interface, and may attenuate chemical concentrations in the contaminated particulates.

<u>Design Criteria/Practices and Management Controls are Relied Upon to Minimize and Prevent Contaminant Releases and to Maintain Integrity of the Landfill Unit</u>[17]

As loads are received, trucks are directed to the active portion of the landfill or landfill cell. Landfill operators receiving wastes from off site may randomly inspect incoming trucks to assess whether the load contains acceptable or unacceptable wastes. This inspection serves as the first level of controlling contaminants coming into the landfill. Depending upon the permit and acceptance criteria for the MSWLF, the facility may accept household and business trash, yard waste, non-hazardous industrial wastes, tires, "white goods", or other materials. Although hazardous wastes are subject to specific treatment, storage, and disposal requirements under Subtitle C, hazardous waste generated by RCRA-conditionally exempt small quantity generators may be accepted at MSWLFs.

The accepted wastes are off-loaded at the active cell and are spread and compacted within the cell to reach a specific depth and slope. At the end of each working day (or periodically, as the MSWLF permit requirements dictate), the active cell will be covered with approximately two feet of soil, which is referred to as the daily cover. Solid wastes will continue to settle as more layers of waste and cover are added to the cell. This process can continue for many years (O'Leary, April 1991).

---

[17] The section provides only a general discussion of design criteria and management controls at landfills. The information is not exhaustive, but highlights the design criteria and management practices that are most commonly used to minimize or prevent contaminant releases. For example, management practices such as recycling are not discussed, but can reduce the influent of contaminants to a landfill.

The potential for leachate from a landfill to reach ground water is of significant concern. Leachate is formed during compaction and through infiltration of water through the landfill. Leachate will drain through the landfill and collect at the base of the landfill (O'Leary, April 1991). As the leachate moves through the landfill, it will carry with it chemical and biological contaminants. The extent to which the leachate transports contaminants is dependent upon the degree to which decomposition is occurring in the landfill, the chemical and physical nature of the contaminants, and the presence of agents that will mobilize the contaminants (e.g., solvents). Generally, organic acids are produced during anaerobic decomposition. These organic acids will solubilize some inorganic materials (O'Leary, April 1991). Factors affecting leachate production include climate, site topography, final landfill cover material, vegetative cover, site phasing and operating procedures, and the type of wastes disposed of in the landfill. The composition of the leachate will depend upon the type and quality of wastes being disposed, temperature, moisture content, moisture routing, depth of fill, stage of decomposition, and ability of cover layers to remove contaminants (O'Leary, July 1991).

Current design and operating requirements seek to limit both leachate formation and the potential for leachate to reach the soil and migrate to ground water. Disposal of liquid wastes generally is prohibited in a MSWLF. The daily cover will limit infiltration of water into active cells, reduce air emissions and odors, and reduce the presence of vectors (e.g., rats, birds, snakes). Closed landfill cells often will be capped with a synthetic membrane and a clay cover to further reduce the potential for water infiltration.

However, due to compaction, leachate formation is possible, and currently active MSWLFs generally will have in place a leachate collection system that channels leachate to a central accumulation point for collection and treatment. As of October 1995, MSWLFs are required to have a synthetic liner in place. The liner must be placed over clay to reduce the potential for leachate migration to ground water should the liner be torn or otherwise fail.

An additional concern for MSWLFs is the formation of methane gas from the decomposition of solid waste. Methane is explosive, and modern landfills have in place a methane gas collection system. The collected methane gas may be flared off or used for energy recovery.

Current Federal and State Requirements Governing the Operation of Landfills (U.S. EPA, March 1993; U.S. EPA, 1995)

Design

Under Federal requirements, new and expanding landfills must be designed for ground-water protection by making sure that levels of contaminants do not exceed Federal limits for safe drinking water. In States and tribes with EPA-approved programs, landfill owners/operators have flexibility in designing their units to suit local circumstances, providing the State or tribal program director approves the design. This allows owners/operators to ensure environmental protection at the lowest possible cost to citizens served by the landfill. This flexibility means, for example, that the use of a liner, and the nature and thickness of the liner system, may vary from State to State, and perhaps from site to site.

In States and tribal areas without EPA-approved programs, owners/operators must build their landfills according to a design developed by EPA, or seek a waiver. The EPA design lays out specific requirements for liners and leachate collection systems. Liners must be composite, that is, a synthetic material over a 2-foot layer of clay. This system forms a barrier that prevents leachate from escaping from the landfill into ground water. The design also requires leachate collection systems that allow the leachate to be captured and treated.

Operation

EPA and the States have developed regulations specifically covering the disposal of hazardous wastes in special landfills. Owners/operators of municipal landfills must develop programs to keep these regulated hazardous wastes out of their units. Twenty-eight States have waste screening restrictions to eliminate acceptance of hazardous or other prohibited wastes at landfills. A typical requirement will establish employee training procedures and call for inspection of three random waste loads per day.

In general, each day's waste must be covered to prevent the spread of disease by rats, flies, mosquitoes, birds, and other animals that are naturally attracted to landfills. Forty-four States require daily landfill cover, with a standard depth of six inches.

So that no pollutants are swept into lakes, rivers, or streams, landfills must be built with ditches and levees to keep storm water from flooding their active areas and to collect and control storm-water run-off. Run-on/run-off requirements are specified by 43 States, and these typically include erosion and sedimentation control devices capable of handling a 25-year, 24-hour storm.

Under Federal regulations, landfills cannot accept liquid waste from tank trucks or in 55-gallon drums. This restriction helps reduce both the amount of leachate (i.e., liquids that have passed through the landfill) and the concentrations of contaminants in the leachate. Twenty-eight States have restrictions for liquid wastes.

Under Federal laws, owners/operators must restrict access to their landfills to prevent illegal dumping and other unauthorized activities. Methane gas, which occurs naturally at landfills, must be monitored routinely. If emission levels at the landfill exceed a certain limit, the proper authorities must be notified and a plan must be developed to solve the problem. Landfills must be operated so they do not violate State and Federal clean air laws and regulations. This means, among other things, that the burning of waste is prohibited at landfills, except under certain conditions. Thirty-six States require landfills to employ air monitoring requirements, typically conducted quarterly for air quality and methane. Some States require gas venting and set maximum combustible levels.

Ground-Water Monitoring and Corrective Action

Generally, landfill owners/operators must install monitoring systems to detect ground-water contamination. Sampling and analysis must be conducted twice a year. States and tribes with EPA-approved programs have the flexibility to tailor facility requirements to specific local conditions. For example, they may specify different frequencies for sampling ground water for contaminants, or phase in the deadline for complying with the Federal ground-water monitoring requirements. At the State level, 45 States require ground-water monitoring, typically on a quarterly or semi-annual basis. Many States also specify the number, location, spacing, and depth of ground-water monitoring wells or systems. Generally, States require at least one upgradient well and three downgradient wells.

If the ground water becomes contaminated, owners/operators in approved States and tribal areas must clean it up to levels specified by the State or tribal director. In States and tribes without EPA-approved programs, the Federal regulations specify that contaminants must be reduced below the Federal limits for safe drinking water. Remediation is required by 38 of the States. If statistically significant evidence of ground-water contamination or physical evidence of release exists, then corrective action is required. Some States require corrective action to correct violations or damage, prevent the escape of waste or leachate, and clean up any improper waste disposal. In addition, 28 States require semi-annual monitoring of surface water bodies potentially affected by a contaminant release from a landfill.

Closure and Post-Closure Care

When a landfill owner/operator stops accepting waste, the landfill must be closed in a way that will prevent problems later. The final cover must be designed to keep liquid away from the buried waste. For 30 years after closure, the owner/operator must continue to maintain the final cover, monitor ground water to ensure the unit is not leaking, collect and monitor landfill gas, and perform other maintenance activities. States and tribes with approved programs may vary this period based on local conditions. Closure and post-closure landfill requirements are specified by 48 of the States and are similar to Federal requirements. States differ on the thickness of the final cover, with 33 States requiring a two-foot thickness and 13 requiring 2.5- to four-foot thickness.

Siting and Location

Landfills are restricted from specific locations or sites that can cause safety or environmental concerns. Landfills may not be located in an area that is prone to flooding unless the owner/operator can prove the landfill is designed to withstand flooding and prevent the waste from washing out. Landfills also cannot be located in areas that are subject to landslides, mudslides, or sinkholes. All solid waste landfills can attract birds that can interfere with aircraft operation; therefore, if a landfill is located near an airport, the owner/operator must show that birds are not a danger to aircraft.

Because wetlands are important ecological resources, new landfills and laterally expanding landfills may not be built in wetlands unless the landfill is in a State or on tribal lands with an EPA-approved program and the owner/operator can show that it will not pollute the area. The owner/operator must also show that no alternative site is available. To prevent pollution that could be caused by earthquakes or other kinds of earth movement, new and laterally expanding landfills may not be built in areas prone to earth movement. The restrictions regarding wetlands and seismic zones do not apply to existing landfills.

In addition, 44 States have specific siting requirements for landfills, and most of these States specify the distance a landfill must be from residences or lakes. Other siting requirements may match the Federal requirements, or limit siting in wildlife refuges or recreational areas.

Financial Assurance

To ensure that monies are available to correct possible environmental problems, landfill owners/operators are required to show that they have the financial means to cover expenses for site closure, post-closure maintenance, and cleanups. The regulations specify ways to meet this requirement, including (but not limited to) surety bonds, insurance, and letters of credit. Some type of financial assurance is required by 38 of the States.

<u>Effectiveness of Current Federal and State Requirements in Ensuring That Landfills will Protect Human and Environmental Receptors in the Short- and Long-term</u>

New Federal requirements for Subtitle D municipal solid waste landfills were instituted in October, 1995. Prior to October, 1995, no Federal requirements for the design of MSWLFs existed. Existing landfills that ceased accepting wastes prior to October, 1995 were closed. Units accepting wastes after October 1995 were required to meet the more stringent Federal requirements, including those requirements described in the previous section. The institution of a requirement for liners, leachate collection, ground-water monitoring, and cleanup will significantly reduce the risk from these units; however, the requirements for MSWLFs are not as stringent as those for hazardous waste (Subtitle C) landfills.

