LOCATIONS, VOLUMES, AND CHARACTERISTICS OF DOE'S MIXED LOW-LEVEL WASTES

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ABSTRACT

The Mixed Waste Treatment Project (MWTP) has collected and analyzed mixed low-level waste data to assist in developing treatment capability for the U.S. Department of Energy's (DOE) wastes. Initial data on the characteristics of mixed waste was obtained from the Waste Management Information System (WMIS) data base, and has been updated based on visits to DOE sites where most of the wastes are generated and stored. The streams of interest have a current inventory of about 70,000 m^3 and a generation rate of about 7,700 m^3/yr. The twelve sites with the most significant processing needs are Fernald, Hanford, K-25 (Oak Ridge), Idaho National Engineering Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory (ORNL), Paducah Gaseous Diffusion Plant, Portsmouth Gaseous Diffusion Plant, Rocky Flats Plant, Savannah River Site (SRS), and Y-12 (Oak Ridge). These twelve sites account for about 98% of the mixed waste volumes.

The wastes have been assigned to specific waste characterization categories. The largest category in current interim storage is inorganic solids, with sludges, filter cakes, and residues the largest specific subcategory. Aqueous liquids are the largest currently generated stream. The other large categories are solid organics, metals wastes, and heterogenous wastes. Organic liquids, which have been a major focus, are the smallest of the categories.

INTRODUCTION

The DOE has generated and continues to generate a significant volume of mixed low-level wastes at 30 different sites across the country. These wastes are generally going into interim storage, and need to be treated to allow their disposal. The Mixed Waste Treatment Project (MWTP) has been established to coordinate DOE's efforts in mixed waste treatment. The primary objectives of the MWTP are to select, integrate, operate, and deploy nationally a set of technologies for mixed waste treatment. The project will identify applicable technologies and then aid in selecting the best set of alternatives for an initial prototype plant. Multiple technologies will require the integration of various parts of the treatment system into a total overall flowsheet. The integration process will need to consider the specific problems at each site and the appropriate method to balance the various site needs into a prototype treatment facility. The initial plant will serve as a standardization facility for subsequent facilities, and will provide the opportunity to improve the system design and operation. The scope and status of the MWTP are described in another paper in this session (1).

A key function of the MWTP is to identify the characteristics and volumes of mixed low-level wastes. This data is needed for the selection of technologies to treat the wastes and the identification of the sites where wastes will need to be treated. The identification of treatment technologies and development needs is also described in a companion paper (2).

Several data bases and waste volume reports have been prepared during the past several years. The major DOE data base for hazardous wastes, called the Waste Management Information System Data Base (WMIS), is maintained by HAZWRAP at Oak Ridge. This data base was first developed for a report entitled the National Report on Prohibited Waste and Treatment Options, completed by DOE in 1989 in response to the Rocky Flats Federal Facilities Compliance Agreement with the Environmental Protection Agency (EPA). It was used for development of the DOE Case-By-Case Extension Application (3) that was recently submitted to the EPA. It is also the major source of information on mixed and low-level wastes for the DOE's Integrated Data Base Report (4). Although these reports contain a detailed listing of the wastes, they did not contain sufficient information for use by the MWTP. While the sites have made substantial efforts to identify hazardous components in the wastes, information on the waste matrix was generally lacking.

DATA-GATHERING ACTIVITIES

To obtain more detailed information about wastes, the authors have visited the major DOE sites to enhance and update the information in the WMIS. The following information was desired for each waste stream:

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- Location and responsible parties
- Unique name
- Description of how the stream was generated and what it is
- Basic RCRA information - its LDR category and applicable EPA codes
- Hazardous constituents, including PCBs and their concentrations
- Chemical matrix and concentration of major components
- Radionuclide types, activity and handling category
- Physical forms and sizes, container sizes, special packaging information
- Waste inventory volumes and location, and expected generation rates.

New information obtained from the visits is being used to update the WMIS data base, and some data is being reported here for the first time. However, much of the desired information was not available for many streams. Information on waste characteristics continues to evolve as regulations governing waste generation, storage, treatment, and disposal are better understood. The quality of the data continues to improve as the sites complete characterization, classification, and treatment activities. The data also continue to be regrouped based on the definition and groupings of waste streams by the various sites.

LOCATIONS AND VOLUMES OF WASTE

The existing data have been sorted by site and aggregated as total current inventory and expected total generation rate. It is very difficult to project the future generation rate of waste streams since DOE programs are continuing to change and sites are having major success in waste minimization activities to reduce future waste generation.

