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INTEGRATED DATA BASE PROGRAM: A STATUS REPORT

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PREFACE

This report summarizes the position of the Integrated Data Base (IDB) Program in early 1984, including the accomplishments that have made it the standard data base for spent fuel and radioactive waste in this country. As the official DOE data base, the IDB is readily available to DOE programs and contractors.

The IDB Program is jointly sponsored by the Office of the Assistant Secretary for Defense Programs, the Office of the Assistant Secretary for Nuclear Energy, and the Office of Civilian Radioactive Waste Management. Suggestions, questions, or requests for information may be directed to any of the following.

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The accomplishments of this program would not have been possible without the dedicated efforts of the staff members whose names and major areas of responsibility are as follows:

C. W. Alexander	ORIGEN2, spent fuel data, and nuclear materials projection code.
W. L. Carter	TRU waste data, remedial action programs data, and reprocessing data
C. W. Forsberg	Overall data tabulation, D&D data, cost data, and source term information
H. W. Godbee	High-level waste data, airborne waste data, and source term information
B. M. Horwedel*	SAS programming
C. W. Gudmundson*	SAS programming
A. H. Kibbey	Low-level waste data and uranium mill tailings data
P. Mason†	Programming for the IBM-PC
S. Mrochek‡	Programming for the IBM-PC
G. W. Morrison*	Data processing methodology, personal computer applications, and waste treatment simulation code.

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INTEGRATED DATA BASE PROGRAM: A STATUS REPORT

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ABSTRACT

The Integrated Data Base (IDB) Program provides official Department of Energy (DOE) data on spent fuel and radioactive waste inventories, projections, and characteristics. The accomplishments of FY 1983 are summarized for three broad areas:

1. upgrading and issuing of the annual report on spent fuel and radioactive waste inventories, projections, and characteristics, including ORIGEN2 applications and a quality assurance plan;
2. creation of a summary data file in user-friendly format for use on a personal computer and enhancing user access to program data; and
3. optimizing and documentation of the data handling methodology used by the IDB Program and providing direct support to other DOE programs and sites in data handling.

Plans for future work in these three areas are outlined in this report.

1. INTRODUCTION

The Integrated Data Base (IDB) Program maintains referenced data on all spent fuel and radioactive waste in the United States. Working with and through U.S. Department of Energy (DOE) lead sites and major programs, it receives and processes data and provides data output in various formats as required.

The purpose of the program is to create and maintain a reliable baseline of quality data and information to be used for program planning, decision making, and other management activities. As the official data base for DOE, IDB is readily available to the DOE community and to DOE-sponsored contractors. Because of the program's wide scope, it has been jointly sponsored by two branches of DOE: the Office of the Assistant Secretary for Nuclear Energy and the Office of the Assistant Secretary for Defense Programs. Beginning in FY 1984, sponsorship will also be shared by the Office of Civilian Radioactive Waste Management.

The IDB Program encompasses data on spent fuel, high-level waste (HLW), transuranic (TRU) waste, low-level waste (LLW), and mill tailings produced by commercial fuel cycles (including decontamination and decommissioning activities), DOE/defense programs, remedial action programs, and institutional and industrial operations.

The program provides access to information on spent fuel and radioactive waste inventories and characteristics, including volume and/or mass, age, radioactivity, heat generation, chemical and physical properties, location, packaging, and nuclide composition. Utilizing a modular system of computer models and codes, the IDB Program also provides projections based on anticipated growth rates, schedules for new facilities, waste generation factors, and treatment assumptions.

Data are collated and integrated to ensure that all forms are counted once and only once. Figure 1 illustrates the primary sources of data that are included. A major program function is to translate various inputs from the numerous sources into a common and internally consistent data base.

The program encompasses three major technical areas: (1) data collection and processing, (2) calculation of isotope generation and depletion, and (3) data base development and user access. The overall flow of data from input to output, including data processing steps, is shown in Fig. 2. During FY 1983, significant program efforts were directed toward three broad objectives:

1. to upgrade, improve, and issue the annual report on spent fuel and radioactive waste inventories, projections, and characteristics, including ORIGEN2 applications and a quality assurance plan;

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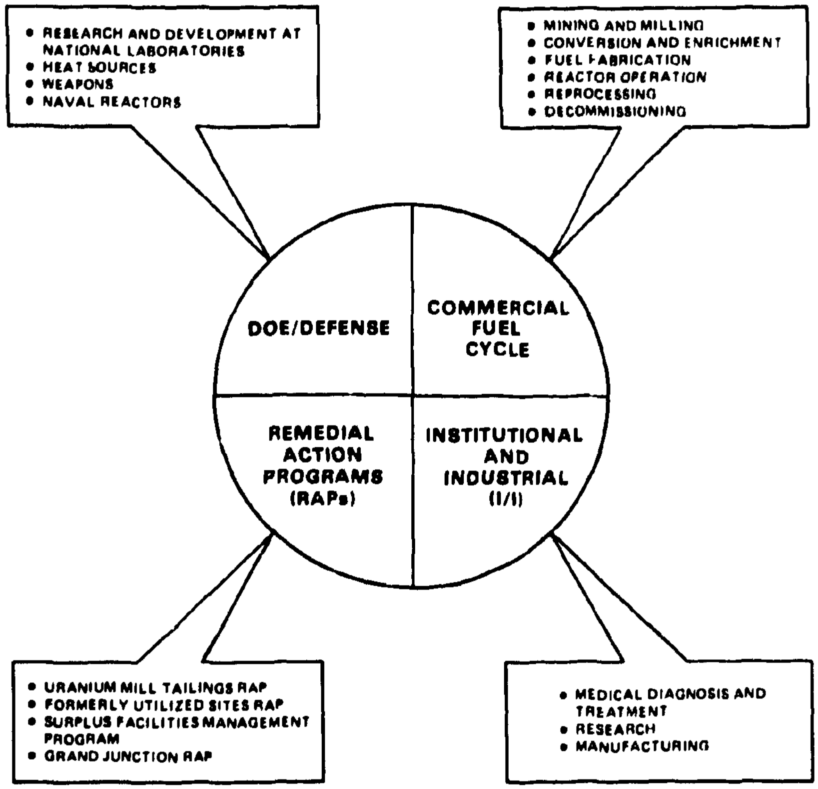

Fig. 1. The IDB Program encompasses data on all domestic sources of spent fuel and radioactive waste.

