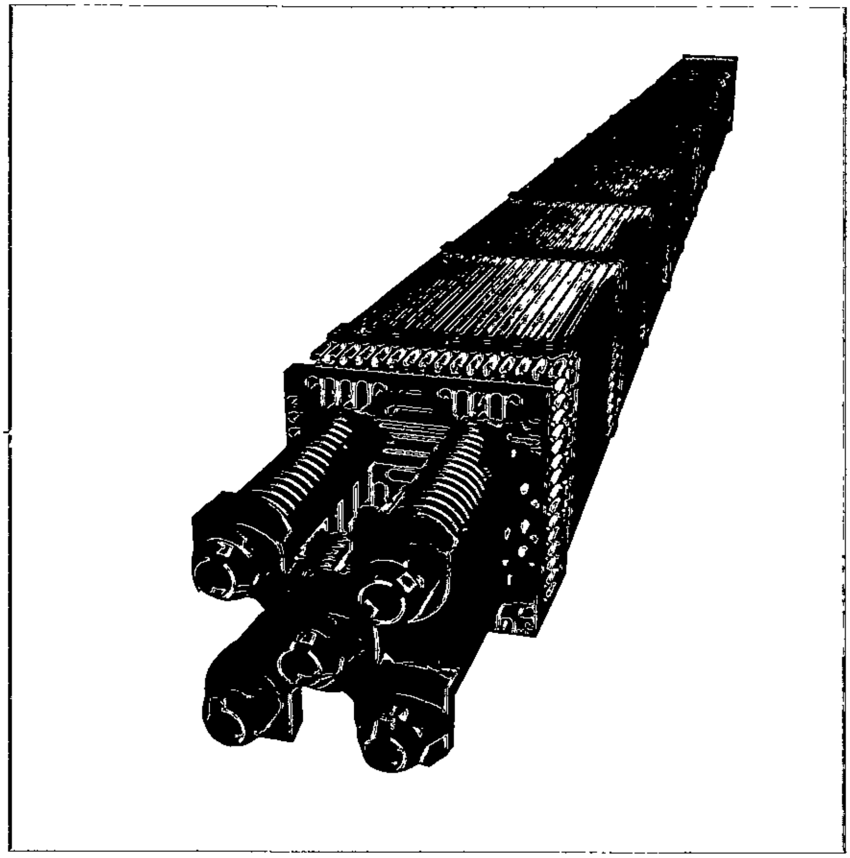
JPL PUBLICATION 77-59, VOLUME II

An Analysis of the Back End of the Nuclear Fuel Cycle With Emphasis on High-Level Waste Management



Prepared for

The Office of Science and Technology Policy

by

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California 91103

COVER: Perspective view of a single pressurized water reactor fuel assembly containing 264 fuel rods. The core of a 1000-megawatt nuclear reactor contains about 190 of these fuel assemblies.

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Thomas D. English
Project Manager

August 12, 1977

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This work was performed by the Jet Propulsion Laboratory, California Institute of Technology, under NASA Contract NAS7-100 for the Office of Science and Technology Policy (OSTP).

FOREWORD

This report - An Analysis of the Back End of the Nuclear Fuel Cycle with Emphasis on High-Level Waste Management - summarizes the results of a research project conducted by the Jet Propulsion Laboratory for the Office of Science and Technology Policy (OSTP).

The broad purpose of the project is to provide analytical support to OSTP in connection with the Federal Coordination Council of Science Engineering and Technology in the area of high-level nuclear waste management. The specific objectives of this project are to:

(1) Examine the most active nuclear waste disposal programs and plans to determine strengths and inconsistencies.

(2) Assess implications of schedules for waste disposal.

(3) Identify necessary but missing elements in waste disposal plans.

This study has been performed by a group drawn from the Jet Propulsion Laboratory, the campus of the California Institute of Technology, and the Scripps Institution of Oceanography. The leader of the team is Thomas English; others principally concerned with the analysis and writing the report include Edward Bullard, Lester Lees, Robert Campbell, Alan Chockie, Calvin Davis, Edward Divita, Edward Edelson, Thomas Kuehn, Joseph Klimberg, Charles Miller and Michael Ziman. The duration of the study was approximately 7 months, and involved 2 man-years of effort.

The work was funded under a National Science Foundation Interagency Agreement No. NSF-CA76-8446. The contract Technical Directors were Dr. Russell Drew, Assistant Director, OSTP and Dr. Joel Snow, Senior Policy Analyst, OSTP.

ACKNOWLEDGEMENTS

The authors are grateful for the time and information given to us during our converstions with persons at the following organizations and agencies:

American Physical Society, Battelle (Pacific Northwest Laboratory), Council on Environmental Quality, Environmental Protection Agency, Electric Power Research Institute, California Energy, Resources, Conservation and Development Commission, Energy Research and Development Agency, Government Accounting Office, Idaho National Engineering Laboratory, Office of Technology Assessment, Lawrence Livermore Laboratory, MIT's Energy Laboratory, National Academy of Science, National Aeronautics and Space Administration, Nuclear Regulatory Commission, Natural Resources Defense Council, National Security Council, Office of Management and Budget, Oak Ridge National Laboratory, Union Carbide's Office of Waste Isolation, Sandia Corp., Scripps Institution of Oceanography, and the U.S. Geological Service.

We appreciate the assistance of the Jet Propulsion Laboratory/ Cal Tech campus, Nuclear Waste Management Review Board in reviewing this report. In addition, we are thankful for the patience and skill of our secretary Jeanne Wadsworth.

DEFINITION OF ABBREVIATIONS

ACDA	Arms Control and Disarmament Agency
ACRS	Advisory Committee on Reactor Safety
AEC	Atomic Energy Commission
AGNS	Allied General Nuclear Services
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
APS	American Physical Society
ARHCO	Atlantic Richfield Hanford Company
AWMP	Air and Waste Management Programs
CERCDC	California Energy Resources Conservation and Development Commission
CEQ	Council on Environmental Quality
CIT	California Institute of Technology
ECT	Environmental Control Technology
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERAMS	Environmental Radiation Ambient Monitoring System
ERDA	Energy Research and Development Administration
ESTF	Earth Science Task Force
FBR	Fast Breeder Reactor
FRP	Fuel Reprocessing Plants
GAO	Government Accounting Office
GEIS	Generic Environmental Impact Statement

GESMO	Generic Environmental Statement on Mixed-Oxide Fuels
HEDL.	Hanford Engineering Development Laboratory
HLW	High-Level Wastes
HTGR	High Temperature Gas Reactor
IAEA	International Atomic Energy Agency
ICPP	Idaho Chemical Processing Plant
IE	Office of Inspection and Enforcement, NRC
ILW	Intermediate Level Waste
INEL	Idaho National Engineering Laboratory
LASL	Los Alamos Scientific Laboratories
LLL	Lawrence Livermore Laboratories
LLW	Low-Level Wastes
LMFBR	Liquid Metal Fast Breeder Reactor
LWBR	Light Water Breeder Reactor
LWR	Light Water Reactor
MIT	Massachusetts Institute of Technology
NAS	National Academy of Science
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NFS	Nuclear Fuel Services
NMSS	Office of Nuclear Material Safety and Safeguards, NRC
NPDES	National Pollutant Discharge Elimination Systems
NRC	Nuclear Regulatory Commission
NRDC	Natural Resources Defense Council
NRDS	Nuclear Rocket Development Station

NRR	Office of Nuclear Reactor Regulation, NRC
NWM	Nuclear Waste Management
NWTS	Nuclear Waste Terminal Storage Program
OMB	Office of Management and Budget
ORNL	Oak Ridge National Laboratories
ORP	Office of Radiation Programs, EPA
OSTP	Office of Science and Technology Policy
OTA	Office of Technology Assessment
OWI	Office of Waste Isolation
PNE	Peaceful Nuclear Explosions
PNL	Battelle Pacific Northwest Laboratory
R&D	Research and Development
RES	Office of Nuclear Regulatory Research, NRC
RSSF	Recoverable Surface Storage Facility
SD	Office of Standards Development, NRC
SGR	Self-Generated Recycle
SIO	Scripps Institution of Oceanography
SRE	Sodium Reactor Experiment
TAD	Technology Assessment Division, EPA, or Technical Alternatives Document
TRU	Transuranic
UFC	Uranium Fuel Cycle
USGS	United States Geological Service
WBS	Work Breakdown Structure
WIPP	Waste Isolation Pilot Plant

ABSTRACT

The programs and plans of the U.S. Government for the "back end of the nuclear fuel cycle" were examined to determine if there were any significant technological or regulatory gaps and inconsistencies. Particular emphasis was placed on analysis of high-level nuclear waste management plans, since the permanent disposal of radioactive waste has emerged as a major factor in the public acceptance of nuclear power. The implications of various light water reactor fuel cycle options were examined including: throwaway, stowaway, uranium recycle, and plutonium plus uranium recycle.

The results of this study indicate that the U.S. program for high-level waste management has significant gaps and inconsistencies. Areas of greatest concern include: the adequacy of the scientific data base for geological disposal; programs for the disposal of spent fuel rods; inter-agency coordination; and uncertainties in NRC regulatory requirements for disposal of both commercial and military high-level waste.

"It is self-evident that, during the growth process, the same challenge is never presented more than once. For, ex hypothesi, so long as growth is being maintained, each successive challenge is being successfully met, or, in other words disposed of as a living issue and relegated to the history books. By contrast we can see that, in a series in which the outcome of each successive challenge is not victory but defeat, the unanswered challenge can never be disposed of and is therefore bound to present itself again and again until it receives some overdue and imperfect answer, or else brings about the destruction of a society which has shown itself inveterately incapable of responding to it effectively."

Arnold Toynbee
A Study of History

SUMMARY

The disposal of radioactive materials produced by nuclear reactors has emerged as a major factor in the public acceptance of nuclear power. The problems of waste disposal cannot be considered in isolation. They are intimately connected with the nature of the fuel cycle as a whole, and in particular with the decision as to whether spent fuel rods are to be reprocessed, stowed-away for possible future reprocessing, or thrown-away irretrievably.

Section I of this report describes the nature of the nuclear spent fuel recycle and waste disposal issues, in addition to the implications of various light water reactor fuel cycle options. Section II describes the complex inter-relationship of Federal, State and private sector decisions on the viability of commercial reprocessing. The economic and resource implications of various decision paths are also discussed. In Section III, the programs of the Federal Government for disposal of high-level waste from commercial reactors are examined in order to determine regulatory and technological gaps and inconsistencies. Section IV discusses the influence of Federal, State and municipal regulatory action on waste management. In addition, the results of an examination of the regulatory requirements for military and commercial high-level waste management are presented. Section V brings together our conclusions. The principal function of the appendices, contained in Volume II, is to describe the present reprocessing and waste management programs of EPA, ERDA and NRC.

To summarize our findings, it appears to us that the following matters are important:

(1) Spent Fuel Rods

The accumulation of spent fuel rods at reactor sites should be limited, since a continuation of present practices into the indefinite future would constitute a de facto form of nuclear waste disposal. Analysis should be carried out and plans should be formulated for the development of both centralized spent fuel pools, and centralized passive spent fuel storage facilities in order to make the "stowaway option" a viable alternative. In addition, methods and schedules for the ultimate disposal of spent fuel rods need to be developed in order to make the "throwaway option" a real alternative.

(2) Federal Program

The resources devoted to high-level waste management by NRC and EPA have been inadequate in view of the critical roles these agencies play in developing standards, criteria and regulations. The budgets of these two agencies have

recently been increased substantially. However, we question whether the resources available to these two agencies are commensurate with their responsibilities. There appears to be a lack of an adequate platform for systematic discussion of the sufficiency of the scientific data base for geologic disposal. An important outcome of such discussion would be the development of decisions as to what parameters should be monitored, and for how long, during the test phase of a specific repository site. In addition, there appears to be a need for improved coordination of the nation's high-level nuclear waste program. One method of providing better coordination would involve formation of a high-level inter-agency committee for nuclear waste management. This committee could provide a mechanism for resolving issues, and could fulfill the function of coordinating the activities of the Federal agencies concerned with nuclear waste processing, packaging, transport, and disposal. Another approach might be to appoint a single individual from, for example, the Executive Office of the President, to serve as a focal point for the nation's high-level nuclear waste management program.

In light of President Carter's decision to defer reprocessing indefinitely, the schedule for operation of a repository for commercial high-level waste by 1985 should be re-examined and revised. In addition, the timing of the promulgation of NRC siting criteria for high-level waste disposal sites, and the site selection activities of ERDA should be revised to make them compatible.

(3) Regulations

NRC is mandated to license both commercial and military high-level waste repositories. NRC has not decided whether to require either site selection review and/or construction licenses for these repositories. We believe that assumption of these responsibilities by NRC could hasten the ultimate development of these repositories. In the area of pilot plant retrievable repositories for high-level waste, NRC plans to license commercial but not military pilot plants. Extending NRC's licensing authority to include military pilot plant repositories would eliminate this inconsistency.

(4) Alternative Fuel Cycles

Alternative fuel cycles,should be systematically studied from the standpoint of reducing the problems associated with waste disposal, proliferation and safeguards.

CONTENTS

VOLUME II

VOLUME II CONTENTS (contd)

VOLUME II CONTENTS (cont)

VOLUME II CONTENTS (cont)

VOLUME II CONTENTS (cont)

LIST OF FIGURES FOR VOLUME II

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

LIST OF TABLES FOR VOLUME II

TABLES

APPENDIX A

STUDY STRATEGY

APPENDIX A

CONTENTS

Figures

I. OBJECTIVES

The broad goal of conducting a "Systems Analysis of Nuclear Fuel Cycle with Emphasis on Nuclear Waste Management" was to provide an analysis of nuclear waste management technology and policy development. The specific objectives of this project were to:

- Examine the most active nuclear waste disposal programs and plans to determine strengths and inconsistencies
- Assess implications of schedules for waste disposal
- Identify necessary but missing elements in waste disposal plans.

Nuclear waste management has been the subject of major policy decisions and of policy review by a variety of institutions during the seven months of our study. These factors made it imperative for us to concentrate our efforts in a few areas rather than to attempt overall comprehensiveness for the complete LWR nuclear fuel cycle. The emphasis of the project was assigned approximately as follows:

- 75 percent effort on High Level Waste Disposal
- 15 percent effort on Fuel Reprocessing
- 10 percent effort on related nuclear energy issues.

II. METHODOLOGY

The Nuclear Waste Disposal Team members involved with this study and other nuclear waste disposal efforts, and their areas of expertise, are shown in Figure A-1. Team members were drawn from the Jet Propulsion Laboratory, the California Institute of Technology, and the Scripps Institution of Oceanography (SIO).

The study followed two parallel lines of investigation, as shown in Figure A-2. The first line of investigation examined overall Federal policy with respect to reprocessing and nuclear waste management. The second line of investigation examined pertinent existing programs in three Federal agencies--the Energy Research and Development Administration (ERDA), the Nuclear Regulatory Commission (NRC), and the Environmental Protection Agency (EPA).

A. REVIEW OF FEDERAL POLICY

Figure A-2 indicates that four types of sources were utilized to gather information on the status and future prospects for Federal policy in the area of reprocessing and waste management:

QUALIFICATION/ EXPERIENCE \ TEAM MEMBER	JPL													CIT		SIO
	DR. T. ENGLISH	DR. C. MILLER	DR. R. CAMPBELL	MR. E. DIVITA	DR. C. DAVIS	DR. R. O'TOOLE	MR. A. CHOCKIE	MR. E. EDELSON	DR. T. KUEHN	MR. R. WILSON	DR. T. HSIEH	MR. M. ZIMAN	MS. SYDNEY IRELAND	PROF. L. LEES	PROF. S. EPSTEIN	SIR E. BULLARD
SYSTEMS MANAGEMENT AND ENGINEERING	X				X			X		X		X				
NUCLEAR SCIENCE AND ENGINEERING	X	X	X	X	X		X				X					
CONTAINMENT MATERIALS		X					X								X	X
SEA AND SEABED																X
SPACE TECHNOLOGY		X	X	X						X				X		
GEOLOGY															X	X
CHEMICAL ENGINEERING		X														
DRILLING TECHNOLOGY		X														
GEOSPHERIC TRANSPORT			X	X											X	X
BIOSPHERIC TRANSPORT			X	X												
HEALTH EFFECTS	X		X													
ECONOMICS					X	X	X		X			X				
SOCIAL						X		X	X					X		
ENVIRONMENTAL	X	X		X	X				X				X	X		
LEGAL AND REGULATORY	X				X		X		X				X	X		
POLICY	X							X	X					X		X

Figure A-1. Nuclear Waste Management Team

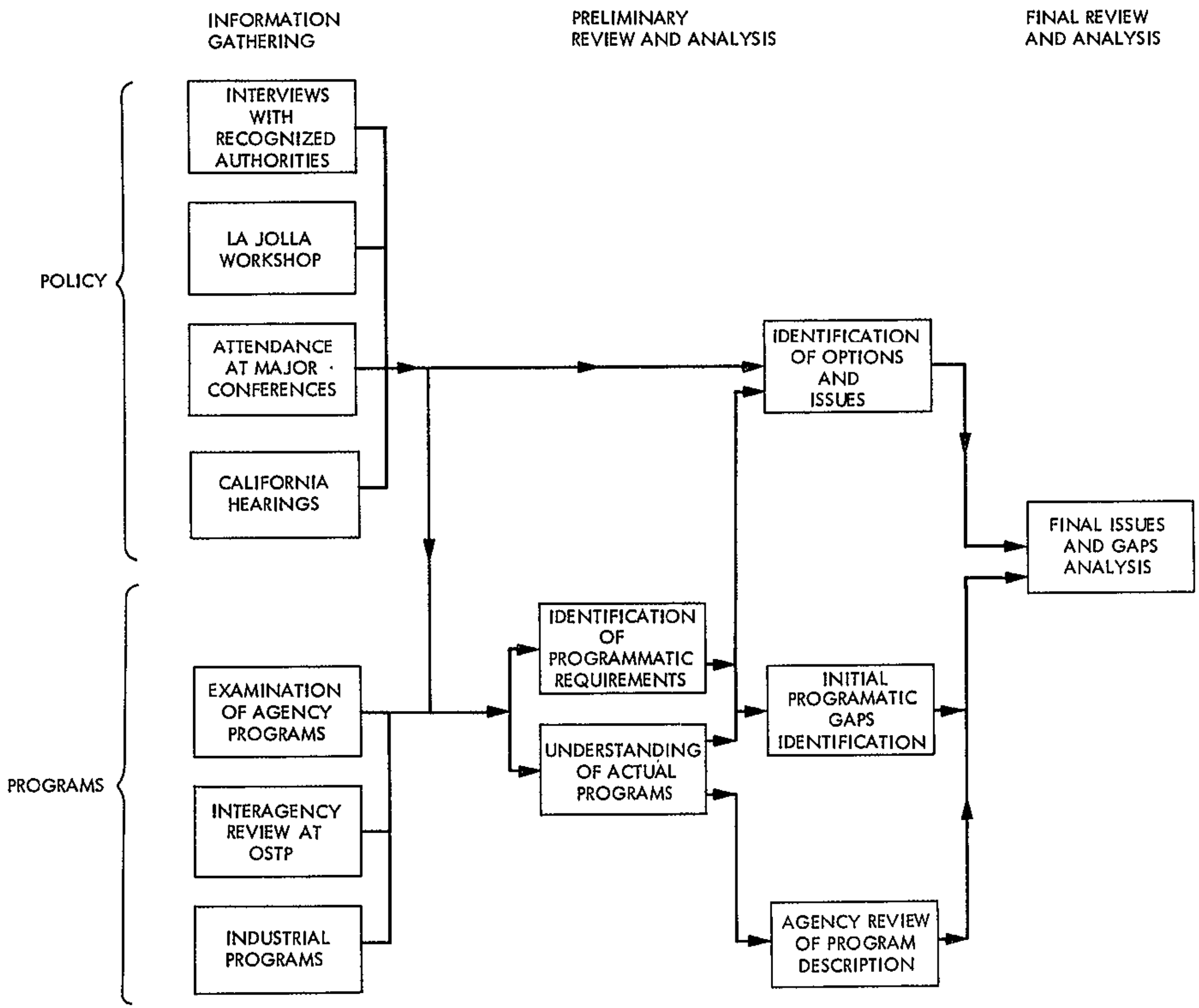


Figure A-2. Overall Study Strategy

(1) Interviews with acknowledged authorities including those specifically recommended by the Office of Science and Technology Policy (OSTP)

(2) Organizing and conducting a Nuclear Waste Management System Overview Workshop at La Jolla, California

(3) Attendance at conferences and workshops

(4) Attendance at and assistance to the State of California extensive hearings on high level waste disposal and commercial reprocessing.

B. REVIEW OF EXISTING FEDERAL PROGRAMS

Based on our general knowledge of the area and on participation at the OSTP interagency review of the plans presented by the Laboratory, the nuclear waste management programs of three Federal agencies were chosen for complete review. The Energy Research and Development Administration (ERDA), the Nuclear Regulatory Commission (NRC), and the Environmental Protection Agency appear to be the key agencies at the present time, even though important roles are being played by USGS, CEQ and NSF.

The emphasis in this part of the study was to examine the programs of these agencies to determine if there were any significant gaps in either the technological or regulatory programs, and to see if the agency programs coincided with the broad goals and policies that have been established.

Specific personnel were assigned to each agency to gather the available information on that agency's existing program. Using interviews, published material and material made available from the agencies, the agency programs were summarized and reviewed. The different legislative and executive mandates made it impossible to establish one comparative format or structure for all three agencies. In this part of the study, the emphasis was on providing a concise description of the agency's program. These descriptions appear in Appendixes B, C, and D. Our description of the pertinent programs of EPA, ERDA, and NRC has been reviewed independently by these agencies. We appreciate their time and effort used in both providing this information to us and reviewing our descriptions of their programs. Wherever we felt it was appropriate, the review comments of the agencies were included in the appropriate appendixes.

The observations on the status of the programs with respect to the agency's goals and policies are based heavily on the interviews and materials received from the agencies. The extent of the comprehensiveness of the description and analysis was dependent on the material supplied by the individual agencies. The Nuclear Waste Management Team found that the agencies, in whole or part, did have difficulty in completely documenting their programs. Although this does not necessarily indicate any problems in their programs, it is important from another perspective, that of public acceptance. All three of these agencies have stated how important public acceptance is to the success of management of nuclear waste. However, the team's experience indicates that detailed programmatic information is not always readily available. Based on our experience, we conclude that the agencies would benefit in placing more emphasis on documenting their programs in a form that is readily available to the public.

III. WASTE MANAGEMENT TEAM VISITS

A list of the people, conferences, workshops and hearings visited and attended by the nuclear waste management team follows:

(1) International Symposium on the Management of Waste from the LWR Fuel Cycle (TAD)

(2) Nuclear Waste Management Systems Overview Workshop (SIO)

(3) Public Policy Issues in Nuclear Waste Management - Conference at Chicago (CHIC)

(4) The Tucson Symposium on Waste Management (U of A)

(5) Workshop on Issues Pertinent to the Development of Environmental Protection Criteria for Waste Management (EPAW)

(6) Sandia Laboratories (WIPP)

(7) Sandia Laboratories (Seabed)

(8) Pacific Northwest Laboratories (PNL)

(9) Nuclear Regulatory Commission (NRC)

(10) Idaho National Engineering Laboratory (INEL)

(11) American Physical Society (APS)

(12) Electric Power Research Institute (EPRI)

(13) Energy Research and Development Administration (ERDA)

(14) Environmental Protection Agency (EPA)

(15) National Aeronautics and Space Administration (NASA)

(16) Office of Management and Budget (OMB)

(17) Oak Ridge National Laboratories (ORNL)

(18) California Energy Resources, Conservation and Development Commission (CERCDC)

(19) Office of Science and Technology Policy (OSTP)

(20) Council on Environmental Quality (CEQ)

(21) Office of Technology Assessment (OTA)

(22) Government Accounting Office (GAO)

(23) David Rose (MIT)

(24) Harvey Brooks (Harvard)

(25) Theodore Taylor (Princeton)

(26) Terrance Lash, Natural Resources Defense Council (NRDC)

(27) Lawrence Livermore Laboratories (LLL)

In order to insure that the entire nuclear waste management team has had a broad exposure to both the technological and regulatory issues, we sent a variety of people to the key sources of information described above. A summary of the personnel who went to these sources is shown in the matrix in Figure A-3.

These activities in addition to the general experience of the study participants have provided the study with a broad view of the present policies and the range of possible policies to be implemented. This knowledge, in addition to the understanding of Federal programs supplied by the other line of investigation, was used to identify the gaps, options and issues that appear in the main report.

The interviews with acknowledged authorities external to ERDA, EPA and NRC included--Harvey Brooks, Theodore Taylor, Hannes Alfven, David Rose and A.R. Tamplin. These interviews are summarized in Appendix F. Summaries of the various conferences attended by representatives of the study team appear in Appendix E. The La Jolla Nuclear Waste Management workshop was organized by the JPL/CIT/SIO nuclear waste management team. It enabled the study team to glean from many experts their views of what the major issues are, and what decisions are needed.

Valuable input that has been utilized by the study team is the Laboratory's involvement in the hearings being held by the California Energy Research, Conservation and Development Commission on high level waste management and reprocessing. The purpose and schedule of these hearings are summarized in Appendix E.

PERSONNEL	LOCATION																										
	TAD	SIO	CHIC	U OF A	EPAW	WIPP	SEABED	PNL	NRC	INEL	APS	EPRI	ERDA	EPA	NASA	OMB	ORNL	ERCDC	OSTP	CEQ	OTA	GAO	MIT	HARVARD	PRINCETON	NRDC	LLL
DR. T. ENGLISH	X	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X				X	X
DR. R. CAMPBELL	X	X			X	X	X	X	X				X	X	X	X	X	X		X	X		X	X	X		
PROF. L. LEES	X	X	X						X				X	X	X	X		X	X		X						
SIR E. BULLARD		X				X	X	X	X					X	X		X	X	X								
MR. E. DIVITA P.E.		X	X					X	X				X	X		X	X	X		X	X						
DR. C. MILLER		X							X		X	X	X	X		X	X	X		X	X					X	X
DR. T. KUEHN		X	X		X									X	X	X		X	X		X		X	X			
DR. A. CHOCKIE		X			X			X		X				X				X					X	X	X		
MR. R. WILSON		X			X				X	X	X			X	X			X	X			X					
MR. N. WILLIAMS		X		X											X												

Figure A-3. Visits of JPL/CIT/SIO Nuclear Waste Management Team

APPENDIX B

DESCRIPTION OF THE EPA PROGRAM FOR REPROCESSING AND HIGH-LEVEL RADIOACTIVE WASTE MANAGEMENT

APPENDIX B

CONTENTS

Figures

Tables

I. INTRODUCTION

A. PURPOSE AND OVERVIEW

This appendix describes the present status of the programs and projects undertaken by the Environmental Protection Agency with respect to nuclear fuel reprocessing and high-level radioactive waste management. Background information on the Agency, including its overall mission and budget, is provided to give the reader an understanding of these specific projects. A detailed budget analysis of radiation activities as well as a discussion of the tasks to be completed in FY 1977 and FY 1978 are presented.

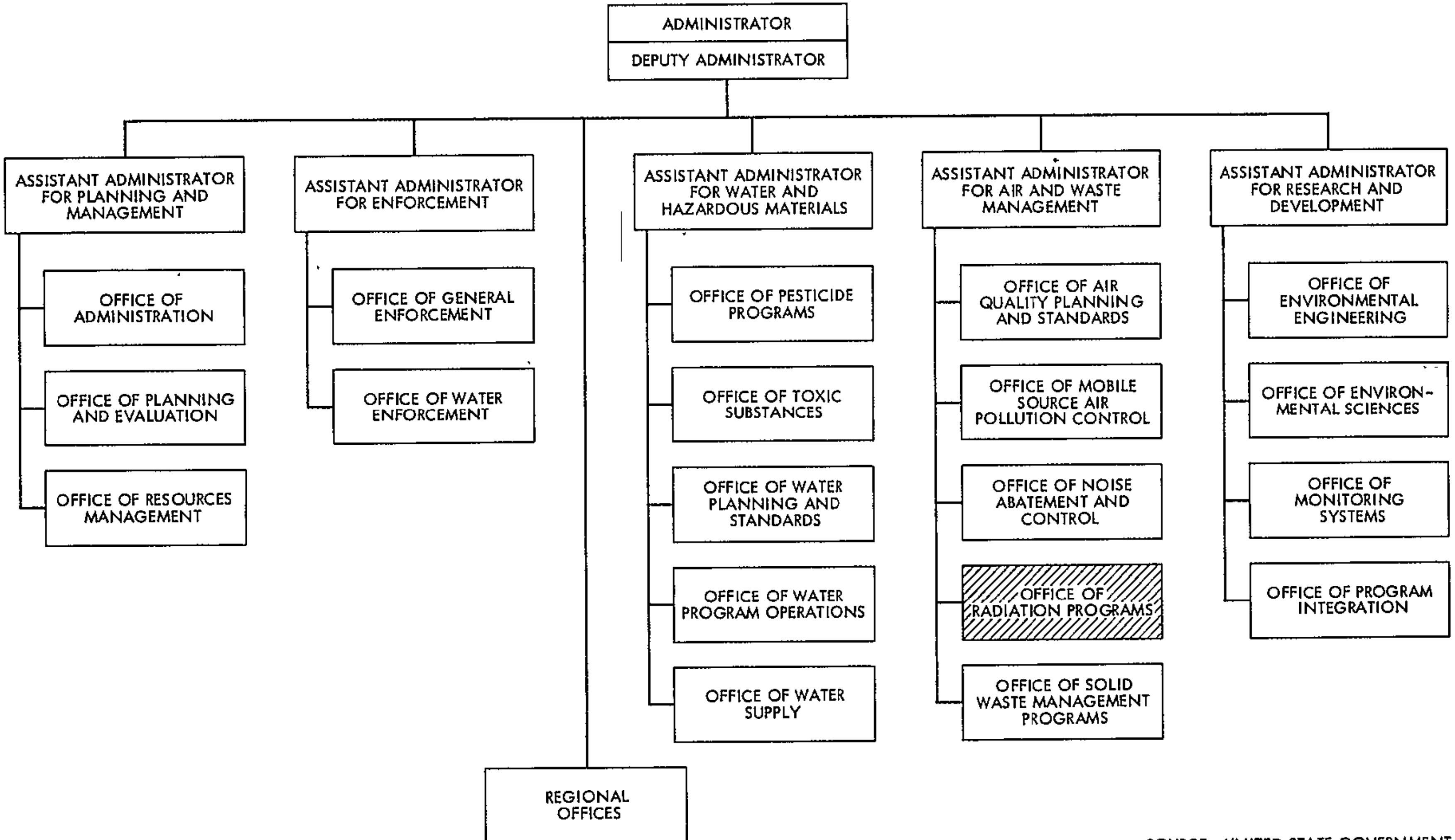
B. ROLES AND ORGANIZATION OF THE ENVIRONMENTAL PROTECTION AGENCY

All of the reprocessing and radioactive waste management activities of the Environmental Protection Agency (EPA) are the responsibility of the Office of Radiation Program (ORP). The ORP is one of five program offices in the Air and Waste Management Programs. The Air and Waste Management Programs (AWMP) is managed by one of the five assistant administrators to the administrator of EPA. (See Figure B-1.)

EPA's stated mission is to serve as the "public's advocate for a livable environment." (Reference B-13.) Its responsibilities for carrying out that mission can be categorized as (1) abating and controlling pollution, (2) reinforcing environmental control efforts by other governmental agencies, and (3) providing independent written comments on environmental impact statements. EPA uses research, monitoring, standard setting and enforcement activities to help in its effort to abate and control pollution. EPA is not, however, an R&D agency, like the Energy and Research and Development Administration, nor is it a basic science research agency like the National Science Foundation or the National Institute of Health.

C. RADIATION PROTECTION AUTHORITY OF THE ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency's (EPA) statutory authorities for radiation protection are primarily concerned with the promulgation of environmental standards and guidelines. EPA also has limited authority for effluent regulation and enforcement activities in some areas, but this responsibility is mainly under the purview of the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA). Table B-1 shows the distribution of responsibility for standards, guidelines and enforcement between the agencies for regulation of uranium fuel cycle facilities, ocean dumping of radioactive wastes, radioactive waste disposal, occupational exposure, plutonium clean-up and restoration, and other program areas.



SOURCE: UNITED STATE GOVERNMENT MANUAL 1975-1976

Figure B-1. Environmental Protection Agency Programmatic Organizational Chart

Table B-1. Responsible Federal Agencies for Program Areas Related to Radiation

PROGRAM AREA	RESPONSIBLE AGENCY			
	ENVIRONMENTAL STANDARDS OR GUIDANCE	EFFLUENTS OR OTHER PLANT SPECIFIC LIMITS	EQUIPMENT PERFORMANCE STANDARD	ENFORCEMENT
URANIUM FUEL CYCLE FACILITIES	EPA	NRC	---	NRC
OCEAN DUMPING RADIOACTIVE WASTE	EPA	EPA	---	EPA
RADIOACTIVE WASTE DISPOSAL	EPA	ERDA NRC STATES	---	NRC STATES
WATER EFFLUENT OF NATURAL RADIOACTIVITY	EPA	EPA	---	EPA
MEDICAL RADIATION	EPA	DHEW STATES	DHEW STATES	FED. AGENCIES STATES
OCCUPATIONAL EXPOSURE	EPA	OSHA (DOL)	---	FED. AGENCIES OSHA (DOL) STATES
PLUTONIUM CLEANUP AND RESTORATION	EPA	---	---	FEDERAL AGENCIES
DRINKING WATER STANDARDS	EPA	---	---	EPA/STATES
NONIONIZING RADIATION	EPA	---	DHEW	FEDERAL AGENCIES

(Hatched) EPA'S PRIMARY AREAS IN RADIATION PROGRAMS

SOURCE: REFERENCE 9, PAGE 5

EPA's authority for radiation protection is derived from a complex package of statutes and executive orders as shown in Table B-2. This authority is of a general nature that provides the EPA administrator with discretionary powers to establish standards required to protect environment and human health. The authority for setting federal radiation guidance was transferred from the Federal Radiation Council to the Environmental Protection Agency by Executive Reorganization Plan No. 3. Pursuant to this transfer, Title 42 of the U.S. Code, the Public Health and Welfare, Sec. 2021h, it is required that:

> "The Administrator shall advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States."

This EPA authority to develop Federal radiation guidance broadly covers all sources of radiation and takes precedence over other Federal agencies (Reference B-8, page 2). Even though several agencies write and enforce various radiation regulations, these must be consistent with basic criteria contained in the EPA guidelines.

The development of generally applicable environmental standards is another area of responsibility of EPA. Reorganization Plan No. 3 also transferred the authority of the Atomic Energy Commission under the Atomic Energy Act, Chapter 14, Section 161.b., to the Environmental Protection Agency to "establish....such standards...as...necessary or desirable...to protect health or to minimize danger to life or property". Reorganization Plan No. 3 defines generally applicable environmental standards as:

> "...limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material."

It is interesting to note that while the U.S. Atomic Energy Commission (AEC) held this authority under the Atomic Energy Act of 1954, no specific environmental standard, such as dose limits to the population or ambient environmental radiation concentrations were ever established by the AEC (Reference 7, page 2). EPA has recently set a new standard for the Uranium Fuel Cycle of 25 millirems annual dose equivalent radiation; a 95% reduction from the original limit of 500 millirems set by the Federal Radiation Council. EPA is presently preparing to promulgate a separate standard for high-level radioactive waste (see Section III) and plans to do the same for low-level and plutonium waste.

Several important authorities for enforcement, monitoring, and inspection are also included under the Federal Water Pollution Control Act of 1972, the Safe Drinking Water Act of 1974, and the Marine Protection, Research and Sanctuaries Act of 1972, and others as shown in Table B-2. These statutes permit monitoring and regulation of ocean dumping and radiation pollution of water resources.

Table B-2. Radiation Authority Environmental Protection Agency

	FEDERAL GUIDANCE	STANDARDS & CRITERIA	MONITOR/INSPECT	ENFORCEMENT	REPORT/PLAN	ENVIRONMENTAL IMPACT REVIEW	TECHNICAL ASSISTANCE	RESEARCH	
ATOMIC ENERGY ACT	X	X							
FEDERAL WATER POLLUTION CONTROL ACT OF 1972		X	X	X			X	X	
SOLID WASTE DISPOSAL ACT					X			X	
SAFE DRINKING WATER ACT OF 1974		X		X			X	X	
CLEAN AIR ACT		X		X		X			
PUBLIC HEALTH SERVICE ACT (42 USC 241 - SECTION 301)			X				X	X	
MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT OF 1972		X	X	X		X	X	X	
NATIONAL ENVIRONMENTAL POLICY ACT - SECTION 102C						X			
EXECUTIVE ORDER 11752		X			X		X		

EPA'S AUTHORITIES FOR STANDARDS AND CRITERIA

SOURCE: REFERENCE 9, PAGE 7

EPA has no direct responsibility for licensing or establishing regulations for specific radioactive waste facilities. The U.S. Nuclear Regulatory Commission (See Appendix C) has the primary responsibility for regulating nuclear facilities with the exception of most ERDA facilities. However, under the Federal Water Pollution Control Act Amendments of 1972, EPA is responsible for issuing National Pollutant Discharge Elimination Systems (NPDES) permits for nuclear facilities. Under the National Environmental Policy Act (NEPA) of 1969, such Federal action requires an Environmental Impact Statement (EIS). However, the Nuclear Regulatory Commission is also required by NEPA to do an Environmental Impact Statement for the same facility. In the "Second Memorandum of Understanding and Policy Statement Regarding Implementation of Certain NRC and EPA Responsibilities" (Reference B-12), the two agencies agreed that a single EIS on a nuclear facility will be prepared by NRC with input from EPA. In July 1976, the U.S Supreme Court upheld this Memorandum of Understanding.

D. RADIATION PROGRAM RESOURCES FOR THE ENVIRONMENTAL PROTECTION AGENCY

The radiation protection responsibilities of EPA are exercised at the discretion of the administrator and, as such, the priorities for radiation activities are set within the agency relative to other EPA missions. The resources assigned to radiation authorities have decreased sharply since FY 1974, as shown in Figure B-2. This decline is largely due to a decision to phase-out the ionizing radiation research programs carried out by EPA's Office of Research and Development. It was thought that these research programs were too small in relation to ERDA and NRC research to make a significant contribution. Although some "confirmatory" research is permitted, present research efforts by EPA in the field of radiation are limited to the identification of health effects of nonionizing radiation. This budgetary trend has been recently reversed. In Figure B-2 the dashed curve shows the budgetary impact of the $2.4 million re-allocation of EPA funds which was made to assist the radioactive waste criteria and standards development program.

The resources allocated to and within EPA for radiation programs are shown in Table B-3. From this perspective one can see that radiation programs are a very small part of EPA's overall mission. Indeed, radiation programs and research accounted for 0.3% of EPA's budget authority for Fiscal Year 1977. Table B-3 also shows that the radiation research programs of EPA's Office of Research and Development have declined sharply between FY 1974 and FY 1977, representing the complete phase-out of ionizing research. These decreases are even greater if they are expressed in terms of constant dollars.

The Office of Radiation Programs' official position with respect to ionizing radiation research is that they are satisfied to leave these activities in the hands of NRC and ERDA, and that the existing scientific knowledge base is adequate for setting environmental standards (Reference B-4). EPA will continue to use ionizing radiation research being carried out by other agencies, most notably by the Energy Research and Development Administration and the Nuclear Regulatory Commission, and

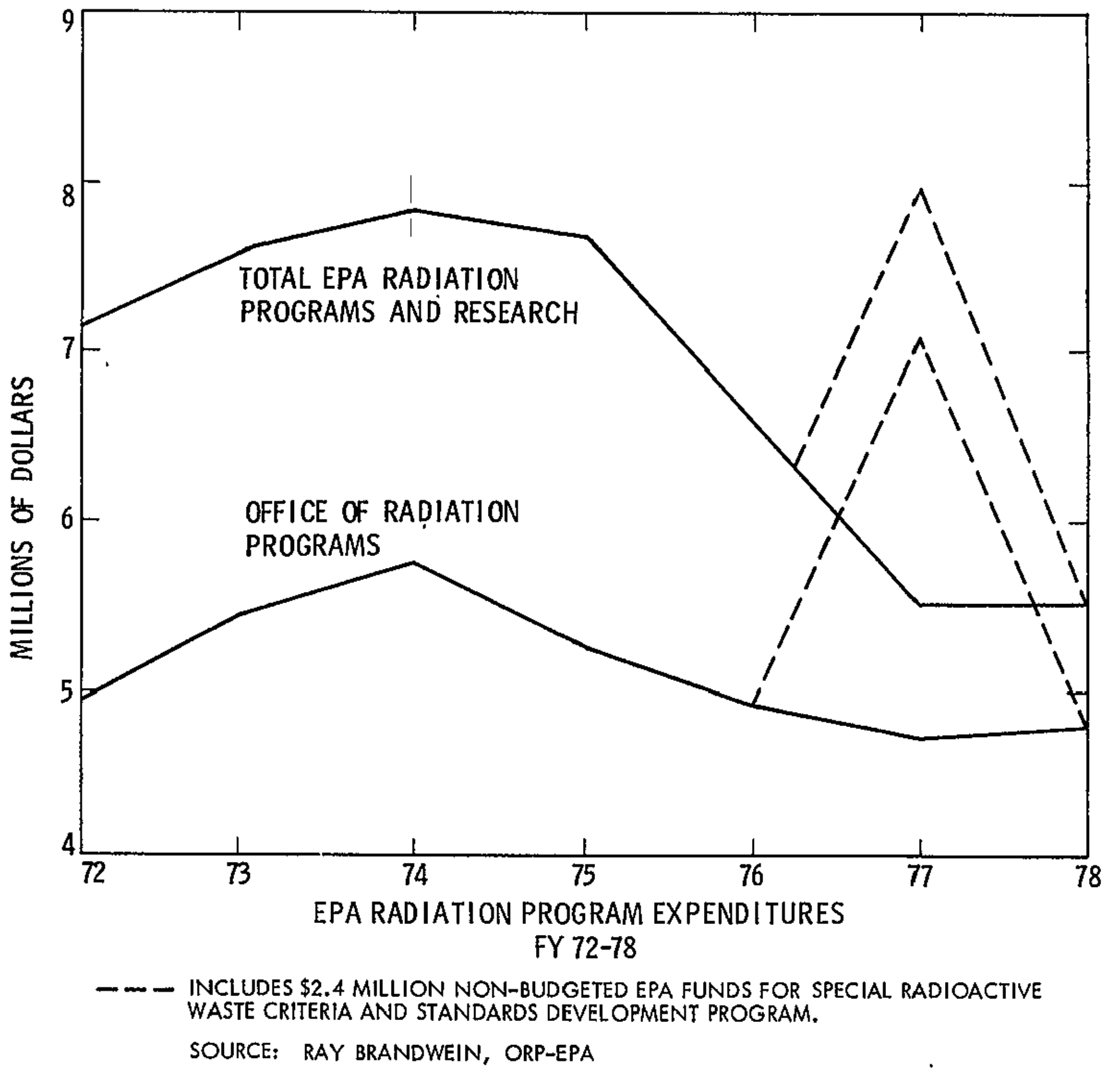


Figure B-2. EPA Radiation Program Expenditures FY 72-78

Table B-3. Resources Allocated to the EPA Radiation Program
FY 1971-1977

Fiscal Year	Office of Radiation Programs (Abatement and Control a/)		Office of Research and Development Radiation Programs		Total EPA Radiation Program		Total EPA Budget Authority	
	Position	$000	Position	$000	Position	$000	Position	$000
1971 (7 months transferred from other agencies--	277	3,284	108	1,314	335	4,598	7198	1,288,781
1972------------	202	4,889.2	93	2,256.3	295	7,145	8050	2,447,520
1973------------	216	5,352.4	88	2,287.0	304	7,639	8858	7,427,143
1974------------	226	5,659.0	82	2,198.8	308	7,857	9203	5,952,445
1975------------	217	6,270.3	72	2,450.2	289	7,720	9203	8,516,362
1976------------	184	4,986.2	50	1,678.9	234	6,665	9550	771,347b/
1977------------	184	4,715.0c/	30	878.9	214	5,594c/	9680	1,860,038
1978------------ (estimated)	184	4,815.0	30e/	830e/	204	5,645	9698	5,302,735d/

a/ Includes Program Management and Support and Regional Office resources

b/ Decrease represents the end of the authority for the sewage treatment construction program

c/ Does not include $2.4 million non-budgeted EPA funds for special radioactive waste criteria and standards development program. See text for description.

d/ $4,500,000,000 of the total is authority for a new construction program.

e/ Data points computed from sources.

Source: Reference 5 except for 1978 data. 1978 data from Environmental News, January 17, 1978 "EPA Announces Proposed 1978 Budget".

the findings from approximately $2 billion invested in the study of ionizing radiation health effects and control technology over the past 25 years. EPA is formalizing cooperative research and operational arrangements with these agencies to assure that the technological bases for EPA standards are founded on sound scientific knowledge. However, no major cooperative research projects have been initiated by ERDA or NRC at the specific request of EPA's Office of Radiation Programs to this date. For example, shortly after the decision to phase-out EPA ionizing radiation research, EPA prepared a report directed to ERDA on needed research. This report, Research and Operational Needs, was prepared in July 1976 and outlined the research needs of the Office of Radiation Programs.

II. THE OFFICE OF RADIATION PROGRAMS

A. GOALS OF THE OFFICE OF RADIATION PROGRAMS

The authority of the Environmental Protection Agency for radiation protection programs is implemented by the Office of Radiation Programs (ORP). The stated goal of the Office of Radiation Programs is "to eliminate unnecessary health effects by controlling population exposure to radiation sources." This goal is to be attained by establishing standards, criteria and guidance to "minimize risk, in a cost-effective manner, from exposure to (1) nuclear energy application, (2) naturally-occurring radioactive materials, (3) medical and occupational radiation, and (4) non-ionizing radiation. However, as comprehensive as these statements sound, EPA has only limited authority (See Section I-C) and resources (See Section I-D) to achieve this goal. Because the EPA has limited direct responsibility for facilities related to nuclear power including waste management, its mission is oriented toward environmental or ambient radiation hazards to the general public.

B. ORGANIZATION

The Office of Radiation Programs is organized to carry out its primary mission of establishing criteria and standards as well as performing necessary monitoring, analysis, evaluation, and enforcement of environmental radiation standards. The organization of ORP is shown by Figure B-3. The persons presently responsible for each division and branch of ORP are included. The functions of the major divisions and facilities are briefly elaborated below.

The Criteria and Standards Division is responsible for formulating and recommending policies, criteria and standards designed to protect the environment, the general public and those occupationally exposed and for evaluating risk/benefit relationships for radioactive programs. The general function of promulgating the high-level waste criteria and standards are coordinated and managed by Dr. James Martin, deputy director of this division.

The Technology Assessment Division is responsible for evaluating major Federal actions involving ionizing and non-ionizing radiation and the design, construction, operation, modification or discontinuance of application of technology related to these radiations in order to assess the radiological impact on the environment and the population.

The Environmental Analysis Division is responsible for a national program to determine the levels of existing radiation for specific sources, and publication of information on the radiological state of the environment.

Las Vegas and the Eastern Environmental Radiation Facility supply general support to the ORP. For example, the Eastern Environmental

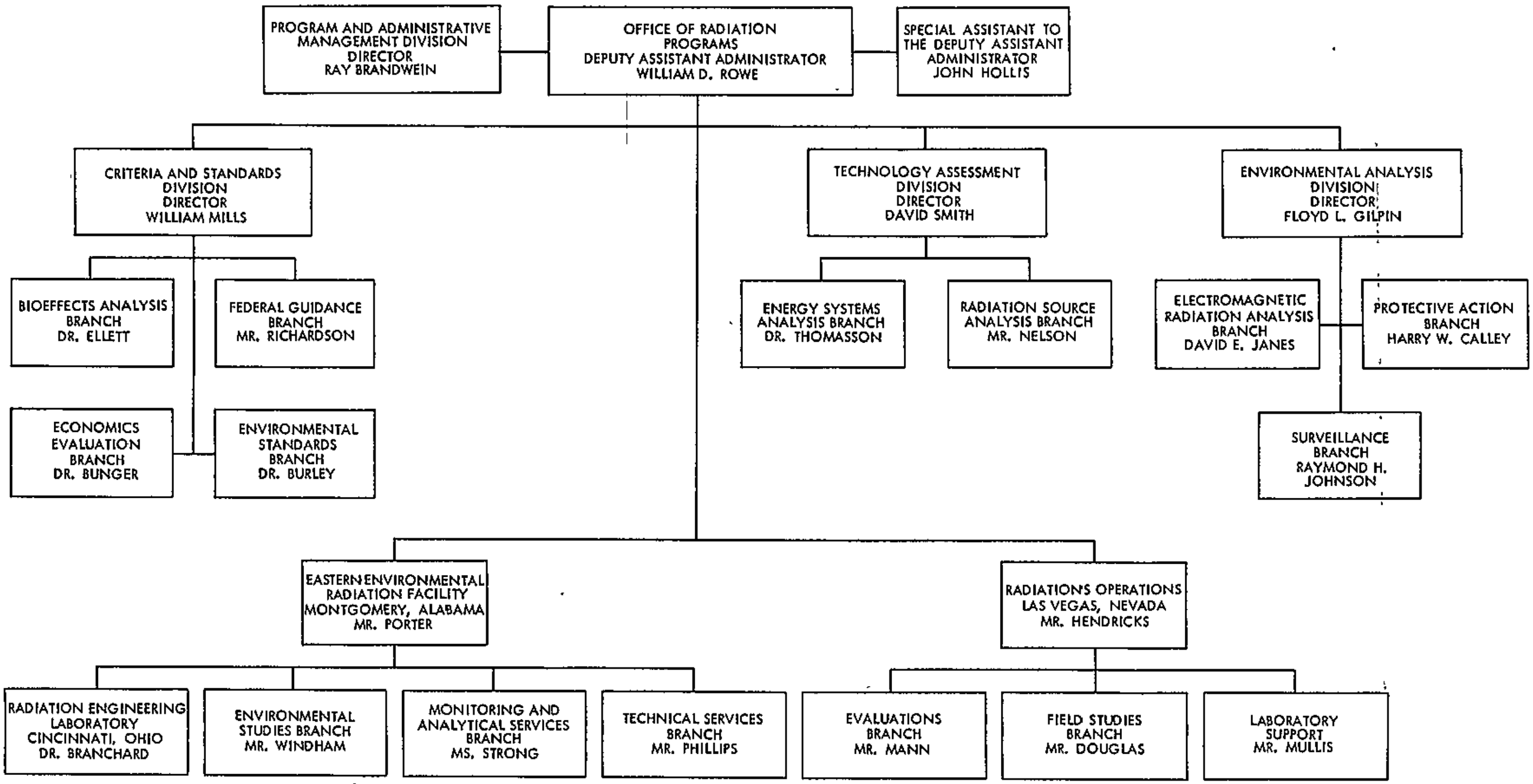


Figure B-3. EPA's Office of Radiation Programs Organization Chart

Radiation Facility provides the analytical laboratory support for the Environmental Radiation Ambient Monitoring System (See Section B). Both facilities carry out field studies of operating nuclear facilities.

The Office of Radiation Programs operates within this framework to influence the radiation programs and policies of other Government agencies from a perspective of comprehensive radiation protection.

C. BUDGET TRENDS FOR THE OFFICE OF RADIATION PROGRAMS

The Program budget of the Office of Radiation Programs is shown in Table B-4 for fiscal years 1975 through 1978. As previously discussed, the overall trend in ORP funding has been a steady decline since fiscal year 1974 especially when actual outlays are corrected for inflation. These budget reductions have not been coupled with proportionate decreases in the responsibilities of the agency. In fact, the recent demands on EPA for the promulgation of standards for uranium fuel cycle and high-level waste management operations have increased the workload of ORP while fiscal resources have substantially declined. President Gerald Ford's Nuclear Policy Task Force gave a high priority for radioactive waste management, including the establishment of a timetable for promulgating environmental standards. However, no new funds or manpower were allocated to ORP for the Fiscal Year 1978 to accomplish this task.

The budget submitted to OMB by ORP included a request for two million dollars that was slated for technology evaluation and standard setting activities. This request was cut by OMB and no additional funds were included in President Ford's FY 1978 budget request to Congress.

In order to finance the radioactive waste criteria and standard setting effort during fiscal year 1977, EPA has authorized $2.4 million in "overtarget" expenditures for ORP. Therefore, these expenditures are not shown in Table B-4. These funds include approximately $1.8 million for technical assistance and documentation work that will be contracted outside the agency. The remainder will be utilized by ORP for related in-house work. These additional funds are being directly applied to the promulgation of the high-level waste management criteria and standards.

Since these funds must be reallocated from EPA's FY 1977 operating budget, they represent a substantial change for the agency. As such, an agreement is being negotiated with the Energy Research and Development Administration for an interagency transfer of funds to help defray the "overtarget" expenditures for promulgating the high-level waste criteria and standard (Reference B-1). Further, no other provisions have been made for fiscal year 1978 program activities under the assumption that all technical contracts that are required for this effort will be funded and completed during the 1977 fiscal year. The program development plan for these activities is discussed in more detail in Section III of this appendix.

Table B-4. Office of Radiation Programs Budget FY 1975-FY 1978

	FY 75		FY 76		FY 77		FY 78	
	Position	$000	Position	$000	Position	$000	Position	$000
Criteria, Standards and Guidelines								
Environmental Standards----------------	31	742.2	29	913.8	25	595.0	25	625
Federal Radiation Guidance------------	17	407.3	22	572.6	26	618.8	26	604
Environmental Impact Assessment								
Monitoring and Analysis---------------	64	1521.8	58	1545.1	58	1388.9	58	1400
Federal Activities/EIS Review---------	22	541.2	18	451.8	15	361.8	16	398
Technology Assessment-----------------	15	361.0	21	591.3	24	821.2	24	975
State Program Support-----------------	42	999.6	36	911.6	36	929.3	25	813
Program Management a/-----------------	26	697.2						
Total, Radiation Abatement and Control--	217	5270.3	184	4986.2	184b/	4715.0c/	184	4815
Less Regional Offices-------------------	18	446.6	17	449.9	21	583.3	21	630
Office of Radiation Programs------------	199	4823.7	167	4536.3	163b/	4131.7c/	163	4185

a/ Broken out for FY 1975 budget only and includes funds for EIS preparation

b/ Includes Congressional Add-on of 10 positions.

c/ Does not include $2.4 million non-budgeted EPA funds for special radioactive waste criteria and standards development program. See text for description.

Source: Dr. Ray Brandwein, Office of Radiation Programs, EPA

D. PROGRAM PLAN AND STRATEGY

EPA's radiation protection strategy focuses on controlling exposure from those radiation sources which present the greatest actual or potential risk for adverse health effects to the population. The general program activities of ORP are outlined in Figure B-4. Medical and occupational radiation, nuclear energy, natural radioactive materials and non-ionizing radiation are the major activity areas. Within these four program areas, priorities are determined by considering several factors: (a) the ability to control the sources, (b) the costs versus the benefits from the controls, and (c) the authority of the agency to implement the controls.

The present strategy for ORP emphasizes two source areas - nuclear energy applications and natural radioactive materials. The areas of interest to this study are shaded in Figure B-4. The rationale for ORP's emphasis on nuclear energy is that "releases of radiation from the various facilities required to produce electric power from nuclear fuels, while not a large source of population exposure now, have the potential for greatly increased future exposures if adequate controls are not instituted now. Some radionuclides such as plutonium-239 and iodine-129 have very long half-lives... even though small amounts are released each year, they will accumulate over time and can present a much larger problem for future generations" (Reference B-9). Thus, ORP's first priority is to set environmental criteria for radioactive waste disposal to protect public health and the environment, and to set specific numerical standards for high level wastes. These two program areas, high-level radioactive waste criteria and standard, are discussed in more depth in the following section. The remaining nuclear energy related activities are briefly discussed in Section IV of this appendix.

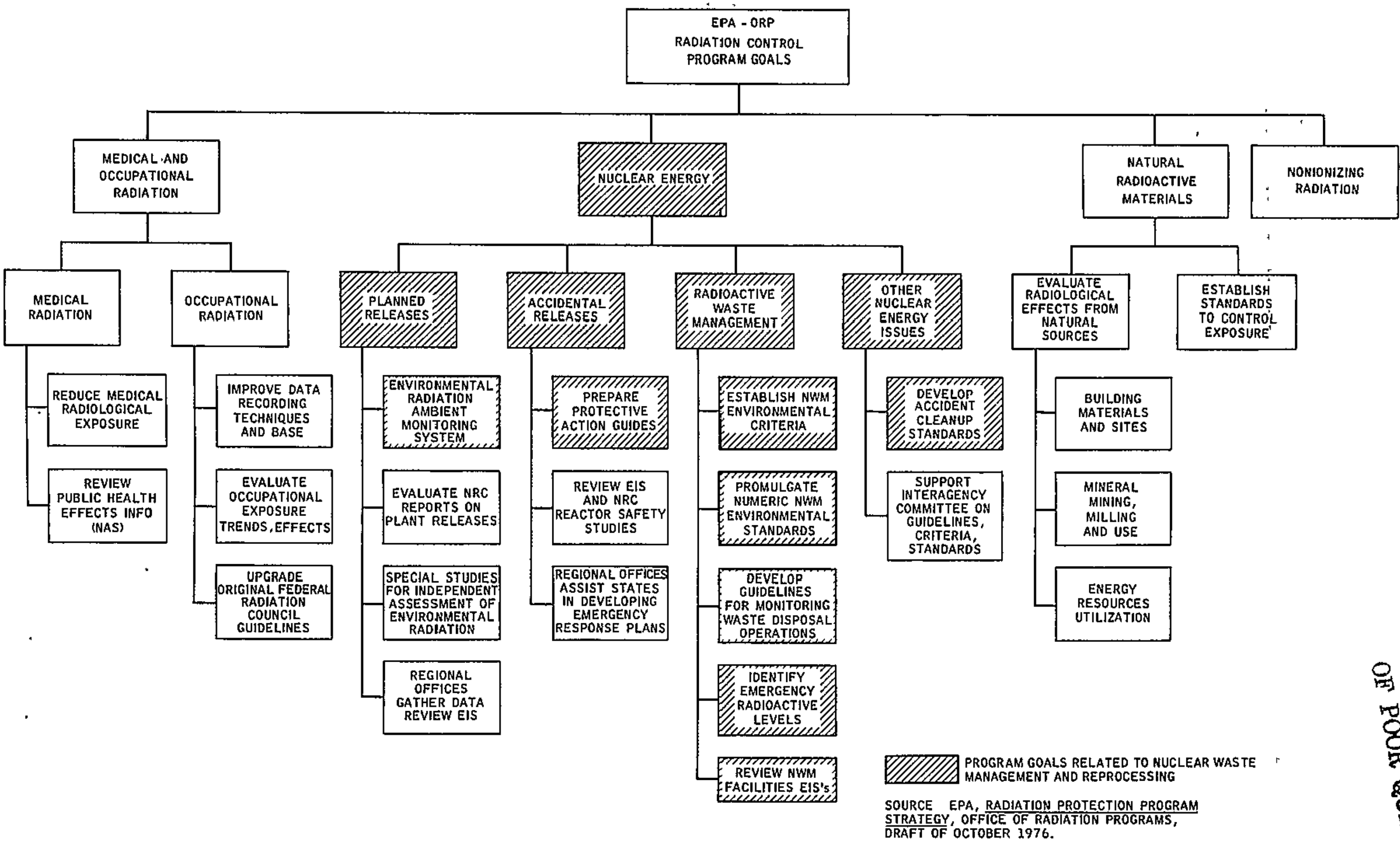


Figure B-4. Program Goals

III. GOALS CRITERIA AND STANDARDS FOR HIGH-LEVEL RADIOACTIVE WASTE

EPA has three goals for high-level radioactive waste management. First, to have all radioactive waste collected, treated, packaged and emplaced at carefully selected geologic terminal disposal sites for containment and confinement of radioactivity. They also state that radioactive wastes should not be released at nuclear facilities for dispersion into the environment. Second, to assure that no unwanted risks are imposed upon present and future generations. Third, to develop, implement, and assure adequate environmental protection for at least one permanent disposal option.

