HAZARDOUS WASTE DATABASE: WASTE MANAGEMENT POLICY IMPLICATIONS FOR THE U.S. DEPARTMENT OF ENERGY'S ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT*

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ABSTRACT

The hazardous waste risk assessment modeling (HaWRAM) database is being developed to analyze the risk from treatment technology operations and potential transportation accidents associated with the hazardous waste management alternatives. These alternatives are being assessed in the Department of Energy's Environmental Restoration and Waste Management Programmatic Environmental Impact Statement (EM PEIS). To support the risk analysis, the current database contains complex-wide detailed information on hazardous waste shipments from 45 Department of Energy installations during FY 1992. The database is currently being supplemented with newly acquired data. This enhancement will improve database information on operational hazardous waste generation rates, and the level and type of current on-site treatment at Department of Energy installations.

INTRODUCTION

The Department of Energy's (DOE's) Hazardous Waste Program addresses waste materials identified as hazardous or requiring regulatory control as stipulated by the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), or the Clean Water Act. The Land Disposal Restrictions regulation 40 CFR 268 under RCRA requires treatment of hazardous constituents of wastes to specific concentration levels before disposal. The U.S. Environmental Protection Agency (EPA) definition of hazardous waste (HW) is "waste material exhibiting a characteristic of ignitability, corrosiveness, reactivity, or toxicity," or any material that is subject to the waste manifest requirements as specified in 40 CFR 261, Subpart C, or in applicable state regulations.

The types and quantities of HW generated vary greatly throughout the DOE complex. Laboratory facilities such as the Argonne National Laboratories (ANL-E and ANL-1), Lawrence Livermore National Laboratory (LLNL), the Sandia National Laboratories (SNL-A and SNL-L), and Fermi National Laboratory generate HW as a result of research and development activities, processing operations, and other activities necessary to carry out their predominantly civilian missions. Production facilities such as the Savannah River Site (SRS), the Oak Ridge Reservation (ORR), the Hanford Site (HS), the Pantex Plant, the Rocky Flats Plant (RFP), the Nevada Test Site (NTS) and the Kansas City Plant (KCP) generate HW primarily as a result of activities connected with the manufacture and retirement of weapons and weapons materials, nuclear fuel, and other production operations. Los Alamos National Laboratory (LANL) and the Idaho National Engineering Laboratory (INEL) have split civilian and non-civilian missions. Some installations, such as Waste Isolation Pilot Plant (WIPP), generate very little HW and may qualify for RCRA conditionally exempt "small quantity generator" status.

The potential public and worker health risk, the ecological risk, the technology and labor cost, and other related environmental and social impacts associated with alternatives to treat, store, dispose, and transport HW are currently being assessed in support of DOE's Environmental Restoration and Waste Management Programmatic Environmental Impact Statement (PEIS). Along with HW, the PEIS assessments include six radioactive waste types. The assessment methodologies covered in other papers at this conference involve the modeling of fixed-facility routine and potential accidental environmental releases of hazardous chemicals/radionuclides and the analysis of potential releases from related transportation accidents.

In support of the PEIS effort, the HW risk assessment modeling (HaWRAM) database is under development at ANL-E. The database's initial design is primarily as a tool to provide the modeling parameters necessary to support the HW transportation accident risk assessment. Expansion and enhancement of the HaWRAM database is a current, ongoing effort to more readily support assessments of additional or refined PEIS alternatives for treatment, storage, and disposal (TSD) technologies, as well as for facility siting, sizing, and costing. This paper will briefly describe the key database improvements planned for the continuing PEIS preparation effort.

The primary intent in developing the HaWRAM database as a transportation risk assessment modeling database required it to meet the following design criteria:

- To identify the quantities of off-site HW shipments, the key physical-chemical HW characteristics, and the treatment technologies used by the commercial TSD facilities;
- To provide the data, such as chemical name, container size, chemical state, and chemical hazard designation (e.g., "poison inhalation hazard"), required to carry out a transportation risk assessment for current as well as future conditions;

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- To provide data for determining the degree and/or type of on-site treatment versus off-site treatment at commercial facilities; and
- To provide data on "as-generated" or "operational" HW from industrial-type processes or laboratory research, versus data on "remediation" HW from decommissioning or Superfund cleanup.

The transportation risk assessment requires the integration of five key analysis areas: 1) the selection of endpoints for identifying human health effects and development of a defensible health effects criteria, 2) the identification of the potential health hazard, 3) the HW truck transportation routing analysis, 4) the consequence assessment, and 5) the truck accident and hazardous chemical release probabilities, and the associated population risk computation. The human health endpoints, effects criteria, and hazard identifications are discussed in a companion paper (1). The population zones at risk (rural, suburban, or urban) from hazardous chemical inhalation exposure in the event of an accident along the HW transportation route are identified through a routing analysis. The potentially exposed population areas are computed with the aid of an air transport and dispersion consequence assessment model (2). Truck accident and release probabilities are obtained through data in published literature (3). The population health risk associated with each health endpoint is calculated with the aid of spreadsheet program.

This paper provides a brief description of the development and current status of the HaWRAM, including the database elements and structure. Key preliminary findings associated with analysis of reports generated from HaWRAM and other data sources are discussed and future database developments are identified. Finally, PEIS implications of the preliminary database findings are provided.