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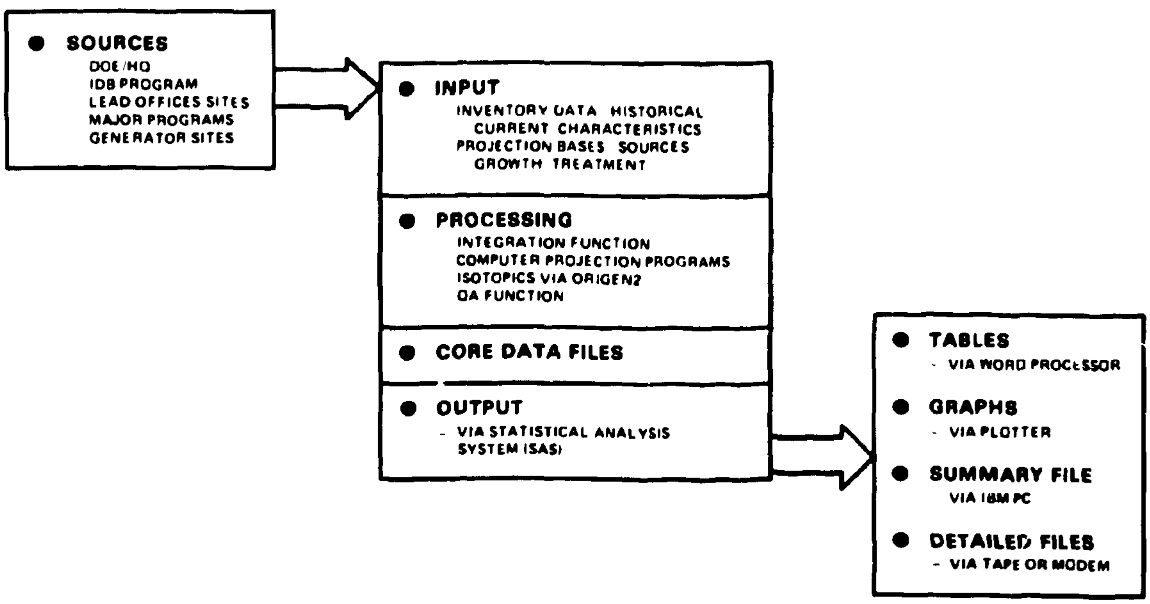

Fig. 2. Conceptual data handling scheme for the IDB Program.

2. to create a summary data file in user-friendly format for use on a personal computer in order to enhance user access to program data; and
3. to optimize and document the data handling methodology used by the program and to provide direct support to other DOE programs and sites in data handling.

Substantial progress was made towards accomplishing these objectives, as described in the following sections. Plans for future work are also briefly outlined.

2. ANNUAL INVENTORY REPORT

2.1. THE 1983 EDITION: DOE/NE-0017/2

The annual inventory report, *Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, has gained widespread recognition and acceptance. The report is in considerable demand. The 1982 edition, DOE/NE-0017-1, was provided to more than 1400 recipients, including 385 copies requested in addition to the standard category distribution and direct primary distribution. For the 1983 edition,[1] 860 copies were issued in the original distribution, and requests are now being filled; these are normally referred to TIC or NTIS. There were 97 additional requests for specific data or information and 80 requests for ORIGEN2-related data in 1983. Most of these special requests for information were handled via phone or letter.

The inventory report includes an overview chapter followed by chapters devoted to the specific waste forms or sources: spent fuel, HLW, TRU waste, LLW, uranium mill tailings, airborne waste, remedial action programs, and decommissioning. A chapter on costs is included to give an economic perspective. This chapter was prepared by Pacific Northwest Laboratory (PNL), following the modular approach designed at ORNL. Appendices provide source terms and flowsheets and projections of spent fuel (or HLW) age at the time of emplacement in a repository. The latter appendix was prepared by NUS Corporation. Projections, which require assumptions concerning power reactor growth and other waste sources and treatments, are made to the year 2020. The latest annual report dealt with a base scenario that includes future reprocessing and the Energy Information Administration (EIA) mid-case projection for power reactors. The total accumulation of spent fuel in the absence of reprocessing is projected and also, in the analysis chapter, the total spent fuel for a reference case and for a lower growth projection. Table 1, reproduced here from the 1983 annual report,[1] shows the summary of spent fuel and waste inventories through December 31, 1982. Table 2 was derived from data in that report and includes projections to 1990, 2000, 2010, and 2020 for both the reprocessing and nonreprocessing cases. A description of the data-handling steps involved in preparing the annual inventory report has been published,[2] as well as a description of the information contained in the core data files.[3] A report on the Statistical Analysis System (SAS) programming used is now in preparation.[4]

Projections given in the annual inventory report depend on the assumptions, source terms, and models used. The basic assumptions on growth, scheduling factors, and capacities are summarized in the overview chapter (Tables 0.1 and 0.2, Ref. 1). Future power reactor capacities and spent fuel discharges were predicted by PNL,[5] based on utilities data for the first ten years and on the EIA mid-case projection[6] after that. The IDB then calculated the resulting requirements for fertile and fissile material and, from that, derived the projected waste streams as a function of time for mining and milling, conversion, enrichment, fabrication, and reactor operation. This was accomplished using the Nuclear Materials Projection Code.[7] For reprocessing and other waste treatment functions, the Waste Treatment Simulation Code was used.[8] Waste sources not covered by these codes, such as some projected DOE/defense wastes and projected institutional and industrial (I/I) wastes, were handled by FORTRAN algorithms written to suit specific cases.

The actual typing of the photomasters for the printed report was done on a CPT-8102 word processor. In addition to the text, all of the computer-generated tables were also done on the CPT, via hardwire hookup to the ORNL PDP-10 for direct access to an IBM-3033 mainframe. Using SAS programming, the desired tables were assembled and formatted, then printed out via the CPT as outlined above. The CPT operator added titles and footnotes to complete the tables.

2.2. ORIGEN2 APPLICATIONS

The ORIGEN2 codes[9] are used by the IDB Program for three purposes: (1) to compute the isotopic content of spent fuel as a function of the initial enrichment, the burnup, and the decay time since discharge; (2) to calculate the decayed isotopics (also radioactivity and thermal power) of all radioactive wastes, both for