These goals are to be attained by establishing criteria and guidance and establishing and enforcing standards. ORP has identified three immediate tasks in its strategy for radiation protection (Reference B-9). The first task, which is now completed, is to promulgate standards for control of population exposure from uranium fuel cycle (UFC) operations. The other two tasks are related directly to radioactive waste management - a part of the fuel cycle that has been excluded from EPA's definition of the uranium fuel cycle. (Uranium mining and power plant decommissioning have also been excluded, by definition, from the uranium fuel cycle).

As mentioned in Section II.D, these immediate tasks are only a part of the whole ORP Program. For a broad overview of the entire program, see Section IV. The remainder of Section III is a detailed explanation of the status of the three tasks identified above.

A. URANIUM FUEL CYCLE STANDARD

The uranium fuel cycle standards were published in the Federal Register on January 13, 1977 (Reference B-7). One stated reason for the exclusion of waste disposal from the uranium fuel cycle is that the Atomic Energy Act mandates that any level of exposure is acceptable only if it is balanced with an offsetting benefit. EPA has stated that

> "In the past, it has been tacitly assumed that the benefits from utilization of radiation far exceed the cost. However, all costs (or risks) resulting from the beneficial use of radiation must be identified and assessed in terms of the net benefit of the activity. Because all costs from waste disposal have not been identified, waste disposal remains a major issue in radiation activities and especially in the nuclear power generation" (Reference B-6).

The Uranium Fuel Cycle Standards, however, do apply to the reprocessing of spent uranium fuel rods. These standards state that fuel cycle operations should be conducted in such a manner as to provide reasonable assurance that: (a) The annual dose equivalent does not exceed 25 millirems to the whole body and 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as a result of exposure to planned discharges...to the general environment from uranium fuel cycle operations.... and (b) the total quantity of radioactive materials entering the general environment from the entire uranium fuel cycle per gigawatt year contains less than 50,000 curies of krypton, 85.5 millicuries of iodine-129, and 0.5 millicuries combined of plutonium-239 and other alpha-emitting transuranic radionuclides with half-lives greater than one year.

The control of krypton-85 was one of the major issues raised by the draft version of the standard. The standard implies a capture of about 87 percent of this gaseous effluent from fuel reprocessing plants. ORP estimates that this will increase the cost of a reprocessing plant by 10%. In addition, they are convinced that the technology is available to control krypton emissions (Reference B-7).

B. DEVELOPMENT PROCESS FOR CRITERIA AND STANDARDS

ORP has been directed to establish a numerical environmental radiation protection standard for the terminal storage of high-level radioactive waste by June, 1978. This deadline was the result of the review conducted by the Presidential Policy Task Force that led to the Presidential Energy Policy Statement of October 29, 1976. The plan for developing the standards and the necessary criteria are discussed below.

Figure B-5 shows the complete process for developing the criteria and standard for high-level radioactive waste management. Though the figure is self explanatory, the emphasis on participation by outside groups and the potential for delays in the overall schedule should be noted.

However, EPA strongly believes that public acceptance is a key factor in the development of nuclear waste criteria and standards, especially in light of the past problems of the Atomic Energy Commission. The public workshop scheduled for February 1977 has been completed. A summary of the major issues and conclusions of the workshop appears in another Appendix.

The task structure for completing the criteria and the tasks for promulgating environmental criteria and standards are shown in Figure B-6. These tasks are explained in Sections III C and III D. The other relevant activities are delineated in Section IV.

C. TASKS FOR DEVELOPING ENVIRONMENTAL CRITERIA (10.0)*

The Office of Radiation Programs has identified four sub-tasks for establishing the fundamental environmental criteria for radioactive waste management. The four sub-tasks are described below.

1. Develop Technical Definitions (10.11)

As a first step, ORP feels that present technical definitions associated with radioactive waste management are inadequate and must be

*Numbers in parenthesis refer to Figure B-6.

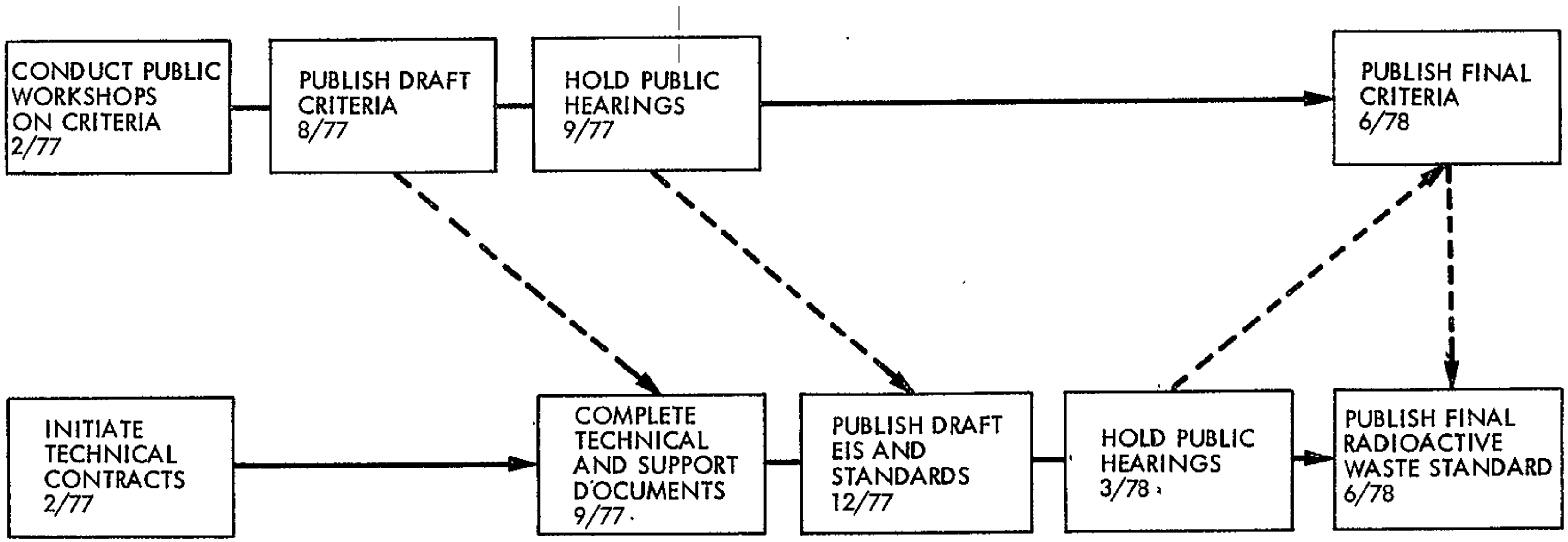


Figure B-5. Development of Criteria and Standard for High-Level Radioactive Waste Management

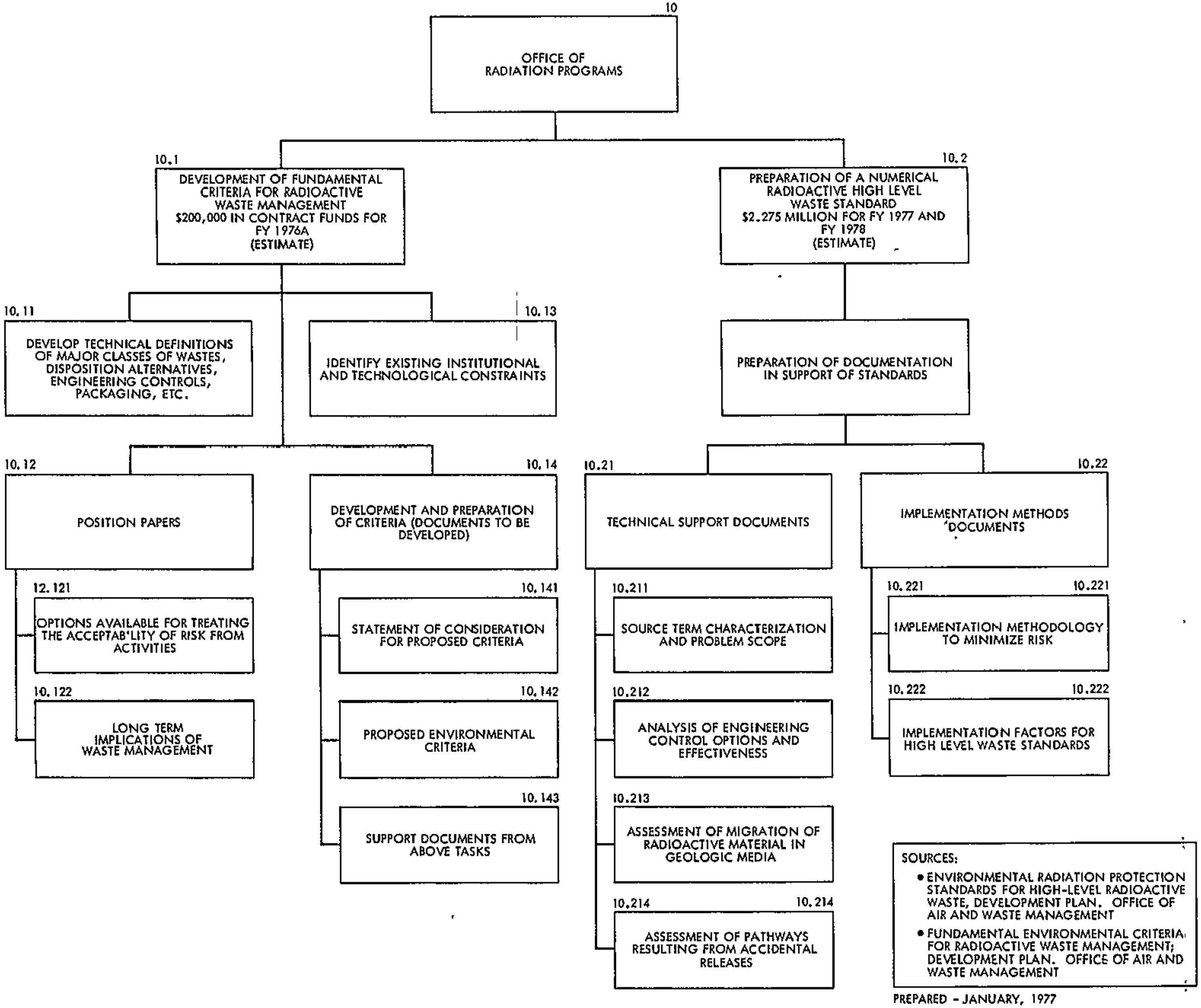


Figure B-6. Nuclear Waste Management Task Structure for the Development of Fundamental Criteria for Radioactive Waste Management and for a Numerical Radioactive High-Level Waste Standard, Environmental Protection Agency either reviewed or developed for the first time (Reference B-8). The terms that need to be better defined include:

(1) High level waste.

(2) Intermediate level waste.

(3) Low level waste.

(4) Disposal.

(5) Containment.

(6) Environmental barriers.

(7) Pathways to man.

(8) Risk.

(9) Long term implications.

(10) Minimum siting criteria.

(11) Environmental criteria.

(12) Retrievability.

(13) Monitoring.

2. Position Papers (10.12)

ORP is concerned with the question of how to determine the public acceptability of risk associated with nuclear waste disposal activities. The purpose of this task is to develop the necessary concepts and methods to answer this question. For example, questions of risk acceptance with respect to radioactive waste management must look not only at high consequence, low probability events, but also at high probability, long term, and low consequence events. Two position papers will be prepared under this task that will attempt to:

(1) Identify, describe and assess the available options for treating the acceptability of risk. (10.121)

(2) Examine the long term implications of waste management, which fall into two categories: potential impact on future generations, and future requirements for control to assure continued safety (10.122). This position paper is intended to:

(a) Suggest possible rationale for deciding the limits of adverse impact on future generations;

(b) Propose possible degrees of control to be reasonably expected; and

(c) Suggest mechanisms for assuming control.

3. Institutional and Technological Constraints (10.13)

This task has three objectives: (1) identify the existing institutional and technological constraints that limit progress in developing the criteria, (2) assess the future possibilities for ameliorating these constraints, and (3) proceed with criteria development with the knowledge of the limitations that cannot be changed by programmatic activities or research and development programs.

4. Development and Preparation of the Proposed Criteria (10.14)

Using reports prepared from the preceding tasks, a background consideration report will be prepared for publication prior to the development of criteria. These will be followed by internal and interagency review, approval, and publication of the draft criteria, and public hearings before the criteria are finalized in June 1978.

The schedule shown in Figure B-7 indicates the proposed timing for the completion of the four tasks as well as the other procedural steps (Reference B8). The amount of rescheduling shown in Figure B-7 is an indication that EPA is incurring some difficulty in meeting its original schedule (Reference B-3).

D. TASKS FOR PROMULGATING A NUMERIC STANDARD FOR HIGH-LEVEL RADIOACTIVE WASTE

Under the authority derived from Reorganization Plan No. 3, EPA feels that a standard is needed to make judgments on the adequacy of the methods used by ERDA to provide protection of the public health and the environment.

To develop a numerical standard for high level waste, the Office of Radiation Programs has identified the need for several studies. These studies will provide the necessary technical support and implementation methods as documentation for the preparation of a numerical radioactive waste standard as described below:

1. Technical Support Studies (10.21)

ORP has identified four technical studies that must be completed before issuing the draft standard. As shown in the breakdown in Figure B-6 the planned studies are:

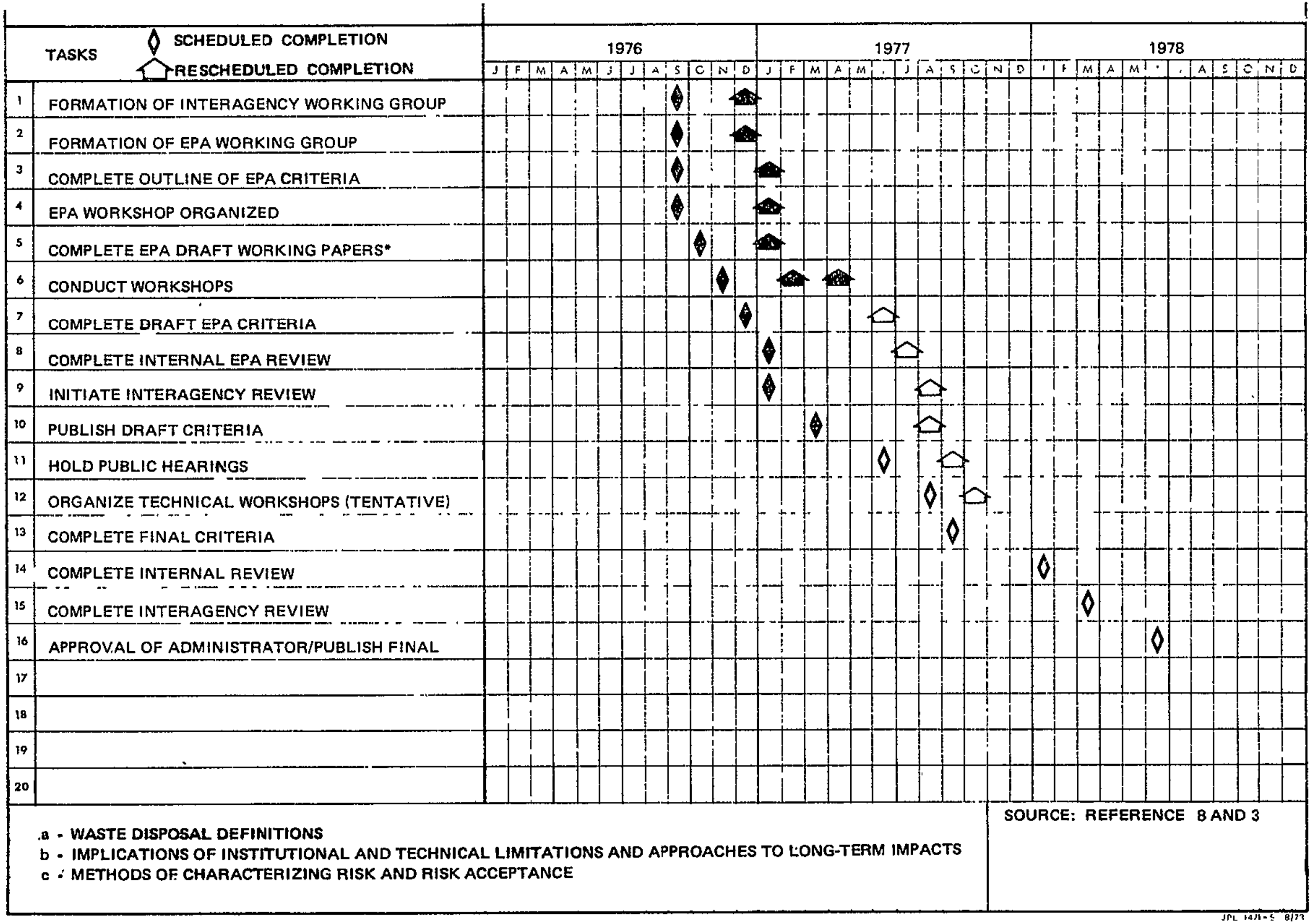


Figure B-7. Schedule for Development of Fundamental Environmental Criteria Updated January 26, 1977 and April 22, 1977

(1) Source term characterization and problem scope.

(2) Analysis of engineering control options and effectiveness.

(3) Assessment of migration of radioactive material in geologic media.

(4) Assessment of pathways resulting from accidental releases.

The first study (10.211) involves the necessary identification and characterization of the total source of high-level waste that might result from each of four fuel cycle options. The options are:

(1) Fuel reprocessing of spent fuel.

(2) Fuel reprocessing of spent fuel including separation of long-term hazardous radiological isotopes.

(3) Throw-away cycle.

(4) Tandem-fuel cycle.

For each fuel cycle option an assessment will be made of the potential hazard of high-level waste with respect to other potential hazards and the length of time required for environmental protection. Both radiological and heat emission problems will be examined.

The second study (10.212) will examine the available engineering control technologies so that the reduced environmental risk from the engineering controls can be balanced with the cost. However, the task description does not say that EPA will do a cost-benefit analysis. The availability of future technologies for the isolation of high-level waste will also be examined. The technologies to be examined will be those applied to:

(1) Waste preparation.

(2) Treatment.

(3) Packaging operations for transportation (but not transportation).

(4) Interim storage.

(5) Final disposal applications.

In the third study, the Office of Radiation Programs will assess the effectiveness of environmental barriers to reduce the transport of radionuclides through geological strata and formations (10.213). The pathways to be examined are those associated with normal operations of a high level waste disposal facility. EPA claims that there is a wide degree of uncertainty associated with the earth science and dose effects analysis that have been performed by ERDA and NRC for a series of geologic field sites (Reference B-2). Note that this appears to contradict the previous EPA statement on page B-6 of the adequacy of the research performed by ERDA and NRC. Other parts of the third study will assess the acceptability of geologic field sites, site selection requirements, the migration potential and associated impacts of radionuclides that are potentially present in the geosphere and/or biosphere, and a comparison of environmental hazards associated with terminal storage sites with other geologic media containing deposits of natural radioactivity.

The fourth study (10.214) will assess the pathways resulting from accidental releases. The Office of Radiation Programs has identified three types of accidental releases:

(1) Events beyond man's control that are associated with accidental release.

(2) Man-related operational features.

(3) Defects in technical programs.

The study will examine both the probability of a release and the resultant consequences, and is expected to reduce the uncertainty and associated costs of perpetual care commitments to future generations. In addition, the study will examine mechanisms for remedial actions at waste management facilities.

These four technical assessments are impressive both in their scope and their level of detail. However, as the schedule in Figure B-8 shows, four months is the present allocation for the completion of these studies. As indicated, ORP is incurring delay in these and associated tasks. The documents resulting from these studies are needed as technical background to assist ORP in arriving at a numerical guide for the proposed high-level waste standard.

2. Implementation Methods Studies (10.22)

The Office of Radiation Programs has scoped out two studies to help prepare an implementation methods document. This document will identify, describe, and assess the various options open to the decision maker to implement both the technical and institutional requirements embodied in the numerical guide for the high-level radioactive waste standard. An Environmental Impact Statement on the standard will be prepared in conformance with the process described in the National Environmental Protection Act, 1969, Section 102(b).

The two backup studies examine the:

(1) Implementation methodology to minimize risk.

(2) Implementation factors for high level waste standards.

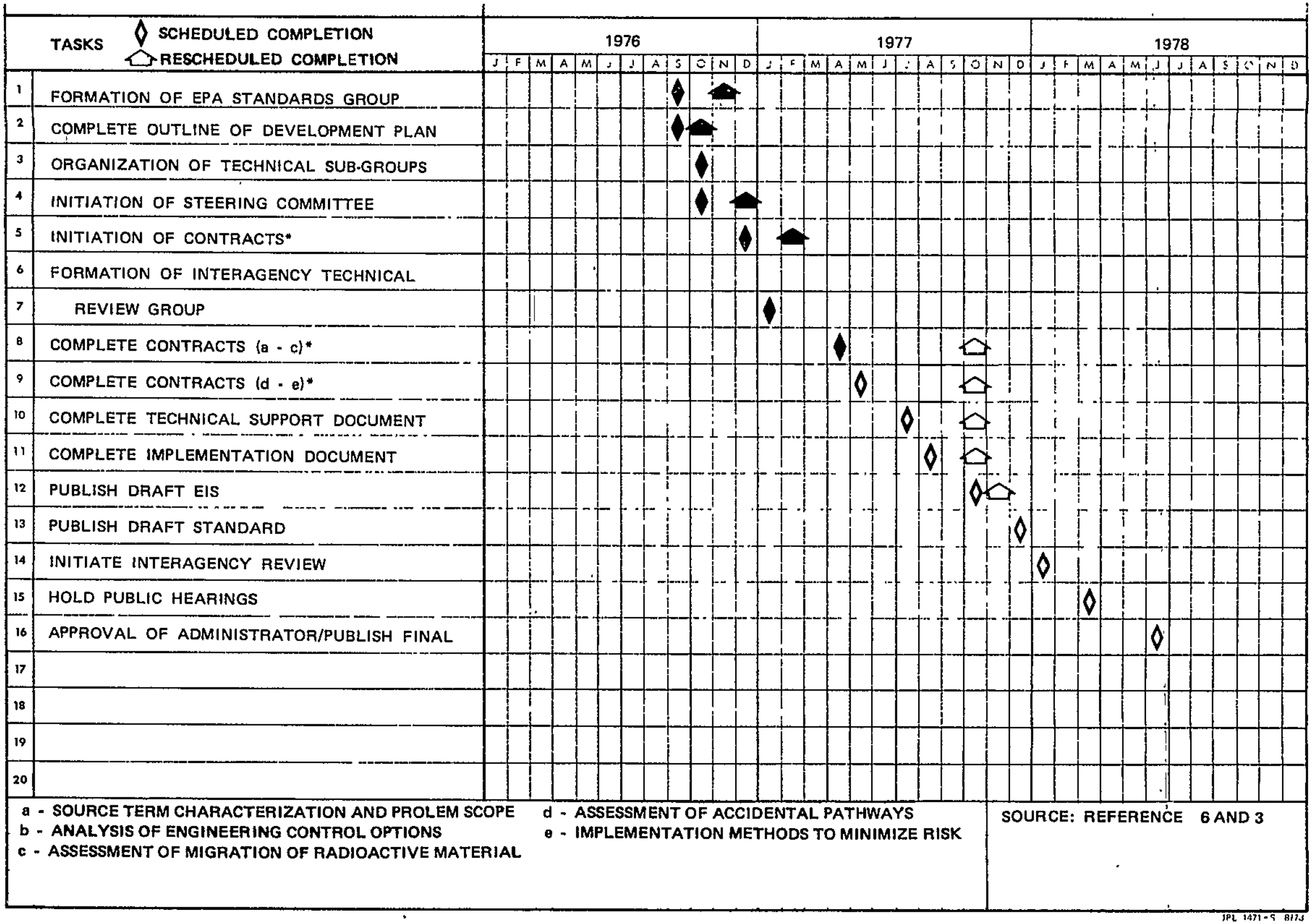


Figure B-8. Schedule for Development of Numerical High-Level Waste Standards
Updated January 26, 1977 and April 22, 1977

The purpose of the first study (10.221) is to develop a model that would permit parametric studies of various numerical standards applied to geologic disposal areas and to waste in different solidified forms. The output of the model will show the potential environmental impact associated with the possible release of radioactivity. The model will use the latest available data and the results from the technical studies identified above.

The second study (10.222) will look at the relevant technical and institutional factors involved in implementing the standard. A series of programs will be developed to help make the standard a workable, easily used frame of reference for industry, the public and other governmental agencies.

As with the technical studies, only five months has been allocated, and ORP plans to use outside contractors for all six studies. The funding needed was estimated to be $2.275 million for Fiscal Year 1977 and 1978. However, no new budget authorities or personnel were provided in the FY 1978 budget and no additional requests have been made that reflect the increases level of activity (See 2.0 for more detail).

Figures B-7 and B-8 indicate the schedules and status of the development of the criteria and the standard. The schedules were originally prepared in October, 1976 (References B-6 and B-8), and were updated on January 26, 1977 (Reference B-3). The updated schedule shows that the program is slipping, and although this does not mean that the June, 1978 deadline will not be met, it is of some concern whether there will be adequate preparation for the declared criteria and standard.

IV. RADIATION PROTECTION ACTIVITIES

The Office of Radiation Programs has a very comprehensive mandate for environmental radiation protection as previously outlined. Numerous programs and tasks are required to implement goals and execute the responsibilities of the agency. These programs and tasks are overviewed in this section via a "work breakdown structure" for both fiscal years 1977 and 1978, and show the major tasks and funding levels assigned to each division of ORP. Nuclear Waste Management related activities are highlighted within the overall task structure of the Office. This technique shows both the objectives and the content of each program area relative to other activities within the operational plan of the ORP. From this data, major gaps in EPA's program can be identified.

The implementation of these programs are complicated by a number of factors and do not necessarily represent the actual activities of the agencies at any given time. The numerous uncertain factors that intervene to affect the day-to-day operations of ORP include national policy directives, changes in control technology, new knowledge on health and environmental effects, and accidents. As an example, in November 1975, ORP prepared a detailed work breakdown structure (WBS) for FY 1977 that showed very little emphasis on high-level radioactive waste management. However, the President's Nuclear Policy Task Force changed EPA's priorities in September of 1976. The WBS has only recently been changed, though the budget request for FY 1977 was updated to reflect these program activities. These data that are included in Figure B-9 reflect the actual activities attempted during Fiscal Year 1977. Therefore, the activities outlined in Figure B-10 for FY 1978 are regarded by ORP not as an inflexible operations plan, but as a general listing for that year.

The major radiation control program goals of ORP are outlined in Figure B-3, which can be compared with actual implementation activities set out in Figures B-9 and B-10. Three of these activities have already been discussed at the task level in Section III. In Sections IV-A and IV-B, the radioactive waste related activities undertaken for FY 1977 and planned for 1978 are delineated. Section IV-A looks at those activities that are listed under criteria, standards and guidelines while Section IV-B examines those activities listed under environmental impact assessment. The numbers in parenthesis refer to Figures B-9 and B-10 unless otherwise noted.

The activities of ORP are subject to periodic change, but generally operate under a consistent set of objectives and assumptions. Because EPA is primarily a regulatory agency, it operates under a set of general authorities. Thus, ORP allocates its resources according to changing priorities at the discretion of the administrator of EPA and his Deputy Assistant Administrator for Radiation Programs. Therefore, individual tasks are not programmed and documented in great detail in advance of the decision to implement them. The tasks identified by ORP for FY 1977 and FY 78 as shown in Figures B-9 and B-10 are discussed below.

A. CRITERIA, STANDARDS AND GUIDELINES (1.0)

The two activity areas under this category are concerned with the development of environmental standards and federal radiation guidance. As discussed in Section III of this appendix, EPA intends to establish environmental criteria for radioactive waste management that will provide environmental and public health guidance to Federal agencies responsible for developing radioactive waste disposal alternatives. In parallel, EPA will develop numeric environmental standards for high level waste disposal. Subsequent efforts will be devoted to developing environmental standards for other types of wastes disposal options and fuel cycles.

Because management of radioactive wastes may entail perpetual care requirements, guidance will be developed for monitoring waste disposal operations. As a precaution against the hazards of unplanned migration from natural-catastrophes or other unforeseen conditions, EPA will identify environmental radiation levels which require actions to avoid unwarranted population exposure. EPA will also review any EIS's which relate to management of radioactive wastes to ensure public health and environmental protection aspects are properly treated.

1. Environmental Standards (1.1)

The priority radiation waste management tasks of the Office of Radiation Programs are specified within this area of activity. These program activities have been discussed in depth in Section III of this appendix, which includes the detailed task breakdowns and schedules shown in Figures B-6, B-7, and B-8. Schedules have been updated to show progress through January 1977. This priority area of the ORP program activity in radiation waste includes the following tasks for FY 1977 as shown with expected dates of completion in Figure B-9a:

(1) Develop draft environmental criteria for radiation waste (discussed in Section III-C).

(2) Prepare technical support document for high-level radioactive waste disposal (discussed in Section III).

(3) Complete final fuel cycle standard (discussed in Section III-A).

The follow-on activities tentatively planned for FY 1978 in the area of environmental standards are shown in Figure B-10a and include these Radioactive Waste Management related tasks:

(1) Prepare Environmental Standard for High-Level Radioactive Waste Disposal (See Section III).

(2) Complete Data Base for Radon Standards and Plutonium Recycle Standards.

(3) Develop Technical Support Document for Plutonium and Thorium Fuel Cycle Standard.

(4) Publish Standard for Plutonium Recycle and Thorium Fuel Cycle.

2. Federal Radiation Guidance (1.2)

The ORP is involved in numerous areas of radiation protection not associated directly with radioactive waste management. For FY 1977, the only task under this category related to radioactive waste management is the proposed publication of guidelines for plutonium clean-up in soil as shown in Figure B-9b. The activities tentatively scheduled for FY 1978 show an intended increase in activities in this area, including the following proposed tasks shown in Figure B-10b:

(1) Publish final guidance for plutonium in soil.

(2) Publish environmental criteria for radioactive waste classes.

(3) Publish protective radiation guides (PRG's) for food and water contaminated by particulate releases.

B. ENVIRONMENTAL IMPACT ASSESSMENT (2.0)

The four activities under this category are monitoring and analysis, federal activities/EIS review, technology assessment, and state program support.

1. Monitoring and Analysis (2.1)

EPA operates a monitoring program (Environmental Radiation Ambient Monitoring System, ERAMS) and conducts special studies at nuclear facilities to provide an independent assessment of environmental radiation and estimates of population exposure on a national basis. (2.1.1.1) ERAMS is a nationwide program designed to acquire data that is used to provide information about radioactivity in our environment. Specifically, the system is designed to:

(1) Provide data for developing the national dose model. The data will be used for input for the model.

(2) Provide a direct assessment of the population intake of significant radioactive pollutants.

(3) Monitor pathways for significant population exposure from routine and accidental releases from major sources.

(4) Estimate ambient levels of radioactive pollutants for standard setting activities, verification of abatement process and environmental trends.

(5) Provide an "early warning" system for emergency abatement actions or to indicate the necessity for further evaluation in the form of contingency sampling operations.

ERAMS is an ongoing activity shown in Figure B-9c and B-10c.

In FY 1977, other activities to be undertaken in this category include the development and validation of a pathway model and a report on the air pathway exposure model validation. In FY 1978, ORP plans to publish an interim hydrogeological model. These activities are shown in Figures B-9d and B-10d.

Related to this category, but not clearly defined in EPA's program budget, is the model development at the University of New Mexico. EPA received an unsolicited proposal from the University of New Mexico in 1975 to develop a comprehensive model to assess the public health effects from using various environmental geologic formations for waste disposal. Professor Stan Logan is the project coordinator. The model is designed to permit parametric studies to be performed for various geologic disposal media and for waste in different forms, such as glass or ceramic. The model's output is to include the potential environmental impact, and the associated costs. The model is to be designed to incorporate the latest available data to permit rapid assessment of the cost effectiveness of various geologic disposal concepts. The model has been developed and is now being thoroughly reviewed before it is applied to the site chosen by the ERDA for its Waste Isolation Pilot Plant.

2. Federal Activities/EIS Review (2.2)

For FY 1977, ORP had identified several impact statements to be reviewed that related to reprocessing and high-level waste management. The relevant environmental impact statements to be reviewed as shown in Figure B-9e are:

(1) Generic EIS on waste management (ERDA).

(2) Generic EIS on mixed oxides (NRC).

(3) EIS on spent fuel storage.

(4) EIS on Exxon fuel reprocessing plant.

In FY 1978, ORP expects to review the federal activities in the areas of safeguards, reprocessing and spent fuel storage. These are shown in Figure B-10e.

3. Technology Assessment (2.3)

Figure B-9f shows that ORP plans to undertake two activities in FY 1977:

(1) Publish an assessment of rad waste disposal site in New York.

(2) Report on the transport of rad waste at West Valley, New York.

In FY 1978, ORP intends to look at three areas as shown in Figure B-10f. These are:

(1) Waste management and siting issues for decommissioning of radioactive facilities.

(2) Site selection and base line monitoring for ocean dumping of radioactive wastes.

(3) The technical analysis needed to analyze the thorium fuel cycle.

4. State Program Support

At this time, there appear to be no activities under this category that relate directly to radioactive waste management or reprocessing.

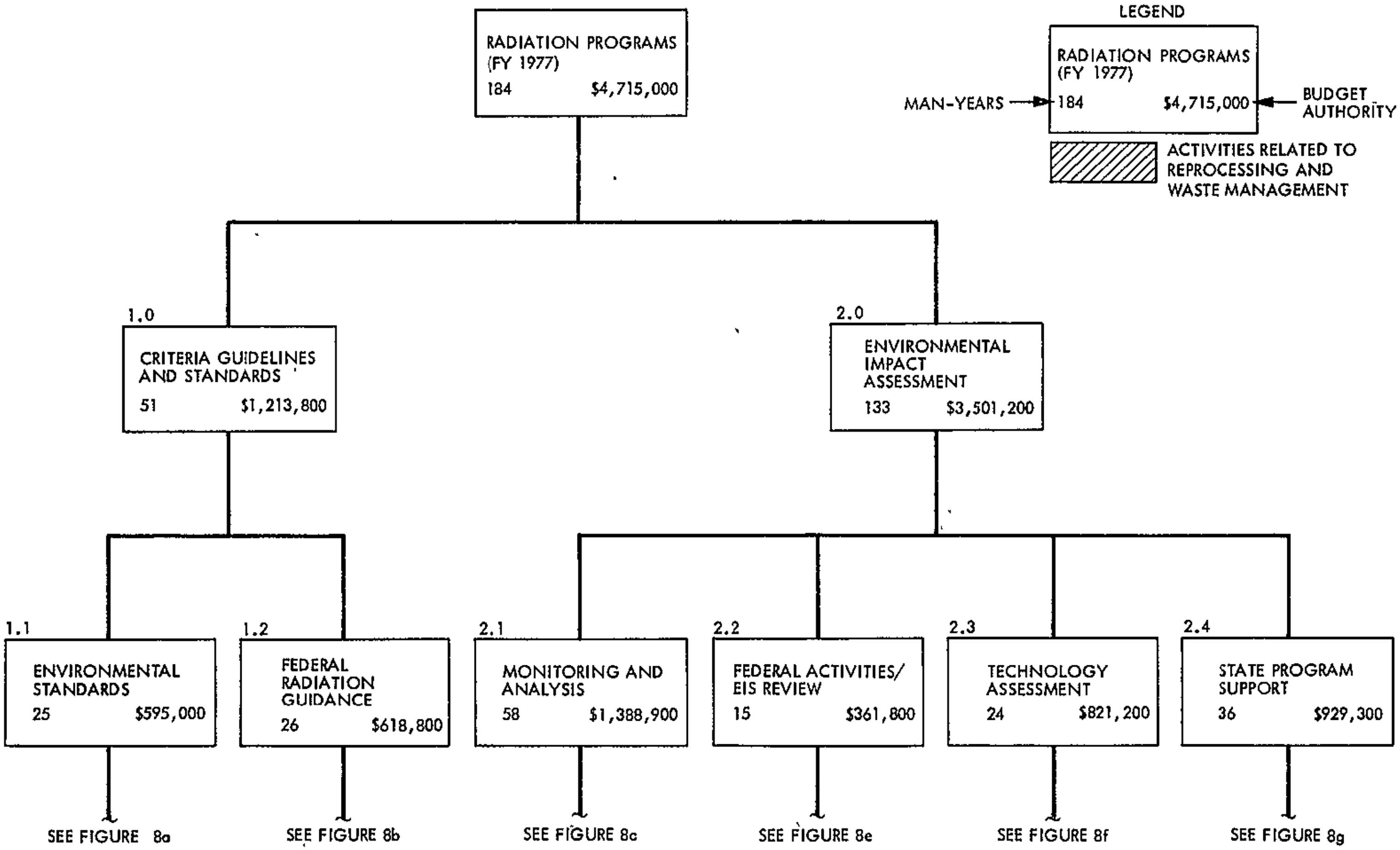


Figure B-9. Office of Radiation Programs - Program Plan for FY 1977

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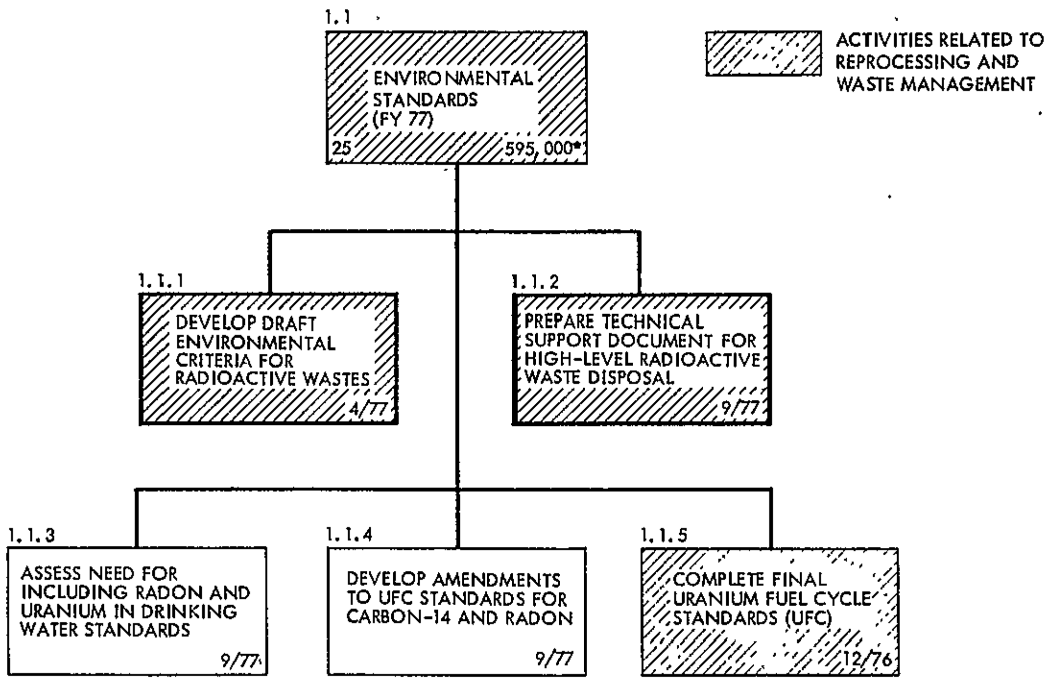

*DOES NOT INCLUDE OVERTARGET FUNDS FOR FOUR ADDITIONAL POSITIONS AND $475,000

Figure B-9a. Office of Radiation Programs - Program Plan for FY 1977 With Expected Completion Dates (Environmental Standards)

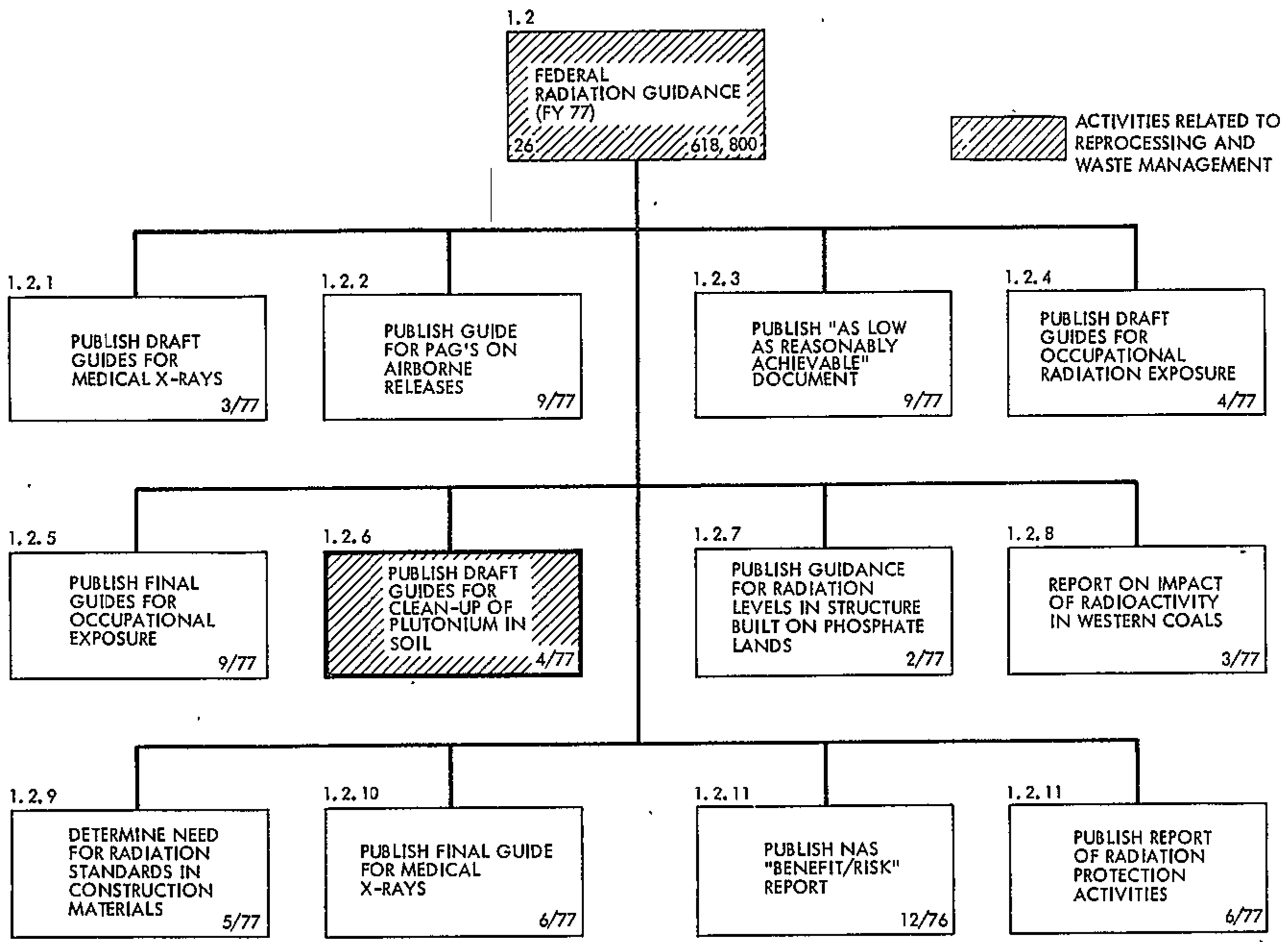

Figure B-9b. Office of Radiation Programs - Program Plan for FY 1977 With Expected Completion Dates (Federal Radiation Guidance)

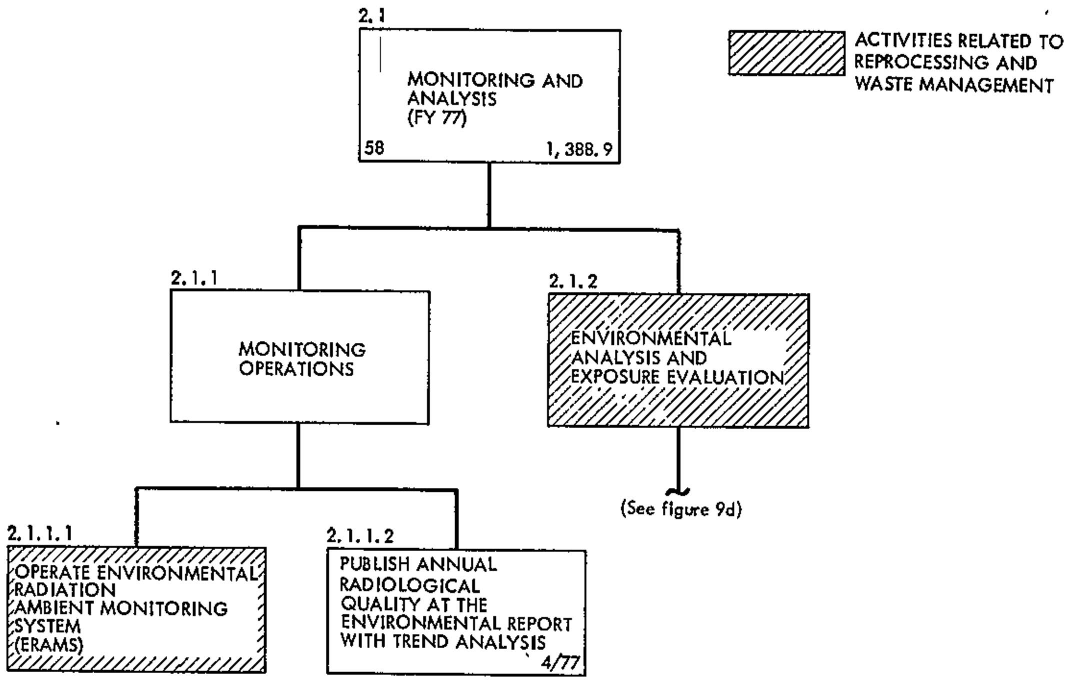

Figure B-9c. Office of Radiation Programs - Program Plan for FY 1977 With Expected Completion Dates (Monitoring and Analysis)

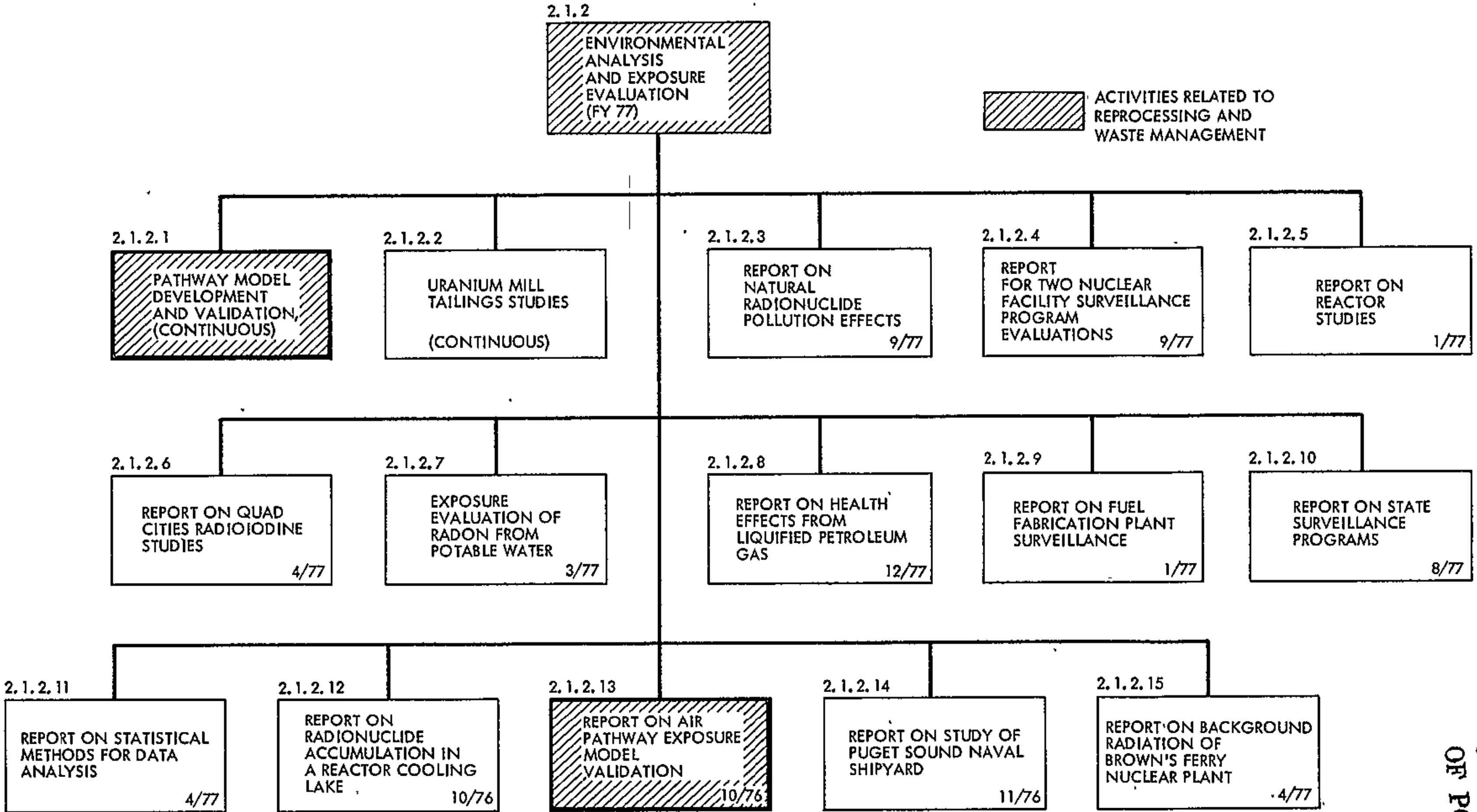

Figure B-9d. Office of Radiation Programs - Program Plan for FY 1977 With Expected Completion Dates (Environmental Analysis and Exposure Evaluation)

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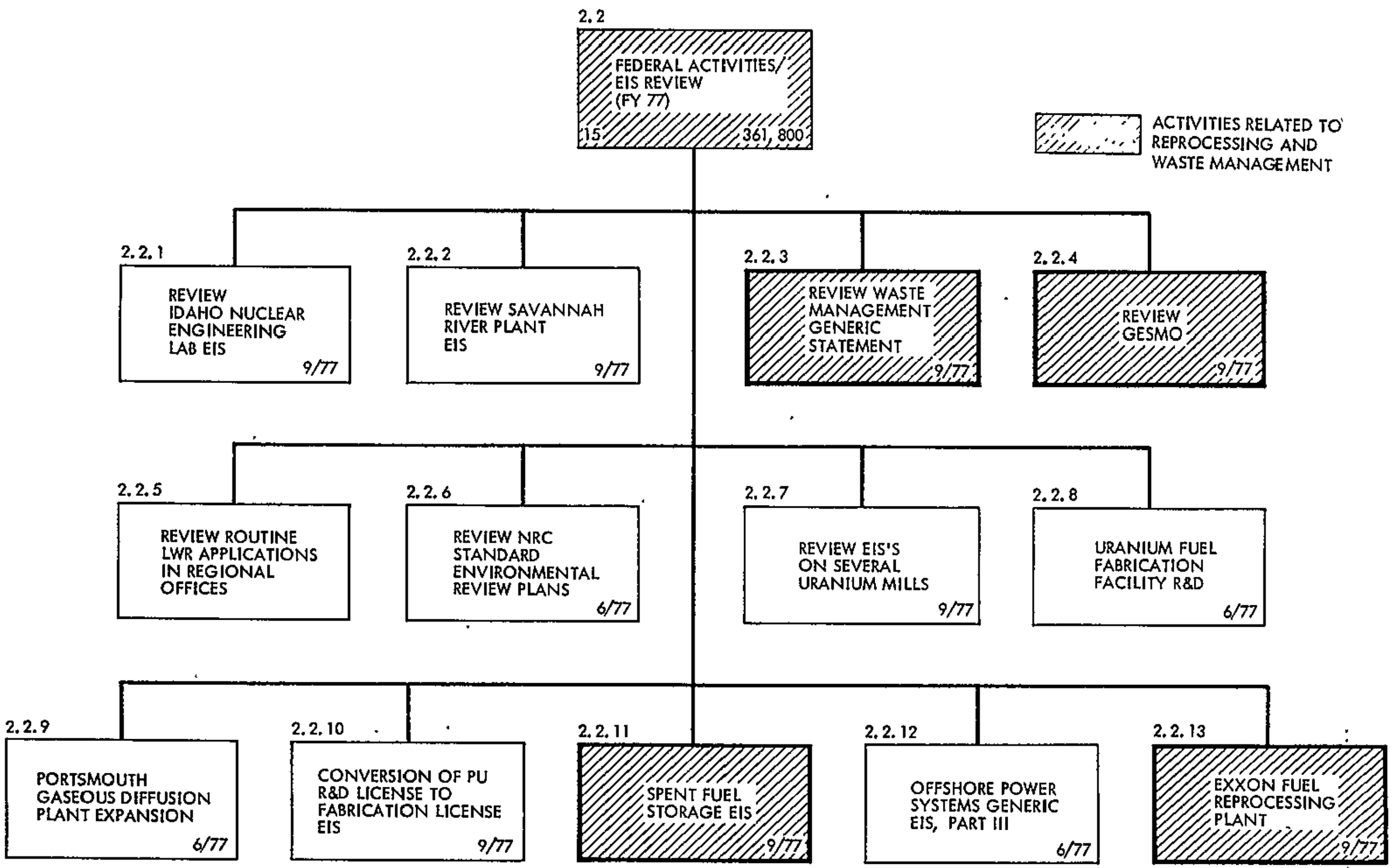
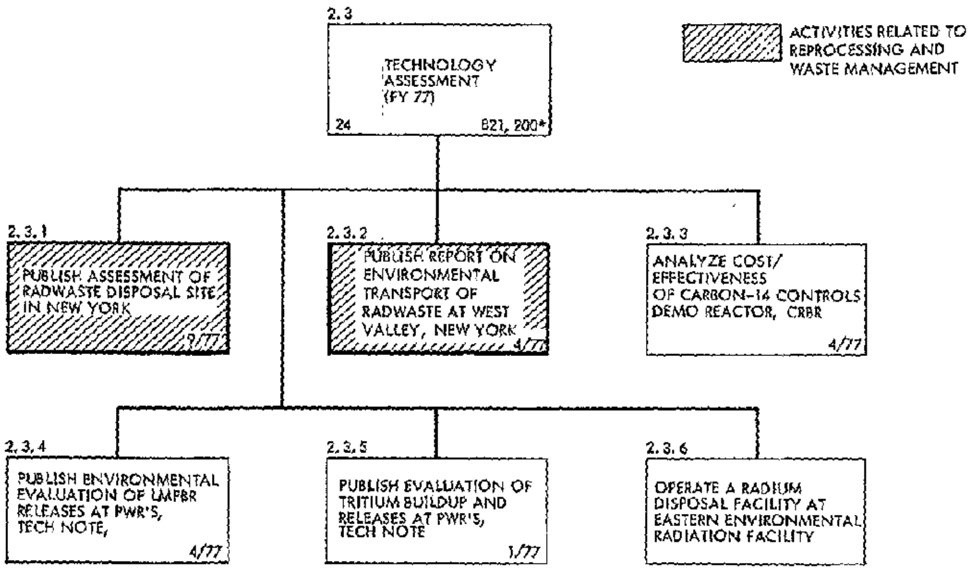


Figure B-9e. Office of Radiation Programs - Program Plan for FY 1977 With Expected Completion Dates (Federal Activities/EIS Review)



*DOES NOT INCLUDE OVERTARGET REQUEST SUBMITTED FOR SIX ADDITIONAL POSITIONS AND $1, 800, 000

Figure B-9f. Office of Radiation Programs - Program Plan for FY 1977 With Expected Completion Dates (Technology Assessment)

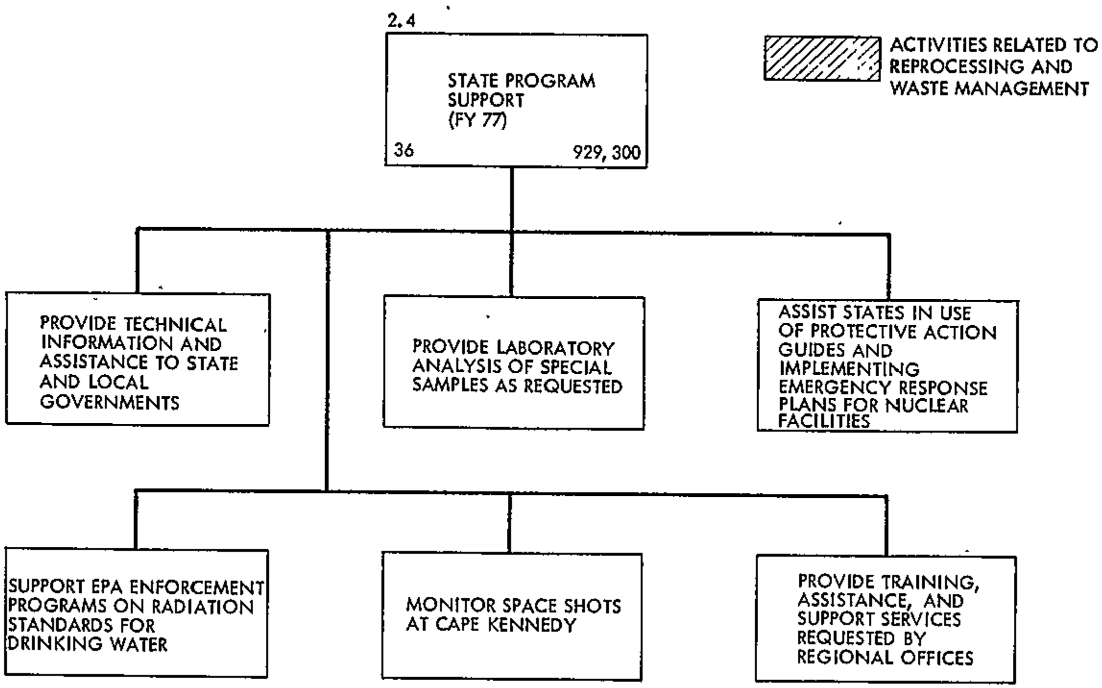


Figure B-9g. Office of Radiation Programs - Program Plan for FY 1977 With Expected Completion Dates (State Program Support)