DATABASE STRUCTURE AND DEVELOPMENT

The HaWRAM database was initially structured to manage information related primarily to HW shipped off-site by DOE for treatment and/or disposal at commercial facilities during FY 1992. Most data were obtained directly from the uniform hazardous waste manifests mandated by both federal and (in most cases) state law for all off-site shipments of HW. The HaWRAM database was created using HyperCard™ 2.1 (Apple Computer, Inc.) and is not a stand-alone application. The database reporting programs are written in the HyperCard scripting language and designed to run on a Macintosh computer. At least 2 Mb of RAM are recommended and at least 8 Mb of hard disk space are required.

The primary initial advantage associated with selection of the uniform HW manifests as the data source was their availability as a potential source of key parameters required for the modeling of transportation accident consequences. The difficulty, of course, was the collection and assembly of a representative set of manifests from over 40 DOE installations. However, nearly all DOE field offices submitted copies of their installations' manifests for HW shipments during most of FY 1992 to a central repository maintained by a private DOE contractor. Apart from this repository, there were few other consolidated sources of information relating to off-site HW shipment activity at the various DOE sites. One exception was the HW shipment data system (HWSDS) developed at INEL (4). The HWSDS was developed in response to DOE's directive to assess the potential public dose of off-site shipments of HW, potentially radioactively contaminated, over a six- to seven-year period between 1984 and 1991(5). Although this database had a distinct advantage of long period of record on DOE installation HW shipments, the data elements in the HWSDS did not have level of detail required to perform HW transportation risk assessments. Since the HWSDS was primarily intended to estimate dose from radionuclides in the transported waste, key parameters (i.e., the chemical composition of the HW, the quantities and states of the hazardous chemical compounds in the waste, and the waste container sizes and numbers) were not included.

It was clear that the uniform HW manifests obtained from the central repository had more key modeling parameters than the INEL database. However, the data reported on these forms in some cases also lacked sufficient detail due to inconsistent reporting and an incomplete period of record. In addition, as shipping documents, the manifests do not provide information concerning the rate or volume of waste generation at a facility. In many cases, it was found the manifests also failed to provide any information concerning the chemical composition or concentration of the waste being shipped (the Department of Transportation [DOT] description is often generic or imprecise), or information that would indicate precisely how the waste was to be treated. To overcome some of these limitations a data call was initiated and site visits were conducted at selected DOE installations. Missing waste manifest sheets were collected, along with manifest container contents sheets, associated land disposal certification and notification forms, and other information.

Once all the available manifest and related shipping information for FY 1992 was entered in the HaWRAM database, it was a relatively simple task to identify HW shipments with the potential to expose the public to adverse health effects and to calculate the volume of waste shipped off-site by each DOE facility. The waste volume data were used to provide an initial ranking of HW shipments for DOE generators. Concurrent with the development of this information, ANL-E was also involved in a review of existing waste management capabilities and alternatives for expanding those capabilities at designated DOE installations (6). Information gathered as part of this investigation indicated that some DOE sites were treating large volumes of HW on-site. Since the existing database only reflected volumes that were shipped off-site, it became obvious that additional information was needed to determine how closely the off-site shipments reflected overall generation rates. This was accomplished by the acquisition and review of the EPA biennial reports and state annual reports required under RCRA (40 CFR 262.41). This effort is further discussed in the "Future Development" section of this paper.

DATABASE ELEMENTS

Some of the key parameters, for each drum of waste shipped off-site (and in some cases containers with HW generated but not shipped during FY 1992), incorporated in the HaWRAM database include the following:

- chemical name and/or its United Nation (UN) or North American (NA) identification number, and whether it is a "poison inhalation hazard" (PIH) chemical;
- physical-chemical state (liquid, solid, or gas/vapor) of waste container contents;
- container size (55-, 30-, or 5-gallon drum), number of containers in shipment, and total quantity of waste in the containers shipped;
- container type (i.e., metal or fabric drum);
- chemical composition and physical-chemical characteristics;

- EPA/state waste codes (i.e., RCRA codes);
- treatment technology groups or modules;
- shipment date;
- EPA and state manifest numbers;
- name, EPA identification number, location, and phone number of the generator and transporter; and
- name, EPA identification number, location, and phone number of the waste shipped to commercial TSD or "bulking" facilities.

The contents of HW containers with chemicals designated as a PIH, according to the Department of Transportation (DOT) regulations (49 CFR 173.115; 49 CFR 173.132-133), are specifically identified in the database. When provided on the uniform HW manifest container content sheet, the concentration of the chemical in solution was included in the database. If this data was missing, but needed in support of the transportation risk assessment modeling, the specific spent chemical waste in solution was assumed conservatively to have concentrations of at least 90% by volume (concentrations of fuming nitric or sulfuric acid are assumed to exceed 70% and 95% by volume, respectively) (7,8).

DATABASE CAPABILITIES

The HaWRAM database identifies the shipment in FY 1992 of 48 different liquid or gaseous compounds as PIH substances (approximately 100 liquids and 70 gases are on the DOT list of PIH substances) (9). The PIH compounds, the number of shipments, and the amount shipped from DOE installations in FY 1992 are identified in Table I.