Hazardous waste landfills are subject to regulation under RCRA Subtitle C as a hazardous waste disposal facility. In addition to certain design standards, hazardous waste landfills are required to comply with operational and recordkeeping requirements. Subtitle C landfills are required to obtain a permit to dispose of hazardous wastes. As part of this permit, a Subtitle C landfill must document and comply with the following:

- Conduct waste analysis
- Install security measures
- Conduct routine inspections

- Conduct training
- Properly manage characteristic hazardous wastes
- Siting in accordance with location standards
- Develop preparedness and prevention procedures and plans
- Develop contingency plans and emergency procedures
- Satisfy all hazardous waste manifest, recordkeeping, and reporting requirements
- Develop and implement closure and post-closure plans
- Obtain financial assurance to assure funds are available to pay for closure.

In addition, the landfill design must incorporate the following elements:

- Two or more liners
- Two leachate collection systems (one above and one between the liners)
- Conduct ground-water monitoring.

6.3.4 Over Which Exposure Pathways is Contaminant Release Likely to Be Mitigated Due to the Physical Properties of Cement-Stabilized Waste?

The multi-media multi-pathway modeling analysis conducted for the national generic HWIR approach in December 1995 modeled a number of different pathways and routes of exposure, including the ground-water, air, overland transport, and direct soil pathways. This section discusses the pathways modeled in support of the December 1995 HWIR proposal, particularly with regard to whether the physical properties inherent to cement-stabilized wastes can effectively prevent the release and transport of waste contaminants to receptors to the extent that certain pathways need not be modeled because the pathways present no risk.[18]

Ground-Water Pathways

Recent studies and findings by the LDR Program are influencing the Agency's current thoughts on the adequacy of stabilization. Current LDR Program discussions indicate that

---

[18] This document discusses the pathways modeled in support of the December 1995 HWIR proposal.

stabilization may not be a viable technology to protect against releases to ground water over the long-term.

If such a perspective is put into action across EPA's Office of Solid Waste, HWIR modeling efforts will face challenges to proposing an approach that is premised on the long-term stability of cement-stabilized wastes disposed within a waste management unit. Until the LDR Program completes the investigation of this issue, it is undetermined whether cement-stabilized wastes have properties that prevent the release of contaminants over the ground-water pathways specifically modeled by the multi-media multi-pathway modeling analysis. As a result, cement-stabilized wastes will not receive any "benefits" associated with eliminating the ground-water module from the multi-media multi-pathway modeling analysis.

Exhibit 6-1 identifies the ground-water pathways over which contaminants could be transported to human and ecological receptors. The multi-media multi-pathway modeling analysis conducted for the national generic HWIR approach in December 1995 modeled a number of different pathways and routes of exposure, including the ground-water pathway. The route of exposure modeled for the ground-water pathway in support of the December 1995 HWIR proposal is listed in Exhibit 6-1.

Exhibit 6-1. Ground-Water Pathways

Pathway Description	Routes of Exposure (and pathway number) [1/]	Does Waste Form "Mitigate" Pathway?
Ground-Water Pathway		
Waste or contaminants are released from management unit to underlying ground-water aquifer	- Ground-water ingestion (1)	Not determined. An assessment of whether cement-stabilized wastes will prevent contaminants from being released to ground water was not conducted in light of recent LDR Program discussions.

1/ The numbers in parentheses correspond to the numerical designations of the routes of exposure and receptors identified in the December 1995 HWIR proposal, and are included as a matter of convenience.

Air Pathways

Cement-stabilized wastes that are in monolithic form are intuitively expected to prevent releases and transport of contaminants from waste management units to receptors. In the short-term, for example, when wastes are being transported to a waste disposal site, the cement matrix will protect individuals from contaminant releases. This conclusion is supported primarily with structural integrity data from a number of stabilization studies that were obtained from a review of the technical literature.[19] Similarly, in the long-term, for example, after wastes have been placed in waste management units, driven over by vehicles, covered with additional layers of waste and cover, the cement matrix remains relatively durable. This conclusion is also supported primarily with structural integrity data obtained from a review of the technical literature.

The most useful data are provided by the results of testing for unconfined compressive strength. For example, studies of 69 industrial wastes solidified using a variety of processes were conducted by Stegemann and his associates in 1988 (Stegemann, 1988). Among other properties, unconfined compressive strength was measured, which is an indicator of the ability of a sample to resist mechanical stresses. Test results for unconfined compressive strength ranged between 75 to 20,000 kPa (i.e., 11 to 2900 psi) for the solidified samples. According to Stegemann, it is not expected that landfilled wastes would be subjected to mechanical stresses (e.g., from overburden and earth-moving equipment) greater than 350 kPa (i.e., 50 psi). Therefore, these results indicate that solidified wastes, in many cases, would not be damaged or broken down by mechanical stresses once disposed of in a waste management unit.[20]

In a 1996 study conducted by the U.S. Army Corps of Engineers on stabilizing contaminated soils, different ratios of cement reagents and wastes met the U.S. EPA criterion of 50 psi for the UCS test (i.e., recommended for land disposal), with the higher reagent-to-soil ratios exhibiting USC values above 2,000 psi. Reagent types included Portland Type I cement and Portland Type I cement with Type F fly ash (Channell, 1996). In a similar study conducted in 1991, the U.S. Army Corps of Engineers studied the effectiveness of cement, kiln dust, and lime with fly ash as stabilization reagents for contaminated soils. UCS values exceeded 1,000 psi in some instances; however, values did not approach the 2,000 values observed in the 1996 study (Fleming, 1991).

Structural integrity data from additional studies are also available, and supplement the data previously presented in this document. In most cases, reagent-to-soil ratios meeting the U.S. EPA criterion of 50 psi were identified.

It is noted that, although particle size distribution data would have provided strong support to the conclusion that monolithic cement-stabilized wastes offer protection over air transport pathways, these data were not readily available for stabilized wastes. Five hypotheses for the lack of available data are offered. First, individuals conducting stabilization studies are primarily concerned with whether the strength and durability of cement-stabilized waste is adequate. Thus, tests are conducted to measure these properties, not whether the stabilized

---

19 The technical literature review was rather comprehensive and supported the development of a waste parameters data base containing physical parameter data that provide an indication of the potential for constituents in wastes to move across exposure pathways. Over 250 sources were reviewed. Limited particle size distribution data were available; none of which were associated with cement-stabilized wastes.

20 Actual physical property data for cement-stabilized wastes was not available in this document.

material is slowly deteriorating over time and producing particulate matter. Second, stabilized waste are often subjected to weathering tests; however, the tests are focused on chemical property tests to assess what concentrations of contaminants are being released to the environment once weathering has occurred. Third, if cement-stabilized wastes are in a monolithic form and visually appear so, the expenditure of time and resources to conduct particle size distribution tests would make no sense. Fourth, waste stabilization presumes that a stabilized waste material will be disposed of. As a result, deterioration of cement-stabilized wastes over the long-term is not a critical concern because, at that point in time, the waste will be safely situated in a unit with appropriate engineering controls. Fifth, and finally, researchers may conduct studies of cement-stabilized wastes yet choose not to publish the results.

Exhibit 6-2 identifies the air pathways over which contaminants could be transported to human and ecological receptors. The multi-media multi-pathway modeling analysis conducted for the national generic HWIR approach in December 1995 modeled a number of different pathways and routes of exposure, including the air pathway. The routes of exposure modeled for the air pathway in support of the December 1995 HWIR proposal are listed in Exhibit 6-2.

Exhibit 6-2. Air Pathways

Pathway Description	Routes of Exposure (and pathway number) [1/]	Does Waste Form "Mitigate" Pathway?
Direct Air Pathway		
Respirable particulates (PM10) are released from management unit into the air	- Inhalation of particulates (2b)	Yes, exposure mitigated - Assuming a monolithic material, the waste matrix will prevent <u>respirable</u> particulates from being released unless the matrix is damaged or destroyed.
Volatile contaminants are released from management unit into the air	- Inhalation of volatiles (2a)	Yes, exposure mitigated - Assuming a monolithic material, the waste matrix will prevent <u>respirable</u> particulates from being released unless the matrix is damaged or destroyed. In addition, exothermic during cement reactions will likely destroy or volatilize organic contaminants.
Air Deposition Pathway		
Particulates or contaminants are released from management unit into air and deposited on soil or plant surfaces	- Soil ingestion (4) - Dermal (soil) (6) -Veg/root ingestion (8) - Beef/ milk ingestion (10)	Yes, exposure mitigated - Assuming a monolithic material, the waste matrix will prevent particulates from being released unless the matrix is damaged or destroyed.
Air Deposition Pathway (Overland Transport Followed by Release to Surface Water)		
Particulates or contaminants are released from management unit into air, transported overland, and released into surface waters	- Drinking water ingestion (20) - Fish ingestion (24) - Beef/milk ingestion (36) - Dermal (bathing) (38)	Same as Air Deposition Pathway - see above
Air Diffusion Pathway		
Contaminants, while in the vapor phase, are released from management unit and diffuse directly into plants	- Veg/root ingestion (8a) - Beef/milk ingestion (10a)	Yes, exposure mitigated - Assuming a monolithic material, the waste matrix will prevent contaminants from vaporizing. In addition, the exothermic conditions during cement reactions will likely destroy or

Pathway Description	Routes of Exposure (and pathway number) [1/]	Does Waste Form "Mitigate" Pathway?
Air Diffusion Pathway (Release Directly to Surface Water)		
Contaminants, while in the vapor phase, are released from management unit and diffuse directly into surface water	- Drinking water ingestion (17) - Fish ingestion (21) - Beef/milk ingestion (33) - Dermal (bathing) (37)	Same as Air Diffusion Pathway - see above

1/ The numbers in parentheses correspond to the numerical designations of the routes of exposure and receptors identified in the December 1995 HWIR proposal, and are included as a matter of convenience.