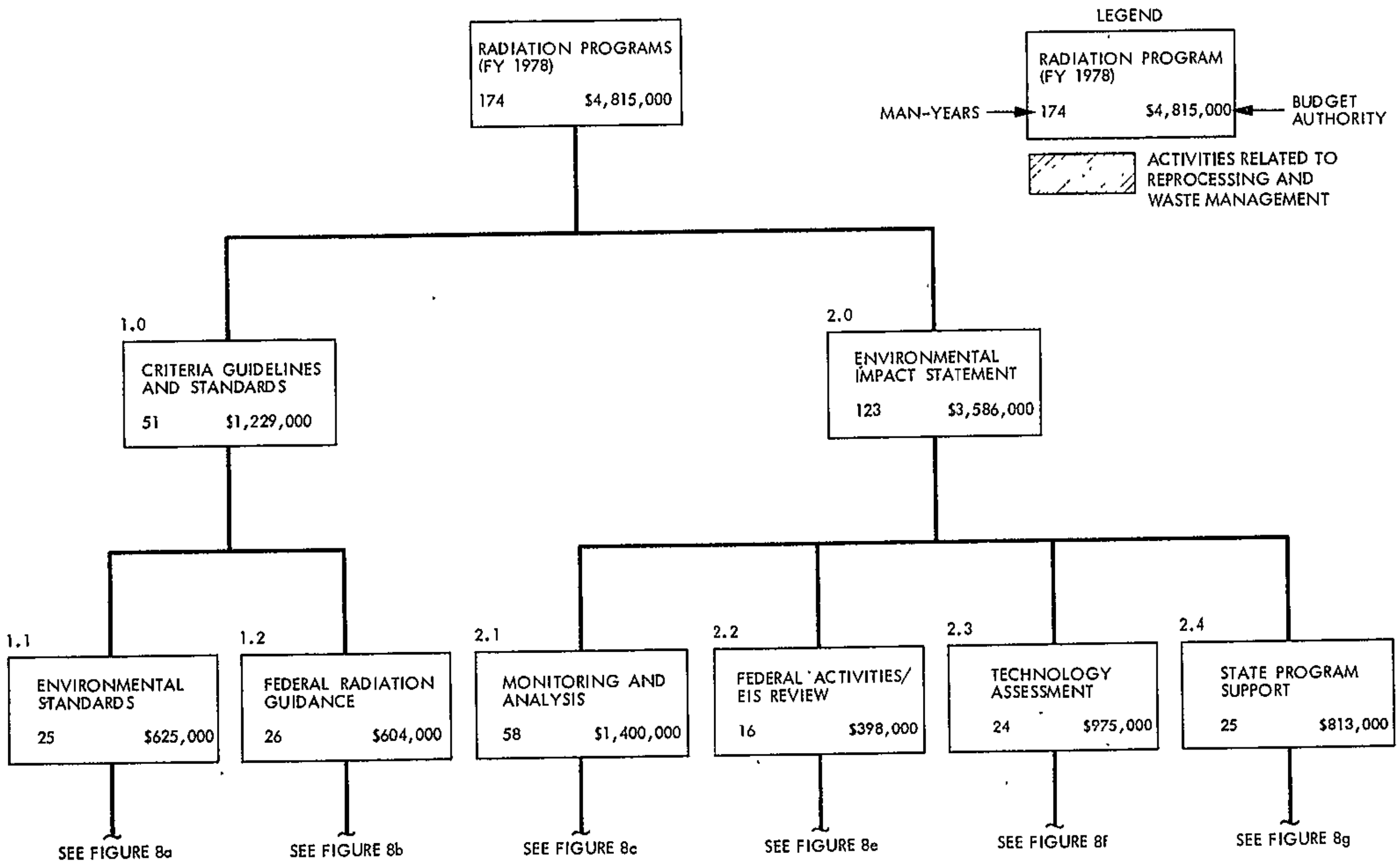


Figure B-10. Office of Radiation Programs - Program Plan for FY 1978

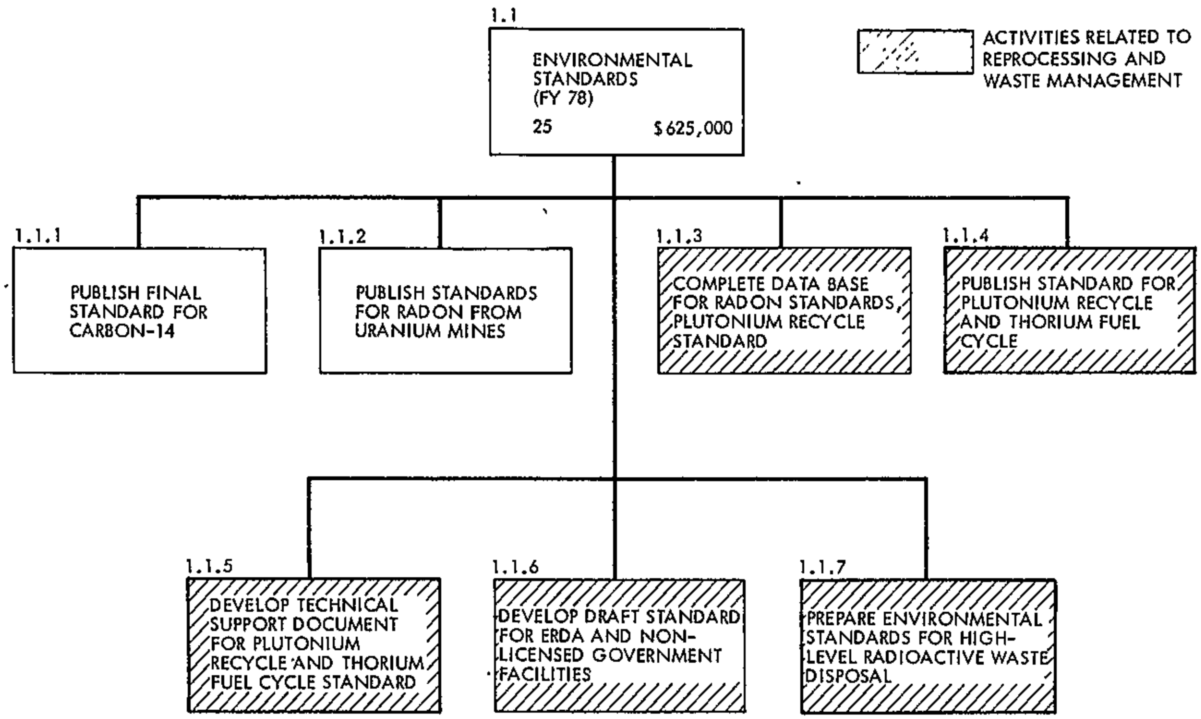


Figure B-10a. Office of Radiation Programs - Program Plan for FY 1978 (Environmental Standards)

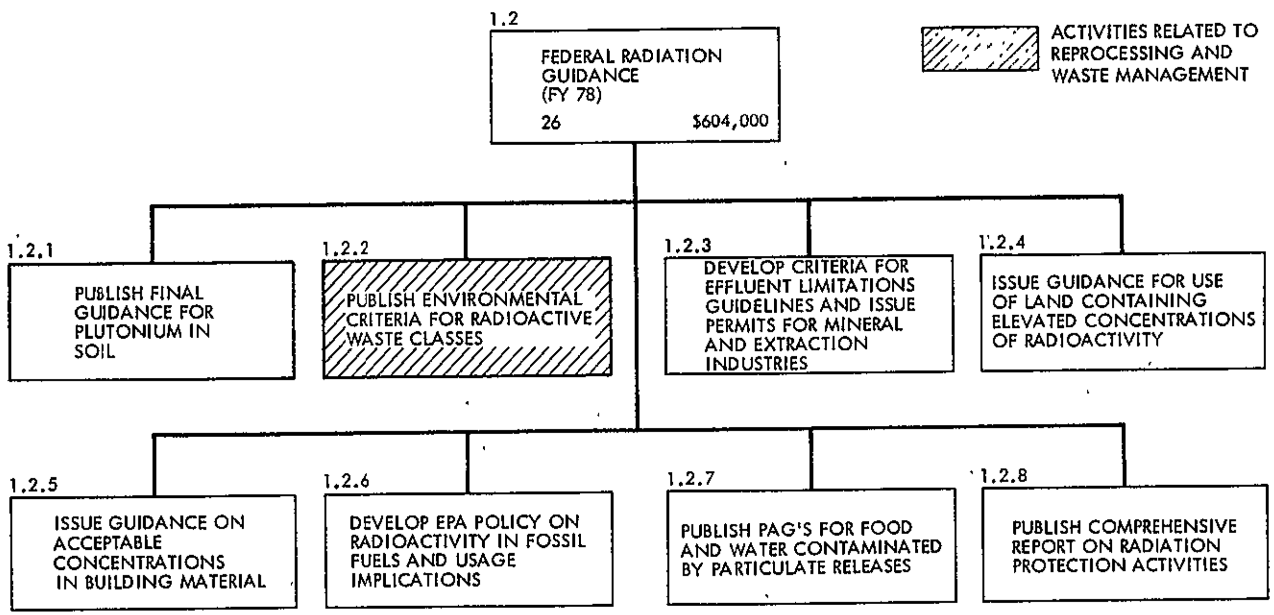


Figure B-10b. Office of Radiation Programs - Program Plan for FY 1978 (Federal Radiation Guidance)

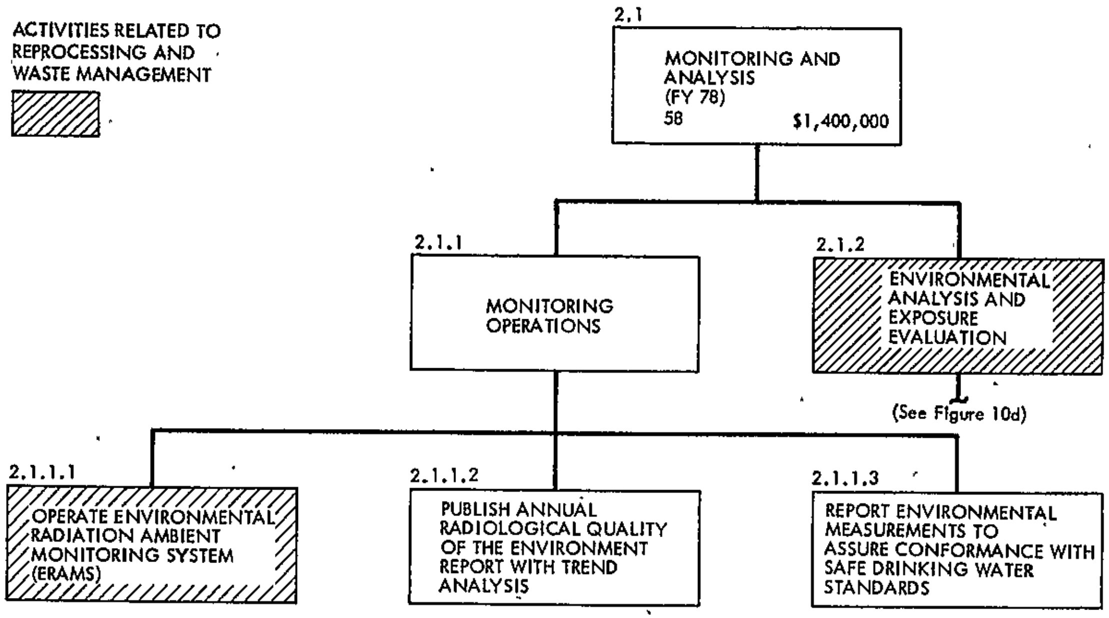


Figure B-10c. Office of Radiation Programs - Program Plan for FY 1978 (Monitoring and Analysis)

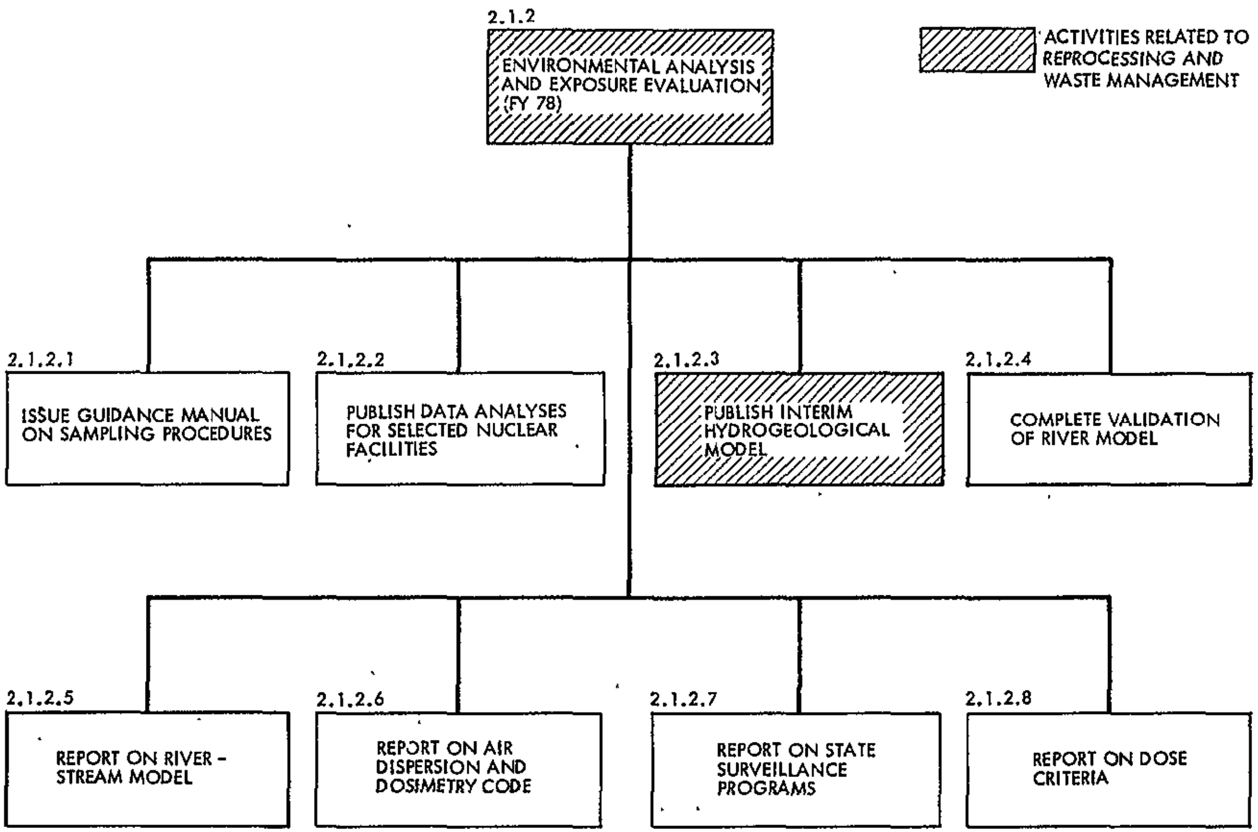


Figure B-10d. Office of Radiation Programs - Program Plan for FY 1978 (Environmental Analysis and Exposure Evaluation)

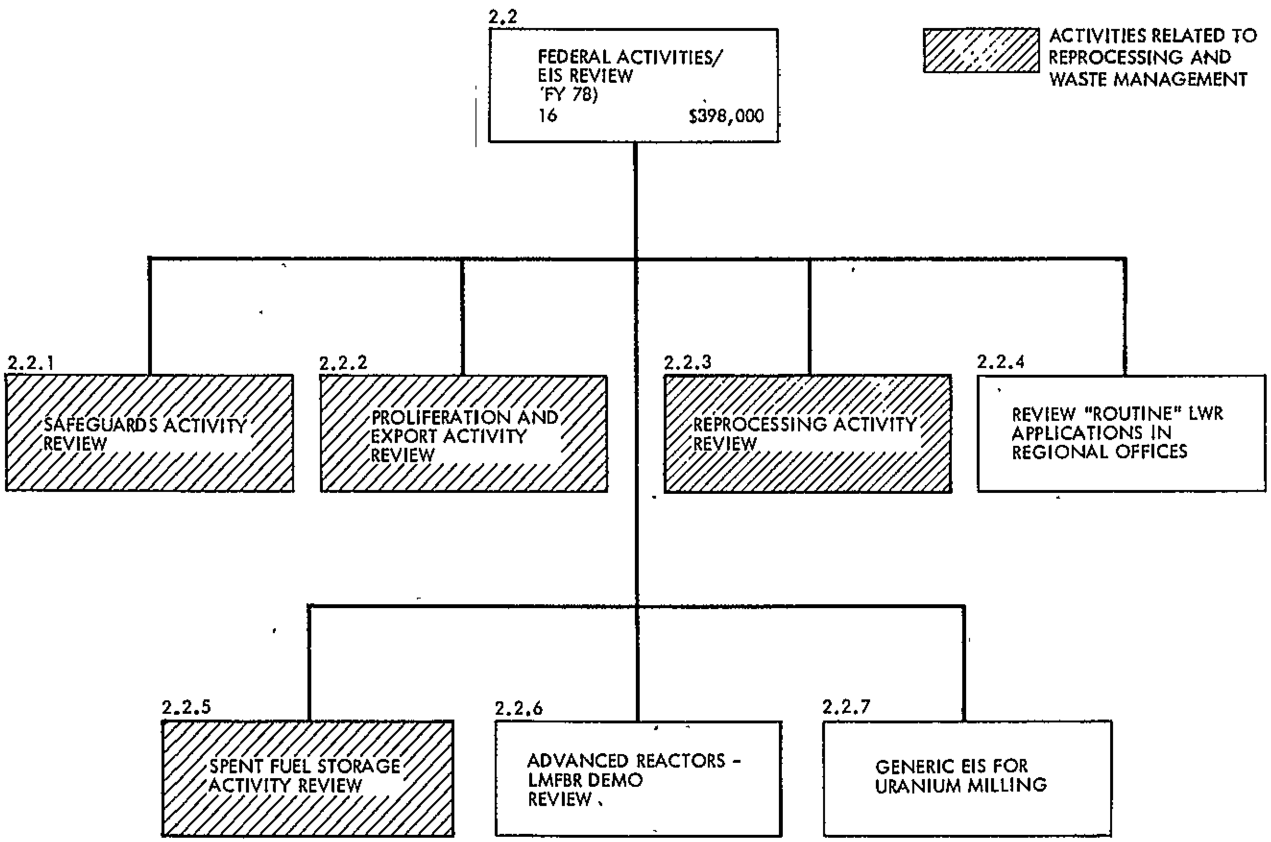


Figure B-10e. Office of Radiation Programs - Program Plan for FY 1978 (Federal Activities/EIS Review)

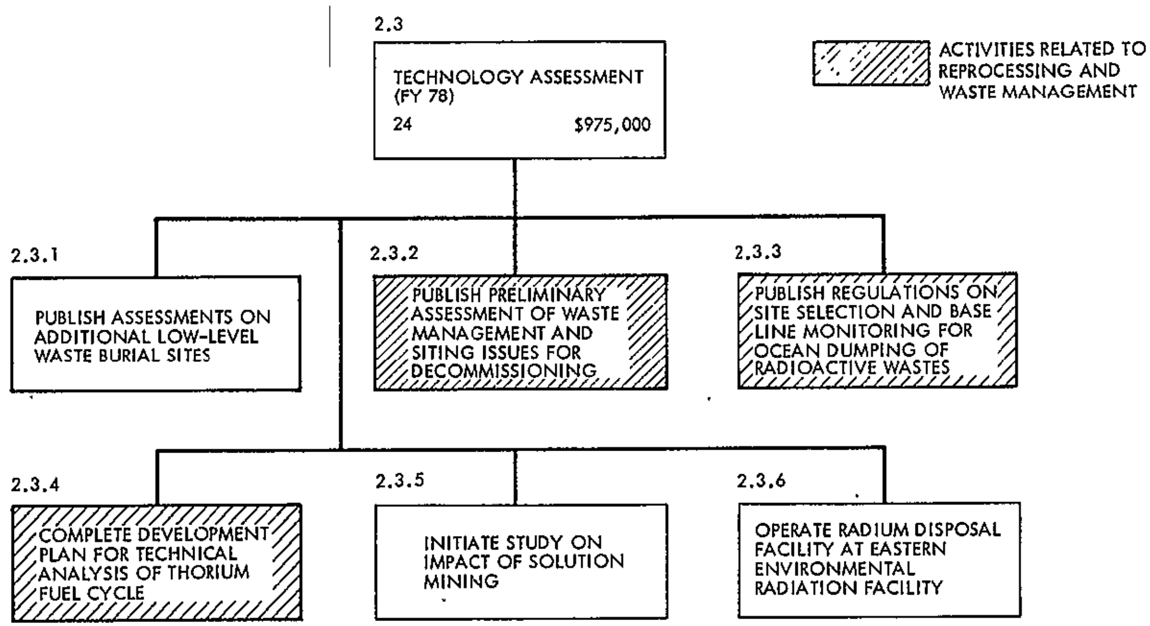


Figure B-10f. Office of Radiation Programs - Program Plan for FY 1978 (Technology Assessment)

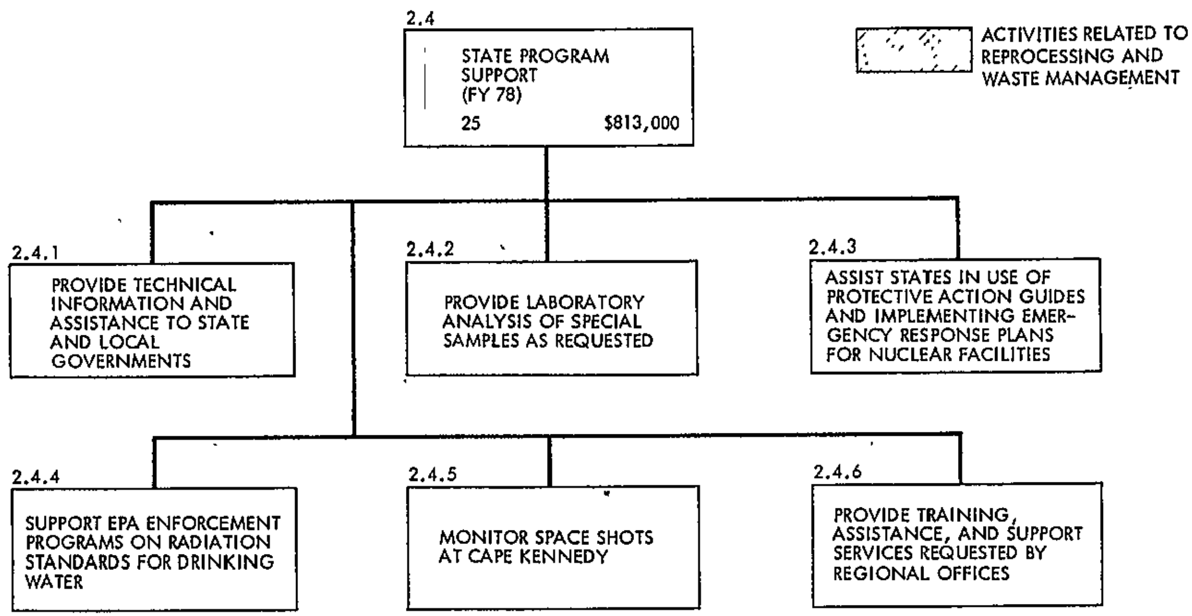


Figure B-10g. Office of Radiation Programs - Program Plan for FY 1978 (State Program Support)

V. OBSERVATIONS

The purpose of this section is to outline important environmental protection issues and problem areas that may be viewed as gaps in the nuclear waste management programs in the government. These observations are limited to the authorities, budget trends, goals, and programs described within this appendix. The problems and issues that have been identified are interdependent and complicated, but can be roughly classified into the following five subject areas:

(1) Scientific Knowledge for Radiation Standards.

(2) Ionizing Radiation Research.

(3) Classification of Radiation Standards.

(4) Environmental Radiation Monitoring.

(5) Resources for Implementing Radiation Standards.

A. SCIENTIFIC KNOWLEDGE BASE FOR RADIATION STANDARDS

The present program strategy of EPA's Office of Radiation Programs is based upon what is believed to be the best scientific knowledge available. However, it is very difficult to evaluate the "adequacy" of this knowledge for establishing either correct or acceptable standards for all aspects of the nuclear fuel cycle. One hears numerous conflicting judgments on the strength of the knowledge base which EPA uses to make its decisions. There are a number of important areas of uncertainty that directly affect EPA's ability to establish acceptable and effective radiation controls:

> "These unknowns lie primarily in policy and responsibility uncertainties, areas of health effects and ecological processes knowledge, and the availability of effective control technologies for nuclear facilities operations and industrial processes. The significance of these unknowns is that, as the program is implemented, developments in these areas could require minor or major modifications, such as changing control procedures, establishing more or less stringent standards, and changing basic philosophies and approaches" (Reference B-9).

ORP has documented much of the knowledge and criteria from which they promulgate radiation guidance and standards, including the supporting materials for the Uranium Fuel Cycle Standard. However, they seem more perplexed than usual when dealing with issues and problems presented by the development of criteria and standard for high-level waste disposal. In their "Issues and Objectives Statements," provided for the recent EPA workshop on Radioactive Waste criteria (Reference B-14), they express uncertainty about three important areas:

(1) Approaches to Rad Waste Management Criteria Development including ways to develop definitive policy positions on such aspects as:

(a) The retrievability of the waste over the short- and the long-term.

(b) The relative importance of environmental barriers such as geological strata versus engineering controls such as containers.

(c) Requirements for long-term care.

(d) Methodology for estimating and quantifying potential environmental and public health impacts.

(e) Compatibility of disposal techniques with various types and forms of radioactive waste.

(2) Risk Considerations of Rad Waste Management, including uncertainty about the correct methodology for assessing the probability of radionuclide release and the issues related to the perception, acceptance, and personal valuation of risk:

(a) Risk and costs are probably shared disproportionately by present and future generations; whereas, present generations derive the benefits.

(b) Balancing of benefit and risk over the period that the wastes remain toxic is difficult, hence, traditional radiation protection standards and underlying philosophies may not be directly applicable.

(c) Calculation of risk to present and future generations is clouded in uncertainties stemming from technical limitations in the sciences and engineering, and by the very long time-frames over which protective controls are expected to operate.

(d) Basic ethical and moral questions permeate the intergenerational risk issue and are not amenable to technical solution.

(3) The Long-Term implications of Radioactive Waste Management is another area of uncertainty related to such problems as:

(a) Institutional longevity (or lack thereof) and its potential impact on radiation exposure levels, and

(b) The dose commitment to future generation, which would result from present decisions regarding the range of available waste management alternatives.

There is, of course, a large body of knowledge on radiation health and environmental effects, but any leading radiation expert can point out the areas of greatest uncertainty and unknown (References B-16 - B-20). The potential for induction of cancer and genetic effects from exposure to ionizing radiation are well known and have been defined primarily from animal investigations and epidemiologic studies of human populations exposed as victims of nuclear weapons. The environmental effects of irreversible environmental contamination of land, air, water and natural resources is also known. However, continuing areas of uncertainty seem to be the transport mechanisms and associated risks from source to exposure to health and environmental impact. One area of controversy is related to the present assumptions used to calculate health risks. The National Academy of Sciences 1972 Report, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation" (Reference B-15), concluded that any radiation exposure involves some biological risk. The risk of lethal cancer induction was estimated as 200 cases of cancer per million man-rems. (Man-rem is the product of the dose, measured in rems, times the number of persons exposed.) This estimate was based on the assumption that a linear relationship between the level of exposure and the risk incurred should be used as a basis for making public health estimates. Many scientists disagree with this assumption either as an overestimate or underestimate of actual effects of long-term exposures to low-level radiation which they claim is not a linear extrapolation of existing high-level radiation data.

Several important questions are thus raised that go far beyond institutional concerns and the programmatic activities of the Office of Radiation Programs. An evaluation of the strengths and weaknesses of the scientific base of setting environmental standards for radioactive waste management seems to be required. Specifically, the following questions need to be addressed:

(1) What is the present status of the scientific base? What are the important areas of knowns and unknowns? What research is required?

(2) What specific data and information is required to set acceptable and effective standards for high-level waste disposal that does not now exist?

(3) If present knowledge base is inadequate, what are the problems and implications of setting standards prematurely?

More specifically, we can also ask questions like:

(1) What are the environmental, social, economic and health effects of radioactive waste management activities?

(2) Are high-level radioactive wastes properly defined and classified?

(3) What are the health risks from radiation in terms of acute, subacute, and latent effects?

(4) What is an acceptable level of risk? What are public attitudes and perceptions of risk?

(5) What are the environmental pathways of releases of radiation from disposal sites? What are the absorption characteristics of radionuclides released in the geosphere?

(6) What are the economic costs and benefits of reprocessing and waste disposal facilities? How do these costs affect the economic demands for nuclear energy compared to other energy sources?

(7) What are the costs of developing advanced nuclear waste management technologies such as laser separation, partitioning, transmutation, or space disposal?

(8) What are the costs of retro-fitting nuclear facilities with new control technology as standards and regulations change?

(9) What are the social and cultural implications of long-term nuclear waste disposal facilities and sites?

There are obviously hundreds of substantive issues and problems that can be listed. The most important should be focused on:

(a) identification of the most important areas affecting high-level waste disposal with scientific uncertainty; and

(b) a normative assessment of the adequacy of this knowledge base for setting the high-level rad waste standard.

B. IONIZING RADIATION RESEARCH

The EPA has wide ranging authority in the area of radiation protection that includes conducting research and development on environmental impacts and control technology. However, efforts in this area have always been modest; $2.5 million was expended by the Office of Research and Development in FY 1975 for radiation research. Since then, all ionizing radiation research has been phased-out.

The rationale for this phase-out was to avoid duplication of efforts with NRC and ERDA, which spend millions of dollars on research on the environmental impacts of radiation. However, it can be argued that there are fewer incentives to properly allocate resources and make research decisions on environmental effects and control technology, since these are not the main concerns of ERDA and NRC. That is, research decisions may be suboptimized relative to each of the missions of ERDA, NRC or EPA. Further, it can be shown that more basic research is needed in the areas of environmental pathways, risk and risk acceptance, and environmental and health impacts of radiation that is clearly in the domain of EPA authorities.

In order to carry out its mission of setting environmental criteria and standards for radiation protections, EPA must have access to up-to-date scientific expertise. To maintain this base of expertise it would seem wise to have some research or research contracting capability and responsibility in areas directly related to ionizing radiation research. This observation seems especially true considering that ERDA and NRC would otherwise have a monopoly on ionizing radiation research without built-in incentives for environmental impact and control technology research and development.

The important areas of uncertainty are reflected in ORP's report "Research and Operational Needs" and in their "Program Strategy," which states that even though there is a tremendous body of research knowledge there are numerous areas where new knowledge is needed.

> "The types of health effects attributable to radiation exposure are well known; however, the specific probabilities of occurrence at low environmental levels have not been clearly demonstrated. Consequently, at this time only a conservative hypothesis can be used to estimate the number of potential health effects. The current and projected quantities of many radionuclides including plutonium and actinides in the environment and their environmental transport modes and mechanisms are also highly uncertain.... The consequences of these uncertainties is that the environmental impacts cannot be precisely projected; therefore, conservatism in judgments is necessary in developing appropriate standards and other controls."

There are also a number of uncertainties about control technology. Not only is there a continuing need for research and development on radiation control technology, but also a requirement to determine the socio-economic cost/benefits in order to promulgate acceptable standards.

> "Although technologies regarding effluent controls and engineered safeguards have been improving since the beginning of the nuclear industry, a number of uncertainties still remain. The majority of these lie in the determination of the acceptable levels of risk from accidents at nuclear facilities; the reliability of emergency systems to mitigate adverse effects in the event of an accident; the development of an environmentally acceptable method for long term disposal of radioactive waste; and the development of systems to control effluents such as carbon-14 and tritium."

The point is, that continued research on the environmental effects of ionizing radiation is required. The issue that is raised is institutional, regarding the best arrangements to assure that this research is properly implemented and used.

(1) What kind of radiation research is required by EPA? Is research on environmental pathways, effects, and radiation control technology being given adequate priority? Does EPA have access to research required to carry out its mandates in radiation protection of the environment and human health?

(2) Should EPA be assigned greater responsibility and resources for Federal R&D on environmental radiation impacts and control technology? Should these functions be assigned to EPA as the lead agency?

(3) What alternative interagency arrangements or mechanisms would assure that EPA participates in decisions on environmental radiation research?

C. CLASSIFICATION OF RADIATION STANDARDS

As discussed in Section III-A, the Uranium Fuel Cycle Standard was promulgated by the EPA on January 13, 1977. This standard is found in Subpart B of Part 190 Volume 40 of the Code of Federal Regulations (40 CFR 190) "Environmental Radiation Protection Standards for Nuclear Power Operations." Based on the definition used for the uranium fuel cycle (see Section III) and the other standards EPA plans to develop, it appears that other subparts of Part 190 will be:

(1) a standard for high-level waste.

(2) a standard for low-level waste.

(3) a standard for plutonium recycle.

(4) a standard for the thorium fuel cycle.

These five standards, and possibly others, will comprise the environmental radiation standard for the nuclear fuel cycle. The nuclear fuel cycle is defined as the operations "associated with the production of electrical power for public use by any fuel cycle through utilization of nuclear energy" (40 FR 1900.02).

Before examining the basis and implications for classifying the standards into the five standards noted above, it is useful to recall EPA's authority for promulgating environmental radiation standards. As stated in the Atomic Energy Act as amended (Chapter 14, Section 161.b), any level of exposure is acceptable only if it is balanced by an offsetting benefit.

So, for example, EPA's rationale for excluding waste disposal activities from the uranium fuel cycle states that:

> "Since the benefit in waste disposal activities, per se, is limited to risk reduction, the concept of balancing risk with offsetting benefits must be reconciled for waste management, especially with regard to the intergenerational aspects of the problem. In the past, it has been tacitly assumed that the benefits from utilization of radiation far exceed the cost. However, all costs (or risks) resulting from the beneficial use of radiation must be identified and assessed in terms of the net benefit of the activity. Because all costs from waste

disposal have not been identified, waste disposal remains a major issue in radiation activities and especially in the nuclear power generation."

This rationale exhibits EPA's mandated concern about establishing the offsetting benefits of utilizing radiation. It also indicates the segregation of the existing nuclear fuel cycle into two subsystems - the uranium fuel cycle and the waste management activities. In this case, waste management includes everything excluded from the uranium fuel cycle - "mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and by-product materials from the cycle" (40 CFR 190.02(b)).

The result is the EPA will perform cost-benefit analysis for each subsystem. Thus, the benefit of electrical power from nuclear energy cannot be associated with the cost of waste disposal, and vice versa. Similarly, the costs and benefits for plutonium recycle can only be those directly associated with the reuse of plutonium.

Without proceeding with a comprehensive analysis of the implications of breaking up the fuel cycle in this manner, one might question if this arbitrary separation will result in optimizing, or choosing the most favorable trade-off, for each subsystem, while suboptimizing for the entire system. By this separation, EPA appears to have discounted all long-term costs and benefits of the uranium fuel cycle to the point that they are not considered when looking at the future costs and benefits of waste disposal. Similarly, the future costs of waste disposal are not at all incorporated in the trade-offs for assessing the trade-offs in the uranium fuel cycle.

The promulgation of separate standards for high-level and low-level waste has also raised concern. Presently, the distinctions appear to be based on the source of the waste and not the quantity and/or quality of the specific radionuclide.

The present classification of the radiation standards raises several questions:

(1) Are the arguments for excluding waste disposal from the uranium fuel cycle and for distinguishing between high and low-level waste scientifically justified? Is this classification scheme a potential cause for public contention and court battles?

(2) Does the exclusion of waste disposal place an extraordinary burden of proof on the benefits of waste disposal? Similarly, does it place too little burden of proven benefits on the uranium fuel cycle?

D. ENVIRONMENTAL RADIATION MONITORING

On July 1, 1973, the EPA, through ORP, implemented a new system for monitoring the national level of radioactivity in the environment. This system, the Environmental Radiation Ambient Monitoring System (ERAMS) (see Section IV-B1) constitutes the Office of Radiation Program's major source of national environmental radiation data acquisition and analysis. In addition, ORP has access to the on-site monitoring done by all nuclear facility operators. ORP has been requested by NRC and ERDA to do other monitoring - usually site specific.

(1) Should all on-site and ambient monitoring be centralized within one agency that is independent of ERDA and NRC? Would such centralization improve the efficiency, economy, and consistency of radiation monitoring?

(2) Is the present capability of ERAMS adequate for monitoring the growing number of facilities and the possibility for non-point source emissions?

(3) Is the system adequate for helping ORP implement and enforce the standards to be promulgated?

E. RESOURCES FOR IMPLEMENTATION OF RADIATION STANDARDS

This final issue is in many ways a summary of the preceding issues. Numerous questions about the adequacy of EPA/ORP's capability to develop and implement a high-level radioactive waste management criteria and standard were pointed out.

While the responsibilities and role of EPA have been greatly expanded under this policy to prepare high-level waste standards by June of 1978, no additional resources have been requested by OMB nor approved by Congress to meet this goal. In fact, the overall trend in EPA's Office of Radiation Programs has been, until the recent budget reallocation, a reduction in both financial and personnel resources.

These conditions are accentuated by the questions raised previously in this Section on, (1) the adequacy of the scientific knowledge base, (2) the status of ionizing radiation research, (3) the classification of radiation wastes, and (4) the status of ERAMS.

(1) What then are the specific barriers - money, manpower, information, authority - to EPA successfully meeting its schedule? What is needed to overcome the barriers? How can the needs be measured and evaluated?

(2) What are the implications if EPA does not meet its schedule? Do the implications differ if the schedule slips by one year, two years, or five years? If so, how do the implications differ?

(3) Would the rescheduling at this early time be better than missing the deadline or meeting the deadline with inadequate preparation? What are the tradeoffs?

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APPENDIX C

DESCRIPTION OF THE ERDA TECHNOLOGICAL PROGRAM FOR RADIOACTIVE WASTE MANAGEMENT AND REPROCESSING

APPENDIX C

CONTENTS

Figures

Tables

I. INTRODUCTION

This appendix describes the present status of the technological programs and some of the major technological projects being undertaken by the United States Energy Research and Development Administration (ERDA) in the areas of radioactive waste management and reprocessing. Background information on ERDA is given to provide a context in which the radioactive waste management and reprocessing programs can be understood. A detailed budget and work breakdown structure, extending down to the project level where data were available for study, is presented. Finally a section with observations about ERDA programs is provided.

II. BACKGROUND INFORMATION

In this section, the following information about the Energy Research and Development Administration is presented: overall goals and objectives; organizational structure; identification of the individual organizations involved in radioactive waste management and reprocessing; and budgetary trends.

A. ERDA GOALS AND OBJECTIVES

As set forth in the Energy Reorganization Act of 1974, the goals and missions of the then newly organized Energy Research and Development Administration were to be the following:

(1) To bring together and direct Federal activities relating to energy R&D.

(2) To assure coordinated and effective development of all energy sources.

(3) To improve government operations in energy areas.

(4) To increase the efficiency and reliability of use of all energy sources to meet the needs of present and future generations.

(5) To increase the productivity of the national economy and strengthen its position in regard to international trade, and to made the nation self-sufficient in energy.

(6) To advance the goals of restoring, protecting and enhancing environmental quality.

(7) To assure public health and safety.

B. ORGANIZATION OF ERDA

ERDA is headed by an administrator, with ten assistant administrators, six of which deal with the following specific energy related areas: Fossil Energy; Nuclear Energy; Environment and Safety; Solar, Geothermal and Advanced Energy Systems; National Security; and Conservation. An ERDA organization chart is provided as Figure C-1.

C. DESCRIPTION OF WASTE MANAGEMENT AND REPROCESSING AREAS

There are three main entities within ERDA that deal with technological R&D in the waste management and reprocessing areas. These are the Division of Waste Management, Production, and Reprocessing; the Division of Environmental Control Technology; and the Division of Military Application. These Divisions and their positions within the ERDA organizations are shown in Figure C-2. The Divisions are shaded to indicate their involvement in the radioactive waste management and reprocessing areas.

1. Division of Waste Management, Production and Reprocessing (2.3.a)

Under the Assistant Administrator for Nuclear Energy are five Divisions (Figure C-2), responsible for the areas shown. The topics in this study's purview are contained within the Division of Waste Management, Production, and Reprocessing. This Division is charged with the responsibility for the development of spent fuel reprocessing technologies for the various fuel cycles (e.g., LWR, LMFBR), for the development of spent fuel rod reprocessing, radioactive waste management, and radioactive waste terminal storage technologies, and for handling of existing inventories of ERDA waste.

The work of this Division is divided into the following programmatic efforts:[1]

(1) Support of Nuclear Fuel Cycle

- (a) Commercial LWR Fuel Reprocessing R&D.
- (b) LMFBR Fuel Reprocessing R&D.
- (c) HTGR Fuel Cycle R&D.
- (d) Thorium Fuel Cycle (LWBR & others) R&D.
- (e) Design for Fuel Cycle Facilities.

(2) Commercial Waste Management

- (a) Terminal Storage R&D.
- (b) Supporting Studies & Evaluations.
- (d) Solidification Process Demonstration Project.

[1] U.S. Government, U.S. Energy Research and Development Administration, Budget Estimates Fiscal Year 1978, Books II and III.

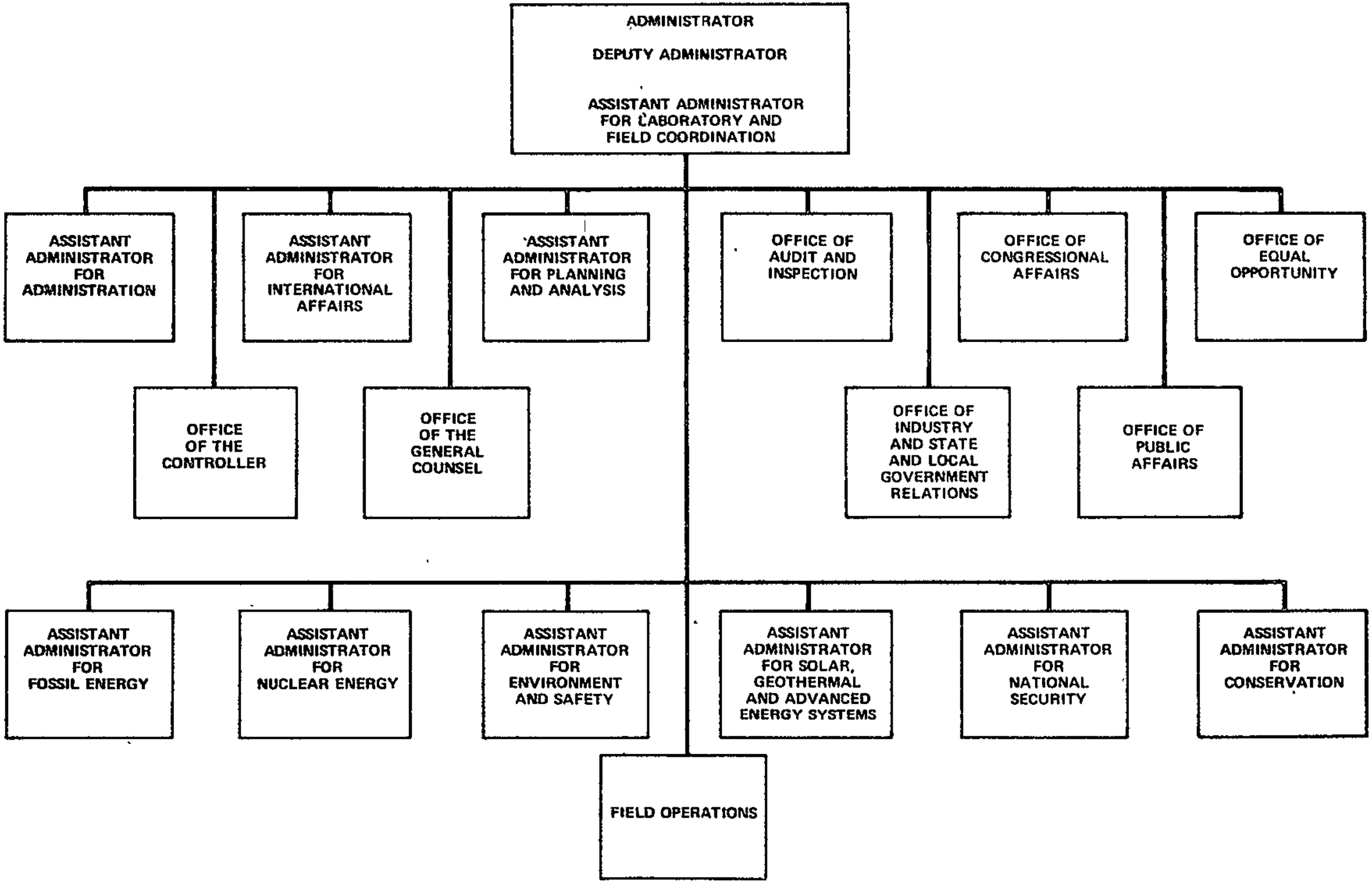

Figure C-1. Energy Research and Development Administration Organizational Chart

(3) ERDA/Defense Waste Management--Interim

(a) Production Reactor Waste.

(b) Non-Production Reactor Waste.

(c) Process Development.

(d) Supporting Services.

(4) ERDA/Defense Waste Mangement--Long Term

(a) ERDA Radioactive Waste R&D.

(b) Storage Operations & Related Activities.

(c) Supporting Services.

Specifically, tasks are being undertaken to provide the following:

(1) Support to the commercial fuel cycle to develop and demonstrate the technologies for spent fuel reprocessing, for recycle of recovered uranium and plutonium, and for radioactive waste treatment.

(2) Development and design of long-term isolation or terminal storage concepts for waste from the commercial nuclear power industry.

(3) Interim management of radioactive waste from ERDA/Defense reprocessing production and non-production reactor fuels.

2. Division of Environmental Control Technology

Under the Assistant Administrator for Environment and Safety are several Divisions and Offices, which are shown in Figure C-2. One of these, the Division of Environmental Control Technology (ECT), has a significant technologically-oriented programmatic effort in the area of nuclear waste management and reprocessing.

That program is responsible for assessing all ongoing and planned energy technology development activities to insure that proper emphasis is given to environmental control research, development, and demonstration. A key function is to promote the evaluation of advanced management and disposal techniques for radioactive wastes, and the research and development on improved methods for shipping nuclear wastes and fuels. Additionally, the Environmental Control Technology Division is responsible for the planning and budgeting for the safe management of all radioactivity contaminated ERDA facilities that are surplus to any other ERDA program.

Systematic assessment is to be made by this Division of energy systems emissions, wastes, and associated environmental impacts.

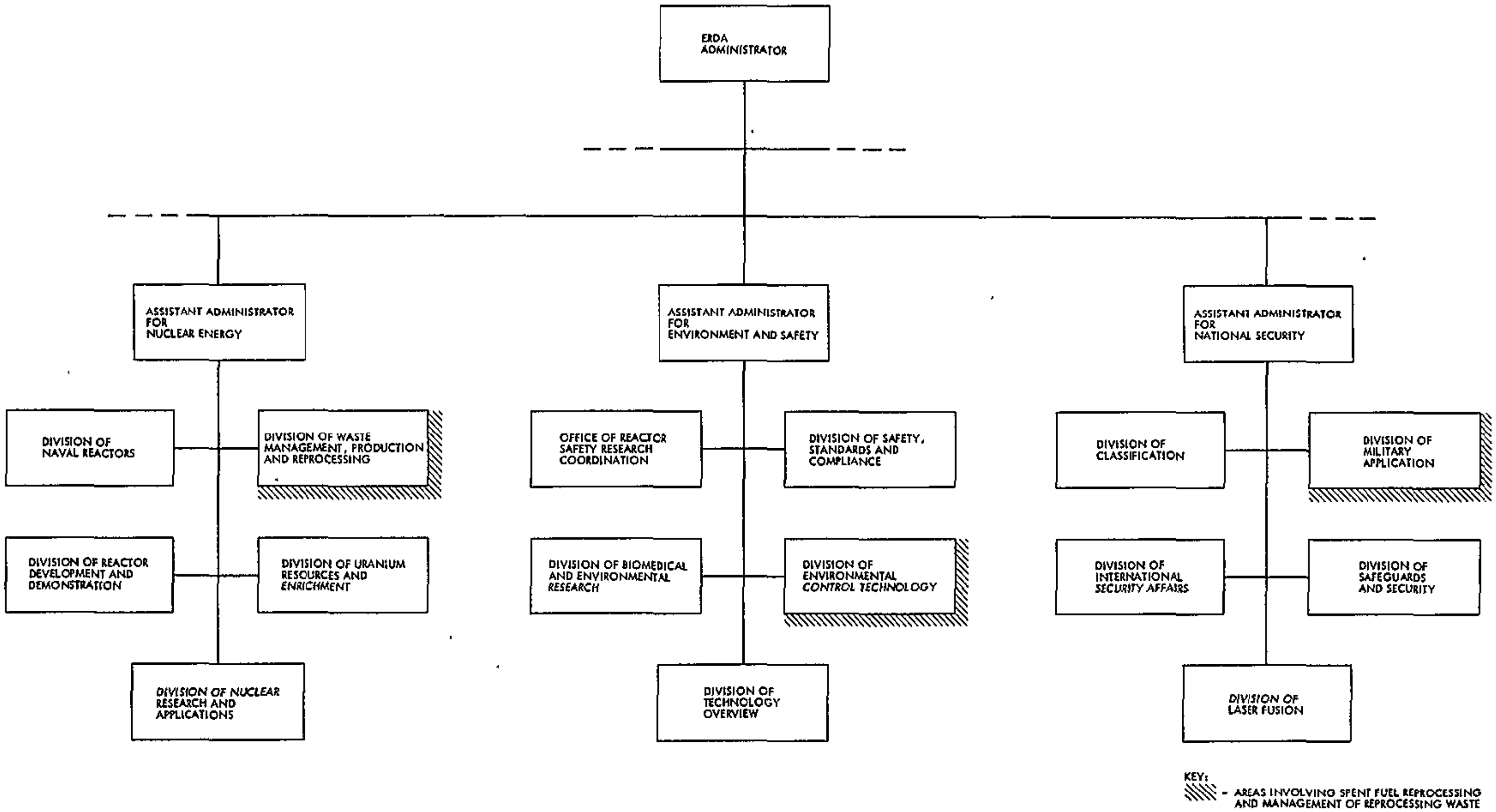

Figure C-2. ERDA Organizational Chart Showing Divisions Concerned With Waste Management

Control options which will provide socially and environmentally acceptable pollution control and waste management strategies will be identified.

Programmatically, the work of the ECT program applicable to nuclear waste management is organized as follows:[2]

(1) Nuclear Energy

  (a) Analysis of Nuclear Fuel Cycles.

  (b) Evaluation of Ocean Bed Disposal.

(2) Management of Surplus Contaminated Facilities

  (a) Surplus Facility Surveillance.

  (b) Disposition Methods R&D.

  (c) Planning for Disposition of Surplus Facilities.

  (d) Disposition of Surplus Facilities.

(3) Transportation

  (a) Energy Transportation Planning & Analysis.

  (b) Environment & Safety (Risk Assessment & Testing).

  (c) Transportation Systems & Technology (Standards and Information).

3. Division of Military Application

In addition to the work being carried out in the Division of Waste Management, Production, and Reprocessing and the Division of Environmental Control Technology, there is a small programmatic effort dealing with disposal cavities that is being undertaken by the Division of Military Applications.

The Division of Military Applications, along with four other divisions, comes under Assistant Administrator for National Security. These are shown in Figure C-2.

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[2] U. S. Government, Public Works for Water and Power Development and Energy Research Appropriations, Senate Hearings, Fiscal Year 1977, Part 5.

Programmatically, the work is organized as follows under Nuclear Explosives Application:[3]

(1) Disposal Cavities (Storage Application Development)

(2) Technology Support

It is comprised primarily of an investigation into the feasibility of using nuclear explosives to create deep geologic cavities in which nuclear waste could be permanently disposed. Additionally, it seeks to provide technology support for the United States' Peaceful Nuclear Explosions (PNE) discussions in the international arena.

D. ERDA BUDGETARY TRENDS

To give a gross indication of the relative emphasis put on technological research and development in the radioactive waste management and reprocessing areas, the overall ERDA budget[4] and the radioactive waste management and reprocessing budget for fiscal years 1975, 1976, 1977, and 1978 are tabulated in Table I below. The categories comprising the waste management and reprocessing budget are outlined in Section III. Plant and Capital Equipment budgets are included in the figures for each of the categories (1 thru 4) shown below.

Table C-1. ERDA Budgetary Trends

	($ in millions)			
	FY 75	FY 76	FY 77	FY 78
Total ERDA Budget (Budget Authority)	$3,579	$4,478	$6,048	$7,841
Waste Management & Reprocessing Budget:	88.2	116.1	234.5	380.9
(1) Commercial Reprocessing R&D	15.9	22.6	54.5	112.1
(2) Commercial Waste Management	9.9	10.0	70.8	127.5
(3) ERDA/Defense Waste Management	55.1	73.8	97.3	120.3
(4) Other	7.3	9.7	11.9	21.0

[3] Ibid.
[4] The FY 75, 76 & 77 overall ERDA budget figures were obtained from various ERDA News Releases, some of which were not dated. The FY 78 budget figure was President Gerald Ford's proposal to Congress.

Between FY 75 and FY 76, the total ERDA budget increased 25%; between FY 76 and FY 77 it increased 35%; and between FY 77 and FY 78, it increased 30%. In contrast, the waste management and reprocessing budget, while being 3-5% of the total budget, increased approximately 32% between fiscal years 75 and 76, 102% between fiscal years 76 and 77, and is scheduled for an increase of 52% between fiscal years 77 and 78. Both the absolute amounts and percentage changes are shown in Figures C-3 and C-4.

The amount for the fuel cycle research and development program reflects the funding contained in the FY 1978 budget submitted to Congress on January 17, 1977. These programs are currently under review by this Administration, and the distribution of funds for these activities and any adjustments to the total required funding, will be provided to the Congress after this review is completed.

III. BUDGETARY AND WORK BREAKDOWN STRUCTURE

This section is divided into two parts: (1) a budget summary of ERDA's waste management and reprocessing activities (Table C-2 thru C-6); and (2) a written description (with an accompanying graphic work breakdown structure) of the programmatic areas and key projects.

A. BUDGETARY SUMMARY OF ERDA's RADIOACTIVE WASTE MANAGEMENT AND REPROCESSING ACTIVITIES

This section gives an overview of ERDA's waste management and reprocessing budget. Four programs related to waste management and reprocessing are presented. The four programs are the following:[5] (1) Fuel Cycle R&D Program; (2) Special (Weapons) Materials Program (3) Environmental Control Technology Program; and (4) Nuclear Explosives Applications Program. These programs and their subprograms are shown in Table C-2 thru C-6.

B. DESCRIPTION OF PROGRAMMATIC AREAS INCLUDING WORK BREAKDOWN STRUCTURE

In this section the programs and subprograms listed in the Tables are described in detail. The material for the description of the programs and subprograms was obtained from the following four sources:

(1) U.S. Government, Public Works for Water and Power Development and Energy Research Appropriations, Senate Hearings, Fiscal Year 1977, Part 5.

(2) U.S. Government, U.S. Energy Research and Development Administration, Budget Estimates Fiscal Year 1978, Books II and III.

[5] U.S. Government, U.S. Energy Research and Development Administration, Budget Estimates Fiscal Year 1978, Books II and III.

