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**Radwaste Inventories and
Projections: An Overview**

Karl J. Notz

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RADWASTE INVENTORIES AND PROJECTIONS: AN OVERVIEW

Karl J. Notz, Editor

Date Published - July 1982

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RADWASTE INVENTORIES AND PROJECTIONS: AN OVERVIEW

Karl J. Notz

ABSTRACT

The Integrated Data Base (IDB) program is sponsored by the Department of Energy (DOE) to provide fully integrated and reconciled inventories, characteristics, and projections (including alternative cases) for spent nuclear fuel and all categories of radioactive waste. The summary papers included in this compendium are drawn from a special session on "Radwaste Inventories and Projections" given at the American Nuclear Society National Meeting in Los Angeles, June 1982. In addition, two other papers are included that were not given at that meeting in order to properly round out this overview.

The IDB program works with, draws on, and provides supporting information to DOE and its contractors in the areas of systems analysis, spent fuel, high-level waste, TRU waste, low-level waste, airborne waste, fuel recycle and transportation, waste isolation, and remedial action programs. The following papers cover: a broad overview of data needs and functions (Chapter 1); the IDB inventory and projection functions (Chapters 2 and 3); systems analysis application (Chapter 4); data needs for national waste terminal storage (Chapter 5); and applications to and from LLW, HLW, and TRU waste (Chapters 6, 7, and 8).

The major results published thus far by the IDB program have been two reports on spent fuel and radwaste inventories and projections. The most recent report (*Spent Fuel and Radioactive Waste Inventories and Projections as of December 31, 1980*, DOE/NE-0017, September 1981) was issued last year. Another updated version is scheduled to be released in September 1982. In addition, supplemental reports dealing with alternatives or providing more detailed backup data will be issued in the future. The program also maintains, updates, and utilizes ORIGEN2 (A. G. Croff, *ORIGEN2 - A Revised and Updated Version of the Oak Ridge Isotope Generation and Depletion Code*, ORNL-5621, July 1980), the most widely used of all the isotopic generation and depletion codes.

1. DATA BASE NEEDS AND FUNCTIONS; NATIONAL PLANNING

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To paraphrase Coleridge's ancient mariner, "numbers, numbers everywhere, but never the ones I really need." We find ourselves inundated by an ocean of numbers, but the data we seek frequently seem to be lost, buried, or obscured in the great volume of extant data. Computerized searching and retrieval is a great help, but it cannot supply that which is not there, nor can it collect, collate, organize, and systematize. There has been a growing need for spent fuel and radwaste inventory and projection data which:

- o cover the total field in an organized and systematic manner;
- o are coherent and self-consistent; in other words, are integrated;
- o are based on clear-cut ground rules and assumptions;
- o have a projection basis which is rational in terms of the current technology;
- o have the capability of dealing easily with alternative projections;
- o start with primary data which are clearly identified as to source;
- o provide a common generic basis for users of such data;
- o provide references or leads to sources of more detailed data, and;
- o are readily available, widely known, and recognized and accepted as the integrated source for such data.

This need has been addressed by the Department of Energy (DOE) by initiating the Integrated Data Base (IDB) program, which is carried out at the Oak Ridge National Laboratory (ORNL). This program integrates all aspects of federal radioactive waste operations, commercial spent nuclear fuel, other commercial, and institutional radioactive waste activities. Program direction is provided by the Resource Management and Planning Office within the Office of the Deputy Assistant Secretary

for Nuclear Waste Management and Fuel Cycle Programs and is jointly sponsored and supported by the Defense Waste and Byproducts Office under the Deputy Assistant Secretary for Defense Programs. ORNL has the primary responsibility for executing the IDB program, but the overall success of the program depends on the cooperation and direct participation of the many program offices and lead offices which have primary responsibilities for spent fuel and the specific radioactive waste forms and waste management functions.

IDB program data, although primarily intended for use by DOE Headquarters, Program Offices and Field Offices, and for Lead Offices and supporting contractors, are also available to other federal and state agencies and the general public. Published information to date includes two inventory and projection reports (see following paper for references) and two bibliographies.^{1,2} In addition, related bibliographies have been issued by the Information Center at ORNL.³⁻⁵ All of the reports in these bibliographies are in the report data base at ORNL and can be machine-searched via the standard indexing methods and by key words.