Gaseous PIH chemical compounds are defined as materials that are gases at 20°C (68°F) or less and at an atmospheric pressure of 101.3 kPa (14.7 psi), and which have animal 50% lethal concentrations (LC50) of 5,000 ppm or less (49 CFR 173.115). Liquid PIH chemical compounds are defined as materials that have LC50 values for acute toxicity on inhalation of vapors of 1,000 ppm or less and a saturated vapor concentration in air at 20°C (68°F) of more than 10 times the LC50 value (49 CFR 173.133). Chemical compounds that do not meet the above toxicity criteria but are known to be so toxic to humans as to pose a health hazard during transportation may also be included as PIH substances by DOT. Potentially life-threatening air concentration (PLC) values for PIH chemical compounds were developed for the PEIS risk assessment (1) using toxicity values based on published data for LC50 and LCLO (lowest concentration of gas or vapor that causes death in any exposed species, obtained from animal tests or accidental human exposure occurrences).

Along with the PIH chemical compounds for which PLC have been estimated, the database also identifies shipped compounds with a potential for any adverse effects and compounds with potential carcinogenic effects. The toxicity criteria developed for the PEIS risk assessment for these health endpoints are also discussed in Ref. (1). Any adverse effect concentration (AAEC) values have been derived for PIH compounds and for compounds that may result in less severe adverse health effects. Increased cancer risk concentrations (ICRCs) have been derived for compounds for which sufficient evidence exists of carcinogenicity for humans or animals. The HaWRAM database identifies the shipment in FY 1992 of 85 different liquid or gaseous compounds as substances with AAEC values, including the shipped PIH compounds, and 32 different liquid or gaseous compounds as substances with ICRCs.

Each of the HW chemicals in the HaWRAM database has been classified according to its physical state as follows:

- **Gas**: Chemicals in a gaseous or vapor state under atmospheric conditions or under pressure in containers are identified as gases.
- **Liquid**: Chemicals in a liquid state under atmospheric conditions or under pressure in containers, as well as chemical gases or solids in solution (less than 10% solute), are identified as liquids.
- **Solid**: Chemicals in a solid state under atmospheric conditions, verified through Merck's Index and related references, are identified as solids.

The categorization of RCRA HW is based on the hazardous components contained in the waste stream and the definitions established by EPA. These categories include wastes that are hazardous by characteristic, and those that are specified (listed) as HW according to 40 CFR 261.

The HaWRAM database can also be used to identify shipments as having properties that are characteristically hazardous (40 CFR 261, Subpart C) based on ignitability, corrosivity, reactivity, or explosivity, or exceed a prescribed concentration when extracted (toxicity characteristic leaching procedure). A HW exhibits the characteristic of ignitability when it meets any of the following criteria: 1) it is a non-aqueous liquid and has a flash point below 60°C (140°F), 2) it is not a liquid and can cause fire through friction, absorption of moisture, or spontaneous chemical change, 3) when ignited, it burns so vigorously and persistently that it creates a hazard, or 4) it is an ignitable compressed gas or an oxidizer. A HW exhibits characteristics of corrosivity when it has a pH ≤ 2 or ≥ 12.5, or it is a liquid that corrodes steel (under prescribed conditions).

In part, a HW exhibits characteristics of reactivity or explosivity when it is capable of: 1) detonation or explosive reaction when subjected to a strong initiating source or heated under confinement, or 2) detonation or explosive decomposition at standard temperature and pressure. Explosives are included under reactivity. Two classes of explosives are recognized: Class A and Class B. Class A contains detonating explosives, including priming devices (such as lead oxide) and high explosives (such as TNT, tetryl, and black powder). Class B contains rapidly burning explosives (such as propellants).

Reports can be generated that identify shipments with one or more of the following hazardous characteristics:

- Toxic ignitables
- Non-toxic ignitables
- Corrosives
- Reactives
- Explosives
- Toxic metals
- Halogenated organics
- Non-halogenated organics
- Inorganic compounds
- Halogenated toxic compounds
- Non-halogenated toxic compounds

The HaWRAM database classifies 828 HW chemicals according to their physical-chemical characteristics. Most of the classifications are halogenated or non-halogenated solvents (approx. 60-70%), several are toxic and corrosive compounds (approx. 10%), and a few are reactive or explosive chemicals (approx. 3%). A considerable fraction of the classified chemicals are toxic metals and their compounds.

TABLE I
Poison Inhalation Hazard (PIH) Compounds Shipped from DOE Installations (FY 1992)

PIH Chemical Name	Quantity Shipped[1] (kg)	No. of Shipments	PIH Chemical Name with Annual Shipments < 10 kg	No.
Sulfuric Acid	4284	5	Methyl Iodide	8
Trimethoxysilane	966	1	Cyanogen Bromide	7
Phenyl Isocyanate	438	4	Acrolein	7
Nitric Acid	230	15	Phosphorus Trichloride	6
Sulfur Dioxide	202	7	Phosphorus Oxychloride	5
Carbon Monoxide	122	12	Cyclohexyl Isocyanate	5
Ammonia	102	6	Methyl Bromide	5
Hydrogen Fluoride	83	3	Tellurium Hexafluoride	5
Bromine or Bromine Solutions	81	5	Selenium Hexafluoride	5
Chlorine	78	12	Hydrogen Selenide	5
Nitrogen Dioxide	49	6	Methyl Chloroformate	5
Titanium Tetrachloride	42	4	Methyl Vinyl Ketone	5
Arsine	41	5	Chloropicrin	5
Thiophosgene	37	2	Sulfur Trioxide	5
Thionyl Chloride	37	3	Methylamine	4
Nitric Oxide	36	3	Hydrogen Cyanide	4
Hydrogen Sulfide	29	5	Phosphine	2
Silicon Tetrafluoride	28	4	Sulfuryl Fluoride	1
Trimethylacetyl Chloride	24	1	Carbonyl Fluoride	1
Boron Trifluoride	22	2	Phosgene	1
Allylamine	22	2	Dimethyl Sulfate	<1
Boron Tribromide	19	1	Ethylene Dibromide	<1
Tungsten Hexafluoride	12	3	Nitrosyl Chloride	<1
Nickel Carbonyl	10	2	Boron Trichloride	<1

[1] If the quantity of a particular PIH chemical in a container was not listed on the waste manifest, the quantity was estimated by proportionately dividing the total quantity of waste in container by the number of PIH chemicals without a specified manifest quantity.