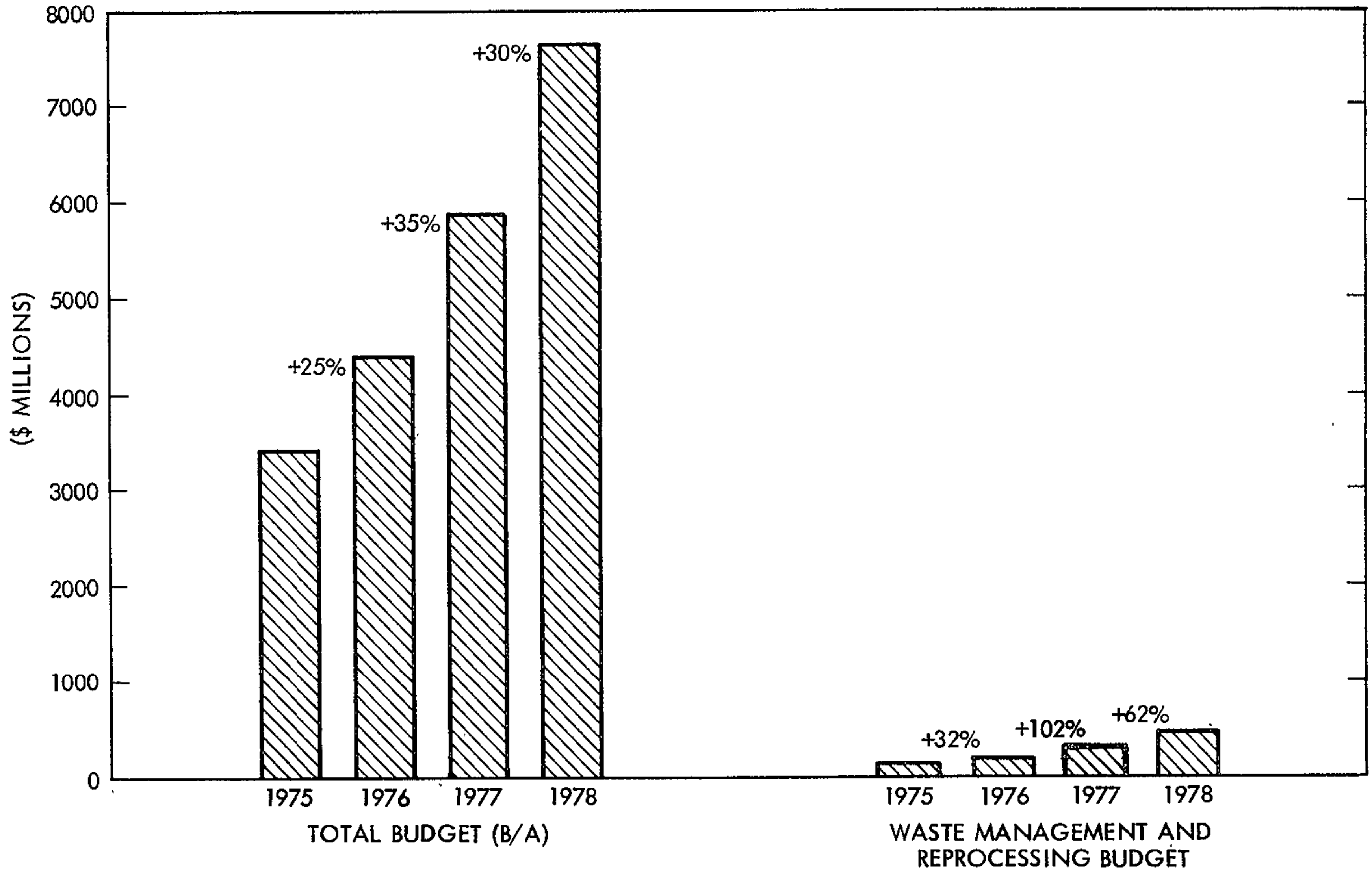

Figure C-3. ERDA Budgetary Trends-Comparison of Total Budget With Waste Management and Reprocessing Budget

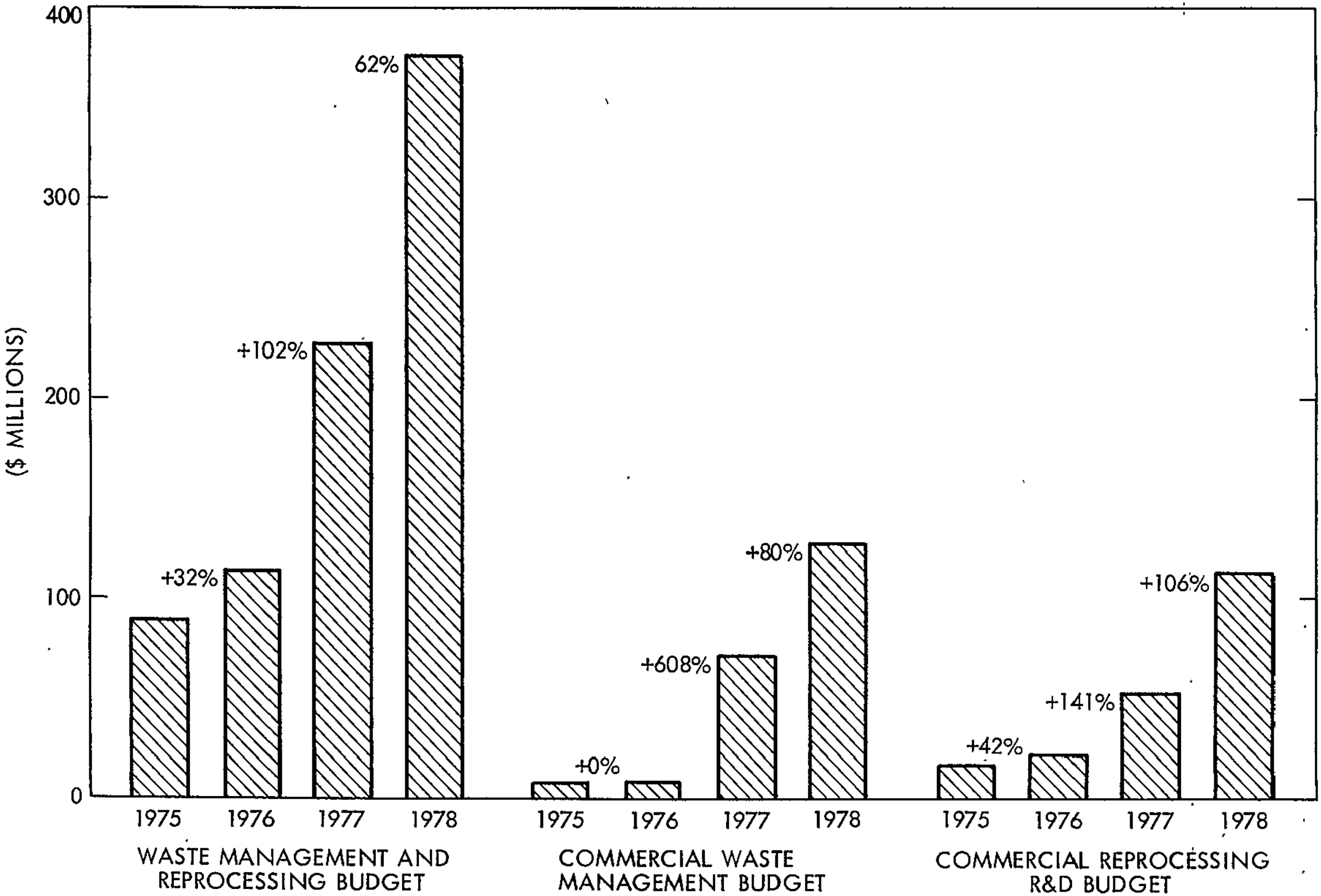

Figure C-4. ERDA Budgetary Trends-Comparison of Waste Management and Reprocessing, Commercial Waste Management and Commercial Reprocessing R&D Budgets

Table C-2. Overview of ERDA's Radioactive Waste Management and Reprocessing Operating Expense Budget

	($ in thousands)			
	Actual FY75	Actual FY76	Estimate FY77	Estimate FY78
I. Fuel Cycle R&D Program	$ 24,487	$ 31,132	$115,770	$221,150
II. Special (Weapons) Materials Production Program	53,940	69,009	91,880	111,500
III. Environmental Control Technology Program	7,143	9,308	10,355	19,300
IV. Nuclear Explosive Applications Program	0	0	1,000	1,000
Total ERDA Radioactive Waste Management & Reprocessing Operating Expense Budget	$ 85,570	$109,449	$219,005	$352,950

NOTE: The totals for each program shown on this page include only those subprograms involving radioactive waste management and reprocessing. These subprograms are shown in detail in the following tables.

SOURCES:

References 2 and 5.

Table C-3. ERDA's Fuel Cycle R&D Operating Expense Budget

	($ in thousands)			
	Actual FY75	Actual FY76	Estimate FY77	Estimate FY78
I. Fuel Cycle R&D Program				
I.A. Support of Nuclear Fuel Cycle				
I.A.1. Commercial LWR Fuel Reprocessing R&D	$	$ 3,783	$ 29,500	$ 33,400
I.A.2. LMFBR Fuel Reprocessing R&D	4,062	4,015	9,200	27,700
I.A.3. HTGR Fuel Recycle R&D	11,046	13,878	11,500	12,000
I.A.4. Thorium Fuel Cycle (LWBR & others)	0	0	0	2,000
I.A.5. Design for Fuel Cycle Facilities	0	0	0	30,000
Total Support of Nuclear Fuel Cycle	$ 15,108	$ 21,676	$ 50,200	$105,100
I.B. Commercial Waste Management				
I.B.1. Terminal Storage R&D	$ 3,394	$ 2,787	$ 38,200	$ 71,050
I.B.2. Waste Processing R&D	4,097	4,765	16,070	23,200
I.B.3. Supporting Studies & Evaluations	1,888	1,904	6,900	9,500
I.B.4. Solidification Process Demonstration Project	0	0	4,400	12,300
Total Commercial Waste Management	$ 9,379	$ 9,456	$ 65,570	$116,050
Total Fuel Cycle R&D Program	$ 24,487	$ 31,132	$115,770	$221,150

SOURCES:

References 2 and 5.

Table C-4. ERDA's Radioactive Waste Management Operating Expense Budget for Special Nuclear Materials

	($ in thousands)			
	Actual FY75	Actual FY76	Estimate FY77	Estimate FY78
II. Special (Weapons) Materials Production Program				
II.A. ERDA/Defense Waste Management - Interim				
II.A.1. Production Reactor Waste	$ 35,307	$ 44,016	$ 52,465	$ 52,150
II.A.2. Non-Production Reactor Waste	1,794	3,951	5,290	6,960
II.A.3. Supporting Services	1,470	3,477	2,835	3,280
II.A.4. Process Development	2,566	---	---	---
Total ERDA/Defense Waste Management - Interim	$ 41,137	$ 51,444	$ 60,590	$ 62,390
II.B. ERDA/Defense Waste Management - LongTerm				
II.B.1. ERDA Radioactive Waste R&D	$ 8,933	$ 13,153	$ 21,050	$ 32,000
II.B.2 Storage Operations & Related Activities	3,870	4,412	7,000	11,810
II.B.3 Supporting Services	0	0	3,240	5,300
Total ERDA/Defense Waste Management - Long-Term	$ 12,803	$ 17,565	$ 31,290	$ 49,110
Total Weapons Materials Production Program	$ 53,940	$ 69,009	$ 91,880	$111,500

SOURCES:

References 2 and 5.

Table C-5. ERDA's Radioactive Waste Management and Reprocessing Operating Expense Budget for Environmental Control Technology

	($ in thousands)			
	Actual FY75	Actual FY76	Estimate FY77	Estimate FY78
III. Environmental Control Technology Program				
III.A. Nuclear Energy				
III.A.1. Analysis of Nuclear Fuel Cycles	$ 507	$ ---	$ 700	$ 750
III.A.2. Evaluation of Ocean Bed Disposal	260	---	1,000	2,750
Total Nuclear Energy	$ 767	$ 1,187	$ 1,700	$ 3,500
III.B. Management of Surplus Contaminated Facilities				
III.B.1. Surplus Facility Surveillance	$ 284	$ 755	$ 840	$ 1,045
III.B.2. Disposition Methods R&D	426	750	785	925
III.B.3. Planning for Disposition of Surplus Fac.	883	1,260	870	1,150
III.B.4. Disposition of Surplus Facilities	3,987	3,590	3,860	9,280
Total Management of Surplus Contaminated Facilities	$ 5,580	$ 6,355	$ 6,355	$ 12,400
III.C. Transportation				
III.C.1. Energy Transportation Planning & Analysis	$ 0	$ 149	$ 400	$ 980
III.C.2. Environment & Safety (Risk Assessment & Testing)	450	1,259	1,660	1,740
III.C.3. Transportation Systems & Technology (Standards & Information)	346	358	240	680
Total Transportation	$ 796	$ 1,766	$ 2,300	$ 3,400
Total Environmental Control Technology Program	$ 7,143	$ 9,308	$ 10,355	$ 19,300

SOURCES: References 2 and 5.

Table C-6. ERDA's Radioactive Waste Management Operating Expense Budget for Nuclear Explosive Applications

	($ in thousands)			
	Actual FY75	Estimate FY76	Estimate FY77	Estimate FY78
IV. Nuclear Explosive Applications Program				
IV.A. Disposal Cavities (Storage Applications Development)	$ 0	$ 0	$ 400	$ 400
IV.B. Technology Support	0	0	600	600
Total Nuclear Explosive Application Program	$ 0	$ 0	$ 1,000	$ 1,000

SOURCES:

References 2 and 5.

(3) Commercial Radioactive Waste Management R&D Program, KK03, Research and Development Branch, Division of Nuclear Fuel Cycle and Production, Energy Research and Development Administration; March 1976.

(4) ERDA Radioactive Waste Management R&D Program, KK0904, Research and Development Branch, Division of Nuclear Fuel Cycle and Production, Energy Research and Development Administration; March 1976.

Unless otherwise noted, the material in this section appearing in quotation is taken from the first two sources listed above.

In most instances, the descriptions in this section will go down to the level shown in Tables C-2 thru C-6. In three areas, however, a more detailed breakdown to the project level is provided. Those three areas are: Waste Processing R&D (I.B.2); Supporting Studies and Evaluations (I.B.3); and ERDA/Defense Radioactive Waste R&D (II.B.1). The information for this continued breakdown comes from the third and fourth sources listed above.

Graphic work breakdown structures showing the programs and subprograms listed in the Tables are provided as Figures. In order to provide easy access to the Figures, they each appear in the section at the point where the discussion of their respective programs and subprograms begins.

Figures C-7b thru C-7d show the continued breakdown to the project level for two of the three areas mentioned above: Waste Processing R&D (I.B.2) and Supporting Studies (I.B.3). Figures C-9a thru C-9c show the continued breakdown to the project level for the third area mentioned above: ERDA/Defense Radioactive Waste R&D (II.B.1). These figures also appear at the point where the written description of their respective areas begins. In all Figures, shading indicates areas or projects that involve high-level waste and/or reprocessing. For the purposes of this Appendix, spent fuel reprocessing and waste management operations are defined as the separations process, the management of the resulting waste, and the management of the spent fuel or waste from alternative operations to the reprocessing scheme.

The separations plant will produce five categories of waste. The first is high-level waste, as defined by 10 CFR 50, the raffinate from the first cycle solvent extraction cycle. Low-level aqueous concentrator waste and some solids will be added to the high-level waste during normal operations. The second category, the intermediate waste stream will contain off-gas treatment system scrubber solutions plus numerous other clean-up solutions. The third waste stream is the low-level liquid waste system which consists of the second and third uranium and plutonium cycle aqueous waste plus streams from the concentrators, vent systems and various other sections of the plant. The fourth waste is off-gas treatment system effluent. The final catetory is solid waste which includes assembly hardware, filters, equipment and other solid wastes from the reprocessing operations. The solid wastes fall in the classes of low-level (<200 mr/hr), intermediate level, and transuranium (TRU) contaminated or not. Intermediate level usually contains mixed fission products and, except for storage pool resins, will also be a TRU waste. Cladding hulls are treated as a separate category and handled as such. The hulls will contain TRU contamination. A further detailed description of reprocessing wastes is in the Alternatives for Managing Wastes From Reactors and Post-Fission Operations in the LWR Fuel Cycle, Vol. 1., ERDA 76-43.

The management procedures for handling this waste involve the storage, packaging, transportation, interim storage, and final disposal. The waste management discussion will also examine programs involving the management of waste resulting from variations to the current reprocessing option. These management operations include such steps as the storage, packaging, transportation, interim storage, and/or disposal of the spent fuel rods, and the possible burn up of partitioned actinides in LWR's. A pictorial representation of the definitional boundaries is shown in Figure C-5.

ERDA's Radioactive Waste Management and Reprocessing Program is comprised of subprograms in the following four programmatic areas: (I) Fuel Cycle R&D; (II) Special (Weapons) Materials Production; (III) Environment Control Technology; and (IV) Nuclear Explosives Applications. These are shown graphically in Figure C-6a on page C-23.

1. Fuel Cycle R&D Program (I)

The Fuel Cycle R&D Program (I) is divided into several subprograms. Those that deal with radioactive waste management and reprocessing are the following: Support of Nuclear Fuel Cycle (I.A.); and Commercial Waste Management (I.B.). These are shown in Figure C-6b, page C-24.

a. Support of Nuclear Fuel Cycle - FY77 $50,200k (I.A.). "The objective of the sub-program to support the nuclear fuel cycle is to develop technology and design bases for reprocessing spent reactor fuels and reusing the recovered nuclear materials; and to perform work to improve the safeguards, operability, and maintainability of large integrated reprocessing and recycle facilities. The purpose is to evaluate fuel recycle concepts amenable to safeguards and non-proliferation objectives; to develop processes, techniques, and components necessary to selected concepts; and to demonstrate design applications of such processes and components. The ultimate objective is to develop safe, protected processes such that, if consistent with U.S. non-proliferation objectives, private industry can make the investment necessary to close the fuel cycle under conditions of reasonable risk."

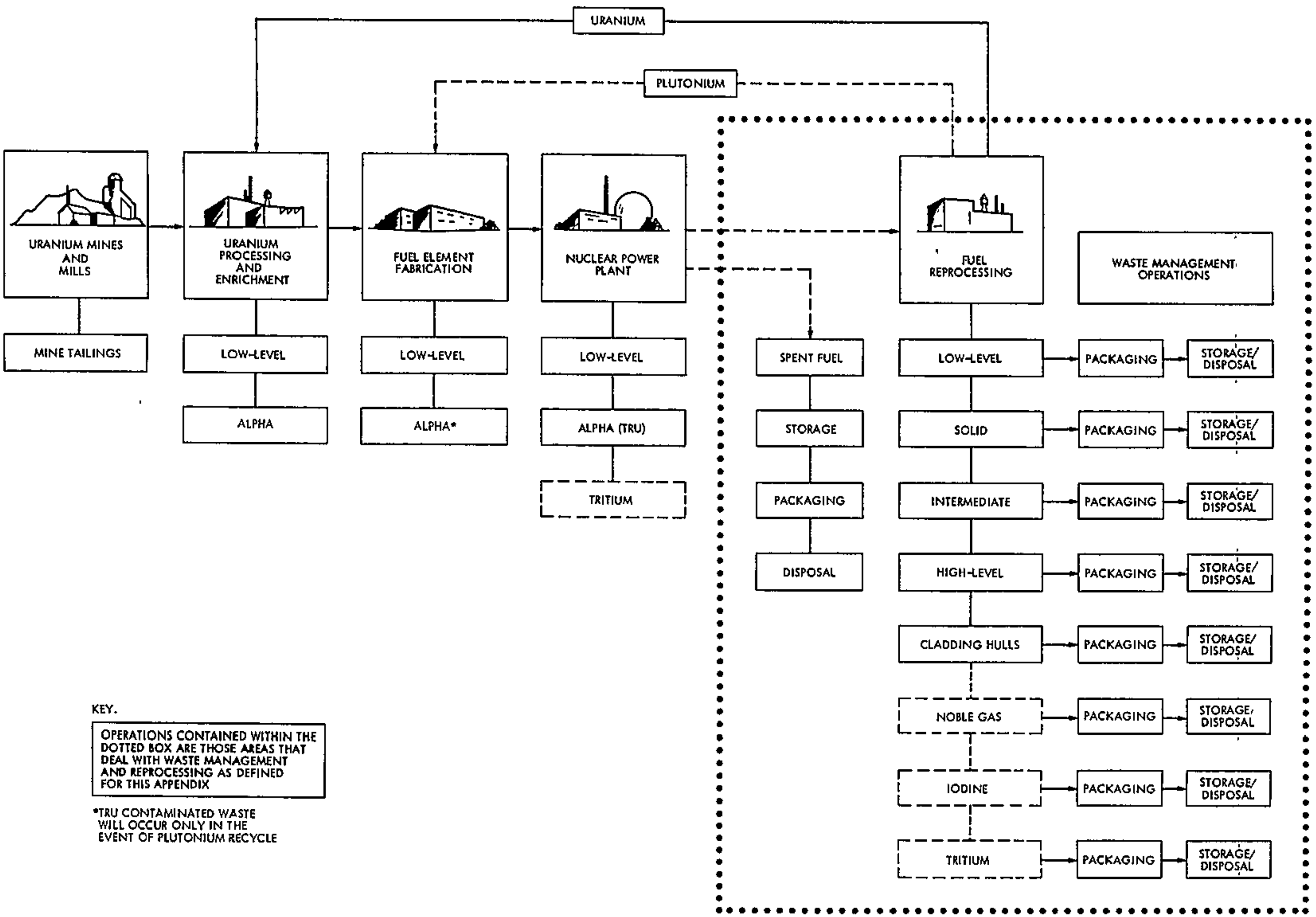

Figure C-5. Definitions of Waste Management and Reprocessing Operations

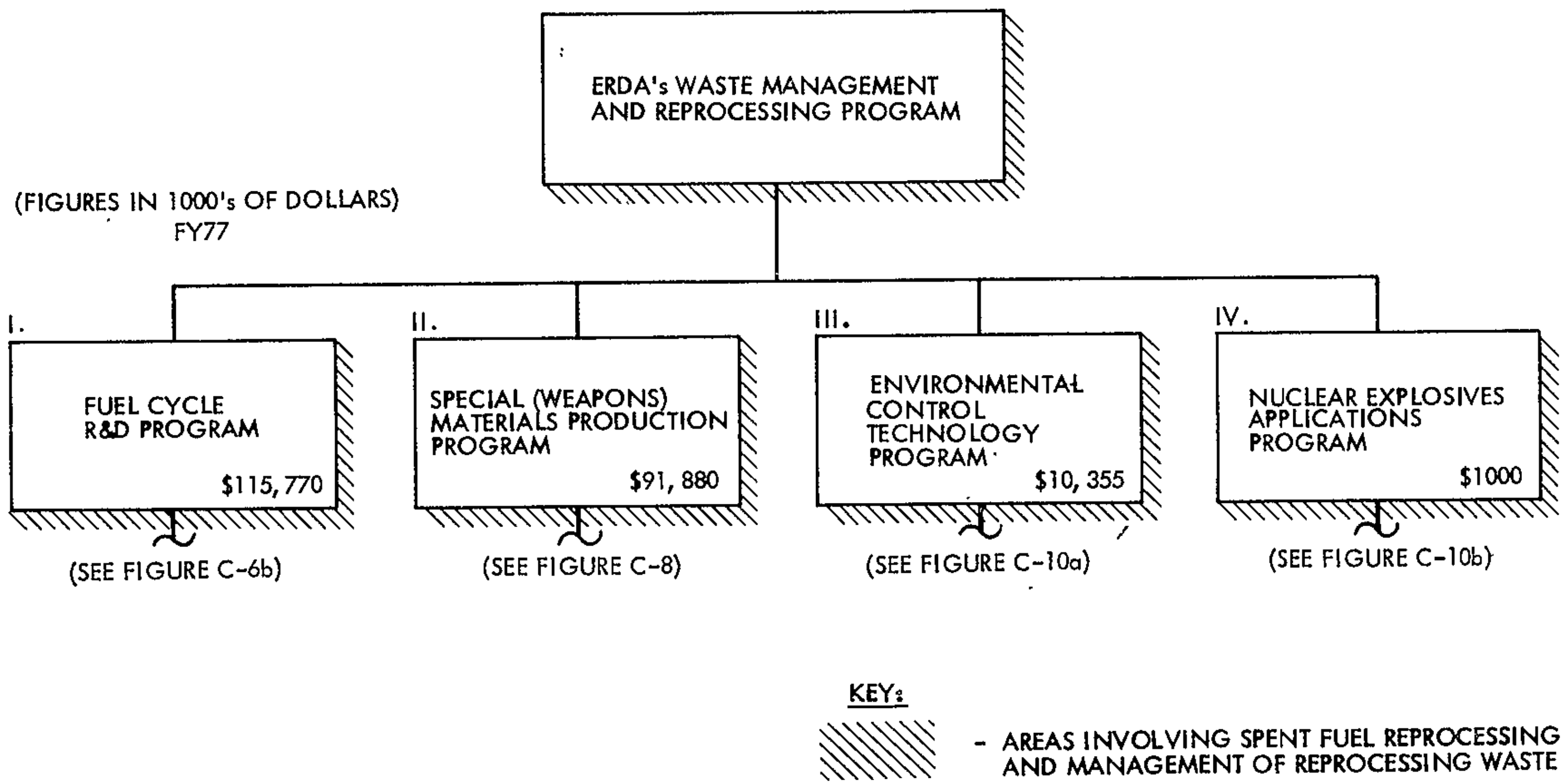

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Figure C-6a. Work Breakdown Structure: ERDA's Radioactive Waste Management and Reprocessing Program

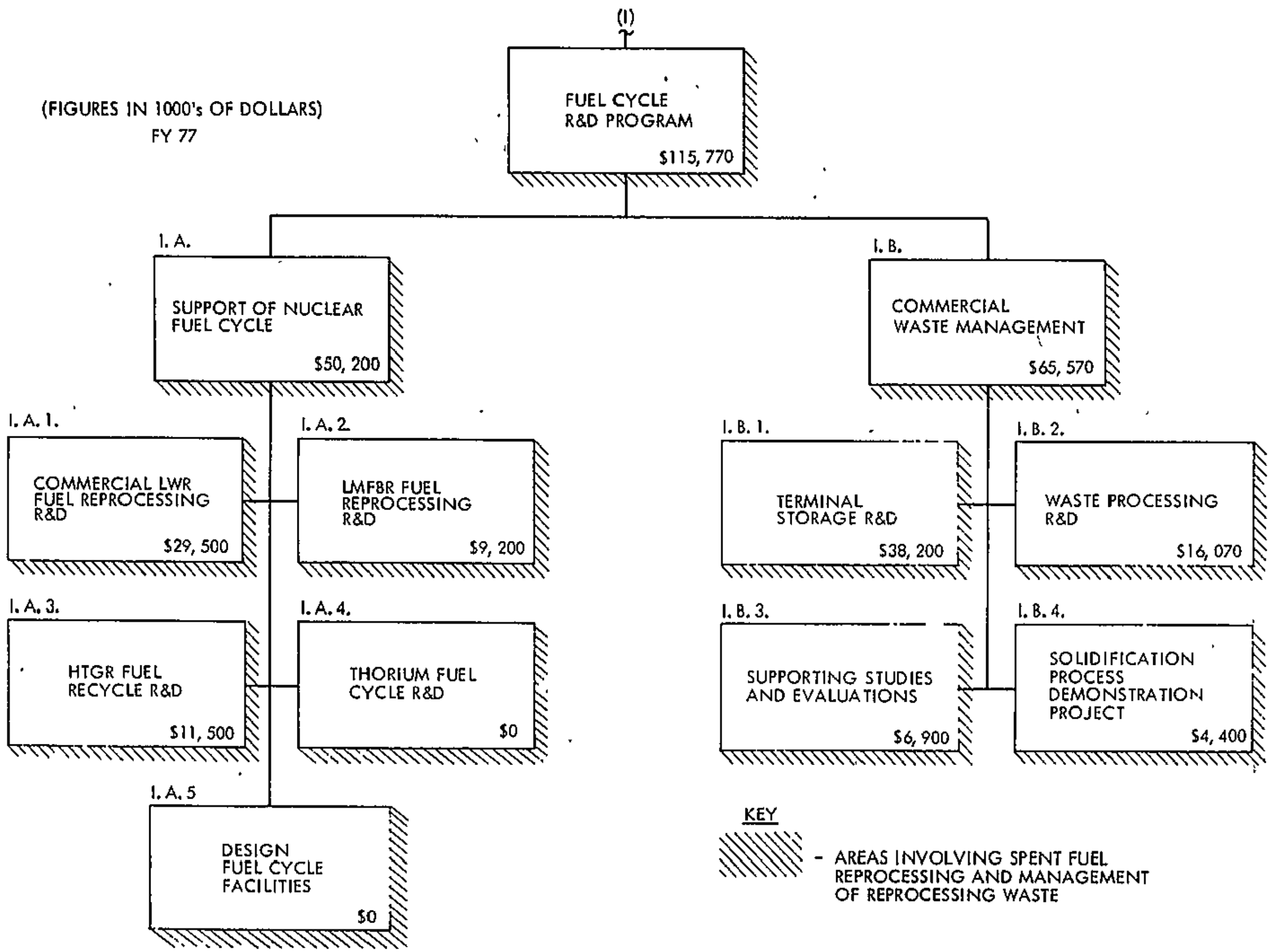

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Figure C-6b. Work Breakdown Structure: ERDA's Radioactive Waste Management and Reprocessing Program (Fuel Cycle R&D Program)

Support of Nuclear Fuel Cycle is divided programmatically into these areas: Commercial LWR Fuel Reprocessing R&D (I.A.1.): LMFBR Fuel Reprocessing R&D (I.A.2.); HTGR Fuel Recycle R&D (I.A.3.); Thorium Fuel Cycle (I.A.4.); and Design for Fuel Cycle Facilities (I.A.5.). This breakdown is shown graphically in Figure C-6b.

1) Commercial LWR Fuel Reprocessing R&D - FY77 $29,500k (I.A.1.). "A revised program is being developed to lead to the earliest practical availability of LWR fuel recycling on a commercial basis." "The funding is directed at expanding the development work on fuel reprocessing and recycle including: dissolution-separation; off-gas treatment; shear head-end treatment voloxidation; investigation of coprecipitation; and plutonium handling in remote facilities. In addition, the funding for the LWR is to perform further technical and engineering study of reprocessing and recycle facilities, and to increase the development effort and the study of safety, effluent control, and radioactivity confinement in these facilities." Efforts will also be directed at the investigation of alternative processes and fuel cycles which may reduce worldwide proliferation risks.

2) LMFBR Fuel Reprocessing R&D - FY77 $9,200k (I.A.2.). Work is being done to develop and test process and equipment concepts suitable for scale-up for use in large LMFBR fuel reprocessing plants, where plutonium would be recovered for recycle. An engineering effort related to the development and testing of equipment components to be used in a hot pilot plant is ongoing. "In addition, funds will be used for the conceptual design of a prototype cold test facility and for the procurement of prototype fuel for conducting tests of equipment components and recycle process steps. At the Oak Ridge Gaseous Diffusion Plant, funding is provided to operate the krypton absorption pilot plant to demonstrate the fluorcarbon-based absorption process for removing krypton and xenon from the off-gas of an LMFBR fuel reprocessing plant."

3) HTGR Fuel Recycle R&D - FY77 $11,500k (I.A.3.). The objective of the HTGR fuel recycle program is to develop and demonstrate recycle technology and to provide the capability to carry out all of the steps of the fuel recycle process for the High Temperature Gas Reactor. Work on the design, development, and continued testing of the spent fuel chemical reprocessing components is being done by General Atomic and Oak Ridge National Laboratory (ORNL). ORNL is also engaged in a program of spent fuel refabrication process and component development work. Additionally, R&D on fuel recycle component cold development will continue, hot cell testing of laboratory and full-scale recycle components designed for demonstration-facility use will increase, and irradiation testing of fuel-element specimens will be maintained.

b. Commercial Waste Management - FY77 $65,570k (I.B.). The programs for the management of commercial waste are concerned with both the high-level radioactive process waste to be generated by commercial fuel reprocessing plants and with the other waste types and forms from the fuel cycle. The objectives of these operations are to provide for research, development, and demonstration of technologies for recovery, volume reduction, solidification, and long-term management, including terminal storage and final disposal. To achieve these objectives, ERDA has divided the Commercial Waste Management program into four sections: Terminal Storage R&D (I.B.1.); Waste Processing R&D (I.B.2.); Support Studies and Evaluations (I.B.3.); and Solidification Demonstration Project (I.B.4.). This breakdown is shown graphically in Figure C-6b on page C-24.

1) Terminal Storage R&D - FY77 $38,200k (I.B.1.). The purpose of the Nuclear Waste Terminal Storage (NWTS) program is to assure that terminal storage sites are available to accept the commercially generated radioactive waste which are considered likely to be transferred to ERDA custody under existing or proposed regulations. Due to the fact that a sequential approach to full scale repositories is time consuming and dependent on the rate of progress and success for each step, the program provides for concurrent investigations in multiple geological locations and in differing geological formations.

The program development sequence is divided into six steps:

(1) Identification of formations of interest.

(2) Reconnaisance surveys.

(3) Area studies.

(4) Detailed confirmation studies.

(5) In-situ tests.

(6) Repository operations.

Prior ERDA studies have identified salt, agrillaceous, crystalline rock, and carbonate rock formations as of possible interest. Reconnaisance studies will provide data necessary on the properties and characteristics of the formations for making regional evaluations. Based on the results of regional evaluations, area and detailed confirmation studies will be undertaken to determine the specific location for consideration as a disposal site. In-situ testing will provide more detailed information on the specific site which must be considered prior to actual repository operations.

To reach the goal of a coordinated development of several sites involving different types of formations for demonstration repository operations by FY 1985 the NWTS program is divided into eight operational topics. These are the office of waste isolation program management, geological projects, technical support projects, engineering studies, facility projects, system studies, regulatory affairs, and public affairs. A brief description of each is presented below and graphically shown in Figure C-7a, page 28.

(1) Program Management FY77 $3,500k

The development and implementation of the terminal storage program's planning and control operations will be handled through this office. Some of the management office's tasks will be program contracting and management, development and preliminary program budget proposals, and fund accounting.

(2) Geological Studies FY77 $22,705k

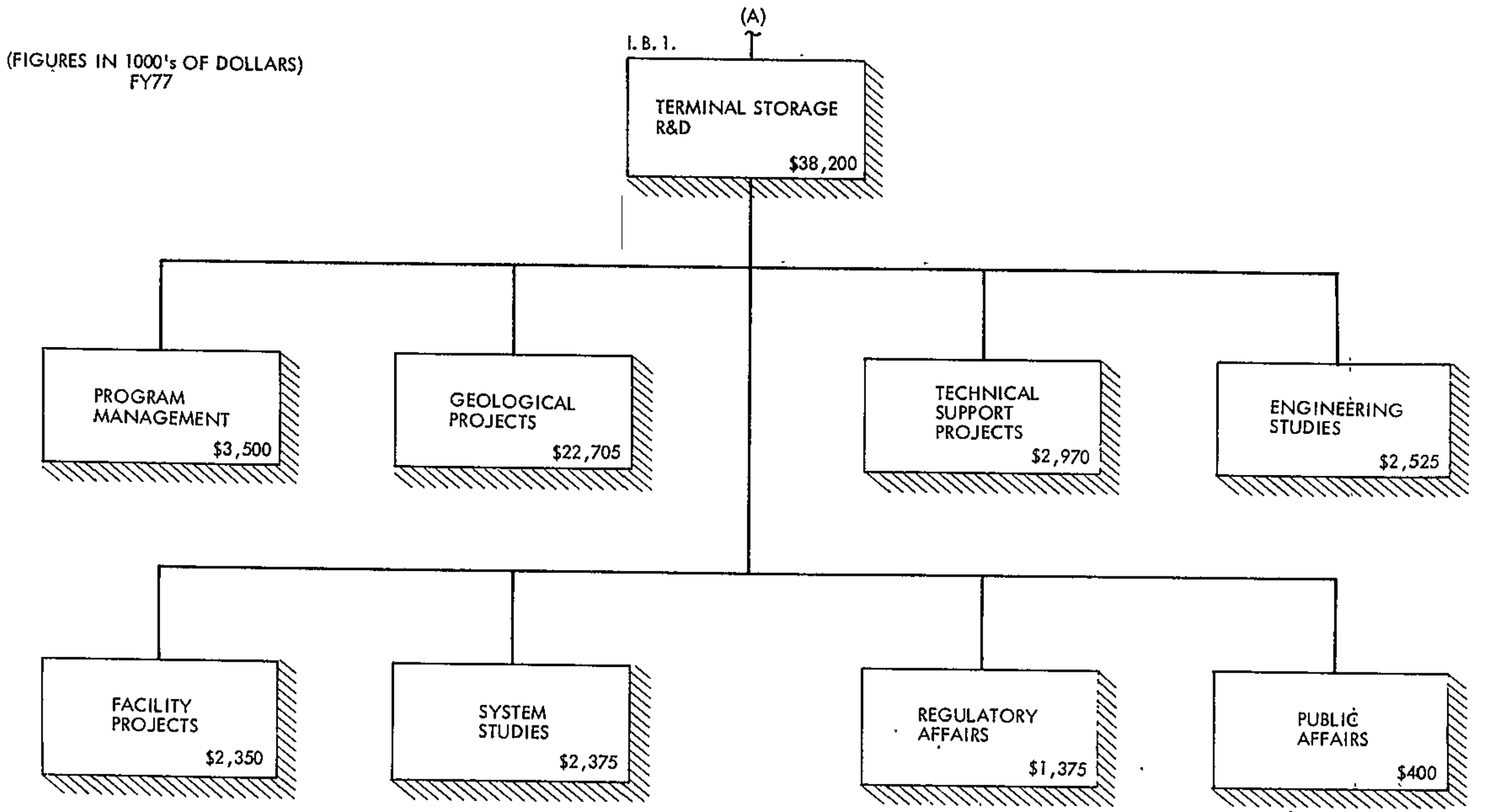
The geological study operations encompass the first four steps of the program development sequence. Investigations will be undertaken on the general characteristics, patterns, and occurrences of various rock types to determine their suitability as disposal sites. After the first step is completed concerning the identification of a formation of interest, reconnaisance surveys will commence. These preliminary studies will provide information to allow for a determination on the suitability of the region as a disposal site. A more detailed investigation will be provided by area studies. These studies will include field geologic work, area surveys, exploration drilling, and geophysical surveys. The final step of the geological operation is the detailed confirmation studies involving extensive and concentrated drilling operations.

(3) Technical Support Studies FY77 $2,970k

The technical support efforts are currently directed toward four studies: Heat transfer/thermal analysis; waste-rock interactions; rock mechanics/mine stability studies; and borehole and mine shaft plugging. These studies as well as the analysis of in-situ field test data will continue for several years.

(4) Engineering Studies FY77 $2,525k

This operation involves the in-situ experimentation of unreprocessed spent fuel elements in the host rock to determine the thermal effects of heat and radiation. The in-situ tests in dome and bedded salt and the near surface experiments in shale are expected to be completed in FY 1978. Also in FY 1978 tests in shale and basalt are scheduled to begin.



SOURCE:
ENGINEERING BRANCH, DIVISION OF WASTE MANAGEMENT PRODUCTION AND REPROCESSING, ERDA

KEY:
AREAS INVOLVING SPENT FUEL REPROCESSING AND MANAGEMENT OF REPROCESSING

Figure C-7a. Work Breakdown Structure - Commercial Waste Management Nuclear Waste Terminal Storage Program (OWI)

(5) Facility Projects FY77 $2,350k

Site confirmation, design, construction, and operation of waste facilities are expected to commence after the geological study program determines that a specific site meets the disposal acceptance criteria. These faciltiy project operations are to be directed towards possible certification of the first two repository sites in FY 1978.

(6) Systems Studies FY77 $2,375k

This operation is concerned with the general waste storage portion of the NWTS program. In FY 1978 the high-level waste cannister envelope and spent fuel cannister studies are scheduled to be finished. Economic studies on the development of storage charges for industry and waste transportation studies will continue for several additional years.

(7) Regulatory Affairs FY77 $1,375k

This task is concerned with the requirement that both occupational safety and environmental safety requirements for licensing of the terminal storage facility are met.

(8) Public Affairs FY77 $ 400k

The primary objective of this operation is to produce public understanding of the NWTS program. To this end, the public affairs efforts will include annual NWTS Program Information Meetings, communication with involved state and local governments, and providing information to the media.

2) Waste Processing R&D - FY77 $16,070k (I.B.2.). The second major part of the Commercial Waste Management program is the processing and packaging of different types of waste in a form acceptable for delivery to terminal storage facilities. Technology and engineering processes will be developed to provide improved and economical operations to reduce the volume of the waste, immobilize the residue, and package the waste in a manner acceptable for disposal. These operations will involve waste from throughout the nuclear fuel cycle though a majority of the projects will be concerned with the waste generated in the reprocessing of spent fuel.

The Waste Processing program consists of three subprograms: Liquid Radioactive Waste R&D (I.B.2.a.); Solid Radioactive Waste R&D

(I.B.2.b.); and Gaseous Radioactive Waste R&D (I.B.2.c.). These operations are discussed below and graphically presented in Figure C-7b on page C-31. The information presented in these discussions was obtained from an ERDA paper released in March 1976.[6]

(It should be noted that the budget figures for the tasks shown in Figures C-7b to C-7d do not coincide exactly with the budget figures given in Tables C-2 thru C-6. This is because the budget figures in the Tables reflect the latest information available, whereas the budget figures for Figures C-7b to C-7d are from March 1976. These figures are retained, nevertheless, to indicate the relative magnitude of emphasis placed on the various topics.)

a) Liquid Radioactive Waste R&D - FY77 $13,760k (I.B.2.a). The Liquid Radioactive Waste R&D subprogram is made up of two topic areas: Solidification and Intermediate Level Waste. This is shown graphically in Figure C-7c, page C-32.

(1) High Level Waste Solidification FY77 $10,850k

The major activities of the solidification program will be to develop waste form and conversion processes to support the design, construction, licensing, and operation of a plant-scale waste treatment facility to be located at a fuel reprocessing plant. This technology is required to convert the aqueous high level waste to a stable solid for shipment to, and terminal storage at, a Federal repository. The program will continue through FY 1985, with the initial goal being to complete technical development in FY 1979 with hot operation start up in FY 1983* for the Allied-General Nuclear Services (AGNS) plan (FY 1980 and FY 1984 for the Exxon facility).

Commercial HLW Vitrification	
. Batelle Northwest Laboratory (PNL)	(see Fig. C-7c, pg. C-32)
. Budget FY 1977: $6,950 K	

Funding will be directed at the development of technology for spray calcination with in-can vitrification and/or fluid-bed calcination with in-can vitrification processes that will be applicable to the AGNS facility. Alternative

* ERDA's review of this appendix states that this date is no longer feasible.

[6] Commercial Radioactive Waste Management R&D Program, KK03, Research and Development Branch, Division of Nuclear Fuel Cycle and Production, ERDA; March, 1976.

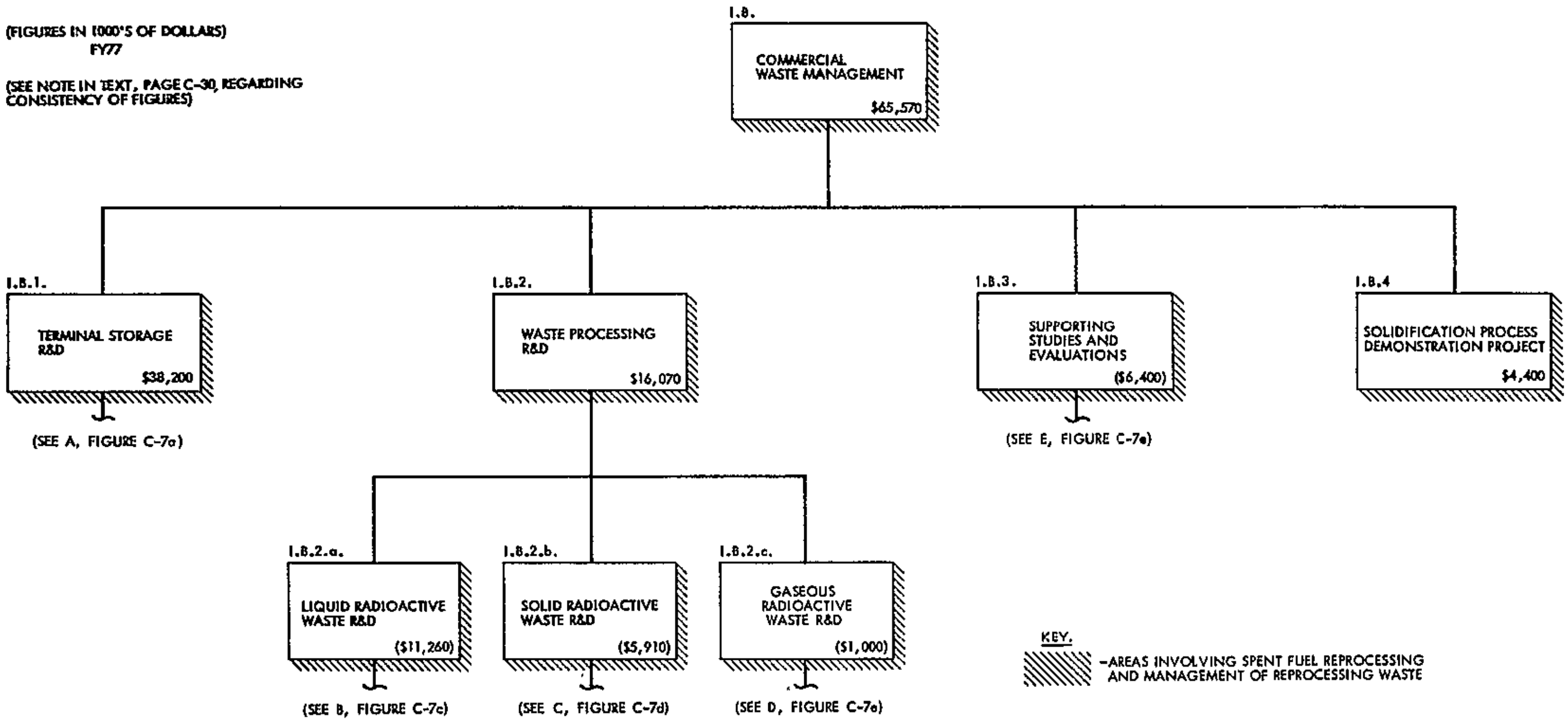


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Figure C-7b. Work Breakdown Structure-Commercial Waste Management

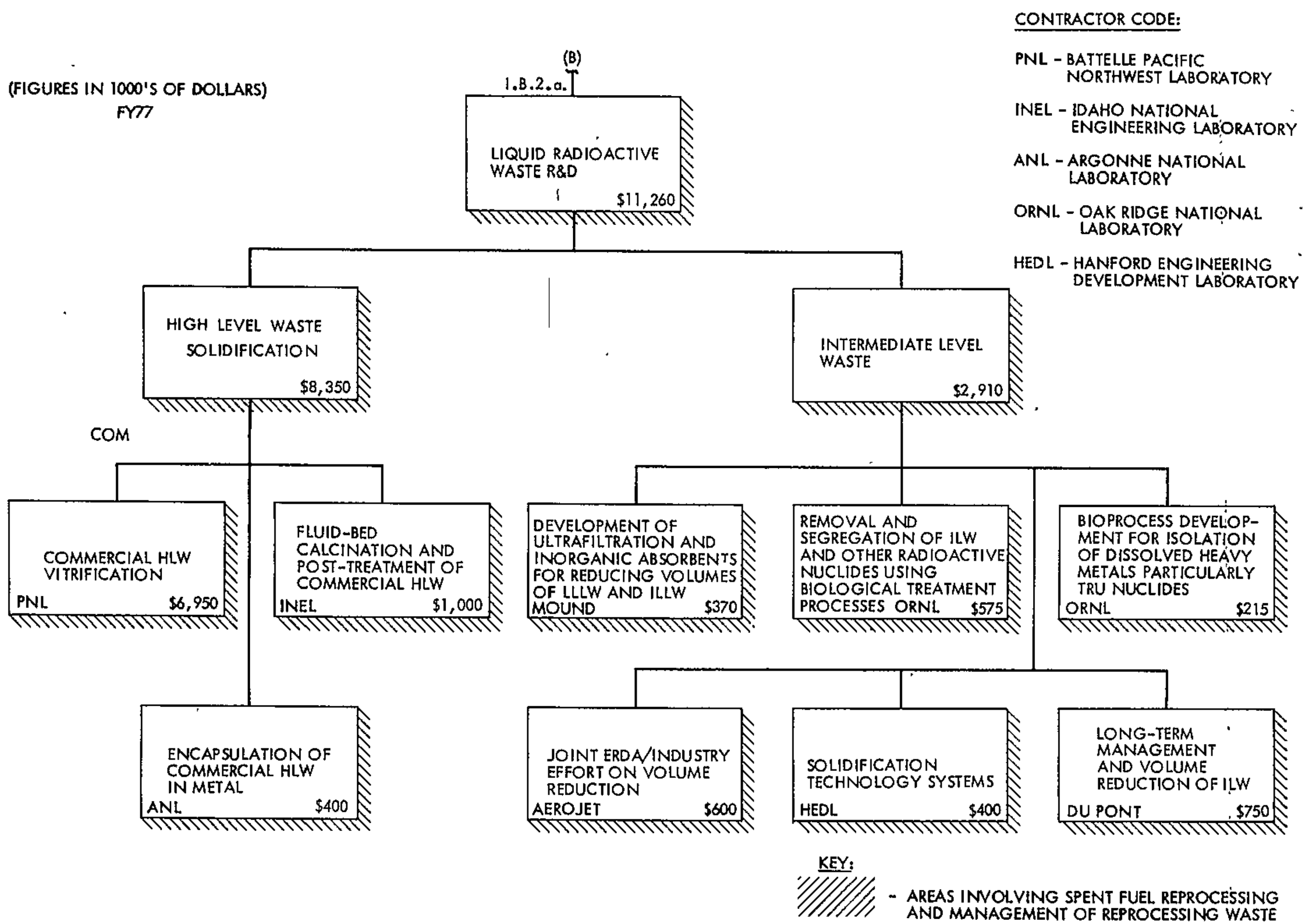

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Figure C-7c. Work Breakdown Structure - Commercial Waste Management (Liquid Radioactive Waste R&D)

methods including ceramic melters are being developed to be applicable to future fuel reprocessing facilities. These calcination-vitrification technologies will also be evaluated to determine their applicability to high-level waste from LMFBR and HTGR fuel reprocessing.

The Waste Solidification-Vitrification project of 1977 is a continuation of the Waste Fixation Program which has been underway for a number of years during which time spray calcination with in-can vitrification has reached a high degree of development. The 1977 program efforts are directed towards the selection of a waste solidification technology (possibly spray calcination/in-can vitrification) and the issuance of data and flowsheets for the design of a full-scale waste solidification facility at a reprocessing plant in 1978. The alternative waste glass processes of fluid-bed calcination, in-can vitrification or ceramic melters will also be tested and evaluated with a goal of starting a pilot plant operation for each process in 1978. Extensive radiochemical studies of the actual processes and resulting waste-glass forms (both non-radioactive and radioactive) and engineering studies of process equipment during 1977 will be undertaken.

Fluid-Bed Calcination and Post Treatment of Commercial HLW	
. Idaho National Engineering Laboratory (INEL)	(see Fig. C-7c, pg. C-32)
. Budget FY 1977: $1,000k	

The basic purpose of the program is to provide calcine (powder) and metal matrix waste form technology as an alternative to that being developed at Battelle Northwest Laboratory. The initial goal is to complete this technology development by FY 1979 and thereby be available for possible utilization in the waste solidification facility expected to commence radioactively hot-operation startup in FY 1983. Other goals are the adoption of the technology to future fuel reprocessing plants, the development of technology for the conversion of calcine waste to a metal matrix form, and to provide technical liaison with Eurochemic concerning their fluid-bed calcination and metal matrix activities. Technical assessment of metal matrix technology development, along with participation in selected programs will be provided by Argonne National Laboratory. The Fluid-bed Calcination Program has been underway at INEL since 1963 utilizing military high-level waste. Recently, pilot scale testing was begun with simulated commercial waste. The primary objective is to verify the applicability of the fluid-bed process to commercial waste and generate data for the design and operation of a demonstration scale plant. In addition, INEL will initiate equipment component development to evaluate alternative methods for calcine conversion to a metal matrix waste form with a goal of plant-scale prototype equipment fabrication in FY 1978.

Encapsulation of Commercial HLW in Metal	
. Argonne National Laboratory (ANL)	(see Fig. C-7c, pg. C-32)
. Budget FY 1977: $400k	

This program, to support INEL in the development of technology for the conversion of calcine to a metal matrix waste form, will continue through FY 1979. The initial goal is to assess the benefits of metal matrixed calcined forms and to evaluate alternative conversion processes. A secondary goal is to develop metal matrixed waste forms and related conversion process technology.

This concludes the discussion of the first section of the Liquid Radioactive Waste R&D (I.B.2.a.) subprogram: High Level Waste Solidication. The second and final part, Intermediate Level Waste, is presented next.

(2) Intermediate Level Waste (ILW) FY77 $2,910k

Intermediate level liquid waste (ILW) is produced in a number of systems, including the scrubber solutions from process vessel off-gas treatment, ion exchange regenerants from spent fuel and solidified high-level waste storage basin cleanup, cask and plant decontamination solutions, waste solutions from solvent washing, and miscellaneous maintenance and laboratory operation solutions.

The objectives of the ILW projects are to separate ILW from process sources, concentrate and reduce the volume, develop solidification methods, and assess and develop available options for long term management of the ILW from reprocessing operations. In FY 1977 a number of projects will be developed and demonstrated utilizing ultrafiltration, biological denitrification and ion exchange technology, and biological organism system to separate or concentrate the waste streams. The goal for FY 1978 is to continue these projects with industry assistance with possible utilization of the technologies on the AGNS reprocessing facility in 1980.

This concludes the description of the Liquid Radioactive Waste R&D (I.B.2.a.) Subprogram.

b) <u>Solid Radioactive Waste R&D - FY77 $5,910k (1.B.2.b)</u>. This is the second part of the Waste Processing R&D program (I.B.2) subprogram. The Solid Wastê R&D operations are divided into two sections --Cladding Hulls and Solid Waste (TRU)--and are graphically presented in Figure C-7d, page C-36.

(1) Cladding Hulls FY77 $940k

The purpose of the waste management projects for cladding hulls is to specify the criteria and identify suitable forms and packaging required. The project is also attempting to develop and demonstrate methods to reduce the volume of hulls, and convert to a form for resource recovery either in the near-term or after long-term storage to allow for radioactive decay.

Projected plans (for FY 1978) are to have the criteria on cladding hulls reviewed by the industry and to conduct a full scale demonstration of resource recovery and volume reduction of the hulls.

(2) Solid Waste (TRU) FY 77 $4,970k

The basic goals of the Solid Waste (TRU) program are to identify the major transuranic (TRU) generating processes, separate and reduce the waste volume, and immobilize the waste prior to shipment to a Federal repository. The various waste management operations are concerned with the TRU solid waste from both the reprocessing operations and the other fuel cycle operations.

With respect to fuel reprocessing generated TRU waste, ERDA is currently investigating: the adaption and demonstration of air incineration for combustible TRU liquid and solid waste; the adaption and demonstration of ERDA developed fluidized-bed incineration and immobilization system; and the development of criteria for fixation, safe handling, shipping, storage and disposal of TRU solid waste.

The objectives of the other ERDA solid TRU waste projects are to determine TRU quantities and generating processes and develop methods to reduce the volumes. These contaminated wastes include intermediate level waste, combustibles generated throughout the fuel cycle, metal waste, and solid

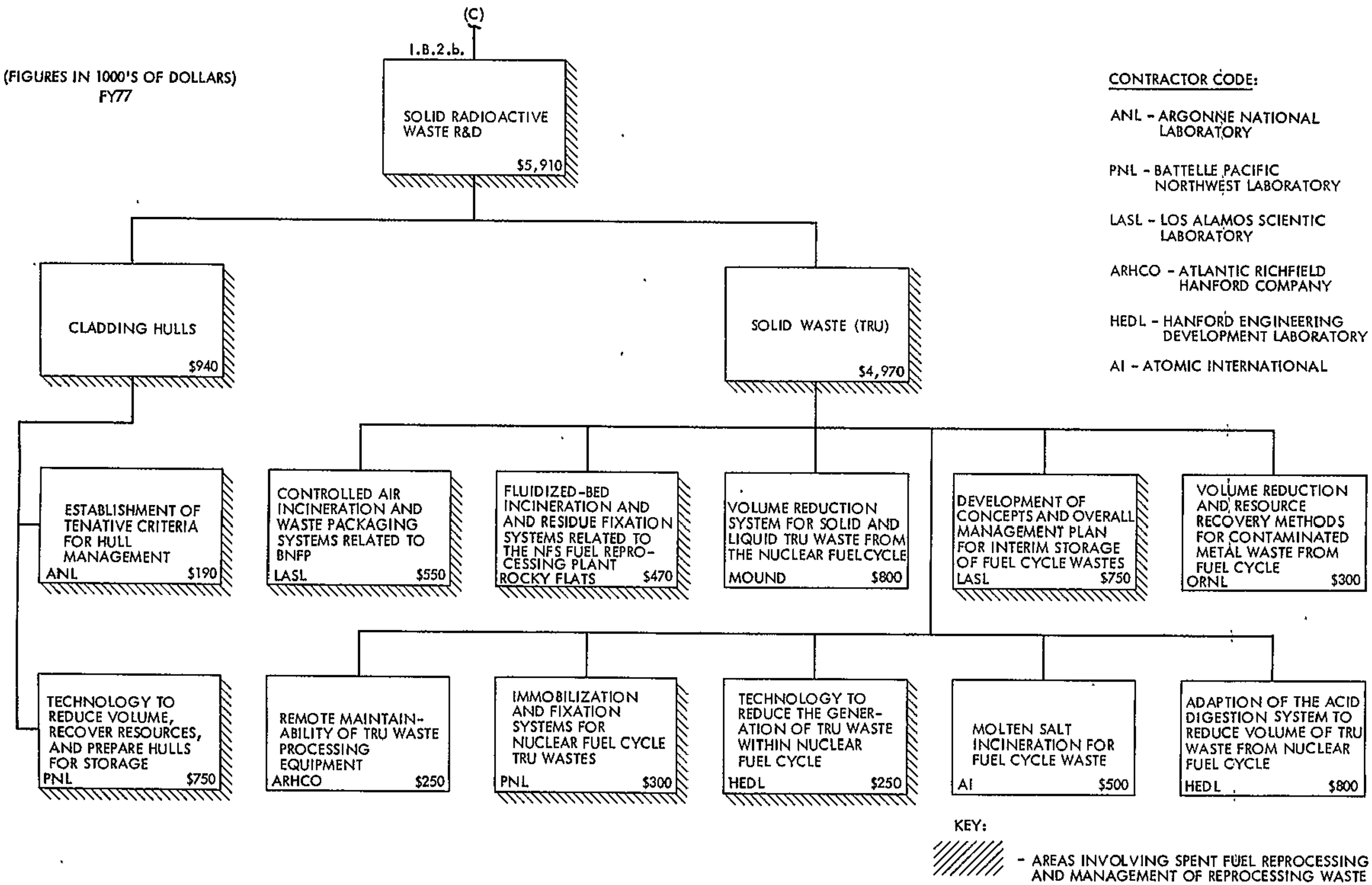

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Figure C-7d. Work Breakdown Structure-Commercial Waste Management (Solid Radioactive Waste R&D)

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and liquid fuel cycle waste. The FY 1978 directions of these projects are to further develop their systems, initiate construction and operational demonstration programs, and participate with the nuclear industry in the potential industrial utilization of the developed systems.

c) Gaseous Radioactive Waste R&D - FY77 $1,000k (I.B.2.c.). The Gaseous Radioactive Waste R&D projects comprise the third and final section of the Waste Processing R&D subprogram. They are shown graphically in Figure C-7e, page C-38.

In the reprocessing of spent fuel rods, quantities of off-gasses are produced. The purpose of this program is to remove certain radionuclides such as carbon-14, iodine-129, and krypton from the off-gas stream and prepare them for interim storage and final disposal.

With respect to carbon-14, the project is aimed at demonstration of an acceptable technology for removing the waste product (as CO_2) from the dissolver off-gas stream and immobilizing it in a solid matrix. Treatment of the AGNS plant off-gas is the reference application to be evaluated with a potential goal of a demonstration operation process prior to FY 1980.

Liquid scrubbing systems, though effective in removing iodine from off-gas, produce a liquid waste product. Several projects are directed at eliminating the liquid scrubber system by removing and fixing the iodine in a solid form or by some other method. One project will evaluate various solidification options while another will attempt to demonstrate a process involving the removal of the silver from the spent silver zeolite iodine absorbent and solidifying the iodine.

The basic goal of the Gaseous Waste Projects' efforts is the possibility of conducting commercial reprocessing demonstration operations by FY 1978-80.

This concludes the discussion of the Waste Processing R&D (I.B.2.) subprogram.

3) Supporting Studies and Evaluations - FY77 $6,900k (I.B.3). The supporting studies will assess the need, methodology and alternatives for radioactive waste management systems. Waste from existing and new (HTGR, LMFBR, LWBR, CTR) nuclear energy systems and secondary waste from waste processing operations will be evaluated. An analysis of the fuel cycle will be undertaken to determine the possibilities of process modifications to reduce the quantities of waste. Also, methods will be evaluated to improve decontamination processes to reduce the volume of contaminated equipment. The Generic Environmental Impact Statement on waste management will be completed and the program of international cooperation continued. Most projects are expected to be completed by FY 1978 at which time the results will be available and recommendations will be made.