Overland Pathways

The transport of contaminants overland also keys on the particle size of the waste. If particulate matter is released, it may have the potential to be transported from a waste management unit to offsite receptors. For similar reasons as those discussed in the previous section on Air Pathways, the matrix of cement-stabilized wastes is expected to protect receptors from contaminant releases. Nevertheless, as also discussed in the previous section on Air Pathways, limited data are available to strongly support this conclusion. Structural integrity data are available that indicate that cement-stabilized wastes hold up well to mechanical stresses; however, actual weathering or particle size distribution data were not located in a comprehensive search of the technical literature.

Exhibit 6-3 identifies the overland pathways over which contaminants could be transported to human and ecological receptors. The multi-media multi-pathway modeling analysis conducted for the national generic HWIR approach in December 1995 modeled a number of different pathways and routes of exposure, including the overland pathway. The routes of exposure modeled for the overland pathway in support of the December 1995 HWIR proposal are listed in Exhibit 6-3.

Exhibit 6-3. Overland Pathways

Pathway Description	Routes of Exposure (and pathway number) [1/]	Does Waste Form "Mitigate" Pathway?
Overland Pathway		
Waste or contaminants are transported through soil erosion to offsite fields	- Soil ingestion (3) - Veg/root ingestion (9) - Beef/milk ingestion (11)	Same as Air Deposition Pathway - see Exhibit 6-2
Overland Pathway (SW)		
Waste or contaminants are transported through soil runoff or soil erosion to surface water	- Drinking water ingestion (19) - Fish ingestion (23) - Beef/milk ingestion (35) - Dermal (bathing) (42)	Same as Air Deposition Pathway - see Exhibit 6-2

1/ The numbers in parentheses correspond to the numerical designations of the routes of exposure and receptors identified in the December 1995 HWIR proposal, and are included as a matter of convenience.

Direct Soil Pathways

The transport of contaminants from direct exposure to contaminated soils also keys on the particle size of the waste. If particulate matter is released, it may have the potential to be transported from a waste management unit to offsite receptors. For similar reasons as those discussed in the section on Air Pathways, the matrix of cement-stabilized wastes is expected to protect receptors from contaminant releases. Nevertheless, as also discussed in the section on Air Pathways, limited data are available to strongly support this conclusion. Structural integrity data are available that indicate that cement-stabilized wastes hold up well to mechanical stresses; however, actual weathering or particle size distribution data were not located in a comprehensive search of the technical literature.

Exhibit 6-4 identifies the direct soil pathways over which contaminants could be transported to human and ecological receptors. The multi-media multi-pathway modeling analysis conducted for the national generic HWIR approach in December 1995 modeled a number of different pathways and routes of exposure, including the direct soil pathway. The routes of exposure modeled for the direct soil pathway in support of the December 1995 HWIR proposal are listed in Exhibit 6-4.

Exhibit 6-4. Direct Soil Pathways

Pathway Description	Routes of Exposure (and pathway number) [1/]	Does Waste Form "Mitigate" Pathway?
Direct Soil Pathway		
Waste or contaminants are released from units onto nearby soils	- Soil ingestion (3) - Dermal (soil) (5) - Veg/root ingestion (9) - Beef/milk ingestion (11)	Same as Air Deposition Pathway - see Exhibit 6-2

1/ The numbers in parentheses correspond to the numerical designations of the routes of exposure and receptors identified in the December 1995 HWIR proposal, and are included as a matter of convenience.

6.3.5 How Would the Agency Develop a Waste Forms Exemption for Monolithic Cement-Stabilized Wastes?

The development of any type of exemption mechanism for wastes classified as hazardous under 40 CFR Part 261 must be premised on technical information that supports that the waste, based on some factor or factors, does not present potential harm to human health and the environment. Ideally, these considerations should be scoped out relatively early in the regulatory development process so that adequate time is available if further studies need to be conducted to support decision-making.

For monolithic cement-stabilized wastes, these considerations may include:

- *How does EPA intend to define a cement-stabilized waste? Will EPA specify certain reagents? Will EPA require samples of cement-stabilized waste to "pass" specific physical property tests (e.g., unconfined compressive strength, freeze/thaw)?* Cement/ lime-pozzolan wastes are a category of waste, comprised of waste types with differing physical and chemical properties. Some stabilized wastes can be a monolith of any practical size or a granular material resembling soil (U.S. EPA, 1993). Some stabilized wastes are resistant to high moisture conditions; others may even be resistant to seawater or sulfate-bearing waters. If EPA decides to identify an HWIR option for cement/ pozzolan wastes, the Agency will also probably have to identify specific criteria for these wastes since not all cement/ pozzolan wastes will provide the same level of protection. Criteria could include standard bulk and dry unit weight, compressive strength, permeability, and durability, use of only certain types of stabilization reagents, etc. (U.S. EPA, 1982; AASHTO, 1995).

- *Will EPA set any restrictions on the amount of reagents used to stabilize a waste, for example, to prevent unnecessary dilution of contaminants?*

- *Will EPA set any restrictions on the types of reagents used to stabilize a waste? If so, as new reagents are determined to be viable, will EPA consider amending previous decisions?*

- *Will EPA set requirements on the type of stabilization (encapsulation or containment)?*

- *Will EPA specify wastes that are "acceptable" to treat using stabilization technologies?* The technical literature supports the use of stabilization to treat hazardous wastes; however, documented cases primarily support the use of stabilization technologies to treat contaminated soils. At this time, a comprehensive study has not been conducted to profile hazardous wastes most likely or already treated using cement. As noted in Section 6.3.2, data provided in the Biennial Reporting System indicate that a number of hazardous wastes are currently treated using cement-stabilization.

- *Will EPA specify constituents that should or should not be stabilized?*

- *Will EPA require claimants to test cement-stabilized wastes for both total concentrations and TCLP concentrations? How will these analytical results be evaluated?*

EPA had neither the time nor the resources under the current effort to explore these many considerations associated with a waste form specific exemption. Most fundamentally, the Agency in conjunction with the broader technical community seeks to establish reasonable assumptions regarding potential releases from stabilized waste forms. Such current and future inquiries would also focus on the long term efficacy of reducing the mobility of hazardous constituents from these forms.

Implementation of an exemption mechanism for cement-stabilized wastes might also raise a number of unique issues, including:

- *Should claimants be required to disclose the nature of the reagents used for stabilization? How will this impact review by the regulatory agency? How will this impact review by the public?*

- *Will claimants be required to test batches of cement-stabilized waste after a notification package has been submitted to the regulatory agency?*

- *Will claimants be required to dispose of cement-stabilized wastes in landfills? If not, can EPA guarantee that cement-stabilized wastes, which have been granted an exemption from classification as hazardous wastes, will not be used as construction materials or in other uses?*

6.4 How Could the Agency Incorporate the Waste Form Approach with Other Contingent Management Options?

The Waste Forms Approach, as envisioned, may include management conditions that are specifically linked to each candidate waste. Under this "contingent management approach", EPA believes that the management unit will provide incremental protection beyond the protection ensured under the nationally-based HWIR program.

In addition to the suggested options in Section 6.1, EPA is considering other factors that could be built-on to the Waste Forms Approach, by EPA or the implementing agency. The development of such options could result in options that are very complex (i.e., multi-dimensional). EPA recognizes that the consideration of additional conditions that would enable claimants to seek regulatory relief from Subtitle C for additional volumes of low-risk waste would increase the utility of the Waste Forms Approach. EPA also acknowledges that multi-dimensional options may not be realistic. The remainder of this section discusses two types of additional conditions that could be built-on to most of the Waste Forms approaches identified in Section 6.1, namely requirements for on site management and reduced waste analysis requirements.

On Site Management Requirements

EPA expressed concern, in its December 1995 HWIR proposal (60 FR 66397), that contingent management options that rely on site-specific factors may be difficult to implement. The Agency noted that it will be difficult for generators to ensure that wastes are actually managed in units that are in compliance with the particular set of controls that are used in establishing unit-specific exemption levels. As mentioned in the December 1995 HWIR proposal, EPA could structure an exemption that restricts waste management to on-site locations. This restriction could be incorporated into either the national "generic" HWIR option or a Waste Forms exemption; however, EPA may see greater utility in including this restriction as a condition to a Waste Forms exemption, particularly if such a condition provided greater assurance that a waste, which meets the less stringent exemption levels of such an exemption, would present little risk to human health and the environment. Regardless, such an exemption would allow generators to dispose of wastes on site, to limit their potential liability under CERCLA, and to guarantee control over the long-term management of the waste. In addition, an exemption such as this would allow generators the opportunity to design a waste management unit with the necessary controls.

Reduction of Target Analyte Lists

A significant deterrent to facilities seeking relief from the hazardous waste regulations under the national "generic" HWIR option is the substantial implementation cost associated with sampling and analysis. In particular, the target analyte list developed for the December 1995 HWIR proposal included approximately 400 constituents. In Section 6.1 of this technical background document, it was explained how the consideration of waste form-waste management combinations might enable the Agency to reduce the number of exposure pathways in its modeling efforts, which might support the development of a less stringent set of exemption levels. EPA could consider structuring another type of Waste Forms exemption -- one that reduces the number of target analytes (and thus implementation costs) yet relies on the exemption levels set for the national “generic” HWIR option. In this case, EPA could identify waste form-waste treatment combinations that provide assurance that certain classes of chemicals are not present in the waste. Then, the Agency could specify conditions in the Waste Forms exemption that a facility must meet with regard to such treatment, instead of or in addition to conditions for management. The relief to the facility would be provided by the smaller subset of chemicals, not a less stringent set of exemption levels. If conditions related to waste management were included in the exemption, then the exemption could also be linked to a less stringent set of exemption levels. Thus, the Agency envisions that a Waste Forms exemption of this type could be structured to look like either of the following:

1. A particular waste that has been treated in a particular manner could be allowed to become exempt if the exemption levels (for the national “generic” HWIR option) for a specific subset of the HWIR target analyte list are met.