PRELIMINARY PEIS APPLICATIONS AND FINDINGS

Several HaWRAM database reports have been generated as a tool in support of PEIS analysis of transportation and facility risk accident assessments, source-term development for routine TSD facility environmental releases, and the development and analysis of the PEIS HW alternatives. The analysis of these data and investigation of recently obtained information from the RCRA regulatory compliance reporting reveals that the HaWRAM database, as currently structured, should be applied primarily to support HW transportation risk analysis. Applications of HaWRAM alone to support TSD facility capacity and cost analysis would, for example, provide incomplete information about the magnitude of the DOE complex-wide HW generation and about the distribution of HW treatment by TSD group. These and related findings are discussed in more detail below.

Representative Hazardous Waste Generation Rates: Biennial Reports Versus Manifests

The HaWRAM database indicates that DOE's Pantex plant shipped the most HW off-site in FY 1992, if non-RCRA waste is included. The effects of the mixed waste moratorium* varied from no influence on HW shipments to commercial TSD facilities, to the prohibition of all commercial shipments.

* DOE moratorium imposed a program, in May 1991, to certify waste as non-radioactive before off-site shipment, to minimize the potential for shippingmixed waste (radioactively contaminated HW) to commercial facilities.

Some installations were affected very little (such as the NTS and INEL), whereas others were greatly affected (such as ORR and SRS). The generation rates for those facilities most affected were adjusted with on-site data when available. A closer look at these generation rates revealed that a much more significant error would result if HW manifest data were alone relied upon to estimate operational HW generation rates for an installation. The breakdown of the top 11 DOE installations by off-site waste shipments is given in Table II by *RCRA*, *Non*-RCRA, and TSCA categories.

All facilities generating more than 1,000 kg of HW in a month (the amount may be less, depending upon the state or the type of waste) must submit a biennial report to EPA (or the state with delegated authority) by March 1 of each even-numbered year, describing all waste management activities that took place during the previous year. It is important to note that most states require annual reporting. The key element of the biennial and annual reports is that the reported data require the certification of the quantity of waste generated and its description, and the technologies or methods used for TSD. Since the data for the most recent reporting period (calendar years 1990 and 1991) had not been officially released, this data could not be used in the initial stages of development of the HaWRAM database. To overcome this problem, contacts were made with the state regulatory agency and/or the RCRA compliance officer at the DOE installation to obtain copies of the biennial reports for the sites that had shipped the most waste off-site during FY 1992. Copies of the biennial reports were also requested for RFP and NTS. The FY 1992 manifest information from these sites was incomplete or nonexistent.

A review of the biennial reports indicated that in 1991, the amount of HW generated and treated on-site was substantially greater than the amount sent off-site for treatment and/or disposal. Installation-specific waste loads and off-site shipment to commercial TSD facilities were identified with the aid of the HaWRAM database. Table III provides the ranking for the top 13 HW generators, shown alongside the rankings of off-site shipments for CY 1991 and FY 1992. The much smaller 1991 off-site shipments from Pantex, Fermi, SNL-A, LANL, LLNL, ANL-E, and SRS when compared with corresponding 1992 off-site shipments are most likely due to the significant "other than RCRA" component (state regulated and TSCA HW) of HW reported on the uniform hazardous waste manifest forms.

Of the 13 sites studied, six sites (INEL, SNL-A, KCP, ORR, SRS, and RFP) provided some type of on-site treatment for over 80% of the HW generated (five of these sites treated more than 99%). Aqueous organic and/or inorganic treatment of hazardous wastewater accounted for most of this on-site treatment. Only three sites (HS, ANL-E, and Fermi) relied upon off-site treatment for all waste generated. Overall,

TABLE II

Top Eleven HW Off-Site Shippers by DOE Installation for Three Types of Regulated Waste (FY-1992) [1]

Generator	Total Waste (t)	RCRA (%)	Non-RCRA (%)	TSCA (%)
Pantex	2,784.3	20	80	0
LANL	2,069.2	9	49	42
LLNL	1,561.3	41	44	15
INEL	782.1	25	0	75
KCP	616.5	96	2	2
Hanford	463.3	40	57	3
SNL	310.0	46	54	0
ANL, E	262.1	76	21	3
ORR	259.1	100	0	0
Fermi	171.4	26	55	19
SRS	159.9	83	16	1
Others	523.4	58	25	17
Total	9,962.6	34	47	19

[1] All Units are in metric tonnes (t)

more than 96% of the total volume of waste generated by DOE in calendar year 1991 was either treated or stored on-site. Figures 1a and 1b show the difference in the relative rankings of the DOE installations when switching from a database that relies primarily on waste manifests to data focused on waste generation and treatment (required under RCRA biennial reporting). Clearly, waste manifests alone cannot be relied upon to provide complete information on waste generation and on-site treatment.