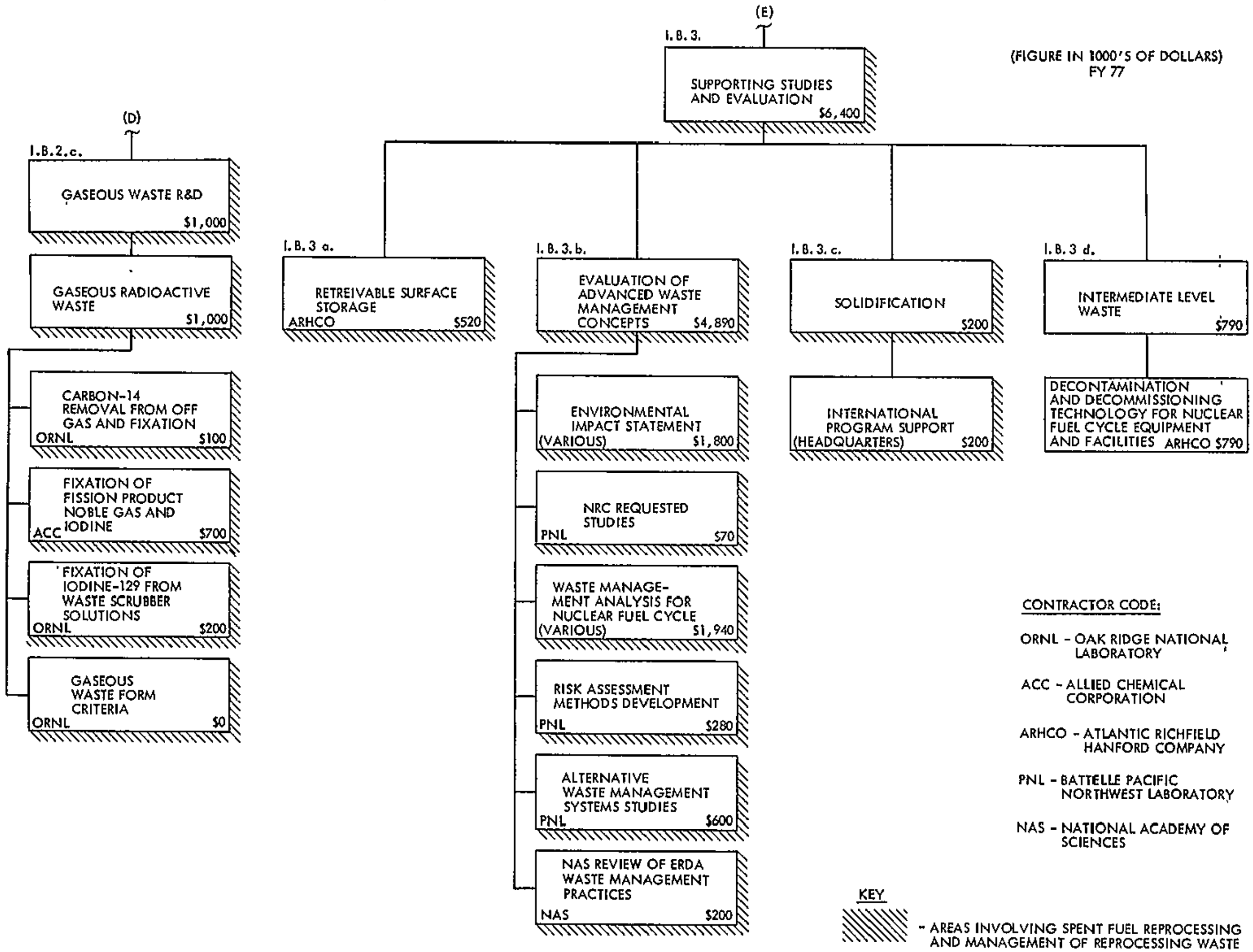

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Figure C-7e. Work Breakdown Structure-Commercial Waste Management (Gaseous Waste R&D and Supporting Studies and Evaluation)

The information for the description of the Supporting Studies and Evaluations program was obtained from a March 1976 ERDA document.[6] Supporting Studies and Evaluations is divided programmatically into four areas as follows: Retrievable Surface Storage; (I.B.3.a.); Evaluation of Advanced Management Concepts (I.B.3.b); Solidification (I.B.3.c.); and Intermediate Level Waste (I.B.3.d.). This is shown in Figure C-7e, page C-38.

(It should be noted that budget figures for the tasks shown in Figure 6-7d do not coincide exactly with the budget figures given in Tables C-2 thru C-6. This is because the budget figures in the Tables reflect the latest information available, while those budget figures in Figure C-7d are from March 1976. These figures are retained to indicate the relative magnitude of emphasis placed on the various topics.)

a) <u>Retrievable Surface Storage - FY 77 $520k (I.B.3.a.).</u> This program is to complete the technical requirements of the Retrievable Surface Storage concept by testing the prototype unit and confirming the design in simulation tests. During FY77 the demonstration of the sealed cask storage unit will continue, primarily in the area of fabricating and loading sealed storage casks with radioactive wastes such as cesium/strontium. Structural integrity testing, and testing the effects on heat transfer and radiation shielding of alternative cooling channel configurations will be completed in FY 1977.

Retrievable Surface Storage project has been in existence for several years and the objective of the 1977 program is to be prepared to construct and assemble a demonstration storage unit containing simulated commercial waste in FY 1978.

b) <u>Evaluation of Advanced Waste Management Concepts - FY77 $4,890k (I.B.3.b.).</u> This is the second section of the Supporting Studies and Evaluation (I.B.3.) subprogram.

Environmental Impact Statements	
. Various contractors	(see Fig. C-7e., pg. C-38)
. Budget FY 1977: $1,800k	

The EIS program is designed to provide funds for the generic environmental statement on commercial radioactive waste management (GEIS) projected for completion in draft form during 1977.

Waste Management Analysis for Nuclear Fuel Cycle
. Various contractors
. Budget FY 1977: $1,940k

(see Fig. C-7e, pg. C-38)

The program purpose is to assess the need, methodology, and new alternatives for radioactive waste management. Fuel cycle and waste management alternatives for present and future nuclear systems will be evaluated and future waste management tasks identified. The FY 1977 efforts will be to develop a cost benefit analysis of the reprocessing of spent fuel which produces two waste streams--one with the long-lived radionuclides and another with the short-lived and inert salts. Though it will be done in the context of the entire fuel cycle, the program will focus on high-level waste from reprocessing operations.

The Oak Ridge National Laboratory is coordinating the broadly based program to develop cost-risk-benefit analysis of actinide partitioning and transmutation as a waste management step. The first year and a half of the three year program (FY 1977-1979) will be devoted to developing flow sheets on reprocessing and refabrication (to be largely verified by experimental work) and providing a cost-risk-benefit analysis of the concept. The remaining time will be utilized in determining the scope and magnitude of the future development program needed to implement this concept. The program is divided into two groups of tasks. The first group is composed largely of experimental work concerned with separations; the second group is concerned with nonpartitioning aspects. The objective of the partitioning task group is to develop flow sheets, based on experimental evidence, of processes for removing the long-lived biologically significant nuclides from all reprocessing and refabrication waste streams and converting them to suitable forms for burning in fission reactors. The experimental projects will be conducted at eight ERDA contractors and will address the issue of minimizing residual losses and accumulations of biologically significant elements recycled for burning and of minimizing the secondary waste volumes. All experimental work is expected to cease and final partitioning flow sheets are expected to be selected by the end of the second year.

The nonpartitioning tasks objectives are to: (1) determine the feasibility and effects of transmuting the nuclides in fission reactors; (2) determine the impact of increased handling of nuclides on non-reprocessing operations; (3) perform a risk-benefit analysis on the entire partitioning-transmutation concept; and (4) update the ORIGEN code with current neutron cross-sections, decay data, and reactor models available. A final task involves coordination and analysis of the entire program.

FY 1979 (the third program year) will be spent mainly in completing the analysis and documenting the results. The program should then provide a quantitative estimate of incremental differences in total cost, risk, and benefits from the concept, as opposed to geological disposal of the entire waste stream. The program should also provide a déscription and schedule of future R&D and demonstration programs need to implement this concept.

Alternative Waste Management Systems Studies	
. Battelle Northwest Laboratory (PNL) . Budget FY 1977: $600k	(see Fig. C-7e., pg. C-38)

The object of this operation is to provide systems analysis and integration of waste management systems from the combinations of alternatives available in waste form, packaging methods, transportation, handling, and storage-disposal methods. The program will describe the benefits of safety, public acceptance, efficiency of operation and cost of various combinations.

The FY 1977 goal will be to provide operation scenario for near-term waste management operations to 1990. The program is expected to continue in FY 1978 to provide scenarios for transitional operations of moving waste material from interim or test repository to conditions of permanent storage--developed, analyzed, and optimized. From this, results will be used in support of operational plans for Federal repository operations.

NRC Requested Studies	
. Battelle Northwest Laboratory (PNL) . Budget FY 1977: $70k	(see Fig. C-7e., pg. C-38)

The program's purpose is to identify and develop a long-term waste management process for neutralized commercial high-level waste and to provide NRC with information developed at ERDA facilities. Following the NRC request, and building on the FY 1976 evaluation of ERDA developed processes potentially applicable to the high level waste at Nuclear Fuel Services plant, a new study in 1977 will be made to identify the optimum management process. During FY 1978 laboratory work will be undertaken to establish technical and preliminary economic feasibility on the recommended process.

Risk Assessment Methods Development	
. Battelle Northwest Laboratory (PNL)	(see Fig. C-7e., pg. C-38)
. Budget FY 1977: $280k	

Risk assessment of commercial radioactive waste management systems will be performed to define the probabilities and quantities of radioactivity released to man's environment from operations related to processing, interim storage, transport, and terminal storage. In addition, identified risks associated with radioactive waste handling will be compared with other known and publicly accepted risks.

The risk assessment for high-level waste management is expected to be completed in FY 1977 with additional efforts directed at extending this study to transuranic and other radioactive wastes. This will lead to an assessment of hazards associated with the total fuel cycle excluding reactors in FY 1978.

NAS Review of ERDA Waste Management Practices	
. National Academy of Science (NAS)	(see Fig. C-7e., pg. C-38)
. Budget FY 1977: $200k	

The National Academy of Science will provide independent reviews and evaluations of ERDA waste management practices, plans, and problems. The studies will review and analyze the current state of knowledge, techniques, practices, and cost alternatives in the management of various types of radioactive waste, and make recommendations concerning both the near and long-term waste management problems.

c) Solidification - FY77 $200k (1.B.3.c.). This is the third area of the Supporting Studies and Evaluation (I.B.3) subprogram.

International Program Support	
. In-house ERDA	(see Fig. C-7e., pg. C-38)
. Budget FY 1977: $200k	

This program provides support of collaborative activities with the radioactive waste management program of the International Atomic Energy Agency. Support of projects of mutual interest, the exchange of data and consultation on technical matters, and sponsorship of workshops and seminars will form the substance of the ERDA contribution.

This completes the description of the Supporting Studies and Evaluations (I.B.3.) subprogram.

4) Solidification Process Demonstration Project - FY77 $4,400k (I.B.4.). The objective of this program is to provide a demonstration of the applicability of existing solidification processes to the high-level waste from LWR fuel reprocessing. Past demonstration projects have utilized simulated radioactive waste. To provide the necessary high-level waste for the program, a small scale (1 metric-ton-uranium/fuel month) LWR fuel reprocessing system will be designed, installed, and operated. This waste will be used in solidification projects. The other program operations will be the procurement of spent fuel, the processing operations to prepare the waste, and the necessary operations associated with disposition of the separate uranium and plutonium.

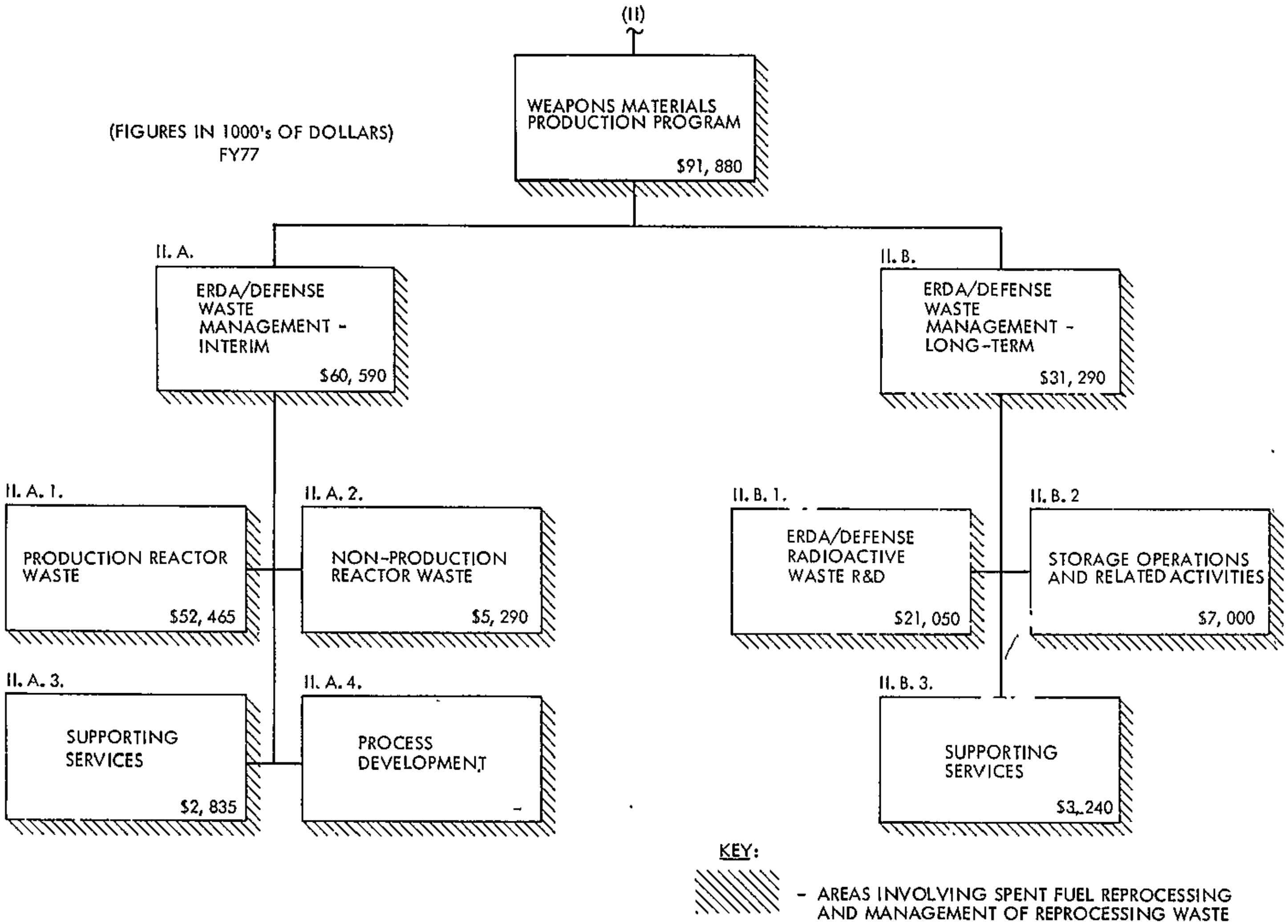
The program objectives for FY 1978 will be the completion of equipment installation, the safety analysis and reviews, and the initiation of cold operations and testing. Hot operations will not take place until FY 1979, when it is intended to produce two cannisters of solidified waste.

2. Special (Weapons) Materials Production Program (II)

The Special (Weapons) Materials Production Program (II) is divided programmatically into several subprograms. Those that deal with radioactive waste management and reprocessing are the following: ERDA/Defense Waste Management--Interim (II.A.); and ERDA/Defense Waste Management--Long Term (II.B.). These are shown in Figure C-8 on page C-44.

a.&b.) Waste Management (ERDA/Defense) - FY77 $91,880k (II.A.&B.). This sub-program provides for the interim and long-term management of radioactive waste from ERDA/defense reprocessing of production, non-production, and Navy propulsion reactor fuels. "Functions included under interim management are surveillance of waste storage tanks and maintenance of waste handling facilities, waste concentration by controlled evaporation, solidification of wastes into safer less mobile forms, fractionization to separate and encapsulate long-lived strontium and cesium isotopes for retrievable storage, management of low-level waste, and related research and development."

"Functions funded under the long-term waste management program consist of planning, research, and development of alternative methods for long-term storage and for solidification of the defense waste into forms for final disposal. Research is also conducted on



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U. S. GOVERNMENT, U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, BUDGET ESTIMATES FISCAL YEAR 1978, BOOKS II AND III.

Figure C-8. Work Breakdown Structure-ERDA's Radioactive Waste Management and Reprocessing Program (Weapons Materials Production)

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the control of airborne waste, volume reduction, and other methods of handling transuranic solid and liquid wastes. Defense-generated transuranic waste terminal storage research and development centers on investigations in south-eastern New Mexico for the location of a pilot plant repository. Funding is also included for ERDA burial grounds for the long-term management of low level solid waste, and for those transuranium-contaminated solids which are placed in retrievable storage."

ERDA/Defense Interim and Long-term Waste Management (II.A. and II.B.) is divided from a budget standpoint into these areas: Production Reactor Waste (II.A.1); Non-Production Reactor Waste (II.A.2.); Supporting Services-Interim (II.A.3.); Process Development (II.A.4.); Long-term ERDA/Defense Radioactive Waste R&D (II.B.1); Long-term Storage Operations and Related Activities (II.B.2.); and Supporting Services--Long-Term (II.B.3.). This breakdown is shown graphically in Figure C-8 on page C-44.

1) <u>Production Reactor Waste - FY77 $52,465k (II.A.1.)</u>. "Included in this estimate are the costs associated with the interim management of production reactor waste. The funding in this category provides for surveillance and maintenance of stored high-level waste, waste concentration, solidification, fractionization, encapsulation, and management of low-level waste." The work is being done at two locations: Savannah River and Richland.

(1) Savannah River $13,000k

This work includes the "handling and storing of liquid radioactive waste from operating facilities at Savannah River. Included are liquid waste storage, concentration, solidification, containment and surveillance." Increases in funding for FY78 will be "for conducting an inspection of waste tanks and evaluating their condition; for repairs to the waste concentrate transfer system; and for waste transfers to new double shell tanks."

(2) Richland $39,465k

This work includes "surveillance and maintenance of underground waste storage tanks and auxiliary tanks, operation of evaporators to concentrate waste liquids, and solidification of these in the form of crystallized salt. The fractionization functions include the operation of a waste transfer vault, a waste fractionization facility, and the waste encapsulation and storage facility to separate strontium and cesium and its subsequent encapsulation and storage. Also included in the management of low-level waste, including maintenance and surveillance of low-level waste disposal sites."

2) <u>Non-Production Reactor Waste - FY77 $5,290k (II.A.2.)</u>. "This category provides for operation of the Waste Calcining Facility at Idaho, which reduces radioactive liquid wastes from the Idaho Chemical Processing Plant (ICPP) to a solid calcined product suitable for interim storage and operation of the Waste Tank Farm." Also provided by the funding is additional maintenance for some increasingly deteriorating plant facilities, especially the Waste Calcinating Facility.

3) <u>Supporting Services--Interim Waste - FY77 $2,835k (II.A.3.)</u>. "These services are in support of major facilities operations of the ERDA/Defense interim waste program. They include costs for the startup of new facilities, shutdown and placing present facilities in standby status, and costs for conceptual engineering studies and environmental studies." The work is being down at the Richland and Idaho locations.

(1) Richland $2,340k

Activities at Richland include surveillance of unoccupied parts of the old Separations Area Plant, U-Plant, and the semiworks, and for conceptual design on interim waste management projects.

(2) Idaho $495k

Conceptual engineering studies in interim waste management projects which include storage bins, plant upgrading and general plant projects, make up the work being done at Idaho.

4) <u>ERDA/Defense Long-Term Radioactive Waste R&D - FY77 $21,050k (II.B.1.)</u>. The ERDA/Defense Waste Management Program is concerned with the long-term management of waste generated at reprocessing operations at Richland, Idaho Falls, and Savannah River, and with transuranic wastes from all ERDA sites. The project's R&D efforts are directed at management methods for this ERDA/Defense waste with possible adaptation to commercial waste management operations at some time in the future. The ERDA/Defense Long-term Radioactive Waste R&D subprogram is comprised of three parts: Terminal Storage R&D (II.B.1.a.); Waste Processing R&D (II.B.1.b.); and Airborne Waste R&D (II.B.1.c). This is shown in Figure C-9a on page C-44. For two of the areas, Waste Processing R&D and Airborne Waste R&D, additional information[7] that enabled a continued breakdown to the project level was available. All of the information in those two sections (II.B.1.b. and II.B.1.c.), was taken from this source.

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[7]ERDA Radioactive Waste Management R&D Program, KK0904, Research and Development Branch, Division of Nuclear Fuel Cycle and Production, ERDA, March; 1976.

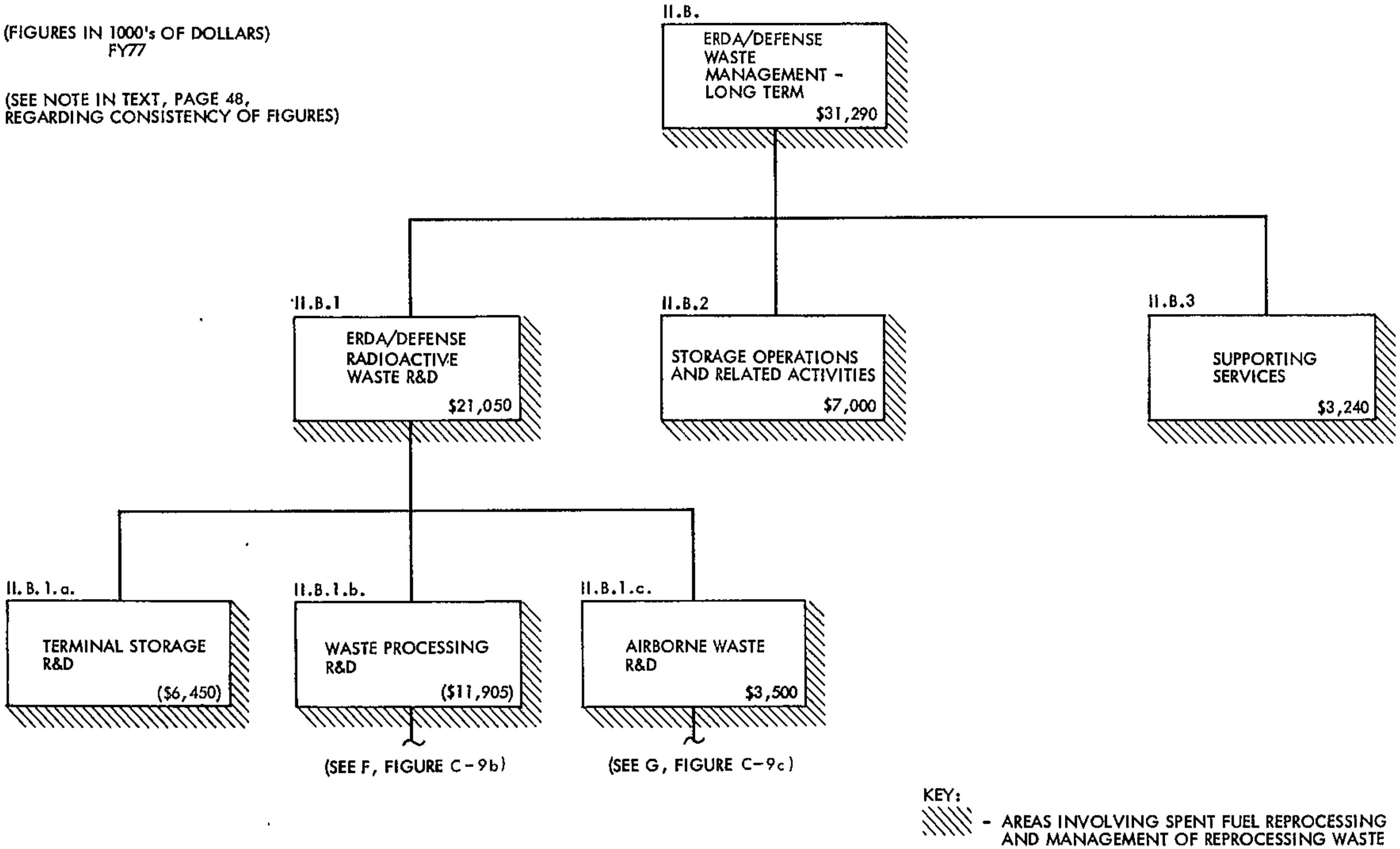

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Figure C-9a. Work Breakdown Structure-ERDA/Defense Waste Management - Long-Term

(It should be noted that the budget figures for the tasks shown in Figures C-9a to C-9c do not coincide exactly with the budget figures in Tables C-2 thru C-6. This is because the figures in the tables reflect the latest available information, while the figures in C-9a to C-9c are from March 1976. These figures are retained to indicate the relative magnitude of emphasis placed on the various topics.)

a) Terminal Storage R&D - FY77 $6,450k* (II.B.1.a.). "The Waste Isolation Pilot Plant (WIPP) project has as its primary goal the development of a permanent disposal repository for transuranium-contaminated solid waste of low or moderate gamma activity, generated by ERDA facilities. It is also planned that the repository as first constructed would have the experimental capability of checking the suitability of the formation for disposal of high-level waste. The target date for beginning operations in the test phase (i.e., with all waste readily retrievable) is 1983."

The WIPP facility will be developed in bedded salt in Southeastern New Mexico. Investigations are underway to determine the characteristics and suitability of the area. These tests include core drilling, geohydrologic studies, and oil, gas and mineral assessments. Included in the WIPP program will be studies examing the waste form and acceptance criteria, borehole plugging techniques, studies on rock properties, heat transfer, and site environment. These studies will provide a basis for the environmental and safety analysis reports.

b) Waste Processing (R&D for Long-Term Management) - FY77 $12,300k (II.B.1.b.). The Waste Processing subprogram is made up of three areas: High-level Waste; Solid Waste (TRU); and Intermediate Level Waste. This is shown graphically in Figure C-9b on page C-49.

(1) High Level Waste FY77 $6,600k

This is the first of the three sections which comprise the Waste Processing (R&D for Long-Term Management) (II.B.1.b.) subprogram.

Long-Term Management of ICPP HLW	
. Aerojet	(see Fig. C-9b, pg. C-49)
. Budget FY 1977: $600k	

The planning, technology, and engineering studies required for the long-term management of Idaho Chemical Processing Plant (ICPP) waste are to be provided by this program. The primary tasks are the calcined waste retrieval, post treatment, actinide removal, storage, and final placement.

*ERDA's response to this Appendix provided this figure. Formerly, it was listed in the Budget Estimate as $5,250k.

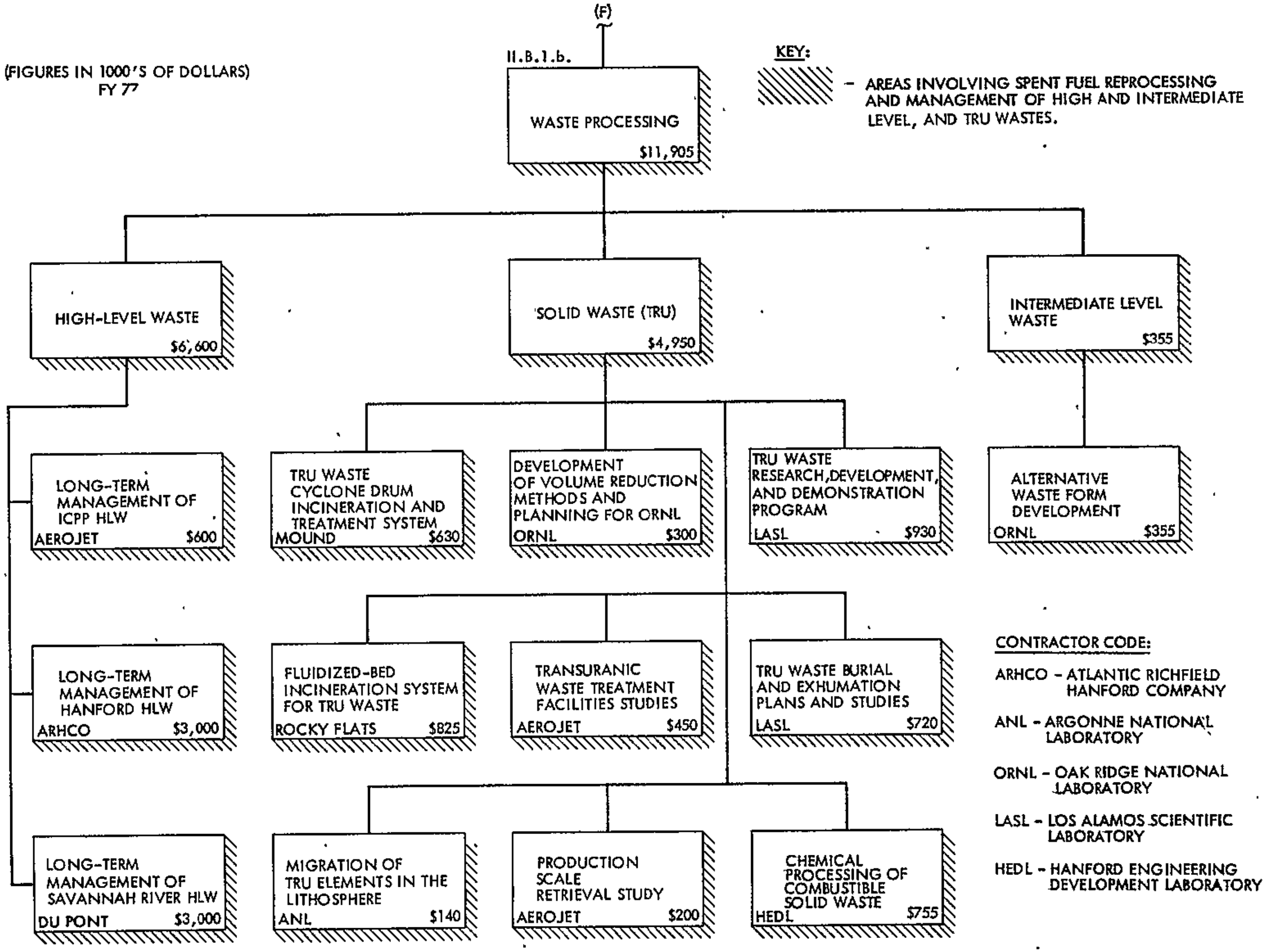

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Figure C-9b. Work Breakdown Structure-ERDA/Defense Waste Management – Long-Term (Waste Processing)

For FY 1977 this will involve bin to bin transfer of the waste and the design and development of bin to packaging processes. Incentives for post calcination treatment and calcine improvements will be evaluated.

This program is a continuation of ongoing operations as set up in FY 1976. The fabrication of the bin packaging, cost-benefit analysis of actinide removal, and conceptional designs for the long-term storage and final placement facilities are expected to constitute the FY 1978 program objectives.

Long-Term Management of Hanford Company HLW	
. Atlantic Richfield Hanford Company (ARHCO)	(see Fig. C-9b, pg. C-49)
. Budget FY 1977: $3,000k	

The objectives of the program for long-term management of high-level waste generated at Hanford will be to provide the necessary planning, technology, and engineering studies. The program will consist of a cold demonstration of retrieval equipment and the completion of a budget package for a radioactive immobilization demonstration facility.

The basic directions of the program were developed in FY 1976 and are expected to continue through FY 1978. Future program objectives are to complete a budget package for waste retrieval, immobilization and storage demonstration facility, and to complete studies on radionuclide migration, ground water management and possible engineering improvements.

Long-Term Management of Savannah River High-Level Waste	
. Du Pont	(see Fig. C-9b, pg. C-49)
. Budget FY 1977: $3,000k	

The major goals of this program are to provide technology and engineering studies necessary for the long-term management of the high-level waste at Savannah River. To accomplish these goals the program consists of an evaluation of management options available, an R&D program to develop, evaluate, and choose waste forms and processes, and engineering studies, cost estimates, design feasibility studies, and risk evaluations of the conceptual processes for solidification, storage, and final placement.

This program's directions will follow from an assessment of options study, and an engineering trade-off study completed in FY 1976 and early FY 1977, respectively. Budget packages for a FY 1978 development of a nonradioactive equipment test facility (estimated $19 million) and a FY 1978 design project of a high-level waste solidification and storage faciltiy (estimated $25 million) will be completed in FY 1977.

This concludes the discussion of the first part of the Waste Processing (R&D for Long-Term Management) (II.B.1.b.) subprogram: High Level Waste. The second part, Solid Waste (TRU), is now presented.

(2) Solid Waste (TRU) FY77 $4,950

The Solid Waste (TRU) program efforts are directed at reducing the volume of the waste, developing packaging processes, and performing studies on the disposal of the TRU waste in a proper burial site — most likely a deep geological formation.

The volume reduction processes being examined involve acid digestion, fluidized-bed incineration, and cyclone incineration. The current program is directed at developing and demonstrating the processes in FY 1977 with continued studies at least through FY 1978.

The conceptual design of a facility for the treatment of exhumed waste at INEL will be completed in FY 1977. The treatment process would involve the sorting, treating and packaging of waste materials. Another project will investigate the most cost-effective technology and equipment for complete exhumation of the 2.3 million cubic feet of TRU waste at INEL.

Other projects are to evaluate the TRU waste management concept and conduct studies to support specific directions for ERDA's management operations. The solid waste programs are projected to be continuing development, evaluation and/or demonstration operations, extending at least through FY 1978 and possibly into the 1980's.

This concludes the description of the second part of the Waste Processing (II.B.1.b.) subprogram, solid waste (TRU) projects. The third and final part is now presented.

(3) Intermediate-level Waste FY77 $355k

This is the third of the three sections under the Waste Processing (II.B.1.b.) subprogram.

Alternative Waste Form Development	
. Oak Ridge National Laboratory	(see Fig. C-9b, pg. C-49)
. Budget FY 1977: $355k	

The alternative waste form development program is to identify and evaluate alternatives to the presently used disposal process of hydrofracturing for the ORNL liquid waste. This has been completed as of March, 1977 according to ERDA's response to this Appendix.

Engineering studies and evaluations are to be undertaken based on recommendations from the FY 1976 program. These studies will define technical, engineering and economic aspects of the recommended processes. The results from these operations will be used to direct the FY 1978 program operations in the design or additional studies of alternative waste form disposal processes.

This concludes the examination of the ERDA Waste Processing (II.B.1.b.) area. Next is presented the Airborne Waste (II.B.1.c.) section, the third and final area under the ERDA/Defense Radioactive Waste R&D (II.B.1.) subprogram. The Airborne Waste area is shown graphically in Figure C-9c on page C-53.

1) Airborne Waste - FY77 $3,500k (II.B.1.c). The airborne waste program is designed to develop, demonstrate and test technology and equipment for the recovery and processing of secondary waste streams. The program is divided into four task groups: (1) particulate filtration development, (2) iodine retention development, (3) tritium retention development and (4) standards development and related services. This is shown in Figure C-9c on the following page. The projects under each heading are to address the problems of retaining the secondary waste resulting from nuclear plants, and process it to a stable form for permanent disposal. The development and demonstration projects, in general, are to be completed in FY 1978 with an assessment of the results at that time as to future project directions.

This concludes the examination of the ERDA/Defense Radioactive Waste R&D programs (II.B.1.). The final two parts of the ERDA/Defense Long-term Management (II.B.) subprogram are now presented. They are Storage Operations and Related Services (II.B.2.) and Supporting Services (II.B.3.).

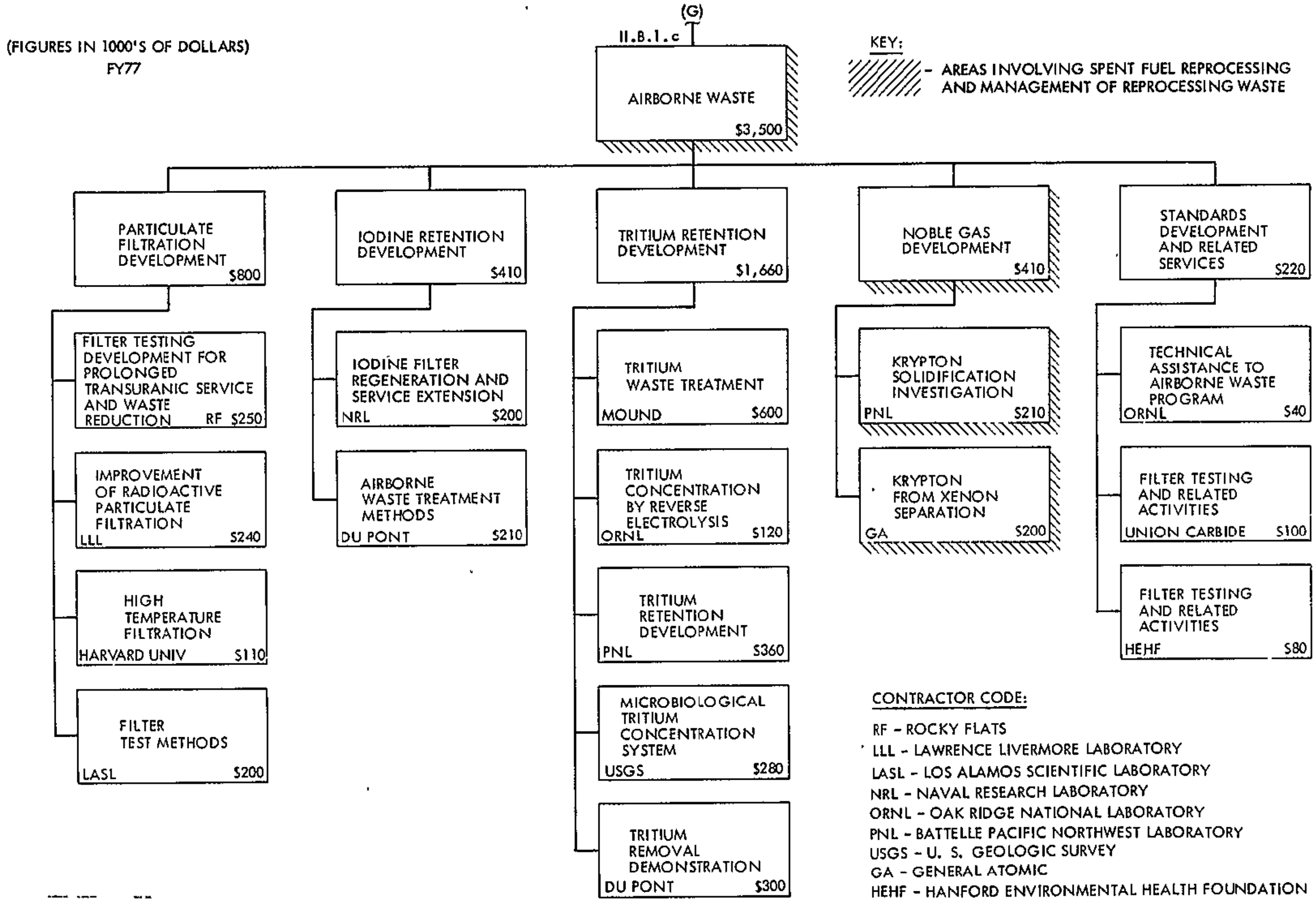

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Figure C-9c. Work Breakdown Structure-ERDA/Defense Waste Management - Long-Term (Airborne Waste)

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2) Storage Operations and Related Activities - FY77 $7,000k (II.B.2.). "These funds provide for the operations of ERDA solid radioactive waste storage and burial activities at the various ERDA sites. This includes the receipt, handling, and routine storage or burial of site-generated solid beta-gamma radioactive waste, and the storage of wastes contaminated with transuranic nuclides which require segregation and storage in an area where they can be retrieved after an extended period. The funding also provides for the continuation of support studies on improved handling and storage methods, and for monitoring programs." "The adequacy of current monitoring practices in detecting migration of radioactivity from buried or stored solid wastes as related to site conditions and migration properties of soils will be studied by the site contractors as well as by the United States Geological Survey."

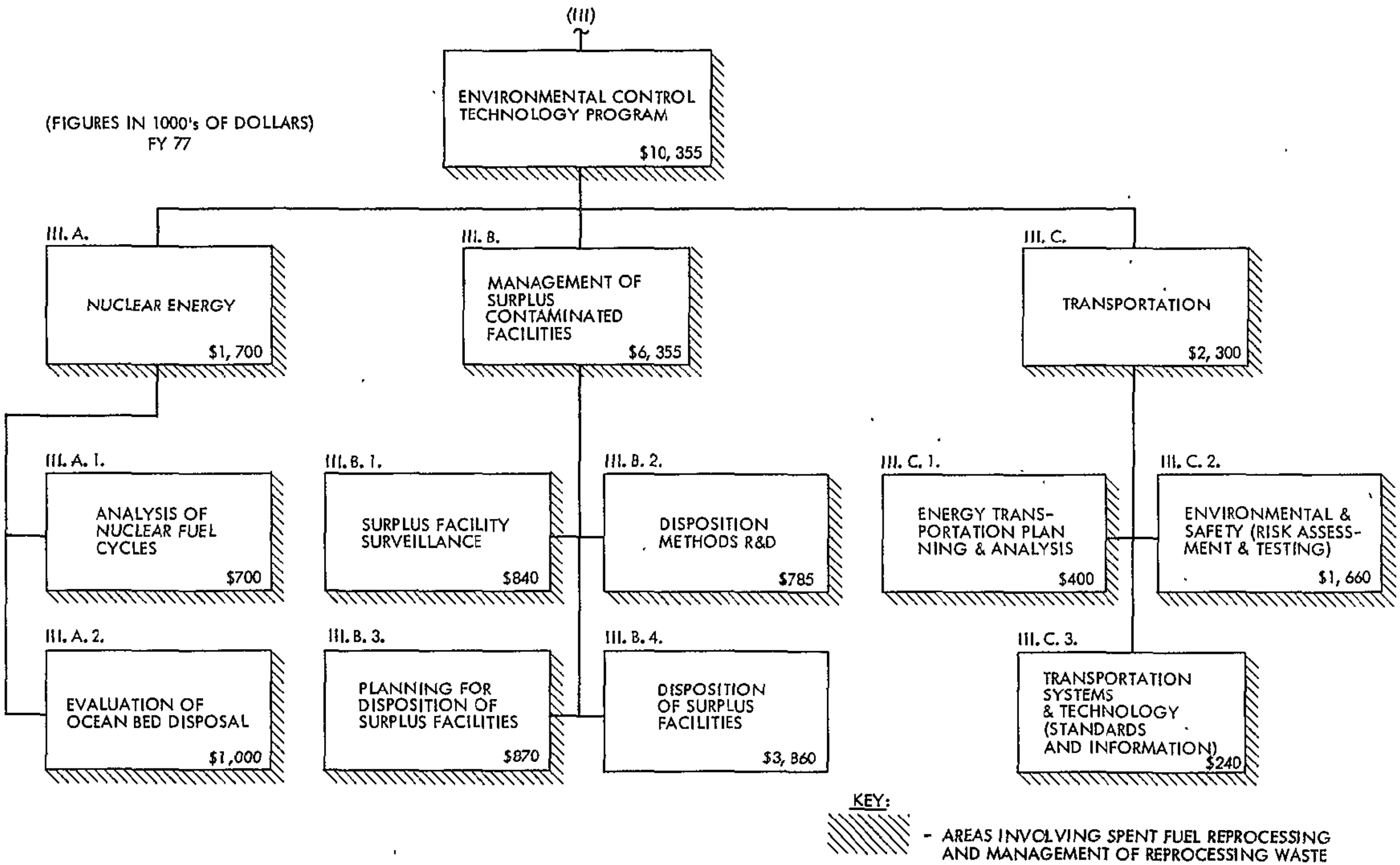
"The general purpose of the studies is to provide data needed to make decisions on (1) the suitability of burial/storage sites for the long-term storage of radioactive solid wastes; (2) improved detection and/or control of migration of radioactivity; (3) stabilization of ground surfaces for long-term waste storage; and (4) the necessity of removal and alternative disposal. Funds are also provided to conduct small scale retrieval of previously buried waste to evaluate the conditions and hazards associated with exhuming the wastes."

3) Supporting Services--Long Term Waste - FY77 $3,240k (II.B.3.). This work includes engineering studies and conceptual design efforts related to proposed waste treatment and storage facilities required for management of ERDA wastes. An adequate design that will favorably influence safety, and cost and time of operation required to place waste inventories in secure long-term storage will be stressed.

3. Environmental Control Technology Program (III)

The Environmental Control Technology Program (III) is divided programmatically into several subprograms. Those that deal with radioactive waste management and reprocessing are the following: Nuclear Energy (III.A); Management of Surplus Contaminated Facilities (III.B); and Transportation (III.C). While management of Surplus Contaminated Facilities is not considered by ERDA to deal with radioactive waste management specifically, it is included because TRU waste is dealt with in other sections of this report. These are shown in Figure C-10a on page C-55.

a. Nuclear Energy - FY77 $1,700k (III.A.). "The categories under Nuclear Energy Systems for which the Environmental Control Technology Program is responsible include: (1) the assessment of



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U. S. GOVERNMENT, U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, BUDGET ESTIMATES FISCAL YEAR 1978, BOOKS II AND III.

Figure C-10a. Work Breakdown Structure - ERDA's Radioactive Waste Management and Reprocessing Program (Environmental Control Technology Program) environmental control systems required to support the timely implementation of the developing nuclear fuel cycles; and (2) the determination of the technical and economic feasibility of advanced long-term waste management systems. The advanced system currently under investigation is the geologic disposal of commercially generated high-level waste by emplacement beneath the ocean floor."

Nuclear Energy (III.A.) is divided programmatically into these areas: Analysis of Nuclear Fuel Cycles (III.A.1.); and Evaluation of Ocean Bed Disposal (III.A.2.).

1) Analysis of Nuclear Fuel Cycles - FY77 $700k* (III.A.1.). This work is part of a continuing program at Pacific Northwest Laboratory, the objective of which is "to identify areas in the developing nuclear fuel cycles where inadequate consideration is being given to environmental controls, including the management of radioactive wastes, or where inconsistencies and conflicts in environmental policy exist." "During FY77, analysis of alternative process facilities to the reference LWR fuel cycle will be completed. The report will include hardware and process descriptions for alternative LWR configurations, cost benefit comparisons of alternative facility/process systems, and improved effluent control." An analysis of the LMFBR fuel cycle will be completed, and "a tabulation of environmental control technologies under development in various ERDA programs to control or eliminate effluents and waste from LMFBR fuel cycle components will be compared with a grouping of LMFBR effluents according to their potential for producing the largest environmental impact."

2) Evaluation of Ocean Bed Disposal - FY77 $1,000k (III.A.2.). The objective of this program is the development and proof of the technical and economic feasibility of the disposal of high-level wastes into the deep ocean floor. Sandia Laboratories are pursuing a program to identify and obtain data on isolated regions of ocean beds judged suitable for high-level waste disposal. "In FY77 several specific objectives will be met: (1) the first conceptual designs of the engineering system needed for seabed disposal will be completed (the "reference system" for this alternative); (2) a plan for the first in situ effects test involving a heat source, isotope tracers, and advanced instrumentation imbedded in the sediment will be developed, and the necessary design of equipment and layout will be started; (3) first measurements of the oxygen exchange rate across the sediment-water interface will be performed; (4) the first geological cruise directed at characterizing the sediments will occur;

*ERDA's response to this Appendix indicated that only about 50% of this figure can be attributed to the back-end of the fuel cycle.

(5) comparison will be made with available data from another deep basin to judge the qualifications of the North Pacific as a "type area" for continued study."

b. Management of Surplus Contaminated Facilities - FY77 $6,355k (III.B.). The Environmental Control Technology Program is responsible for the planning and budgeting for the safe management of all ERDA facilities that are radioactive contaminated and surplus to the needs of any ERDA program. The long-term objective is to reduce the inventory of such facilities to the greatest extent practical in order to allow land to be released with no restrictions on future use, and to minimize the potential for environmental contamination and the need for perpetual surveillance and maintenance. In addition, this program is responsible for developing improved methods for the safe and economic decontamination and disposition of radioactive facilities and equipment." Presently, there are approximately 200 facilities in the program.

Management of Surplus Contaminated Facilities (III.B.) is divided programmatically into these areas: Surplus Facility Surveillance (III.B.1.); Dispositions Methods R&D (III.B.2); Planning for the Disposition of Surplus Facilities (III.B.3.); and Disposition of Surplus Facilities (III.B.4.).

1) Surplus Facility Surveillance - FY77 $840k (III.B.1). The funding here provides for routine surveillance and periodic maintenance of facilities to insure a safe condition prior to the undertaking of disposition actions. These activities are provided for facilities at the Idaho National Engineering Laboratory, the Hanford Plant in Washington, the Oak Ridge National Laboratory in Tennessee, and facilities at various other sites. "It is expected the surveillance and maintenance of these facilities will continue until they have been decontaminated to safe levels or disposed of."

2) Dispositions Methods R&D - FY77 $785k (III.B.2.). "Emphasis is being placed on the need to develop methods for the decontamination and disposition of equipment and buildings, for the volume reduction of contaminated process equipment, and for the resource recovery of contaminated metals. Smelting experiments have been initiated and methods for separating the radioactivity in the molten slag are being investigated. The contractors in this program are Atlantic Richfield Hanford Company, National Lead, and Argonne National Laboratories." They will be conducting studies in the following areas: preliminary conceptual design of a hot demonstration facility; completion of a prototype electric arc melt facility and a cold meltdown demonstration; design of an off-gas handling system for the hot demonstration facility; investigation into the feasibility of portable metal smelting facilities; and decontamination techniques for plutonium and uranium contaminated metals and equipment.

3) Planning for the Disposition of Surplus Facilities - FY77 $870k (III.B.3.). This program will develop a long-range plan for the decontamination and disposition of facilities. "The program includes: (1) a study of the various classes of contaminated facilities at Hanford to establish methods, costs, priorities and alternatives for their dispositions; and (2) the identification and performance of supporting research and development for decontamination and decommissioning (D&D) projects." Studies of burial grounds, radioactive inventories, and migration will be factored into an overall plan for cleanup, corrective action, and disposition of Hanford land and facilities. Plans for disposing of the ORNL excess reactor facilities will also be developed, and cost estimates priorities, and schedules for the Oak Ridge facilities will be established.

4) Disposition of Surplus Facilities - FY77 $3,860k (III.B.4.). Two facilities, the Nuclear Rocket Development Station (NRDS) and the Sodium Reactor Experiment (SRE), are in the process of being dismantled. Activities such as fuel decladding operations; cell cleanup, fuel shipment; removal of the internal workings from the reactor vessel; removal of sodium service systems, waste tanks and lines; the dismantling of the fuel handling machine; remote cut-up of the reactor vessel; removal and burial of nonsalvageable scrap; and facility radiological surveys are included in the disposition activities.

c. Transportation - FY77 $2,300k* (III.C.). The transportation project will undertake studies, tests and assessments to: develop the data and methodology for evaluating risks and environmental effects of shipments; assure development of fuel cycle transport technology optimized for safety, cost, security, and operating efficiency; and provide information to the public and industry concerning the various aspects of fuel and waste transport. Individual projects will be directed at areas of interest determined by concerned governmental agencies and the transportation industry. The initial program effort began in FY 1977 and will be expanded in FY 1978 to survey, assess and identify gaps in ongoing Federal and industry R&D programs for safe and environmentally acceptable transportation of fuel and waste.

Transportation (III.C.) is broken into three project areas: (1) Energy Transportation Planning and Analysis (III.C.1.); (2) Environment and Safety (Risk Assessment and Testing) (III.C.2.); and (3) Transportation Systems and Technology (Standards and Information) (III.C.3.).

*ERDA's response to the Appendix has indicated that approximately 10% of this figure can be associated with high-level waste transport, but that it would be impractical to define an exact figure that applied only to high-level waste transport.

1) Energy Transportation Planning and Analysis - FY77 $400k (III.C.1). The objective of this program is to provide planning and analysis operations required for the development of a coherent transportation program to assure a safe and publicly acceptable system for fuel and waste transport on a timely basis. Identification of government and industry transportation research and development programs will be undertaken to determine what possible important areas are not receiving proper attention. Studies of the safety, environmental, and economic trade-offs on fuel/waste transportation will be initiated in FY 1977.

A study on the transportation system development characteristics and trends through the year 2000 will continue into FY 1978. The principal objective is to identify potential safety and environmental problems so as to reduce the potential for crises. The needs and objectives for transportation R&D carried out under the energy technology development programs will be assessed for environmental and safety adequacy. The primary product of this program study will be a list of the requirements and tasks to be carried out to provide an adequate evaluation of the environmental impacts and safety of fuel/waste transportation.

2) Environmental and Safety (Risk Assessment & Testing) - FY77 $1,660k (III.C.2.). The objective of this program is to perform transportation mode and risk assessment studies so as to provide a basis for developing cost effective minimum risk fuel/waste transportation systems that protect both the environment and the public. A study will be undertaken of the relevance and adequacy of the existing criticality control standards for nuclear shipments. Another important area of risk assessment, which will be addressed by an ERDA study, is the determination of stress factors that may lead to damage or material release. The output of this study will be a major input into the continuing transportation risk assessment of a variety of fuels and waste.

In FY 1976, scale model tests were run of truck and rail car crashes. In FY 1977, limited model tests will be undertaken to compare scale model and full scale crack conditions. The FY 1977 program is limited to containers for nuclear materials though in FY 1978, the testing will be expanded to other energy program materials. The bulk of FY 1978 work will be done with full scale vehicle and systems tests to determine accident response. Another major task is the continued destructive testing of obsolete casks.

3) Transportation Systems and Technology (Standards and Information) - FY77 $240k (III.C.3.). The goal of this program is to identify the need for a comprehensive body of consistent and supportable safety and operating standards for fuel/waste transportation. The program is also to provide information to the general public and transportation industry concerning the environmental and safety problems and inherent risks.

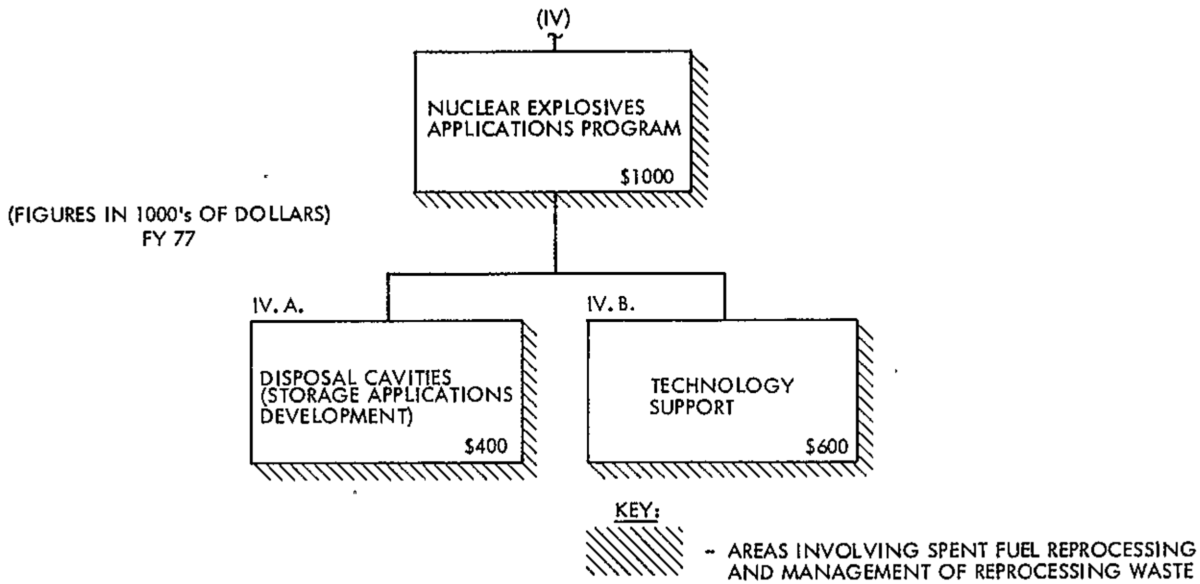
The work in progress is part of a continuing operation. Work will continue in the area of technical information to maintain the existing transportation accident data bank and to publish statistics and data on ERDA's transportation program. Other activities will include the developing of films, booklets and exhibits on the environmental and safety aspects.

4. Nuclear Explosives Application Program (IV)

The Nuclear Explosives Applications Program is divided into two subprograms: Disposal Cavities (Storage Applications Development) (IV.A); and Technology Support (IV.B). These are shown in Figure C-10b on the following page.

a. Disposal Cavities (Storage Applications Development) - FY77 $400k (IV.A.). This subprogram provides for the study of the formation of cavities and/or rubblized chimneys in suitable geologic formations to investigate the technical feasibility of utilizing very deep undergroup cavities for permanent disposal of radioactive wastes by encapsulation in a melted and resolidified rock formation. A preliminary survey of the Nevada Test Site has indicated the existence of suitable sites for conducting a low-yield nuclear experiment to study this matter.

b. Technology Support - FY77 $600k (IV.B.). This subprogram has two main thrusts: explosive phenomenology and international program support. "The purpose of the explosive phenomenology part is to develop an understanding of the effects of multiple explosions in a closely spaced array. Emphasis will be on improving computational and predictive techniques. In addition, studies of the migration of radioactivity in the ground will continue." "The purpose of the international program support part is to provide the United States with a limited capability to respond to foreign requests for peaceful nuclear explosions (PNE) assistance in feasibility studies and to actively participate with the international community in meetings and studies."



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ERDA RADIOACTIVE WASTE MANAGEMENT R&D PROGRAM, RESEARCH AND DEVELOPMENT BRANCH, DIVISION OF NUCLEAR FUEL CYCLE AND PRODUCTION, ERDA; MARCH, 1976.

Figure C-10b. Work Breakdown Structure-ERDA's Radioactive Waste Management and Reprocessing Program (Nuclear Explosives Applications Program)

IV. SUMMARY AND OBSERVATIONS

The overall goal of ERDA's waste management and reprocessing operations is to provide for safe, efficient, and timely handling and processing of spent reactor fuel and the fuel cycle wastes. To this end ERDA has developed numerous programs and projects to examine those areas determined to have unanswered technical or regulatory questions.

Many of the reprocessing and waste management programs have been in progress for a number of years. During this time their program objectives have been revised as a consequence of new findings or analysis. New programs and projects are developed to examine additional subjects and others are abandoned or significantly reduced in the operations. The actual program directions, depth of study, and number of projects is determined by both the technical and political concerns of the specific area to be examined. A gross indication of the interest in any subject can be obtained through the examination of budgetary trends. In the case of waste management and reprocessing programs, the funding has increased approximately 100% in FY 1977 and 60% in FY 1978 (projected). This is in relation to the total ERDA budget increase of 35% and 30% respectively. Significant funding increases occurred in the areas of nuclear fuel cycle supportive operations (FY 76-77-78, over 100% per year), waste management commercial (FY 76-77, 600%; FY 77-78, 78%), long-term waste management ERDA (FY 76-77, 80%), and management of surplus contaminated facilities (FY 77-78, 97%).

An analysis of the budgetary trends in combination with the program, project, and task descriptions provides a basis for evaluation of ERDA's program directions. Unfortunately the specific technical and budgetary information concerning all the projects and tasks being conducted by ERDA with respect to waste management and fuel reprocessing was not available for this study. With what information was available, there appear to be two significant areas of waste management that are not currently being addressed by ERDA. The first is the question of the possibility of not reprocessing the spent fuel rods and either storing them for an indefinite time, or disposing of them (the stowaway or throwaway alternatives). The specific aspects of the stowaway/throwaway option that are of growing concern are the long-term storage, packaging, and final disposition of the spent fuel rods. The second area ERDA does not appear to be investigating is the management operations in the case of no plutonium recycling. Specifically, what waste management operations would be affected by the inclusion of plutonium in the waste stream and how the potential hazard and the projected pathways to man would be affected.