The overall objective of the IDB program is to provide a consistent, reliable, and referencable set of baseline data for planning and decision-making purposes. Additional objectives include:

- (a) Maintenance of historical and current inventory data, with automated data transfer via magnetic tapes or telephone hookup. This will allow inventory updating to be done easily, smoothly, and essentially error-free. Once set up and running, it will greatly simplify record transfers between generator sites, lead offices, and IDB. It will also assure a consistent set of data for all of the active participants.
- (b) Building a data file of spent fuel and radwaste characteristics, physical and chemical properties, basic packaging data, and basic cost data.
- (c) Dealing with alternative projection cases in an efficient manner via a system of computer codes.
- (d) Providing integrated data and related information to DOE and its support contractors.

The next paper (Notz et. al.) in this special session addresses the subject of inventories. The following paper (Forsberg et. al.) addresses projections. Other papers in this session deal with various aspects of inventories, projections, characteristics, and user needs.

The IDB program is one component of a broader program of supporting functions directed by the Resource Management and Planning Office. Some of these other, related elements are:

- (a) Systems Integration and Comprehensive Program Implementation Plan;⁶
- (b) Development of the Federal plan for Radioactive Waste Management; and
- (c) Preparation of a Waste Management Data Book and a Nuclear Fact Book.

REFERENCES

- 1.a. C. A. Johnson, Radioactive Waste Management Integrated Data Base: A Bibliography, ORNL/TM-7385/V1 (Indices) (September 1980).
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2. C. A. Johnson, Radioactive Waste Management: A Bibliography for the Integrated Data Base Program, ORNL/TM-7385/V3 (1981 Edition) (October 1981).
3. C. S. Fore et al., Low-Level Radioactive Waste Technology: A Selected Annotated Bibliography, ORNL/EIS-133/V1 (September 1978); Vol. 2 (October 1980); Vol. 3 (October 1981).
4. R. A. Faust, C. S. Fore, and N. P. Knox, Nuclear Facility Decommissioning and Site Remedial Actions: A Selected Bibliography, ORNL/EIS-154/VI (September 1980); Vol. 2 (October 1981).
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6. DOE Nuclear Waste Management Comprehensive Program Implementation Plan, NUS-3902 (November 1981).

2. INTEGRATED DATA BASE FOR SPENT FUEL AND RADWASTE: INVENTORIES

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INTRODUCTION

The Integrated Data Base (IDB) program provides and maintains current, integrated data on spent reactor fuel and radwaste, including historical data, current inventories, projected inventories, and material characteristics. This program collects, organizes, integrates, and — where necessary — reconciles inventory, projection, and characteristics (I/P/C) information to provide a coherent, self-consistent data base on spent fuel and radwaste. The major spent fuel and waste forms or functional sources covered by IDB are:

Reactor Fuel

- Spent Fuel

Major Waste Categories

- High-Level Waste
- TRU Waste
- Low-Level Waste

Remedial Action Programs (RAP)

- Uranium Mill Tailings (UMTRAP)
- Formerly Utilized Sites (FUSRAP)
- Surplus Facilities Management Program (SFMP)
- Grand Junction (GJRAP)

Other Wastes

- Active Uranium Mill Tailings
- Airborne Waste
- Reprocessing Waste and Cladding
- D&D of Active Sites

IDB PROGRAM OVERVIEW

The IDB program covers all U.S. sources and foreign fuel shipped to the U.S. Generically, spent fuel and radwaste derive from three sources:

Commercial Fuel Cycle:

- Mining and Milling
- Conversion and Enrichment
- Fabrication
- Reactor Operation
- Decontamination and Decommissioning
- Reprocessing and Refabrication

Institutional and Industrial (I/I):

- Medical Applications
- Research (Universities and private)
- Industrial Operations

Government ("Defense") Functions:

- Naval Reactors
- Weapons
- Research and Development
- Secondary Sources (e.g., WIPP, DWPF, and TWTF)
- Reprocessing

The overall program includes data collection and evaluation, modeling and projecting via the ORGENTRE code system, isotopic generation/depletion calculations via the ORIGEN2 code, and support activities such as waste management bibliographies and preparation of a radwaste glossary. The major published results to date have been spent fuel and radwaste inventory and projection reports. The first¹ was issued in 1980 and was expanded and updated in September 1981.² The latest version (DOE/NE-0017, the so-called "Blue Book"), distributed under category UC-70:

- updates inventory data through 1980
- gives projections to year 2000 that are
 - integrated
 - reconciled

- consistent
- accepted
- o provides more characteristics such as
 - volumes
 - radioactivity
 - thermal power
 - mass of TRU elements
- o provides references for all primary data.