The data for inventory and generation rate are listed by site in Table I. Four major waste streams have been omitted from the data base. Two streams are at the Hanford site, where much of the single-shell and double-shell tank wastes are classified as mixed waste. These two streams are the largest DOE mixed-waste streams and amount to about 218,000 m^3 of existing inventory and 13,000 m^3/yr of annual generation. A grout treatment facility has been established at Hanford to treat these wastes and prepare them for disposal. The third waste stream is a partially cemented and uncemented sludge from the waste pond at the K-25 site. This stream, with a volume of about 28,000 m^3, is also large enough to be treated in a dedicated facility, although such a facility is yet to be defined. The fourth waste stream is the "Pondcrete" at the Rocky Flats site. This stream is currently being treated.

The 12 sites with the most significant processing needs are Fernald, Hanford, K-25 (Oak Ridge), Idaho National Engineering Laboratory (INEL), Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), Paducah Gaseous Diffusion Plant, Portsmouth Gaseous Diffusion Plant, Rocky Flats Plant (RFP), Savannah River Site (SRS), and Y-12 (Oak Ridge). These 12 sites account for about 98% of the mixed waste volumes. The relative current inventory and generation rate for the largest sites are shown in Fig. 1.

As can be noted, INEL currently has the largest inventory of waste. The waste, however, will be from reclassification of currently stored TRU wastes that were shipped from RFP. Y-12, SRS, and K-25 are the other sites with significant current inventories. INEL also has the largest generation rate as the result of one large stream that they plan to evaporate and treat with their intermediate-level waste. Without that stream, INEL's generation rate is only 31 m^3/yr and they are one of the smaller waste generation sites. Likewise, the high generation rate at SRS is from aqueous waste streams. It is not expected that these streams will continue to be stored as high volume aqueous streams, but that they will be treated and appear as concentrates or sludges in the future.

WASTE CHARACTERISTICS

To develop additional information about the wastes, each stream has been assigned a waste matrix category. The first digit of the code assigns the waste stream to one of seven major treatment categories: aqueous liquids, organic liquids, inorganic solids, metal wastes, organic solids, heterogenous wastes and potential problem wastes. The division between aqueous and organic liquids is the 1% organic level in reflection of the RCRA requirements. The inorganic solids leave a high residue in incineration processes and may be processed by melting or vitrification-type thermal processes. The metal wastes represent nearly pure metal streams that may require specific treatment technologies. The organic solids are generally those that would produce less residue from incineration or other thermal processes. The inorganic solids and organic solids are divided between wet and dry solids since that division can be important for some process operations. The heterogenous wastes are the most difficult to treat and contain mixtures of inorganic solids, metals, and organic solids. It may be desirable or necessary to separate the heterogenous wastes into the other three types of solids for processing. The last category is the potential problem wastes. These wastes need further evaluation to allow their incorporation into one of the other categories or to determine if specific processes are needed for them. The relative quantities of major categories of waste are shown in Fig. 2. As can be noted, the inorganic solids are the largest current inventory with nearly equal amounts of metal wastes, organic solids, and heterogenous wastes. It is interesting to note the relatively small volume of organic liquids, which have been a primary focus of much of the previous technology development activities.

As shown in Fig. 3, the seven categories have been further subdivided to provide additional details where possible. Each waste stream has been generally assigned to a specific subcategory. Wastes with multiple characteristics or that could not be defined at a lower level were generally assigned to the major category. For example, if the waste is acidic (W110) and contains a toxic metal (W150), it is simply included as an aqueous liquid waste (W100). Likewise, a large metal stream exists at INEL that cannot be separated into ferrous and nonferrous streams. This stream was included in the "W400-Metal Waste" stream. These resulted in wastes for the major categories of W100, W400, and W600, but not the other major categories. A priority was assigned to wastes with mercury, lead, or PCB content. Wastes with one of these components were grouped together in those specific categories regardless of their other characteristics. The national volumes and