2. A particular waste that has been treated in a particular manner could be required to be disposed of in a particular type of waste management unit (e.g., landfill) if the exemption levels for a specific subset of the HWIR target analyte list are met.

This type of Waste Forms exemption might be most applicable to treatment technologies that destroy organic contaminants, such as incineration or high temperature recovery methods. If the operating parameters (e.g., residence time, temperature) of such technologies ensure that toxic organic chemicals will not be present in treatment residues, then perhaps the facility should be given “credit” for use of such a technology. Such a “credit” could be provided through a Waste Forms exemption. The exemption could be tailored to restrict the types of waste treated (e.g., by waste matrix), so as to further assure that waste treatment is adequate and proper.

References for Chapter 6

American Association of State Highway and Transportation Officials (AASHTO), Standard Specifications for Transportation Materials and Methods of Sampling and Testing, 17th Edition, 1995.

Baily, P.E. and W.D. Ward (eds.), 1990. *Understanding Ground-Water Contamination: An Orientation Manual*. New York, NY: Executive Enterprises, Inc., p. 33.

California Portland Cement Company (CPCC), 1996. Letter to the EPA RCRA Docket, Docket No. F-95-PRLP-FFFFF, providing comments on the proposed listing of spent catalysts as RCRA Hazardous Wastes, 60 FR 57747, November 20, 1995.

Channell, M.G. April 1996. An Evaluation of Solidification/Stabilization for Treatment of Contaminated Soils from the Umatilla Army Depot Activity. Technical Report EL-96-04. Vicksburg, MS: U.S. Army Corps of Engineers Waterways Experiment Station.

Fleming, E. and M.J. Cullinane, Jr., August 1991. Evaluation of Stabilization/ Solidification for Treatment of Contaminated Soils From Waldick Aerospace Devices, Inc. Site, New Jersey. Vicksburg, MS: U.S. Army Corps of Engineers Waterways Experiment Station.

O'Leary, P. and P. Walsh, July 1991. "Leachate Control and Treatment," *Waste Age.*

O'Leary, P. and P. Walsh, April 1991. "Landfilling Principles," *Waste Age*.

Schroeder, R. L., 1994. The Use of Recycled Materials in Highway Construction", Public Roads On-line.

Stegemann, J., et al. 1988. Preliminary Results of an International Government/ Industry Cooperative Study or Waste Stabilization/ Solidification. Hazardous Waste: Detection, Control, Treatment. Amsterdam: Elsevier Science Publishers B.V.

U.S. EPA, October 1995. State Requirements for Industrial Non-Hazardous Waste Management Facilities. Washington, DC: U.S. EPA, Office of Solid Waste, Municipal and Industrial Solid Waste Division. pp. 12-16.

U.S. EPA, December 1993. Report to Congress on Cement Kiln Dust, Volume II: Methods and Findings.

U.S. EPA, August 1993. Evaluation of Solidification/ Stabilization Treatment Processes for Municipal Waste Combustion Residues. EPA/600/R-93/167. Cincinnati, OH: U.S. EPA, Office of Research and Development, Risk Reduction Engineering Laboratory.

U.S. EPA, March 1993. Safer Disposal for Solid Waste: The Federal Regulations for Landfills. EPA/530-SW-91-092. Washington, DC: U.S. EPA, Office of Solid Waste, Communications Service Branch.

U.S. EPA, Engineering Bulletin: Solidification/Stabilization of Organics and Inorganics, EPA/540/S-92/015, February 1993.

U.S. EPA, 1990. Technology Evaluation Report. Chemfix Technologies, Inc. Solidification/ Stabilization Process, Clackamas, Oregon, Volume I. EPA/540/5-89/011a. Cincinnati, OH: U.S. EPA, Office of Research and Development, Risk Reduction Engineering Laboratory.

U.S. EPA, September 1982. Guide to the Disposal of Chemically Stabilized and Solidified Waste, SW-872.

Appendix A

Mapping of Form Codes Into System Type Codes

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	**Associated Form Codes Occuring above Threshold Quantity [1]**	**Associated Form Codes Occuring above Threshold Frequency [1]**
M011-Metals Recovery	B304- Other "dry" ash, slag, or thermal residue (IS0)	B505-Untreated plating sludge without cyanides (ISL)
M012-Retorting	B310- Spent solid filters or adsorbents (IS0)	B117-Waste liquid mercury (IL) B319- Other waste inorganic solids (Specify in Comments) (IS0)
M013-Secondary smelting	B304-Other "dry" ash, slag, or thermal residue (IS0)	B319-Other waste inorganic solids (Specify in Comments) (IS0) B003-Mixed lab packs (LP)
M014-Other metals recovery for reuse: e.g., ion exchange, reverse osmosis, acid leaching, etc. (Specify in Comments)	B304-Other "dry" ash, slag, or thermal residue (IS0) B306-"Dry" Lime or metal hydroxide solids not "fixed" (IS0) B504-Other wastewater treatment sludge (ISL)	B107- Caustic solution with metals and cyanides (IL)
M019-Metals recovery - type unknown	B310-Spent solid filters or adsorbents (IS0) B519-Other inorganic sludges (Specify in Comments) (ISL) B219- Other organic liquids (Specify in Comments) (OL)	B107-Caustic solution with metals and cyanides (IL) B319-Other waste inorganic solids (Specify in Comments) (IS0) B117-Waste liquid mercury (IL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M021-Fractionation/distillation	B204-Halogenated/nonhalogenated solvent mixture (OL) B202- Halogenated (e.g., chlorinated) solvent (OL) B203- Nonhalogenated solvent (OL) B201-Concentrated solvent-water solution (OL)	B202-Halogenated (e.g., chlorinated) solvent (OL)
M022-Thin film evaporation	B203-Nonhalogenated solvent (OL)	B211-Paint thinner or petroleum distillates (OL)
M023-Solvent extraction	B202- Halogenated (e.g., chlorinated) solvent (OL)	B202-Halogenated (e.g., chlorinated) solvent (OL)
M024-Other solvent recovery (Specify in Comments)	B202-Halogenated (e.g., chlorinated) solvent (OL)	B202-Halogenated (e.g., chlorinated) solvent (OL)
M029-Solvents recovery - type unknown	B219- Other organic liquids (Specify in Comments) (OL)	B202-Halogenated (e.g., chlorinated) solvent (OL)
M031-Acid regeneration	B202-Halogenated (e.g., chlorinated) solvent (OL)	B103-Spent acid with metals (IL) B119-Other inorganic liquids (Specify in Comments) (IL) B105-Acidic aqueous waste (IL) B202-Halogenated (e.g., chlorinated) solvent (OL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M032-Other recovery: e.g., waste oil recovery, nonsolvent organics recovery, etc. (Specify in Comments)	B603-Oily sludge (OSL) B219- Other organic liquids (Specify in Comments) (OL)	B003- Mixed lab packs (LP)
M039-Other recovery - type unknown	B207-Concentrated aqueous solution of other organics (OL) B119-Other inorganic liquids (Specify in Comments) (IL)	B202-Halogenated (e.g., chlorinated) solvent (OL)
M040- Not Defined by BRS	ZERO TONS	B003-Mixed lab packs (LP)
M041-Incineration - liquids	B115-Scrubber water (IL) B101- Aqueous waste with low solvents (IL) B102-Aqueous waste with low other toxic organics (IL)	B003-Mixed lab packs (LP)
M042-Incineration - sludges	B607-Biological treatment sludge (OSL) B504-Other wastewater treatment sludge (ISL)	B003-Mixed lab packs (LP) B101- Aqueous waste with low solvents (IL)
M043-Incineration - solids	B319-Other waste inorganic solids (Specify in Comments) (IS0) B301-Soil contaminated with organics (IS0)	B401-Halogenated pesticide solid (OSO)
M044-Incineration - gases	B801-Organic gases (OG)	B801-Organic gases (OG)
M045-Not Defined by BRS	ZERO TONS	B511-Air pollution control device sludge (e.g., fly ash, wet scrubber sludge) (ISL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M049-Incineration - type unknown	B503-Waste water treatment sludge with toxic organics (ISL)	B003-Mixed lab packs (LP)
M051-Energy recovery - liquids	B204- Halogenated/nonhalogenated solvent mixture B219-Other organic liquids (Specify in Comments) (OL)	B204- Halogenated/nonhalogenated solvent mixture (OL) B203- Nonhalogenated solvent (OL) B219-Other organic liquids (Specify in Comments) (OL)
M052-Energy recovery - sludges	B609- Other organic sludges (Specify in Comments) (OSL)	B604- Organic paint or ink sludge (OSL) B609- Other organic sludges (Specify in Comments) (OSL)
M053-Energy recovery - solids	B409- Other nonhalogenated organic solids (Specify in Comments) (OSO) B407-Other halogenated organic solids (Specify in Comments) (OSO)	B409- Other nonhalogenated organic solids (Specify in Comments) (OSO)
M059-Energy recovery - type unknown	B009-Other lab packs (Specify in Comments) (LP)	B003-Mixed lab packs (LP)
M061-Fuel blending	B204- Halogenated/nonhalogenated solvent mixture (OL) B603-Oily sludge (OSL) B206-Waste oil (OL) B203- Nonhalogenated solvent (OL)	B203- Nonhalogenated solvent (OL) B211-Paint thinner or petroleum distillates (OL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M071-Chrome reduction followed by chemical precipitation	B114- Other aqueous waste with low dissolved solids (IL) B103-Spent acid with metals (IL)	B003-Mixed lab packs (LP)
M072-Cyanide destruction followed by chemical precipitation	B107- Caustic solution with metals and cyanides (IL)	B107- Caustic solution with metals and cyanides (IL)
M073-Cyanide destruction only	B107- Caustic solution with metals and cyanides (IL)	B004-Lab packs containing acute hazardous wastes (LP)
M074-Chemical oxidation followed by chemical precipitation	B115-Scrubber water (IL)	B107- Caustic solution with metals and cyanides (IL) B105-Acidic aqueous waste (IL)
M075-Chemical oxidation only	B116-Leachate (IL)	B104-Spent acid without metals (IL)
M076-Wet air oxidation	B306-“Dry” lime or metal hydroxide solids not “fixed” (IS0)	B306- “Dry” lime or metal hydroxide solids not “fixed” (IS0)
M077-Chemical precipitation	B114-Other aqueous waste with low dissolved solids (IL) B116-Leachate (IL)	B103- Spent acid with metals (IL)
M078-Other aqueous inorganic treatment: e.g., ion exchange, reverse osmosis, etc. (Specify in Comments)	B103- Spent acid with metals (IL) B119-Other inorganic liquids (Specify in Comments) (IL)	B504-Other wastewater treatment sludge (ISL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M079-Aqueous inorganic treatment - type unknown	B112-Aqueous waste with other reactives (e.g., explosives) (IL)	B106-Caustic solution with metals but no cyanides (IL) B102- Aqueous waste with low other toxic organics (IL)
M081-Biological treatment	B101- Aqueous waste with low solvents (IL) B102- Aqueous waste with low other toxic organics (IL)	B101- Aqueous waste with low solvents (IL) B102- Aqueous waste with low other toxic organics (IL) B116- Leachate (IL)
M082-Carbon adsorption	B105- Acidic aqueous waste (IL) B116-Leachate (IL)	B116-Leachate (IL)
M083-Air/steam stripping	B101- Aqueous waste with low solvents (IL)	B101- Aqueous waste with low solvents (IL)
M084-Wet air oxidation	B101-Aqueous waste with low solvents (IL)	B101-Aqueous waste with low solvents (IL)
M085-Other aqueous organic treatment (Specify in Comments)	B116-Leachate (IL) B101-Aqueous waste with low solvents (IL)	B219- Other organic liquids (Specify in Comments) (OL)
M089-Aqueous organic treatment - type unknown	B102- Aqueous waste with low other toxic organics (IL)	B219-Other organic liquids (Specify in Comments) (OL)
M091-Chemical precipitation in combination with biological treatment	B116-Leachate (IL)	B114-Other aqueous waste with low dissolved solids (IL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M092-Chemical precipitation in combination with carbon adsorption	B101-Aqueous waste with low solvents (IL) B116-Leachate (IL)	B101-Aqueous waste with low solvents (IL) B103- Spent acid with metals (IL)
M094-Other organic/inorganic treatment (Specify in Comments)	B102- Aqueous waste with low other toxic organics (IL) B114-Other aqueous waste with low dissolved (IL) B101-Aqueous waste with low solvents (IL) B115-Scrubber water (IL)	B101-Aqueous waste with low solvents (IL)
M099-Aqueous organic and inorganic treatment - type unknown	B204-Halogenated/nonhalogenated solvent mixture (OL)	B119-Other inorganic liquids (Specify in Comments) (IL)
M101-Sludge dewatering	B115-Scrubber water (IL) B603-Oily sludge (OSL) B504- Other wastewater treatment sludge (ISL)	B504-Other wastewater treatment sludge (ISL)
M102-Addition of excess lime	ZERO TONS	B502- Lime sludge with metals/metal hydroxide sludge (ISL) B504-Other wastewater treatment sludge (ISL) B514-Drilling mud (ISL)
M103-Absorption/adsorption	B302-Soil contaminated with inorganics only (IS0)	B301-Soil contaminated with organics (IS0) B202-Halogenated (e.g., chlorinated) solvent (OL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M104-Solvent extraction	B209-Organic paint, ink, lacquer, or varnish (OL)	B203-Nonhalogenated solvent (OL)
M109-Sludge treatment - type unknown	B603-Oily sludge (OSL)	B603-Oily sludge (OSL) B502-Lime sludge with metals/metal hydroxide sludge (ISL)
M111-Stabilization/Chemical fixation using cementitious and/or pozzolanic materials	B511-Air pollution control device sludge(e.g., fly ash, wet scrubber sludge) (ISL) B303-Ash, slag, or other residue from incineration of wastes (IS0)	B319- Other waste inorganic solids (Specify in Comments) (IS0)
M112-Other stabilization (Specify in Comments)	B306- “Dry” lime or metal hydroxide solids not “fixed” (IS0) B502-Lime sludge with metals/metal hydroxide sludge (ISL) B319-Other waste inorganic solids (Specify in Comments) (IS0)	B319- Other waste inorganic solids (Specify in Comments) (IS0) B306-“Dry” lime or metal hydroxide solids not “fixed” (IS0)
M114-Not Defined by BRS	ZERO TONS	B203-Nonhalogenated solvent (OL)
M119-Stabilization - type unknown	B319-Other waste inorganic solids (Specify in Comments) (IS0)	B603-Oily sludge (OSL)
M121-Neutralization only	B115-Scrubber water (IL) B105- Acidic aqueous waste (IL)	B003-Mixed lab packs (LP) B103- Spent acid with metals (IL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges	(OSO)- Organic Solids	(OL)- Organic Liquids	(OG)- Organic Gases	(LP)- Lab Packs
(ISL) - Inorganic Sludges	(ISO) - Inorganic Solids	(IL) - Inorganic Liquids	(IG) -Inorganic Gases	