The last point, referencing of all primary data, is a major improvement over other published inventory compilations. It allows tracing of data back to sources and, therefore, independent verification, if required. The next I/P/C report is scheduled for September 1982.

Projections and alternatives are handled via the ORGENTRE code system,³ which has three major components: Defense and I/I Projection Code, Nuclear Materials Projection Code, and Waste Treatment Simulation Code. These three codes, coupled to Inventory Data and Projection Source Terms, generate a data base from which desired output is extracted.

Radioactive decays are computed via the ORIGEN2 code.^{4,5} This code is the most widely used of all the isotopic generation and depletion codes, and is well documented. In general, this code is most used for the isotopics of spent fuel and HLW, but it is equally applicable to TRU waste, LLW, and RAP waste.

INVENTORIES

The summary data given in the table were taken from ref. 2, and are for December 31, 1980. The installed nuclear capacity at that time was 53.8 GW(e), with 36.0 from PWRs and 17.8 from BWRs. There were 21 uranium mills operating at that time (22 in 1981). The majority of HLW and TRU waste is derived from government functions and has not yet been placed in permanent isolation. The buried LLW is split between government and commercial sources, with the latter deriving about equally from commercial fuel cycle and I/I operations. Mill tailings, both RAP and

active mills, are the greatest volume of any waste form. Other Remedial Action Programs and commercial reprocessing have not yet generated any large volumes of waste.

The Inventory, Projections, and Characteristics report² includes chapters on spent fuel, HLW, TRU waste, LLW, remedial action waste, active uranium mill tailings, and airborne waste. Each of these chapters (except the last two) is supported by an Appendix giving additional details. Inventory data are supplemented by data on properties and characteristics. The report consists of almost 300 pages in a single volume and includes 124 tables and 11 figures.

The oral report given at the meeting will also include data for 1981, both annual additions and accumulated totals. This information will be gathered after this summary was written. These data will be included in the next I/P/C report,⁶ along with characteristics and projections through year 2020. The next report will also include LWR reprocessing.

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1. U.S. Department of Energy, Spent Fuel and Waste Inventories and Projections, ORO-778 (August 1980).
2. U.S. Department of Energy, Spent Fuel and Radioactive Waste Inventories and Projections as of December 31, 1980, DOE/NE-0017 (September 1981).
3. C. W. Forsberg, C. W. Alexander, and G. W. Morrison, Integrated Data Base: Projections, this meeting, special session 5.9.
4. A. G. Croff, ORIGEN2 - A Revised and Updated Version of the Oak Ridge Isotope Generation and Depletion Code, ORNL-5621 (July 1980).
5. A. G. Croff, A User's Manual for the ORIGEN2 Computer Code, ORNL/TM-7175 (July 1980).
6. U.S. Department of Energy, Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics as of December 31, 1981, DOE/NE-0017/V2 (to be published).

Spent fuel and radwaste inventories as of December 31, 1980

<u>Spent fuel</u>	<u>Mass, MTU</u>	<u>Activity, kCi</u>	<u>Heat, kW</u>
BWRs	2,800	3,800,000	14,000
PWRs	3,900	6,600,000	25,000
<u>High-level waste</u>	<u>Volume, m³</u>	<u>Activity, kCi</u>	<u>Heat, kW</u>
Savannah River	97,000	700,000	2,100
Idaho CPP	11,000	50,000	170
Hanford	183,000	560,000	1,100
Nuclear Fuel Services	2,200	37,000	110
<u>TRU waste</u>	<u>Volume, m³</u>	<u>Activity, kCi</u>	<u>TRU elements, kg</u>
DOE, buried	273,000	400	1,000
DOE, stored	61,000	1,050	800
Commercial, buried	(in with LLW)	---	130
<u>Low-level waste</u>	<u>Volume, m³</u>	<u>Activity, kCi</u>	<u>Land area, ha</u>
DOE sites	1,523,000	26,000	156
West Valley (closed 1975)	66,000	580	3
Maxey Flats (closed 1977)	135,000	2,400	6
Sheffield (closed 1978)	88,000	60	4
Barnwell, SC	324,000	2,000	17
Beatty, NV	87,000	300	8
Richland, WA	61,000	900	3
<u>Remedial Action Programs</u>	<u>Volume, m³</u>	<u>Activity, kCi</u>	<u>No. of sites</u>
UMTRAP	19,000,000	300	25
FUSRAP	450,000	---	31
SFMP	1,560,000	---	~500
<u>Active mill tailings</u>	<u>Volume, m³</u>	<u>Activity, kCi</u>	<u>Heat, kW</u>
21 active mills	102,000,000	900	20