TABLE I

Waste Volume Information for the DOE Sites

	Current Iventory (m^3)[(a)]	Generation Rate (m^3/yr)
Ames Laboratory	0.10	0.10
Argonne National Laboratory - East	0.00	36.24
Argonne National Laboratory - west	9.05	0.95
Bettis	6.56	0.35
Brookhaven National Laboratory	15.83	10.65
Colonie Interim Storage Site	38.77	0.00
Fermi National Accelerator Laboratory	2.10	0.00
Fernald	3928.70	16.80
Grand Junction Project Office	0.06	0.09
Hanford Site	2285.98	144.20
Idaho National Engineering Laboratory	26716.26	2758.51
IT Research Institute	0.20	1.00
K-25 Site	7035.50	112.00
Kansas City Plant	3.73	2.47
Knolls Atomic Power Laboratory	0.00	0.45
Lawrence Berkeley Laboratory	3.80	0.02
Lawrence Livermore National Laboratory	134.50	102.00
Los Alamos National Laboratory	323.93	85.34
Mound Facility	40.60	2.00
Nevada Test SitE	0.00	48.70
Oak Ridge National Laboratory	1268.16	16.28
Paducah Gaseous Diffusion Plant	602.96	30.62
Pantex Plant	95.47	5.30
Portsmouth Gaseous Diffusion Plant	4900.57	311.59
Princeton Plasma Physics Laboratory	0.02	0.01
Rocky Flats Plant	3438.25	423.20
Sandia National Laboratory Albuquerque	0.00	166.80
Sandia National Laboratory Livermore	0.14	0.42
Santa Susana Field Laboratory (etec)	3.32	0.00
Savannah River Site	9038.51	1610.65
Weldon Spring Site Remedial Actions	56.05	0.00
West Valley	20.00	1.00
Y-12	9972.30	1801.02
Totals	69941.42	7688.71

(a) Note the number of significant figures shown for consistency in calculations exceeds the accuracy of the data.

generation rates for each of the major categories and subcategories are shown in Table II. The subcategories provide additional details about the relative waste quantities. The highest volume current inventory subcategory is W311 (sludges, filter cakes, and residues), which is generally generated from waste water treatment. The other large subcategories are cemented sludges, metal wastes, dry organic solids, and construction, cleanup, and process debris. It can also be noted that aqueous acidic wastes amount to nearly half the current waste generation. Significant aqueous streams have been classified as mixed wastes at both INEL and SRS. The largest potential problem waste is also an aqueous waste with some tritium contamination. Further evaluation is needed to determine the significance of the tritium contamination. It can be noted that there are only small waste volumes for many of the subcategories, suggesting a need for processes that can treat several subcategories of wastes rather than having specific treatments for each waste category. Also, although wastes have been assigned to a specific category, they will likely contain other waste categories. For example, most of the wastes are contained in plastic bags and drum liners that would be solid organics. The drums may not be readily separable from the waste, and so the waste will also contain the metal from the drum. It has also been reported that hardware items may have been disposed within sludge drums to minimize the volume of waste shipped. Therefore, the waste streams are not pure materials, and the processes selected for their treatment will need to accommodate various components.

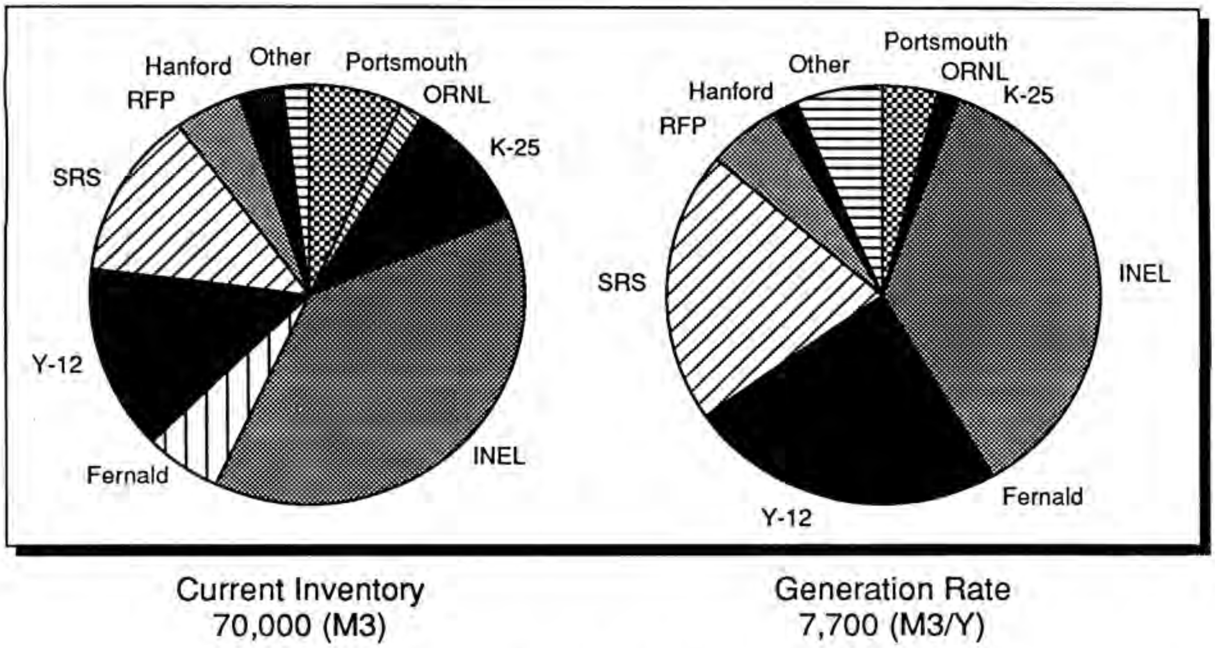

Fig. 1. Distribution of mixed low-level wastes at DOE sites.

