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NATIONAL WASTE TERMINAL STORAGE PROGRAM

MANAGEMENT AND TECHNICAL PROGRAM PLAN

For the Period
FY 1976 through FY 1978

April 21, 1976

UNION CARBIDE

OFFICE OF WASTE ISOLATION
OAK RIDGE, TENNESSEE

prepared for the **U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION**
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Union Carbide Corporation - Nuclear Division

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FIGURES

FIGURES (continued)

I. SUMMARY

This report presents a management plan and a technical program plan for the National Waste Terminal Storage (NWTS) program. It was prepared by the Office of Waste Isolation (OWI) which is part of Union Carbide Corporation-Nuclear Division (UCC-ND). These plans are based on guidance provided by the Energy Research and Development Administration (ERDA). The technical plan is an extension of over 15 years of studies of waste storage in geologic formations. The objectives of the program are to:

1. Provide terminal storage facilities for commercial radioactive waste in various geological formations at multiple locations in the USA in a time frame that assures nuclear power is a viable energy option.

2. Provide the capability to safely dispose of any commercial radioactive waste which must be delivered to a Federal Repository for terminal storage.

A Federal Repository constructed in a geological formation would consist of a large number of excavated rooms located several hundred feet below the surface of the ground. The total excavation might cover as much as three square miles. On the surface would be located receiving and handling facilities for containerized high-level and low-level waste which would be delivered by truck or rail. Shafts would connect the receiving facilities to the mine for delivery of the waste to transporter vehicles which would move the waste to its point of storage. Surrounding the excavated central area would be an outer controlled area in which drilling and mining operations would be controlled to avoid any compromise of the safe operation of the repository.

An important feature of the NWTS program is the concept of placing terminal storage facilities at multiple geographic locations. This approach incorporates the following advantages into the program:

1. Feasibility of a timely operation of a terminal storage facility is improved because of a parallel approach.

2. A retrievability concept for the stored waste can be included.

3. It will make it possible for more than one site to serve the country as a terminal storage facility.

4. Reduced transportation costs are possible if more than one facility is used.

The principal organizations involved in the overall management of the NWTS program include the ERDA Division of Nuclear Fuel Cycle and Production (NFCP), the Oak Ridge Operations Office of ERDA (ERDA-ORO) and the UCC-ND, OWI. The program responsibilities of each of these organizations are as follows:

NWTS Program Responsibilities

NFCP	Policy Formulation Program Objectives and Definition Providing Overall Direction for Program Management Approving Key Technical Decisions Final Determination of Budget
ORO	Program Coordination Federal Interagency Agreements Participation of ERDA Field Organizations Facility Design and Construction Contracts Administer UCC-ND Contract
OWI	Program Contracting and Management Technical Coordination of ERDA Contractors Public Affairs Activities Developing and Presentation of Overall Budget Accounting for all Funds Other Management Activities Deemed Necessary

The principal guiding objective for structuring OWI is to create a strong program management organization which can direct contracts and other support activities outside the organization. Over 85% of all funds for the program will support activities outside of OWI. The organization will have six major departments, namely: (1) Technical Projects, (2) Facility Projects, (3) Planning, (4) Regulatory Requirements, (5) Public Affairs, and (6) Administration.

A wide spectrum of support on a national scale is required to achieve the goals of the NWTS program. It is the intent of OWI to seek this support through contractual arrangements emphasizing support from local contractors in regions where facilities might be located. For each pilot plant, OWI will seek a major subcontractor to manage the development of the facility and to operate it. In a similar manner, other major phases of the NWTS program will also be managed by other organizations under contract to ERDA or UCC-ND, and under the direction of OWI. Many organizations will support the program as subcontractors to the organizations with management responsibility for major portions of the program.

The general NWTS program schedule is based on having available at the earliest possible time a pilot plant for geological disposal of commercial nuclear waste. This condition makes it necessary to focus on salt formations for the first pilot plant rather than other types of formations because of the present advanced state of knowledge about salt formations. Current planning indicates that the time required from the start of the search for acceptable pilot plant locations until nuclear waste is received in the pilot plant is almost nine years. As a result, the first pilot plant is expected to start receiving actual waste by July 1985.

The first two pilot plants are planned to start simultaneously at two different geographic locations and are to be constructed in salt formations. The startup for receiving actual waste for both pilot plants is July 1985. The next set of two facilities will start operation simultaneously two years later. The fifth and sixth pilot plants will start at two-year intervals after the second set of two. A total of six pilot plants are currently planned for development with the last four preferentially constructed in formations other than salt.

The technical program required to achieve the objectives of the NWTS program are conveniently divided into four main activities which are: (1) geological studies required to identify and certify locations in the many candidate rock formations, (2) technical support covering a broad area of studies and analyses, (3) engineering program involving design studies and field experiments leading to data needed for facility design, and (4) facility projects for the construction and operation of the pilot plant, expanded pilot plant, and Federal Repository.

The interrelationship between these technical activities can be illustrated by examining the major steps leading to a waste repository. These steps can be generalized as follows:

1. Technical evaluation of certain rock types in a particular geologic setting to determine their suitability for waste disposal. This evaluation includes an in-depth review of available information on a regional or basin-wide basis.

2. A detailed study of promising areas including development of new data from exploratory drilling and other geological investigations as well as in situ tests.

3. Geologic formations of interest will be studied further with "vault tests" which closely simulate on a reduced scale all aspects of an actual facility including the influence of radioactivity. These tests would be conducted in specially constructed experimental facilities.

4. The next step is to narrow the studies to specific locations to confirm that the geological characteristics and properties of those sites are favorable for constructing a pilot plant.

5. Following the identification of favorable sites, a pilot plant would be constructed which would be limited in the total quantity of waste it can receive, is capable of handling waste at a limited rate, and maintains all of the waste in a readily retrievable configuration.

6. After the pilot plant has operated for a limited period of time it would be modified to an expanded pilot plant to evaluate full-scale handling and storage operations and to fully certify the site for terminal storage. In this step the waste would also be readily retrievable.

7. The final step is to convert the facility into a Federal Repository with a license from NRC which would be obtained as early as possible when all required information is available.

At the present time, twelve geologic formations have been identified as offering potential for waste terminal storage purposes and are under investigation:

1. Salina salt formation of the Appalachian basin in Michigan, northeastern Ohio, western Pennsylvania, and New York.

2. The Interior province of the Gulf Coast Salt Dome region in northeast Louisiana, central Mississippi, and east Texas.

3. Mid-continent shales, especially in the Illinois basin and the southern flank of the Appalachian basin.

4. Mid-continent limestone, specifically the Columbus limestone in central Ohio.

5. Permian basin salt in the Oklahoma-Texas panhandle region.

6. The shales contained in several closed Triassic basins along the east coast of the United States.

7. Volcanic rocks of several types, especially the Columbia River flood basalts in southeastern Washington.

8. Igneous crystalline rocks such as granitoid intrusions in both the U. S. portions of the Canadian Shield and the core of the Appalachian mountains.

9. The Paradox salt basin located in Colorado and Utah bordering Arizona and New Mexico.

10. The Pierre shale formation throughout the northern high plains, especially Wyoming, western North Dakota, South Dakota, and Nebraska.

11. The thick clay formations along the Gulf Coast.

12. The Eleana formation occurring on portions of the Nevada Test Site, especially the clay-shale "J" unit.

The first 5 of the above list of formations are considered to be of the greatest interest for study while the remaining formations are about equal but of lower interest at the present time. Additional formations holding promise may be identified and added later. Geologic investigations of all 12 formations are planned and include studies of seismicity and tectonics, erosion and denudation, mineral resource evaluation, and rock structure and stratigraphy.

Technical support studies comprise a number of long-term generic study programs that are essentially independent of specific types of rocks or their location yet provide necessary support to the overall program. Currently, studies are underway in four areas:

1. Heat transfer/thermal analyses.

2. Waste-rock interactions.

3. Rock mechanics.

4. Borehole plugging.

Engineering programs include field testing studies and design studies. In the first case, a variety of tests are possible including preliminary experiments in an exposed surface outcrop of the rock formation, field tests constructed in existing underground excavations which are heavily instrumented and may involve simulated waste canisters, and vault tests in specially constructed excavations in the candidate rock formations utilizing electric heaters and/or canisters of simulated waste. Examples of design studies include preliminary pilot-plant design studies, alternative waste-emplacement concept studies, and establishment of the criteria for converting a pilot plant into a Federal Repository.

The first two pilot plants will be located in salt formations as indicated previously. The search for favorable sites is already underway with the plan to identify the two required sites by the fourth quarter of FY-1978. Site-specific studies will follow identification of sites with the objective of constructing the pilot plants during the period of FY-1981 through FY-1984. After a shake-down period, actual waste will be received at pilot plants 1 and 2 by the fourth quarter of FY-1985. Conversion of the pilot plants to expanded pilot plants is planned to take five years. This activity will proceed while the pilot plant is in operation.

Environmental studies are planned for all geologic regions of interest. They will proceed in the following sequence:

1. Determine base line environmental study requirements in each region where a pilot plant might be located.

2. Perform base line environmental studies in each region until a specific pilot plant site is identified.

3. Perform site-specific base line environmental studies leading to an EIS, an ER, and continuing through the duration of the project.

System studies planned at this time include: (1) a canister envelope study for high-level waste, (2) a waste transportation study, and (3) an economic analysis to determine charges for storage of waste.

Included in the report are detailed bar graphs with milestones for progress in major tasks. The last section includes an overall logic diagram and schedule for the program.

II. MANAGEMENT PLAN

A. The Program

In 1957, a National Academy of Sciences–National Research Cour advisory committee suggested burial of solid radioactive waste bedded salt deposits as the best of the many methods it had co sidered[1]. Since that time, this disposal method has been unde continuous study and development including, in the late 1960's ground vault tests in a bedded salt mine at Lyons, Kansas. Th work was under the direction of the Oak Ridge National Laborat (ORNL) which is operated by Union Carbide Corporation–Nuclear sion (UCC-ND). Although further development of the vault test a demonstration facility at Lyons, Kansas, was not pursued, OR work has continued at a low level of effort toward identifying locations in bedded salt of potential interest as well as a va alternative geological formations that could be acceptable for minal storage of radioactive waste.

In the early 1970's, the Atomic Energy Commission (AEC) author Atlantic Richfield Hanford Company (ARHCO) to design a Retriev Surface Storage Facility (RSSF) to receive and store high-leve active waste on a schedule compatible with the then-planned op schedule of the commercial nuclear fuel reprocessing industry. ever, since schedules for nuclear facilities have changed and allow several additional years until the final repository is n there is time to implement a full-scale geological terminal st program.

On February 19, 1976, the Energy Research and Development Admi tion (ERDA) announced a greatly expanded program in the area o ment of ERDA and commercial radioactive waste. In the announc ERDA indicated it had assigned to the new Office of Waste Isol (OWI) in UCC-ND the responsibility for program management of th national effort to provide terminal storage facilities in geol formations for waste from commercial facilities. Simultaneous assigned to ERDA-Oak Ridge Operations Office (ORO) the lead re bility for coordinating the program. The program has been des as the National Waste Terminal Storage (NWTS) Program. Its ob are:

1. Provide terminal storage facilities for commercial radioactive waste in various geological formations

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[1]Disposal of Radioactive Wastes on Land, Publ. 519, National A emy of Sciences-National Research Council, Washington, D. C.,

at multiple locations in the USA in a time frame that assures nuclear power is a viable energy option.

2. Provide the capability to safely dispose of commercial radioactive waste shipped to ERDA as required by 10 CFR 50, Appendix F, and any other waste which must be delivered to a Federal Repository for terminal storage.

Regulations in 10 CFR 50 pertain to Licensing of Production and Utilization Facilities, and Appendix F refers to siting reprocessing plants and related waste management facilities. In brief, Appendix F requires that: (a) a fuel reprocessing plant's inventory of high-level liquid radioactive wastes[2] will be limited to that produced in the prior five years; (b) high-level liquid radioactive waste shall be converted to a dry solid and placed in a sealed container prior to transfer to a Federal repository; and (c) all high-level wastes shall be transferred to a Federal repository no later than 10 years following separation of fission products from the irradiated fuel.

Other requirements for shipment of waste to a Federal Repository may be included in changes to 10 CFR 20. Regulations in 10 CFR 20 pertain to Standards for Protection Against Radiation. Current proposed changes relate to transuranic waste disposal and will require that waste with contamination levels as low as 10 nanocuries of transuranic elements per gram of waste must be transferred to ERDA for storage as soon as practicable but within five years after its generation.

Should fuel recycle be authorized, the schedule for availability of terminal storage facilities would be dependent on the start-up operating plans of the commercial reprocessing plants. The earliest solid high-level waste would be available from these facilities is now estimated to be 1983. Consequently, based on 10 CFR 50 and the availability of solid high-level waste, waste storage facilities would be required no later than 1988.

It should be noted here that the Carlsbad Waste Isolation Pilot Plant (WIPP) in New Mexico, which is being developed by Sandia Laboratories for ERDA for terminal geologic storage of low-level and intermediate-level waste from ERDA sources, is not part of the NWTS Program.

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[2]High-level liquid wastes means those aqueous waste resulting from the operation of the first-cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for processing irradiated reactor fuels.

B. Responsibilities

Formation of the OWI and the assignment of the program management responsibility for the National Waste Terminal Storage (NWTS) Program was given March 29, 1976 by ERDA. The current roles of the principal organizations involved in the overall management of the program were described as follows:

1. The Division of Nuclear Fuel Cycle and Production (NFCP) will be responsible for policy formulation, establishing program goals and objectives, final determination and defense of total decisions, and providing overall direction for management of the program.

2. ORO will exercise lead responsibility in the overall program coordination in addition to its normal responsibilities for program management and contract administration. ORO will be responsible for establishing interagency agreements, for the assistance and participation by other Federal agencies, arrangements for the participation by other ERDA field offices, contractors, and energy research centers, and any other cooperative arrangements requiring ERDA execution. ORO will be responsible for any future construction activities in accordance with normal procedures for administration, design, and construction of ERDA facilities. ORO will also exercise usual responsibilities for program direction, financial management, and approvals required by contract provisions and other instructions.

3. Under NFCP policy guidance, the UCC-ND Office of Waste Isolation (OWI) will have program management responsibility for all activities conducted by other units of UCC-ND, subcontractors to UCC-ND, and other non-ERDA organizations and contractors. The OWI will be responsible for the technical coordination of all activities conducted by other ERDA contractors and organizational units and other Federal agencies. The OWI will be responsible for preparing and updating the Terminal Storage Program Plan; for developing master schedules, public acceptance plans, and technical reporting requirements; for developing and presenting an overall program budget; for accounting for all fund allocations and costs; and for other related management activities deemed necessary.

C. General Program Schedule and Logic

In section I A, it was noted that if fuel recycle was authorized, it was estimated that 1983 was the earliest a commercial nuclear fuel reprocessing plant would produce solid high-level waste. For planning purposes, the 1983 availability date indicates that a waste storage facility for nuclear waste should be available no later than

1988. However, if recycle is not approved, it is necessary to have the waste storage facility available at the earliest possible date for disposal of spent fuel elements and other containerized waste directed to a Federal Repository. Therefore, the objective of the general program schedule is to have the earliest possible startup date for a pilot plant for geologic disposal.
The general steps to creating a waste storage facility in a geological formation are:

1. Fundamental studies,
2. In situ experiments,
3. A vault test with simulated or actual nuclear waste,
4. Pilot-plant operation,
5. Expanded pilot-plant operation, and
6. Federal Repository operation.

As a result of the earlier work performed by ORNL, the first three time consuming steps for salt formations have been advanced to the point where step four may be considered. Still remaining is a search for several acceptable locations for a pilot plant, geologic confirmation of those locations to select the most favorable ones, and then site-specific studies directed at construction of the pilot plant. A more detailed schedule for the first pilot plant is shown in Figure 1 and in Section II E.

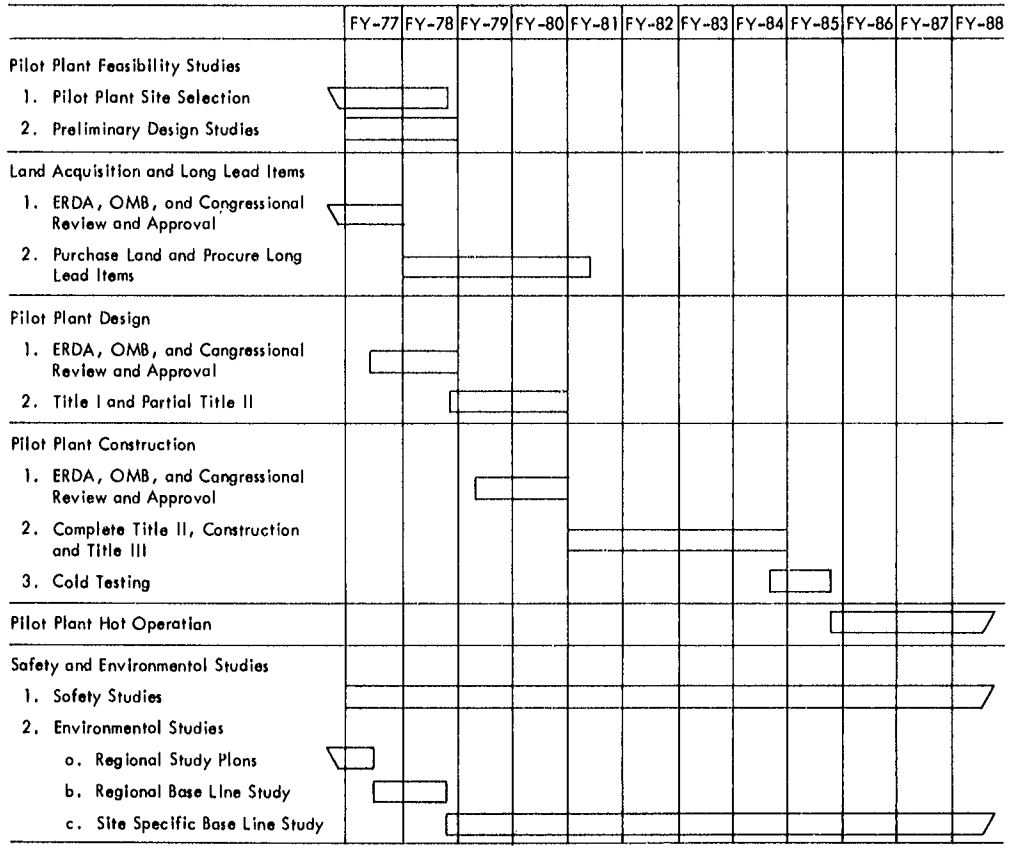
The time elapse required from start of the search for acceptable locations after the fundamental work is completed and until nuclear waste is received in the pilot plant is estimated at almost nine years. Therefore, a reasonable estimate for early operation of a pilot waste storage plant is FY-1985. In the pilot-plant configuration, there would be limited surface and underground capacity available in order to minimize the capital investment committed to the pilot-plant confirmation, but yet sufficient capacity would be made available in each scheduled pilot plant to handle the total waste generated while the pilot plants are in operation prior to start up of the first expanded pilot plant.