Table 1. Spent fuel and radwaste inventories as of December 31, 1982

Spent fuel	Mass, MTU	Activity, MCi	Thermal power, kW
BWRs (20,702 assemblies)	3,733	3,530	12,900
PWRs (12,520 assemblies)	5,256	7,558	28,700
High-level waste	**Volume, m^3**	**Activity, MCi**	**Thermal power, kW**
Savannah River (DOE)	115,000	828	2,490
Idaho (DOE)	11,500	72	217
Hanford (DOE)	183,000	487	1,400
West Valley (commercial)	2,320	36	106
Transuranic waste[a]	**Volume, m^3**	**Activity, MCi**	**TRU elements, kg**
DOE, buried	298,000	1.06	762
DOE, stored	72,000	2.04	1,112
Low-level waste	**Volume, m^3**	**Activity, MCi**	**Land used, ha**
DOE sites	1,971,000	9.8	122
West Valley (closed 1975)	66,500	0.58	3
Maxey Flats (closed 1977)	135,000	2.4	10
Sheffield (closed 1978)	88,000	0.06	4
Barnwell, SC	397,000	2.1	20
Beatty, NV	94,000	0.44	12
Richland, WA	142,000	1.08	16
Active uranium mill tailings	**Volume, m^3**	**Activity, MCi**	**Thermal power, kW**
At mill sites[b]	98,500,000	0.41	9
Remedial Action Programs (DOE)	**Volume, m^3**	**Activity, MCi**	**No. of sites**
UMTRAP (Uranium Mill Tailings)	Projected[c]	0.14	24
FUSRAP (Formerly Utilized Sites)	27,000		36
SFMP (Surplus Facilities)	1,570		~500
GJRAP (Grand Junction Remedial Action Program)	52,000[d]		
Commercial decommissioning	**LLW, m^3**	**Activity, MCi**	**No. of reactors**
Decommissioned reactors	e		5
Mothballed reactors	e		10

[a]Based on the old 10 nCi/g definition of TRU wastes. With the new 100 nCi/g definition these volumes will decrease as the old wastes are reassayed.

[b]Licensed mills; not all are in operation at this time. Currently 16 mills are active, 26 mills are licensed.

[c]Projected to start in 1983.

[d]In form of mill tailings.

[e]Very little of this has been done to date, mostly to small test reactors. The LLW generated is included above.

Source: Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/NE-0017/2, U.S. DOE, September 1983.

Table 2. Current and projected volume, radioactivity, and thermal power of spent fuel and radioactive waste[a]

Source of material and type	End of CY-1982 Volume[b] (10^3 m^3)	End of CY-1982 Radioactivity (10^6 Ci)	End of CY-1982 Thermal power (10^3 W)	End of CY-1990 Volume[b] (10^3 m^3)	End of CY-1990 Radioactivity (10^6 Ci)	End of CY-1990 Thermal power (10^3 W)	End of CY-2000 Volume[b] (10^3 m^3)	End of CY-2000 Radioactivity (10^6 Ci)	End of CY-2000 Thermal power (10^3 W)
DOE/defense									
HLW									
Interim storage	310	1,400	4,100	315	1,700	5,400	315	1,200	5,800
Glass				0.35	26	83	3.6	260	820
TRU									
Buried	298	0.3	5.4	298	0.2	5.3	298	0.2	5.2
Stored	72	1.6	38	107	3	81	145	4.6	130
LLW	1,970	9.8	16	2,570	17	21	3,600	23	26
RAP									
Mill tailings	52			23,500			23,500		
LLW and TRU	27			480			904		
Commercial									
Spent fuel									
No reprocessing	3.9	11,000	42,000	11.6	30,900	115,000	25	42,000	150,000
With reprocessing	3.9	11,000	42,000	11.0	30,600	114,000	17	38,000	140,000
LLW (no reprocessing)									
Fuel cycle	550	0.8	(28)	1,310	(3.3)	(24)	2,450	(3.6)	(24)
All other	390	2.6		800			1,480		
D&D	10			25			25		
Mill tailings	98,500	0.4	9.1	177,000	1.1	23	296,000	2	42
Reprocessing waste									
HLW									
Interim storage	2.3	36	110						
Glass				0.3	208	650	1.7	2,900	9,700
TRU				2.2	1.4	10	26	25	160
LLW (additional)				1.3	0.0012	0.003	15	0.02	0.06
Airborne									
Iodine + carbon				0.03	0.46	0.4	0.33	6.9	5.5
Krypton				0.001	2.2	3.3	0.012	32	48

Source of material and type	End of CY-2010 Volume[b] (10^6 m^3)	End of CY-2010 Radioactivity (10^6 Ci)	End of CY-2010 Thermal power (10^3 W)	End of CY-2020 Volume[b] (10^6 m^3)	End of CY-2020 Radioactivity (10^6 Ci)	End of CY-2020 Thermal power (10^3 W)
DOE/defense						
HLW						
Interim storage	294	1,200	4,000	285	[illegible]	4,200
Glass	6.8	500	1,600	8.9	720	2,250
TRU						
Buried	[illegible]	0.2	5	298	0.2	4.9
Stored	183	6.1	180	221	7.5	22
LLW	4,540	[illegible]	29	[illegible]	29	32
RAP						
Mill tailings	23,500			23,500		
LLW and TRU	904			[illegible]		
Commercial						
Spent fuel						
No reprocessing	42	[illegible]	220,000	63	83,000	290,000
With reprocessing	21	51,000	190,000	22	69,000	250,000
LLW (no reprocessing)						
Fuel cycle	3,900	(4.1)	[illegible]	5,630	(4.6)	(26)
All other	2,300			3,200		
D&D	100			575		
Mill tailings	438,000	5.4	69	[illegible]	[illegible]	100
Reprocessing waste						
HLW						
Interim storage						
Glass	4.4	9,300	30,000	[illegible]	17,000	55,000
TRU	75	66	[illegible]	143	[illegible]	[illegible]
LLW (additional)	45	0.36	0.2	[illegible]	[illegible]	[illegible]
Airborne						
Iodine + carbon	1	20	[illegible]	[illegible]	[illegible]	[illegible]
Krypton	0.05	[illegible]	[illegible]	[illegible]	150	250

[a]Based on data from *Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/NE-0017/2, U.S. DOE, September 198[illegible].

[b]The volume of HLW glass is the volume of glass and not the volume of canisters (which are normally 85% full). The volume of DOE/defense stored TRU waste includes compaction for volume reduction. The volumes of DOE/defense buried TRU waste and commercial TRU waste do not include the use of volume reduction techniques (i.e., compaction, incineration, and smelting). The volume of LLW includes compaction for volume reduction. The volume of spent fuel is based on the overall outside dimensions of an assembly with no volume reduction (i.e., rod consolidation) applied. The volume of airborne waste is for (1) concrete products containing insoluble compounds of iodine and carbon and (2) gas cylinders containing compressed krypton.

the present time and for projections; and (3) to derive isotopic values for unusual situations or purposes.