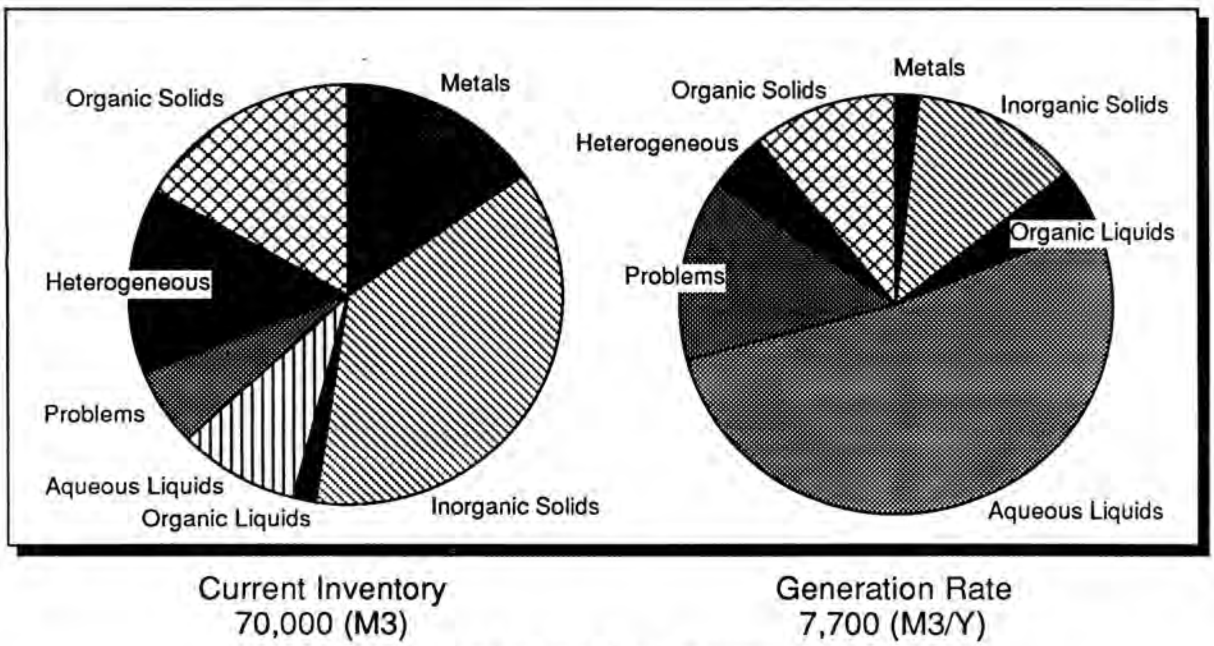

Fig. 2. Relative fractions of major waste categories.

The distribution of the waste types at each of the 12 major sites was also determined and is shown in Table III for both the current inventory and generation rate by major category of waste. Analysis of the waste stream information from each of the sites shows that no two sites have the same distribution of wastes, and in fact each site is dominated by a different type of waste. For the current inventory of wastes, aqueous wastes are of the highest inventory at ORNL and SRS; inorganic solids at Fernald, Hanford, K-25, LANL, Paducah, Rocky Flats, and Y-12; metal wastes at INEL; and heterogenous solids at Portsmouth. For generation rates, aqueous wastes represent the greatest generation rate at INEL, LLNL, and Y-12; organic liquids at Fernald, ORNL and Paducah; inorganic solids at K-25, LANL, and Rocky Flats; organic solids at Hanford; PCB wastes at Portsmouth; and tritium aqueous wastes at SRS. This distribution suggests that the treatment technologies selected will need to accommodate major changes in the waste compositions.