At about the same time each pilot plant starts confirmation operation, design work would start on expanding the facility. The objective of the expansion would be to evaluate full-scale handling and storage operation and to fully certify a site for terminal storage. Upon completion of all tests, the expanded facility would be operated at capacity. At some point in the facility testing sequence when all required information is available, an application for a license to operate a Federal Repository will be submitted.

Figure 1

GEOLOGIC TERMINAL STORAGE

PILOT PLANT NO. 1 DESIGN AND CONSTRUCTION SCHEDULE



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An important feature of the NWTS program is the concept of placing terminal storage facilities at multiple geographic locations. This approach incorporates the following advantages into the program:

1. Feasibility of a timely operation of a terminal storage facility is improved because of a parallel approach.

2. A retrievability concept for the stored waste can be included.

3. It will make it possible for more than one site to serve the country as a terminal storage facility.

4. Reduced transportation costs are possible if more than one facility is used.

The first two pilot plants are scheduled to start simultaneously at two different geographic locations and to be constructed in salt formations. The next two facilities are scheduled to start two years later in geologic formations to be determined, but with intent of placing each of them in geologic formations other than salt. The two-year delay in starting these facilities is to allow for fundamental studies, in situ experiments, and vault tests which are needed to advance the state of qualification of other potential geologic formations to the present state of qualification that has been achieved for salt formations. Each subsequent facility will be started on two-year intervals after the start of plant No. 4.

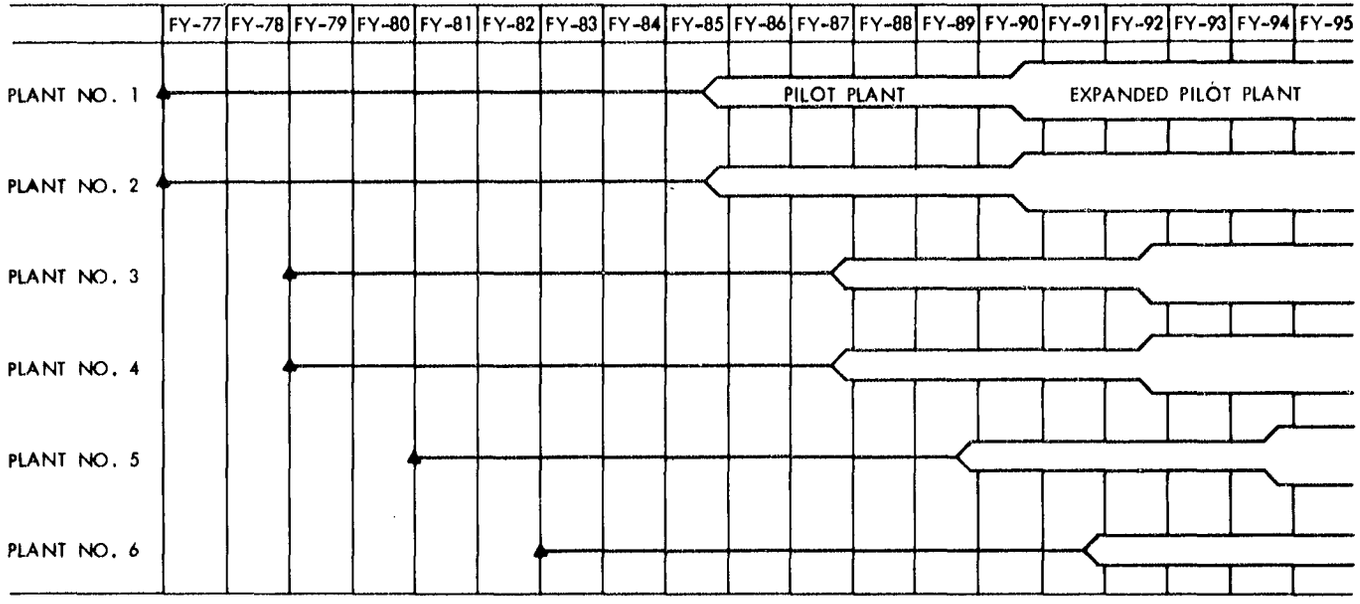
A generalized schedule for the facilities is shown in Figure 2. In that figure, the solid triangle indicates the time a search is started for acceptable locations in a particular generic geologic formation. This will occur after fundamental and geologic studies of each formation of interest have been completed.

The schedule shown in Figure 2 is based on the concept that both the pilot plant and the expanded pilot plant are study facilities. Their purpose is to certify the acceptability for waste disposal of a particular geologic formation in the region of the plant. It is possible that after the start of one of these facilities, additional technical information derived from its operation might dictate changes and even relocation of the plant. In this event, the retrievability feature built into the facility would permit any required change with relative ease. The redundancy incorporated into the general schedule, by starting the first two facilities at the same time, makes allowance for the possibility that one facility might be shut down at some time for changes leaving the other in operation with the capacity to handle the waste being shipped by commercial sources expected at

Figure 2

GEOLOGIC TERMINAL STORAGE

GENERAL PLAN



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that time. The second set of two facilities will also be started at the same time, and on the same schedule in geologic formations other than salt as described above. The planned schedule for the second pair is similar to the first pair and assumes that one of the pair will always be in operation as a minimum condition. Of course, the capacity of the facilities will be planned to accommodate this approach.

Although the first four pilot plants are referred to as sets of two, it should be remembered that each of the pilot plants in each set will be located at widely separated geographical locations to eliminate any risk of operation stoppage associated with local conditions.

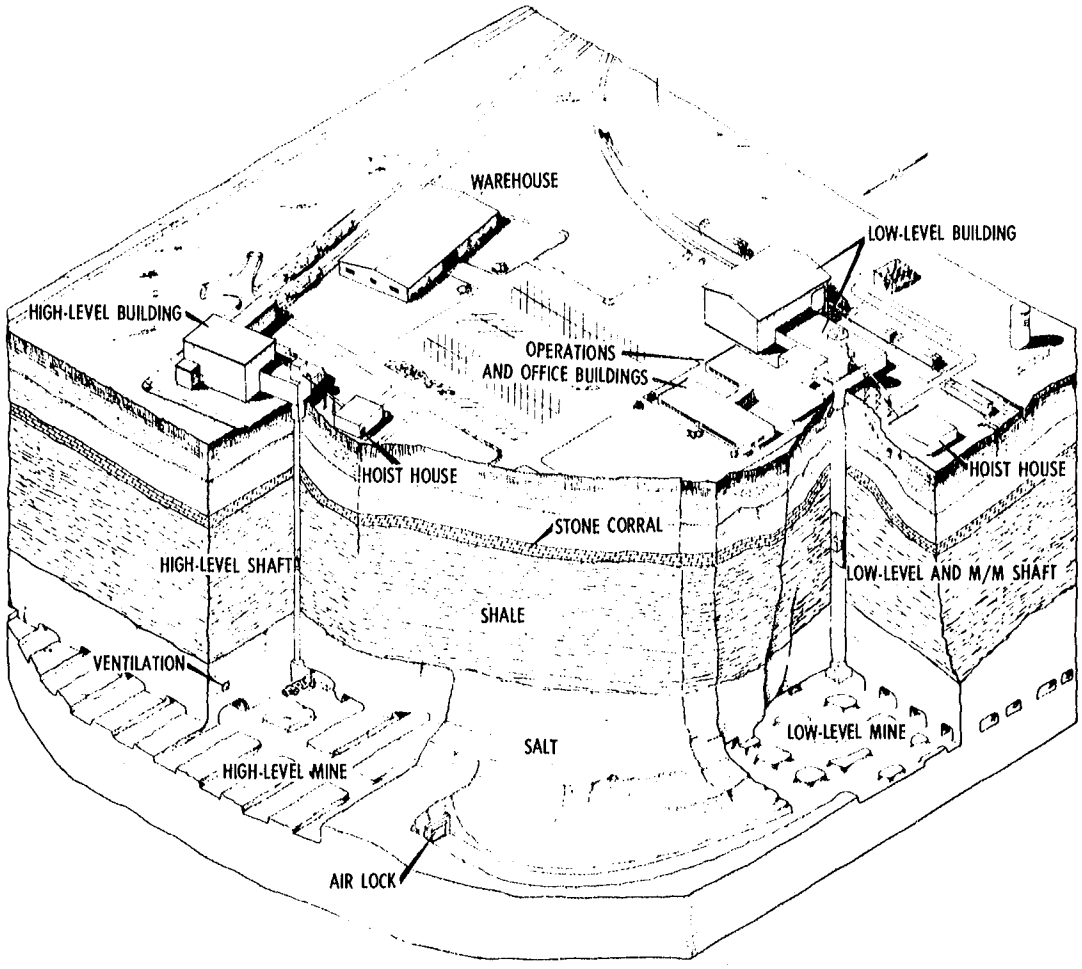
After the first four pilot plants are started, the fifth and sixth pilot plants can start on two-year intervals without concern for redundancy because by that time the capacities of the first two pilot plants will have been greatly expanded, and will have started operation as expanded pilot plants within one year of the time that the fifth pilot plant starts operation. As a result, the total system will always have the required capacity to meet the nation's needs for waste disposal.

Figure 3 shows an artist's concept of a final Federal Repository. In this drawing, the storage facility is located in a salt bed. It is expected that the underground excavation would cover an area of about 3 square miles, while the surface facilities might be located on a few acres. Surrounding the facility would be an area where drilling and mining would be controlled so that the safety and desired operating performance of the repository would not be compromised.

OWI Organization and Facilities

In order to provide the appropriate level of management attention to the National Waste Terminal Storage Program, OWI has been organized to report to Mr. R. F. Hibbs, President of UCC-ND. The structure of the OWI organization is shown in Figure 4.

The principal guiding objective for structuring the OWI organization as shown in Figure 4 is to create a strong program management organization which will properly address the major activities of concern in the program. Each of the organizational elements will be briefly described below in order to provide an interview of how OWI will perform its management job. Since over 85% of all program funds will be expended outside the OWI, the total OWI organization will only include a staff of approximately 56 people. General, Administrative, and General Plant Services will be provided by UCC-ND with major support being provided by various groups at the UCC-ND Y-12 Plant where OWI will have its offices.



ARTIST'S CONCEPT FEDERAL REPOSITORY

Figure 3

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OFFICE OF WASTE ISOLATION

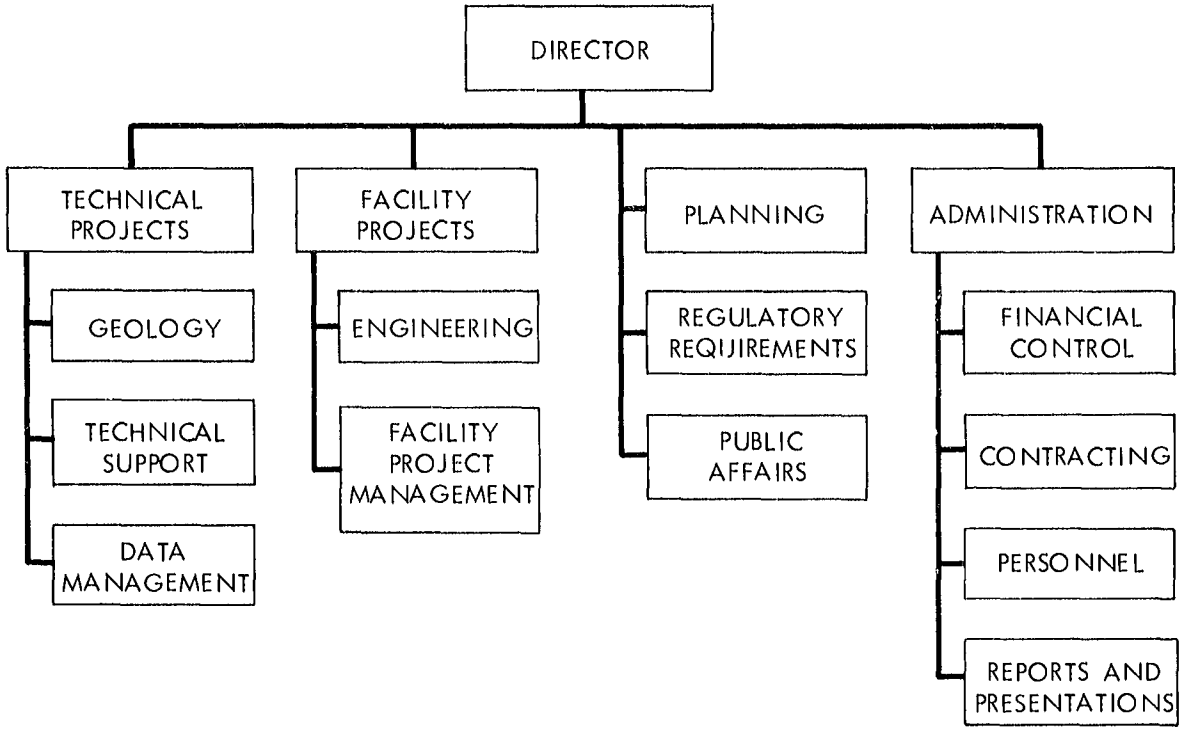


Figure 4

The following are brief descriptions of the major functions of OWI. They are presented in the order they appear on the organization chart.

1. Technical Projects

   The technical projects organization is responsible for: (a) initiating and project managing all geological and fundamental studies leading to the identification of locations for pilot-plant facilities; (b) providing geological and technical support for the facility projects organization during the pilot plant and demonstration plant development, construction, and operation; and (c) managing the data storage and retrieval activities.

2. Facilities Projects

   The facilities projects organization is responsible for: (a) initiating and project managing the engineering activities leading to the selected designs and the construction of the pilot plant, expanded pilot plant, and Federal Repository; (b) providing engineering support for the technical projects organization as required; (c) providing facility project management for each facility from the time it is designated for development at a specific location until it is qualified as a Federal Repository; and (d) in the case of facility project management, the designated project manager in OWI will have total responsibility and accountability for the facility project. All other organization elements of OWI will provide management assistance and support through their individual expertise or through the resources they manage in UCC-ND or in other organizations. This management arrangement will prevail in all cases and will be particularly applicable and appropriate where an operator/contractor is placed in charge of a specific facility.

3. Planning and Program Control

   Major responsibilities of the Planning and Program Control organization are: (a) coordinating the detailed planning for the NWTS program and maintaining the continuity records of those plans; (b) maintaining planning records of activities not supported by OWI but related to the NWTS program so they can be factored into the NWTS program plans; (c) establishing and providing a centralized program evaluation and scheduling service utilizing computer programs such as PERT to aid in project management; (d) providing project evaluation reports on all projects to project managers and to OWI management; and (e) initiating and obtaining through organizations outside of OWI terminal storage systems studies to assure high quality plans. This organization will receive major support from UCC-ND Computer Sciences Division and other organizations to fulfill its responsibilities.

4. Regulatory Requirements

This function will be primarily responsible for managing or coordinating all activities leading to licensing of all Federal Repositories. Principal subsections of the organization will include environmental studies and requirements, and safety studies and requirements. This organization will include the experts who can address and manage their areas of concern for all disposal facilities, and will be the centralized coordinating authority for all licensing in the national program. Should an operator be be designated to manage a facility and be required to submit a license application to NRC, the Regulatory Requirements organization of OWI would provide direct guidance and coordination for that effort.

5. Public Affairs

This important activity is essential to the success of the program. Through this function, information will be disseminated to the public, in general, and to interested organizations and individuals in localities where program activities are contemplated or under way. The objective of this function will be to achieve a widespread and thorough understanding of the program, and through this understanding to have the program accepted on its merits. This will be an aggressive activity with the purpose of seeking out those that should know and provide the information needed. Support studies will also be initiated to determine the socio-economic impacts of the program, and to determine information aids and areas where they might best be used. The public affairs plan is described in a subsequent section of the program plan.

6. Administration

The major responsibilities of the Administrative organization include financial control, contracting, personnel, and reports and presentations. In all of these areas, existing organizations in UCC-ND will be utilized for major direct support with management direction provided by OWI. One of the principal responsibilities of the Manager of Administration is to exercise overall financial management of OWI and for this reason all activities that lead to financial commitments are positioned in that organization.

A headquarters office building to house the entire OWI staff will be located at the North Portal of the UCC-ND Y-12 Plant. The building will be outside the security fence to facilitate ease of access by uncleared personnel and foreign nationals working in the area of terminal storage of nuclear waste or related fields.

E. Management Approach

The principal objective and task of the NWTS program is to provide a waste disposal facility as soon as possible to assure nuclear power as a viable energy option and to develop the facility into an approved Federal Repository in an acceptable time frame. This task will have the highest priority of the NWTS program and will dictate the priority for allocation of funds and resources in conformance with the general schedule shown in Figure 2. In order to assure the success of this task and the entire NWTS program, OWI believes certain management conditions must prevail:

1. The public affairs activities related to the NWTS program must be centralized within OWI. This is necessary because OWI will have a central role in the national program and will have the major input to the public affairs activity. This means that the general direction of the public affairs activities of each disposal facility will come from OWI, and that OWI will have final review responsibility for information to be released so that it properly reflects the overall approach to the program. In this same regard, information released by ERDA related to the NWTS program must also be transmitted to OWI for review and comment before release to assure a properly coordinated program.

2. Regulatory affairs must be centralized in OWI although the operating organization at each facility may make application for license or other permits.

3. The coordinating role of ERDA-ORO and the guidance responsibility of the Division of NFCP, as outlined in section I B, must be organized and managed to reinforce OWI's responsibility and accountability as program managers to plan, organize, lead, and control the entire NWTS program.

In order to achieve the objectives of the NWTS program, a wide spectrum of support is required on a national scale. It is the intent of OWI to seek this support through contractual arrangements, emphasizing support from local contractors in regions where a facility might be located. For each facility, OWI will seek a major subcontractor to manage the development of the facility and to operate it. In this mode of operation, many of the support organizations could be placed directly under contract to the facility operator. The specific arrangements with operating organizations will depend on the overall capabilities and interests of the operator and the particular circumstances that prevail with each facility.