The HaWRAM database is currently being enhanced with data compiled from the biennials to better account for waste generation rates and on-site treatment. The "Future Developments" section of this paper discusses these enhancements.

Commercial Off-Site Treatment

The treatment of DOE HW employs a variety of both on-site and off-site technologies. For off-site treatment, the manifest information contained in the HaWRAM database is used to estimate waste volumes that were treated through the use of various commercial technologies in FY 1992. It is important to note that the manifests themselves do not specifically indicate how a particular waste was treated. Referring to the DOT shipping description of the waste, the EPA hazardous waste code(s), and the facility to which the waste was shipped, one can often make assumptions as to how the waste was most likely managed. Listed below are the technologies or technology groups that were routinely used for the off-site treatment of DOE waste in FY 1992 (the order of appearance reflects the overall ranking of each technology based on waste volumes treated):

- **Incineration (1,688.1 t)**: Principal form of treatment for a wide range of organic wastes; used extensively by DOE for the treatment of lab packs, also used frequently by DOE to manage wastes more amenable to other forms of treatment (e.g., aqueous wastes, corrosive wastes, petroleum-contaminated soils).
- **Organic Removal/Recovery (981.6 t)**: Primarily the use of fuel blending/burning and solvent recycling/distillation.
- **Stabilization (218.0 t)**: Most commonly used for inorganic waste; waste is mixed with solidification agent such as Portland cement or cement kiln dust prior to land disposal.
- **Deactivation (183.0 t)**: Primarily applied to corrosive wastes (neutralization) and explosives (controlled detonation, reaction, or deactivation); limited DOE application for cyanide/sulfide wastes.
- **Metal Removal/Recovery (123.4 t)**: Often involves precipitation of heavy metals from aqueous solutions; resulting precipitate may be further treated to recover metals or stabilized prior to land disposal; many DOE sites generate silver-bearing wastes amenable to other types of common metal recovery technologies.
- **Mercury Recovery/Treatment (122.3 t)**: Specialized treatment offered by only a few commercial facilities in U.S. (for example, Hg roasting or retorting, amalgamation, incineration of organic wastes containing Hg).
- **Aqueous Treatment (52.3 t)**: Wide range of technologies including biological treatment, wet air oxidation, and chemical oxidation/reduction (some of the metal removal technologies noted under "Metal Removal/Recovery" [above] could be considered a form of aqueous treatment).
- **Direct Land Disposal (33.7 t)**: Future volumes will likely diminish with the development of Land

TABLE III

Ranking of the Top 13 DOE Installations by HW Generation Rates and Off-Site Shipments to Commercial Facilities[1]

DOE Installation	HW Generated in 1991 (t)	DOE Installation	HW Shipped Off-Site in 1991 (t)	DOE Installation	HW Shipped Off-Site in 1992 (t)
KCP	343,229.2	LLNL	1,199.0	Pantex	2,784.3
SNL-A	130,271.0	KCP	565.5	LANL	2,069.2
ORR[2]	70,906.3	Pantex	562.0	LLNL	1,561.3
SRS	59,073.7	Hanford	185.5	INEL	782.1
RFP	43,127.8	ORR[2,3]	131.5	KCP	616.5
INEL	33,490.0	LANL	121.0	Hanford	463.3
Pantex	6,388.7	SNL-A	87.8	SNL-A	310.0
LLNL	1,673.2	SRS	86.8	ANL-E	262.1
Hanford	327.7	ANL-E	55.7	Fermi	171.4
LANL	162.4	NTS	47.0	SRS	159.9
ANL-E	57.3	INEL	34.7	ORR[2]	118.6
NTS	49.3	RFP	17.1	NTS	97.3
Fermi	28.5	Fermi	16.6	RFP	67.9
Total	688,785.1	Total	3,110.2	Total	9,463.9

[1] All Units are in metric tonnes (t)
[2] Combined total for three ORR installations: ORNL, K-25, Y-12
[3] An additional 425.5 t was shipped for on-site storage or incineration at the K-25 site.

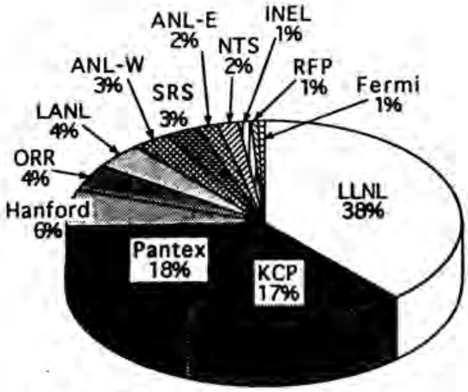

FIG. 1a Top 13 DOE Installations Ranked Hazardous Waste Off-Site Shipments in 1991

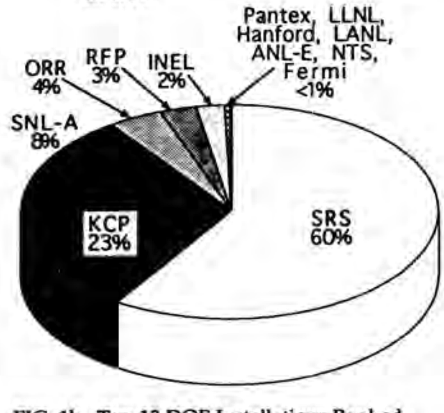

FIG. 1b Top 13 DOE Installations Ranked Hazardous Waste Generation in 1991

Fig. 1. Distribution of top 13 DOE hazardous waste generators and shippers, 1991.