A regular "maintenance" function is performed to keep the various ORIGEN2 libraries up to date. This includes, for example, decay parameters (half-life, branching ratios) and neutron functions (cross sections by energy groups). Reactor models must also be upgraded. Because of current interest in higher burnups and longer cycle times, a study of the effects of batch averaging was done, using spent fuel data for a Zion-1 reactor discharge batch of 65 assemblies, where the average assembly burnups varied from 27,900 to 35,850 MWd/MTIHM. For each assembly, axial effects were also considered. The results showed a trivial effect on fission products, total radioactivity, and total thermal power, but a significant effect on those transuranics resulting from multiple neutron captures. Some, such as ^{245}Cm and ^{246}Cm, were underestimated by 36 to 49%, respectively, using the batch averaging. This work will be reported at the Waste Management '84 conference and published in the *Proceedings.*[10]

In the past, ORIGEN2 has been calibrated by comparing the computed results for selected isotopes with the measured values obtained in hot cell experiments. This prior work was done with lower burnup fuel. Increased emphasis on higher burnups has provided the incentive to carry out verification work with higher burnup fuel. Limited experimental work was begun using Oconee-1 fuel at ~40,000 MWd/MTIHM. This fuel has been acquired and dissolved (inside hot cells) by ORNL's Fuel Reprocessing Program, and the major cost to IDB was in analyses for special isotopes such as neodymium (to verify burnup) and the transuranics (where most of our interest lies). Additional fuel is expected to become available from the Fast Flux Test Facility (FFTF) and Monticello reactors, at about 60,000 MWd/MTIHM, and from Big Rock Point and Quad Cities, at "high" burnup.

One of the questions directed to IDB that required funding by the requestor involved a detailed analysis of the alpha-decay behavior of the major sources of alpha radiation in waste. This study, which included 38 source isotopes, has been published.[11] The results were presented graphically, using the ORMANG routine to convert the tabular data. An example of the resulting graphs is shown in Fig. 3.

Another separately funded ORIGEN2 study involved calculations for the Office of NWTS Integration (ONI) that dealt with consolidated fuel (i.e., the fuel and cladding considered separately from the end fittings and other structural material). The calculations were done for pressurized-water reactor (PWR) and boiling-water reactor (BWR) once-through fuel at standard burnup and for PWR fuel at extended burnup. The results are to be published.[12]

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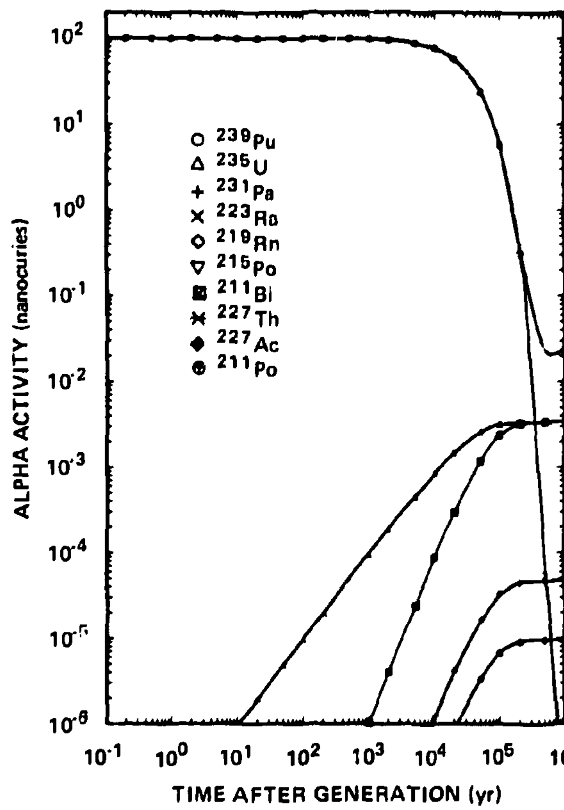

Fig. 3. Alpha decay projections for 100 nanocuries of ^{239}Pu.

2.3. QUALITY ASSURANCE PLAN

The principal quality assurance (QA) control point is the annual inventory report, since this is the driving force for new data input each year and since the core data files are updated in the process. A preliminary plan has been prepared and reviewed by the Steering Committee, with major emphasis on the annual schedule (Table 3) and on a mechanism for dealing with the inevitable changes and corrections needed annually. After comments were received, the QA plan was expanded to include other elements; it has been published as a program document.[13]

Table 3. Schedule for the IDB Program annual report on spent fuel and radioactive waste inventories, projections, and characteristics

Date (responsibility)	Description
October-November (All)	Receive specific comments, questions, or criticisms; response by IDB as appropriate.
December	Prepare suggestions for next annual report, identifying recommended changes in format or data handling and any problem areas.
January (IDB)	Formal call for data to lead sites; response needed by March 30.
February (All)	At Steering Committee meeting, review the call for data and the overall format for the next report.
February 15 (IDB)	Agreed-to assumptions provided for projection basis and spent fuel projection scenario.
March 30[a] (Lead Sites)	Response received by IDB after initial QA by lead sites; electronic computer output preferred, otherwise as hard copy.
April 1 to 30[a] (IDB)	IDB review and QA of data received and initial resolution of questions by phone.
April 30 (IDB)	Letter documentation of any unresolved issues, with copy to DOE; final resolution by lead sites and DOE.
June 15 (IDB)	Issue and distribute draft report for review. Cite any special assumptions and resolution of comments. Response needed by July 5.
July 15[a] (Lead Sites)	Final comments provided by Lead Sites. Detailed review completed at Steering Committee Meeting.
July 15-Aug. 15[a] (IDB)	Incorporation of final comments and preparation of photomasters for reproduction; QA proofing by IDB staff.
August 15[a] (DOE and Lead Sites)	Final draft ready for QA proofing by Lead Sites and DOE. Send via priority mail; 10-day turnaround required.
August 31 (IDB)	Final draft to HQ for sign-off, printing, and distribution.
September (DOE-HQ)	Report issued.

[a]Required QA of numerical data.

2.4. FUTURE WORK

Future plans in matters related to the annual inventory report include the following:

1. Improved formatting of the report to enhance readability and overall utility. Typesetting of the text, rather than use of the CPT word processor, will give a more readable, two-column format and conserve space. Typography will involve interfacing the CPT word processor with an APS-μ5 typesetter, using special communications software. Tabular data will later be handled in a similar manner.

2. The information presently supplied in the source terms appendix will be expanded, upgraded, and published as a separate document. The annual inventory report will include only a summary of this information.

3. The appendix on analysis will be expanded to include more alternatives. Two reactor growth scenarios will be dealt with in the main body of the report. This will provide a basis for simple sensitivity analyses.

4. The chapter on costs will be improved by stressing the modular approach, so that elements of cost can be more easily related to alternative scenarios.

5. The ORIGEN2 codes, written in FORTRAN and presently run on the IBM-3033 mainframe, will be adapted to run on an IBM-PC with expanded memory, a numeric coprocessor, and an emulator. The decay code portion of ORIGEN2 will then be transformed into a user-friendly subset for application to all the waste forms.

6. The QA plan, after review by the Steering Committee, will be revised and issued as a technical memorandum with normal category distribution.

3. IDB USER ACCESS

A major objective of the IDB Program is to make existing data files directly accessible to the DOE network. This objective is being met through two avenues: (1) the summary data file, which does not require programming skills, is available in user-friendly format on floppy disks, and (2) direct access to the core data files via SAS programming; SAS is widely known and used.