The array of support organizations required for the NWTS program will be extensive. Some of the organizations that are expected to make a contribution are:

Geological Service Firms	Geological Consultants
U. S. Geological Survey	State Geological Surveys
Universities	Drilling Management Firms
Drilling Contractors	A-E Contractors
Construction Firms	Facility Operators
Systems Analysis Firms	Engineering Design Firms
ERDA Laboratories	Environmental Sciences Firms
Safety Analysis Firms	

Since the location, development, and construction of a facility will proceed from generalized studies of a basin which may cover a number of states to specific studies at a specific site, it will be essential to acquire the guidance of those most knowledgeable about the technical aspects of the regions of interest. In addition, it is essential that all interested technical and political organizations be kept informed. To accomplish these objectives, it is planned that a review group will be established for each basin and for each specific state where detailed studies are contemplated. The purpose of these groups will be to review and provide guidance for those activities planned for their area of responsibility to enhance the chances for success for each activity.

F. Administration Plan

As noted earlier, the major responsibilities of the Administrative organization include financial control, contracting, personnel, and reports and presentations.

The financial control function will initially focus its attention on the methods used to collect, analyze, store, and report information with the objective of providing appropriate and timely information for comparison with the plan. Using UCC-ND's existing accounting structure, we expect to develop an effective system which will provide this information quickly and may serve as a basis for decisions on the continuation, redirection, or extension of specific projects. This work will be coordinated closely with that undertaken by Planning. The contracting function will serve to facilitate and expedite the initiation or modification of contracts to meet changing program needs. This will involve the development and maintenance of current awareness of contractor capabilities along with procedures for redirecting contractor participation without incurring inordinately high penalty costs. The major thrust of the personnel function, initially, will be to acquire approximately thirty-five professional personnel with

the wide range of backgrounds and experiences required to manage the NWTS program. These personnel will range from specialized scientific managers to engineers who will be responsible for direct coordination of field tests and experiments. The search for the best qualified candidates will, of course, be coupled with programmatic advances and needs. The objective of the reports and presentations function will be to assist in the generation of material which will effectively communicate NWTS program information. This assistance will be provided in several ways; e.g., technical editing, visual aids assistance, formulation of outlines, etc. The assistance and support of service groups already established in UCC-ND will be used wherever possible.

G. Public Affairs Plan

A key aspect of the Public Affairs Program of the Office of Waste Isolation is obtaining public understanding of the OWI project. It is recognized that the success of the OWI effort will hinge, to a great extent, on the effectiveness of the Public Affairs Program.

Among the major elements of the Public Affairs Program Plan are:

1. State and Local Relations

   Emphasis will be placed on achieving a basic understanding of the objectives of the OWI program in advance of actual work in the field through contacts with cultural, political, and administrative leaders, and close working arrangements with the media.

2. OWI Newsletter

   An OWI newsletter will be initated and designed for disseminating information to political and cultural leaders, contractor and academic participants, industry, the media, and other interested persons.

3. General Descriptive Brochure

   This publication will serve to outline the scope of the program and its objectives. It will be designed both as an information tool and a recruitment publication.

4. OWI Fact Sheet

   This simple information tool will be designed in a question-answer format. The fact sheet will try to answer questions concerning waste isolation, in general, and questions about OWI's activities in particular. It will be updated periodically.

5. News Releases

A key part of the public awareness program will be the periodic issuance of news releases describing various aspects of the program. The purpose of this activity is to demonstrate an "open" program by keeping the press and public aware of activities at all times.

6. Audiovisual Presentations

Slides and color video presentations will describe the types of investigations being made in the field. These will be suitable for showing to a variety of audiences.

7. Public Understanding Film

A lay-level film will be produced to describe the importance of waste management. It will be used to supplement presentations by members of the OWI staff.

8. Conferences, Meetings, Information Programs

The public affairs staff will play an active role in the development of such programs and will encourage press attendance. Follow-up materials on the results of these activities will be sent to a special mailing list which will be developed as part of the information program.

9. Exhibits

At least two exhibits will be developed. One will be designed for viewing by technical audiences and one for lay audiences.

10. Speakers' Bureau

As OWI moves into field operations, it will be necessary to maintain contact with various interested public groups. The public affairs staff will have an active program to effectively communicate the OWI information through the use of the program staff to speak to these groups.

11. Outside Consultation/Regional Representation

Because of the geographical diversity of the OWI operations, Public Affairs will seek to develop a consulting relationship with a major public relations firm to assist with activities in various areas as may be needed.

12. Clipping Service

In order to monitor opinion expressed through the media and to determine areas where problems may be developing, a clipping service has been obtained. Copies of various clips will be sent to the Program Director and other interested persons.

13. Related Activities in Social and Economic Analysis of the Impacts of Waste Isolation Facilities

It is recognized that the preparation of environmental statements covering plans for establishment of terminal storage facilities will require analysis of their social and economic impacts. With this in mind, plans are to conduct two independent studies to develop a social impact assessment prospectus for the NWTS Program. These studies will assess potential impacts covering a range of assumptions with respect to the location, size, scope, and construction and operating requirements of terminal storage facilities. These analyses will be directed toward the public hearing process with respect both to generic issues and those involving particular areas which might be selected.

In essence, the Public Affairs Program is in two parts:

(a) The provision of support activities to achieve understanding and acceptance of the NWTS program; and

(b) Social and economic studies to assess impacts.

A detailed public affairs program involving all fo the above facets and identifying interrelationships, communications channels, and responsibilities will be prepared.

III. TECHNICAL PROGRAM PLAN

A. Introduction

The technically oriented effort required to accomplish the goals of establishing geologic waste terminal storage facilities are described in this section. Conceptually, it is convenient to divide the technical effort into four main activities:

1. Geological studies and investigations required to identify and certify specific locations in the many candidate rock formations;

2. Technical support covering a broad area of studies and analysis which are relatively independent of rock type and geographic location and including, for example, heat transfer/thermal analysis, rock mechanics, and physical/chemical compatability of the waste and rock;

3. Engineering programs involving design studies comparing alternative approaches to waste management concepts and especially field scale experiemnts, as appropriate, in order to develop the specific data needed for facility design;

4. Facility projects which are considered separately primarily because of the scope of activities required for the construction and operation of the pilot plant, expanded pilot plant, and Federal Repositories.

The interrelationships between these program activities and the way in which they are integrated to achieve the program objectives can be illustrated by examining the major milestones in the progression leading to a waste repository for a hypothetical and generalized case. The starting point is the technical evaluation that a certain rock type in a particular geologic setting may be suitable for waste disposal based upon general geologic principles. The first step in evaluation of the rock type is an in-depth review of the available information on the properties and characteristics of the formation. This review is regional or basin-wide in scope and emphasizes those features which are important for waste disposal. These preliminary studies will either confirm or refute the original premise. If the original premise is valid, these studies will produce supporting documentation and will serve to identify specific areas (perhaps as large as 1000 sq. miles) qualifying for closer examination.

The next step involves a much more detailed study of those promising areas, and includes the development of new data from field geologic work, aero surveys, geophysical surveys, geological exploration drilling, and other special geological investigations. At the same time, engineering properties will be examined by a series of in situ tests supported by appropriate laboratory, analytical, and theoretical studies. The first of these tests would be very limited in scope and intended primarily as a basis for more elaborate subsequent tests. These preliminary tests might, for example, consist of a few electrical heaters installed in the formation, or even a mineralogically similar formation, at or near the surface. Because these preliminary tests are "scouting" in nature, examining the gross response of the formation to the effects of waste (usually limited to the effects of heating), no attempt will be made to rigorously simulate either the geometry or the properties of real waste.

Depending upon the results of both the preliminary tests and the geological investigations, the next step might be field tests where an effort is made to simulate actual waste disposal conditions while still limiting the scope of the experiments as much as possible. If these field tests are implemented, they might be carried out in existing mines or other available excavations in the geological formation of interest (or similar formations) or perhaps in or near surface excavations specially constructed for the purpose.

These field tests will be scheduled so that the results are available at about the same time the specific geological investigations of the study areas are nearing completion. Those geological investigations (and the field tests) will again serve to evaluate the suitability of the particular formation and will identify several smaller locations (of perhaps 10-20 sq. miles each) which show the most promise of containing potential sites for facilities if any exist. The next step then is to identify the sites specific geological studies are required to locate, and more importantly, to confirm the geological characteristics and properties of those sites. These investigations will involve extensive and concentrated exploration drilling and testing both of core samples and in the hole. At the same time, the next phase of in situ experiments would be undertaken. This phase is called "Vault Tests" and its objective is to closely simulate all aspects of an actual facility (including radioactivity) on a much reduced scale. Vault tests could be conducted in specially excavated portions of existing mines in the formation of interest, if available. In at least some of the formations, suitable existing excavations will not be available and it will be necessary to construct the entire experimental facility. In these cases, the vault test may be located at a promising repository site but this would not be an essential requirement.

Following the identification and confirmation of a suitable site, and the successful performance of a vault test, the next step would be the establishment of a pilot plant. A pilot plant is defined as an actual storage facility handling real waste produced by the fuel cycle operations of the commercial nuclear power industry. However, it is also a facility which is limited in the total quantity of waste it can receive (to perhaps 2000 canisters of solidified high-level waste), is capable of handling the waste at a limited rate, and maintains all of the wastes in a readily retrievable configuration. Being limited in this way, the pilot plant is obviously also an experimental facility and serves to confirm essentially all aspects of the suitability of geologic terminal storage in the particular formation. The limited scope of the pilot plant approach serves to accomplish this objective with the minimum construction costs and without an irrevocable commitment of waste at the site.

After the pilot plant has operated for a limited period of time it could be modified to an expanded pilot plant by an add-on construction to answer any questions that remain on the scale of operations. This construction would provide full repository handling capacity, both in terms of throughput and total inventory, but the waste would be maintained in a retrievable configuration.

The above illustration was based on a hypothetical and unspecified geologic formation and implicitly assumed that all of the investigations and experiments produced positive results at each step. It is necessary to temper this scenario with a few comments based upon other possibilities. In the geological investigations and qualification experiments, it is recognized that there is a greater probability that a particular site will be found unsuitable rather than suitable and consequently rejected. Our approach to overcoming these adverse odds is to examine a multiplicity of rock types in a number of regions. Twelve generic formations/regions having potential have been identified (see section B) and others will be added to this list as the program progresses. Within each formation, the geological investigations are structured to identify at least six areas qualifying for detailed examination in the expectation that no more than two will be qualified as prospective sites.

In the remaining sections of the Technical Program Plan, a number of projects are outlined in each of the main activities of the technical effort. They are presented in this manner for convenience. However, it is anticipated that individual contractors may be selected in some cases who will be responsible for a number of the tasks or portions of the tasks from all the technical activities.

B. Geological Studies

The general approach of the geological programs, progressing in three stages from preliminary regional evaluations through special investigations at study areas to detailed confirmation and qualification of prospective facility sites, was outlined in the previous section. In each phase, the range of the investigations encompasses essentially the entire scientific discipline of geology, with the depth of detail and the location specificity increasing with each phase. For our purposes, it is convenient to summarize this broad range of tasks and effort under the following headings:

1. Seismicity and tectonics - primarily concerned with the evaluation of the structural stability of the formation, particularly for the long periods into the future over which the waste must be contained.

2. Erosion and denudation - includes evaluation of normal geologic processes which could, over the long times involved, result in a breach of the geologic containment of the waste.

3. Mineral resource evaluation - includes those items relating to man's activities in the subsurface in or near the formation which could alter the natural geological conditions.

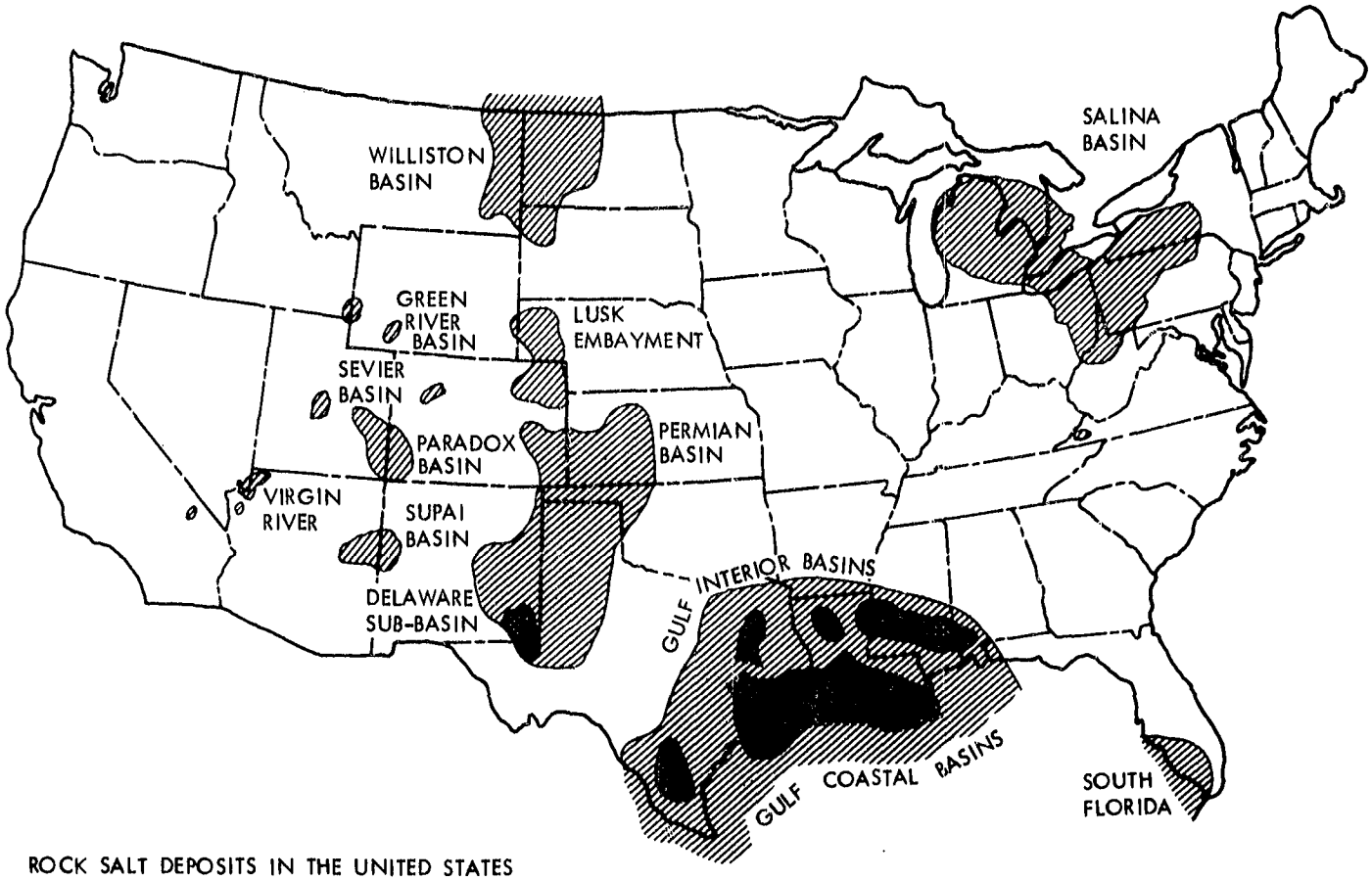
4. Rock structure and stratigraphy - the studies in this category include those necessary to thoroughly characterize the subsurface geologic conditions of the formation and its surroundings.

5. Hydrology - studies under this heading are related to the preceding items but are identified separately in order to emphasize their importance. That importance results from the fact that for geologic terminal storage, transport of radioactive materials by circulating ground water is by far the most likely mode of containment failure.

At the present time, twelve specific geologic formations have been identified as offering potential for waste terminal storage purposes and are under investigation (see Figures 5, 6, and 7):

1. Salina salt formation of the Appalachian basin in Michigan, northeastern Ohio, western Pennsylvania, and New York.

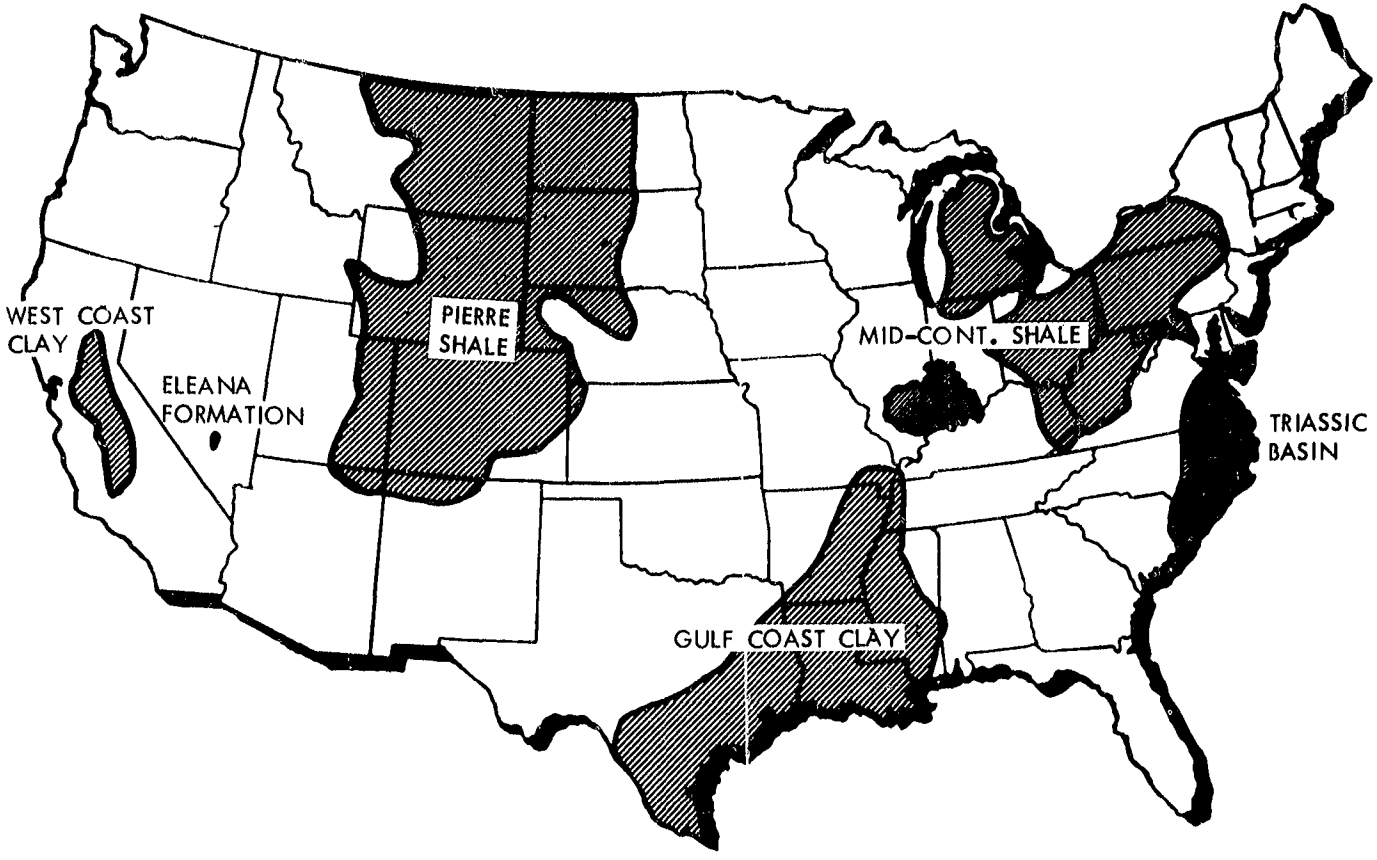
2. The Interior province of the Gulf Coast Salt Dome region in northeast Louisiana, central Mississippi, and east Texas.