3. INTEGRATED DATA BASE PROJECTIONS

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SUMMARY

An improved methodology is being developed for tracking current nuclear waste inventories and projecting future waste quantities. This approach projects all types of wastes and characterizes wastes by location, physical form, chemical content, packaging, year generated, and radionuclide content. It can simulate the operation of waste generating facilities, including tracking the events of radioactive decay on processing and projecting waste characteristics as a function of facility type and feed. An example of the last capability is projection of reprocessing wastes as a function of fuel type, burnup, and age. With this capability, more accurate projections of waste characteristics as a function of time are available for designers of waste treatment facilities and of disposal sites such as repositories. The approach is incorporated into a modular computer code system called ORGENTRE, which is shown in Fig. 1.

The central component of ORGENTRE, the Past/Present/Future Radwaste Data Base, contains one file for each batch of waste in inventory or projected to exist in future inventories. A batch of waste may be a single container of waste or a waste tank farm, depending upon the degree of detail desired. Each batch of waste is fully characterized, including its radionuclide content as a function of time. A series of codes inputs the data for each batch of waste to this data base, while a data base manager searches the material for the desired information and outputs projections as required.

Four sets of codes input data on existing and projected batches of waste into the Past/Present/Future Radwaste Data Base. Inventory codes input existing inventory data, while Defense and Institutional/Industrial Projection codes project future amounts of these specialized wastes. Two codes in sequence are used for fuel cycle projections. The Nuclear Materials Projection code, when supplied with a reactor growth schedule, projects the numbers, locations, capacities, fuel throughput, and characteristics of all fuel cycle operations. The Nuclear Waste Treatment Simulation Code then uses this information as input, simulates the operation of each facility for each time of interest, and outputs the various waste streams produced by each facility.

The Nuclear Waste Treatment Simulation Code simulates plant operations by simultaneously solving mass balance and radionuclide decay equations for all processes in any specified flowsheet. This capability enables the user to follow radionuclides and radioactive decay through any "plant" (e.g., a reprocessing plant, a high-level waste (HLW) tank farm or a disposal site. This is possible because both the equations of radioactive decay and the equations for mass balances within a plant can be represented by:

$$\frac{dN_i}{dt} = \sum_j \lambda_{ij} N_j + B_i .$$

Here N is the quantity of a radionuclide or chemical in a particular process, t is time, λ is a decay or transport rate, B is a continuous addition rate, and i and j denote particular chemicals, radionuclides, or process steps in the plant. In ORGENTRE, these equations are solved by using components of the radioactive decay code ORIGEN2.¹ As an example, this technique could be used to calculate the wastes from a reprocessing plant operating in 1995 on fuel discharged from a BWR reactor in 1973.

The waste treatment codes project waste treatment operations such as solidification of defense HLW and burial of wastes. The Waste Treatment Schedule Code schedules treatment operations by specifying the type of treatment, the wastes in inventory to be treated, and the

detailed schedule of treatment. The output is sent to the previously described Nuclear Waste Treatment Simulation Code, which simulates the waste treatment operation and writes the waste characterization information into the Past/Present/Future Radwaste Data Base. ORGENTRE has been designed to allow addition of an economics code, if desired.

ORGENTRE can be used for both general waste projections and special projects. It was used to generate the projections in the last official DOE waste report, Spent Fuel and Radioactive Waste Inventories and Projections as of December 31, 1980, DOE/NE-0017.² It has also been used for several special studies. For example, the DOE fuel reprocessing program staff needed to know the quantities of plutonium that could be recovered by the Allied-General Nuclear Services plant using (1) the existing spent fuel inventories as of December 31, 1982; and (2) the existing high-level waste tanks, while limiting the ^{240}Pu content of the product plutonium to 20% or less. With these constraints, ORGENTRE determined that 11.8 to 17.4 metric tons of plutonium could be recovered, depending on specific operating process assumptions.

ORGENTRE is an advanced waste projection system which can simulate plant operations as well as track radioactive materials through different facilities as a function of time. These capabilities make it useful for both waste projection work and studies in which radioactive decay and flow of materials must be followed simultaneously.

REFERENCES

1. A. G. Croff, ORIGEN2 — A Revised and Updated Version of the Oak Ridge Isotopic Generation and Depletion Code, ORNL-5621, Oak Ridge National Laboratory (July 1980).
2. Spent Fuel and Radioactive Waste Inventories and Projections as of December 31, 1980, DOE/NE-0017, U.S. Department of Energy (September 1981).