3.1. SUMMARY DATA FILE

The summary data file was created in the spring of 1983, for use on the IBM-PC or IBM-PC-compatible personal computers such as the Compaq. The programming was done in dBase II, using SAS to create the necessary data files from the core files. Essentially all of the computerized data in the core files, except detailed isotopic compositions, are available through the summary file. By virtue of the menu options offered by the summary file, data can be extracted that is not directly available in the 300-page annual inventory report. This summary file is contained on two floppy disks: one for the program and one for the data. The diskettes will be updated annually, along with the core files, as the annual inventory report is issued.

The original programming for the summary data file is now being documented,[14] and a user's manual will soon be available.[15] However, a manual is not essential, since the summary file is self-booting and tutorial in nature, with a menu and multiple choice options. Output (in tabular or graphical format) can be either by terminal screen or printer. Examples of menu options and data output are shown in Figs. 4-9. A detailed description of the IDB summary file and the core files will be given at the Tucson meeting.[16]

3.2. DIRECT USER ACCESS

The core data files are produced and updated annually by a combination of programming using FORTRAN, COBOL, PL-1, and SAS as well as manual keyboarding for some data. When possible, data input is via tapes or floppy disks, or via modem if time is limited. Both FORTRAN and COBOL are being used for data transmission; these are compiled using SAS programming[17] to create the desired data files for the annual inventory report or the summary data file. These SAS files, which have been previously described, include the detailed isotopic data generated by ORIGEN2 runs for spent fuel and HLW.[3]

The core data files are accessible from remote locations via a 1200-baud modem and a password; SAS programming skills are required. This is a highly efficient way to access the data, but some familiarity with the SAS files is essential.[2,3] The EIA of DOE has utilized this data base recently, and the necessary instructions are available to all qualified DOE programs.

```
        Welcome to IDB Personal Computing System

            Options available are listed below

    1.  Tables - reports of annual and cumulative waste.
    2.  Graphics - bar and pie charts of annual and cumulative waste.
    3.  Help.
    4.  Quit.

    Your choice? : :
```

```
Which type of waste?
Choose one of the following (1,2,3, or 4)     :0:
-------------------------------------------------------
        1.  Transuranic   (TRU)
        2.  Low-level    (LLW)
        3.  High-level    (HLW)
        4.  Spent fuel    (SF)
        (Spent fuel is for Commercial data only)
-------------------------------------------------------
```

```
Which source of waste?
Choose one or more of the following (1-4)
-------------------------------------------------------
      1.  DOE/Defense    (D)
      2.  Commercial    (C)
      3.  Institutional & Industrial   (I)
          (I only for LLW)
      4.  All sources
-------------------------------------------------------
```

Fig. 4. Generic menu choices from the summary data file.

```
Do you want this report for:
-----------------------------------
    1.  One year only?
    2.  Al. years?
-----------------------------------
Choose one of the above. :0:
```

```
Which year will be used ?
Choose one of the following (1-22)
(Years 1969 - 1974 for spent fuel only)
(HLW does not occur until 1982)    :   0:
-----------------------------------------------
  1.   1969 (69)          12.   1980 (80)
  2.   1970 (70)          13.   1981 (81)
  3.   1971 (71)          14.   1982 (82)
  4.   1972 (72)          15.   1985 (85)
  5.   1973 (73)          16.   1990 (90)
  6.   1974 (74)          17.   1995 (95)
  7.   1975 (75)          18.   2000 (00)
  8.   1976 (76)          19.   2005 (05)
  9.   1977 (77)          20.   2010 (10)
 10.   1978 (78)          21.   2015 (15)
 11.   1979 (79)          22.   2020 (20)
-----------------------------------------------
```

```
Will output go to line printer or screen?
Choose 0 or 1  :0:
----------------------------
0.  Line printer
1.  Screen
----------------------------
```

Fig. 5. Additional generic menu choices from the summary data file.

```
'Form' of spent fuel.        :0:
-----------------------------------------------
1.  Boiling water reactor (BWR)
2.  Pressurized water reactor (PWR)
3.  both
-----------------------------------------------
Form of high-level waste.
Choose one or more of the following (1-7)
            --------------------
            1.  Liquid (L)
            2.  Sludge (S)
            3.  Salt (N)
            4.  Calcine (C)
            5.  Capsule (P)
            6.  Glass (G)
            7.  Slurry (H)
            8.  All forms
            --------------------

Burial & storage sites of high-level waste for DOE/Defense.
Choose one or more of the following (1-4)     :0:
        -----------------------------------------
        1.  Hanford (HANF)
        2.  Idaho Falls (ICPP)
        3.  Savannah River (SRP)
        4.  All sites
        -----------------------------------------
```

Fig. 6. Summary data file menu choices for spent fuel and HLW.

```
Form of TRU waste.
Choose one or more of the following (1-4)
            ------------------------------
            1.  Contact Handled (C)
            2.  Remote Handled (R)
            3.  Buried (B)
            4.  All forms
            ------------------------------

Form of low-level waste for Commercial
Choose one or more of the following (1-5):0:
-------------------------------------------
1.  Classification A (LA)
2.  Classification B (LB)
3.  Classification C (LC)
4.  Other  (LU)
5.  All forms
-------------------------------------------

Burial & storage sites of low-level waste for Commercial.
Choose one or more of the following (1-7)     :0:
        ----------------------------------------
        1.  Barnwell (BARN)
        2.  Beatty (BETY)
        3.  Maxey Flats (MFKY)
        4.  Richland (RICH)
        5.  Sheffield (SHEF)
        6.  West Valley (WVNY)
        7.  U.S. General (USGEN)
        8.  All sites
        ----------------------------------------
```

Fig. 7. Summary data file menu choices for TRU waste and LLW.