ROCK SALT DEPOSITS IN THE UNITED STATES
(AFTER PIERCE AND RICH, U.S.G.S. BULL. 1148)

Figure 5

OWI-76-25



ARGILLACEOUS FORMATIONS IN UNITED STATES

OWI-76-26

Figure 6

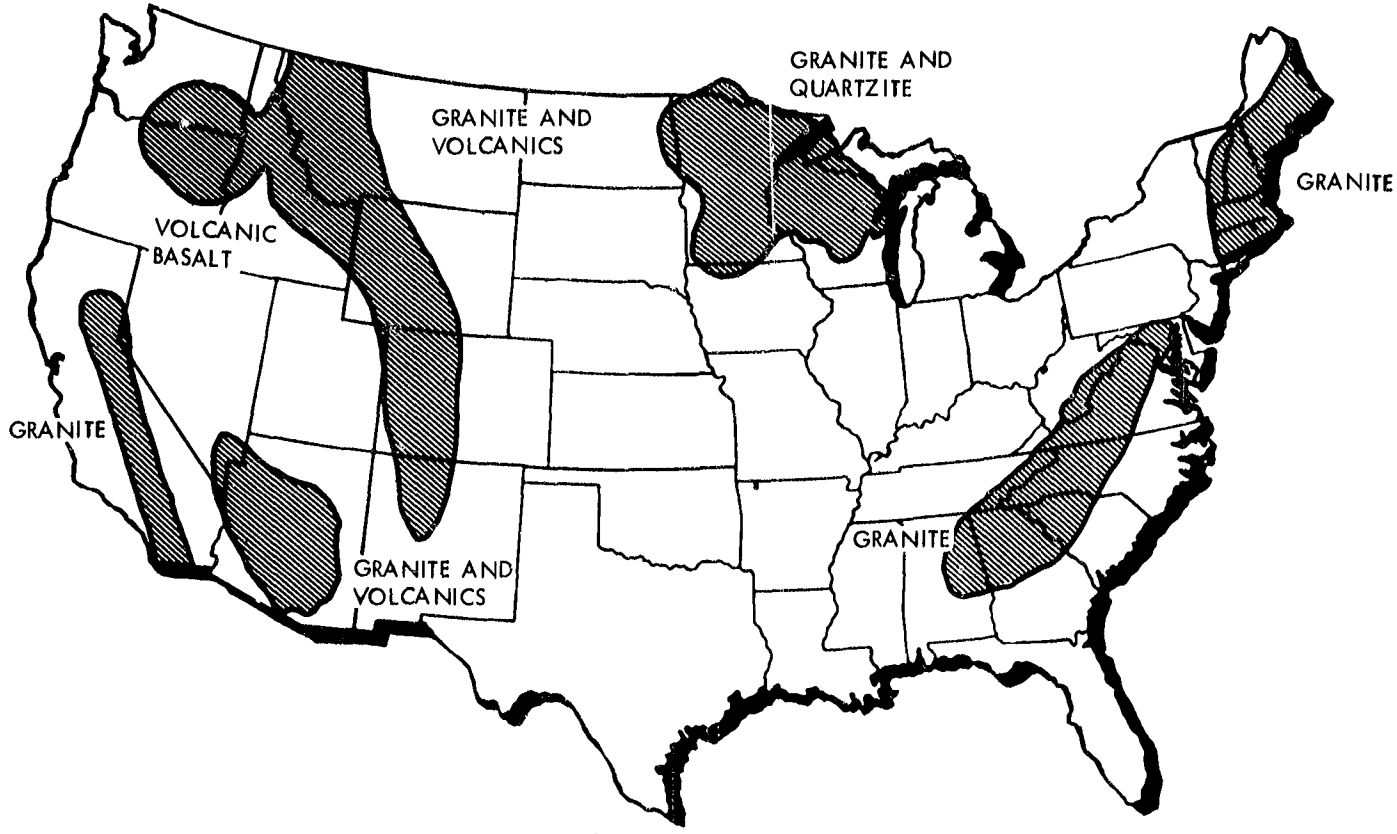

GRANITE AND
QUARTZITE
GRANITE AND
VOLCANICS
GRANITE
VOLCANIC
BASALT
GRANITE
GRANITE AND
VOLCANICS
GRANITE
CRYSTALLINE FORMATIONS IN UNITED STATES
OWI-76-27

Figure 7

3. Mid-continent shales, especially in the Illinois basin and the southern flank of the Appalachian basin.

4. Mid-continent limestone, specifically the Columbus limestone in central Ohio.

5. Permian basin salt in the Oklahoma-Texas panhandle region (a separate program is examining the Delaware basin portion of the Permian basin salt in southeastern New Mexico for its waste disposal possibilities).

6. The shales contained in several closed Triassic basins along the east coast of the United States.

7. Volcanic rocks of several types, especially the Columbia River flood basalts in southeastern Washington.

8. Igneous crystalline rocks such as granitoid intrusions in both the U. S. portions of the Canadian Shield and the core of the Appalachian mountains.

9. The Paradox salt basin located in Colorado and Utah bordering Arizona and New Mexico.

10. The Pierre shale formation throughout the northern high plains, especially Wyoming, western North Dakota, South Dakota, and Nebraska.

11. The thick clay formations along the Gulf Coast.

12. The Eleana formation occurring on portions of the Nevada Test Site, especially the clay-shale "J" unit.

This listing of geologic formations reflects the current scope of geological studies. Future results may disqualify some of these formations, at which time they would drop from the list. On the other hand, additional formations holding promise will be identified and added.

To a certain extent, the list of formations also reflects the cu rent degree of interest in the particular formation. That interest is itself a combination of the overall program objectives and schedules and the state of knowledge. For example, the emphasis on the Salina salt of the Appalachian basin and the Gulf Coast salt domes results from the need for pilot plants in operation by the mid-1980s and the conclusion that this can best be accomplished in salt formations because of the considerable confirming fundamental work that has been completed in this type of formation in previous programs. The fifth-ranked

Permian basin salt in included at a high priority primarily as a contingency for the two top ranked salt formations. The third and fourth ranked shale and limestone formations are considered to be the most promising non-salt prospects and are given priority attention because of the programmatic desire to diversify the fundamental rock types considered for waste terminal storage. All of the remaining geological formations should be considered to be approximately equal at the present time. As the results of preliminary investigations become available, those offering the greatest potential will be identified for additional investigations while those with lesser potential will be deemphasized.

The geological investigations for each of the listed formations are summarized on the following bar charts. In general, the preliminary regional studies have been completed only for the Michigan basin portion of the Appalachian basin and the northeastern Louisiana portion of the Gulf Coast Salt Dome province. Specific investigations at identified study areas in these two regions will be initiated during FY-1976. The investigations of all of the other formations are in progress but only at the preliminary regional stage.

It is planned that preliminary geological and hydrological studies described above for the priority formations and preliminary studies of other formations of interest will proceed with the assistance of local and state scientists intimately familiar with the formations.

C. Technical Support Studies

Technical support studies comprise a number of long term generic study programs that are essentially independent of specific types of rock or their location, yet provide necessary support to the overall program. Currently, studies are under way in four areas:

1. Heat transfer/thermal analyses,
2. Waste-rock interactions,
3. Rock mechanics, and
4. Borehole plugging.

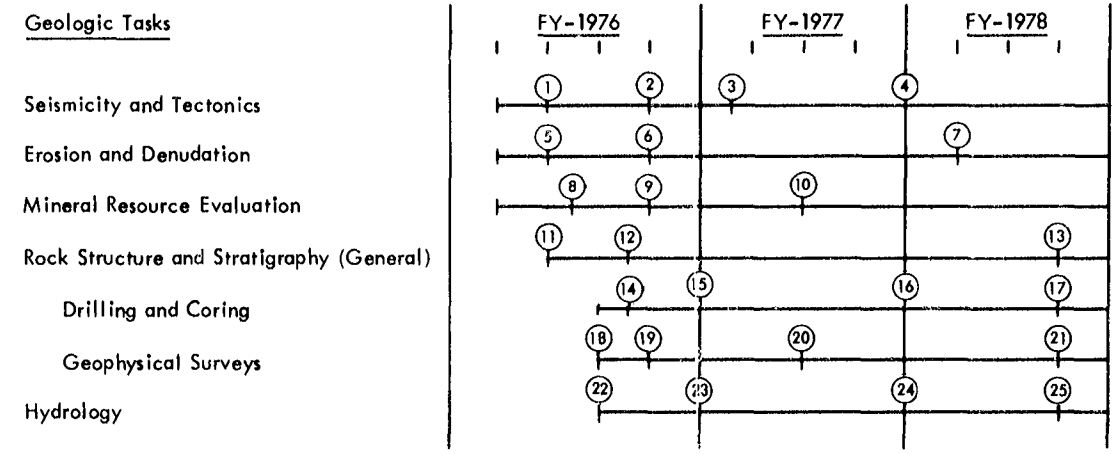
1. Heat Transfer/Thermal Analyses Studies

Since nuclear wastes, particularly high level wastes, generate heat, and all rock properties are temperature dependent, there is a need to develop the heat transfer/thermal analyses capability to calculate temperature profile as a function of heat load and time, not only for the waste canister, but also for the rock,

Figure 8

MAJOR GEOLOGIC TASKS MILESTONE CHART

Appalachian and Michigan Basins - Bedded Salt



(1) Document regional framework
(2) Initiate localized studies in Michigan
(3) Initiate localized studies in Ohio and New York
(4) Report on local conditions and initiate specific site work
(5) Document regional character
(6) Initiate localized studies
(7) Report on local variations
(8) Complete report on regional oil and gas potential
(9) Initiate local studies
(10) Report on local resources
(11) Start general studies
(12) Initiate detailed mapping
(13) Report on local and subsurface data
(14) Start exploratory drill hole 1
(15) Complete drill hole 1 and start drill holes 2-9
(16) Complete drill holes 2-9 and start drill holes 10-17
(17) Complete drill holes 10-17, select site study area

(continued)

Figure 8 (continued)

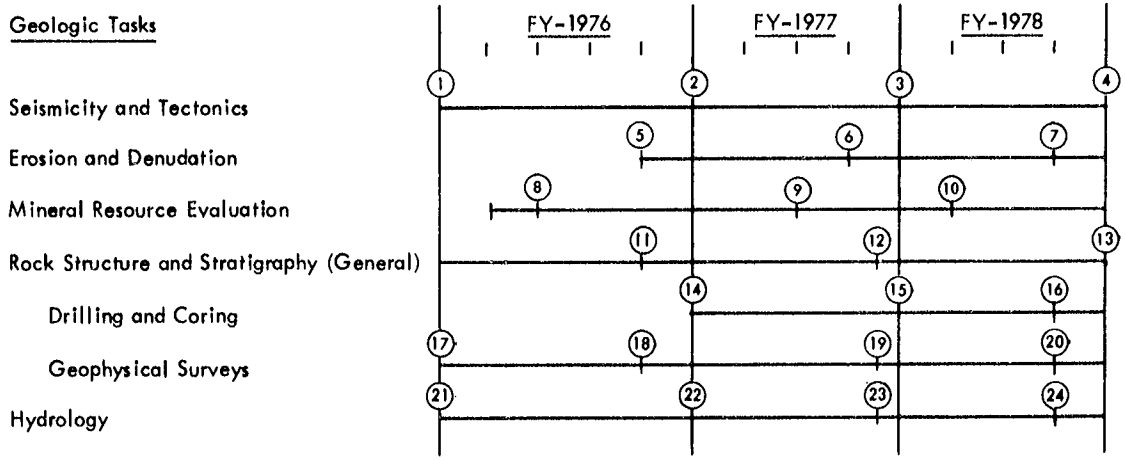
Appalachian and Michigan Basins - Bedded Salt

(18) Start study of existing data
(19) Report on data search and initiate localized surveys
(20) Preliminary report on new survey data
(21) Report on all survey data
(22) Assemble generalized data
(23) Report on borehole 1 test data
(24) Report on boreholes 2-9 test data
(25) Report on boreholes 10-17 test data

Figure 9

MAJOR GEOLOGIC TASKS MILESTONE CHART

Gulf Coast Salt Domes



(1) Preliminary report on N. Louisiana Basin
(2) Preliminary report on "target" domes in N. Louisiana Basin and regional aspects of N. Texas and Mississippi Basins
(3) Preliminary report on "target" domes in N. Texas and Mississippi Basins
(4) Detailed report on study domes
(5) Start regional studies of Interior Basins
(6) Report on regional findings and start studies of "target" domes
(7) Report on findings for "target" domes
(8) Report on generalized oil and gas potential of Interior domes
(9) Report on total resource potential of "target" domes in N. Louisiana Basin
(10) Report on total resource potential of target domes in Mississippi and Northeast Texas Basins
(11) Generalized reports on N. Louisiana, N. Texas, and Mississippi Basins
(12) Preliminary reports on "target" domes in Interior Basin
(13) Report on study domes

(continued)

Figure 9 (continued)

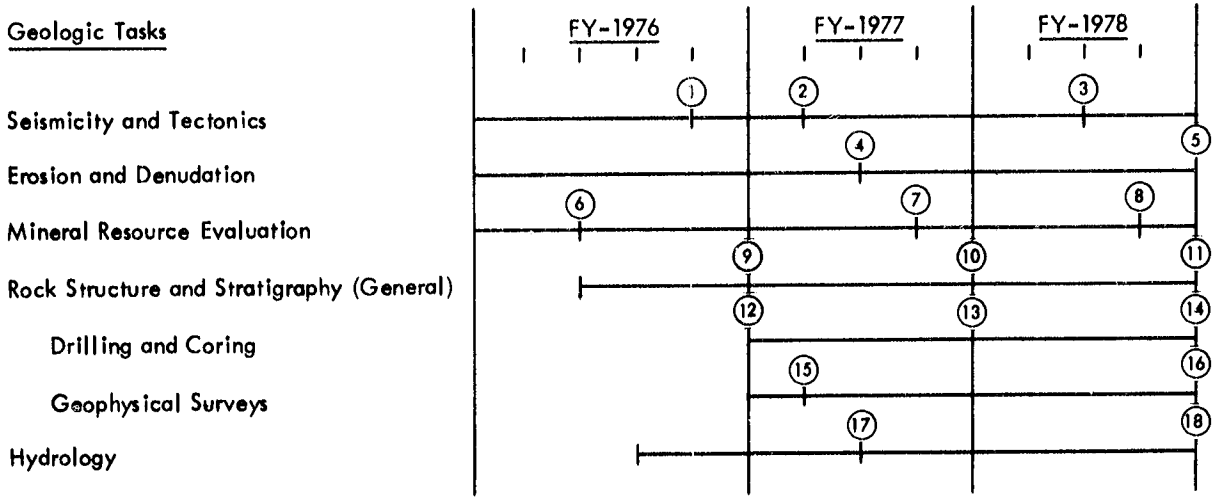
Gulf Coast Salt Domes

(14) Start exploratory boreholes 1-12
(15) Complete boreholes 1-12 and start boreholes 13-25
(16) Complete boreholes 13-25
(17) Report on "target" dome of N. Louisiana Basin
(18) Report on second "target" dome of N. Louisiana Basin
(19) Report on first and second "target" domes of Mississippi and Northeast Texas Basin
(20) Report on study domes
(21) Report on preliminary data on N. Louisiana Basin
(22) Report on preliminary data of N. Texas and Mississippi Basins
(23) Report on general rates of dissolutioning of "target" domes
(24) Determinations of hydrologic stability of study domes

Figure 10

MAJOR GEOLOGIC TASKS MILESTONE CHART

Mid-Continent Shale

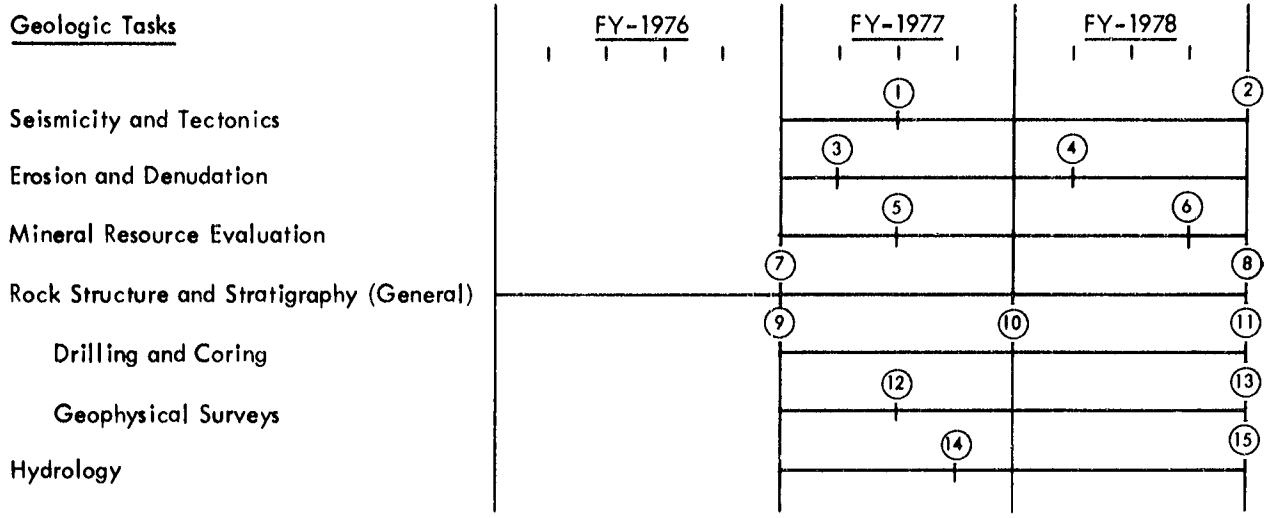


(1) General evaluation
(2) Preliminary reports on regional characteristics
(3) Report on localized assessments
(4) Regional characterizations
(5) Localized characteristics
(6) Preliminary survey of oil and gas potential of paleozoic shales
(7) Complete regional surveys of paleozoic and menozoic shales
(8) Report on analyses of borehole samples
(9) Regional features of paleozoic shales
(10) Preliminary report on localized areas
(11) Documentation of subsurface geologic conditions from drill holes and geophysical surveys
(12) Start drill hole 1
(13) Complete borehole 1 and start boreholes 2-4
(14) Complete boreholes 2-4
(15) Report on existing data and start local studies
(16) Preliminary report on local surveys
(17) Summarize generalized regional data
(18) Report on data from borehole and in situ tests