Fig. 1. ORGENTRE code system for radwaste inventories and projections.

4. RAWSYM — RADIOACTIVE WASTE MANAGEMENT SYSTEM

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INTRODUCTION

The computer program, RAWSYM (RadioActive Waste Systems Model)¹ has been developed by NUS for the Department of Energy, Nuclear Waste Management and Fuel Cycle Programs. The RAWSYM program is an analytical tool for evaluating the future time behavior of any and all waste inventories, as to type, amount, location, processing, transport, disposal, and facility utilization. It develops these waste characterizations based on user-specified inputs as to the availability, location and capacity of new facilities of all types, and user-specified rates for the generation of any and all waste types. Its intended use is in policy-or-planning-related analyses of the detailed and aggregate characteristics of waste and waste facilities and the macroscopic impact of various policy or programmatic alternatives. It does not explicitly follow isotopics or radioactivity decay, but maintains the waste identities and ages so that this can be done separately.

This paper summarizes general characteristics of RAWSYM, and presents its application capabilities.

WASTE TYPES, GENERATING SOURCES, AND WASTES FACILITIES

RAWSYM is designed to handle all types of radioactive wastes from all generating sources in the United States; spent fuel, LLW, TRU, and HLW; from defense, industrial/institutional and commercial fuel cycle activities. The RAWSYM waste inventory data base is obtained from, and is consistent with, ORNL's Integrated Data Base.²

The facilities in which waste is generated, stored, processed, reprocessed, transported, and disposed of are user-specified or controlled as to type, timing, maximum rates and capacities, and location.

Transportation via truck or rail casks is simulated, and shipment destinations are selected on the basis of the minimum-cost destination. The waste transport simulation is based on the Spent Fuel Logistics Model, developed by ORNL³ under sponsorship of Sandia's Transportation Technology Center.

RAWSYM CONFIGURATION

The overall configuration of RAWSYM is schematically illustrated in Fig. 1. RAWSYM starts with existing inventories of spent fuel, LLW, TRU and HLW, projects them into the future, and transports them to user-designated destination facilities based on minimum transportation costs.

The functional capabilities of RAWSYM can be applied to analyses of all wastes or to individual wastes such as:

- Management of spent fuel and/or reprocessing-derived TRU and HLW from commercial fuel cycle activities (consistent with assumed nuclear power growth).
- Management of LLW from commercial fuel cycle activities and power reactor operations (consistent with assumed nuclear power growth).
- Management of any other individual wastes such as LLW, TRU and HLW from defense, industrial/institutional and commercial fuel cycle activities.

APPLICATION TO WASTE MANAGEMENT

The analysis capability of RAWSYM is extensive and flexible. Since RAWSYM is designed to satisfy a wide range of radioactive waste analysis needs, it may be used, for example:

- to evaluate the number, size, timing, and location of new facilities;
- to assess impact on storage facility requirements of delays in key waste processing and disposal facilities;
- to analyze impact of policies (reprocessing, regional moratoriums, etc.) and regulations on waste inventories and facilities; and
- to perform sensitivity analysis.

RAWSYM is operational and is now being applied in support of planning and policy-related analyses for the Department of Energy.

REFERENCES

1. NUS-3867, User's Manual for Radioactive Waste Systems Model (RAWSYM), August 1981.
2. Spent Fuel and Radioactive Waste Inventories and Projections as of December 31, 1980," DOE/NE-0017, U.S. Department of Energy (September 1981).
3. Private communications with David S. Joy of ORNL, 1981.

Fig. 1. Radioactive Waste Systems Model (RAWSYM) configuration.

5. NWTS PROGRAM WASTE PROJECTION DATA NEEDS

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The National Waste Terminal Storage (NWTS) program was established in 1976 to implement a timely national effort to develop the technology and provide the facilities for the safe, environmentally acceptable, permanent disposal of high-level and commercially generated transuranic nuclear waste (HLW and TRU) for which the Federal Government is responsible. The strategy is directed toward providing the nation with at least one licensed, fully operational mined geologic repository by the turn of the century. The timely realization of this goal, as well as the demonstration of tangible progress in the intervening period, is believed crucial to the continued viability and renewed growth of the nation's nuclear power capability.

In order for the NWTS program to properly define its activities, realistic and consistent projections on the waste that is destined for disposal is needed. Since 1979, when NWTS activities in this area were phased out, this need has been satisfied by the Integrated Data Base (IDB) program. The following paragraphs summarize, in more detail, the NWTS waste projection data needs.