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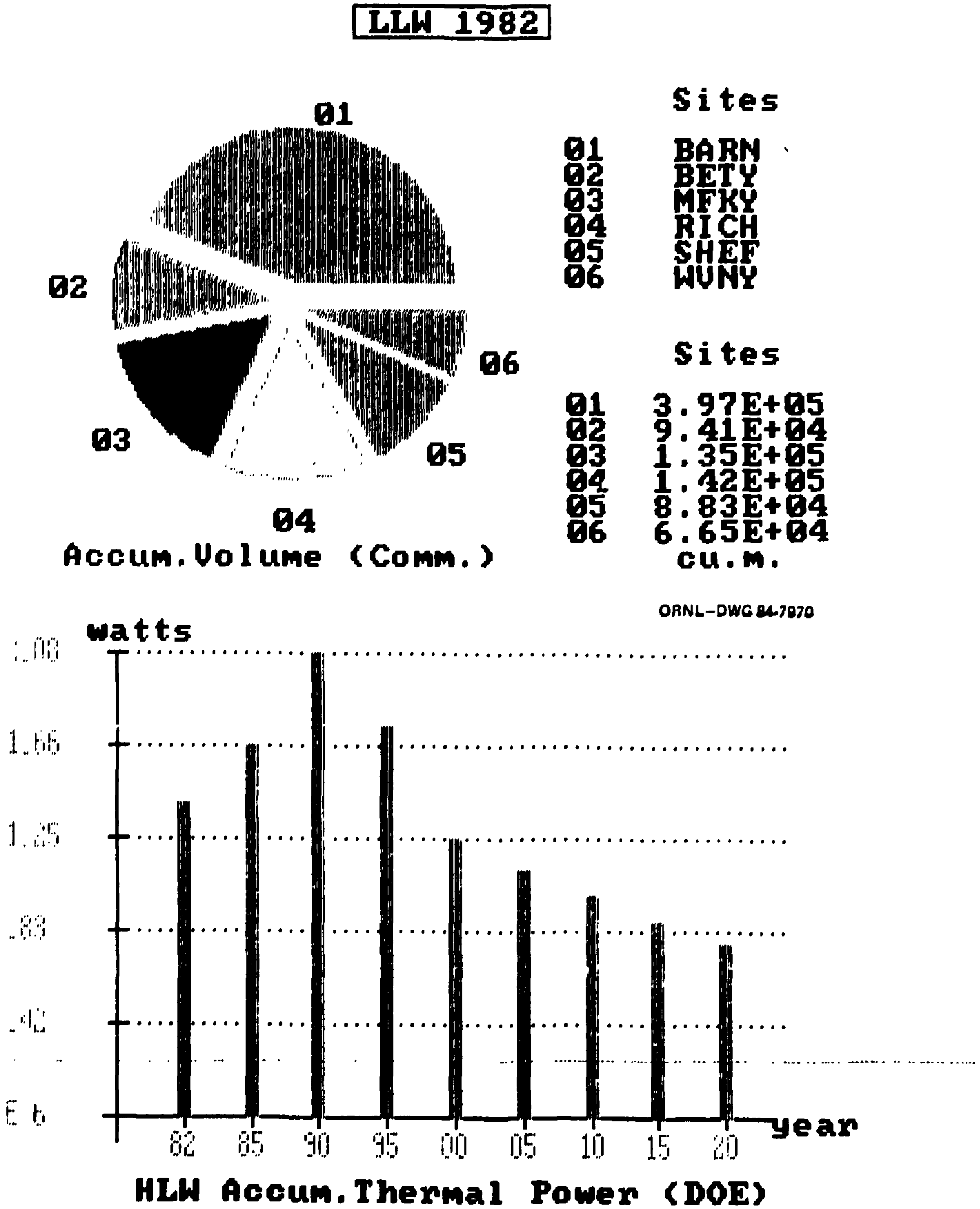

Fig. 8. Samples of graphical output from the IDB summary data file. (a) Accumulated volume of LLW for 1982; (b) accumulated thermal power projections for HLW.

Historic and projected volumes, radioactivity, thermal power, and transuranic mass DOE/Defense TRU wastes by category

End of calendar year	Volume (cu.m.)		Radioactivity (kilocuries)		Thermal power (kilowatts)		Mass of TRU elements (kg)	
	Annual rate	Accumu-lation	Annual rate	Accumu-lation	Annual rate	Accumu-lation	Annual rate	Accumu-lation
				Contact Handled, Remote Handled				
1975	5285.1	37412.3	99.7	795.0	2.4	20.5	71.5	504.9
1976	2788.6	40200.9	91.8	865.4	2.2	22.3	50.1	555.0
1977	6396.0	46597.0	120.5	963.1	2.7	24.5	88.5	643.4
1978	4494.9	51091.9	105.3	1043.8	2.5	26.4	68.2	711.6
1979	6220.6	57312.5	170.3	1188.1	3.4	29.3	110.9	822.5
1980	4444.0	61756.5	87.6	1246.5	2.2	31.0	54.5	876.9
1981	4947.6	66704.2	76.3	1292.8	1.9	32.3	45.7	922.6
1982	5202.5	71906.7	294.7	1557.3	6.3	38.0	189.5	1112.1
1985	5910.1	86620.7	235.7	2062.6	6.3	52.9	112.1	1374.7
1990	3802.1	106731.2	249.6	2963.3	7.2	80.6	72.6	1746.1
1995	3802.1	125741.7	249.6	3817.5	7.2	107.1	72.6	2109.0
2000	3802.1	144752.2	249.6	4625.0	7.2	132.3	72.6	2471.9
2005	3802.1	163762.7	249.6	5394.4	7.2	156.6	72.6	2834.8
2010	3802.1	182773.2	249.6	6129.8	7.2	179.9	72.6	3197.6
2015	3802.1	201783.7	249.6	6833.6	7.2	202.3	72.6	3560.3
2020	3802.1	220794.2	249.6	7508.0	7.2	223.9	72.6	3923.0

DOE/Defense site(s): All sites

Fig. 9. Sample of tabular data output from the summary data file.

3.3. FUTURE WORK

The major near-term effort in this area is to convert the programming for the summary data file from dBase II to Knowledge-Man (K-Man). This will have no effect on the user, other than to provide more menu choices and improved options. K-Man is a more versatile data base management system than dBase II; it requires greater programming skill but will provide improved output to the user.

A longer-term effort is to enhance the direct access to the core files, particularly by the DOE programs (such as TWSO or Isolation) that have need for detailed data in specific areas. The basic mechanism already exists, but two factors need attention to make this avenue more reliable and useful: standardization of the IDB core data files and closer interaction with the lead sites. Work on both aspects is currently underway, and significant progress is expected during FY 1984.

4. OTHER PROGRAM OBJECTIVES

Another major objective of the IDB Program is to develop and apply data processing methodology that provides both flexibility and accessibility and to share this methodology with other DOE programs. This objective is being met through utilization of widely accepted state-of-the-art technology, including SAS programming, microprocessors (personal computers), and current-generation software on floppy disks. Making IDB Program capabilities known to others is also important, and this is done through the Steering Committee, by site visits, with a public information booklet, and by participation in national American Nuclear Society and waste management meetings.[18]

4.1. DATA PROCESSING METHODOLOGY

The IDB Program is committed to the concept of minimizing manual input or manipulation of data and maximizing electronic, computerized transfer and processing of data. We believe this will save time and money, preclude transcription errors, and provide the only practical means of handling and updating the huge volume of data.

In principle, once the original data entry for a package is made into the generator site computer files, no further manual data input should be required. With a properly designed system, data can be selectively extracted and transferred within and between sites to meet virtually all needs: shipping papers, certification forms, site monthly reports, local DOE field office reports, lead site data summaries, IDB data files, and accountability records. Some sites are already utilizing these automated data transfers.