The data on RCRA and radioisotope contamination have also been accumulated to provide additional perspectives. The RCRA divisions are based on the EPA codes assigned to the streams. The wastes have been divided into three categories: 1) characteristic or regulated organic-containing wastes, 2) wastes with heavy metals that require stabilization or immobilization, and 3) wastes that are both organic or characteristic, and heavy metals. The relative fractions are shown in

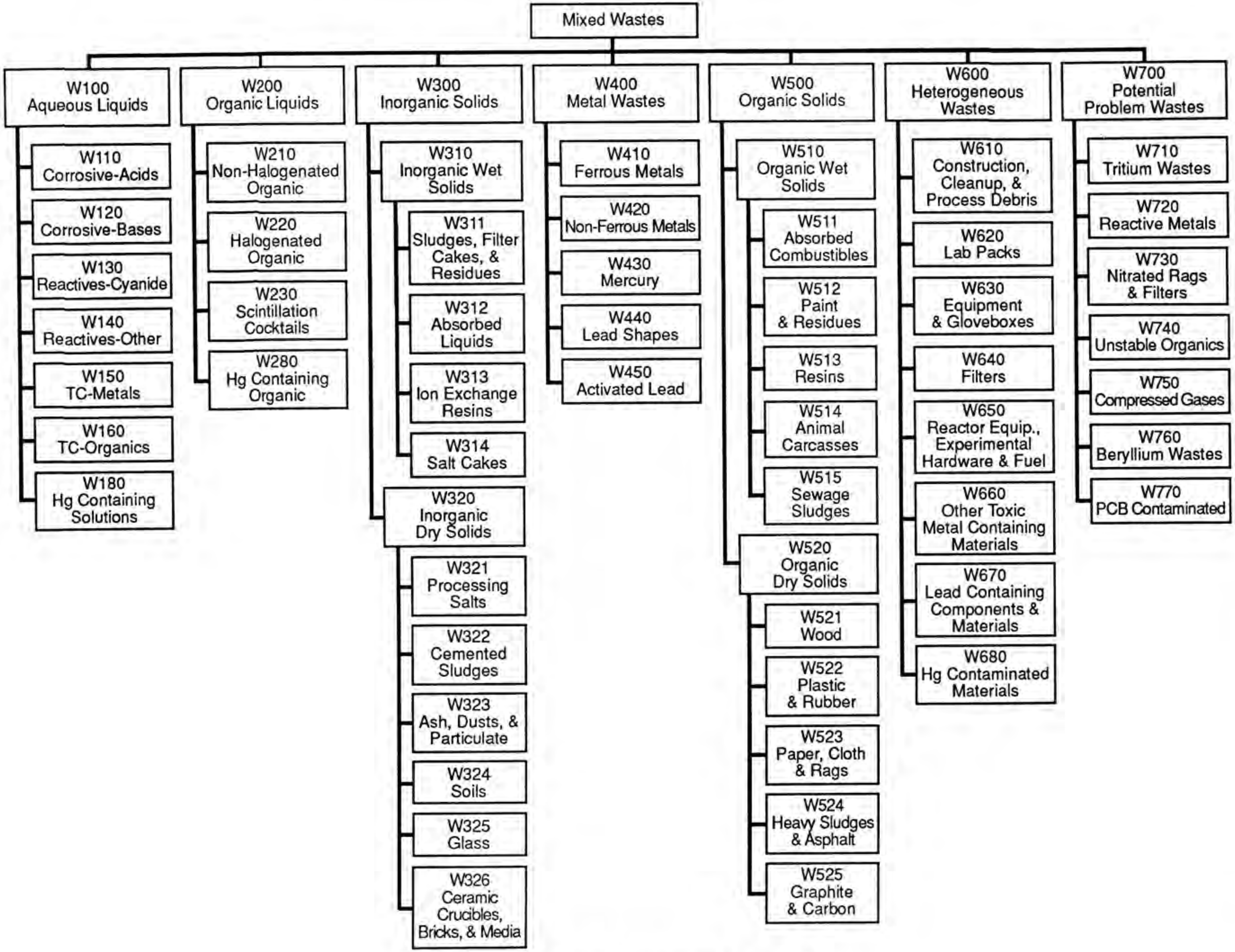

Fig. 3. Mixed waste matrix characterization categories.