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M122-Evaporation only	B114-Other aqueous waste with low dissolved solids (IL) B116-Leachate (IL)	B114- Other aqueous waste with low dissolved solids (IL) B119-Other inorganic liquids (Specify in Comments) (IL)
M123-Settling/clarification only	B207- Concentrated aqueous solution of other organics (OL)	B207- Concentrated aqueous solution of other organics (OL) B504- Other wastewater treatment sludge (ISL)
M124-Phase separation (e.g., emulsion breaking, filtration) only	B219-Other organic liquids (Specify in Comments) (OL)	B207- Concentrated aqueous solution of other organics (OL)
M125-Other treatment (Specify in Comments)	B102-Aqueous waste with low other toxic organics (IL) B113-Other aqueous waste with high dissolved solids (IL) B205-Oil-water emulsion or mixture (OL) B504- Other wastewater treatment sludge (ISL)	B306- “Dry” lime or metal hydroxide solids not “fixed” (IS0)
M126-Not Defined by BRS	ZERO TONS	B404-Spent carbon (OSO)
M129-Other treatment - type unknown	B219-Other organic liquids (Specify in Comments) (OL) B119-Other inorganic liquids (Specify in Comments) (IL)	B219-Other organic liquids (Specify in Comments) (OL) B319-Other waste inorganic solids (Specify in Comments) (IS0)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges (OSO)- Organic Solids (OL)- Organic Liquids (OG)- Organic Gases (LP)- Lab Packs

(ISL) - Inorganic Sludges (ISO) - Inorganic Solids (IL) - Inorganic Liquids (IG) -Inorganic Gases

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M131-Land treatment/application/farming	B409- Other nonhalogenated organic solids (Specify in Comments) (OSO)	B409- Other nonhalogenated organic solids (Specify in Comments) (OSO) B503-Wastewater treatment sludge with toxic organics (ISL) B603- Oily sludge (OSL) B301- Soil contaminated with organics (IS0)
M132-Landfill	B319-Other waste inorganic solids (Specify in Comments) (IS0) B305-"Dry" lime or metal hydroxide solids chemically "fixed" (IS0)	B301-Soil contaminated with organics (IS0) B319-Other waste inorganic solids (Specify in Comments) (IS0)
M133-Surface impoundment (to be closed as a landfill)	B603-Oily sludge (OSL) B502-Lime sludge with metals/metal hydroxide sludge (ISL)	B404-Spent carbon (OSO)
M134-Deepwell/underground injection	B102- Aqueous waste with low other toxic organics (IL) B219-Other organic liquids (Specify in Comments) (OL) B114 -Other aqueous waste with low dissolved solids (IL) B113-Other aqueous waste with high dissolved solids (IL) B207-Concentrated aqueous solution of other organics (OL)	B101-Aqueous waste with low solvents (IL)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

Summary of RCRA Waste Forms Managed in Specific Treatment Systems

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M135-Direct discharge to sewer/POTW (no prior treatment)	ZERO TONS	1 COUNT EACH FOR B102-Aqueous waste with low other toxic organics (IL) B105-Acidic aqueous waste (IL) B115-Scrubber water (IL) B306- “Dry” lime or metal hydroxide solids not “fixed” (IS0) B609-Other organic sludges (Specify in Comments) (OSL)
M137-Other disposal (Specify in Comments)	B114-Other aqueous waste with low dissolved solids (IL) B101-Aqueous waste with low solvents (IL) B219-Other organic liquids (Specify in Comments) (OL)	B201-Concentrated solvent-water solution (OL)
M141-Transfer facility storage, waste was shipped off site with no on-site TDR activity	B105- Acidic aqueous waste (IL)	B202- Halogenated (e.g., chlorinated) solvent (OL) B211-Paint thinner or petroleum distillates (OL)
M203-Not Defined by BRS	ZERO TONS	B203- Nonhalogenated solvent (OL)
M209-Not Defined by BRS	ZERO TONS	B202-Halogenated (e.g., chlorinated) solvent (OL) B407-Other halogenated organic solids (Specify in Comments) (OSO)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges
(ISL) - Inorganic Sludges
(OSO)- Organic Solids
(ISO) - Inorganic Solids
(OL)- Organic Liquids
(IL) - Inorganic Liquids
(OG)- Organic Gases
(IG) -Inorganic Gases
(LP)- Lab Packs

SYSTEM TYPE	Associated Form Codes Occuring above Threshold Quantity [1]	Associated Form Codes Occuring above Threshold Frequency [1]
M243-Not Defined by BRS	ZERO TONS	B205-Oil-water emulsion or mixture (OL)
M411-Not Defined by BRS	ZERO TONS	B212-Reactive or polymerizable organic liquid (OL)
M416-Not Defined by BRS	ZERO TONS	B203- Nonhalogenated solvent (OL)
M504-Not Defined by BRS	ZERO TONS	B319-Other waste inorganic solids (Specify in Comments) (IS0)
M611-Not Defined by BRS	ZERO TONS	B203- Nonhalogenated solvent (OL)
M999-Not Defined by BRS	ZERO TONS	B409- Other nonhalogenated organic solids (Specify in Comments) (OSO)

[1] Predominant Quantity and Frequency Form Codes determined based on a threshold cutoff where for a range of decreasing values A, B, C, D, E and F, the selected cutoff is C, when C is generally two times greater than D.