The major hardware components used by the program are shown in Fig. 10: (1) hard disks to store the core data files after generation on IBM-3033 and PDP-10 mainframes, (2) personal computers for accessing the summary data file and numerous other program applications, and (3) a word processor to produce camera-ready copy of both text and tables.

The overall data handling system is illustrated in Fig. 2, and the methodology of various steps involved in data input, processing, and output have been discussed in prior sections of this report. The foundation of the IDB Program is, of course, the individual generator and storage sites and their QA programs. They are both the originators and the primary users of our data base. Therefore, the IDB Program is working closely with both lead sites and generator sites to assure that our data handling approach is amenable to their needs and procedures and that our data structure adequately reflects the physical reality of the materials that they produce and handle. The Steering Committee (Table 4), which meets semiannually, has been effective in promoting good communications among all factors.

The most crucial QA of the data flow process can be handled routinely at the source. The responsible operator enters data from the original hard copy into the computer. This is most easily done via a terminal with a monitor, so the original entry can be checked and held in temporary storage. A printed copy of the file is then reviewed independently by someone with practical knowledge of the material being handled. The reviewer corrects any obvious errors using his own terminal, and then converts the data into a permanent data file. At least one site (LANL) has been using this technique, and it's adoption is planned for ORNL.

Cost data are also handled by the IDB Program, since they are amenable to grouping by waste form and type. Additional cost factors are added for complete ..ass (e.g., transportation, storage and disposal). Cost data are supplied to the IDB Program by PNL under separate funding from DOE. An overall diagram showing basic cost elements for commercial waste was developed by ORNL (Fig. 11) to serve as a foundation for future modeling work.

The RAWSYM code, developed by NUS, incorporates and simplifies several ORNL codes to compute projected spent fuel and fuel cycle waste for various scenarios.[19] The code has several modules, which are not close-coupled, to allow greater flexibility. Using the RAWSYM approach, a test study was done dealing with the relative benefits of dry cask storage.[20] The results showed that rod consolidation provides major benefits from many aspects, that transportation costs are a small fraction of total storage expenses, and that semipermanent storage using many casks will become very expensive. For the long run, a more user-friendly RAWSYM model is needed.

4.2. SUPPORT TO OTHER PROGRAMS

Improvements in data handling, QA, and hardware/software applications are of generic benefit to all the programs that participate in IDB. Separate funding support was provided in three areas of the program for FY 1983.

A unified annual call for TRU waste data was developed in conjunction with TWSO, Solid Waste Information Management System (SWIMS), and all of the DOE generators or storage sites for TRU waste. After a review of site needs, capabilities, and special problems, we prepared basic lists of terms, definitions, and required information. These went through several iterations using mail and phone contact, and a workshop was held to achieve final resolution and consensus. Results were distributed to the participants and other interested parties for subsequent implementation by TWSO and Albuquerque Operations Office (ALO).[21] After the list of terms and definitions was mutually understood and agreed upon, the six specified data tables for TRU wastes were accepted with only minor revisions.

The general approach used for the summary data file (see Sect. 3.1) was adapted and modified to suit the needs of the TRU waste operations and is in the process of implementation at ORNL. User access is via the IBM-PC in a stand-alone mode.

There are, however, four significant differences from handling of the summary file. These are: (1) direct entry of primary data on TRU waste; (2) inclusion of more detail, on a package-by-package basis, to satisfy the needs of the data users; (3) addition of a hard

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Fig. 10. Hardware used by the IDB Program (from top to bottom): hard disks, personal computers, and word processors.

Table 4. Steering Committee for the Integrated Data Base Program

Functional responsibility	Committee member	Technical liaison	DOE liaison
Program Manager	J. A. Klein, ORNL	R. C. Ashline, ORNL W. L. Carter, ORNL C. W. Forsberg, ORNL H. W. Godbee, ORNL A. H. Kibbey, ORNL G. W. Morrison, ORNL	D. E. Large, ORO
DOE/HQS/NE	E. F. Mastal, DOE/HQS/NE	E. F. Mastal	J. P. Thereault, DOE//HQS/NE
DOE/HQS/DP	W. A. Frankhauser, DP/HQS/DP	W. A. Frankhauser	J. E. Dieckhoner, DOE/HQS/DP
DOE/HQS/RW	G. S. Chaconas, DOE/HQS/RW	G. S. Chaconas	C. R. Head, DOE/HQS/RW
HLW	W. R. Cornman, SRL	W. R. Cornman	H. B. Saucier, SRO T. Ridout, SRO
LLW	E. Jennrich, EG&G/ID	H. M. Batchelder, EG&G/ID S. E. Everette, EG&G/ID	M. Barainca, IDO
TRU Waste	L. J. Smith, RI/RF	J. A. Detamore, RI/RF	M. H. McFadden, ALO
Isolation	E. F. Benz, Weston	E. F. Benz	J. W. Bennett, DOE/HQS/RW
Transportation	J. W. Cashwell, Sandia	J. W. Cashwell	K. Golliher, ALO
Spent Fuel and Economics	B. M. Cole, PNL (G. M. Holter, PNL)	R. A. Libby, PNL (Spent Fuel L. R. Dodd, PNL Economics)	P. A. Craig, RL
Electrical Demand and Spent Fuel Projections	J. A. Disbrow, DOE/EIA	J. A. Disbrow	R. G. Clark, DOE/EIA
Generic Analysis	H. C. Burkholder, PNL	R. W. McKee, PNL	P.F.X. Dunigan, RL
SFMP	D. Burnett, UNC-NI	R. N. Coy, UNC-NI	C. Miller, RL
UMTRAP	J. Moric , ALO	W. C. Barber, Jacobs Engr.	J. Morley, ALO
FUSRAP	E. L. Keller, ORO	J. D. Mahler, ORO	E. L. Keller, ORO
Systems Support	N. B. McLeod, NUS	N. B. McLeod	E. F. Mastal, DOE/HQS/NE
WIPP	R. L. Dintaman, WPO	J. E. Johnson, W/WIPP	J. M. McGough, WPO