TABLE II

Volumes and Generation Rates for Categories of Wastes

Code Number	Mixed Waste Category	Current Inventory (m^3) [(a)]	Generation Rate (m^3/yr)
W100	Aqueous Liquids	1974.96	249.31
W140	Reactives - Other	0.00	0.00
W150	TC -Metals	3990.89	197.02
W160	TC-Organics	64.08	68.95
W180	Hg Containing Solutions	102.08	0.02
	Subtotal	6285.80	4264.01
W200	Organic Liquids	0.00	0.00
W210	Non-Halogenated Organic	259.09	226.29
W220	Halogenated Organic	794.92	112.14
W230	Scintillation Cocktails	146.09	26.58
W280	Hg Containing Organic	4.48	0.54
	Subtotal	1204.58	365.55
W300	Inorganic Solids	0.00	0.00
W310	Wet Inorganic Solids	0.00	0.00
W311	Sludges, Filter Cakes, & Residues	11812.44	685.33
W312	Absorbed Liquids	320.71	0.06
W313	Ion Exchange Resins	0.00	0.00
W314	Salt Cakes	127.50	0.00
W320	Dry Inorganic Solids	1408.09	0.07
W321	Processing Salts	133.33	4.11
W322	Cemented Sludges	9236.20	250.20
W323	Ash, Dusts, and Particulates	1017.46	36.08
W324	Soils	363.59	38.11
W325	Glass	577.14	8.47
W326	Ceramic Crucibles, Bricks, & Media	873.46	1.00
	Subtotal	25869.92	1023.43
W400	Metal Wastes	9976.19	36.00
W410	Ferrous Metals	0.00	0.00
W420	Non-Ferrous Metals	4.80	1.00
W430	Mercury	2.76	0.68
W440	Lead Shapes	754.79	107.98
W450	Activated Lead	1.29	0.07
	Subtotal	10739.83	145.73
W500	Organic Solids	0.00	0.00
W510	Wet Organic Solids	33.34	9.52
W511	Absorbed Combustibles	113.22	31.08
W512	Paint & Residues	30.81	10.36
W513	Resins	10.00	0.00
W514	Animal Carcasses	0.00	0.02
W515	Sewage Sludges	0.00	0.00
W520	Dry Organic Solids	7731.10	115.30
W521	Wood	0.00	0.00
W522	Plastic & Rubber	74.60	1.40
W523	Paper, Cloth & Rags	3647.97	2.83
W524	Heavy Sludges & Asphalt	142.60	0.83
W525	Graphite and Carbon	0.00	217.00
	Subtotal	11783.63	388.34
W600	Heterogeneous Wastes	26.62	6.20
W610	Construction, Cleanup & Process Debris	7523.94	86.36

TABLE II
(Cont.)

Code Number	Mixed Waste Category	Current Inventory (m^3)[(a)]	Generation Rate (m^3/yr)
W620	Lab Packs	84.27	26.16
W630	Equipment and Gloveboxes	2.50	3.00
W640	Filters	2058.59	60.63
W650	Reactor Equipment, Exp. Hardware & Fuel	0.22	140.81
W660	Other Toxic Metal Containing Materials	96.77	12.75
W670	Lead Containing Components and Materials	6.62	1.09
W680	Hg Contaminated Materials	109.43	31.96
	Subtotal	9908.96	368.96
W700	Potential Problem Wastes	0.00	0.00
W710	Tritium Wastes	36.71	973.87
W720	Pyrophorics	6.11	0.46
W730	Nitrated Rags and Filters	12.48	0.00
W740	Unstable Organics	0.00	0.00
W750	Compressed Gases	8.10	8.10
W760	Beryllium Wastes	1.20	0.80
W770	PCB Contaminated	4084.11	149.45
	Subtotal	4148.71	1132.68
Total all Categories		69941.43	7688.71

[(a)] Note the number of significant figures shown for consistency in calculations exceeds the accuracy of the data.

Fig. 4. As can be noted, over half the existing wastes require treatment for both reactives or organics and heavy metals, whereas about 60% of the current generation wastes will require treatment for characteristic or organic content. The large fraction of wastes that will require treatment for both types of content indicate a strong need for flexible treatment, stabilization or immobilization technologies. A large fraction of the stored wastes are mixtures of kinds of wastes described as debris in EPA's recently proposed rule (5). Here, treatment for regulated constituents is extraction, destruction, and immobilization. Specific treatments are assigned to waste categories. In cases of mixtures of waste categories, trains of treatment processes are anticipated.