APPENDIX D

DESCRIPTION OF THE NRC PROGRAM

FOR

HIGH-LEVEL

NUCLEAR WASTE MANAGEMENT

APPENDIX D

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CONTENTS

FIGURES

Tables

I. NUCLEAR REGULATORY COMMISSION - BACKGROUND AND MISSION STATEMENT

A. BACKGROUND

The Nuclear Regulatory Commission (NRC) was established in October, 1974 by PL 93-438, The Energy Reorganization Act of 1974. This law created a 5-member Commission, appointed by the President with the advice and consent of the Senate for 5 year terms. This act transferred the following functions from the Atomic Energy Commission:

(1) All licensing and regulatory functions (Chapters 6, 7, 8, and 10) of the Atomic Energy Act of 1954, as amended.

(2) The functions of the Atomic Safety and Licensing Board and the Atomic Safety and Licensing Appeal Board.

(3) The functions of the Advisory Committee on Reactor Safeguards, whose members are appointed by the Commission for 4 year terms.

(4) Authority to conduct extensive studies on safeguards, needs and techniques.

Below the Commission level, the law specifies establishing an Executive Director for Operations and three line offices:

(1) Office of Nuclear Reactor Regulation (NRR).

(2) Office of Nuclear Material Safety and Safeguards (NMSS).

(3) Office of Nuclear Regulatory Research (RES).

The Commission later added two additional offices:

(1) Office of Standards Development (SD).

(2) Office of Inspection and Enforcement (IE).

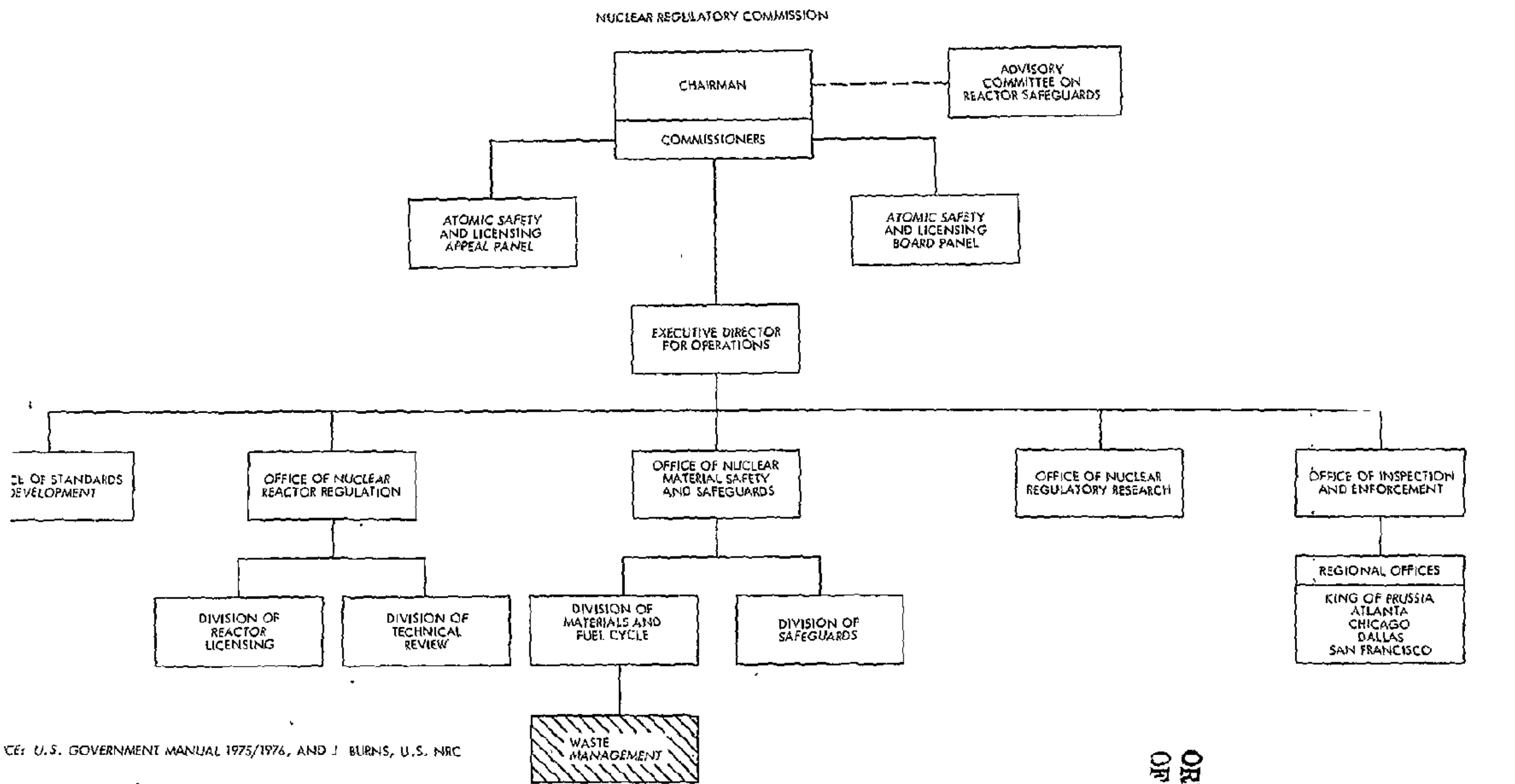
These offices as well as the Boards and Committee noted above are shown in Figure D-1.

Special functions assigned to NRC by PL 93-438 included:

(1) Licensing authority over selected Energy Research and Development Administration facilities including:

 (a) Facilities used for receipt/storage of high-level radioactive wastes (HLW) from licensed facilities.

 (b) Retrievable Surface Storage Facilities and other facilities authorized for interim storage of high-level waste which are not generated by research and development activities.



…CE: U.S. GOVERNMENT MANUAL 1975/1976, AND J BURNS, U.S. NRC

Figure D-1. NRC Programmatic Organization

(2) Development of a capacity to perform confirmatory research assessment.

(3) A requirement to report on a quarterly basis to Congress all abnormal occurrences at, or associated with, licensed or regulated facilities. (An abnormal occurrence is defined as an unscheduled event that the Commission determines is significant from the standpoint of public health or safety).

B. CONGRESSIONAL OBJECTIVES AND INTENT IN LEGISLATION (PL 93-438)

Public Law 93-438 lists several objectives for the establishment of a separate Commission to regulate the use of nuclear energy. The objectives pertinent to this report are:

(1) Requires the NRC to have an independent capability to develop and analyze technical information on reactor safety, safeguards and environmental protection as a basis for licensing and regulation.

(2) Examine the implications for safety and safeguards in nuclear energy centers.

C. NRC MISSION STATEMENT, GOALS AND OBJECTIVES

In signing the Energy Reorganization Act of 1974, President Gerald Ford indicated the agency's overall mission by stating that:

> "The highly technical nature of our nuclear facilities and the special potential hazards which are involved in the use of nuclear fuels fully warrant the creation of an independent and technically competent regulatory agency to assure adequate protection of public health and safety."[1]

The Annual Report of the U.S. Nuclear Regulatory Commission also describes the goals and objectives indicated in Sections A and B. Of interest to this appendix is the statement that the goals of the Commission:

> "...require the establishment and attainment of both short-term objectives--for example, the early resolution of technical problems arising in the operation of today's light-water-cooled power reactors, and the assurance of safe interim storage for spent nuclear fuel elements--and longer-term objectives such as closing the nuclear fuel cycle, regulating the safe disposition of high-level radioactive wastes, and improving capability to evaluate the safety of advance reactor proposals.

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[1]U.S. Nuclear Regulatory Commission, Annual Report, 1975, pg 1.

"Balancing the benefits of nuclear activities against safety, security, and environmental costs and risks in the public interest is the heart of NRC decision-making."[2]

The Annual Report also stated the high priority NRC was giving to several objectives including:

(1) "Addressing a number of important unresolved policy issues, especially in the nuclear fuel cycle area."

(2) "Improving coordination with, and reducing unnecessary overlaps among government agencies at all levels."[3]

D. ORGANIZATION AND BUDGET

Figure D-1 shows the overall operational organization of the NRC. The high-level waste management activities are the responsibility of the Assistant Director for Waste Management. Altogether there are four assistant directors in the Division of Materials and Fuel Cycle. Authorization for the Assistant Director for Waste Management took place in March 1977.[4] A branch for high-level waste and transuranic waste, and another for low-level waste were also recently authorized. Prior to these organizational changes, the majority of the waste management activities was the responsibility of the Waste Management Branch of the office of the Assistant Director for Fuel Cycle Safety and Licensing.

Table D-1 shows the budget and personnel positions for the five operational offices. The Office of Nuclear Material Safety and Safeguard has shown the fastest budget growth since Fiscal Year 1976--more than double the growth rate of the next fastest growing division.

Further organizational breakdown of the budgets and positions for these fiscal years is presented in Section III. In addition to the budget breakdowns, organizational charts and explanatory text are provided for each of the offices. The budgets for the Waste Management activities are discussed in Section II.

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[2] U.S. Nuclear Regulatory Commission, Annual Report, 1975, pg 4.
[3] Ibid, pg 5.
[4] Personal communication; Jackie Burns, USNRC with E. Edelson, JPL, 3/31/77.

Table D-1. Operational Budget and Personnel, Nuclear Regulatory Commission, FY 1976 to FY 1978 (Thousands of dollars)

Operational Office	FY 1976 (Actual)	FY 1977 (estimate)	Percent Change FY76 to FY77	FY 1978 (estimate)	Percent Change FY77 to FY78
Nuclear Material Safety and Safeguard	$11,728 (192)	$18,740 (264)	60% (38)	$22,090 (284)	18% (8)
Nuclear Reactor Regulation	32,038 (597)	40,580 (613)	27 (3)	39,990 (14)	-1% (11)
Nuclear Regulatory Research	98,055 (118)	121,980 (135)	24 (14)	148,400 (150)	22% (11)
Standards Development	8,832 (132)	11,880 (153)	35 (16)	12,130 (153)	2% (0)
Inspection and Enforcement	19,605 (507)	28,760 (592)	47% (17)	30,050 (666)	4% 13
TOTAL OPERATIONAL BUDGET	170,258 (1546)	221,940 (1757)	30 (14)	252,660 (1871)	14% (6)
TOTAL NRC BUDGET	217,423	248,780	14%	292,150	17%

Note: Personnel authorizations are in parenthesis

Source: Nuclear Regulatory Commission, Budget Estimates Fiscal Year 1978, pages 2, 13, 18, 26, 33 and 46.

II. HIGH-LEVEL NUCLEAR WASTE MANAGEMENT

A. PROGRAM DEVELOPMENT

The Commission originally assigned responsibility for the development of the Waste Management Program to the Waste Management Branch of the Office of Nuclear Materials Safety and Safeguards. As noted in Section I-D, this branch has been recently elevated to the assistant division director level. Change in the program support budget and number of positions coincided with this organizational change.[5] These changes, shown in Table D-2, represent reallocations in NRC and not new appropriation requests.[6] Program support budget refers to expenditures in addition to the personnel and some overhead. Most of the program budget is reserved for outside contracts.

Table D-2. Waste Management Budget Program Changes

	1976	1977	1978
Original Estimates*			
Budget	$343,000	$1,779,000	$2,500,000
Positions	8	13	24
Current Estimates**			
Budget	$343,000	3,600,000	4,650,000
Positions	8	31	38
Percent Change			
Budget	0%	102%	86%
Positions	0%	138%	58%

*U.S. Nuclear Regulatory Commission, Budget Estimates Fiscal Year 1978, page 40.

**Personal Communication with J. Burns, March 30, 1977.

[5] Personal communication; J. Burns, USNRC, with E. Edelson, JPL, March 30, 1977.

[6] Personal communication; C. Beckwith, USNRC, with E. Edelson, JPL, April 1, 1977.

The program support budget for the assistant division director for waste management does not give a complete picture of NRC's effort in waste management. In Table D-3, the waste management activities of the other offices are summarized. The dollar and personnel totals of these offices are representative of NRC's complete nuclear waste management effort. High-level waste management is only a part of this overall effort. Some indication of the level of effort in high-level waste management is provided by the discussion of ongoing contracts in Section II-D.

It is useful to compare the nuclear waste management program support estimates to the program support at higher levels in the NRC. For instance, the new FY 1977 estimate of $3.6 million represents 70% of the program support budget for the Division of Fuel Cycle Material Safety and 19% of the total budget for the Office of Nuclear Materials Safety and Safeguards. In relation to all of the NRC program support, the Waste Management effort represents less than 2%.

Table D-3. Estimated Waste Management Expenditures, FY 1977

	NUCLEAR MATERIAL SAFETY AND SAFEGUARDS (NMSS)	STANDARD DEVELOPMENT (SD)	NUCLEAR REACTOR REGULATION (NRR)	INSPECTION AND ENFORCEMENT (LE)	NUCLEAR REGULATORY RESEARCH (RES)	TOTAL
1) No. of FTE Waste Management Activities (a)	31	4	8	11	1	55
2) Estimated Waste Management Personnel Expenditures	1,150,968	165,420	347,424	422,730	44,590	2,131,132
3) Waste Management Program $ (Contracts)	3,600,000	450,000	--	--	1,908,000	5,958,000
4) Estimated Total Waste Management Expenditures	4,750,968	615,420	347,424	422,730	1,952,590	8,089,132

NOTES:

a) Full Time Equivalent Manpower Estimates, provided by C. Beckwith, 2/77.

Because of the high visibility and institutional complexity of the waste management situation, a variety of educational backgrounds is required to resolve the problems associated with waste management. In a February 2, 1977 document entitled, "NRC Waste Management Personnel Data," the educational backgrounds listed were: nuclear engineering, chemistry, biophysics, physics, chemical engineering, health, physics, and civil engineering. There was only one social scientist listed. Recent communications with NRC officials indicate that changes in the mix of educational backgrounds of the personnel have been initiated.[7]

In summary, the waste management branch has 1) been elevated organizationally, 2) increased its program support budget and number of personnel and 3) initiated changes in the mix of educational backgrounds of its personnel.

B. WASTE MANAGEMENT PROGRAM

The Nuclear Regulatory Commission (NRC) has responsibility under the Atomic Energy Act for regulating management of nuclear wastes at licensed facilities, and at disposal sites. Under the Energy Reorganization Act, NRC was given additional licensing responsibility for long-term storage and disposal of high-level radioactive wastes arising from both ERDA and commercial operations. In addition, the National Environmental Policy Act (NEPA) requires the NRC to assess the environmental impacts of proposed waste management regulations. While NRC responsibilities are in the area of regulation, the Commission is closely working with other agencies to help assure the soundness of the program for dealing with nuclear wastes. The overall nuclear waste management program is designed to assure that necessary facilities and arrangements will be in place when they are needed to deal with nuclear wastes in a safe and environmentally acceptable manner.

The next few years will be critical to the development of an efficient and effective regulatory program for high level waste. This program must be done in a time frame which will provide guidance to ERDA and the nuclear industry, and permit NRC to take action in the national effort to develop effective means for managing and disposing of nuclear wastes. Revised NRC plans and resource requirements to meet the schedule that appeared in President Ford's October 1976 message have been reviewed and authorized as noted in Sections I-D and II-A.

In FY 1976, staffing was begun and work initiated on outlining the program for the regulation of nuclear wastes. The program effort in FY 1977 will emphasize planning and preliminary program development. To achieve this it was necessary to internally reprogram additional staff positions and program support. The increase of positions and

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[7] Personal communication; J. Burns, USNRC with E. Edelson, JPL, March 30, 1977.

program support in FY 1978 will be used for development of the regulatory base: standards, criteria, and licensing methodology.

Based on the ERDA program plan, in FY 1978 one or two requests are expected for site review and early licensing review of selected repository sites for commercial high level wastes. These site reviews will be based on the draft site selection criteria now being developed by NRC. It is expected that ERDA will request NRC to perform an informal review to determine the "licensability" of the repository now being designed under the Waste Isolation Pilot Plan (WIPP) program.

Both a methodology and a supporting data base are being developed in order to make independent assessments of management systems proposed by industry and ERDA. Especially important is development of a methodology for assessing risk associated with long term geologic disposal of high level and transuranic wastes. This program, under the technical management of RES is planned to provide information to assist NMSS and SD in formulating regulations, criteria and standards in a time frame consistent with the licensing schedule.

A framework of regulations, standards, and criteria must be completed at an early date in order to provide guidance for ERDA and the nuclear industry. Through informal agreement with the Office of Standards Development (SD), actions begun by NMSS in the development of standards will be transferred to SD for completion. Increased effort is needed as preliminary studies and other data gathering operations that began in FY 1976 and FY 1977 provide the basis for development of regulations and standards.

The regulatory framework described above must be supported by a comprehensive series of environmental impact statements (EIS). The EIS's required for HLW management are indicated as objectives in the schedules shown in Figures D-2a, D-2b and D-2c. These figures are discussed in Section II-C which provides the general outline for the high-level waste management program, while Section II-D details some of the on-going contracts in high-level waste management.

CURRENT HIGH-LEVEL WASTE MANAGEMENT PROGRAM

The current NRC high-level waste management program consists of 5 major areas:

(1) General Program Planning and Development.

(2) High Level Waste (HLW) Standards Development.

(3) HLW Methodology and Data Base Development.

(4) HLW Licensing.

(5) Agency Interfaces.

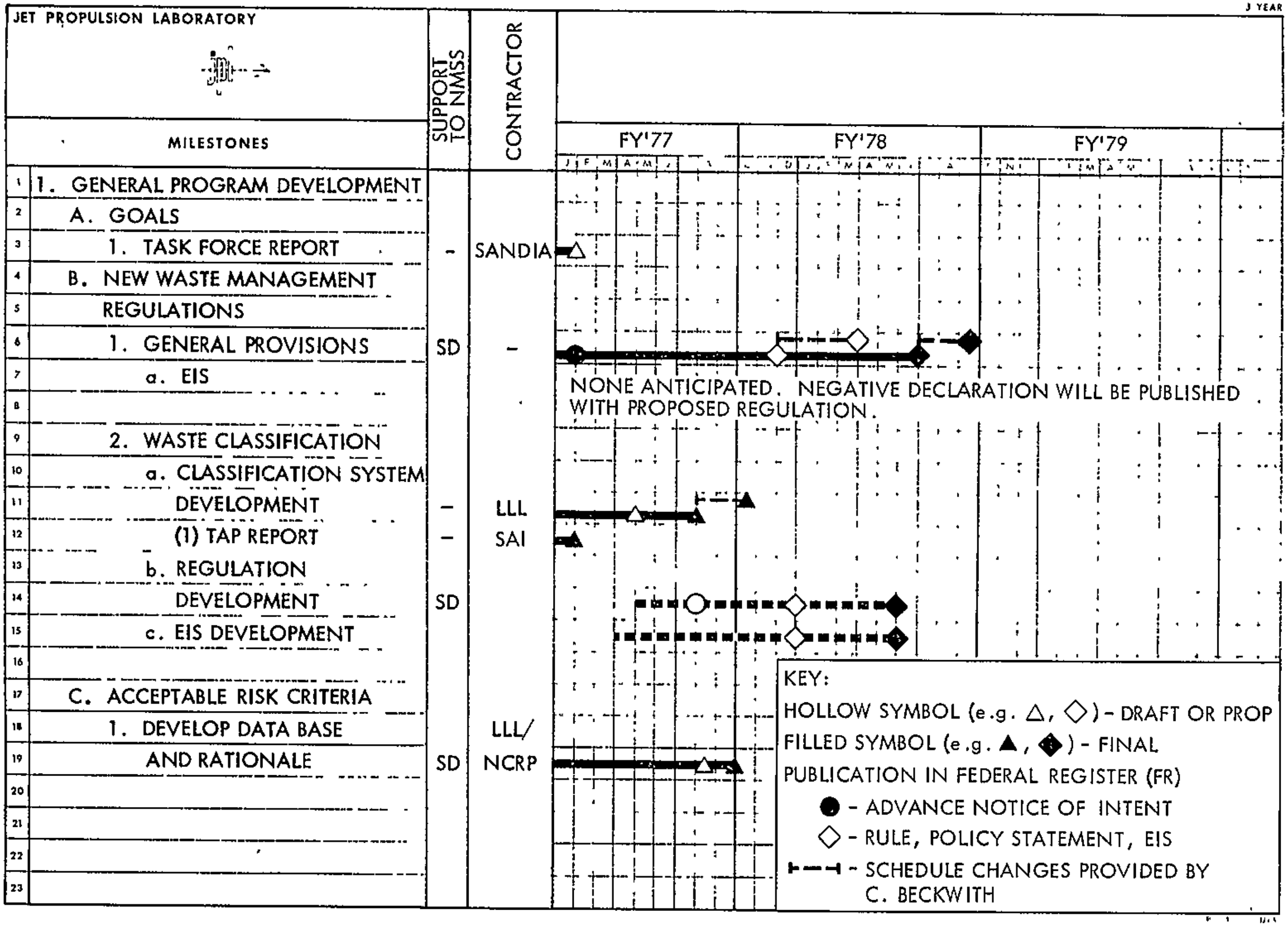

Figure D-2a. Preliminary MBO Schedule--High-Level Waste Management Program (Updated April 27, 1977)

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3 YEAR

JET PROPULSION LABORATORY

MILESTONES	SUPPORT TO NMSS	CONTRACTOR
II. HIGH LEVEL WASTES (HLW)		
A. REGULATIONS/STANDARDS DEVELOPMENT		
1. HLW SOLIDS PERFORMANCE CRITERIA		
a. DEVELOP CRITERIA		LLL
b. REGULATION DEVELOPMENT	SD	
c. EIS DEVELOPMENT		LLL
2. REPOSITORY SITE SELECTION CRITERIA		
a. DEVELOP CRITERIA	NRR	LLL/SANDIA
b. REGULATION DEVELOPMENT	SD	
c. EIS DEVELOPEMNT		
3. REPOSITORY GENERAL DESIGN AND OPERATING CRITERIA		
a. DEVELOP CRITERIA	NRR	LLL
b. REGULATION DEVELOPMENT	SD	
c. EIS DEVELOPMENT		
d. BRANCH POSITION PAPER		
4. RULEMAKING FOR MANAGEMENT OF EXISTING COMMERCIAL HLW (NFS REPROCESSING WASTES)		
a. DEVELOP CRITERIA		BNWL
b. REGULATION DEVELOPEMNT	SD	
c. EIS DEVELOPMENT		

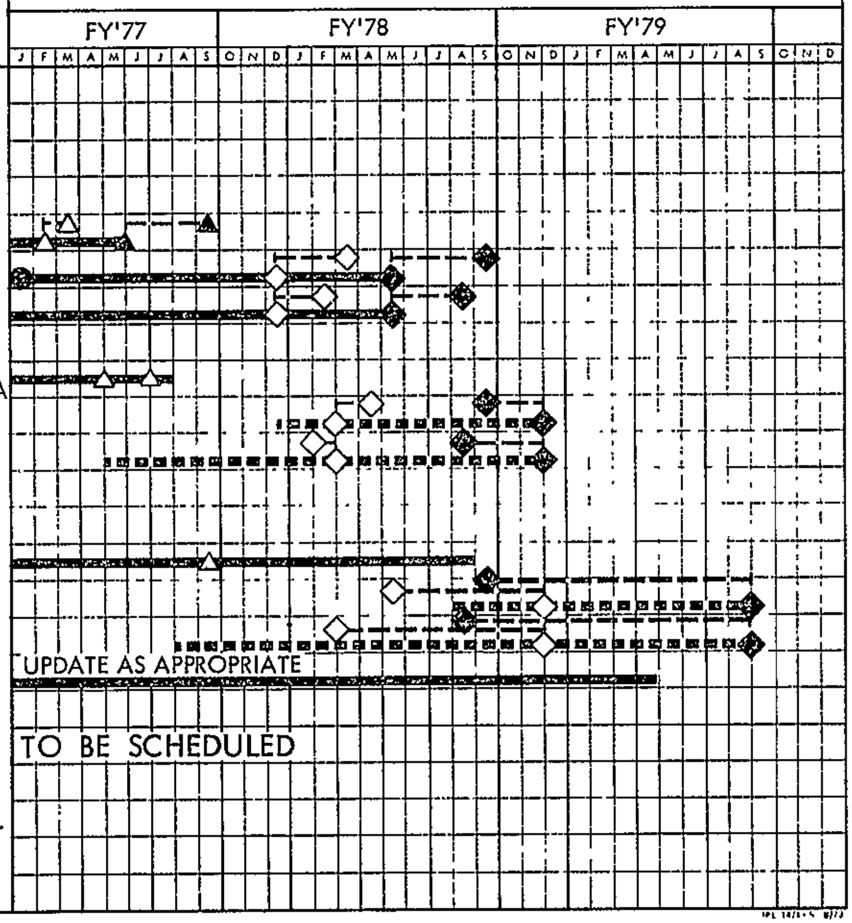

Figure D-2b. Preliminary MBO Schedule--High-Level Waste Management Program (Continuation 1) (Updated April 27, 1977)

JET PROPULSION LABORATORY

MILESTONES	SUPPORT TO NMSS	CONTRACTOR	FY'77 / FY'78 / FY'79
B. METHODOLOGY AND DATA BASE			
1. METHODOLOGY FOR RISK ASSESSMENT OF LONG-TERM ISOLATION	RES/ NRR	SANDIA HOLLISTER	
2. GEOLOGIC SITE PREDICTION			
3. PARTITIONING OF WASTES - FEASIBILITY AND DESIREABILITY			
4. SOLIDIFICATION TECHNOLOGY STUDY		NAS	
5. GEOLOGIC REQUIREMENTS FOR WASTES REPOSITORY		NAS	
6. COLLOCATION OF NUCLEAR FACILITIES AND WASTE DISPOSAL SITES			TO BE SCHEDULED
7. DISPOSAL OF HLW IN SEABED REPOSITORIES		NAS	TO BE SCHEDULED
C. REPOSITORY LISCENCING			
1. PRESENT ERDA SCHEDULE			
a. PRELIMINARY SITE REVIEW	NRR		
b. SITE DEVELOPMENT PLAN REVIEW			
2. TO MEET PRESIDENT'S SCHEDULE			
a. PRELIMINARY SITE REVIEW			
b PSAR	NRR		
c EIS			

Figure D-2c. Preliminary MBO Schedule--High-Level Waste Management Program (Continuation 2) (Updated April 27, 1977)

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Figures D-2a, D-2b and D-2c show a preliminary management by objectives schedule prepared by NRC. The areas listed above are shown in the schedules and are described in the following subsections.

1. General Program Planning and Development

Figure D-2a shows three activities in the area of general program planning and development. The first activity was the organization of a task force to look into the goals of waste management. The task force in its draft reports[8] set forth three guiding principles for NRC's licensing functions:

(1) The burden of proof that the goals of a waste management system are met must rest with the proponents of the technology, and not with the opponents.

(2) Reversibility in the selection and implementation of waste management options is a virtue, and irreversibility is a flaw.

(3) Full and effective public participation must be provided at all stages of the decision-making and implementation process.

The following issues and concerns in the area of nuclear waste management were identified in the draft task force report:

(1) Magnitudes and lifetimes of the potential hazards.

(2) Technologies necessary for the management of the wastes.

(3) Institutions and institutional arrangements required for such management.

(4) Economic considerations (both short- and long-term).

(5) Interference with utilization of other resources.

(6) Foreclosure of future options.

(7) Impact on decisions and/or actions of future generations.

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[8] NRC Task Force Report, Waste Management, October 1976.

(8) Time frames for action (e.g. immediate actions, horizons for prediction, perceived limits for commitment or prediction, etc.).

(9) Uncertainties that will remain during decisionmaking; public involvement in the decisionmaking.

The second activity shown in Figure D-2a is the development of new waste regulations that incorporate the goals listed above in "a framework of regulations, policy statements, standards, and guides for management of nuclear wastes within which NRC can effectively and efficiently carry out the functions dictated by its responsibility to protect the public health and safety."[9] The regulatory framework "will have to be supported by a comprehensive series of environmental impact statements."

10 CFR Part 60, entitled "Licensing of Waste Management Facilities" is presently being developed as the first part of developing waste regulations. Proposed 10 CFR Part 60 including the General Provisions and high level waste subsections is scheduled to be published in March, 1978. Included in these provisions are the administrative procedures and performance criteria for all waste licensing activities. These include criteria for:

(1) High-level waste solidification

(2) Repository Site Selection

(3) Repository Design and Operation

Other efforts that the Nuclear Waste Management staff has recognized are needed include:

(1) Development of a methodology for implementing the goals and regulations.

(2) Development of a data base to be used with the methodology.

(3) Development of a waste classification scheme.

(4) Development of a means of quantifying risk for accidental releases from nuclear waste management operations.

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[9] Malaro, James C., "An Overview of the NRC Nuclear Waste Management Program," U.S. NRC, 1976, page 2.

The third activity is the development of criteria for judging the acceptability of risk. This activity emphasizes criteria, while the fourth need identified immediately above emphasizes the capability of quantifying the risk. The Lawrence Livermore Laboratory has undertaken the responsibility for the development of these criteria in conjunction with the National Council for Radiation Protection. A more detailed description of the contract appears in Section II-D-1.

2. High-Level Waste Standards Development

Figure D-2b shows the four major milestones in the area of standards development for high-level waste as described in the following paragraphs.

The Lawrence Livermore Laboratory (LLL) is developing a system analysis model to help establish performance criteria for high-level solidified waste. The criteria will be established to ensure safety during handling, transportation, storage and disposal of wastes. The model considers normal and potential accident environments. It was developed under the guidance of NRC's Nuclear Waste Management Branch.

An in-house (NRC) earth science task force completed (in October 1976) the initial efforts to define earth science parameters involved in deep geological HLW repository site selection. The task force is now addressing criteria to determine site suitability, with a broader parallel effort to be conducted at LLL. Publication of both proposed site selection criteria and an EIS on the criteria are scheduled for early 1978.

Although a study of the development of design and operating criteria for a repository has not been defined, NRC will include the following in the criteria:

(1) Design of waste handling and safety related systems.

(2) Performance of containment barriers.

(3) Compatibility of waste forms and containment media (radiation, thermal, and chemical effects).

(4) Quality assurance measures for design and construction.

(5) Pre-operational testing.

(6) Accountability of wastes.

(7) Interim storage on site.

(8) Pre-emplacement verification of wastes.

(9) Physical protection of facility (natural phenomena and hostile acts).

(10) Emergency planning (operational phases).

(11) Surveillance (operational and post-operational).

(12) Licensing specifications (limiting conditions for operation).

The fourth activity in standard development is NRC's effort with respect to the reprocessing plant in West Valley, New York. NRC issued an ERDA report "Alternative Processes for Managing Existing High Level Radioactive Wastes" for public comment (April 9, 1976). A proposed regulation governing the management of some 600,000 gallons of liquid high-level waste stored at the NFS reprocessing plant site is planned but not yet scheduled.[10]

3. High-Level Waste Methodology and Data Base Development

NRC requires, but is still trying to develop, an independent capability to evaluate systems proposed by industry and ERDA for the treatment of high level wastes. To accomplish this, a methodology of assessment with an accompanying data base is needed. The following list describes NRC activities in six of the areas shown in Figure D-2c under Methodology and Data Base.

(1) Methodology Development for Risk Assessment of high level waste isolation - Sandia has been contracted to develop a method which can be used to assess the risk to the public health and safety from isolation of high level waste in deep geologic repositories. This program will provide insights and will assist in licensing evaluations. These insights will help identify the important risk related characteristics of the waste isolation process. This contract is discussed in Section IID4 on page D-31.

(2) Geologic Site Prediction - Consultants are working for NRC to determine the feasibility of developing a predictive model involving global geological processes.

(3) Partitioning - A workshop in June 1976 established a basis for further action on the subject of partitioning transuranium elements from nuclear wastes.

(4) Co-location - A study is planned for assessing the value of co-locating nuclear facilities and disposal sites to reduce potential for transportation related accidents.

[10] Personal communication with J. Burns, U.S. NRC March 30, 1977.

(5) Seabed and Other NAS Programs - Contract with NAS includes review and assessment of:

   (a) HWL solidification technology.

   (b) Geological requirements for assessing stability and integrity of HLW repositories.

   (c) Disposal of HLW in seabed repositories.

   Items a and b are scheduled for September, 1977 and item c will be scheduled for some time in 1978.

(6) Earth Science Task Force (ESTF) - The ESTF will identify NRC staff requirements for model development, review methodology development and specific site testing requirements. (February 1977). This will be integrated into NRC models and assessment methodologies. The need and scope of such models and methodologies will be a continuing subject of future waste management program efforts along with development of a Standard Review Plan for a proposed HLW Repository.

4. High-Level Waste Licensing

To support licensing reviews of ERDA HLW facilities (Section 202 of the Energy Reorganization Act of 1974) consideration is being given to techniques for protecting public health and safety, assuring timely licensing decisions, and obtaining public participation. Figure D-2c shows two schedules for repository licensing--the schedule before President Ford's October message and the schedule required by that message. Two areas of confusion that need to be resolved in high-level waste licensing are:

(1) Clarification of NRC Ownership of Waste, per 10 CFR 50 - Granting title to NRC for the radioactive waste material transferred to a federal repository has been a source of confusion to both NRC and ERDA personnel. Action is underway to get this resolved.

(2) Environmental Impacts for Repository Licensing, Where Two Federal Agencies are Involved - Formal licensing for a repository requires resolution of the environment impact statement, where two Federal Agencies are involved. Questions of scope of these EIS's must be resolved.

5. Agency Interfaces

As part of the Waste Management Program, the NRC staff must interact with a number of other Federal Agencies. A brief description of these activities follows:

(1) NRC/ERDA - Currently the Waste Management Program Staff is working with ERDA Headquarters, ERDA Field Offices at Richland, Washington and Battelle Northwest Laboratories regarding the GEIS on Waste Management. NRC plans to prepare a description of the NRC Waste Management Program for inclusion. NRC is also advising ERDA on responses to various issues including policy statements by the President which accelerate the federal schedule for providing disposal of nuclear high level wastes, and the concept of a national Waste Management corporation as proposed by Mason Willrich.[11]

(2) Licensing - The problems of ownership of nuclear high level waste covered by 10 CFR 50 and the resolution of EIS's for two Federal Agencies are being actively coordinated between NRC/ERDA.

(3) Non-Licensing Reviews - NRC Waste Management Program Staff also conducts reviews prepared by, or for, ERDA or its contractors which are not part of the licensing jurisdiction. Examples include: interim management of Savannah River Plant wastes during development of technology for the long term; EIS's for Hanford Reservation and the Idaho National Engineering Laboratory. It is expected that this will also be accomplished for long-term management of nuclear military wastes.

(4) NRC/EPA - Waste Management Program Staff is participating in a working group convened by EPA to develop General Environmental Radiation Standards. Arrangements have been made for other NRC and LLL personnel to support this activity. Waste Management Program staff is assisting EPA in preparing U.S. policy regarding ocean disposal of radioactive wastes in reaction to IAEA proposals.

[11] Mason Willrich, Radioactive Waste Management and Regulation, Draft Report to ERDA from MIT Energy Laboratory, September 1, 1976.

(5) Interagency Groups - In March, 1976, an interagency task force was convened by OMB, to review WM programs and to help structure these into an integrated federal program. Chaired by OMB, representatives include NRC, ERDA, EPA, CEQ, NSF, and USGS. Issues addressed to date include: ERDA's proposed schedule for construction of HL waste repository, NRC's role in licensing the initial repository, and agencies' roles in developing nuclear waste management criteria. This task force was phased out at the end of July, 1976 and replaced by the Fri Committee. The Fri Committee finished its activities in October 1976.

Another important interface is with the states, especially with respect to siting of repositories. NRC is aware of the need for carefully handling this interface. Plans call for involving the state in the upcoming workshops to discuss the siting criteria developed by Lawrence Livermore Laboratory (see II-D-1).

D. NRC WASTE MANAGEMENT PROGRAM--ON-GOING CONTRACTS

NRC has a number of on-going contracts in nuclear waste management that support the program areas described above and as shown in Figures D-2a, D-2b, and D-2c. Figure D-3 and Table D-4 summarize all the contracts on-going in Fiscal Year 1977. Figures D-4 through D-8 show the task breakdowns for each of the high-level waste related contracts. These figures were generated by JPL based on information provided by NRC.

Details of the objectives and tasks of the high level waste management contracts are presented below. All of these descriptions are taken directly from the NRC's "189 Forms" and the descriptions of the contracted efforts. The numbers in parentheses refer to the major boxes shown in Figures D-3 through D-7.

1. Technical Support in the Development of Nuclear Waste Management Criteria (1.1)

The Nuclear Regulatory Commission is currently developing a framework of regulations, criteria, and standards within which it can effectively and efficiently regulate, manage and dispose of radioactive wastes as described in sections II-C-1, and II-C-2. Lawrence Livermore Laboratory (LLL) is currently providing broad technical support on a continuing basis to aid in developing such a framework. Their technical capabilities will be utilized to develop computer model simulations, environmental impact statements for specific regulations, and to aid in establishing criteria for acceptable risk in conjunction with the National Council for Radiation Protection. LLL will perform the following tasks as shown in Figure 4.

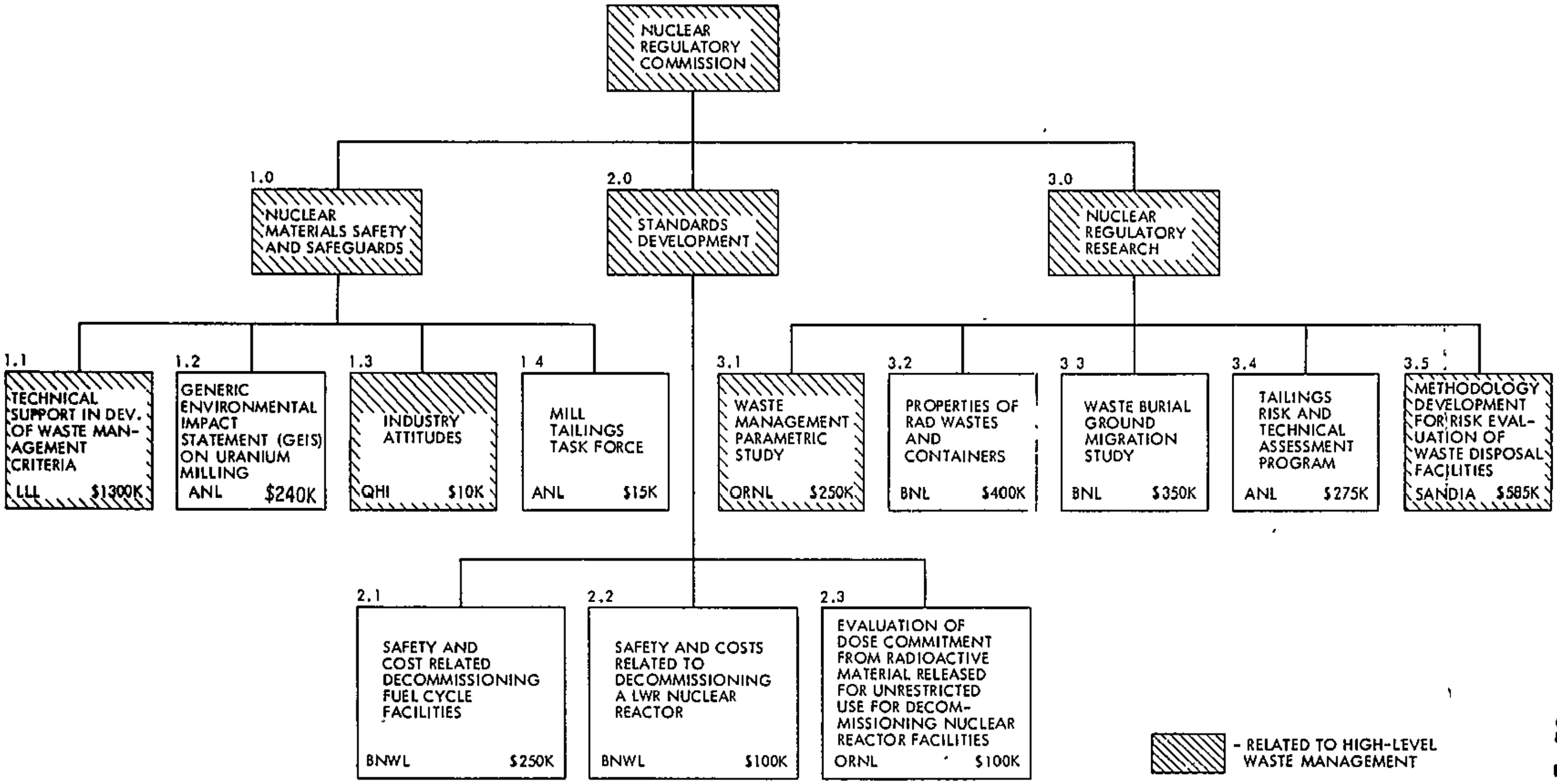

Figure D-3. NRC On-Going Contracts in Waste Management, FY 1977

Table D-4. Waste Management Program Contracts - Ongoing

Title	FY 77 (K$)	Performance Start	Performance End	Office	Contractor
Technical Support in Development of Nuclear Waste Management Criteria	1300	10/76	FY 78	NMSS	LLL
GEIS on Uranium Milling	240	8/76	FY 78	NMSS	ANL
Industry Attitudes	10	11/76	3/77	NMSS	QHI
Mill Tailings Task Force	15	3/76	6/77	NMSS	ANL
Review of Non-Fuel Cycle Waste	63	7/76	9/77	RES	University of Maryland
Waste Management Parmetric Study	250	6/75	FY 78	RES	ORNL
Properties of Radwastes and Containers	400	8/75	6/78	RES	BNL
Waste Burial Ground Migration Study	350	6/75	FY 80	RES	BNL
Tailings Risk and Technical Assessment Program	275	4/76	FY 78	RES	ANL
Methodology Development for Risk Evaluation of Waste Disposal Facilities	585	2/76	9/78	RES	Sandia
Safety and Cost Related to Decommissioning Fuel Cycle Facilities	250	7/74	9/77	SD	BNWL
Safety and Costs Related to Decommissioning a LWR Nuclear Reactor	100	7/76	9/78	SD	BNWL
Evaluation of Dose Commitment from Radioactive Material Released for Unrestricted Use from Decommissioning Nuclear Reactor Facilities	100	FY 76	9/77	SD	ORNL

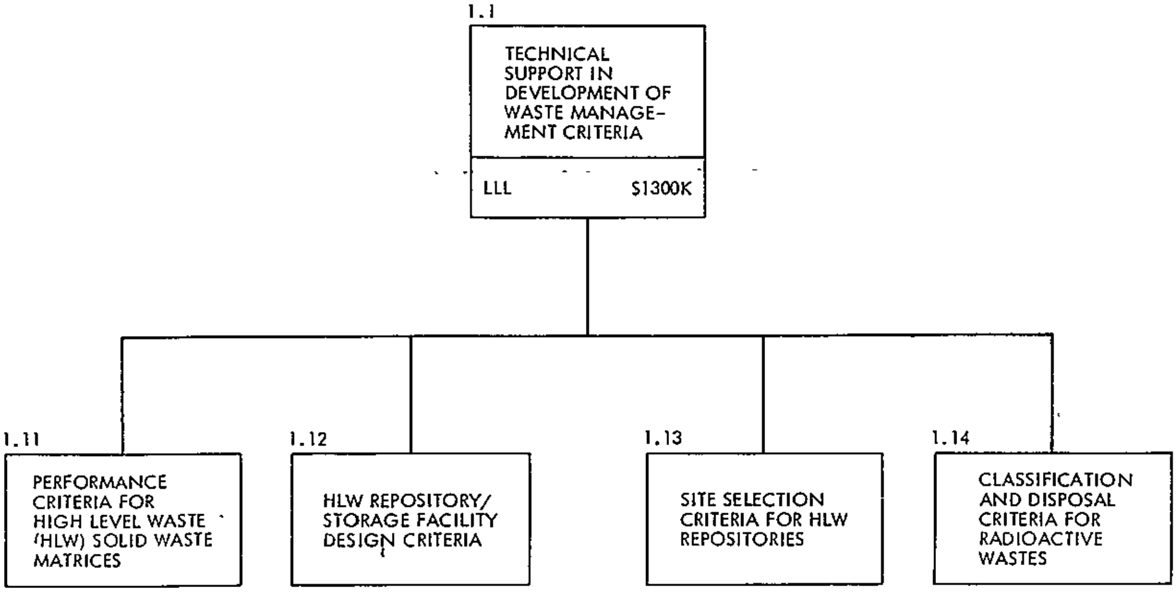

Figure D-4. Lawrence Livermore Laboratory, Nuclear Waste Program for NRC, FY 1977

Task 1. Performance Criteria for Solidified HLW (PCSHLW) (1.11). Figure D-2b shows the schedule for the LLL task in the area of developing criteria for solid waste performance. "LLL will verify its analytical findings and recommendations from its FY 76-76T work on PCSHLW. LLL will extend the analytical model developed during FY 76-76T and use the extended model in its verification. LLL will provide a documented technical basis for its findings, analytical models, and analytical assumptions and provide the data base used as a basis for their recommendations. This information will be summarized in a draft report by May 1, 1977 and in a final report by July 1, 1977.

LLL will also analyze the impact of a regulation setting forth PCSHLW and submit to the NRC an impact statement in a format and form to be specified by the Waste Management Technical Monitor (WMTM). The impact statement will be submitted in preliminary draft form for NRC review by June 1, 1977 and in final draft form by July 25, 1976."

Task 2. Classification of Radioactive Wastes (1.14). As shown in Figure D-2a, the development of a waste classification system is part of the development of new waste management regulations. "In FY 76-76T LLL participated in a waste management program funded task force charged with reviewing proposed and potential waste management classification systems and developing and recommending a classification system for NRC regulatory use. In continuation of that effort, LLL will provide a technical basis for the classification system adopted by the Waste Management Program (WMP) that considers in detail the pros and cons of using that classification system. The technical basis will be compiled in a report and submitted to the NRC by June 1, 1977.

"LLL will also assess the environmental impacts associated with adopting the classification system for regulatory use and submit a draft environmental impact assessment for WMP staff review by June 1, 1977."

Task 3. "HLW Repository Site Selection Criteria (1.13). "LLL will develop site selection criteria for HLW repositories taking into account earth science parameters, test boring restrictions, demography, transportation, socioeconomic factors, natural resources, and other pertinent factors germane to locating a HLW repository. LLL will consider potential NRC data requirements, including input from the WMP Earth Sciences Task Force, in developing the criteria. LLL will consolidate their recommendations in a report to the NRC by April 15, 1977." This task will support the NRC in-house task force described in Section II-C-2.

"LLL will also assess the environmental impacts of a regulation based on the PCSHLW. LLL will submit to the NRC an impact statement in a format and form to be specified by the WMTM. The impact statement will be submitted in preliminary draft form for NRC review by November 1, 1977."

Task 4. Acceptable Risk Criteria. As mentioned in section II-C-1, "LLL will evaluate and develop a basis for criterion, setting forth 'acceptable risk' for use in waste management evaluations. LLL will evaluate alternative methods and levels of risk, report their findings to the NRC, and provide a technical basis for their findings. LLL will coordinate their activities with those of the National Council on Radiation Protection. LLL will submit draft and final reports on July 1, 1977 and September 1, 1977, respectively, as indicated in the preliminary schedule in Figure D-2a.

2. Assessing Industry Awareness of Issues Surrounding Nuclear Wastes (1.3)

"In an effort to establish a publicly, politically, economically, and technologically acceptable waste management system, it is important that NRC be familiar with issues that are relevant to electric power consuming industries." The tasks required can be separated into two phases as shown in Figure D-5. Quarry Hill, Inc. is the contractor.

3. Parametric Study of Management of Wastes from LWR Fuel Processing Plants (3.1)

"The objective of this study by the Oak Ridge National Laboratory (ORNL) is to assess the impact on fuel cycle industries of licensing requirements that might be imposed for purposes of effluent control and waste management. (See Figure D-6.) The cost/benefit analyses presented in previous ALARA (as low as reasonably achievable) reports are limited to reducing the amounts of radioactive materials released at the plants. However, an analysis of all of the costs that would occur in meeting licensing requirements is required for the computation of a true cost/benefit analysis.

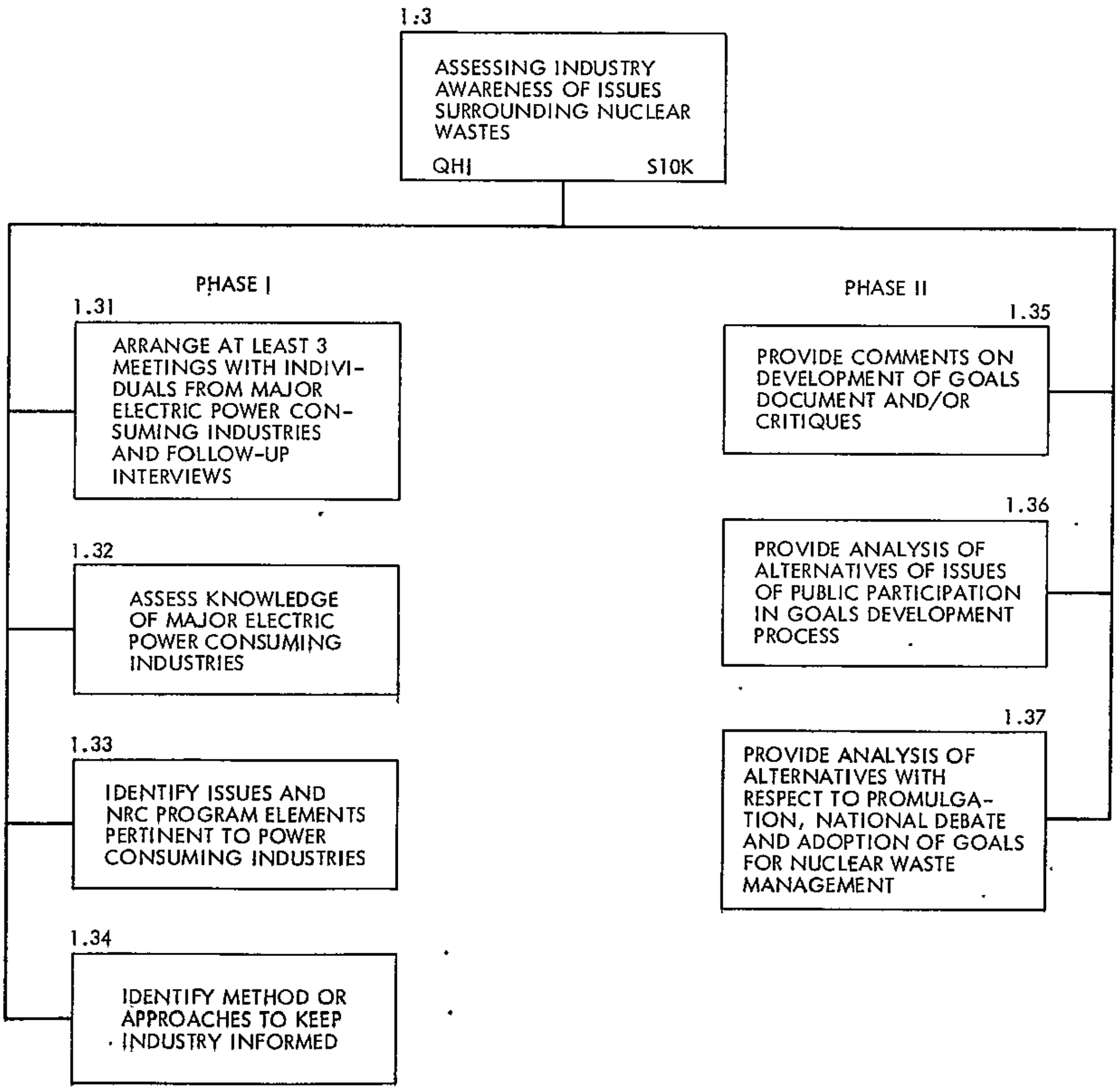

Figure D-5. Quarry Hill, Inc., Nuclear Waste Contract, FY 1977

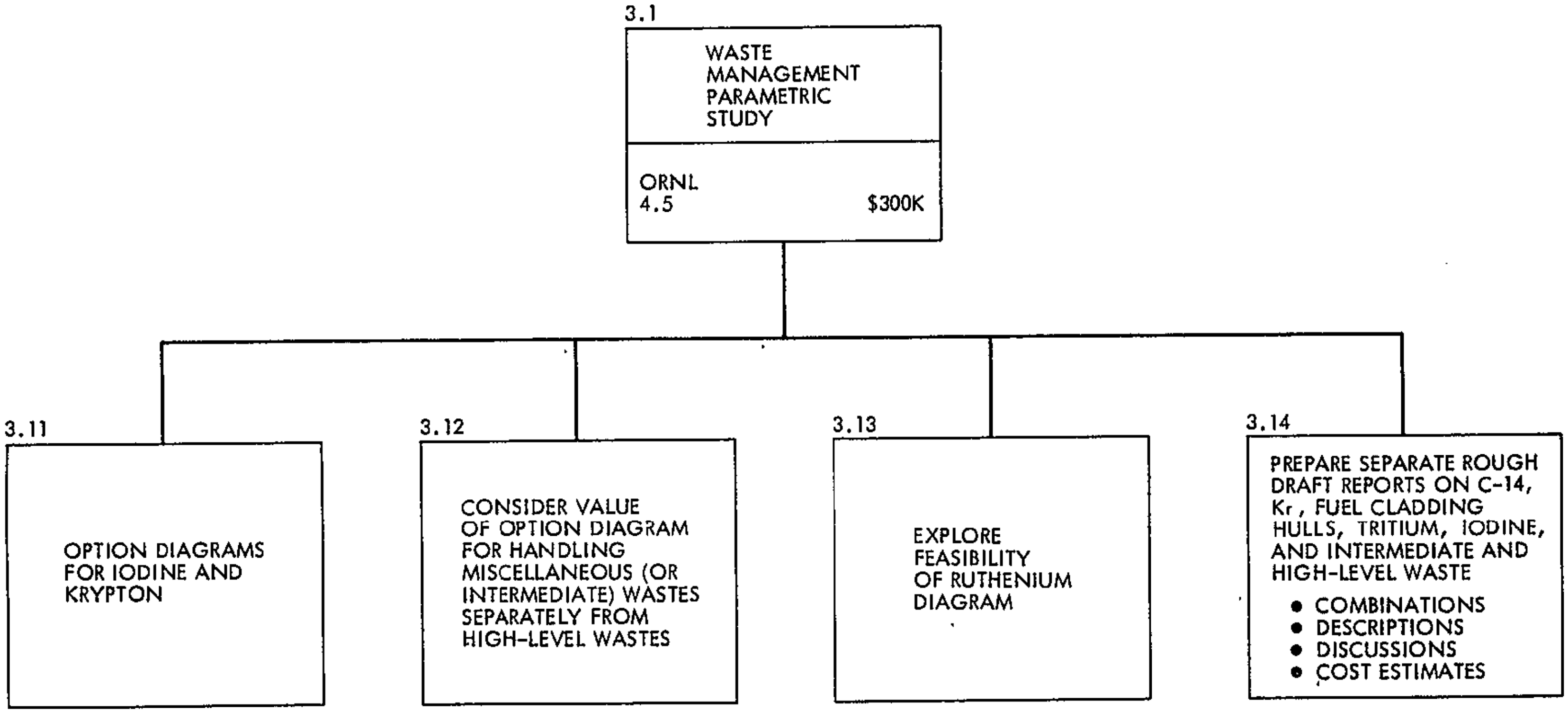

Figure D-6. Oak Ridge National Laboratory Nuclear Waste Contract, FY 1977

"A parametric study will be made of the principal options that are available or that can be developed within the next decade for reducing radioactive releases to the environment. Each waste stream will be considered at every stage of its management from collection, conditioning, and storage within the plant, through its shipment and final disposal. The incremental cost for performing each operation, including any necessary R&D, will be estimated. Then, the total cost will be computed for management by the different paths available. Current collection, treatment, and disposal practices will be used as a base case. The first phase will consider the wastes from LWR fuel reprocessing plants. The waste from fuel fabrication and other fuel cycle facilities will be studied later.

"A computer program for a model fuel reprocessing plant was written which calculates the internal and output flowrates and concentrations for over twenty radionuclides. The output of this program provides the compositions and flowrates of effluent streams which must be collected, treated, packaged, stored, transported, and ultimately permanently isolated. A complete listing of all the wastes, their estimated generation rates, and the radioactivity in them was compiled. Each waste has several treatment options available. These options are being charted to produce a network diagram amenable to computer analysis. The large number of waste management paths generated in this analysis can be handled by use of a digital computer simulation program. A large part of this effort will be to study the interaction between fuel reprocessing and waste disposal. Cost algorithms will be derived for each step. Much of the needed cost information will come from a search of the literature. Determination of the waste management procedures that meet proposed regulatory standards at the lowest cost will require searching for the optimal waste handling paths. Dynamic programming might also be used for this purpose. The objective is to keep the total unit cost of waste disposal and reprocessing ($/kg uranium reclaimed) as low as possible for a given regulatory standard."

"The first draft of a report describing the economics of alternative processes and mixes of processes for waste management in a fuel reprocessing plant will be prepared and issued. The report will illustrate the use of computer analysis to optimize the selection of waste management methods (most economical) for alternative regulatory standards. Studies on the economic interaction between fuel fabrication and waste management will begin."

"The first draft of a report describing the economics of processes and mixes of processes for waste management in a fuel fabrication plant will be prepared and issued." The results of this contract, although not specifically shown in NRC's management by objectives schedule, should be helpful in methodology and data base development discussed in section II-C-3."

4. Risk Assessment Methodology Development for High Level Waste Isolation (3.5)

As noted in section II-C-3, Sandia Laboratory is developing a risk assessment methodology for evaluating repository safety. "The risk assessment is to be in terms of post commissioning time, i.e., after the facility has been sealed. The time periods, t, initially chosen for analysis following commissioning are:

$0 \leq t \leq 10^2$ years - natural subsidence times

$10^2 \leq t \leq 10^3$ years - decay of fission products

$10^3 \leq t \leq 10^6$ years - decay of actinides

Time subdivisions may be altered by natural changes in the systems or by the 'natural epochs-of-change.'

"Initially the assessment is to be in terms of hazards to man and their attendant probabilities. However, analysis should be compatible with the eventual assessment of resource commitment and resource denial. Resource commitment implies the potential need of resources to ameliorate the effects of an incident outside the design envelope and to recover from the effects of the incident. If it is not possible to recover from the effects of an incident, there may be some resource denial, e.g., contaminated water supply."

"Output of the risk assessment is to be compatible with WASH-1400 to enable the eventual assessment by NRC of risks for the complete nuclear fuel cycle."