Figure 11

MAJOR GEOLOGIC TASKS MILESTONE CHART

Mid-Continent Limestone

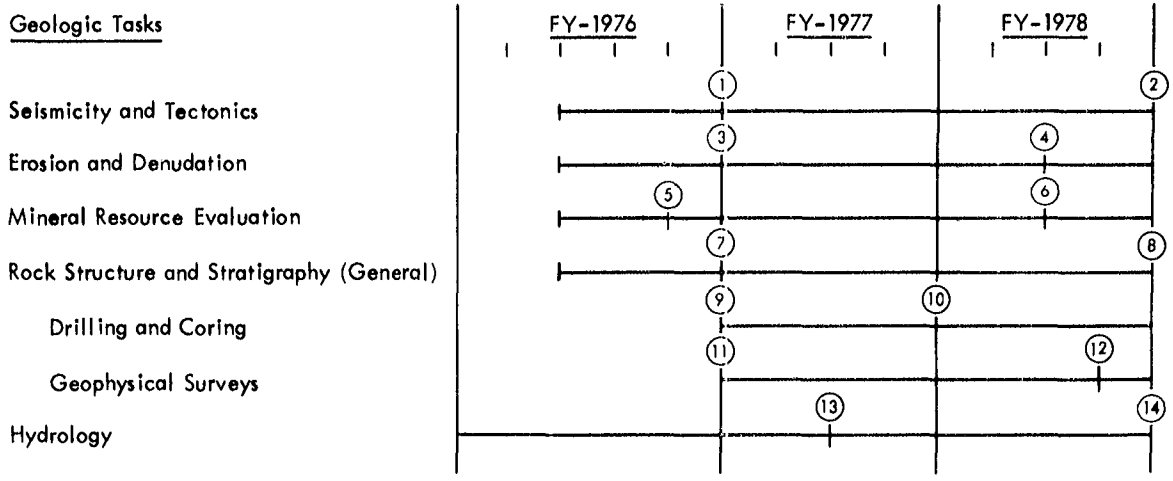


(1) Report on generalized conditions
(2) Evaluation of local study areas
(3) Generalized assessments
(4) Document localized assessments
(5) Preliminary report on oil and gas potential
(6) Detailed evaluation of oil and gas potential
(7) Documentation of regional conditions
(8) Preliminary report on subsurface conditions
(9) Start borehole 1
(10) Complete borehole 1 and start boreholes 2-4
(11) Complete boreholes 2-4
(12) Document review of existing data
(13) Report on local surveys
(14) General survey report
(15) Preliminary report on borehole tests

Figure 12

MAJOR GEOLOGIC TASKS MILESTONE CHART

Permian Basin Bedded Salt

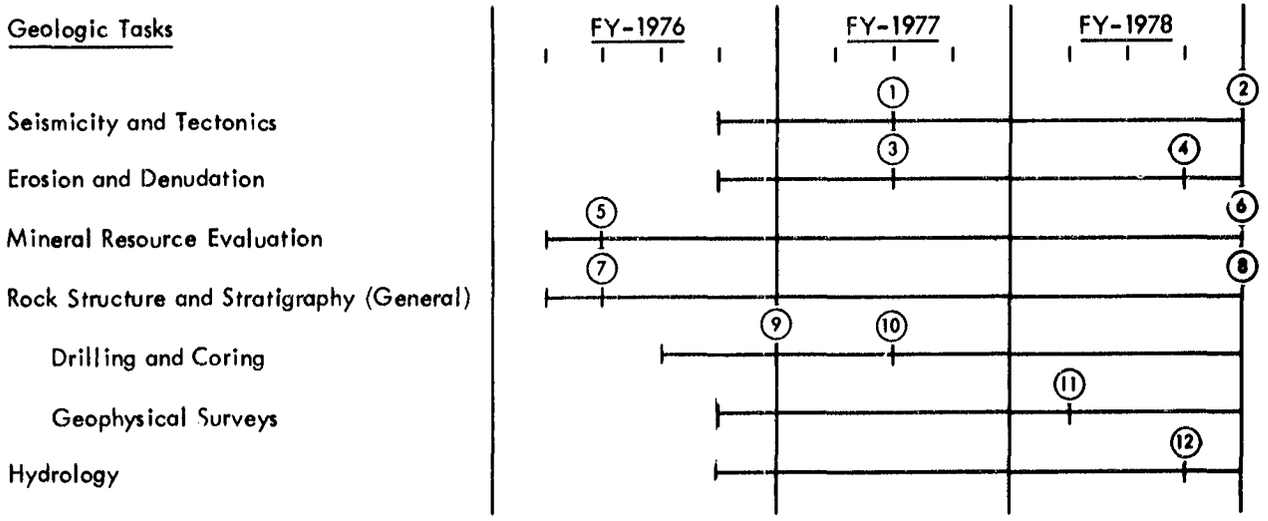


(1) Regional characteristics defined
(2) Report on localized conditions
(3) Regional setting characterized
(4) Preliminary results of local studies
(5) Regional oil and gas appraisal made
(6) Preliminary report on local resources
(7) Documentation and interpretation of existing data
(8) Preliminary report on subsurface geology
(9) Start borehole 1
(10) Complete borehole 1 and start boreholes 2-4
(11) Begin field surveys
(12) Preliminary report on field surveys
(13) Regional characteristics documented
(14) Preliminary report on borehole tests 1 and 2

Figure 13

MAJOR GEOLOGIC TASKS MILESTONE CHART

East Coast Triassic Shale Basins

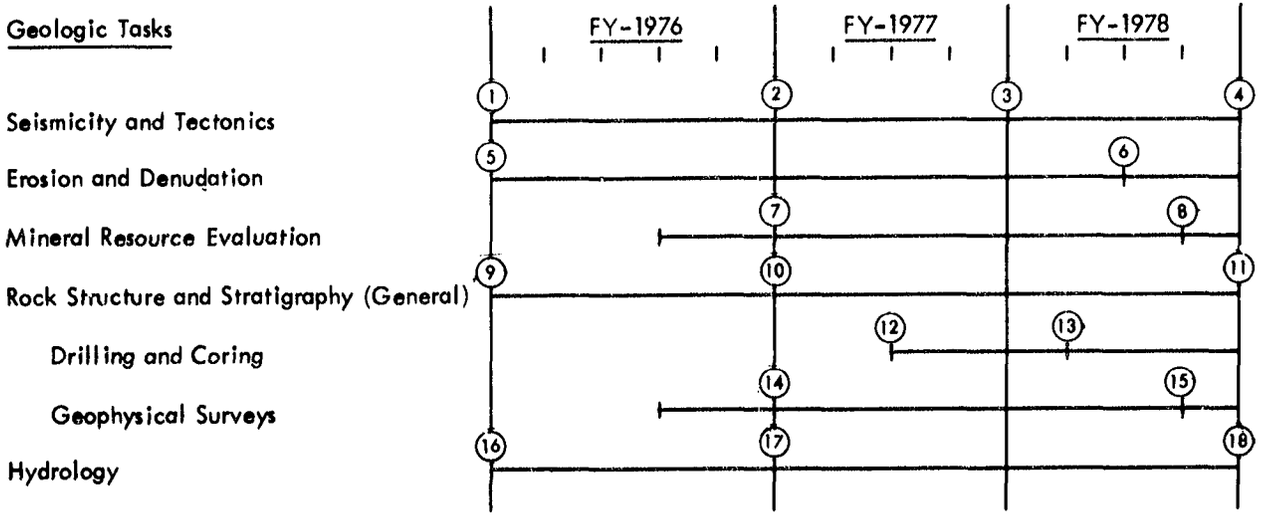


(1) Documentation of generalized data
(2) Report on state-of-stress
(3) Document regional rates
(4) Local characteristics established
(5) Preliminary oil and gas potential made
(6) Report on local resources
(7) Regional framework reported
(8) Status report on subsurface geology
(9) Report on USGS corehole
(10) Start work to deepen existing boreholes
(11) Report on surveys
(12) Report on laboratory and field studies

Figure 14

MAJOR GEOLOGIC TASKS MILESTONE CHART

Volcanic Rocks

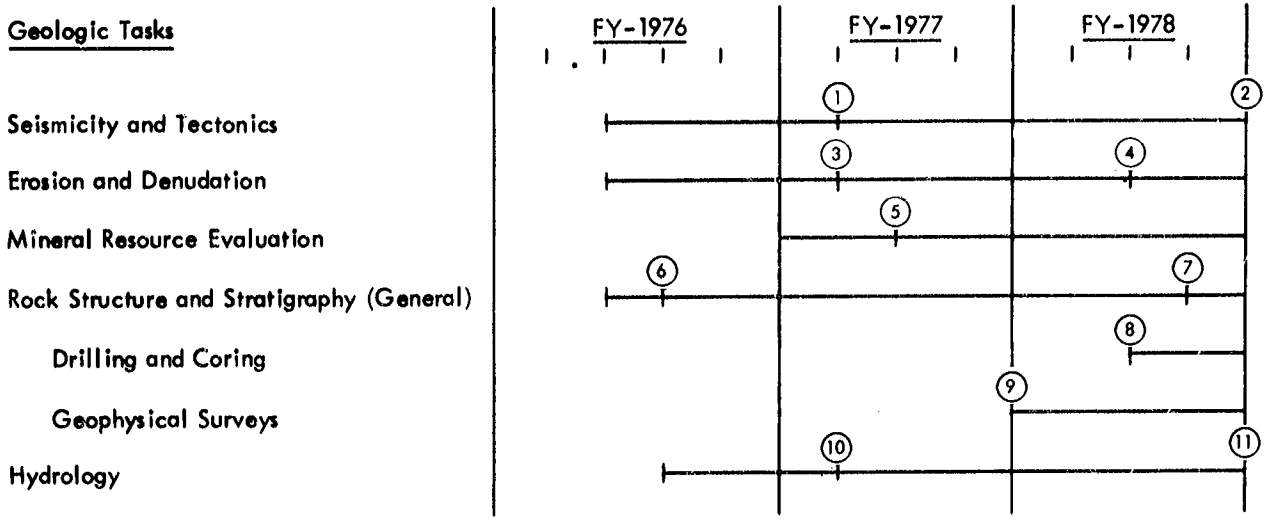


(1) Survey report from generalized data
(2) Comprehensive report from all available data
(3) Status report
(4) Preliminary report on local microseismicity
(5) Summary report from generalized data
(6) Preliminary report on local variations
(7) Generalized assessment
(8) Localized determinations
(9) Summary report
(10) Comprehensive report on existing knowledge
(11) Status report on investigations
(12) Start borehole 1
(13) Complete borehole 1 and start borehole 2
(14) Comprehensive report on existing data
(15) Preliminary report
(16) Summary report from generalized data
(17) Review report of available data
(18) Status report

Figure 15

MAJOR GEOLOGIC TASKS MILESTONE CHART

Crystalline Rocks

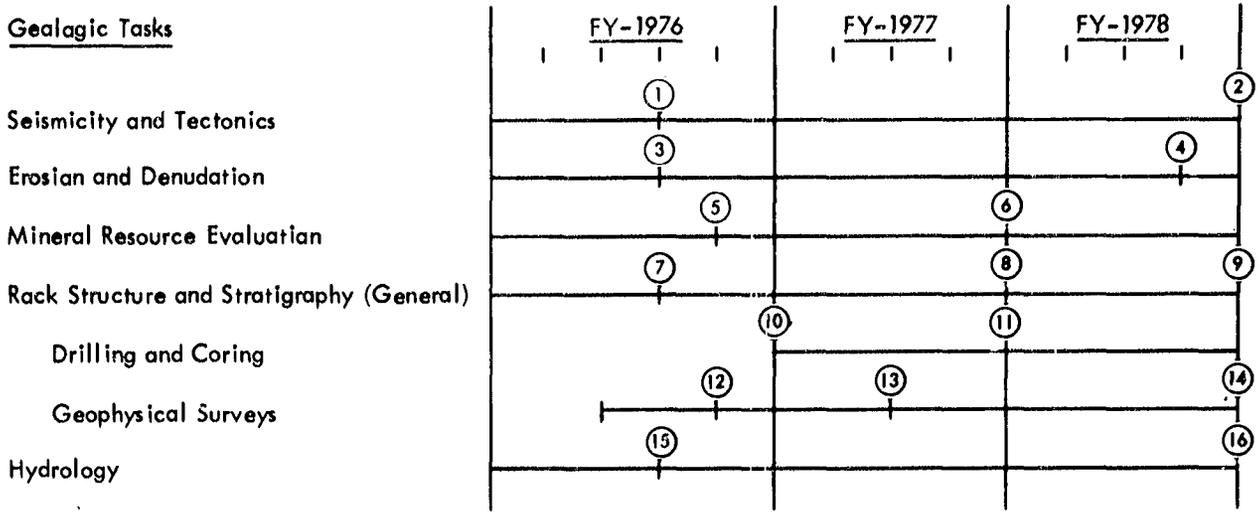


(1) Regional characteristics documented
(2) Preliminary report on local variations
(3) Generalized rates established
(4) Regional variations and glacial rebound assessed
(5) Preliminary assessments made
(6) Geologic framework outlined
(7) Status report
(8) Initiate test drilling
(9) Start aero-surveys
(10) Report on deep mine investigations
(11) Preliminary report on laboratory and field tests

Figure 16

MAJOR GEOLOGIC TASKS MILESTONE CHART

Paradax Basin Salt

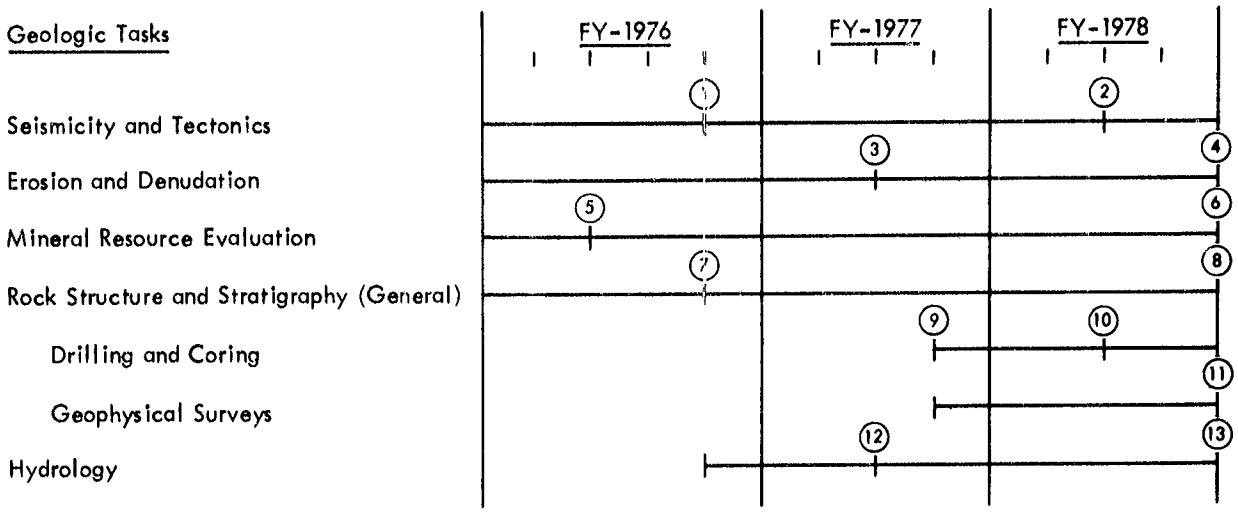


(1) General evaluatian
(2) Status report
(3) Regional appraisal
(4) Report on lacalized conditions
(5) Preliminary appraisal af potash
(6) Generalized oil and gas appraisal
(7) Report on Salt Valley anticline
(8) Summarize initial findings fram drilling
(9) Status report an subsurface geolagy
(10) Start drill hole 1
(11) Complete drill hole 1 and start hales 2 and 3
(12) Report on existing data
(13) Report on vertical profiling
(14) Report on surveys af Salt Valley anticline
(15) General appraisal
(16) Report on borehale tests

Figure 17

MAJOR GEOLOGIC TASKS MILESTONE CHART

Pierre Shale

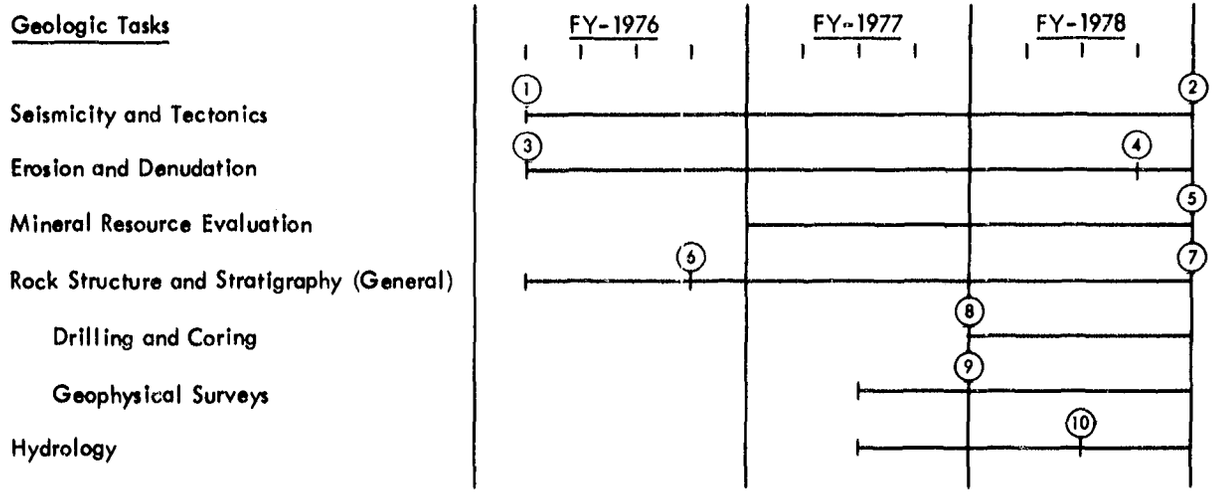


(1) General evaluation of Pierre Shale
(2) Report on localized assessments
(3) Regional characterizations made
(4) Localized characteristics summarized
(5) Preliminary survey of oil and gas potential of paleozoic shales
(6) Report on localized surveys
(7) Generalized report on Pierre Shale
(8) Preliminary report on localized areas
(9) Start drill hole 1
(10) Complete borehole 1 and start boreholes 2-3
(11) Preliminary report
(12) Summarize generalized regional data
(13) Report on data from boreholes