Disposal Restriction treatment standards for "newly identified" wastes in 1994.

- **Recycling (13.0 t)**: Most DOE "recycled" wastes are lead acid storage batteries and scrap metal (not regulated as a HW when recycled).
- **Decontamination (0 t)**: Used infrequently for off-site treatment; most applicable to on-site treatment of remediation waste

Table IV shows the new preliminary HW generation rate rankings, on-site treatment, on-site storage and off-site treatment for the top DOE generators in 1991 summarized from the available biennial reports. The available data show that the installations with the highest HW generation rates, the top seven generators, account for over 90% of the DOE complex-wide HW generation. Each of these generators has a very large wastewater treatment operation, accounting for over 78% of their total HW generation.

DOE On-Site Treatment

The biennial reports indicate that the following technologies were used for the on-site treatment of DOE waste during calendar year 1991 (once again, the order of appearance reflects the overall ranking of each technology based on waste volumes treated):

- **Aqueous Treatment of Organics and Inorganics (> 667,000 t)**: Most commonly employed in the treatment of hazardous wastewater at INEL, Pantex, ORR, KCP, SRS, and RFP; figures do not include groundwater treatment associated with remediation.
- **Deactivation (456.6 t)**: Used primarily for controlled detonation or destruction of explosives at Pantex (78,717 kg) and ORR (327,891 kg), and for neutralization of corrosive waste (over 50,000 kg) at SNL-A, ORR, and Fermi.
- **Incineration (70.4 t)***: Incineration capabilities exist at SRS, ORR, INEL, and LANL; information contained in reference 6 would suggest that only the incinerators at ORR and SRS are of the type suitable for the destruction of lab packs (the largest category or type of HW generated by DOE that routinely requires incineration); two installations reported on-site incineration in 1991 (17.4 t at INEL and 53.0 t at ORR).
- **Organic Removal/Recovery (12.3 t)**: Primarily batch distillation of spent solvents at LANL, KCP, SRS, and NTS.
- **Metal Removal/Recovery (7.8 t)**: Primarily silver removal/recovery at SRS (silver removal/recovery from photographic solutions could easily be conducted at all DOE sites generating this type of waste).
- **Stabilization (2.3 t)**: Stabilization occurred only at INEL; from a practical standpoint, sites conducting stabilization generally require a permitted on-site HW landfill for final deposition of the stabilized waste.

The above information indicates that DOE is treating over 96% of the RCRA HW generated on-site. Off-site treatment, while a critical part of the overall waste management program, accounts for less than 1% of the total volume of HW generated. This information is consistent with a study recently conducted by Environmental Information, Ltd., on behalf of the National Solid Waste Management Association (10). Though the study concluded that more than 95% of U.S. manufacturing facilities that generate HW send all waste off-site for treatment and/or disposal, it was also noted that larger generators with in-house wastewater treatment plants or underground injection wells treat approximately 95% of their HW on-site. This is consistent with operations at INEL, Pantex, ORR, KCP, SRS, and RFP.

Figure 2 compares relative differences in off-site versus on-site treatment within each of the nine TSD technology groups. This comparison provides a clear picture DOE's HW management practice, even though the comparison is between non-completely overlapping periods (calendar year 1991 for the biennial reporting of on-site treated waste versus FY 1992 for manifested data on the HW shipped and treated off-site). Except for the aqueous and deactivation HW treatment, most of the HW was treated by commercial facilities rather than by DOE facilities. In the case of incineration, the thermally

* Due to the HW moratorium, all waste thermally destroyed in the K-25 incinerator at ORR was classified as mixed waste. It is unknown how much of the 53 t incinerated in 1991 was in fact non-contaminated HW.

TABLE IV

Hazardous Waste Generation, Treatment, Storage and Shipment Data for the Largest DOE HW Generators[1]

DOE Sites	Generated t	On-Site Wastewater Treatment t (%)	Other On-Site Treatment t (%)	Shipped Off-Site t (%)	Stored On-Site t (%)
KCP[2]	343,229.2	342,582.2 (99.8)	3.8 (~0.0)	565.5 (0.18)	77.7 (0.02)
SNL-A	130,271.0	130,176.4 (99.9)	6.8 (0.0)	87.8 (0.1)	0.0 (0.0)
ORR[3]	70,906.3	55,740.5 (78.6)	394.9 (0.6)	557.4[4] (0.8)	14,213.5 (20.0)
ORNL	*1,277.2*	*0.0 (0.0)*	*0.0 (0.0)*	*541.8[4] (42.4)*	*735.4 (57.6)*
K-25	*62,529.1*	*50,069.0 (80.1)*	*67.0 (0.1)*	*0.0 (0.0)*	*12,393.1 (19.8)*
Y-12	*7,100.0*	*5,671.5 (79.9)*	*327.9 (4.6)*	*15.7 (0.2)*	*1,084.9 (15.3)*
SRS[2]	59,073.7	58,941.6 (99.7)	33.5 (0.06)	86.8 (0.15)	11.8 (0.02)
RFP	43,127.8	43,102.2 (99.9)	0.9 (0.0)	17.1 (0.1)	7.6 (0.0)
INEL	33,490.0	33,372.8 (99.7)	19.8 (0.0)	34.7 (0.1)	62.7 (0.2)
Pantex	6,388.7	3,058.3 (47.8)	83.2 (1.3)	562.0 (8.8)	2,635.2 (41.2)
LLNL	1,673.2	245.7 (14.7)	43.5 (2.6)	1,199.0 (71.6)	185.0 (11.1)
HS	327.7	0.0 (0.0)	0.0 (0.0)	185.5 (56.6)	142.1 (43.4)
LANL	162.4	0.0 (0.0)	1.7 (1.0)	121.0 (74.5)	39.8 (24.5)
ANL-E	57.3	0.0 (0.0)	0.0 (0.0)	55.7 (97.2)	1.6 (2.8)
NTS	49.3	0.0 (0.0)	2.3 (5.0)	47.0 (95.0)	0.0 (0.0)
Fermi	28.5	0.0 (0.0)	0.0 (0.0)	16.6 (58.2)	11.9 (41.8)
Total	688,785.1	667,219.7 (96.9)	590.4 (0.1)	3,536.1 (0.5)	17,388.9 (2.5)