FORM CODE CATEGORIES

(OSL)- Organic Sludges	(OSO)- Organic Solids	(OL)- Organic Liquids	(OG)- Organic Gases	(LP)- Lab Packs
(ISL) - Inorganic Sludges	(ISO) - Inorganic Solids	(IL) - Inorganic Liquids	(IG) -Inorganic Gases	

Appendix B

RCRA Waste Code/BRS Form Code Pairing

Appendix C

Waste Form Profile Template

Appendix D

BRS Form Codes ("B-Codes") and
BRS System Type Codes ("M-Codes")

Appendix E

Form Code/System Type Code Combinations

~ Screening Results ~

Waste Category: Inorganic Liquids

Universe

Number of Form Code/System Code Combinations in BRS waste file: 161
Total Volume of Waste Managed: 361,552 tons
Total Number of Waste Streams: 2,515

SCREEN 1

Large Waste Volume Criterion	Form Code/System Code Combinations > 7,417 tons
OR	
Large Number of Waste Streams	Form Code/System Code Combinations > 100 streams

After Screen 1

Number of Form Code/System Code Combinations in BRS waste file: 10
Total Volume of Waste Managed: 335,979 tons
Total Number of Waste Streams: 1,661

SCREEN 2

"Definability"	Remove "other" type categories

Post Screen 2

Number of Form code/System Code Combinations in BRS waste file: 9
Total Volume of Waste Managed: 328,563 tons
Total Number of Waste Streams: 1,654

SCREEN 3
Transfer Facility Storage

Post Screen 3

Number of Form Code/System Code Combinations in BRS waste file: 5
Total Volume of Waste Managed: 325,499 tons
Total Number of Waste Streams: 779

SCREEN 4
Remove Reuse/Recycle/Recovery Destinations (40 CFR 266)

Post Screen 4

Number of Form Code/System Code Combinations in BRS waste file: 4
Total Volume of Waste Managed: 325,111 tons
Total Number of Waste Streams: 596

SCREEN 5
Deepwell Injection

Post Screen 5

Number of Form Code/System Code Combinations in BRS waste file: 3
Total Volume of Waste Managed: 223,871 tons
Total Number of Waste Streams: 540

SCREEN 6
Coverage Under Other EPA Rules

Post Screen 6

Number of Form code/System Code Combinations in BRS waste file: 3
Total Volume of Waste Managed: 223,871 tons
Total Number of Waste Streams: 540

Waste Category: Organic Liquids

Universe

Number of Form Code/System Code Combinations in BRS waste file: 481
Total Volume of Waste Managed: 7,002,678 tons
Total Number of Waste Streams: 175,302

SCREEN 1

Large Waste Volume Criterion	Form Code/System Code Combinations >41,949 tons
OR	
Large Number of Waste Streams	Form Code/System Code Combinations > 100 streams

After Screen 1

Number of Form Code/System Code Combinations in BRS waste file: 79
Total Volume of Waste Managed: 6,863,119 tons
Total Number of Waste Streams: 172,156

SCREEN 2

"Definability"	Remove "other" type categories

`

Post Screen 2

Number of Form Code/System Code Combinations in BRS waste file: 61
Total Volume of Waste Managed: 3,733,011 tons
Total Number of Waste Streams: 163,212

SCREEN 3
Transfer Facility Storage

Post Screen 3

Number of Form Code/System Code Combinations in BRS waste file: 50
Total Volume of Waste Managed: 3,574,438 tons
Total Number of Waste Streams: 91,125

SCREEN 4
Remove Reuse/Recycle/Recovery Destinations (40 CFR 266)

Post Screen 4

Number of Form Code/System Code Combinations in BRS waste file: 17
Total Volume of Waste Managed: 1,391,727 tons
Total Number of Waste Streams: 11,706

SCREEN 5
Deepwell Injection

Post Screen 5

Number of Form Code/System Code Combinations in BRS waste file: 16
Total Volume of Waste Managed: 400,828 tons
Total Number of Waste Streams: 11,682

SCREEN 6
Coverage Under Other EPA Rules

Post Screen 6

Number of Form Code/System Code Combinations in BRS waste file: 16
Total Volume of Waste Managed: 400,828 tons
Total Number of Waste Streams: 11,682

Waste Category: Solids and Sludges

Universe

Number of Form Code/System Code Combinations in BRS waste file: 1,008
Total Volume of Waste Managed: 3,603,851 tons
Total Number of Waste Streams: 64,537

SCREEN 1

Large Waste Volume Criterion	Form Code/System Code Combinations > 9015 tons
OR	
Large Number of Waste Streams	Form Code/System Code Combinations > 100 streams

After Screen 1

Number of Form Code/System Code Combinations in BRS waste file: 126
Total Volume of Waste Managed: 3,304,596 tons
Total Number of Waste Streams: 59,678

SCREEN 2

"Definability"	Remove "other" type categories

Post Screen 2

Number of Form Code/System Code Combinations in BRS waste file: 83
Total Volume of Waste Managed: 2,639,001 tons
Total Number of Waste Streams: 36,032

SCREEN 3
Transfer Facility Storage

Post Screen 3

Number of Form Code/System Code Combinations in BRS waste file: 61
Total Volume of Waste Managed: 2,595,041 tons
Total Number of Waste Streams: 25,961

SCREEN 4
Remove Reuse/Recycle/Recovery Destinations (40 CFR 266)

Post Screen 4

Number of Form Code/System Code Combinations in BRS waste file: 42
Total Volume of Waste Managed: 1,682,043 tons
Total Number of Waste Streams: 19,575

SCREEN 5
Deepwell Injection

Post Screen 5

Number of Form Code/System Code Combinations in BRS waste file: 42
Total Volume of Waste Managed: 1,682,043 tons
Total Number of Waste Streams: 19,575

SCREEN 6
Coverage Under Other EPA Rules

Post Screen 6

Number of Form Code/System Code Combinations in BRS waste file: 36
Total Volume of Waste Managed: 1,411,311 tons
Total Number of Waste Streams: 16,057

Waste Category: Wastewaters

Universe

Number of Form Code/System Code Combinations in BRS waste file: 285
Total Volume of Waste Managed: 75,741,226 tons
Total Number of Waste Streams: 7,428

SCREEN 1

Large Waste Volume Criterion	Form Code/System Code Combinations > 902,995 tons
OR	
Large Number of Waste Streams	Form Code/System Code Combinations > 100 streams

After Screen 1

Number of Form Code/System Code Combinations in BRS waste file: 22
Total Volume of Waste Managed: 69,849,190 tons
Total Number of Waste Streams: 5,469

SCREEN 2

"Definability"	Remove "other" type categories

Post Screen 2

Number of Form Code/System Code Combinations in BRS waste file: 20
Total Volume of Waste Managed: 68,889,749 tons
Total Number of Waste Streams: 2,692

SCREEN 3
Transfer Facility Storage

Post Screen 3

Number of Form Code/System Code Combinations in BRS waste file: 15
Total Volume of Waste Managed: 65,537,942 tons
Total Number of Waste Streams: 2,692

SCREEN 4
Remove Reuse/Recycle/Recovery Destinations (40 CFR 266)

Post Screen 4

Number of Form Code/System Code Combinations in BRS waste file: 13
Total Volume of Waste Managed: 65,530,306 tons
Total Number of Waste Streams: 1,852

SCREEN 5
Deepwell Injection

Post Screen 5

Number of Form Code/System Code Combinations in BRS waste file: 9
Total Volume of Waste Managed: 58,458,606 tons
Total Number of Waste Streams: 1,661

SCREEN 6
Coverage Under Other EPA Rules

Post Screen 6

Number of Form Code/System Code Combinations in BRS waste file: 9
Total Volume of Waste Managed: 58,458,606 tons
Total Number of Waste Streams: 1,661

Appendix F

Waste Treatment Applicability to Waste Forms

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M071	Chrome reduction followed by chemical precipitation	Chemical reduction involves the transfer of electrons from one compound to another, and is used to either render compounds nontoxic, or to enable compounds to undergo chemical destruction or physical removal. Hexavalent chromium is reduced to the less toxic trivalent form through the addition of a compatible reducing agent, such as reduced sulfur compounds (sodium sulfite salts or sulfur dioxide). Precipitation of recovered metals is required after reduction.[2]	Chemical reduction is best applied to liquid wastes free of organic compounds. Because reducing agents are not selective, organic compounds present in treated solutions will decrease destruction efficiency. It has limited application to treatment of slurries, tars, or sludge because surface contact is difficult to achieve. Solid hazardous materials must be liquefied prior to treatment by reduction. The efficiency of chrome reduction is >90%.[2]	**B106 - Caustic solution with metals but no cyanides** **B107 - Caustic solution with metals and cyanides** **B103 - Spent acid with metals**
M072	Cyanide destruction followed by chemical precipitation	See process descriptions for cyanide destruction and chemical precipitation.	See waste applicability for cyanide destruction and chemical precipitation.	**B107 - Caustic solution with metals and cyanides**
M073	Cyanide destruction	Cyanide destruction can be accomplished by chemical oxidation with chlorine. Cyanide is first converted to a less toxic cyanate, which is further destroyed into nitrogen. When cyanide is in the form a iron or nickel complexes, the destruction of cyanide by chlorine is more difficult.[4]	Cyanides.	**B108 - Caustic solution with cyanides but no metals** **B312 - Metal-cyanide salts** **B313 - Reactive cyanide salts** **B506 - Untreated plating sludge with cyanides** **B507 - Other sludge with cyanides**
M074	Chemical oxidation followed by chemical precipitation	See process descriptions for chemical oxidation and chemical precipitation.	See waste applicability for chemical oxidation and chemical precipitation.	**B107 - Caustic solution with metals and cyanides** B115 - Scrubber water B116 - Leachate