"The results of the FY 77 activity will be reported in a draft document and with the associated outlined as follows:

<u>Introduction</u>

Chapter I.	Definition of a Reference System for Analysis (1/31/77)
Chapter II.	Analysis of Normal Behavior of Reference System (2/28/77)
Chapter III.	Analysis of Reference System Failure (3/31/77)
Chapter IV.	Transfer of Radionuclides to the Biosphere (12/31/76)
Chapter V.	Pathways to Man (4/30/77)
Chapter VI.	Dosimetry (3/31/77)
Chapter VII.	Dose Response (2/28/77)
Chapter VIII.	Risk Model Development, and Calculations (4/30/77)

Chapter IX. Guidelines for Site Selection Criteria (5/31/77)

Chapter X. Risk Perspectives (7/31/77)

Appendices

Definitions of Terms

Bibliography

Acknowledgments"

Figure D-7 shows the task breakdown for this risk assessment program.

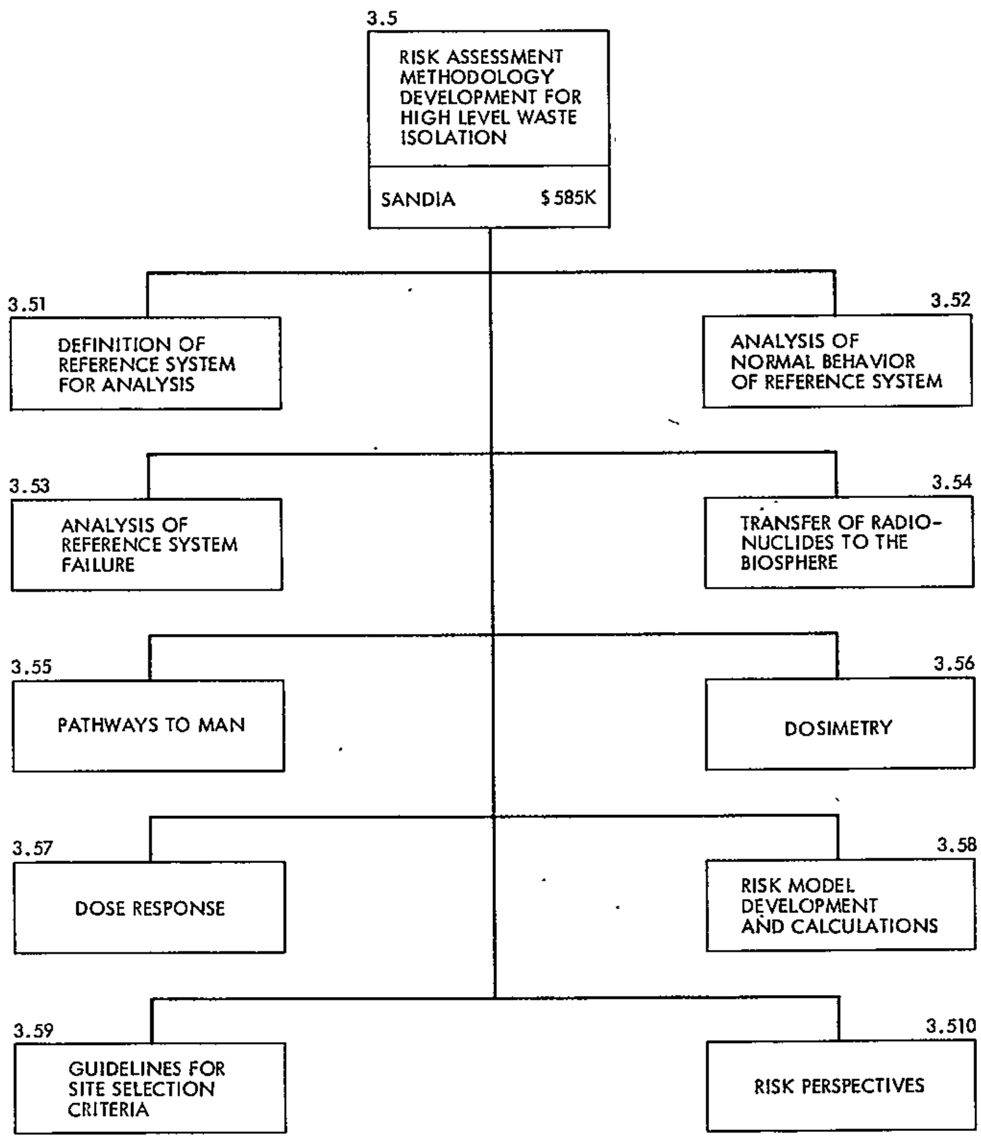

Figure D-7. Sandia Laboratories, Nuclear Waste Management, Contract, FY 1977

III. ORGANIZATION OF NRC OFFICES

Figure D-1 (page D-5) showed the overall operational organization of the NRC. Table D-1 (page D-8) showed the budget for the five line offices. Further breakdowns of Figure D-1 and Table D-1 are provided below. In Sections A to E the objectives, organization, responsibilities and budget for each of the five line offices are described. Since this section emphasizes those activities related to nuclear waste management, it should be noted that a given office will undertake activities in addition to those listed here.

A. OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARD

The overall responsibility of the Office of Nuclear Material Safety and Safeguard (NMSS) has been described as ensuring public health and safety, and the safety of environment in licensing and regulation of all facilities and materials associated with the processing, transport, and handling of nuclear materials, including review and assessment of the safeguard of materials against potential threats, thefts and sabotage. As noted previously, the NMSS office exhibits the largest growth of the five offices. The organizational chart in Figure D-8 shows that NMSS has two divisions: (1) Safeguard and (2) Fuel Cycle and Material Safety.

1. Safeguards Division

The Division of Safeguards is responsible for developing, implementing and evaluating an overall nuclear safeguards program including:

(1) Monitoring, testing and recommending improvements for the physical protection of nuclear facilities and material.

(2) Accounting and control of nuclear materials.

(3) Developing contingency plans for dealing with threats, thefts, and sabotage relating to nuclear materials, high-level radioactive wastes and nuclear facilities.

(4) Reviewing physical security and material accountability measures proposed in license applications.

(5) Developing and maintaining a nuclear safeguards information system.

(6) Assisting U.S. Government agencies, and foreign governments, in their international physical security and safeguards programs.

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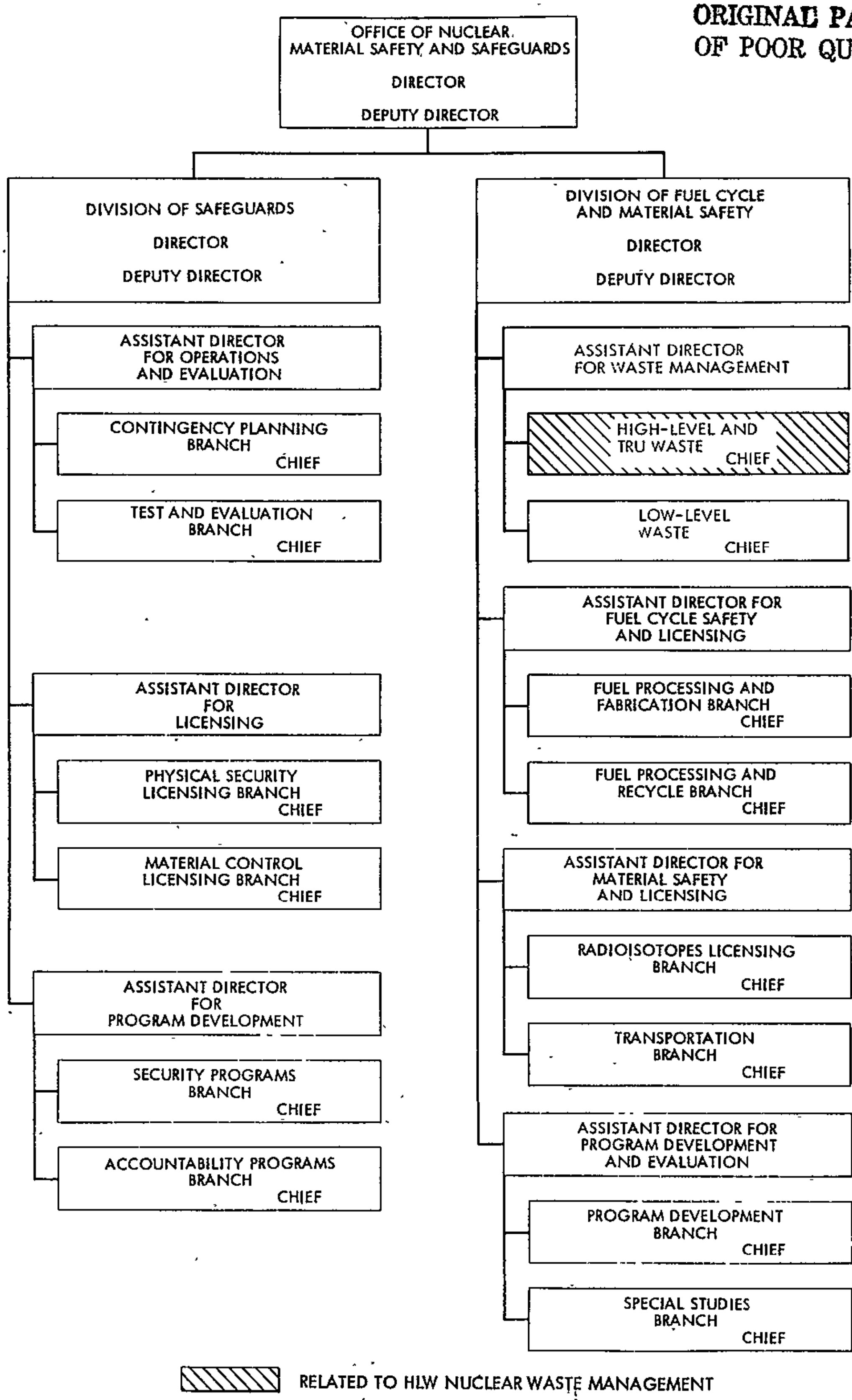

Figure D-8. Organization Chart for Office of Nuclear Material Safety and Safeguards (NMSS)

NRC's 1977 budget estimate gives high priority to safeguards. (See Table D-5). This increased effort is reflected in the increased resources requested to establish an effective safeguards organization and to accelerate studies to develop integrated and effective safeguards systems consisting of upgraded material control and accounting measures and physical protection measures. Safeguards research will be expanded to develop a more systematic and comprehensive criteria for NRC safeguards policy and programs, and to improve procedures for licensing review and inspection.

2. Fuel Cycle and Material Safety Division

The Division of Fuel Cycle and Material Safety has assistant directors for Fuel Cycle Safety and Licensing, Material Safety and Licensing and Program Development and Evaluation. (See Figure D-8.) The former is responsible for safety and environmental reviews in conjunction with:

(1) The licensing of all types of non-reactor nuclear fuel facilities.

(2) The licensing of containers for shipment of spent fuel and other radioactive materials.

(3) The licensing of waste disposal facilities.

(4) The administration of the program for cooperation with Agreement States.

Additional support is also directed towards assessment of evolving technology for the improvement of safety and environmental protection; the preparation of broad programmatic environmental statements, and the identification and coordination of related standards and research requirements. Resources are also being used to prepare testimony for hearings and rulemaking with respect to the General Environmental Impact Statement on Mixed-Oxide Fuels. A detailed budget breakdown appeared in Table D-5.

In mid-March, the NRC established a third assistant director in NMSS - an assistant director for radioactive waste management. There will be two branches under the assistant director: (1) high-level waste and TRU's Waste Branch and (2) low-level waste branch. Thirty-one positions have been authorized for this new division. Some of the responsibilities of the assistant director for Fuel Cycle, Safety and Licensing have been transferred to the new assistant director.

B. OFFICE OF NUCLEAR REACTOR REGULATION

The goal of the Office of Nuclear Reactor Regulation is to assure, through the licensing process, the protection of the public's health and

Table D-5. Budget for the Office of Nuclear Material Safety and Safeguards (NMSS)

	Actual FY 1976		Estimate FY 1977		Estimate FY 1978	
	Dollars	People	Dollars	People	Dollars	People
Safeguards	$ 937	69	$3,627	104	$ 4,744	124
Fuel Cycle and Material Safety	2,884	98	5,110	122	6,082	142
Management Direction and Support	46	16	137	16	145	18
Studies and Analysis	1,693	9	0	22	0	0
Total Program Support	$5,560	192	$8,874	264	$10,971	284
Other *	6,168		9,866		11,119	
TOTAL	$11,728		$18,740		$22,090	

*Includes Personnel Compensation, Personnel Benefits, Administrative Support, Travel, and Equipment

Source: U.S. Nuclear Regulatory Commission, Budget Estimates, Fiscal Year 1978, pg 33.

safety, the environment, national security, and the satisfaction of anti-trust considerations. To accomplish these objectives, NRR responsibilities include:

(1) development of regulatory, policies and procedures, governing construction and operation of Nuclear Reactors, licensed under the Atomic Energy Act of 1954 and Energy Reorganization Act of 1974.

(2) review of the safety, safeguards, and environmental impact of such facilities.

(3) licensing of operators of such facilities.

(4) providing special assistance in materials involving facilities exempt from licensing.

In the case of fuel cycle and waste management, NRR provides direct support to NMSS in fuel cycle facility safety reviews. This effort, principally in the fields of seismology, geology and meteorology. Figure D-9 shows the organization of NRR. Table D-6 provides a detailed budget breakdown for the Office of Nuclear Reactor Regulation. Note that the budgetary emphasis is on construction permit and operating reactor activities.

C. OFFICE OF NUCLEAR REGULATORY RESEARCH

As shown in Table D-7, about 80% of all program support of the Office of Nuclear Regulatory Research (RES) goes to reactor safety research.

However, this office is also responsible for the development of an independent assessment capability of the safety and environmental impacts of the nuclear fuel cycle. In the past, the biological and environmental programs of AEC had a much broader motivation than specifically serving regulatory needs. They ranged from very basic research to applied research. All these programs remained in ERDA after the division of the AEC. In developing its own mission-oriented program to supply the confirmatory assessment needs in these areas, NRC has started with the extensive data base developed by AEC and is coordinating its efforts with the large ongoing program in ERDA. Initial NRC efforts cover four principal areas: (1) health and environmental impact, (2) fuel cycle assessment research, (3) waste management, and (4) transportation. Confirmatory assessment activities planned for 1977 will continue and expand on the 1976 program.

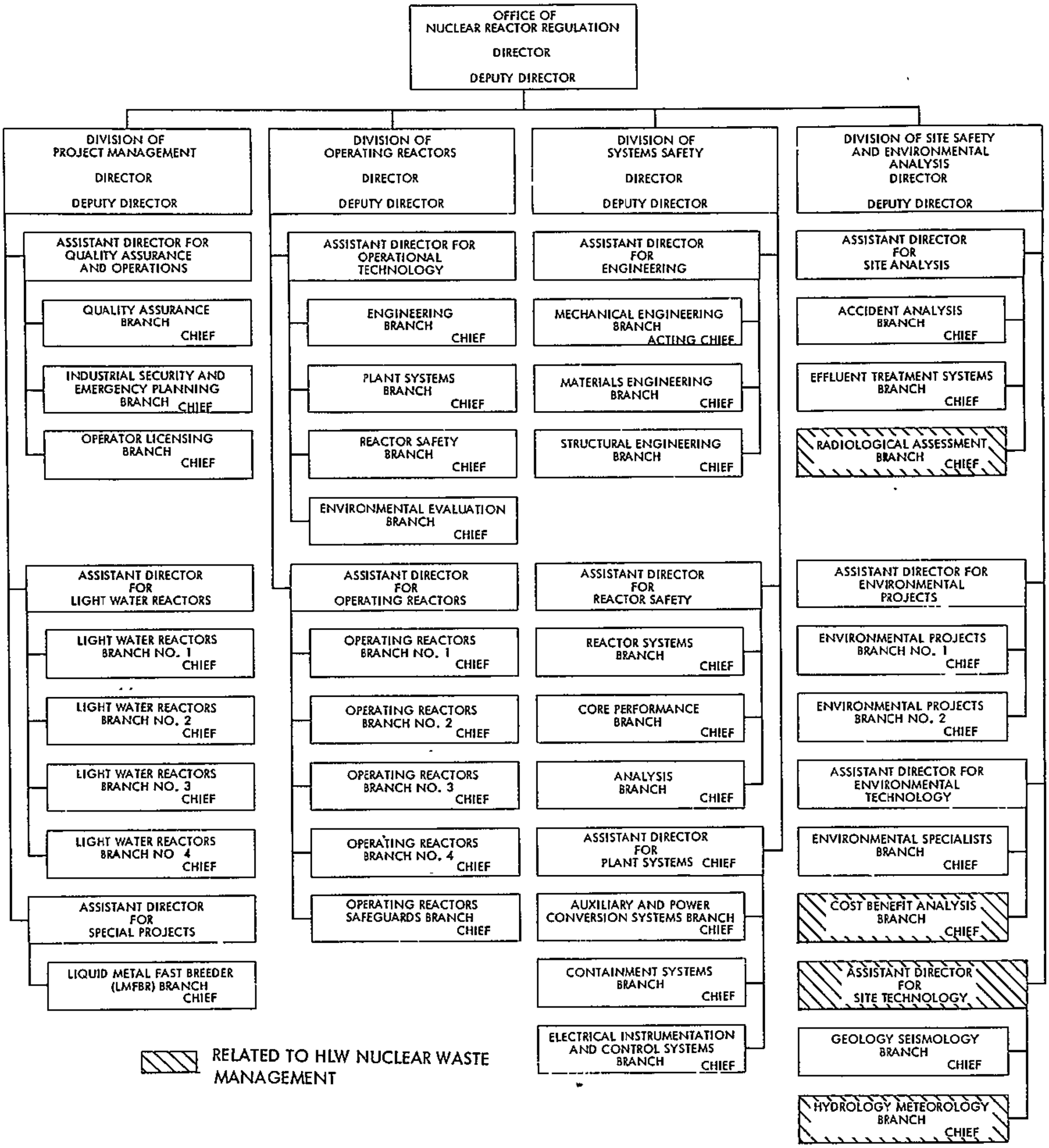

Figure D-9. Organization Chart for Office of Nuclear Reactor Regulation (NRR)

Table D-6. Budget for the Office of Nuclear Reactor Regulation (NRR)

	Actual FY 1976		Estimate FY 1977		Estimate FY 1978	
	Dollars	People	Dollars	People	Dollars	People
Operating Reactors	$ 360	172	$ 1,885	189	$ 3,330	223
Safeguards	0	6	500	24	600	22
Operating Licenses Reviews	0	52	900	49	1,100	51
Construction Permit Reviews	5,702	213	6,312	199	5,037	178
Technical Projects	3,552	90	3,973	91	3,586	101
Standards	0	22	0	22	0	13
Management Direction and Support	289	42	840	39	654	30
Total Program Support	$ 9,903	597	$14,410	613	$14,307	618
Other*	22,135		26,170		25,683	
TOTAL	$32,038		$40,580		$39,990	

*Includes Personnel Compensation, Personnel Benefits, Administrative Support, Travel, and Equipment

Source: U.S. Nuclear Regulatory Commission, Budget Estimates, Fiscal Year 1978, pg. 13.

Table D-7. Budget for the Office of Nuclear Regulatory Research (RES).

	Actual FY 1976		Estimate FY 1977		Estimate FY 1978	
	Dollars	People	Dollars	People	Dollars	People
Reactor Safety Research	$74,496	68	$ 86,454	80	$106,200	88
Environmental and Fuel Cycle	6,910	15	12,468	18	15,675	22
Safeguards Research	2,831	10	9,113	10	10,935	13
Management Direction and Support	0	25	0	27	0	27
Total Program Support	$84,237	118	$108,035	135	$132,810	150
Other*	4,195		5,853		6,290	
Equipment and Construction	$ 9,623	0	$ 8,092	0	$ 9,300	0
TOTAL	$98,055		$121,980		$148,400	

*Includes Personnel Compensation, Personnel Benefits, Administrative Support, Travel, and Equipment

Source: U.S. Nuclear Regulatory Commission, Budget Estimates, Fiscal Year 1978, pg. 46.

A third group, the probabilistic analysis branch reports directly to the director of RES and has responsibility for the management of technical direction over major programs in waste management. This program entitled, "Risk Assessment Methodology Development for High-Level Waste Isolation", is being carried out at Sandia Laboratories. This program, described in more detail in Section II-D-4, is designed to provide instructions and information which will assist the Office of NMSS in the licensing of waste repositories, specifically in establishing site selection criteria, site suitability criteria, and repository design criteria.

An organizational chart for the Office of Nuclear Regulatory Research appears in Figure D-10.

D. OFFICE OF STANDARDS DEVELOPMENT

The objective of the Office of Standards Development (SD) is to develop the standards NRC needs to regulate nuclear facilities and commercial uses of nuclear materials. By the end of 1976, most of the standards for light-water reactors and the current system of safeguards will essentially be completed. In 1977, emphasis will be on programs related to development of new safeguards systems for the nuclear fuel cycle of the future. There will be a substantial increase in effort on improved material control systems to include the physical protection of special nuclear material in transit.

NRC employs three types of standards:

(1) NRC Regulations - statements of public policy, establish acceptable levels of performance and form basis for enforcement actions.

(2) NRC Guides - detailed engineering or other technical standards which describe in detail acceptable methods of achieving the required levels of performance.

(3) Consensus Standards - developed by National Standard Program with participation of NRC staff. If found acceptable after thorough, independent review by the NRC staff they are endorsed in regulations or regulatory guides.

The task areas of the Office of Standards Development are:

(1) Site Safety Standards Program.

(2) Environmental Standards Program.

(3) Nuclear Power Plant Standards.

(4) Materials and Plant Protection Safeguard Standards.

(5) Fuel Cycle Facility Standards.

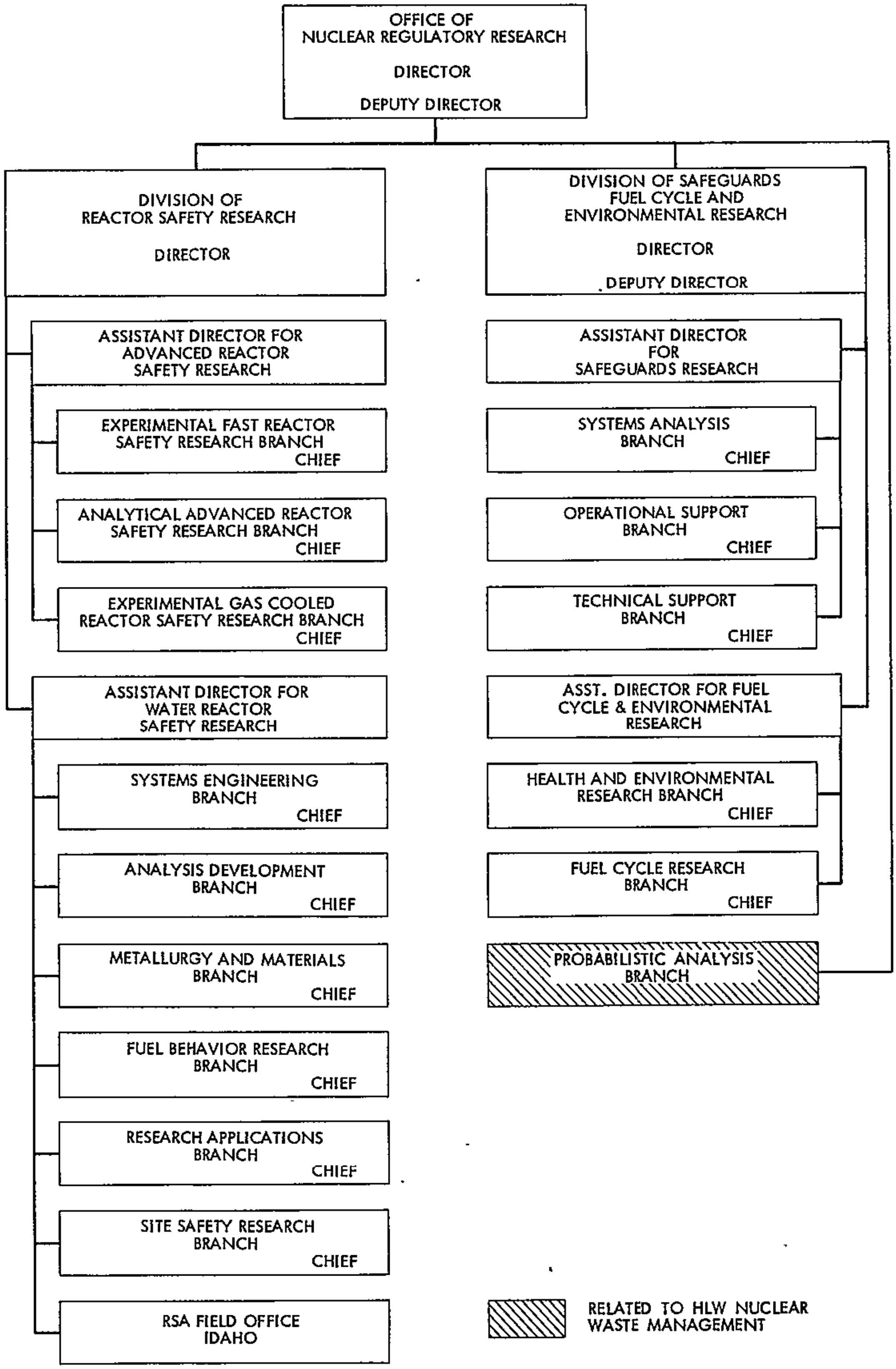

Figure D-10. Organization Chart for Office of Nuclear Regulatory Research (RES)

(6) Transportation and Product Standards.

(7) Radiation Standards.

In the area of Fuel Cycle Facility Standard SD plans to:

(1) Develop general design criteria for interim and ultimate waste disposal facilities.

(2) Issue for public comment the general design criteria for mixed oxides fuel fabrication facilities and issue an effective general design criteria for fuel reprocessing plants.

(3) Issue for public comment the standard format and content of license application for commercial waste burial grounds.

(4) Continue development of guidance on classification of structures, systems and components of fuel reprocessing plants and mixed oxide fuel fabrication plants in accordance with their importance to safety.

(5) Obtain basic information required to establish decommissioning criteria to be used in the design of fuel reprocessing plants and mixed oxide fuel fabrication plants. Continue to establish the engineering bases for establishing as-low-as-reasonably achievable limits on release of radioactivity in effluents from light-water reactor fuel cycle plants.

In the areas of Transportation and Product Standards, SD will:

(1) Develop comprehensive standards for design and quality assurance of packages used in transporting radioactive material with particular emphasis on packages used in air transport.

(2) Develop an environmental impact statement pertaining to air shipment of plutonium, developing packaging criteria for air shipment of plutonium, defining acceptable level of risk in transport of plutonium, and standardization of package designs to provide improved safety and minimize applicant and licensing safety analysis efforts.

Other tasks include establishing physical protection measures, material control and material accounting measures, as well as efforts aimed at the resolution of the interface between structural design standards and siting criteria related to man-made and natural events that could affect the safe operation of nuclear facilities, e.g., earthquakes, floods, off-site explosions, and air crashes.

An organizational chart for SD appears in Figure D-11 and a budget breakdown in Table D-8.

E. OFFICE OF INSPECTION AND ENFORCEMENT

The Office of Inspection and Enforcement (IE) is responsible for the development and administration of the following policies and programs:

(1) Inspection of materials and facilities licensees to determine whether operations are in compliance with the license and the commission's rules.

(2) Determination that requirements for the docketing and the issuance of a construction permit have been met.

(3) Determination that the requirements for the issuance of an operating license have been met.

(4) Investigation of accidents, incidents and allegations of improper action.

(5) Investigation of possible diversion of special nuclear material

In FY 1977 there will be an increase in the number of safety inspections to accommodate the increase in operating power plants and new construction of power plants. (See Table D-9). There will also be an increased inspection effort in the areas of nuclear fuel cycle facilities and safeguards. The vendor quality assurance program will remain at essentially the same level as 1976.

An organizational chart appears in Figure D-12 and a budget breakdown appears in Table D-9.

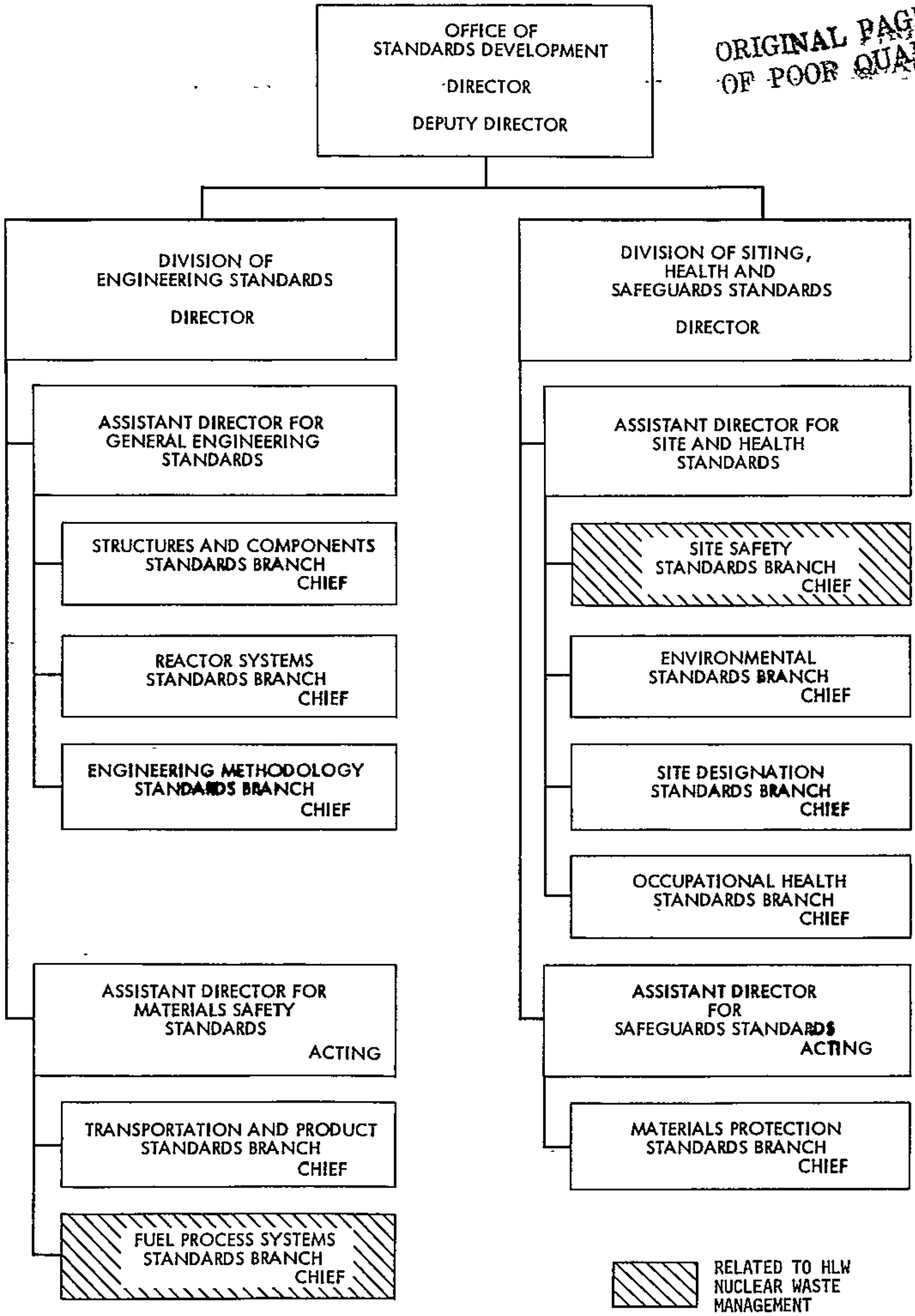

Figure D-11. Organization Chart for Office of Standards Development

Table D-8. Budget for the Office of Standards Development (SD)

	Actual FY 1976		Estimate FY 1977		Estimate FY 1978	
	Dollars	People	Dollars	People	Dollars	People
Site Standards	$1,066	30	$2,048	31	$1,597	31
Nuclear Power Plant Standards	957	42	1,046	51	1,102	51
Fuel Cycle Facility and Waste Management Standards	607	11	532	13	860	13
Safeguards Standards	1,050	13	1,555	14	1,500	14
Transportation and Products Standards	592	10	332	14	388	14
Radiation Standards	88	8	150	11	300	11
Management Direction and Support	0	18	0	19	0	19
Total Program Support	$4,360	132	$5,663	153	$5,747	153
Other*	4,472		6,217		6,383	
TOTAL	$8,832		$11,880		$12,130	

*Includes Personnel Compensation, Personnel Benefits, Administrative Support, Travel, and Equipment

Source: U.S. Nuclear Regulatory Commission, Budget Estimates, Fiscal Year 1978, pg. 18

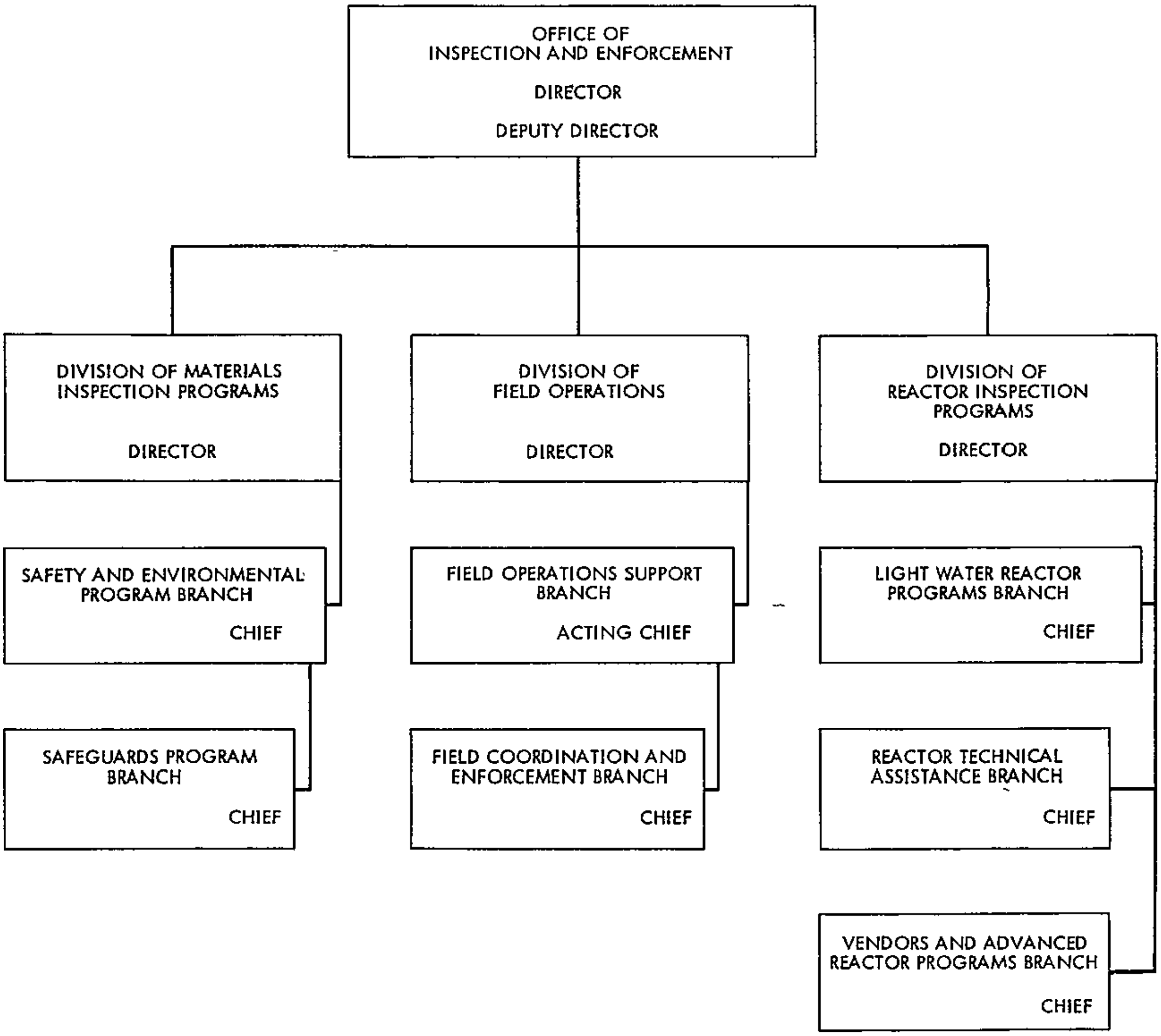

Figure D-12. Organization Chart for Office of Inspection and Enforcement (IE)

Table D-9. Budget for the Office of Inspection and Enforcement (IE)

	Actual FY 1976		Estimate FY 1977		Estimate FY 1978	
	Dollars	People	Dollars	People	Dollars	People
Environmental Monitoring	$ 841	0	$ 965	0	$1,395	0
Safeguards	1,260	53	1,020	70	1,065	85
Reactor Health and Safety	102	288	125	347	290	400
Nuclear Materials Health and Safety	0	75	0	75	0	75
Vendor Quality Assurance	0	32	0	32	0	32
Management Direction and Support	409	59	2,847	68	1,229	74
Total Program Support	$ 2,612	507	$ 4,957	592	$ 3,979	666
Other*	16,993		23,803		26,071	
TOTAL	$19,605		$28,760		$30,050	

*Includes Personnel Compensation, Personnel Benefits, Administrative Support, Travel, and Equipment

Source: U.S. Nuclear Regulatory Commission, Budget Estimates Fiscal Year 1978, pg. 26.

IV. OBSERVATIONS

The examination of various NRC document and presentations in addition to discussions with various NRC representatives has raised several questions and concerns. These observations can be broadly divided into four areas:

(1) The independence of NRC's confirmatory research capability.

(2) Trends in manpower and resources.

(3) Scheduling constraints for having a HLW respository for 1985.

(4) Regulatory disparities between commercial and defense high level nuclear waste.

NRC is aware of many of the questions in each of these areas. However, answers to these questions are still needed. Further studies of NRC and of the Federal governments overall waste management program should address these areas.

A. INDEPENDENCE OF NRC'S CONFIRMATORY RESEARCH CAPABILITY

Table D-4 listed all the contracts in the area of nuclear waste management, including high level waste management. These contracts and their FY'77 budget do not yet reflect the recent (March, 1977) budget revisions noted in Section IIA and Table D-2. However, the list of contracts does indicate the number of contracts and their dollar value that has been negotiated with ERDA laboratories - LLL, ANL, ORNL, and BNL. Sandia Laboratories, although not an ERDA Laboratory, does a significant amount of its work for ERDA. However, for this analysis it is not included as an ERDA laboratory. Altogether there are 13 contracts budgeted at $4 million, only five of these are to non-ERDA laboratories for a total of $1 million (25% of the total amount). That is, 75% of the contract budget goes to ERDA laboratories. These calculations are conservative since one of the two contracts with non-ERDA laboratories is non-technical, and the other is with Sandia.

By law, NRC is required to have an independent confirmatory research capability so that it can effectively regulate the promotion of the nuclear industry. However, as the contracts show, the splitting of the Atomic Energy Commission into the ERDA and the NRC has not been accompanied by the instantaneous creation of an independent research capability. This does not necessarily have an adverse affect on the operation of NRC; however, it may reduce public confidence in NRC's regulatory independence.

NRC is developing an independent confirmatory research capability in the area of waste management but has indicated that this will take time. With the present Federal schedule for developing a repository for commercial high-level waste, the NRC needs support immediately. However, without the appearance of an independent confirmatory research the credibility of NRC's activities could become a source of public contention. This would argue for a delay in the schedule for developing a high-level waste repository. On the other hand, meeting the present Federal schedule is also considered to be essential if the nuclear option is to retain public confidence.

B. TRENDS IN PERSONNEL POSITIONS, RESOURCES AND COORDINATION

As noted in Section I-D and II-A, there has been some significant increase in the allottment of positions and in the amount of contractual dollars available to the nuclear waste management program. In addition, the designation of an assistant director for nuclear waste management should also be helpful in expanding and coordinating NRC's efforts in waste management. Based on our review, these changes appear to be appropriate.

One trend that is also beginning to develop is the diversification of backgrounds required by the nuclear waste management program. As noted in Section II-A, as of early February, 1977, there was only one social scientist associated with the waste management program. However, the waste management program will be involved with more non-technical problems that will require experience and expertise from many different types of professional backgrounds. Recent discussions have indicated that the people in the Waste Management Program are sensitive to this need and that they are trying to make appropriate changes.

C. REPOSITORY SITE SELECTION SCHEDULING

ERDA is planning to select two nuclear high-level waste repository sites by 1978.[12,13] NRC is planning to propose repository suitability criteria by January 1978 and finalize the criteria by September 1978.[14] According to R. Cunningham of NRC,[15] " . . this is a very difficult schedule to meet . . . but we think we can do it. . . . A big unknown is how long the public hearing procedures go on. . . That's something we can't control."

A summary of the response of Dr. William Taylor, Science Advisor to the Governor of Michigan, to the above plan follows.[16]

[12] Office of Waste Isolation Annual Report, 1976.

[13] Kuhlman, C., ERCDC Testimony, March 24, 1977.

[14] Conversation, J. Milaro (NRC) with T. English (JPL), 4/7/77.

[15] Cunningham Testimony at ERCDC Hearings, 3/24/77, pg. 147.

[16] Taylor Testimony at ERCDC Hearings, 3/24/77, pg. 223.

"The program outlined by Dr. Kuhlman specifies the location of the first two repositories by 1978. And that is the program that's been given to us in Michigan, the program that we feel we're operating under. Yet, the technology for reprocessing, for solidification, and even for the design of the repository, is not scheduled to be completed by 1978. We've heard from Dr. Cunningham today that the criteria for sites would not be out until 1979, perhaps 1980. The design of the repository is scheduled for completion in 1982. This means that the states that are being considered are really being asked to agree to the selection of a site in their state on the promise that the activities can be operated safely.

Now, even if you can convince the state government officials--the Governor, the Legislature, an Energy Commission--that the risks are small and that the problems will be solved before nuclear waste is finally reposited in 1985 or, as Mr. Shealy[17] recommended, that we can convince a group of state officials that the problems can be solved, I don't think we're going to convince the people that the problems are going to be solved in 1978 when the site has to be selected."

It appears that the order of acitivites for the selection of sites and the development of site selection criteria should be reconsidered, in order to avoid needless difficulties with the states. This may require a change in the 1985 deadline for an operational High Level Waste Repository. However, it does not appear that there are any compelling technical reasons for an operational repository by 1985, so the schedules and activities should be revised in order to avoid needless irritation of the states.

D. REGULATORY DIFFERENCES BETWEEN MILITARY AND COMMERCIAL HLW

A summary of the major regulatory interactions between NRC and ERDA for high-level military waste is shown in Volume I, Figure 4-2. This figure represents one possible interpretation[18] of the present military waste legal requirements and contrasts dramatically with the commercial requirements shown in Figure 3-5. Other interpretations are possible since NRC hasn't ruled which licensing requirements are pertinent to HLW repositories. It could rule to require dual licensing for repositories analogous to 10 Code of Federal Regulations 50 which requires both a construction license and an operating license. Or they could rule that HLW repositories fall under 10 Code of Federal Regulations 40 (source material) or 10 Code of Federal Regulations 70 (special nuclear material). An NRC operating license is required for both commercial and military high-level waste.

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[17] Shealy ERCDC Testimony, March 24, 1977, page 174 ff.

[18] Natural Resources Defense Counsel suit against the Nuclear Regulatory Commission.

Since the regulatory procedures for HLW repositories are intended to insure the health and safety of present and future generations, it is difficult to understand the basis for following different regulatory procedures for military and commercial HLW.[11]

Slight variations in regulations may be appropriate because of the different sources of HLW; however, major regulatory processes such as site approval, construction licensing, and operational licensing should be under NRC's jurisdiction.

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Testimony by Chairman Marcus A. Rowden, Hearings Before the Subcommittee on Environment and Safety of the JCAE, May 12, 1976, "Radioactive Waste Management".

NUREG 0116, Appendix C, "The NRC Waste Management Programs" and Appendix D, "Evolution of Waste Management and Reprocessing Policy and Philosophy", October 1976.

Testimony of Victor Gilinsky, Commissioner USNRC, before the California Energy Resources Conservation and Development Commission, Informational Hearings on Nuclear Fuel Reprocessing and Waste Disposal, January 31, 1977.

Material, including NRC's program plan, the Management by Objectives schedule, information on specific projects and the FY78 budgetary submission to Congress, supplied through the courtesy of the Office of the Executive Director for Operations and the Office of the Controller, February 14, 1977.

APPENDIX E

SUMMARY OF MAJOR MEETING ISSUES

APPENDIX E

CONTENTS

SECTION I

INTERNATIONAL SYMPOSIUM ON THE MANAGEMENT OF WASTES FROM THE LWR FUEL CYCLE

DENVER, COLORADO
July 11-16, 1976

Sponsored by

Energy Research and Development Administration

A. OBJECTIVE AND STRUCTURE

The objective of the symposium was to review the current status of nuclear waste management technology and to present the proposed programs necessary to develop the technology needed to manage the wastes from postfission fuel-cycle operations. The symposium and its proceedings[1] were conceived of as a complement to the Technical Alternatives Document[2] so that together they could represent the past experience and current technological base for nuclear waste management (NWM). The meetings covered a four and one-half day period. The first day of presentations was concerned with international and U.S. programs, governmental responsibilities and the public's interest and concern. The next three days were devoted to technical presentations and discussions. A final half-day was devoted to open questions and discussions.

B. INTERNATIONAL PROGRAMS

Since NWM is of worldwide concern, the meeting was international in nature with 13 countries represented. The NWM programs of several foreign countries were presented in detail even though the source of the wastes was not always the LWR fuel cycle. The major problems arising in waste management appeared to be independent of the fuel cycle producing the waste. Highlights of the major foreign programs will be discussed briefly below.

1. United Kingdom

The United Kingdom has been reprocessing spent metal fuel from power reactors for about 20 years and started reprocessing the higher burnup oxide fuel around 1970. These present-day high burnup fuels have been substantially more difficult to reprocess than the earlier metal fuel with low burnup. Sir John Hill, of the U.K. Atomic Energy Authority,

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[1] "Proceedings of the International Symposium on the Management of Wastes from the LWR Fuel Cycle," CONF-76-0701, 1976.

[2] "Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle," ERDA-76-43, Vol. 1-5, 1976.

indicated that they have "processed well over 20 metric tons of plutonium and have fabricated the plutonium fuel charge for the 250 MW fast reactor at Dounreay." The high level liquid waste is currently stored in high-integrity tanks contained in stainless steel lined concrete cells.

One of the United Kingdom's guiding principles in the management of nuclear waste is to avoid irreversible processes, yet do all they can to avoid the need for backtracking at some later date. With this view in mind, high level liquid will remain stored pending a proved and accepted ultimate disposal concept. They are confident that their present storage methods should be satisfactory for some decades to come. They feel two dangers must be guarded against. The first is that of prematurely adopting inadequate disposal methods because of some short-term expediency. The second is the possibility that the decision making process could become so paralyzed that their nuclear program would be delayed until a final solution was found. They are presently participating in a number of international programs to determine the most suitable method of ultimate disposal.

2. France

In France, reprocessing has been underway since 1966 with no safety-related incident having been reported. An industrial scale pilot plant has taken 25,000 liters of high level waste solution, representing 800 tons of irradiated fuel, and processed it into 6.5 cubic meters of glass. A full scale vitrification plant was projected to be operational in a year at Marcoule. Another is planned for La Hague. C. Fréjacques, of the Commissioniat à l'Energie Atomique, said: "Within a few years, these installations will have processed all of the solution presently stored in tanks." The storage of this solid waste is to be considered reversible - for at least a certain period - to allow for both any future technological advances and possible problems. They are looking at geological formations as a permanent disposal site but are not in any rush to pick a site. They are also investigating partitioning of the actinides.

3. Federal Republic of Germany

The German waste disposal program will utilize an integrated system with reprocessing and recycling, as well as waste handling, treatment, storage and disposal co-located at one site. The system is planned to be applicable to spent fuel from all types of reactors. High level waste will be solidified and placed in intermediate engineered storage until a final disposal site is developed and successfully demonstrated. "The feasibility of plutonium recycle has been successfully demonstrated in our demonstration plants during the last 5 years," said Schmitt-Kürster, of the Bundesministerium für Forschung and Technologie. Plans are to store plutonium in pure form for only "relatively short periods of time." They have had a demonstration disposal site (Asse II - a former salt mine) in operation since 1967. Solidified low and medium-level wastes are presently being stored. By the end of this decade, test storage runs are planned using high-level-waste glass blocks.

4. U.S. Program

The program in the United States was presented by CEQ, EPA, NRC and ERDA. In general, the various agencies tried to convey the idea that our present NWM program has been well thought out, organized, implemented and scheduled with a maximum of cooperation between government agencies.

(1) Council on Environmental Quality

The CEQ chairman, Russell Peterson, was confident that the problems surrounding reactor safety, safeguards and waste management could be resolved. He was also aware that this opinion was not shared by much of the general public. He expressed a need for continuing efforts to reduce nuclear hazards.

(2) Environmental Protection Agency

The regulatory side of the waste management issue was presented by both the NRC and EPA. W. D. Rowe of the EPA felt there was "no question that the technology for waste management is attainable or will be within reasonable development capability." What has been neglected is the development of a method to evaluate environmental impact so that the selection of technologies will meet acceptable environmental goals. The program the EPA has undertaken involves three steps: (1) development of fundamental criteria for waste, (2) develop generally applicable environmental standards and (3) develop standards and regulations where the EPA has regulatory authority (Ocean Dumping Act, Federal Water Pollution Control Act and Safe Drinking Water Act). They are aware of the difficulty of the problem and admit that a basic set of definitions in the area of NWM does not even exist. They are also aware that their program must be performed on a timely basis to assure a continuing nuclear power industry. They indicated that they were not developing consistent protection criteria for other energy sources since not enough is known about their environmental effects.

(3) Nuclear Regulatory Commission

It is the responsibility of the NRC to insure that NWM is safe, workable and environmentally sound. Their program has three major elements: (1) establish performance goals and criteria, (2) develop a data base and methodology for assessing programs against these goals and (3) provide regulations, standards and guides to protect the public health and safety. It was indicated that they would work together with EPA in resolving difficulties arising from areas of overlapping jurisdiction. Marcus Rowden, chairman of the NRC, indicated that it was time to begin the process of exposing NWM technology to broad review by scientists, industry, government and the public, now that "we have set in motion the vigorous steps necessary for establishing and implementing a sound rational waste management policy."

(4) Energy Research and Development Administration

Carl Kuhlman summarized ERDA's current waste management program. He indicated it had three somewhat differing objectives: namely, (1) to develop, construct and operate high-level waste respositories for industry, (2) to develop processes to convert waste into forms suitable for disposal, and (3) to develop a generic environmental impact statement for each of the waste streams from the post-reactor fuel cycle. A draft of such a statement was expected to be issued in the spring of 1977. The design of the waste solidification plants is to be initiated by FY-77 and 78 with a full-scale facility for high-level liquid waste solidification in operation by 1983. A target date of the end of 1984 has been set for the testing phase of at least one repository. ERDA has decided that deep geologic disposal was the only solution that could be accomplished by the mid 1980s. Three types of geologic formations were considered potentially usable: rock salt, crystalline rocks and argillaceous formations. Kuhlman said, "the technique for emplacing fuel elements in a repository was demonstrated as long ago as 1960, and, compared to the solidification of liquid waste from a reprocessing plant, little more R&D on processing are required."

The details of ERDA's technology programs were presented during the 3 days of technical sessions. The discussions included types of wastes, options for their management and the investigation of possible exposure pathways in the event of a release. Waste types included high level, non-high level in both liquid and solid form, gaseous as well as all waste from decommissioning nuclear facilities. The management of the waste included packaging, transportation and storage in various geologic formations and the sea bed. Finally, the geospheric and biospheric transfer of released radionuclides was discussed along with the potential exposures to man. The technical issues discussed in these papers were many and too detailed for presentation here.

C. GENERAL ISSUES

One of the most common concerns expressed throughout the meeting was that of public perception and acceptance of the waste disposal program. The public perception often seems grounded in a general distrust of institutions based on previous mismanagement and lack of concern for the public. Technology is no longer accepted without question, but now must prove the adequacy of its solutions to problems not only for the present but into the future. The nuclear industry has not, to date, been able to meet the needs of public concern and it was not clear that they were sure of how best to proceed to accomplish the goal of public acceptance. Carl Kuhlman of ERDA felt it was their job to find a mechanism where all points of view, including the two polarized extremes, can be brought together for guidance of the NWM program. Further, he felt it must be done in a timely manner before critical decisions can be made.

A second area that gave rise to considerable discussion, especially considering its minor role in the official program, was that of radiation exposure. The use and implications of the man-rem concept were presented in a paper by L. S. Taylor. He pointed out that its use depends on a linear dose-effect relationship which many study committees of radiobiologists do not accept as being universally applicable. Questions were also raised concerning the toxicity of plutonium and other actinides. Although some future reduction in plutonium exposure standards is generally agreed upon, the reduction factor recommended varies from a factor of 2 up to 400. Excessive concentrations of actinides detected in the gonads of animals led to questions of why they are not considered the critical body organ. A final question raised was whether the dose commitments to future generations were being considered when setting standards for the longer lived isotopes. It was indicated that the International Commission on Radiological Protection is changing its methodology to include the dose commitment and that the EPA has already performed analyses of the worldwide effects of a number of long-lived isotopes.

An attempt was made to inquire as to how the federal NWM program related to the California State bills on reprocessing and waste disposal. In particular, it was asked when and in what form of documentation will the federal government provide its approval of the back end of the nuclear fuel cycle. The comments were that they did not know how to respond to the State of California's legislation.

As a final note regarding the worldwide concern with NWM, an ad hoc international committee was set up to coordinate radioactive waste management, development and demonstration. The U.S. agreed to take the initiative in establishing the committee as a formal and operative international working group.

SECTION II

PUBLIC POLICY ISSUES IN NUCLEAR WASTE MANAGEMENT

DES PLAINES, ILLINOIS (CHICAGO)
October 27-29, 1976

Co-sponsored by the Energy Research and Development Administration, Nuclear Regulatory Commission, National Science Foundation, Council on Environmental Quality, and The Environmental Protection Agency.

A. OBJECTIVES

This Conference on Public Policy Issues in Nuclear Waste Management was intended as an open public forum that would focus on the "non-technical" public policy issues as a follow-on to the "technical" conference previously held in Denver, Colorado. The purpose of the conference was announced in the official program as follows:

> "The Conference on Public Policy Issues in Nuclear Waste Management is designed to provide a public forum in which to identify and to discuss the legal, institutional, social, environmental, and other public policy issues relating to nuclear waste management. It is not a purpose of the conference to debate the acceptability of nuclear energy. It is intended to encourage public input in establishing a national nuclear waste management program and to improve public understanding of the implications of technical alternatives."

B. VIEWPOINTS

The sponsors hoped to focus the conference on an exchange of viewpoints which should be considered in the preparation of environmental impact statements for nuclear waste management programs of the government. These viewpoints were being solicited for the express purpose of assisting Federal decision-making in this area. The approach to the conference was to organize a series of panel and optional workshop sessions in order to provide opportunities to exchange views and information between invited speakers, panelists, and registrants with opportunities for questions at all sessions. The pre-arranged program included numerous prepared papers, panelists, and moderators. The content of the presentations was very general and non-technical. A few of the remarks that were frequently made and with which many people seem to agree are as follows:

(1) The public is concerned about the long-term risks of nuclear wastes. (John Busterud (CEQ))

(2) A satisfactory nuclear waste management (NWM) program is needed to make nuclear energy acceptable. (John Busterud)

(3) The political, social, and economic issues require an equal effort with the technical issues. (Alan Campbell, Syracuse University.)

(4) There is no agreement on causality of NWM problems and risks even among experts. (Alan Campbell, Syracuse University.)

(5) "Openness" and public participation is the only way to restore trust in NWM policy decisions. (Alan Campbell, Syracuse University.)

(6) Policy decisions have been made to expand NWM programs in all government agencies. (Carl Kuhlman, ERDA)

(7) Policy issues and technical issues cannot be separated. (Carl Kuhlman, ERDA)

(8) NWM operations include treatment, storage, transportation, and final disposition of radioactive waste. (John Bartlett, Battelle)

(9) Most of the required commercial NWM technology has been developed, but some R&D is still needed. (John Bartlett, Battelle)

(10) It is society's responsibility to guide technology to minimize social impacts. Choices should not be defaulted to "technological determinism." (Laurence Moss, Sierra Club)

(11) Implementation of NWM involves complex moral and ethical issues. It is easy to form goals, but far more difficult to implement them. (Harold Green, George Washington Univ.)

(12) Nuclear risk factors include problems of large populations, irreversible impacts, intergenerational burdens, long-term effects to future generations. (Mark Sharefkin, Resources for the Future)

(13) We have an ethical obligation to provide maximum information to future generations on our NWM decisions. (Gene Rochlin, U.C. Berkeley)

(14) Criteria for the future should be based only on ethical and moral actions and responsibility. (Gene Rochlin, U.C. Berkeley)

(15) Two factors to consider in NWM are technical irreversibility of waste disposal (recoverability and contamination) and multiplicity of disposal sites as a hedge against uncertainty and risks. (Gene Rochlin, U.C. Berkeley)

(16) It is important to state assumptions and uncertainty about criteria for NWM decisions. Public participation and open process are necessary to set goals and criteria. (Bill Bishop, NRC)

These random comments are representative of the mood of the conference. The proceedings of the Conference are being published though most of the prepared papers were general in nature and many people felt that no "new" information or data was being provided. The conference seemed to be aimed at a level where the general public or lay person and the media could relate.

The reaction of some of the "public" in attendance at the conference was reported in The Energy Daily of Friday, October 29, 1976 under the headline "Nuclear Debate Polarizes Waste Management Conference in Chicago" as follows:

> "The federal government's highly touted conference on Public Policy Issues in Nuclear Waste Management opened in Chicago last week to accolades proclaiming it a unique experiment in public participation in nuclear decision-making. But before the conference was four hours old, it already had run head on into confrontation with the very force it was designed to appease: the nuclear opposition. As the programs, panel discussions and workshops continued, it became clear there were actually two conferences going on: The formal one, and an undercurrent of simmering frustration among environmentalists and citizens advocates who considered the "unique experiment" little more than another Washington snow job. . . .
>
> Ironically, this was just what sponsors of the event had tried so hard to avoid. The idea of a conference to air the social, ethical and institutional problems of radioactive waste management has been around for more than a year. The Chicago conference, in fact, was a companion piece to an international symposium on the technical side of the waste dilemma held by the Energy Research and Development Administration in Denver last July. . . .
>
> Environmentalists were not the only faction unhappy with the tenor of the conference. Utility men, too, complained that their view was being consistently (and consciously) underplayed in the panel discussions, which featured mostly academic or think tank people like Dean Abrahamson and Mason Willrich. . . .
>
> In any event, citizen advocates were unanimous in criticism of the interagency effort. 'It's more ERDA shadow-boxing.' said Cubie, while Sinclair complained that 'the real issues' - like potential geological problems with salt beds - were not being discussed at all. Although some were willing to give the government credit for trying, they felt it was a waste of time. . . ."