[1] From 1991 biennial reports; all units are in metric tonnes (t)

[2] Excludes wastewater treatment of groundwater remediation waste reported in KCP and SRS biennial reports

3 Oak Ridge National Laboratory (ORNL), K-25 Site , and the Y-12 Plant make up the Oak Ridge Reservation

[4] Amount includes 425.5 t shipped for on-site storage or incineration at the K-25 site.

destroyed waste (in the TSCA incinerator at ORR/K-25 site) was characterized as mixed/HW in the biennial report.

FUTURE DEVELOPMENTS

The HaWRAM database has initially been established as an information source for data related primarily to shipments of HW by the various DOE facilities around the country. As discussed above, off-site shipments account for less than 2% of the HW generated by DOE. It is clear from review of recently obtained alternative data sources that this database needs to be enhanced and improved. The incorporation of data from the biennial reports in the database would provide a more accurate assessment of the utilized treatment technologies and the actual HW generation rates. To realize the full capabilities of the system, the database would need to be expanded to include information from the biennial reports (especially from the 1993 biennial reports expected to be submitted to EPA in March 1994), as well as other important sources of information.

Efforts to obtain information for the HaWRAM database highlighted that there is no single, centralized source of information for all data associated with DOE HW management activities. The HaWRAM database could easily be expanded to meet this need. Such an expansion would not require the DOE installations to develop or prepare any new reporting forms or other documents. It would require a commitment by each DOE site to submit duplicate copies of reports prepared for EPA or the authorized state(s) to the HaWRAM database management center*. All appropriate information could then be entered in the HaWRAM database. For the first time, there would exist a readily accessible central repository for detailed information concerning HW management activities at all DOE sites.

Along with data from the manifests and biennial reports, the HaWRAM database could also be expanded to include data from other information sources (for example, annual or even quarterly reports are available from many of the states in which DOE operates).

PEIS IMPLICATIONS

The HaWRAM database, as originally structured, is a transportation or shipment modeling database and is therefore not applicable to the accurate accounting of HW generation or the accurate identification of existing on-site treatment, such as wastewater treatment.

When updated with data from the biennial reports and other data sources, the HaWRAM database, in conjunction with its use in the PEIS risk and cost assessments, will help

* Biennial report information is usually not available from EPA until two to three years after the required submission date.

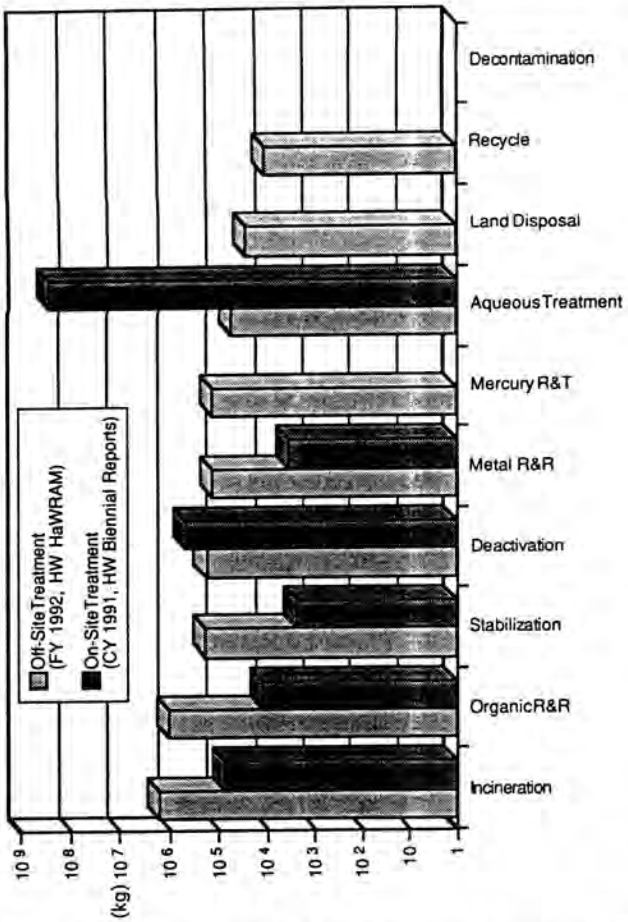

Fig. 2. On-site versus off-site hazardous waste treatment, by treatment group.

DOE determine the extent to which it should continue current HW management practices. DOE is in the process of evaluating the potential public and worker health risks, TSD technology costs, and other potential environmental impacts associated with four alternatives for HW management at DOE installations. Each of these alternatives is briefly described below.