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M075	Chemical oxidation	Chemical oxidation is a process which oxidizes ions or compounds to render them non-hazardous or to make them more amenable to subsequent removal of destruction processes. Species are oxidized by the addition of a chemical oxidizing agent which is itself reduced.[2]	Chemical oxidation is most suited to treatment of hazardous organic and inorganic contaminant in the aqueous phase, but can also be used for slurries and sludges.[1,2] Since oxidating agents tend to be non-selective and represent a major portion of the treatment cost, this type of treatment is most suited to wastes with low organic content (less than 1%). Organic wastes that have been treated by chemical oxidation include phenols, amines, mercaptans, chlorophenols, and organic acids.[1,2] Its major use has been for treating cyanide in plating wastes and it has also been used to treat non-chlorinated pesticides.[2]	**B506 - Untreated plating sludge with cyanides**
M076/ M084/ M093	Wet air oxidation	Wet air oxidation is the destruction of dissolved or suspended organic or inorganic substances at elevated temperature and pressure. It converts hazardous wastes to less toxic substances. The complete destruction of organic material in supercritical oxidation eliminates the need for additional treatment except for ammonia nitrogen removal where required.[2]	Organic compounds applicable to WAO destruction include aliphatic hydrocarbons, halogenated aliphatics, aromatic hydrocarbons, halogenated aromatics, aliphatic alcohols, aromatic alcohols, aldehydes, ketones, esters, and MEK, and organic nitrogen compounds.[1] It is best suited to cyanide destruction and pretreatment of organics-containing aqueous hazardous wastes too toxic for biological treatment or too dilute for incineration. Certain highly chlorinated aromatic organics such as pentachlorophenol, PCBs and DDT are resistant to destruction in the conventional WAO process.[2]	**B102 - Aqueous waste with low other toxic organics** **B207- Concentrated aqueous solution of other organics** **B108 - Caustic solution with cyanides but no metals**

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M077	Chemical precipitation	Chemical precipitation is a process in which a dissolved contaminant is transformed into an insoluble solid, facilitating its subsequent removal from the liquid phase by sedimentation or filtration. The process involves 1) adjustment of pH in order to shift the chemical equilibrium to a pont that no longer favors solubility, 2) addition of the chemical precipitant, and 3) flocculation in which precipitate particles agglomerate into larger particles.[2]	Chemical precipitation is applicable to the treatment of aqueous hazardous wastes containing toxic constituents that may be converted to insoluble form. This includes wastes containing the metals: arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. Other aqueous wastes that commonly contain metals that are removable by precipitation are corrosive wastes and spent pickle liquor from steel finishing operations in he iron and steel industry (K062).[1]	**B103 - Spent acid with metals** **B106 - Caustic solution with metals but not cyanides** B116 - Leachate
M081	Biological treatment	Biological treatment processes make use of microbiological species to degrade certain contaminants from a toxic to a less or non-toxic form. The processes range from simple composting techniques to sophisticated biological contactors. Degradation may occur in an aerobic or anaerobic condition, depending on the biological species used.[5]	Applies to wastewaters and some soil applications containing most hazardous organics. Moderately high levels of heavy metals inhibit the system.[1]	**B101 - Aqueous waste with low solvents** **B102 - Aqueous waste with low other toxic organics** **B503 - Wastewater treatment sludge with toxic organics** **B504 - Other wastewater treatment sludge** **B608 - Sewage or other untreated biological sludge**

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M082	Carbon adsorption	Carbon adsorption is a separation technology used to remove and/or recover dissolved organics and certain inorganics from single-phase fluid streams.[2]	Activated carbon can be used to remove a wide variety of contaminants from liquid or gaseous streams. It is most frequently used for organic compounds, although some inorganic species are also efficiently adsorbed. Organic compounds amenable include aromatic solvents, polynuclear aromatics, chlorinated aromatics, phenolics, high-molecular- weight aliphatic amines, surfactants, soluble organic dyes, fuels, chlorinated solvents, and aliphatic and aromatic acids[1], cresol, polyethers, various halogenated organics, cyanide, and chromium.[2]	**B101 - Aqueous waste with low solvents** **B102 - Aqueous waste with low other toxic organics**
M083	Air/steam stripping	Air and steam stripping are the removal of gases or volatile organics from a liquid phase.[2]	Air and steam stripping can be used to remove VOCs from water or aqueous waste streams. VOCs having Henry's constants above 10 atm and concentrations less than 100 mg/L are readily air-strippable. These include chlorinated solvents, aromatic solvents, and trihalomethanes. Steam stripping is applicable to less volatile compounds including acetone, methanol, and pentachlorophenol and higher concentrations.[1]	**B101 - Aqueous waste with low solvents** **B102 - Aqueous waste with low other toxic organics** B105 - Acidic aqueous waste B110 - Caustic aqueous waste

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M091	Chemical precipitation in combination with biological treatment	See process descriptions for chemical precipitation and biological treatment.	See waste applicability for chemical precipitation and biological treatment.	B101 - Aqueous waste with low solvents B102 - Aqueous waste with low other toxic organics B103 - Spent acid with metals B105 - Acidic aqueous waste B106 - Caustic solution with metals but not cyanides B107 - Caustic solutions with metals and cyanides B108 - Caustic aqueous waste B115 - Scrubber water B116 - Leachate
M092	Chemical precipitation in combination with carbon adsorption	See process descriptions for chemical precipitation and carbon adsorption.	See waste applicability for chemical precipitation and carbon adsorption.	B101 - Aqueous waste with low solvents B102 - Aqueous waste with low other toxic organics **B103 - Spent acid with metals** **B106 - Caustic solution with metals but not cyanides** B113 - Aqueous waste with high dissolved solids B114 - Aqueous waste with low dissolved solids **B115 - Scrubber water** **B116 - Leachate**

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M111	Stabilization /chemical fixation using cementitious and/or pozzolanic materials	Solidification/stabilization is used to reduce the mobility of pollutants in the environment making disposal safer. Materials are mixed with wastes to chemically and physically immobilize the wastes constituents.[2]	The process is usually applied to concentrated waste solids, sludges, and slurries; however, liquid wastes may also be treated. Cement, lime, and pozzolan based techniques are used for inorganic solidification/stabilization. Metals are usually precipitated as hydroxides or sulfides before using solidification/stabilization processes.[2] Stabilization with cement is commonly used for the fixation of metal hydroxide sludges from the plating industry. Organics interfere with the hydration process and may reduce the strength.[4]	**B303 - Ash, slag, or other residue from incineration of wastes** **B304 - Other "dry" ash, slag, or thermal residue** **B305 - "Dry" lime or metal hydroxide solids chemically fixed** **B306 - "Dry" lime or metal hydroxide solids chemically fixed** **B502 - Lime sludge with metal./metal hydroxides sludge** **B505 - Untreated plating sludge without cyanides** B506 **-** Untreated plating sludge with cyanides B511 **-** Air pollution control device sludge **B513 - Sediment or lagoon dragout contaminated with inorganics only**
M121	Neutralization	Neutralization involves combining either an acid or a base with a hazardous waste stream to adjust liquid pH to acceptable levels. Additional treatment is usually required after neutralizing hazardous waste to remove dissolved and suspended metals and organics.[2]	Neutralization is applicable to caustic and acid waste streams.[2]	B103 **-** Spent acid with metals **B104 - Spent acid without metals** B106 **-** Caustic solution with metals but no cyanides B107 **-** Caustic solution with metals and cyanides B108 Caustic solution with cyanides but no metals **B109 - Spent caustic**

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M122	Evaporation	Evaporation is the vaporization of a liquid from a solution or a slurry through the application of an energy source to form a more concentrated waste. It is commonly used as a pretreatment to decrease quantities of materials for final treatment.[1]	Depending on the design of the equipment, evaporation is applicable to various waste forms including aqueous, nonaqueous, slurries, sludges and tars. It is used for the treatment of hazardous wastes such as radioactive liquids and sludges, metal-plating wastes, and other organic and inorganic wastes.[1] Solar evaporation is used to concentrate waste streams such as metal hydroxide slurries, corrosives, acids, alkalis, aqueous streams contaminated with organics and cyanide wastes with less than 100 ppm cyanide.[2]	B103 - Spent acid with metals B104 - Spent acid with metals B105 - Acidic aqueous waste B106 - Caustic solution with metals but not cyanides B107 - Caustic solutions with metals and cyanides B108 - Caustic aqueous waste B109 = Spent caustic B110 - Caustic aqueous waste **B113 - Aqueous waste with high dissolved solids** **B501 - Lime sludge without metals** **B502 - Lime sludge with metal/metal hydroxides sludge** **B505 - Untreated plating sludge without cyanides** B506 - Untreated plating sludge with cyanides
M123	Settling/ clarification	Sedimentation is the separation from water, by gravitational settling, of suspended particles that are heavier than water.[7] Clarification removes suspended solids from aqueous streams in concentrations of typically less than 100 ppm.[6]	Settling/clarification is most applicable to aqueous streams, not sludges or solids.[6]	**B113 - Aqueous waste with high dissolved solids** **B114 - Aqueous waste with low dissolved solids**