C. DISCUSSION PRESENTATIONS

The presentations and topics covered in the structured sessions are outlined as follows:

Session I: Status and Key Issues in Current Waste Management Program (Wednesday, October 27, 1977)

"Introduction"
John Busterud
(Acting Chairman, CEQ)

"Chairman's Remarks"
Alan K. Campbell
(Dean, Maxwell School of Public Affairs, Syracuse University)

"Statement on ERDA Waste Management Program"
Carl W. Kuhlman
(Asst. Director for Waste Management, Division of Nuclear Fuel Cycles and Production, ERDA)

"Nuclear Waste Management: Options and Implications"
John W. Bartlett
(Nuclear Waste Technology Program Office, Battelle-Northwest Labs)

Session II: Goals of Nuclear Waste Management Program and Selection of Criteria for Evaluating Policy Alternatives (Wednesday, October 27, 1976)

"Psychological Factors in the Perception and Acceptability of Risk: Implications for Nuclear Waste Management"
Paul Slovic
(Decision Research, Eugene, Oregon)

"Goals for a Waste Management System: A Task Force Report"
William Bishop
(Chief, Waste Management Branch, NRC)

Session III: Goals and Criteria (Continued) (Thursday, October 28, 1976)

"Choosing Among Waste Management Alternatives: Relevant Criteria and Their Implications"
Mark Sharefkin
(Resources for the Future, Inc.)

"Irreversibility and Multiplicity: Two Criteria for the Disposal of Nuclear Wastes"
Gene Rochlin
(Institute for Government Studies, Univ. of Calif. Berkeley)

Session IV: Organizational Responsibilities and Alternatives (Thursday, October 28, 1977)

"Institutional Arrangements for Radioactive Waste Management"
Mason Willrich
(Director, International Relations, Rockefeller Foundation)

"Problems of Organizational Structure in the Federal/State System"
William O. Doub
(Attorney)

Session V: Issues in Implementation of Nuclear Waste Management Programs (Friday, October 29, 1977)

"Social, Ethical and Moral Issues in the Implementation of Radioactive Waste Management Objectives"
Dean E. Abrahamson
(School of Public Affairs, Univ. of Minnesota)

"Interactions Between Scientific Experts and Lay Public in Implementation of Nuclear Waste Management Goals"
Eugene B. Skolnikoff
(Director, Center of International Affairs, MIT)

SECTION III

TUCSON SYMPOSIUM ON WASTE MANAGEMENT

TUCSON, ARIZONA
October 4-6, 1976

Sponsored By

University of Arizona, Arizona Atomic Energy Commission, Western Interstate Nuclear Board

On October 4, 5, and 6 the University of Arizona held a symposium on Waste Management. Papers were presented by government, industry, and academia from Western Europe and North America.

A. DOMESTIC PROGRAMS

Dr. D. Rose of the Massachusetts Institute of Technology put the problems of managing nuclear wastes into perspective, by listing the hazards to modern man in decreasing order, as: "wastes" from nuclear war; the greenhouse effect from carbon dioxide buildup in the atmosphere; particulates from the burning of fossil fuels, especially sulphur dioxide; transportation accidents; mining; and finally, nuclear wastes. Regarding nuclear waste disposal, Rose pointed out the gap between the 5- to 10-year perspective of the private sector and the 600 year and the 10^6 year problems, and commented that $20B would be required to clean up Hanford.

Dr. James Liverman of the Energy Research and Development Administration (ERDA) commented that our present disposal problem is to dispose of wastes from the nuclear weapons program.

James Malaro of the Nuclear Regulatory Commission (NRC) emphasized the value of performance standards over specifications, and the need for worldwide coordination of policies, standards, and procedures. Risk criteria for long-lived wastes are being developed by Lawrence Livermore Laboratory, and risks from geologic burial of high level wastes are under study by Sandia. A workshop in prediction of performance of geological disposal on a worldwide basis will be held in 1977. An early assumption, now modified, was that geologic retention should be designed without any dependence on the container per se. The current view expressed by Malaro is that the container must make a significant contribution to safety.

Dr. William Rowe of the Environmental Protection Agency (EPA) pointed out that EPA cognizance of nuclear radiation does not extend inside of nuclear facilities, and that the technical and administrative interfaces between ERDA, NRC, and EPA are not fully clear. Ocean dumping, however, is solely under EPA cognizance.

The primary responsibility distribution among these agencies was given as follows:

ERDA: development and operations
NRC: licensing and criteria (site specific)
EPA: criteria and standards (neither site nor method specific)

To resolve technical interfaces, an interagency working group has been established.

EPA is looking 200 years ahead, and the agency is convinced that basic philosophical questions must be addressed before they can develop criteria. A key question is "What is our legacy to future generations - how do we approach considerations that will affect their lives?" Below this comes the questions "How do we define risks from waste management and compare them with risks from other sources?" A criteria document for ERDA and NRC use is scheduled for completion in November, 1977. These criteria will serve as a basis upon which to develop numerical guides and standards for high level waste disposal. The EPA approach is to gather data from ERDA and NRC pertinent to accidental and migratory pathways to man's environment, and then fill in the gaps. EPA is concerned over how it can be shown that some criteria (requirements) can or cannot be met 1000 years from now. Numerical criteria will emerge from joint efforts by EPA, NRC, and ERDA, with public hearings held and final standards published by mid-1978.

Dr. Art Carson of General Electric presented the industry viewpoint, emphasizing the need in waste management for not only good goverment regulations, but also stable regulations. He expressed a dislike for interagency groups, and pleaded for early integration of government agencies.

Dr. Carson favors performance objectives over the specification approach. Regarding acceptable levels of risk exposure and standards, he felt that we are a long way from agreement on units; methodology; relative toxicity; and realistic, consistent, and widely accepted agreements on the trade-offs between health hazards and costs to ameliorate the hazards. Two other major concerns of industry were (1) acceptable standards for demonstrating the adequacy of waste treatment and disposal, and (2) how much "superstructure" or "over-burden" can the industry bear. ("A safe industry is a dead industry.")

Mike Karol of the University of Arizona delivered a paper entitled "Special By-Product Applications," covering many beneficial uses of certain elements in nuclear waste - such as krypton 85, strontium 90, and the noble metals - as well as uses of the radiation itself coupled with decay thermal energy. The dominant example of the latter (primarily from cesium) was in sludge treatment to destroy pathogens and to dry the sludge. Munich, Germany has a large sludge treatment facility, a 120 dry ton per day test facility is due for installation in Washington, D.C., and a 40 TPD pilot plant in Albuquerque. Funding is from both ERDA and EPA.

Dr. Thomas Pigford spoke on the effect of fuel cycle alternatives. For comparing no recycle versus recycle hazards, he first described the LWR waste decay as the 600 year fission product period followed by the americium period, the plutonium, the radium 226, and finally the iodine period. The radium hazard arises from its greater mobility. Of the four fuel cycles he had studied, the worst toxicity increase over the LWR was a 50 fold increase occurring in the actinide period, but Pigford felt that no significance could be attached to this. Pigford feels that spent fuel "must be retrievable because of its tremendous value," and mentioned that removal of americium and curium would be helpful.

L. E. Trevorrow of Argonne National Laboratories (ANL), spoke on the characteristics of wastes from LWR's as derived from surveys or reactor operations. He assumed a ratio of two PWR's to one BWR in calculations of the radioactivity of zirconium and stainless steel hulls, and he noted that the radioactivity of these metals exceeds that of the fuel itself. Regarding separation of the actinides from the hulls, the speaker identified the following approaches: (1) pyrochemical techniques, (2) chloride volatility techniques, and (3) for zirconium and zirconium oxide, ion exchange techniques such as are under study at Sandia Laboratories.

R. Bruns of ARCHO, speaking on the general problems of hazards from toxic chemicals, presented an equation for hazard index which accounted for transport factors (pathways to man).

Carl Unruh of Battelle PNL spoke on their study for ERDA of a generic environmental statement for commercial nuclear waste management. The recommended environmental criteria will <u>not</u> be site specific; and for each waste system there will be both an environmental analysis and a cost/benefit analysis. The generic environmental impact analysis will be integrated and multi-disciplinary and will include consideration of accidents, available technologies, and appropriate waste treatment at each step. It will conclude with a cost/benefit analysis. The study team includes 30 task leaders, and the report will be submitted to ERDA in draft form on May 30, 1977

Arthur J. Toy, a biophysicist from Lawrence Livermore Laboratories (LLL), spoke on environmental criteria for nuclear waste management. The approach is to develop in the big picture sense a computer model of waste management systems, defining critical pathways to man and showing relationships among key variables out to 50 years from the time of initial isolation. A minimum performance level will be defined for waste isolation, and comparisons among the options will be generated by making small selected changes in the key variables so that sensitivities of the major parameters can be quantified. The evaluation of management options will be based on considerations of the radiation dose to an individual and to populations using 10 CFR 20 dose limits. The nuclear hazard will be compared with natural hazards. Parameters for use in measuring the quantity of waste will be \$ per man-REM, and man-REM per MW_e-year. For a megawatt-year of reactor operation, the acceptable dose is assumed to be 0.1 man-REM per year. This was stated to be 0.1 percent of naturally occurring background radioactivity, and to be attainable at a cost of 0.05 percent of the cost of the electricity. In the analyses, accidents are expected to be the dominant scenarios.

At lunch on 10/5/76 the film "Banished Matter" was shown which revealed detailed operations at the German Radioactive Disposal Facility at Asse, West Germany.

Dr. William Lyons of ERDA spoke on ERDA's waste management R&D programs, and noted that the agency's responsibility is for both commercial and defense wastes. Due to early inefficiencies, the bulk commercial waste in the year 2000 will be approximately 10 percent of defense wastes today. Sodium Hydroxide was added to neutralize the wastes, which makes it difficult to classify.

Don E. Larson of Battelle PNL presented a paper entitled "High Level Waste Vitrification by Spray Calcination/In-Can-Melting." This method of immobilizing solid waste has been demonstrated, and a pilot plant has been designed. Process development and demonstration at scaled up levels has not yet been accomplished. An alternate calcination process using a fluid bed is being examined by Battelle PNL and by ERDA.

Clay Zerby of Union Carbide, Office of Waste Isolation, spoke on geologic storage. His analysis assumed the total installed electric power in the year 2000 to be 1500 GW_e, of which 40 percent is nuclear--mostly LWRs. He gave the National Waste Terminal Storage (NWTS) program objective as providing storage facilities in various deep geologic formations, and indicated that for salt bed the fenced area would be 100 acres, and the controlled area 2 miles in radius. The design storage capacity of a site was based on the accumulation of the following volumes of waste by the year 2005:

High Level Waste	221 (thousand ft^3)
Cladding Waste	326
Intermediate Level Waste	1621
Low Level Waste	4940
Spent Fuel Declared as Waste	?

The NWTS Multiple Site Approach to Federal Repositories envisions 6 sites, widely dispersed. The search for sites is underway, and they will be identified by FY '78. Hot operation is foreseen in FY '85 on a pilot plant basis with full operational status four- and one-half years later.

OWI is carrying on safety studies continually, and plans a draft EIS in FY '80. Spending by OWI, at an annual rate of $40M in FY '77, is expected to rise, and participation by other groups in the OWI program was encouraged.

Wendell Weart of Sandia spoke on salt bed disposal, and addressed himself exclusively to the pilot program in southwest New Mexico 30 miles east of Carlsbad. Transuranics will be placed at 2100 ft., and the heat producing wastes at 2600 ft. where the salt is purer and thicker. The site is to be designed to accept both defense and commercial wastes out to the year 2000. The facility will phase into a fully operational mode after the pilot program is concluded. The schedule highlights are:

(1) Preparation of EIS has been underway for 1 year, and consideration is being given to credible and incredible accidents.

(2) Conceptual design studies are in progress.

(3) Construction funds to be requested in FY '79.

(4) First waste cannisters to be accepted for storage in FY '83.

Sandia has a significant effort directed toward interaction with environmental groups, and the governor of New Mexico has established a Technical Review Group to foster technical dialogue.

Alfred W. Western of Reynolds Electrical and Engineering Co. spoke on deepwell disposal of transuranic waste in shot holes from nuclear weapons tests at the Nevada Test Site. There have been 350 underground detonations there--all above the water table--equivalent to 3×10^6 tons of TNT which have left a radioactivity of 1.8×10^8 curies plus neutron activation products. These "post shot" locations are proposed for disposal purposes because the incremental contamination from low level contaminated plutonium waste is insignificant. Scores of cavities are available at no cost. So far, 25,000 gallons of waste have been disposed of at depths of 2000 ft. which is the greatest depth of the aquifers. No migration has been detected from sampling of local water wells, and underground water in the Yucca Basin (an alluvial zone) drains so slowly that to reach off-site locations would require from thousands of years to 2×10^6 years.

Ken Apt of Los Alamos Scientific Laboratories (LASL) spoke on OKLO and its geologic isolation implications. The French discovered this depletion anomaly in a uranium mine in Gabon, west central Africa. The fissioning began some 2 billion years ago, at which time the U235 concentration was 4 percent, and proceeded for some 600,000 years. About 6 tons of fission products resulted from the thermal fission reaction in which water saturation served as a control mechanism. Temperatures of 274°C were reached. Much plutonium 239 was produced, but it was stable chemically and did not migrate.

Al Friedman of ANL spoke on plutonium migration, posing the question with regards to where it migrates and how fast. The case of major interest is the salt bed surrounded by rock. Plutonium in the plus IV valence state was said to be immobile, with a solubility of 1 atom per cc of water. Other oxidation states must be considered, including Pu in the plus VI state. PuO_4 in the minus II state has vastly different behavior. Los Alamos prepared many micrograms of neutral aqueous solutions of Pu plus VI and tested it in local tuff. The plus VI was far more soluble than plus IV. The plus IV tends to be stripped from plutonium in saturated brine, and the diffusion rate is very low--some 300 micrometers per meter of H_2O movement, compared to 0.1 km to 1.0 km/year in an aquifer.

B. FOREIGN PROGRAMS

The international sessions were introduced by Dean Lee Thompson, Chairman AAEC. the first paper was entitled "Joint Nordic Programs and Approach to Waste Management" by Jorma Heinonen of Finland, but was delivered by Dr. J. O. Liljenzin of Sweden. Sweden's current policy and approach is to retain the TRU wastes and try to recover Cm, Am, Pu, U, and Cs. From the fission products they want to separate strontium. Separation schemes are under development and are viewed optimistically. The major hazard from the long-lived wastes was stated to be in 10,000 years due to radium as a daughter product.

French programs and approaches were presented by Andre Redon of C.E.A., who is studying a new immobilization process using thermosetting resins, and a new cryogenic compaction process which increases density by a factor of 10. A cryogenic compaction plant will be in operation this year.

Minimizing waste generation is a French objective. Separation of the actinides from the alpha emitting fission products is another.

Early in the French waste disposal program, concrete was used for disposal, but the method did not turn out well. It was replaced in 1966 when a plant was completed for using a bituminous matrix in which the product is screw extruded into drums for storage. Matrix temperatures up to 290°C are safe against explosion.

A new thermosetting resin embedment approach for fission products is being pursued in Grenoble. Self-heating temperatures up to 800°C are acceptable, and the process shows a substantial volumetric improvement over concrete. For high_level waste, embedment in glass was chosen, although synthetic mica was a candidate. Glass is easier to use and allows more flexibility as to composition of the fission products. A continuous vitrification process was selected, and the volumetric efficiency of the process can be inferred from the 6 to 1 ratio of LWR fuel waste mass to the mass of glass required to contain it.

In 1968 cannisters were buried which contained 5 to 15 kg of high level waste in a glass matrix with a resulting radioactivity level of 100 Ci/liter. These cannisters are now to be dug up and examined. The effect of the alpha emitters in de-vitrifying the glass is being studied.

Waste processing plant construction was begun in June 1974 in Marcoule, France, and active testing will begin in May 1977. Forced air cooling of the cannisters is required.

Ryohei Kiyose of the University of Tokyo gave an overview of waste management in Japan. Low level waste disposal is currently based on the use of a concrete matrix contained within a drum. The disposal method selected for tests and evaluation over the next 5 years is ocean dumping in an area southeast of Tokyo Bay. High level waste processing on a pilot plant scale of 0.7 tons/day will begin in early 1977 when cold tests are completed. A 5 ton/day plant is in the planning stage, and is scheduled for completion in the late 1980's. For wastes presently being generated, storage tanks now are in place sufficient to accommodate needs up until 1982.

Concerning R&D activities, Kiyose mentioned krypton extraction, and both ocean and geologic disposal of high level waste with both cement and bitumen as candidate matrix materials.

Sigurd O. Nielson of Denmark's Symplexor Engineering spoke on ocean disposal. He listed Danish program objectives as follows:

(1) Capability to monitor and to retrieve cannisters from storage.

(2) International arrangements for re-importation.

(3) Capability to partition wastes to 1 part in 10^4 within 25 years.

(4) Container integrity maintained for 700 years.

The time table given for the project was:

(1)	Ocean engineering	4 years
(2)	Classification	7 years
(3)	Partitioning	15 years (to attain 99.9 percent separation)

Recognizing the legal questions of ocean disposal arising from the 1972 London Convention, Neilson offered no alternative, and cited the value of having no heat transfer problems and the benefit of short lead time. He identified partitioning as the cost driver for ocean disposal and recognized the need to address the concerns of container deterioration, handling accidents, and the maximum credible accident.

T. J. Carter of Canada spoke on waste management practices of Ontario Hydro. His remarks were in reference to waste from CANDU heavy water reactors, which will amount to 11,000 M^3 of low level waste by 1990. The criterion for release of toxic substances is ALARA (as low as reasonably achievable). Under this criterion, wastes are doubly contained in retrievable storage in shallow concrete basins. The subsurface drainage system is designed to permit monitoring tritium and the alpha and beta emitters, and to permit identification of the source of leakage.

More recently, above ground storage has been studied, based on bulk resin embedment for which a facility life of 100 years is felt to be acceptable. The costs of disposal--capital costs plus operations--were given as:

Trench	$1000/$m^3$	($30/$ft^3$)
Tile	$8000/$m^3$	($240/$ft^3$)
Quadrille	$8000/$m^3$	($240/$ft^3$)

The cost of disposal of non-transuranics was given as 0.10 mills per kWh.

Dr. Herman A. Haug of GFK in Karlsruhe, Germany, presented a paper entitled "Relative Toxicity and Long Term Problems of Actinide Bearing Wastes from Fuel Reprocessing." He compared alpha emitting actinides with radium 226; showed that after 1000 years the actinides will have decayed to the equivalent of low grade uranium ore; and defined a dimensionless radiotoxicity index as the ratio of water volume contaminated to an equal amount of 0.2 % grade ore.

Dr. Luigi Massimo of CEC spoke on the CEC program for waste-management including risk assessment. The European Communities consist of 9 member countries which are cooperating in a $22M waste management program. A pilot facility based on plastic resin embedment is scheduled for completion in 1979, and will compare one French process with one German process.

A major effort is planned for the disposal of high level waste and long lived alpha emitters in geologic formations as noted below. The holes in the salt deposits will be 2600 meters deep.

Salt Deposits:	Germany and Netherlands
Clay Formations:	Belgium and Italy
Hard Rock:	England and France

A long term evaluation of waste hazards is budgeted at $9.5 M/yr and will use a fault tree approach. The study includes the following elements:

(1) Barrier model development.

(2) Long term stability evaluation of vitrified HLW.

(3) Approaches to monitoring actinides.

(4) Inhalation versus ingestion studies.

(5) Chemical separation of actinides.

(6) Measurement of cross-sections for transmutation by fast breeder reactors.

The inhalation risk falls with time whereas the ingestion risk rises in later years due to the generating of Ra. Barriers that are effective for 10^3 to 10^6 years will be studied. Chemical separation of actinides is presently possible to the extent of 99 percent per step, but the program goal is 99.9 percent.

SECTION IV

NUCLEAR WASTE MANAGEMENT SYSTEMS OVERVIEW WORKSHOP

LA JOLLA, CALIFORNIA
January 24-25, 1977

Sponsored By

Jet Propulsion Laboratory/California Institute of Technology/Scripps Institution of Oceanography

The workshop was developed to provide a systems overview of the major problems associated with nuclear waste management, and was sponsored by the Jet Propulsion Laboratory, California Institute of Technology and the Scripps Institution of Oceanography.

The sessions consisted of both invited papers and workshops. The invited papers presented a broad overview of the significant problems and attempted to put them in proper perspective. The speakers along with their paper titles are given in Table I. The workshops were divided into the following four sessions: (A) Systems for Nuclear Waste Disposition, (B) Fuel Cycles and Reprocessing Issues, (C) Regulatory Requirements and Policy Issues, and (D) Criteria for Nuclear Waste Management Decisions.

A. Systems for Nuclear Waste Disposition

The issues discussed were those associated with preparation and treatment of waste. The primary objective is to maintain management control over the waste so as to preclude harmful exposure of the workers or the public in any accidental situation, either natural or manmade. ERDA has developed such a control system that can be thought of in terms of three elements:

(1) A monitoring or control capability to prevent the spread of contamination and exposure of people while the radioactive material is in a relatively mobile form.

(2) Immobilization or the conversion of waste into material forms that will not spontaneously disperse in the environment.

(3) The isolation of waste material in some location outside the biosphere in a passive storage mode.

There are some prospects for preparation and treatment of all waste that show promise of a resulting material form that meets most of the proposed operating criteria for a licensed repository.

The stow away issue was raised and the consensus was that it is a technically feasible means of disposition but that it must be regarded as temporary. Temporary for how long becomes important. Three waste storage concepts were defined as:

(1) Water basins - this is the state-of-the-art storage which requires hands-on control.

(2) Air-cooled vault storage - such vaults were built and tested using electric heaters before the project was dropped. Canada has much more interest in this type of storage and is doing it now. We might accept it as a temporary system only. This is the way we would go if we want to delay reprocessing fuel.

(3) Retrievable and irretrievable isolation - is retrievable isolation desirable or necessary? There appear to be two reasons to retrieve:

  (a) Dislike of the way or location in which it was deposited.

  (b) Need to do experiments and examine the material. Retrievability is attractive politically because it keeps options open.

B. FUEL CYCLES AND REPROCESSING ISSUES

It must be determined if we should or should not reprocess. The advantages and disadvantages were discussed. The advantages of reprocessing are:

(1) It represents a conservation of our energy sources.

(2) It makes the use of the breeder possible.

(3) It represents potential economic gain.

(4) The long-term toxicity of the waste is reduced by removing the Pu^{239}.

Disadvantages:

(1) Increased emissions of radioactive material from the reprocessing and refabrication plants.

(2) Greater occupational exposure to those who are operating the facilities.

(3) Additional low and intermediate waste will result.

(4) Additional transportation of radioactive material will be required.

(5) Potential impacts on safeguards and proliferation.

Another issue addressed was that of private vs. government operation of reprocessing facilities. Some advantages of government operation would be the simplicity of the implementation and organization of the operations (e.g., nuclear power parks). The government could redistribute the costs better and should be able to do the job cheaper if they can do it efficiently. However, the general view was that industry could do it more efficiently. Government operation of the reprocessing plants could simplify any international grievances that might occur due to reprocessing.

The advantages of the breeder economy were discussed briefly. Advantages included (1) extended use of nuclear fission as an energy source, (2) breeders are better transmutation devices, (3) they offer a better potential for the introduction of advanced and future reprocessing methods which might be better as far as preservation is concerned, (4) they offer higher thermal efficiencies, (5) they would be able to burn up the tremendous volumes of U-238 now stored as gas at the gaseous diffusion plants. One prominant disadvantage is the ready availability of Pu for use as weapons by either terrorist groups or other nations. On the other hand we could use all of the Pu in bombs in our breeder reactors and people could get some of their money back that went into the weapons program.

The session concluded with a brief discussion of the tandem fuel cycle. Discussion centered on whether such a cycle was technically sound and if it would really accomplish its end objectives. It was felt that repackaging the fuel elements would not be a simple thing to do.

C. REGULATORY REQUIREMENTS & POLICY ISSUES

The discussion opened by expressing the need to clarify the jurisdictions of EPA and NRC especially with regard to long-term disposal sites. There appeared to be three types of boundaries--time, geology and technology. The problem, of course could not be resolved here, but its need for attention was highlighted.

The use of decision analysis in the solution of policy issues was discussed. One proponent felt it could resolve issues in the area of politics, sociology, economics, resources and the environment. Others were much more skeptical. It was ascertained that such analysis should not look at some kind of a "micro-optimum;" that it should rather look at a global optimum.

The next question addressed was whether there is a need for outside review and critiques of agency plans. Do the agencies become psychologically incapable of being able to judge their own output because they are too familiar with it? One response was that agencies have enough technically competent people working on numerous problems and that they can always have enough people to carry out unbiased reviews. However, it was pointed out that the aerospace industry has had both success and failures with outside reviews.

Regarding licensing, it was stated that if materials are generated in a NRC licensed facility, then the waste has to be licensed whether it is high, intermediate or low level. In the case of ERDA waste, the final disposal of high-level waste requires a license while disposal of intermediate and low-level waste do not.

D. CRITERIA FOR NUCLEAR WASTE MANAGEMENT DECISIONS

The first question addressed was how the regulators or a responsible legislature look at an assertion by the technical community. As an example, what sort of evidence would the California Energy Commission need to show that a technology exists so that it can approve further reactor starts? Is actual demonstration of a full scale process necessary? Must operational reliability be shown? For how long? It was not possible to come to any resolution of this issue.

Another issue was related to the Decision Criteria. The decision not to reprocess now and the decision to have a "once through fuel cycle" are clearly not the same. The implication derived from this will be profoundly different in terms of actions that might be taken in our needs, programs, and implementation of policy that might result. It is not really clear which decision, if either, has been made at this point. We must also ask if we can afford, at this time, to make a decision. There seemed to be a tacit assumption that we can, at least in the interim.

The issue of whether waste management is ready for criteria was also raised. The answer resulted in another question: "Is not the lack of criteria, at least one of the reasons we do not get along with waste disposal, because we don't have this framework in which to operate and make choices among various alternatives to get moving with the operations?"

A final point was the question of hierarchy of criteria, and what drives this system. One view was that the criteria are responsible to political forces, another was that the national security interests will always control. For example, issues such as proliferation will be the driving function for options that come from it. The panel was polled to find out if there was any dissension to that type of assertion and no one disagreed with it.

Conferees agreed that a system is needed that will eliminate the difficulties of writing and bureaucratic involvement, currently associated with the statement of criteria. A suggested general criteria that should be stressed is the fact that "we don't want to hurt anyone."

Table 1. Invited Speakers

OPENING REMARKS: DR. TOM ENGLISH, JET PROPULSION LABORATORY

WELCOME AND COMMENTS: DR. WALTER MUNK, SCRIPPS INSTITUTION OF OCEANOGRAPHY

COMMENTS ON JPL ENERGY ACTIVITIES: DR. BRUCE MURRAY, DIRECTOR, JET PROPULSION LABORATORY

A VIEW OF MAJOR PROBLEMS: SIR EDWARD BULLARD, SCRIPPS INSTITUTION OF OCEANOGRAPHY

A CAUTIONARY VIEW: DR. HANNES ALFVEN, UNIVERSITY OF CALIFORNIA AT SAN DIEGO

AN INTERNATIONAL OVERVIEW: DR. ROBERT RAMSEY, ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

A STATE OF CALIFORNIA PERSPECTIVE: COMMISSIONER EUGENE VARANINI, STATE OF CALIFORNIA ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION

NRDC OVERVIEW OF FUEL CYCLE: DR. TERRY LASH, NATURAL RESOURCES DEFENSE COUNCIL

TECHNICAL ALTERNATIVES FOR NUCLEAR WASTE MANAGEMENT: DR. JOHN BARTLETT, BATTELLE, PNL

INSTITUTIONAL AND POLITICAL FACTORS IN NUCLEAR WASTE MANAGEMENT: PROFESSOR LESTER LEES, CALTECH

ISSUES IN THE DEVELOPMENT OF RADIATION PROTECTION CRITERIA AND STANDARDS FOR NUCLEAR WASTE MANGEMENT: DR. ROBERT KAUFMANN, ENVIRONMENTAL PROTECTION AGENCY

PARTITIONING AND TRANSMULATING IN PERSPECTIVE: DR. TEX BLOEMEKE, OAK RIDGE NATIONAL LABORATORY

SEABED DISPOSAL: DR. DANIEL ANDERSON, SANDIA

CONCEPT FOR DISPOSAL OF NUCLEAR WASTE IN SPACE: MR. PHIL COMPTON, NASA HEADQUARTERS

WASTE ISOLATION PILOT PLANT: MR. LEO SCULLY, SANDIA

SECTION V

NUCLEAR ENERGY AND PROLIFERATION

AAAS ANNUAL MEETING

DENVER, COLORADO
February 24-25

A. BACKGROUND

There were two symposiums held at the AAAS Annual Meeting dealing with issues related to nuclear energy development and proliferation. These sessions were well attended by what appeared to be a mixture of nuclear experts, AAAS members, interested citizens, and the press. The viewpoints presented ranged from official government postures, and third-world positions, to independent economic and political evaluation of the issues and problems of proliferation and nuclear waste management. The meetings provided objective and thought-provoking discussion on these issues. Highlights are outlined below.

B. NUCLEAR POWER AND NUCLEAR WEAPONS

This symposium included several presentations on the problems of radioactive waste and proliferation. As nuclear energy begins to generate a significant share of the world's energy, a principal hazard facing us is the spread of nuclear weapons to more governments, and perhaps to revolutionary, terrorist, and criminal groups. This session focused on the problems of proliferation and the steps being taken by the U.S. government to control and limit the problem.

(1) Theodore B. Taylor of Princeton University outlined the history of nuclear energy and non-proliferation efforts. Taylor defined vertical, horizontal and latent proliferation, outlined present IAEA Safeguards, and concluded that the proliferation problem was technically and economically solvable, but the institutional problems looked "gloomy." The Thorium cycle was proposed as an alternative to the physical security type of safeguard measures.

(2) Richard Wilson of Harvard University made an excellent case that advancing the peaceful use of nuclear energy was actually a way to reduce the risk of proliferation. Wilson argued that it would be cheaper for any government who desired nuclear weapons to develop the technology directly rather than via nuclear power plants. Once the power plants were operational under IAEA controls it would be even more

difficult for a nation to proliferate because controls would raise the level of surveillance of all nuclear activities. Third world countries who wanted nuclear energy might be forced to make a bomb before vendor nations would agree to transfer power plant technology. Improved inspections and controls are needed and more open negotiations must take into account third world needs and opinions.

(3) Thomas Davies of the U.S. Arms Control and Disarmament Agency outlined the political, legal, and technical tools his agency was using to control proliferation. The present U.S. nuclear power technology was historically and technically based on military weapons production. Therefore, these nuclear energy system designs create the proliferation problem by production of plutonium as a by-product. The system can be redesigned to minimize the proliferation and safeguards problems using alternative fuel cycles such as the CANDU, tandem, or thorium cycles. The agency is analyzing these and other techniques to make the diversion of nuclear materials and proliferation more technically and physically difficult. Davies' presentation showed that the ACDA was deeply involved in the analysis of alternative fuel cycles including the conceptualization of problems and solutions to the management and disposal of radioactive wastes.

C. NUCLEAR ENERGY POLITICS AND INTERNATIONAL CONSEQUENCES

This session was originally intended to bring together a variety of key people representing the U.S. Government, foreign governments, including the third world, business and academia - to discuss the issues with an international or total world perspective. However, none of the planned participants were able to make it and the following substitutes were not really representative, though some were interesting.

(1) Arnold Kramish, a private consultant formerly with OECD and UNESCO, reported that President Carter now has a new policy report on proliferation that will replace the Frye report and policy statements made by President Ford on October 28. He also claimed that this Ford policy was perceived by the developing countries as breaking out commitments under the Non-Proliferation Treaty and the Atoms for Peace program to develop peaceful uses of atomic energy in the underdeveloped world.

(2) Nassem Mirxa, the Deputy U.N. Ambassador from Pakistan, argued their case for nuclear energy development in terms of energy independence, lack of other alternatives, and IAEA international safeguards. First, atomic energy is badly needed by under developed countries for economic growth because of the high price of oil. Second, Pakistan has uranium but no oil or coal, and few other alternatives.

Third, IAEA safeguards are adequate to prevent diversion of nuclear materials for military purposes. Pakistan would consider use of international fuel reprocessing, if positive steps were taken to develop such facilities.

(3) Dr. Ervin Bupp of Harvard Business School has just published a new book, Light Water on the development of the commercial light water reactor. His economic analysis of the growth of the nuclear industry identified several serious problems:

(a) The capital costs of nuclear plants have not stabilized and will continue to inflate at the historic rate for the foreseeable future.

(b) The operating record of on-line LWR has not been good with extraordinary variance in success between plants.

(c) The commercial fuel cycle does not have the facilities to supply uranium fuel on the large scales projected for 1980's.

(d) Nuclear energy is not cost effective with coal plants and possibly will not be competitive even with oil plants.

D. CONCLUSIONS

The problems are economic and political rather than engineering. The growing controversy and awareness of these problems will make large scale development of nuclear power unlikely for this century. Developing nations still believe that nuclear energy is viable alternative for them, but new economic data suggests it is not. Nuclear energy decisions will be made at symbolic level, in an atmosphere of technological uncertainty and, therefore, more on the basis of fears, hopes, and expectations rather than analysis.

SECTION VI

NUCLEAR FUEL CYCLE INFORMATIONAL HEARINGS
SACRAMENTO, CALIFORNIA
January-June 1977

Conducted by the
CALIFORNIA ENERGY RESOURCES CONSERVATION
AND DEVELOPMENT COMMISSION

A. THE LEGISLATION

On June 3, 1976, Governor Brown signed into California law three major pieces of legislation concerning nuclear power:

- AB 2821, requiring a study of underground siting of nuclear power plants (Not being dealt with in the set of hearings described in the summary).
- AB 2820 and 2822, dealing with reprocessing and high level nuclear waste disposal.

AB 2820 (Fuel Rod Reprocessing) prohibits the Energy Commission from approving any nuclear power plant "requiring the reprocessing of fuel rods" until the Commission "finds that the United States through its authorized agency has identified and approved, and there exists a technology for the construction and operation of nuclear fuel rod reprocessing plants." In addition to these generic findings, AB 2820 requires the Commission to make an affirmative finding, on a case-by-case basis, "that facilities with adequate capacity to reprocess nuclear fuel rods from a certified nuclear facility or to store such fuel if such storage is approved by an authorized agency of the United States are in actual operation or will be in operation at the time such nuclear facility requires such reprocessing or storage; provided, however, that such storage of fuel is in an offsite location to the extent necessary to provide continuous onsite full core reserve storage capacity."

AB 2822 bars the Commission from certifying any nuclear power-plant unless and until the Commission finds "that there has been developed and that the United States through its authorized agency has approved and there exists a demonstrated technology or means for the disposal of high-level nuclear waste." A later section adds that, "As used in this section, 'technology or means for the disposal of high-level nuclear waste' means a method for the permanent and terminal disposition of high-level nuclear waste. It shall not necessarily require that facilities for the application of such technology and/or means be available at the time the commission makes its findings."

B. COMMISSION PLANS

The Commission is considering the reprocessing and waste disposal bills on an integrated basis due to the close relation of the technical and policy aspects of these facets of the "back end" of the fuel cycle and the parallel legislative review requirements. On October 22, 1976, the Commission formally adopted an order instituting informational hearings "of an informal nature, designed to obtain a wide range of information and opinion in the areas of nuclear waste management and reprocessing." These informal hearings, along with staff and contractor studies, are intended to provide the basis to properly scope and structure the Commission's investigations pursuant to these bills. The informational hearings are being held from January 31, 1977 to June 17, 1977, covering roughly 20 hearing days before the full Commission. Witnesses from government industry, public interest groups, and academia will be invited. However, any conclusory findings would be made in subsequent, more formal proceedings.

The hearing order identified nine topical areas to be covered in the hearings (roughly in chronological order):

(1) Overview of reprocessing and waste disposal activities in the commercial nuclear fission program.

(2) Operating history and status of reprocessing technologies.

(3) Options for the management of high-level nuclear wastes.

(4) Nuclear fuel cycle alternatives (including reactor alternatives), comparative economic, social, and environmental impacts of each alternative, and the implications for reprocessing requirements and waste disposal.

(5) "Safeguards" implications of reprocessing.

(6) Existing major problems in the development of commercial-scale reprocessing, mixed oxide fuel fabrication, waste reduction and solidification, and waste disposal technologies.

(7) Public and private roles in waste management and reprocessing.

(8) Schedules and milestones for developing commercial-scale reprocessing and waste management processes and facilities.

C. RESULTS TO DATE

Six sets of hearings have been held to date.

(1) Overview hearings (January 31, February 1, and February 2, 1977)

(2) Fuel Reprocessing and Spent Fuel Storage (March 7, 8 and 10, 1977)

(3) Waste Isolation (March 21, 22 and 24, 1977)

(4) International Issues (April 19, 1977)

(5) Public & Private Roles (May 26 and 27, 1977)

(6) Safeguards, Proliferation and Alternate Fuel Cycles (June 13, 14, 16 and 17, 1977)

During the overview hearings, the Commission attempted to solicit answers to two key questions raised by the two legislative bills noted above.

(1) What is a definition of "Federal Approval?"

(2) Does waste disposal technology exist?

SECTION VII

WORKSHOP ON ISSUES PERTINENT TO THE DEVELOPMENT OF ENVIRONMENTAL PROTECTION CRITERIA FOR RADIOACTIVE WASTES

RESTON, VIRGINIA
February 3-5, 1977

Sponsored By

Environmental Protection Agency

A. HISTORY AND PURPOSE

The Environmental Protection Agency (EPA) has two basic authorities for setting radiation protection standards that involved nuclear energy activities, one being the responsibility to set generally applicable environmental standards for radioactive materials for exposures outside nuclear site boundaries, and the second being to provide radiation guidance for all radiation affecting health. With respect to the first authority, EPA presented the generally applicable environmental standards for the uranium fuel cycle in the January 13, 1977, issue of the Federal Register. These standards were concerned with only planned radiation releases. The issue of radioactive waste management was not addressed, since the objective of waste management has been to have no planned release to the environment. Also, a different assessment of risks, costs, and benefits is required in determining radioactive waste standards.

President Ford on October 28, 1976, issued a message on reprocessing and the export of nuclear technology which specifically required EPA to set numerical standards for high-level waste by the middle of 1978. To this end EPA organized two public workshops to obtain a wide range of viewpoints and data to assist them in developing the criteria on which to base the standards for waste management. The first session was in Reston, Virginia, February 3-5, 1977, and the second is scheduled for Albuquerque, New Mexico, on April 12-14, 1977.

B. WORKSHOP FORMAT (RESTON, VIRGINIA)

The first EPA workshop in Reston, Virginia, consisted of three working sessions; approaches to criteria development, risk considerations of radioactive waste management, and the long-term implications of radioactive waste management. The major portion of the first day involved presentations by invited speakers on key issues in each of the topical areas. The remaining workshop time was dedicated to the working sessions with a presentation of the summary reports on the last day.

C. PROBLEMS AND ISSUES ADDRESSED

Prior to the working sessions, the EPA issued a background paper entitled, "Issues and Objectives Statements" which presented a discussion and list of issues for each working group to consider. The environmental radiation protection criteria for waste management was described as a generalized agency policy statement detailing the basic philosophy, conditions, and issues that must be considered in the development of environmental radiation standards (envisioned to be numerical limits) and in the selection of appropriate disposal technologies and sites. In the development of the criteria a number of issues were presented for consideration, including acceptable risk and how to determine it, the question of the legacy of the long-lived radionuclides, the extent to which emphasis should be given to minimizing long-range impact, and the economic costs involved in selecting disposal technologies and sites.

Risk (a function of the probability of a radionuclide release and the consequence) consitutes a key issues in the management of radioactive waste and as such an entire working session was devoted to risk considerations. Also of importance are the issues of perception, acceptance, and personal valuation of risk. Three major areas fundamental to the consideration of risk from waste management listed for discussion were the methodology for identification and assessment of risk (emphasis on methodology), risk associated with the management of radioactive wastes (emphasis on product of risk assessment efforts), and the incorporation of risk and risk acceptance in decision-making.

The long half-lives of many of the radionuclides in high-level waste require that efforts be directed toward the identification of those factors contributing to the long-term radiological impact of waste management activities. Two specific areas that were to be addressed in this context by Working Group III were the institutional longevity (or lack thereof) and its potential impact on radiological exposure levels, and the dose commitment to future generations which would result from present decisions regarding the range of available waste management alternatives.

The working groups generally directed their discussions toward answering the issue questions posed in the EPA paper. The conclusions presented by each working group were a general consensus of the participants and included the views of the invited speakers (panel members) as well as those of interested individuals.

D. WORKING GROUP I - APPROACHES TO RADIOACTIVE WASTE MANAGEMENT CRITERIA DEVELOPMENT

The general conclusion reached by Working Group I was that environmental protection criteria may be extremely difficult to establish, especially in a form that would be effective for all types of waste. Although sufficient data may exist to set numerical criteria, it was generally agreed that it has not yet been brought together. Despite this fact the group concluded that environmental radiation protection criteria should:

(1) Be generic for mitigating risks due to radiation exposure.

(2) Be measurable.

(3) Be economically feasible.

(4) Recognize both the operational and disposal phases of waste management.

(5) Protect both present and future generations.

(6) Leave room for improvements such as new technology.

(7) Provide increased assurance of environmental protection from radioactive wastes.

E. WORKING GROUP II - RISK CONSIDERATION OF RADIOACTIVE WASTE MANAGEMENT

The ten questions presented to the group for discussion dealt with the three basic issues of risk identification, assessment and incorporation into decision-making as previously discussed. There was a great number of diverse opinions expressed but there appeared to be a general consensus concerning the fact that:

(1) The criteria should address unplanned or accidental events.

(2) Quantitative risk analysis should be attempted but it should be regarded as an imperfect tool.

(3) Appropriate programs sponsored by ERDA and NRC should be relied upon as the primary data source for the risk analysis.

(4) Potential health effects to present and future generations constitute the most important consequence of concern in the risk assessment.

(5) Risk assessment acceptability has to be determined by decision-makers and/or the public.

(6) All benefits and costs should be treated equally, regardless of incidence.

(7) There is a need for caution in comparing by means of a single numerical index the low-probability, high-consequence events and the high-probability, low-consequence events.

F. WORKSHOP III - LONG-TERM IMPLICATIONS OF RADIOACTIVE WASTE MANAGEMENT

The general discussion followed the list of questions dealing with the specifics of longevity of institutions and the commitment to future generations. The groups' general consensus was that:

(1) Risks and benefits, both calculated and perceived, should be factors in criteria development.

(2) Criteria should take into account impacts on the international community.

(3) The public, local governments, and state governments should be involved in the decision-making process.

(4) The criteria should consider that disposal solutions should be independent of the stability of societal institutions.

(5) It seems reasonable to assume that there exists suitable stable geological formations for waste disposal.

(6) Risks to future generations must be considered with a ranking of priorities as follows:

   (a) Minimize long-term risks.

   (b) Minimize short-term risks.

   (c) Minimize cost.

(7) Options should be left open for future generations to improve on current technology - but not at a compromise to safety.

(8) The form of the waste and method of disposal need to be considered in criteria development.

These views and suggestions will be combined with those obtained at the Albuquerque meeting in April 1977 and used by the EPA to assist them in developing the criteria on which to base the generally applicable environmental radiation protection standards.

APPENDIX F

SUMMARY OF KEY VISITS WITH RECOGNIZED AUTHORITIES

APPENDIX F

CONTENTS

During the course of the contract, the Nuclear Waste Management Team discussed some of the important issues with noted authorities in the field. This appendix summarizes the main points that were examined during interviews with:

Dr. Hannes Alfven
Dr. Theodore B. Taylor
Dr. Arthur Tamplin
Dr. Harvey Brooks
Dr. David Rose

I. Hannes Alfven, University of California

Dr. Alfven was an active proponent of nuclear energy in Sweden from the World War II years through 1967 when he left that country to take up residence in the U.S. He felt that nuclear energy was something good and worth having. Then, during the early seventies, numerous objections to nuclear energy were raised. Of these many objections he has focused on four that he feels are of serious concern. The first of these objections is to the very large quantities of "poisonous materials" that are generated by the power reactors. His second objection is the coupling between nuclear energy and nuclear arms. Third, he concludes that nuclear energy is not necessary because of the many other energy sources available. Finally, he points out that nuclear energy is no longer as cheap as originally claimed by the proponents. He also points to the study by Shipper and Lichterberg (Science, Vol. 194, page 1001, 1976) that shows that although Sweden and the U.S. have comparable standards of living (gross national product per capita), the energy usage in Sweden is only 50 to 60 percent that of the U.S. His concern is that we should examine to what extent we could redirect our energy usage to lessen the need for nuclear energy. Addressing the final disposal of radioactive waste from the nuclear fuel cycle, he is more concerned with the human and societal issues rather than with pure technology. Even though an adequate technology may exist, he does not feel we can count on the reliability of man over long periods of time. As to the technology itself, he is concerned that we do not know enough about all the processes involved to make an adequate extrapolation over the long time periods involved to satisfactorily contain the radioactive waste. According to Alfven, the recent defeat of the political party that had governed Sweden for 44 years was largely due to the opposition party's rejection of the need for nuclear power in Sweden. He does point out, however, that it will be a difficult job to change the energy policy of that country.

II. Theodore B. Taylor, Princeton University

Dr. Taylor's principal concern for the nuclear fuel cycle is the diversion of nuclear fuel material for use in nuclear weapons. In addition to the generally used meaning of proliferation, he is also concerned with the concept of "latent proliferation." This phrase was conceived by H. A. Feiveson to include those activities that fall short of actual diversion of nuclear material, but rather facilitates some future decision to make nuclear weapons. The issue of diversion is most critical for the plutonium breeder concept, where large amounts of weapons-grade plutonium will be separated from spent fuel elements, since plutonium is available at many stages of the fuel cycle. He is concerned that we will commit the country to the plutonium breeder without having adequately assessed other options which would considerably lessen the problem of proliferation. Two of these options are (1) the once-through fuel cycle with an orderly phase out of nuclear power and (2) the thorium-uranium cycle. Since the once-through cycle does represent a limited energy potential, Taylor's main emphasis is on the thorium-uranium cycle. Although U-233 is also weapons-grade material, it could be "denatured" (diluted) with U-238 to such a degree that the U-233 would be unusable as weapons material without isotope separation. Dilution is not possible with plutonium since any of its isotopes produced in significant quantities can be used for making nuclear weapons. The U-233 would not be directly usable as weapons material if it were "denatured" with 7 or 8 parts U-238 to one part U-233. It is proposed that the processes of denaturing and removal of plutonium be done at a few international facilities operating with strong safeguard requirements. The main objection to the "denaturing" of the U-233 is its deleterious effect on the conversion ratio. Any long-term use of the cycle would require a heavy water moderated reactor concept to make the cycle self-sustaining. Even using plutonium to breed additional U-233 at the international facilities, the "denatured" fuel cycle using heavy water moderator would require a slower growth in nuclear power than now anticipated and it would be hard to make the transition in an orderly way with a growth rate greater than that corresponding to an annual power consumption of 300 gigawatts in the year 2000. An additional advantage of the Th-U cycle that Taylor pointed out is the fact that it will generate considerably less long-lived transuranics in the spent fuel elements and therefore may simplify somewhat the problem of high-level waste disposal. Taylor admits that this solution (the Th-U cycle) is not ideal and that more serious problems may arise on further study, but his principal concern is that we do not irreversibly commit ourselves to a specific nuclear future without proper consideration of these alternatives. He has suggested a moratorium on specific commitments until 1985 by which time all alternatives could have been evaluated.

III. Arthur Tamplin, Natural Resources Defense Council (NRDC)

Dr. Tamplin indicated that there are several issues concerning the health effects of radiation that would be addressed over a period of the next four months by the NRDC. The first of these issues would be a reduction in the standards for intake of plutonium by man. He indicates that the need for reduction comes from two separate areas of concern. The first of these is the "hot particle" issue which addresses the cancer risk due to non-uniform irradiation of the lungs by inhaled particulate plutonium. Even though the National Academy of Sciences (for the EPA), the British Medical Research Council, the NCRP, and the National Radiological Protection in the U.K., have rejected the "hot particle" hypothesis, Tamplin feels they fail to address the current issue--that of irradiation induced tissue damage or lesions. The NAS, on the other hand, says that cancer formation and tissue damage represent different aspects of radiation effects which cannot be directly correlated. The NRDC would have raised this issue again at both the GESMO hearings and the Clinch River Breeder Reactor hearings. A second research area, indicating that tighter plutonium standards are needed, involves studies of Pu uptake in animal bones. On the basis of these studies, Dr. K. Z. Morgan recommends a reduction in the body burden by a factor of 240 when bone is the critical tissue. The NRDC will petition for such a reduction.

A second issue of concern to the NRDC is the reduction of occupational exposure levels by a factor of 10 to 12. This is based in part on the recent study by Mancuso, Stewart and Kneale of the deaths of 3,883 persons who had worked at Hanford. The study indicated that about 6 percent of the cancer deaths would not have occurred if the workers had avoided radiation. (One other study of the same data refutes these results.)

The final item discussed was the NRDC's concern over possible national and subnational proliferation of nuclear weapons if we proceeded into a plutonium fueled economy.

IV. Harvey Brooks, Harvard University

Dr. Brooks believes that public perception of the nuclear power industry has worsened in the last 6 to 9 months. He indicates that the recent court cases involving nuclear power plants have had a definite negative impact. The industry must continue to gather information on various options open to it without giving the public the idea that decisions are already made. We should never be in a position of not being able to consider an apparently attractive option because the R&D in that area is so far behind. R&D is cheap compared to the enormous future investment that will be required once a given option is chosen. He believes that major commitments should be delayed as long as possible to allow adequate investigation of possible alternatives.

One of the big questions today is what does constitute a reasonable proof of a viable nuclear waste disposal option. Brooks says there are several things to do. The risk of a given disposal concept must be calculated in a manner similar to the Rasmussen Report. He wonders if it is really an unaddressable problem. He concludes that it is desirable to set some upper limits to the consequences of a release no matter what happens. Disposal beneath the ocean floor looks good to him, and he feels that it should be thoroughly investigated.

Concerning safeguards, Brooks feels that too much emphasis is placed on how to safeguard rather than on studies of the validity of proposed incentives to make weapons. He feels there is no need to set super high excessively severe restrictions on power reactors, since it soon becomes easier to make weapons some other way. He feels that the problem of terrorism is heavily dependent on the publicity given to the subject in the media and therefore presents a difficult dilemma between public discussion of the issue and enhancement of a self-fulfilling prophecy.

Dr. Brooks feels that energy policy impinges on so many different aspects of national, social, economic and environmental policy that it will be very difficult to achieve a coherent energy policy unless some immediate crisis elevates energy to a status which overrides almost all other national goals.

V. David Rose, Massachusetts Institute of Technology

Dr. Rose is of the opinion that there are no real technical problems associated with the nuclear fuel cycle that cannot be adequately solved. The real problem lies in public acceptance of nuclear energy and the industry can no longer ignore their questions and criticisms. He is not sure this country will go ahead and "do it" even when it can be done. He is concerned that the nuclear community is strangling itself with regulations that are too top heavy and late, forcing them into a position of "playing catch-up ball." They have failed to face the big problems first and as a result are always looking at them after they have occurred rather than before.

Rose believes that there are no compelling reasons to reprocess fuel at the present time, but says if the social issues could be solved satisfactorily, there is no reason not to begin reprocessing on a limited basis so as not to foreclose on any other options. Associated with reprocessing is the major problem of proliferation. Rose is concerned about this on a national basis, but feels the terrorist aspect is overrated. Yet he feels strongly that it is not morally right for the "nuclear have" nations to deprive or limit this source of energy from the "have not" nations.

Rose indicates that the nuclear waste problem is the biggest public issue at present. He feels that Bernard Cohen's calculations are essentially correct, but the attitude in which they are presented is much too simplistic. He thinks that sea bed disposal looks very promising and should be thoroughly investigated. The technology associated with military waste will be different although the public may not perceive it as such.

He indicates that we should not assume a false air of morality concerning the current issues. We are not the first generation to consider the social aspects of technology or to worry about the effects on future generations.

APPENDIX G

TRANSURANICS IN HIGH-LEVEL WASTE

This Appendix compares the transuranics content of the high-level waste for several alternative LWR fuel cycles with that in the spent fuel from the U-fueled LWR ("open-cycle"). After about 1,000 years of storage when virtually all the fission products have disappeared, the radioactivity and relative toxicity of either the spent fuel or the high-level waste are dominated by the amounts and isotopic composition of plutonium, americium and curium. These characteristics are quite sensitive to the plutonium/uranium ratio in the reactor fuel input, and to the degree of separation (if any) of plutonium from the spent fuel during reprocessing. In order to illustrate this important point, four typical cases are considered:

Case I. Open cycle U-fueled LWR with no reprocessing and no recycling.

Case II. U-fueled LWR with uranium recycling only; 99.5% of the (U+Pu) is assumed to be separated from the spent fuel, leaving the fission products, 0.5% of (U+Pu), and the other actinides in the high-level waste. Pu is stored for future use.

Case III. Self-generated U+Pu recycle LWR (SGR), in which both the U and Pu recovered by reprocessing spent fuel from a single LWR is recycled through a similar LWR.

Case IV. Pu recycle option, in which the plutonium from two LWR's is fed into a third LWR. The Pu from the 3rd LWR is recycled back to the 3rd LWR.

In both Cases III, and IV, we assume that 99.5% of the (U+Pu) is removed from the spent fuel during reprocessing.

Tables G-1 and G-2 show the mass and radioactivity content of the isotopes of plutonium, americium and curium in the spent fuel 150 days after discharge from a typical 1,000 MW(e) "open-cycle" LWR operating at 80% capacity for one year.[1]

In Case II (LWR with reprocessing and U-recycle only) the quantities of Pu and its isotopes are reduced by a factor of 200. However, the quantities of americum and curium are the same as for Case I. During storage ^{244}Cm decays rapidly to ^{240}Pu, and ^{242}Cm decays to ^{238}Pu. The curie content of the major radioactive isotopes in the waste for Cases I and II after 1,000 years is shown in Table G-3.

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[1]Pigford, T.H. and Ang, K.P., "The Plutonium Fuel Cycle," Health Physics, Vol. 25, October, 1975, pp. 451-468.

Table G-1. Plutonium Isotopes in Spent Fuel (Case I) at t = 150 Days

Isotope	Half-Life	Kg	Curies (Ci.)*
^{238}Pu	86 years	5.9	$1x10^5$
^{239}Pu	$2.4x10^4$ yr.	142.0	$8.8x10^3$
^{240}Pu	$6.6x10^3$ yr.	58.6	$6.3x10^4$
^{241}Pu	13 years	27.4	$2.8x10^6$
^{242}Pu	$3.9x10^5$ yr.	9.5	38
Total Pu		244 Kg	
Total α - rad.			$1.23x10^5$
Total β - rad.			$2.8\ x10^6$

Table G-2. Americium and Curium Isotopes in Spent Fuel (Case I) at t = 150 Days

Isotope	Half-Life	Kg	Curies (Ci.)**
^{241}Am	458 years	1.3	$4.5x10^3$
^{243}Am	$7.5x10^3$ yr.	2.5	$4.8x10^2$
^{242}Cm	162 days	0.13	$4.4x10^5$
^{244}Cm	18 years	0.91	$7.4x10^4$

*For ^{241}Pu the radioactivity is mainly β - particles, while for all the other Pu isotopes it consists of α - particles (helium nuclei).

**The other Am and Cm isotopes, i.e., ^{242}Am, ^{243}Cm and ^{245}Cm are negligible.

Table G-3. Radioactive Content in Spent Fuel or HLW After 1,000 Years of Storage

Isotope	Open-Cycle LWR (Case I)	U-Recycle Only (Case II)	SGR. (Case III)
	Ci	Ci	
^{241}Am	2,000	2,000	6,700
^{243}Am	500	500	3,000
^{238}Pu	40,000	200	≅1,000
^{239}Pu	8,800	44	70
^{240}Pu	40,000	200	≅2,000
Total	91,300	2,944	≅12,800

Thus, the radioactivity in the nuclear waste (Case II) compared with that of the spent fuel (Case I) is reduced by a factor of about 30.

In Case III (SGR) the annual amount of recycled Pu increases from its initial value of about 244Kg/GW(e)-year in the first recycle to an "equilibrium" value of about 480Kg/GW(e)-year (60% fissile) after 5 or 6 cycles. This build-up is caused by the increase in Pu production in the reactor generated by the neutron flux from the recycled Pu itself. 480Kg of Pu is blended with about 8,300 Kg of natural uranium, and fed into the reactor (as mixed UO_2 + Pu O_2) to provide about 1/3 of the fuel required. Two-thirds of the fuel consists of about 18,400 Kg of uranium enriched to 3.3% ^{235}U. Compared to the LWR operated on UO_2 fuel alone (Case I), the Pu content in the spent fuel is increased by a factor of about 2.0. However, the isotope composition is shifted toward ^{238}Pu, ^{240}Pu and ^{241}Pu, and away from ^{239}Pu, as shown in Table G-4.

The higher ratio of Pu to U in the SGR compared to the LWR operated on UD_2 above has an even more important effect on the amounts of americium and curium in the spent fuel, also shown in Table G-4.

Table G-4. Comparison of Transuranics in HLW After 1,000 Years for Cases I & III (Reference 2)

Isotope	Weight Ratio Case III to Case I
^{241}Am	3.35
^{243}Am	6.18
^{242}Cm	4.57
^{244}Cm	11.0
^{238}Pu	2.65
^{239}Pu	1.60
^{240}Pu	2.48
^{241}Pu	2.19
^{242}Pu	3.84
Overall Pu	2.02

The net result of these increased actinides for Case III is that the radioactivity content of the isotopes after 10^3 years is larger for the SGR (Case III) than it is for the LWR with reprocessing and U-recycle only (Case II) as shown in Table G-3.

The reduction in radioactivity in the nuclear waste is about a factor of 8 for the SGR (Case III), compared to the open-cycle LWR without reprocessing (Case I) (Table G-3).

[2] Generic Environmental Statement on the Use of Recycle Plutonium in Mixed-Oxide Fuels in Light Water Cooled Reactors; NUREG--0002, Vol. 3, pp. IV-E-18 to IV-E-22, August, 1976.

In Case IV, about 480 Kg of Pu per GW(e)-year is recycled, and an additional 500 Kg of Pu is added to the reactor fuel from the output of two other LWR's. This case is worked out in the paper by Pigford and Ang.[1] The net result is that the total radioactivity of Pu in the high-level waste after 1,000 years is about 10^4 Ci, and the radioactivity of the americium isotopes is about 2×10^4 Ci, for a total of about 3×10^4 Ci per GW(e)-year. In this case, the reduction in radioactivity compared to the U-fueled reactor without reprocessing is a factor of about 3. The results are summarized in Table G-5.

Table G-5. Radioactivity Comparison After 1,000 Years of Storage

Ratio	Ratio of Ci Contents
II/I	30
III/I	8
IV/I	3

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