There is a need for waste inventories and characteristics at least through the year 2030 in order to determine the number, timing and size of repository facilities, and establish operating rates. In general, it is expected that spent fuel will not be disposed of in a mined geologic repository (except for limited quantities declared to be waste). Thus, there is a need for information on HLW and TRU projections and characteristics. The current reference data source for waste projections¹ provides a listing of inventory quantities and projections out to the year 2000. The wastes from nuclear reactors are specified as spent fuel. Thus there is a need to extend the time period covered by the

data base and to consider a number of scenarios that could be operable around the turn of the century that would influence the characteristics of the waste forms. In developing facility design concepts, the NWTs program must be aware of the range of disposal services that may be needed. In addition to waste quantities, data on treatment, form, logistics, and primary packaging are equally important because these data define both the quantities and characteristics of materials destined for transport and disposal. Initially, it is not possible to obtain such information from a waste projection data base. Rather, information such as waste form product specifications are obtained through formally established agreements between projects to exchange data or by working groups established to develop such data. Once such detailed technical data is developed, it is then possible and highly desirable to incorporate the key characteristics in the waste projection data base.

In order for the NWTs program to evaluate the viability and economics of a system of regional repositories, material flow, transportation logistics, and economics data is needed. With the assistance of the Transportation Technology Center (TTC), such a study was made for a system of regional repositories for spent fuel.² These studies are now being expanded to consider the range of disposal services that may be needed. These studies will be able to evaluate effects of facility location, receiving rates, capacity, startup schedules, and facility life. Such studies cannot be completed until an expanded data base, identifying the range of disposal services that may be needed, is available.

In addition to the need for realistic and consistent projections of waste quantities and characteristics, there is also the need for quick evaluations using the data base supporting the projections as the information source. Recently, the IDB program was asked to provide an estimate of the total quantity of spent fuel that would be discharged assuming the growth scenario in ref. 1 and 30-year reactor operation. Within a day, the answer was given: 139,000 MTU. Thus, two moderate-sized repositories would meet the current commitment made by electrical utilities in the United States.

These few examples show there is a need for consistent and realistic projections of waste quantities and characteristics. Such projections are a key factor in assessments that show how the isolation system being developed by the NWTs program can meet nuclear industry needs.

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6. LOW-LEVEL WASTE MANAGEMENT DATA BASE SYSTEM

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Of the many studies conducted on different aspects of low-level radioactive waste management, few have addressed the total system. This paper discusses a study undertaken to display the relationships among the various processes of the low-level waste system on a management level. The study utilized a "top-down" analysis to produce a description of low-level radioactive waste generated in the United States. This study was initiated to develop an understanding of the total system and to determine the information needed to characterize the system and its operations. This defined the basis for a data base system on low-level radioactive waste to serve the national needs.

The low-level radioactive waste data base was modeled after the system description structure. It is "relational" in structure to best link its data entities to each other. This was established on a data base management system called "NOMAD", provided by the National Computer Software System Corporation. The data base has been loaded with available data; however, many of the nodes in the model are still not information satisfied. In the future, more data and a better means of data update are expected to help complete the model.

The future of the data base will be determined by the ability of the system to track the various aspects of low-level radioactive waste management and relate this data to the centralized model. As this occurs, there will be an expansion of the information and, as a result, the ability to predict net effects of the impact of change on the low-level radioactive waste system caused by any new technology, policies,

or procedures put on the system. Currently, the available data is limited and used to provide the ability to make future projections of low-level radioactive waste generation utilizing some basic assumptions and to generate a variety of reports. The data base is designed to be used by individuals who are not computer professionals.

The data base has been designed with an operating procedure that is tutorial in nature. A user may request the projections program, which generates more detailed volume projections through the year 2000. Within the program, the user is given the opportunity to change growth parameters and examine the impact of future waste volumes.

The projections program begins by extracting one year's historical data from the low-level waste data base to use for future waste projections. These data consist of totals for each of the 50 states in the following categories:

- o number of commercial nuclear power reactors currently operating;
- o rated megawatts of power for all commercial nuclear power reactors;
- o cubic meters of low-level radioactive waste produced by the reactors;
- o cubic meters of low-level radioactive waste produced by the state's industry; and
- o cubic meters of low-level radioactive waste produced by the state's institutions.

In order to project the volume of waste that will be produced by each state up to the year 2000, a set of questions must be answered permitting the user to supply his own values or use the system-supplied values.