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M124	Phase separation	Phase separation can either be the separation of a solid phase from a liquid phase or one liquid phase from a second liquid phase (e.g., oil and water). Phase separation can be achieved through gravity or a mechanical mechanism. Gravity separation is widely used as a waste treatment process for the removal of settleable suspended solids, oil and grease, and other material heavier or lighter than the carrying fluid (usually water). Filtration is usually used to separate solids from liquids. Dissolved-air flotation is commonly used to separate oil from water.[6]	Phase separation is typically applicable to liquids streams or sludges, not solids.	**B205 - Oil-water emulsion mixture** B206 - Waste oil B209 - Organic paint, lacquer, or varnish
M131	Land Treatment	Waste treatment and disposal process whereby a waste is mixed with or incorporated into the surface soil and is degraded, transformed, or immobilized. Land treatment uses the surface soil as a treatment medium and is based primarily on the principle of aerobic decomposition for organic hazardous-waste constituents.[1]	Biodegradable wastes are suitable for land treatment. Radioactive waste; highly volatile, reactive, or flammable liquids; and inorganic wastes such as heavy metals, acids and bases, cyanides, and ammonia are not considered candidates for land treatment.[1] Land farming is most effective in treating non-halogenated volatile organics and fuel hydrocarbons. Halogenated volatiles and semivolatiles, non-halogenated semivolatiles, and pesticides also can be treated, but the process may only be applicable to some compounds in these groups.[3]	B101 - Aqueous waste with low solvents B207 - concentrated aqueous solution of other organics B201 - Concentrated solvent-water solution B301 - Soil contaminated with organics only B402 - Nonhalogenated pesticide solid
M132	Landfill	A landfill is a system designed and constructed to contain discarded waste so as to minimize the release of contaminants to the environment.[4]	Many but not all hazardous wastes can be disposed of on land in properly designed landfills. Noncontainerized wastes containing free liquids and containers holding free liquids are prohibited from landfills with the exception of batteries and lab packs.[1]	B001 - Lab packs of old chemicals only B002 - Lab packs of debris only B003 - Mixed lab packs B404 - Spent carbon B406 - empty fiber or plastic containers B607 - Biological treatment sludge

Code	Treatment Technology	Process Description	Waste Applicability	Applicable Waste Forms*
M133	Surface Impoundment	Surface impoundments are land-based units including pits, ponds, and lagoons.[4] Disposal surface impoundments are designed to allow closure as landfills.[6]	The level of environmental protection provided by, and therefore, the waste applicability of, surface impoundments depends upon the design and construction.[4]	**

*Waste forms that are best suited to the treatment technology are indicated in bold, non-bold waste forms may be treated by the specified treatment technology, but the efficiency of treatment cannot be predicted based on the limited description of the waste form. These selections are based on engineering judgement.
**Waste forms appropriate for land-based units (e.g., landfills and surface impoundments) are subject to Land Disposal Restriction rules.

[1]Standard Handbook of Hazardous Waste Treatment and Disposal by Harry M. Freeman, McGraw-Hill, 1989.
[2]Briefing:Technologies Applicable to Hazardous Waste, Metcalf & Eddy, Inc., May, 1985.
[3]Remediation Technologies Screening Matrix and Reference Guide, U.S. EPA and U.S. Air Force, July, 1993.
[4]Hazardous Waste Management, LaGrega, Buckingham, and Evans, McGraw-Hill, 1994.
[5]Compendium of RCRA Handling and Treatment Processes Potentially Requiring a Subpart X Permit, Center for Environmental Research Information, December, 1992.
[6]Standard Handbook of Hazardous Waste Treatment and Disposal by Harry M. Freeman, Second Edition, McGraw-Hill, 1998.
[7] Wastewater Engineering: Treatment, Disposal, and Reuse, McGraw-Hill Series in Water Resources and Environmental Engineering, 3rd Edition, Metcalf & Eddy, Inc., 1991.

Appendix G

Unit Pathways and Receptors

Appendix G
Unit Pathways and Receptors

The exhibit that follows shows the pathways, routes of exposure, and receptors for waste management units historically modeled by EPA in its multi-media multi-pathway modeling analysis. The information was extracted, in part, from the documentation for the modeling conducted in support of the December 1995 HWIR proposal. Note this table does not necessarily reflect the pathways represented in the current 3MRA model. Information in the exhibit describes important elements related to the exposure of receptors to contaminants over pathways. The information is particularly useful for understanding how contaminants present a problem to human and ecological receptors, and over which pathways contaminants travel to reach those receptors.

Unit Pathways and Potential Receptors[1/]

Pathway Description	**Physical Nature of Release**	**Routes of Exposure (and pathway number)**	**Human Receptor (and pathway number)**	**Ecological Receptor (and pathway number)**
Ground-Water Pathway				
Waste or contaminants are released from management unit to underlying ground-water aquifer	Contaminant solubilized in aqueous or organic liquid	-Ingestion (1) Not Included: -Dermal (bathing) (14)	- Adult (14) - Child (14)	
Ground-Water Pathway (Release to Surface Water)				
Waste or contaminants are released from management unit and contaminate surface water	Contaminant solubilized in aqueous or organic liquid	- Ingestion of drinking water (18) - Fish ingestion (22) - Direct contact (40)		- Mammals (18, 22) - Birds (18, 22) - Fish (22, 40) - Daphnids (40) - Benthos (40)
Direct Air Pathway				
Respirable particulates (PM10) are released from management unit into the air	Contaminant adsorbed onto particulates	- Inhalation of particulates (2b)	- Adult (2b, offsite pathway) - Worker (2b, onsite pathway)	

Pathway Description	Physical Nature of Release	Routes of Exposure (and pathway number)	Human Receptor (and pathway number)	Ecological Receptor (and pathway number)
Volatile contaminants are released from management unit into the air	Contaminant in vapor phase	- Inhalation of volatiles (2a)	- Adult (2a, offsite pathway) - Worker (2a, onsite pathway)	
Air Deposition Pathway				
Particulates or contaminants are released from management unit into air and deposited on soil or plant surfaces	Contaminant adsorbed onto particulates	- Soil ingestion (4) - Dermal (soil) (6) -Veg/root ingestion (8) - Beef/ milk ingestion (10) - Drinking water ingestion (20) - Fish ingestion (24)	- Adult (4,6, 20, 24) - Child (4, 6) - Subs. farmer (8, 10) - Home gardener (8) - Subs. fisher (8, 24) - Fish consumer (24)	- Mammals (4, 8, 20, 24) - Birds (4, 8, 20, 24) - Plants (6) - Soil fauna (4, 6) - Fish (24)
Air Deposition Pathway (Overland Transport Followed by Release to Surface Water)				
Particulates or contaminants are released from management unit into air, transported overland, and released into surface waters	Contaminant adsorbed onto particulates. Contaminant eventually solubilized or entrained in surface water	- Beef/milk ingestion (36) - Dermal (bathing) (38)	- Adult (38) - Child (38) - Subs. farmer (36)	- Fish (38) - Daphnids (38) - Benthos (38)
Air Diffusion Pathway				
Contaminants, while in the vapor phase, are released from management unit and diffuse directly into plants	Contaminant in vapor phase	- Veg/root ingestion (8a) - Beef/milk ingestion (10a) - Drinking water ingestion (17) - Fish ingestion (21)	- Adult (17, 21) - Subs. farmer (8a, 10a) - Home gardener (8a) - Subs. fisher (21) - Fish consumer (21)	- Mammals (8a, 17, 21) - Birds (8a, 17, 21) - Fish (21)
Air Diffusion Pathway (Diffusion Directly to Surface Water)				

Pathway Description	Physical Nature of Release	Routes of Exposure (and pathway number)	Human Receptor (and pathway number)	Ecological Receptor (and pathway number)
Contaminants, while in the vapor phase, are released from management unit and diffuse directly into surface water	Contaminant in vapor phase	- Beef/milk ingestion (33) - Dermal (bathing) (37)	- Adult (37) - Child (37) - Subs. farmer (33)	- Fish (37) - Daphnids (37) - Benthos (37)
Direct Soil Pathway				
Waste or contaminants are released from units onto nearby soils.	Contaminant absorbed into soil matrix, or contaminant solubilized in aqueous or organic liquid in soil pores	- Soil ingestion (3) - Dermal (soil) (5) - Veg/root ingestion (9) - Beef/ milk ingestion (11) - Soil fauna ingestion (11a, 11c) - Animals ingestion (11b, 11d)	- Adult (3, offsite pathway) - Child (3, offsite pathway) - Worker (5, onsite pathway)	- Mammals (3, offsite pathway; 9; 11a; 11b; 11c; 11d) - Birds (3, offsite pathway; 9; 11a; 11b; 11c; 11d) - Plants (5) - Soil fauna (3, onsite and offsite pathways; 5)
Overland Pathway				
Waste or contaminants are transported through soil erosion to offsite fields.	Contaminant absorbed into soil matrix, contaminant solubilized in aqueous or organic liquid in soil pores	- Veg/root ingestion (9) - Beef/milk ingestion (11) - Drinking water ingestion (19) - Fish ingestion (23)	- Adult (19, 23) - Subs. farmer (9, 11) - Home gardener (9) - Subs. fisher (23) - Fish consumer (23)	- Mammals (9, 19, 23) - Birds (9, 19, 23) - Fish (23)
Overland Pathway (Release to Surface Water)				
Waste or contaminants are transported through soil runoff or soil erosion to surface water.	Contaminant absorbed into soil matrix, or contaminant solubilized in aqueous or organic liquid in soil pores	- Beef/milk ingestion (35) - Dermal (bathing) (42)	- Adult (42) - Child (42) - Subs. farmer (35)	

1/ The numbers in parentheses correspond to the numerical designations of the routes of exposure and receptors identified in the December 1995 HWIR proposal, and are included as a matter of convenience.