Figure 18

MAJOR GEOLOGIC TASKS MILESTONE CHART

Southeastern/Gulf Coast Clays

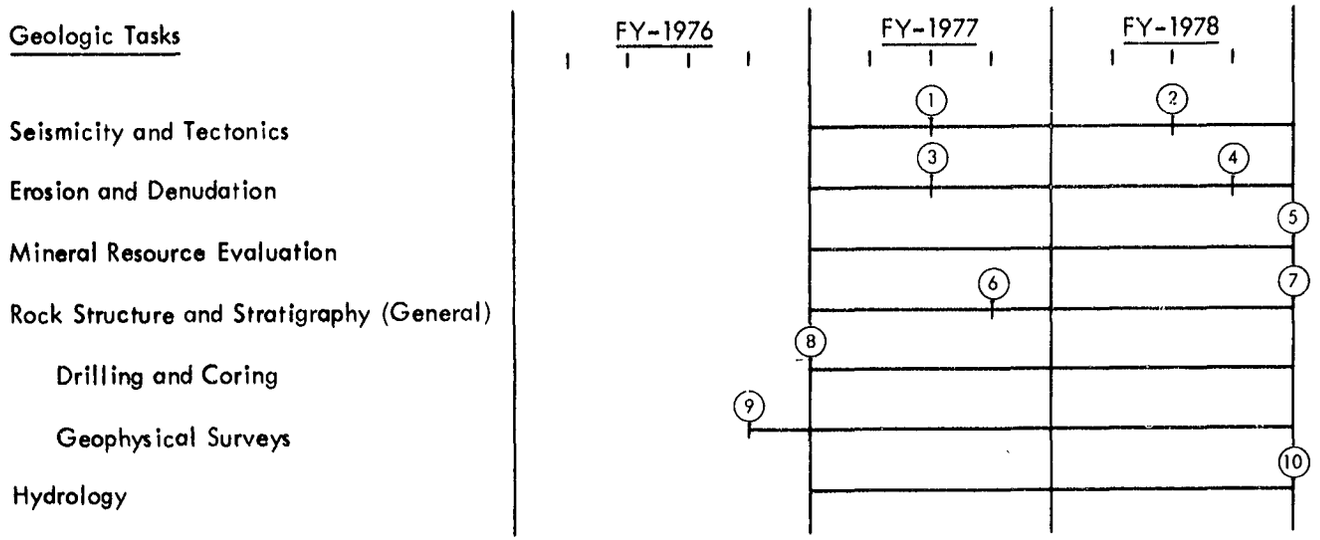


(1) Generalized framework documented
(2) Local patterns established
(3) Regional rates identified
(4) Local conditions evaluated
(5) Regional appraisal completed
(6) General report of N. Mississippi
(7) Status report of subsurface geology
(8) Start borehole 1
(9) Summarize existing data
(10) Assessment of general characteristics

Figure 19

MAJOR GEOLOGIC TASKS MILESTONE CHART

Eleana Formation (NTS)



(1) Report on existing data
(2) Age and activity of tectonic features
(3) Generalized appraisal
(4) Report on local conditions
(5) Report on regional and local resources
(6) General report on nature and occurrence of siltstone and shale
(7) Status report
(8) Commence exploratory drilling
(9) Start surveys
(10) Preliminary report on borehole tests

both in the immediate vicinity of the canister, as well as throughout the underground workings and the surrounding geologic formations. The approach to this need has been to first develop mathematical models to describe the heat flow and then to write and validate, using field test data, computer codes of sufficient size and versatility to perform the needed analyses. These codes are available and are being used as shown in the milestone chart:

a. To assist in the design of the in situ field experiment in salt;

b. To analyze the thermal problem associated with waste disposal facilities in pilot plants in salt, shale, and limestone.

2. Waste-rock Interactions

Although the intent of any waste facility is to isolate the waste from the rock until after the facility is permanently sealed, ultimately the canister will fail, allowing waste to contact the rock. The waste-interaction studies will provide information about the chemical and physical reactions of any type of waste with all types of rock associated with waste disposal facilities. These studies will identify and define problem areas, perform the needed research and development, analyze and interpret results, and provide for the distribution of the information via reports, workshops, or other appropriate means. In addition, this program includes a study of the OKLO phenomenon (a natural criticality event which occurred in Africa), the rock analysis program, radiochemical and radiation damage (stored energy) studies, and the development and assessment of mathematical models which describe various pathways, usually involving water, for radionuclide migration to the biosphere.

3. Rock Mechanics Studies

The rock mechanics study covers three areas:

a. To provide information on current mining equipment, methods, and techniques;

b. To measure the thermal and mechanical properties of all rocks associated with waste repositories;

c. To provide the computational ability to analyze the stability of the underground workings.

The approach to the third area has been to develop mathematical models and computer codes to analyze the design of the underground workings and to predict their stability for the depth, heat load, and time frames specified. Two codes are being developed, one using a finite element method and the other using a semi-empirical displacement-discontinuity method. The status of these studies are shown in Figure 20.

4. Borehole Plugging Program

Boreholes, whether adjacent to or actually penetrating the underground waste facility, offer a possible pathway for water to enter the underground workings and, thus, should be plugged. The problem is to develop the material and the technique to emplace a plug with properties equal to or better than those of the surrounding rock. The broad range of tasks and studies may be summarized as follows:

a. A review of current practices for sealing civil engineering projects (i.e., underground gas storage facilities, dams, etc.), and plugging oil and gas wells;

b. The development of suitable plugging material, such as compacted earthen material and cement based plugs;

c. The development of methods to emplace a plug in an existing borehole;

d. The design of field test experiments and the instrumentation to evaluate the tests to demonstrate the efficacy of borehole plugs.

The status of the program is shown in the milestone chart, Figure 20.

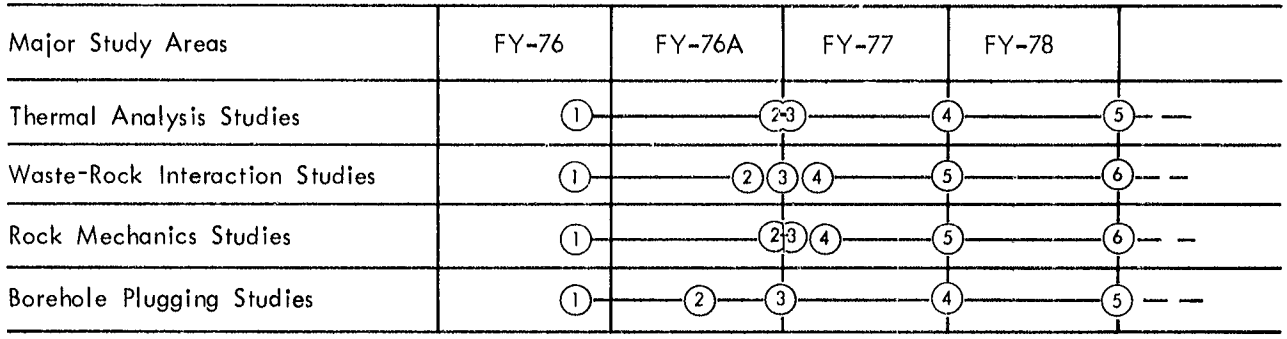
D. Engineering Studies

1. Field Testing Studies

Experience has shown that, while laboratory data characterizing rock properties are both necessary and useful for preliminary design studies, ultimately the behavior of the rock must be determined by in situ tests, preferably carried out at about the same depth and in the same formation horizon to be utilized as the receptacle for waste containers. Since field testing is expensive, the sequence of increasingly sophisticated field tests (shown in Figure 21) which, in general, parallel the sequence of geologic studies discussed in section II B, has been devised to obtain the in situ data needed for pilot plant design studies.

Figure 20

TECHNICAL SUPPORT STUDIES - MILESTONE CHART



Milestones - Technical Support

Thermal Analysis:

1. Complete the design and thermal analysis of thermal aspects of in situ experiments in salt formation; start studies for in situ test in shale and limestone.
2. Complete development and testing of procedures for analyzing data from in situ test.
3. Start the analysis of thermal problems associated with pilot plants in salt formations.
4. Start the analysis of thermal problems associated with pilot plants in shale and limestone formations; interim report on in situ test results.
5. Continue thermal analysis of pilot plant in salt, limestone, and shale and issue of interim report.

(continued)

Figure 20 (continued)

Waste-Rock Interaction Studies:

1. Workshop on geologic data requirements for radioactive waste management assessment models.
2. Completion of methodology studies and equipment design to determine brine (water) migration, sleeve corrosion, rock behavior, etc., for the in situ tests in salt, shale, and limestone.
3. Redirect and expand the radionuclide migration modeling and risk assessment programs.
4. Plan for and initiate research and development efforts to obtain experimental data needed to verify radionuclide migration models.
5. Interim report analyzing data obtained from in situ test in salt.
6. Complete the preliminary radiation efforts and chemical, physical, and thermal properties evaluation of samples from the site exploration boreholes in salt formations.

Rock Mechanics Studies:

1. Complete the design of the rock mechanics instrumentation for in situ experiments in salt formations.
2. Complete the code development and verification of the finite element analysis programs for deformation of salt.
3. Redirect and expand the displacement discontinuity mathematical modeling and code development program to handle mine stability analysis in all rock formations.
4. Initiate the analysis of mine stability for a pilot plant in salt formations using both finite element and discontinuity displacement models.
5. Initiate the analysis of mine stability for a pilot plant in shale and limestone.
6. Interim report - continuing programs.

(continued)

Figure 20 (continued)

Borehole Plugging Studies:

1. Complete engineering studies to (a) develop a program plan for the in situ field demonstration of borehole plugging technique and materials, and (b) develop the research and development program to provide the instrumentation necessary to evaluate the in situ demonstration tests.
2. Complete the "State of the Art" Study of Borehole Plugging Techniques and Experience in the oil and gas industry.
3. Initiate planning for in situ field testing, the instrumentation research and design program, and planning for in situ field test of in situ salt dissolution around a borehole.
4. Initiate the borehole plugging field demonstration program.
5. Interim report - field demonstration program.

Figure 21

GENERALIZED IN SITU FIELD TESTING SEQUENCE

IN-SITU TEST	OBJECTIVE	SCOPE
1. Preliminary Experiments	Identification of gross formation characteristics and behavior	- Electrical heaters only - Surface or existing underground excavations - Experimental location
2. Field Test	Preliminary engineering design and geological containment data	- Electrical heaters and possibly radiation sources (removed at termination of experiment) - Existing excavations - Experimental location
3. Vault Test	Formation certification	- Electrical heaters and small quantities of simulated waste (removed at termination of experiment) - Specially constructed excavations - Experimental location

Preliminary test experiments consist of an electric heater placed in a hole usually drilled in an exposed surface outcrop of the rock formation. Data are obtained by observation and from a minimum number of instruments. Field tests are designed to provide fairly accurate information about (1) the thermal and mechanical behavior of the rock as a function of temperature, (2) the mechanical, chemical, and thermal behavior of the simulated waste canister, and (3) the behavior of canister protective devices to assure retrievability. They are usually constructed in existing underground excavations and are extensively instrumented.

Vault tests are elaborate, extensively instrumented experiments placed in excavations specially constructed in the candidate rock formation. They utilize both electric heaters and/or canisters of simulated waste. Vault tests provide extensive information on the thermal, mechanical, and chemical behavior of the rock, the waste canister, and the canister protective devices as well as information on the stability of the underground mine layout.

It is not always necessary to perform the complete sequence of tests. For instance, the extensive information available from the commercial mining of salt plus that obtained from both previous and current field tests should eliminate the need to perform a vault test before designating a pilot plant location in a salt formation. In situ field tests are currently contemplated in salt, shale, and limestone formations. The status of the tests is shown in Figure 22.

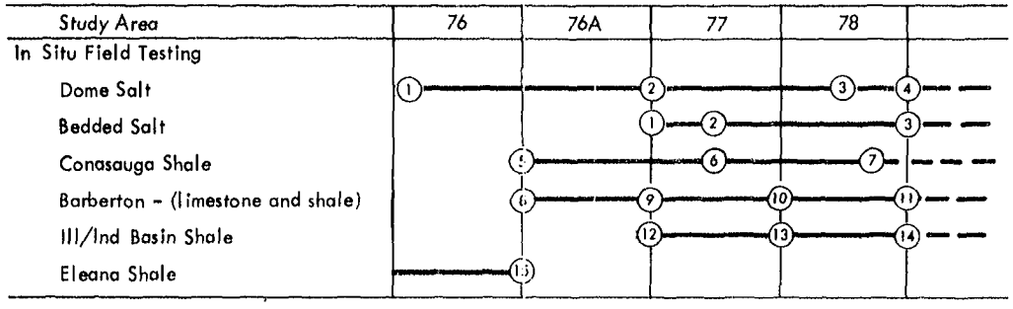
2. Design Studies

Included in this category are those studies which are generic to the waste-disposal program, which must be completed before specific facility design studies discussed in section II can be started, and which provide cooperative efforts with other parts of the ERDA waste management program, such as the waste isolation pilot-plant program at Sandia. Typical of the generic studies is the Alternative Waste Emplacement Concept study. This study will evaluate all alternative waste emplacement concepts which utilize retrievable waste canisters, such as, matrix holes, super deep holes, solution mining, and disposal in holes in the sea bed. It would determine for each concept the "state of the art," its engineering feasibility, areas where research and development effort is needed, the extent and cost of the research and development effort, and public acceptance problem areas.

A second generic program is a study to establish criteria for converting a pilot-plant project to a Federal Repository. A few of the areas which this study would examine and analyze include the

Figure 22

ENGINEERING STUDIES — IN SITU FIELD TESTING MILESTONE CHART



1. Initiate design of field test experiment.
2. Start field test experiments.
3. Complete field test experiments.
4. Complete post experiment examination and issue report.
5. Initiate design of preliminary test experiments.
6. Start preliminary test experiments.
7. Complete field test experiment.
8. Lease Barberton, Ohio limestone mine.
9. Design and install field test in limestone horizon of Barberton mine.
10. Start limestone field test. Start design and construction of field test in shale horizon of Barberton mine.
11. Continue limestone field test and construction of field test in shale.
12. Design and stort construction of field or vault test in Illinois/Indiana shale basin.
13. Continue construction of Illinois/Indiana shale test.
14. Start operation of Illinois/Indiana shale test.
15. Evaluate preliminary test experiment site studies.

operating experience of existing waste disposal facilities, risk analyses of long term hazard to the environment and the population, plans for decommissioning the repository, and monitoring of the site.

Studies which must be completed before the Title I designs for the specific facilities can be started include: (a) a preliminary pilot-plant cost estimate for a pilot plant in salt using conventional underground mining methods, and, (b) a parallel, independent feasibility design study to evaluate methods for (1) handling waste containers in the surface facilities, (2) lowering the containers into the mine, (3) handling them in the underground workings, and (4) excavating the underground workings.

The status of studies currently underway or soon to be started is shown in Figure 23.

E. Waste Facility Projects

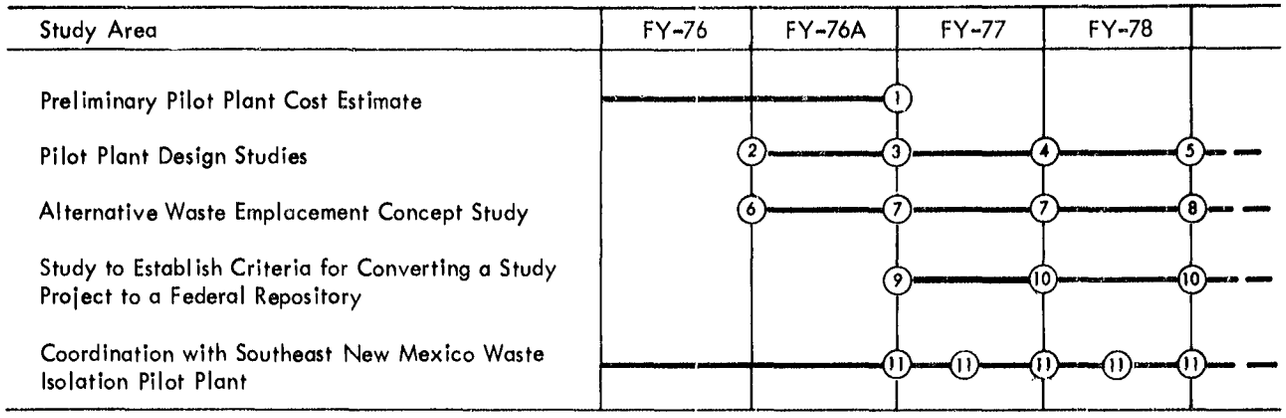
The general facility testing sequence for the pilot plants is shown in Figure 24. The objective for the pilot plant is to evaluate handling and storage operations and confirm design and analysis. This will be done with limited handling equipment at the surface and limited underground excavations in order to minimize investment until the objectives are achieved. The next step is to expand the pilot plant to evaluate full-scale handling and storage operations and fully certify the site for terminal storage. The final step in the testing sequence is to operate the pilot plant as a full-scale facility. At some point in this sequence an application will be submitted to NRC for a license to operate the facility as a Federal Repository. This will be done when sufficient information is available to make the application.