- **Alternative 0 - No Action**: This alternative would first encourage HW minimization to the extent possible. It would continue to maintain and operate existing and approved DOE HW TSD facilities at DOE installations according to approved permit requirements. It would also continue manifesting and packaging of HW for shipment to commercially permitted TSD facilities.
- **Alternative 1 - Decentralization**: Under decentralization, the "no action" alternative would continue at each DOE site, but shipment to commercial TSD facilities would be optimized by eliminating or limiting the amount of "brokered" HW. Brokered waste is waste that is sent to a bulking facility where combined or bulked with waste shipments from other generators before shipment to another broker or to final treatment and disposal. This alternative would also include planned new, but not approved, TSD capacity.
- **Alternative 2 - Regionalization**: This alternative targets approximately 50% of DOE's commercially treated HW (primarily waste for incineration and organic removal/recovery) for treatment at five designated DOE TSD facilities or regional hubs (LANL, INEL, HS, SRS, and ORR). To accomplish this target, the top 11 generators would send two-thirds of their waste requiring incineration or organic removal/recovery ("waste-fuel" burning) to three DOE regional hubs (LANL, HS, and ORR). Two installations (SRS and INEL) would treat only their HW. Hazardous waste not treated at these five installations would be sent to commercial TSD facilities. The remaining HW would be shipped off-site to selected commercial facilities.
- **Alternative 3 - Centralization**: This alternative targets approximately 80-90% of the complex-wide commercially treated HW for treatment at two designated centralized DOE TSD facilities. To accomplish this target, the top 11 DOE generators would send over 95% of their waste requiring incineration and organic removal/recovery to two DOE centralized hubs, ORR and INEL. Complex-wide commercially treated HW remaining under the "no action" alternative would be shipped off-site to commercial facilities.

Preliminary database findings could be used in defining, adjusting, and refining the detail needed to evaluate these alternatives. For example, the 11 designated DOE installations referenced in the regionalized and centralized alternatives were selected based on the relative magnitude or quantities of manifested HW, geographic location, and the physical-chemical representativeness of the manifested HW to that of the DOE complex as a whole. The preliminary data on HW generation obtained from the review of the biennial reports instead of manifests indicate that although the relative rankings of the top 11 generators change (see Figs. 1a and 1b), the only change in the mix of designated installations would involve replacing the RFP for Fermi (see Table III) in the evaluation of alternatives. This adjustment, although probably relatively minor from a risk and cost perspective, may not be minor from a HW management practice or policy perspective.

In addition to necessary adjustments or refinements of alternatives, further detail or refinements can also be used to define alternatives to the level required for assessing risk and environmental impacts, and eventually provide information on how these alternatives, if selected by DOE, might be implemented in the most practical and cost-effective manner. As an example, further examination of the preliminary findings reveals that more than 98% of the HW routinely generated by DOE is already being treated on-site. To provide for treatment of the remaining waste fractions (the 2% or less that is currently being sent off-site), the evaluation of the proposed regionalized and centralized alternatives can use this and other information to provide for more efficient utilization of both existing DOE and commercial capabilities. Analysis of the proposed regionalized and centralized alternatives could consider the following:

- Wastes that require incineration could be managed by both DOE and commercial facilities. All such waste from the eastern half of the U.S. would be shipped to ORR or SRS (the only DOE facilities that have the type of incinerator suitable for treating most types of waste). In the West, if current conditions prevail (many existing commercial incinerators operate well below capacity), all incinerable DOE waste could be shipped to one or two selected commercial facilities. If this excess commercial capacity is not projected to continue to exist, then DOE regionalized and/or centralized western TSD hubs could be established.

- Much of the DOE waste that is being treated through an organic removal/recovery technology is currently being blended at commercial sites for use as HW fuel. Some DOE sites already have most of the equipment and expertise needed for fuel blending. Selected sites could provide this service in-house for all DOE facilities. Properly blended HW fuels could be used as an auxiliary fuel at any of the existing DOE incinerators (LANL, INEL, ORR, or SRS). Excess HW fuel could be sent to commercial industrial facilities permitted to burn this energy source.
- Both Pantex and ORR have the resources to treat reactive (explosive) HW on-site. Pantex and ORR would appear to be a likely choice for providing this type of treatment for all the other DOE facilities.
- DOE sites that are already managing large volumes of waste through some type of on-site aqueous treatment could accept and treat similar waste from smaller DOE installations. These smaller installations are typically constrained to use TSD facilities with existing DOE contracts.
- All remaining wastes could be shipped directly to carefully selected commercial facilities. Care should be taken to assure that the facilities selected provide the most effective type of treatment for the particular waste. In the past, the off-site treatment technologies selected by some DOE sites were not the most appropriate for the waste being managed (e.g., incineration of aqueous or corrosive wastes, incineration of large volumes of petroleum-contaminated soil).
- When not constrained by treatment technologies or treatment levels mandated in EPA's land disposal restrictions, the choice of treatment technology by the individual installations for the various waste types is often made not based on the least costly treatment technology but with a bias on favoring incineration (lower liability problems) and/or based on long-term contractual arrangements with commercial TSD facilities. Conservation of resources (e.g., recovery of silver from photographic waste) and minimizing cost often were not important considerations for outside waste shipments. An aggressive overall DOE strategy that specifically targets resource conservation with much more emphasis on recycling and other pollution prevention measures could lead to significant cost savings through better resource recovery and smaller waste-loads needing treatment.

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