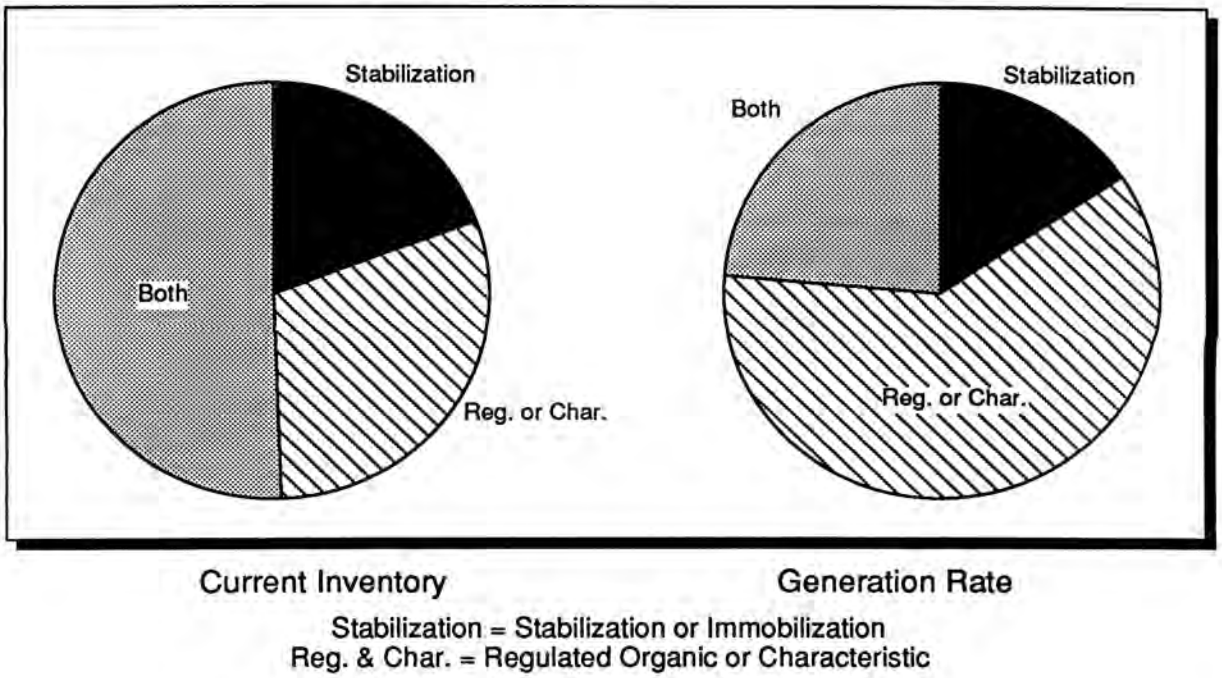

Fig. 4. Distribution of RCRA treatment needs for all wastes.

TABLE III

Current Inventory and Generation Rates at the Twelve Major Sites for Various Waste Types

	Current Inventory (m^3)							
Site	W100	W200	W300	W400	W500	W600	W700	Site
Fernald	14	418	2647	0	151	699	0	3930
Hanford Site	1	0	1829	116	187	119	33	2285
INEL	122	4	5052	10152	7328	4058	0	26716
K-25 Site	112	50	6856	0	18	0	0	7036
LLNL	43	0	0	0	43	49	0	135
LANL	7	70	154	62	10	8	13	324
ORNL	1092	108	63	1	4	1	0	1268
Paducah	0	87	476	3	6	2	29	603
Portsmouth	95	39	187	38	3	3926	613	4901
Rocky Flats Plant	57	110	2749	50	351	109	12	3438
Savannah River Site	4740	5	34	293	3632	291	45	9039
Y-12	0	204	5776	0	37	557	3398	9972
Total of Major Sites	6282	1095	25823	0715	11769	9819	4142	69645
	Annual Generation Rates (m^3/year)							
Site	W100	W200	W300	W400	W500	W600	W700	Site
Fernald	1	9	0	0	7	0	0	17
Hanford Site	0	0	14	33	53	34	9	144
INEL	2735	3	4	10	0	6	0	2758
K-25 Site	17	25	65	0	5	0	0	112
LLNL	80	6	2	0	0	14	0	102
LANL	1	17	50	12	3	2	0	85
ORNL	1	13	0	1	1	1	0	16
Paducah	0	25	3	1	1	0	0	31
Portsmouth	38	11	59	15	33	56	100	312
Rocky Flats Plant	1	18	300	29	56	18	1	423
Savannah River Site	389	191	1	6	0	43	981	1611
Y-12	983	30	501	0	227	20	40	1801
Total of Major Sites	4246	349	999	106	386	195	7412	6264

(a) Note the number of significant figures shown for consistency in calculations exceeds the accuracy of the data.

The majority (about 90%) of the wastes has been categorized according to their radioactive content based on the content of potentially restrictive radionuclides. The content of Pu-238 is viewed as the most restrictive, then Pu-239; fission products; specific radionuclides, with tritium and technetium being the most dominant; and finally uranium, which was considered the least restrictive. Many streams have multiple nuclides. Specific activities for the nuclides in many streams were not available. Therefore, it was considered that any content of the more restrictive nuclide would put that stream into the more restricted category. Obviously, additional characterization data will show that this approach is overly conservative. The results of this categorization are shown in Fig. 5. As can be noted, the largest category is the Pu-239 contamination with uranium-only contamination being the next largest group. System studies will be needed to determine if separate facilities for uranium-only streams are justified.