The future of the system and the low-level waste data base concept depends on the ability to gain good data from waste generators, transporters, and disposers. It can be the central point for all waste tracking and can be utilized by anyone since the network is nationwide. Models already written can be added to the system at their respective nodes and utilized with accepted common data.

7. WASTE SLUDGE COMPOSITION AT THE SAVANNAH RIVER PLANT

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Radioactive liquid waste from operations is presently stored in shielded tanks at the Savannah River Plant (SRP). Several programs are now under way to design and build a Defense Waste Processing Facility (DWPF) to produce waste forms suitable for permanent isolation. To design a process that will solidify the waste, the waste composition must be known. This work was directed toward establishing the composition of the sludge solids that comprise the bulk of the material that must be solidified into a high integrity form for disposal in a permanent repository.

As a result of waste management practices at SRP, liquid wastes can be classified into three general components — sludge, supernate, and salt cake. In January 1981, the liquid waste at SRP consisted of approximately 11 million liters (2.8 million gallons) of sludge, approximately 68 million liters (18.1 million gallons) of supernate, and approximately 26 million liters (6.9 million gallons) of salt cake, stored in 37 waste tanks. The sludge contains most of the radionuclides and will be a principal component of a waste form for permanent isolation. However, nonradioactive components make up more than 90% of the sludge, and waste forms must accommodate these nonradioactive components as well as the radionuclides.

Waste tank histories show that sludge can be further categorized into six types related directly to processes at SRP: Purex HAW, Purex LAW, HM HAW, HM LAW, HM HAW/LAW blend, and zeolite resin. The volumes of each of these waste categories can be estimated using the histories for each waste storage tank containing sludge. The highly variable composition of SRP sludge, both within a tank and between tanks, requires these simplifying assumptions to use available analytical data¹⁻³ as a basis to calculate the overall sludge composition:

- o Except for zeolite resin, 234 g/liter (1.95 lb/gal) of insoluble solids were assumed for the sludge (observed range = 180 to 350 g/liter). The actual weight of zeolite added to the tank was used.
- o The arithmetic average composition of several washed sludge analyses for specific waste categories was used (2 to 8 analyses for samples of each waste category).
- o Sludge components are present as simple compounds.
- o Seventy-five percent of the $\text{Al}(\text{OH})_3$ in HM HAW and HM LAW is diverted to salt/supernate by caustic treatment prior to washing. This assumption is consistent with present plans to prepare feed for the DWPF.

Using these above assumptions, the weight of each simple compound in the sludge was calculated, and the total waste inventory was obtained by summing the weight of each component from each sludge category. The weight percent of each component was then calculated.

The results from these calculations provide a general sludge composition needed to design and test various processes to solidify SRP sludge. The components listed in Table I comprise more than 99.9 wt % of the sludge. The observed range of individual components are included to illustrate the variability in the sludge as dictated by the six waste categories previously cited. These ranges are also useful to test the sensitivity of a particular process to feed variations.

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Table I. Composition of SRP sludge after $\text{Al}(\text{OH})_3$ dissolution

Assumed sludge species	Waste inventory (MT)	Wt %	Range of wt %
$\text{Fe}(\text{OH})_3$	943	37.90	5 - 65
MnO_2	159	6.40	1 - 16
$\text{UO}_2(\text{OH})_2$	105	4.23	0.1 - 13
$\text{Al}(\text{OH})_3$	394	15.85	5 - 25
CaCO_3	124	4.98	0.4 - 5
CaSO_4	14.8	0.59	0.05 - 2
CaC_2O_4	12.5	0.50	0 - 2
$\text{Ca}_3(\text{PO}_4)_2$	11.5	0.46	0.01 - 3
CaF_2	3.24	0.13	0 - 0.4
$\text{Ni}(\text{OH})_2$	60.3	2.42	0.4 - 11
NaOH	102	4.08	1 - 6
NaNO_3	87.5	3.53	0.7 - 5
NaCl	3.07	0.12	0 - 2
NaI	0.233	0.01	0 - 1
HgO	49.4	2.00	0 - 8
RuO_2	7.48	0.30	0.04 - 0.7
SiO_2	182	7.30	0.04 - 90
ThO_2	18.0	0.72	0 - 4
BaSO_4	7.85	0.32	0.1 - 0.5
PbSO_4	4.53	0.69	0.07 - 2
$\text{Ce}(\text{OH})_3$	17.1	0.18	0.07 - 2
$\text{La}(\text{OH})_3$	4.01	0.16	0.05 - 0.4
$\text{ZrO}(\text{OH})_2$	13.7	0.55	0.2 - 0.8
$\text{Cr}(\text{OH})_3$	12.0	0.48	0.02 - 1
AgOH	0.544	0.02	0 - 0.4
$\text{Cu}(\text{OH})_2$	3.55	0.14	0.04 - 0.3
$\text{Co}(\text{OH})_3$	1.76	0.07	0 - 0.2
$\text{Pr}(\text{OH})_3$	3.65	0.15	0.05 - 0.3
$\text{Zn}(\text{OH})_2$	8.98	0.36	0.06 - 0.8
$\text{Mg}(\text{OH})_2$	15.8	0.63	0.1 - 0.7
Coal	3.18	0.13	0 - 0.5
Zeolite	114	4.60	0 - 100
TOTAL	2488		