The general schedule for all the pilot plants is shown in Figure 2. The first two of these plants will be located in salt formations as discussed in section I C. A more specific schedule for the first two pilot plants is shown in Figure 25. This figure shows that the sites for the pilot plant will be identified by the fourth quarter of FY-1978, the construction will span a four year period covering FY-1981 through FY-1984, and actual waste will be received by the fourth quarter of FY-1985.

The capital plant project for the first two pilot plants is planned to go forward in three phases as follows:

Figure 23

ENGINEERING STUDIES - DESIGN STUDIES MILESTONE CHART



1. Complete preliminary pilot plant cost estimate.
2. Initiate planning of pilot plant design studies.
3. Select subcontractors and start parallel pilot plant design studies.
4. Interim report and review - pilot plant design studies.
5. Complete reports of pilot plant design studies.
6. Initiate planning of alternative Waste Emplacement Concept Study (AWECS).
7. Interim report and review of AWECS.
8. Complete report of AWECS.
9. Initiate study - pilot plant conversion to expanded pilot plant criteria.
10. Continue study.
11. Coordination with Sandia - WIPP (semi-annual review meeting).

Figure 24

GENERALIZED FACILITY TESTING SEQUENCE

FACILITY	OBJECTIVE	SCOPE
PILOT PLANT	EVALUATE HANDLING AND STORAGE OPERATIONS AND CONFIRM DESIGN AND ANALYSIS	– LIMITED RECEIVING RATE AND CAPACITY FOR COMMERCIAL WASTE – WASTE RETRIEVABLE – EXCAVATION IS A PROTOTYPE SECTION OF A FULL-SCALE FACILITY – EXPERIMENTAL LOCATION
EXPANDED PILOT PLANT	EVALUATE FULL-SCALE HANDLING AND STORAGE OPERATIONS AND FULLY CERTIFY SITE FOR TERMINAL STORAGE	– FULL-SCALE RECEIVING RATE AND CAPABILITY TO EXPAND TO FULL-SCALE CAPACITY FOR COMMERCIAL WASTE – WASTE EASILY RETRIEVABLE
EXPANDED PILOT PLANT	FULL SCALE	– OPERATE AT CAPACITY – MAINTAIN RETRIEVABILITY UNTIL LICENSED – FINAL SITE

Figure 25

DESIGN AND CONSTRUCTION SCHEDULE

Pilot Plants No. 1 and 2

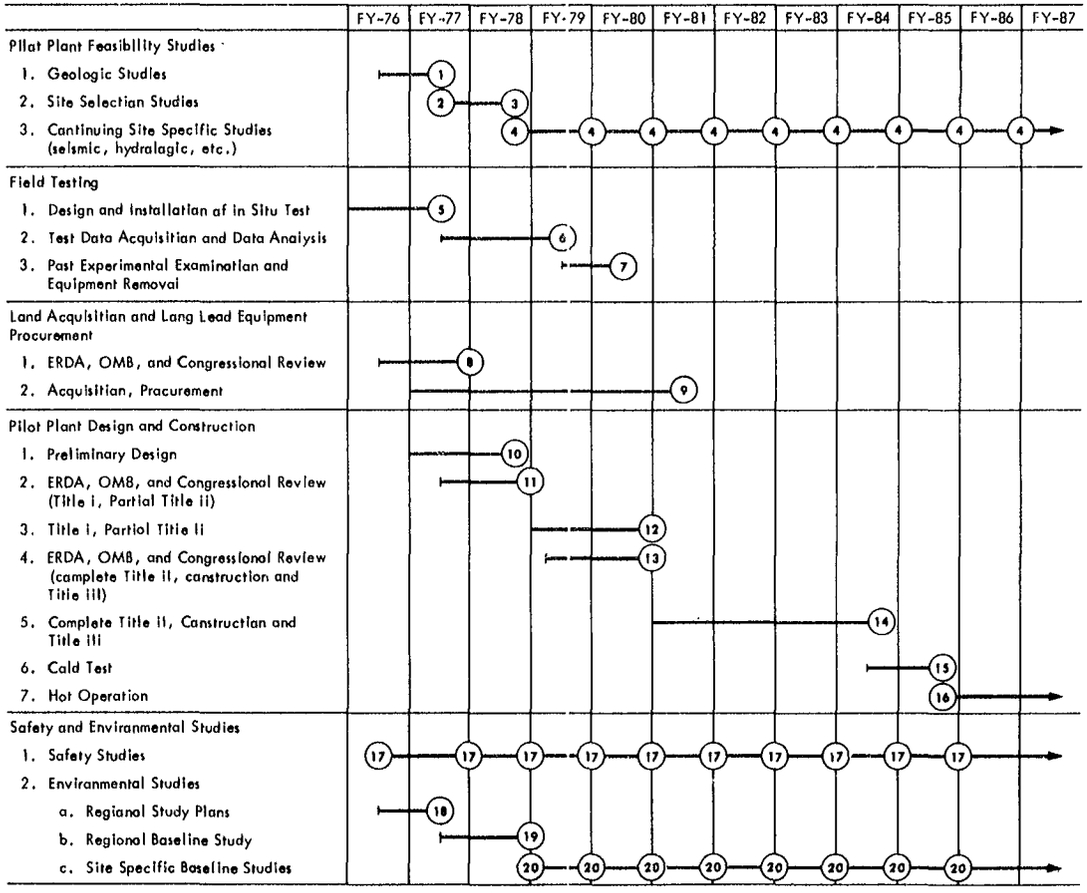


Figure 25 (continued)

MILESTONES

1. Geological studies completed.
2. Site confirmation studies start.
3. Site selected and certified.
4. Continuing seismic, hydrologic, etc. site-specific studies and annual report.
5. Complete design, construction, and installation of in situ field test.
6. Completion of test data acquisition and data analysis.
7. Completion of post experimental examination, equipment removal and final report.
8. Congressional approval and funding.
9. Land and long lead items acquired.
10. Preliminary design completed.
11. Congressional approval and funding.
12. Complete Title I and partial Title II design.
13. Congressional approval and funding.
14. Complete Title II, construction, and Title III.
15. Cold testing completed.
16. Hot operation starts.
17. Initiate continuing safety studies and annual report.
18. Regional environmental studies - plans and criteria.
19. Regional environmental base line study completed.
20. Continuing site specific environmental base line studies and annual report.

Phase	Item	Authorization Fiscal Year	Expenditure Fiscal Years
I	Land Acquisition and Long Lead Items	1978	1978 - 1981
II	Title I and II Designs	1979	1979 - 1980
III	Construction and Title III	1981	1981 - 1985

It is assumed that a number of questions, such as the size of the pilot plant (waste package capacity), the method of emplacing waste packages, and the method of transporting high-level waste canisters from the shipping casks to the underground workings will have been worked out in the design studies described in section II D.

Conversion of the pilot plant to an expanded pilot-plant status is expected to take five years as indicated in Figure 2. In order to achieve such a schedule, a capital plant project for the expansion will be requested for funding authorization starting in FY-1985 so work can progress on the expansion while the pilot plant is in operation.

F. Environmental Studies

Previous studies have identified regions of the United States where geological formations of interest exist. These formations have been s t into a very general priority list for investigation as possible locations for pilot plants. Environmental studies in these regions are planned to proceed in three steps as follows:

1. Determine base line environmental study requirements in each region where a pilot plant might be located;

2. Perform base line environmental studies in each region until a specific pilot plant site is selected;

3. Perform site-specific base line environmental studies when a site is selected leading to an EIS, an ER, and continuing through duration of the project.

A similar sequence is planned for all other regions of interest and for pilot plants subsequent to pilot plants 1 and 2; however, the work will be stretched out to provide a schedule compatible with the requirements of the later pilot plants. The schedule for these studies applicable to pilot plants 1 and 2 is shown in Figure 25.

G. System Studies

System studies will be carried out to provide guidance and direction to the Office of Waste Isolation Terminal Storage program. The three studies described below will be started in fiscal year 1976 (see Figure 26). Others will be started as problem areas and their concomitant studies are identified.

1. Canister Envelope Studies

A waste canister envelope study for high-level waste will be performed which will ultimately result in recommending a canister configuration compatible with both the nuclear industry and ERDA waste disposal facilities. A preliminary study has been started to produce a background report and to define the tasks for the final study.

2. Waste Transportation Study

In cooperation with the ERDA transportation branch, national laboratories, DOT, NRC, commercial nuclear material transportation companies, railroads, etc., a systems analysis will be made of the methodology, equipment, procedures, nuclear safety, safeguards, transportation safety, and routing philosophy for tranporting radioactive waste from the point of generation to the ERDA waste storage facilities. This study will include interfacing the equipment with both commercial plants and waste storage facilities.

3. Economic Studies

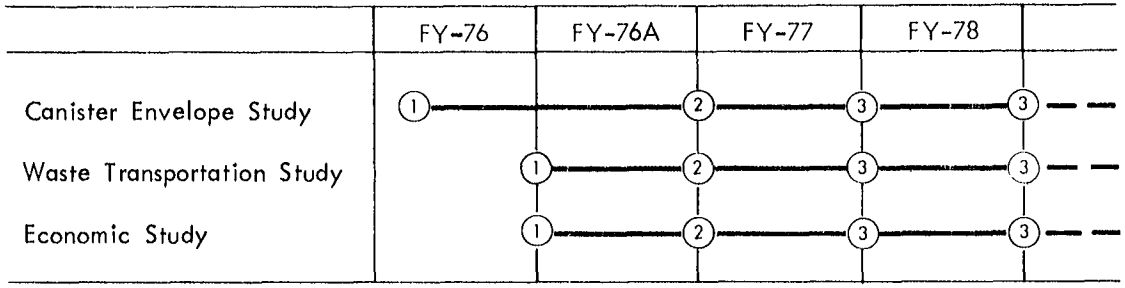
An economic systems analysis will be performed to (1) develop the basis, models, and methodology for determining changes to the nuclear industry for ERDA waste management, and (2) study the overall waste management concepts to identify areas of high cost impact and initiate efforts to reduce these costs.

H. Data Management

The various technical program tasks will generate large amounts of information in many forms (such as written, data-logging tapes, and core samples), all of which must be recorded, catalogued, and stored. To provide for the ready access and retrieval of information that waste isolation program personnel will need, as much of the information generated as possible will be stored in a computerized information system. Such a system will permit the stored information to be displayed, analyzed, interpreted, revised, edited, and corrected with the end result being either a printout or a plot in any specified format.

Figure 26

SYSTEM STUDIES - MILESTONE CHART



Milestones

1. Initiate pre-study planning
2. Initiate study
3. Interim review and report

OWI-76-35

I. International Activities

Disposal of radioactive waste is of concern not only to the USA but also to other countries which have or are planning to have a nuclear power capability. Since many of these countries are engaged in planning (and research and development efforts) for the disposal of nuclear waste, usually in suitable geologic formation within their own boundaries, it would be mutually advantageous to exchange information. Within the scope of existing international technology exchange agreements and understanding on radioactive waste management, OWI will explore areas where it would be meaningful and useful to enter into bilateral or multilateral efforts involving exchange of manpower for temporary duty, joint experimentation or investigations, or providing certain technological data.

IV. PROGRAM PLAN DIAGRAMS

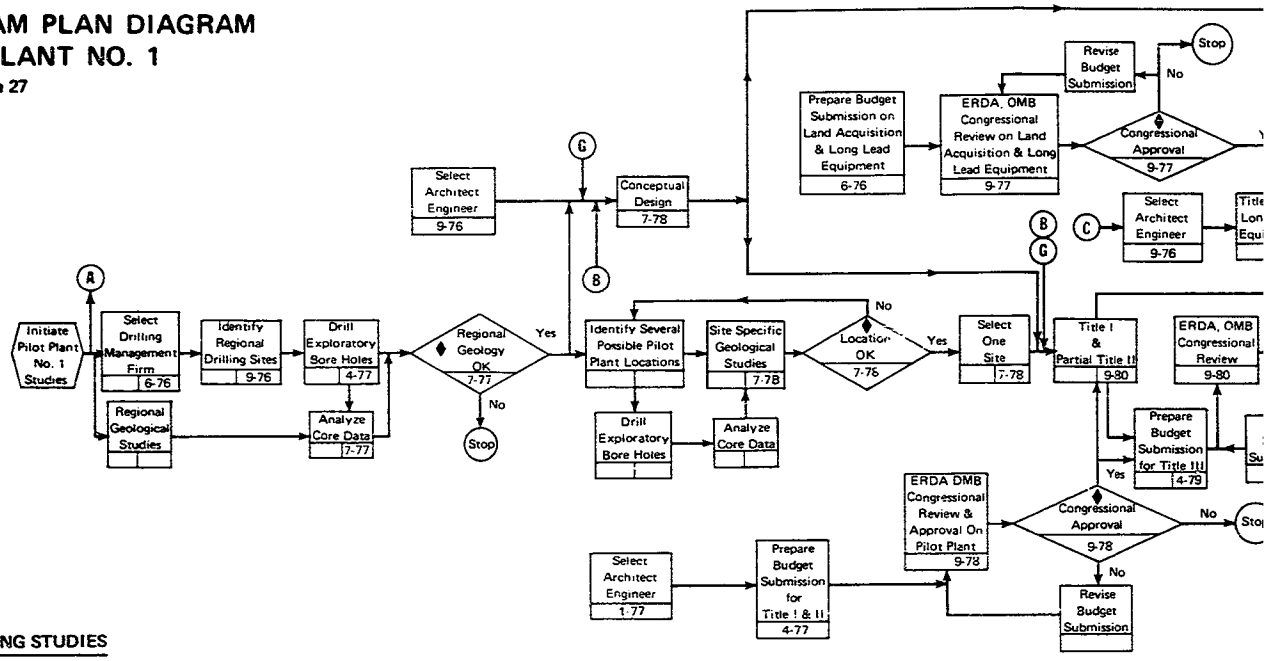
Program Plan Diagrams have been developed to show both the sequence of activities and the time frame within which the activities must be completed to insure that the six pilot plants specified by the NWTS program plan are operational at the times shown in Figure 2. Detailed diagrams are shown for pilot plants 1 and 2 and reflect the phased construction schedule which provides sufficient time (4 yrs) to construct the facility if hot operations are to start in July 1985. The generic diagram for pilot plants 3, 4, 5, and 6, which are scheduled for hot operation during or after 1987, uses a more conventional construction schedule.

Public Affairs activities are vital to the successful implementation of the NWTS program, yet they are only shown in the diagrams as mandatory activities at the several decision points. By definition, mandatory public affairs activities are considered to be the culmination of an intensive Public Affairs program publicizing the events, etc. which lead up to that particular decision; they are not a single activity occurring at a specific time.

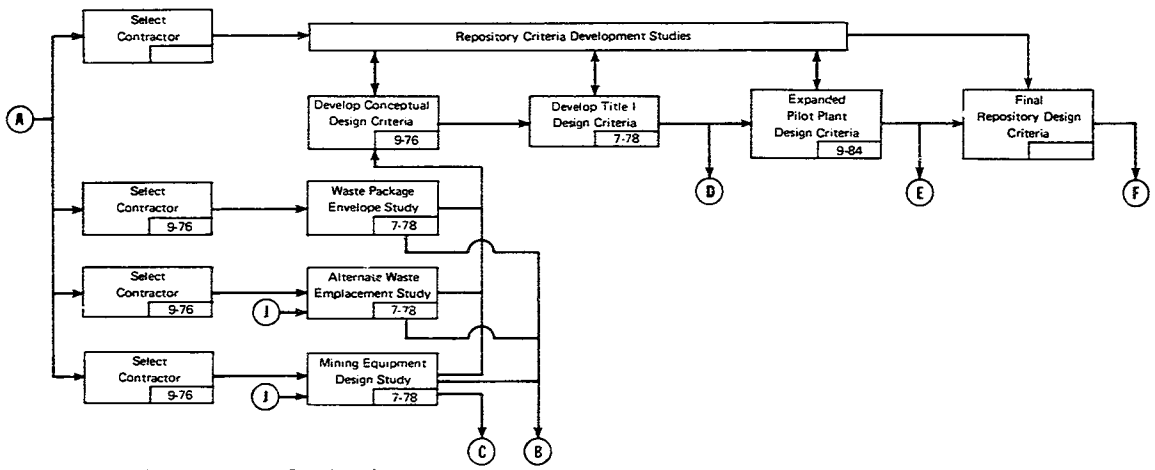
All the diagrams include under Engineering studies an activity called Repository Criteria Development Studies. These studies will ultimately provide the criteria which will be used to determine the modification (if any) and the date when an expanded pilot plant will be converted to a Federal Repository. This long term study will, as shown, provide input to and receive information from all phases of the design, construction, and operation of a waste disposal facility.