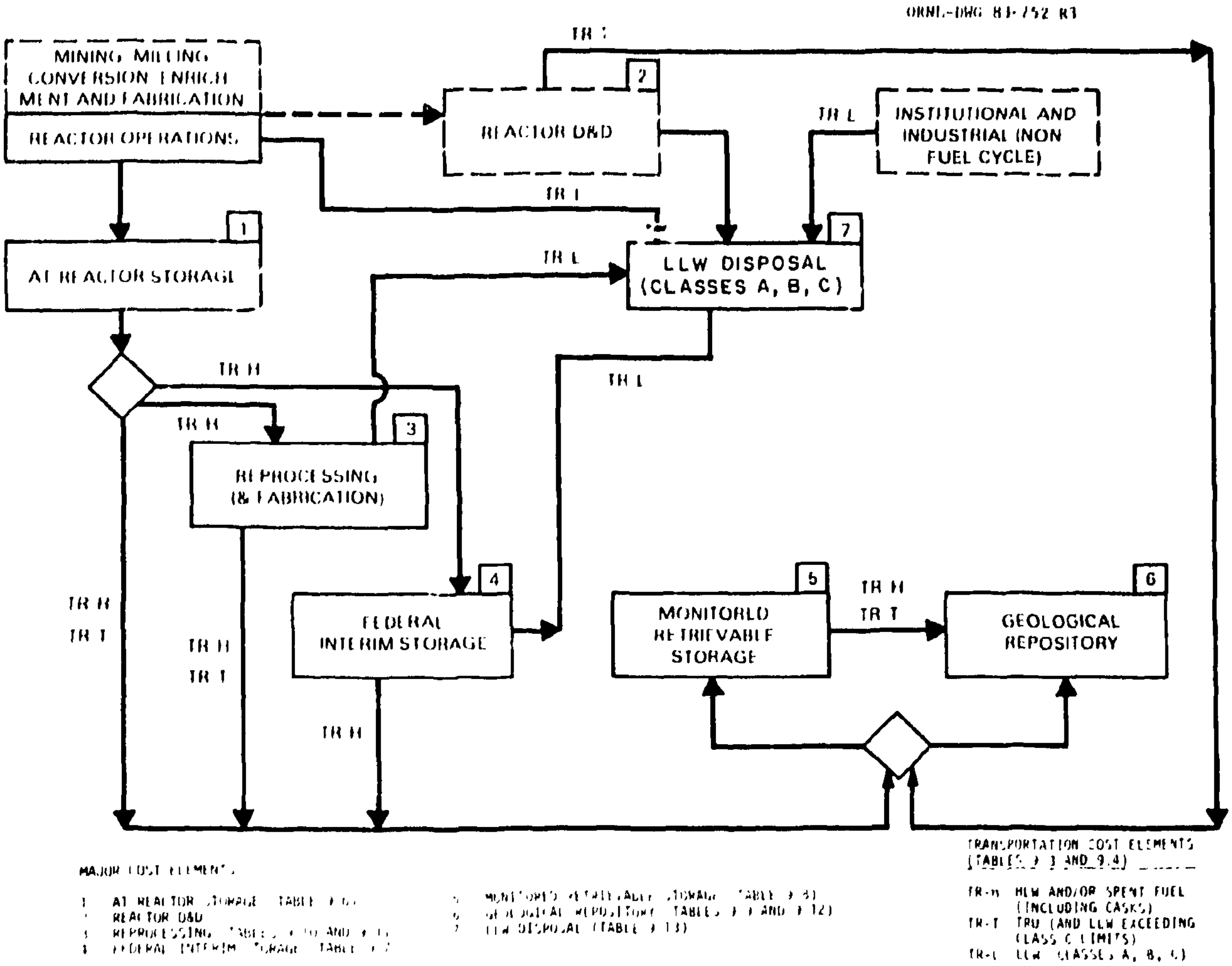

Fig. 11. Diagram of commercial waste cost elements.

("Winchester") disk for data storage; and (4) less emphasis on user-friendly software and more emphasis on data base management system (DBMS) capabilities. The new system utilized SAS to move the previously used COBOL files on TRU waste to the IBM-PC, and both Micro RIM and K-Man are employed. For ORNL, where the total TRU inventory is about 3000 packages, the entire data file fits on one hard disk. Other sites (RI/RFP and NTS) have expressed interest in this system, and the IDB Program has made ORNL-developed software available to them. The ORNL system for TRU waste is described in a program report[22] and will be reported at the Tucson meeting.[23] The ORNL data handling system for TRU waste is in the process of being expanded to include LLW.

There is a high degree of interest in personal computers for IDB Program applications because of the improved capabilities now available at moderate prices and because software has become easier to use and relatively interchangeable. The IDB Program selected the IBM-PC because it offers an excellent range of hardware capabilities, quality performance, a large selection of software, ease of interfacing with existing IBM-3033 programs, the capability of upgrading the numeric processing ability, and the potential for networking. Other personal computers also offer many of these benefits. Use of personal computers will encourage direct involvement of technical staff other than computer specialists in the data processing, which is highly desirable.

4.3 FUTURE WORK

Future developments of the IDB Program will place more emphasis on personal computers and less on the large mainframes. We have shared our experience and knowledge in this field with other members of the Steering Committee. One of our staff (G. W. Morrison) has extensive experience with personal computers in addition to his programmatic involvement and has visited several sites as an adviser. He is available, on a limited basis, for consultation with other DOE sites, and some consulting is already planned for FY 1984.

With the increased emphasis on personal computers, an eventual objective of the IDB Program is to transfer the entire core data file to Winchester disks. Networking will also be implemented. Onsite networking is planned for late 1984, with offsite development to follow as funding permits.

Modeling programs will also be written for the IBM-PC, with the objective of developing simplified models to allow faster and easier testing of alternatives and to screen out unrealistic cases. Nuclear materials (fuel cycle) projection models will be developed first and then cost modeling programs. The more sophisticated models already available will be used to verify the results and to calibrate and fine-tune the simplified modeling programs.

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APPENDIX. MEETINGS AND PUBLICATIONS

MEETINGS

1. American Nuclear Society, annual meeting, November 1982; "Radioactive Waste and Spent Fuel Inventories, Characteristics, and Projections: An Integrated Data Base," by C. W. Forsberg and K. J. Notz. Published in the *Proceedings*, Vol. 43: TANSAO 43 (1982), pp. 429-30.
2. Steering Committee, semiannual meeting, Oak Ridge, Tennessee, February 9-10, 1983.
3. Steering Committee, semiannual meeting, Las Vegas, Nevada, June 21-23, 1983.
4. Steering Committee, semiannual meeting, Seattle, Washington, January 24-25, 1984.
5. TRU Data Call Workshop, Oak Ridge, Tennessee, November 29-30, 1983.
6. Spent Fuel Workshop, DOE/Headquarters, Germantown, Maryland, April 12-13, 1984
7. Waste Management '84, Tucson, Arizona, March 11-14, 1984; four papers to be presented, see references 10, 16, 18, and 23. These will also be published in the *Proceedings*.

PUBLICATIONS

See references 1-4, 10-16, 18, 20, 22, and 23 of this report.

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65-69. G. S. Chaconas, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, RW-13, Washington, DC 20585

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80. N. B. McLeod, NUS Corporation, 910 Clopper Road, Gaithersburg, MD 20878

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