PLANNED IMPROVEMENTS TO DATA

Our reviews of the data determined that improvements in data quality and consistency are needed since the waste streams and classifications are defined by the 30 different sites. The data would be improved with uniformity in definition of waste streams and classification of specific streams. Currently there are differences with respect to classification of high-level waste, transuranic waste, low-level waste, and PCB waste streams. For example, at Hanford the estimated fraction of low-level waste in double- and single-shell tanks is included as low-level waste, whereas at SRS, wastes in such tanks are classified as high-level waste. With transuranic waste the opposite has occurred: SRS and INEL have included their estimated volume of <100 nCi/g TRU waste as low-level waste, whereas at Hanford, in the absence of adequate characterization information, all suspect waste is categorized as transuranic waste. Resolution of these types of differences would further improve the data. One effort in this direction is the use of common classifications or categories for both the

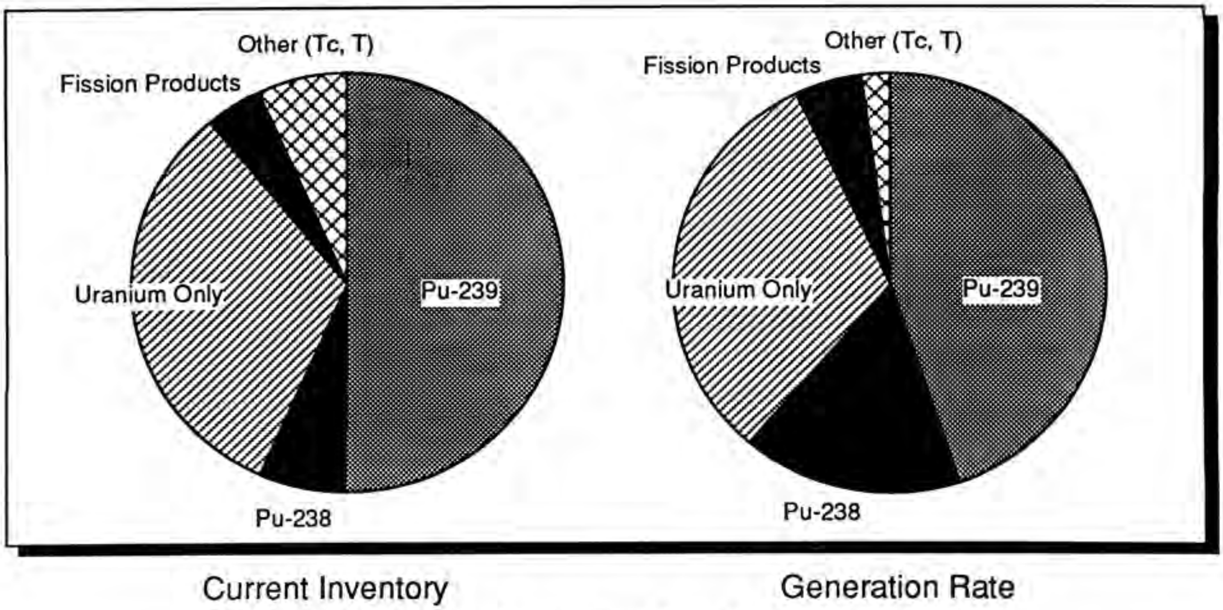

Fig. 5. Distribution of restrictive radionuclides in waste types.

MWTP and the case-by-case data. These efforts will continue to improve the quality and reliability of the mixed waste data. For many specific waste streams, additional review is needed to further increase the amount of information available and to resolve apparent inconsistencies.

Environmental restoration wastes, particularly those resulting from decontamination and decommissioning of many DOE facilities, are anticipated to be of a large volume, although no data are available. Specific information about many of these wastes also will need to be added to data base so that more comprehensive evaluations and plans can be completed.

SUMMARY AND CONCLUSIONS

Mixed waste data are being collected and evaluated by the MWTP together with HAZWRAP and individual sites. The data have indicated several important factors:

- Most wastes are at a few of the 30 DOE sites reporting mixed low-level waste inventory or generation.
- The most significant waste volumes for treatment considerations are the inorganic solids, with the generation of aqueous streams being important at several sites.
- The types of waste in inventory and being generated at each site are different, and flexible processes are needed to minimize the number of treatment processes in the planned MWTP prototype facility.
- Continued data collection and evaluation will be useful in clarifying details and updating the information as additional site characterization efforts are completed.

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