8. A SUMMARY OF THE CHARACTERISTICS OF TRANSURANIC WASTE
FOUND AT DEPARTMENT OF ENERGY SITES

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This work summarizes a report of transuranic (TRU) waste inventories and projections within the Department of Energy (DOE). The report was taken from a comprehensive study of the characteristics of TRU waste which will soon be released by the Transuranic Waste Systems Office (TWSO). These data were compiled to assist the planning and analysis activities of that office and other participants in the DOE Transuranic Waste Management program. This program is managed by the Albuquerque Operations Office (ALO), with Rockwell International, Rocky Flats Plant (RI-RFP), as the lead support contractor.

TRU waste is material, excluding high-level waste, that is contaminated with certain alpha-emitting radionuclides of long life and high specific radiotoxicity to a level greater than 10 nanocuries per gram.¹ Before 1970, all TRU waste was buried in pits and trenches. Approximately 272,800 cubic meters were buried in five sites. In addition, anywhere from 131,515 to 2,595,000 cubic meters of soil have been contaminated to greater than 10 Ci/g with TRU radionuclides.² The five sites include all sites in Table I, except the Nevada Test Site.

In March of 1970, the U.S. Atomic Energy Commission (AEC) instituted a policy requiring that waste known or suspected of containing TRU radionuclides be segregated from other types of radioactive waste. Such waste was to be packaged and stored so as to be retrievable, in contamination-free containers, for a period of at least 20 years, pending the development of a suitable federal repository.³ In this report, waste that was packaged and set aside is referred to as "stored" waste.

Table 1 shows the current inventory of stored wastes at DOE sites. Waste at these sites is separated into the categories of contact and remote handled. Contact handled generally refers to waste that is less than 200 mrem/h at the surface. Table 1 shows only the contact handled wastes. There are also 617 cubic meters of remote handled waste. The percentage of combustible wastes and the expected annual storage rate for the next ten years is also shown in Table 1. Further details on waste forms and radionuclide content can be found in this report.

Figure 1 shows the types of containers which are used to store TRU waste. Additional details of the waste forms found in each kind of container, as well as the method of storage, are covered in this report.

Finally, Table 2 shows the expected amount of various waste forms that will be generated. Exact locations, the types of processes involved, and the percentage of various waste forms for each site have been assembled in this report.

The data presented in this summary were abstracted from an extensive compilation recently prepared for TWSO.⁴

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Table 1. Current inventory of transuranic waste at
Department of Energy sites (contact handled)

Site	Volume to December 31, 1980 (m ³)	% Combustible	1981-1990 average increase (m ³ /yr)
Hanford	10,537	67	1,369
Idaho National Engineering Laboratory	42,370	19	2,021
Los Alamos National Laboratory	4,352	19	507
Nevada Test Site	235	65	25
Oak Ridge National Laboratory	381	55	30
Savannah River	2,555	82	365
TOTAL	60,430		4,317

**INVENTORY TO DECEMBER 31, 1980
VOLUME %**

**FORECAST - 1980 TO 1990
VOLUME %**

*** PLYWOOD UNTIL 1983 - METAL THEREAFTER**

Containers used in storing transuranic waste.

Table 2. Projected transuranic waste forms (1981-1985)

Waste forms	Contact handled, volume		Remote handled, volume	
	(m ³ /yr)	(%)	(m ³ /yr)	(%)
Glass and metal	1837	39	12	16
Combustibles	1180	25	50	67
Absorbed liquids or processed sludges	604	13	0	0
Filters and filter media	316	7	10	14
Dirt, gravel and asphalt	227	5	0	0
Concrete or cemented waste	86	2	0	0
Other	432	9	2	3
TOTAL	4682		74	