PROGRAM PLAN DIAGRAM
PILOT PLANT NO. 1

Figure 27

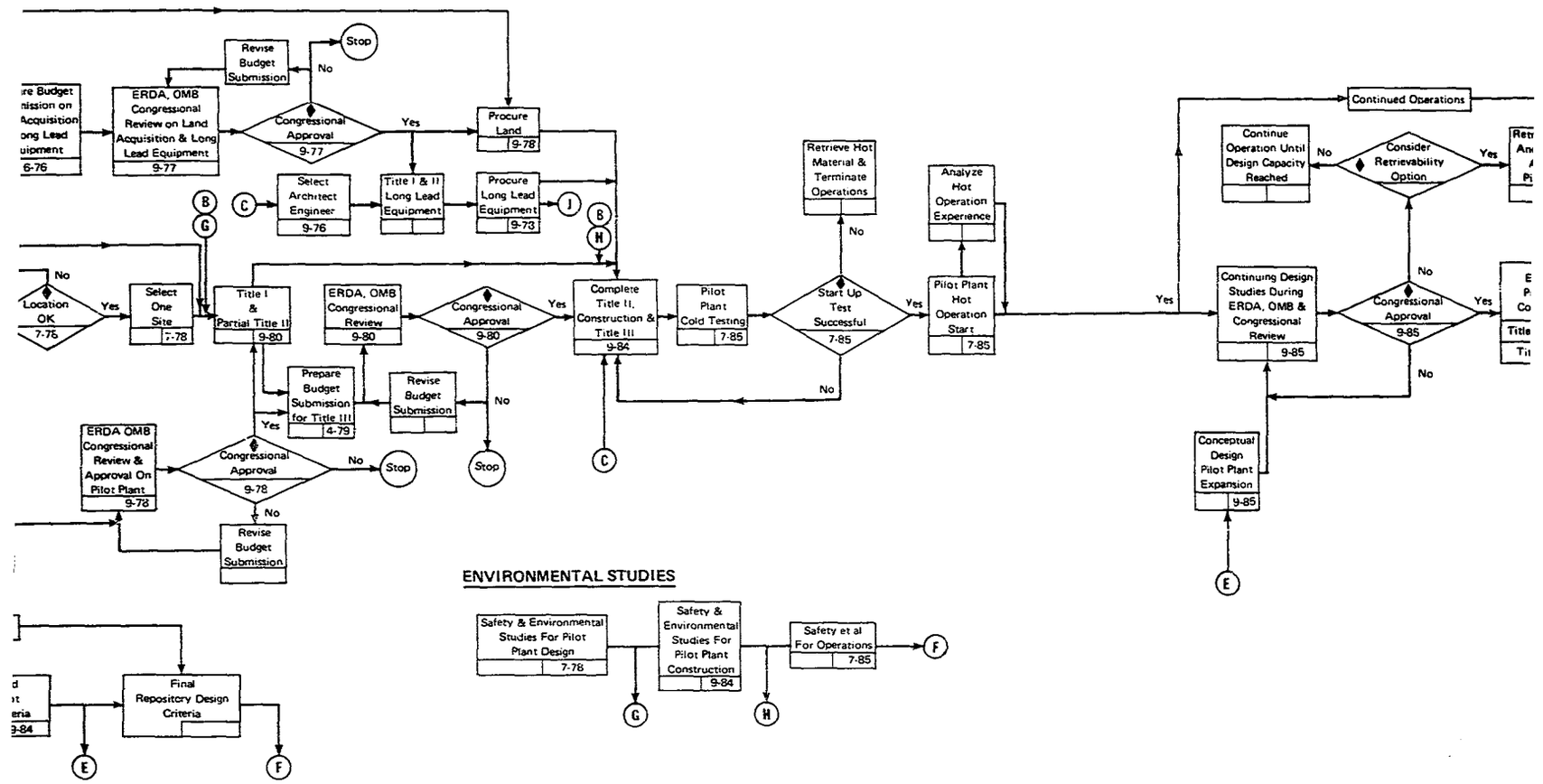


ENGINEERING STUDIES



TECHNICAL SUPPORT STUDIES (Continuous Data Input)

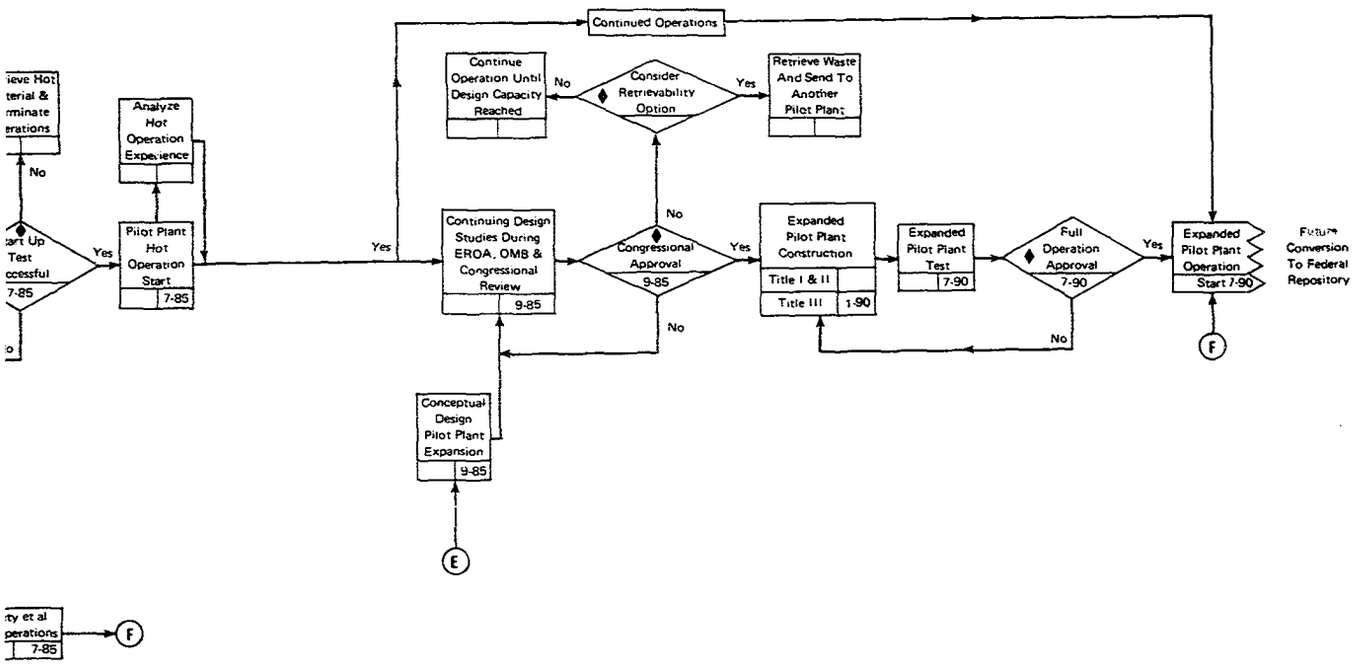
Note: ♦ Mandatory Public Affairs Activities



Continuous Data Input To All Pilot Plant Activities

Note: ♦ Mandatory Public Affairs Activities

Note: All Dates Are Activity Completion Dates Unless Otherwise Stated.



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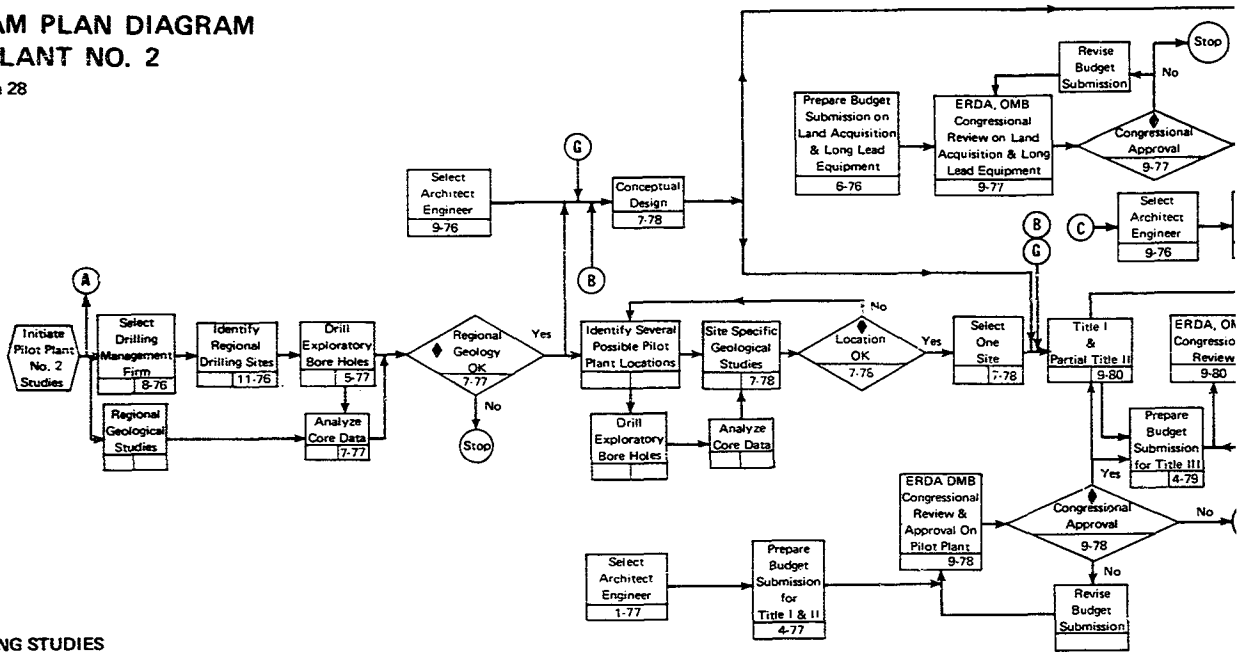
PROGRAM PLAN DIAGRAM
PILOT PLANT NO. 2

Figure 28



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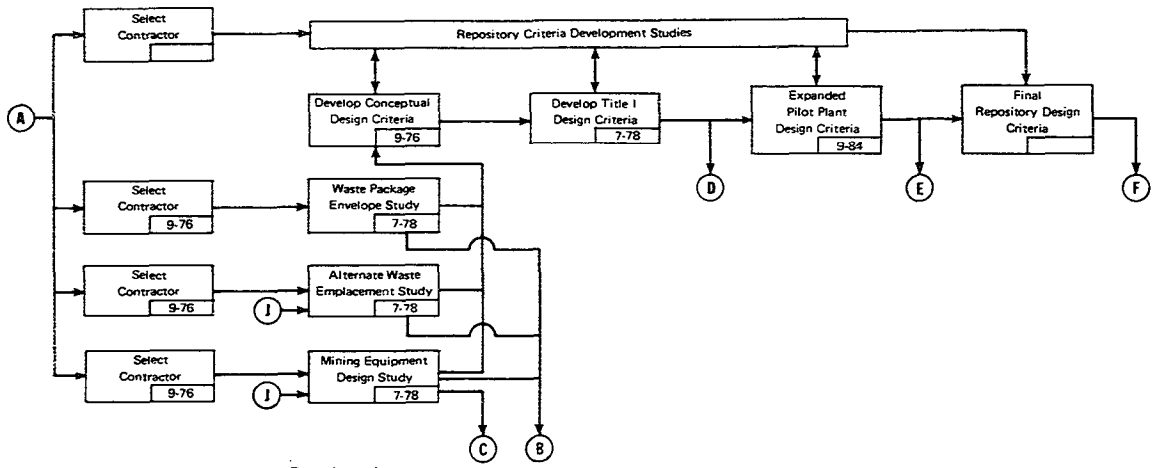
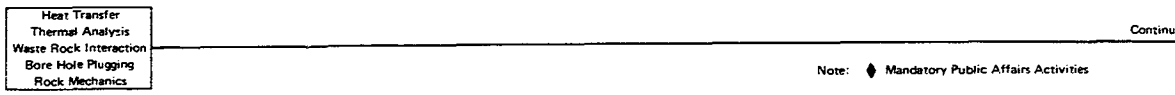
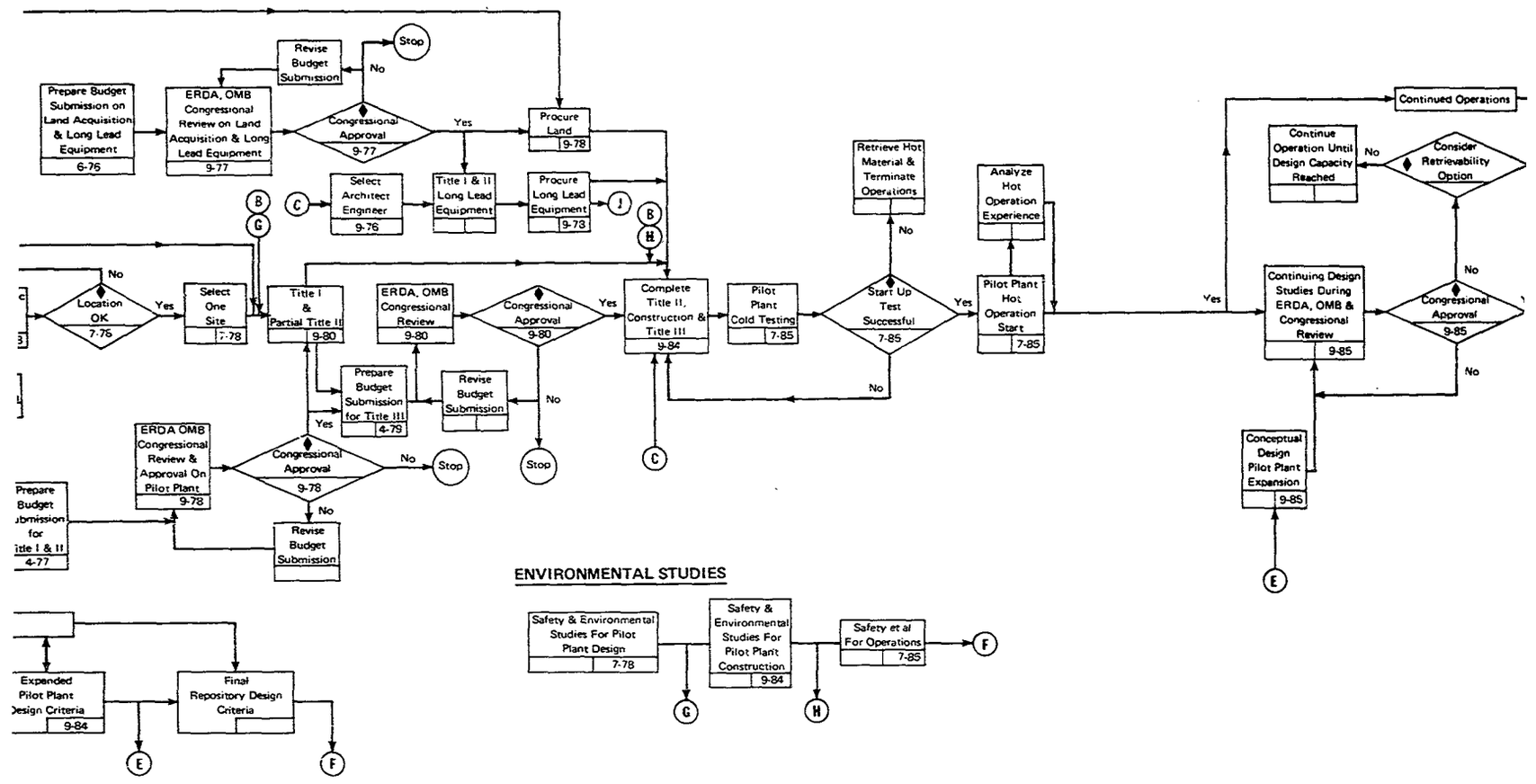


TECHNICAL SUPPORT STUDIES (Continuous Data Input)



Note: ♦ Mandatory Public Affairs Activities

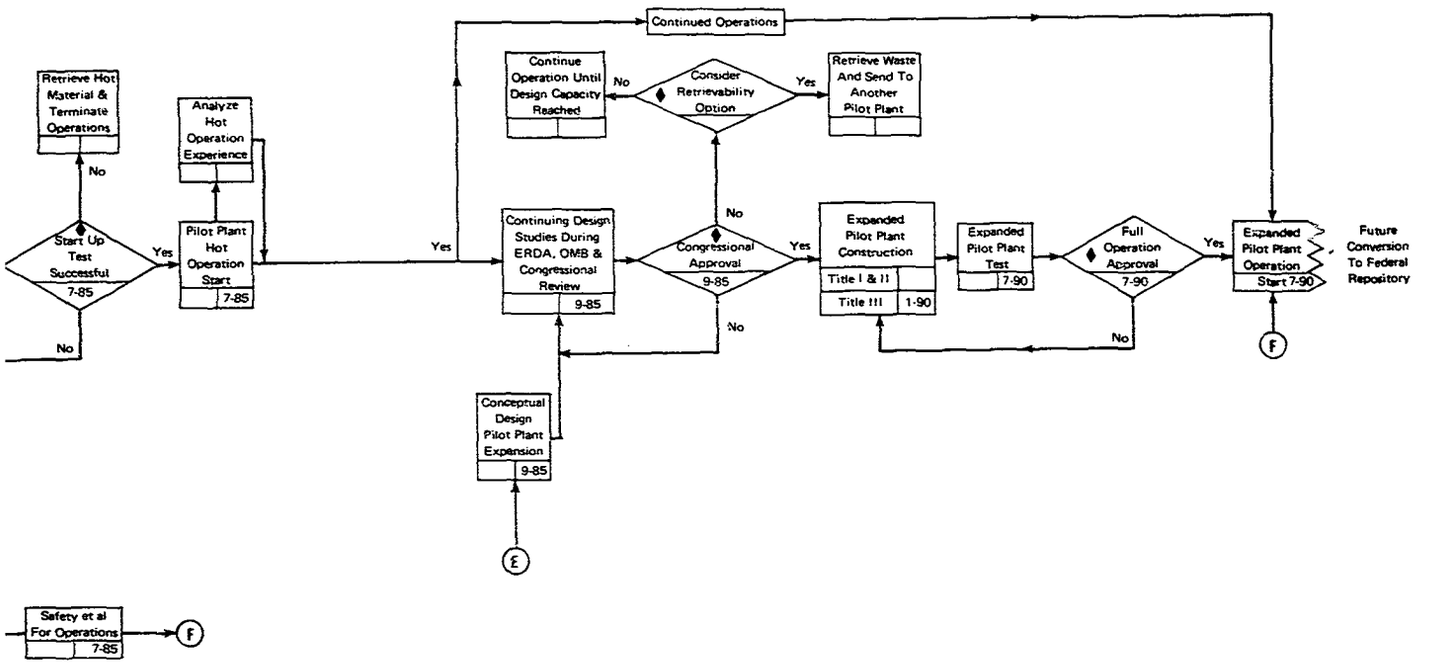


ENVIRONMENTAL STUDIES

Continuous Data Input To All Pilot Plant Activities

Note: ♦ Mandatory Public Affairs Activities

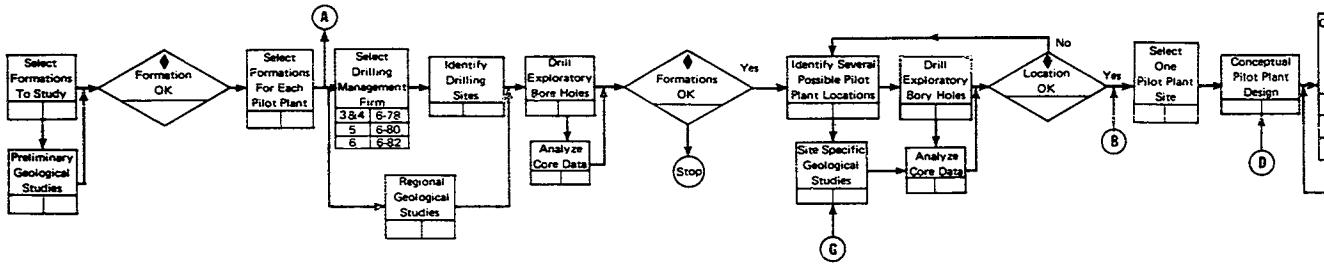
Note: All Dates Are Activity Completion Dates Unless Otherwise Stated.



Note: All Dates Are Activity Completion Dates Unless Otherwise Stated.

PROGRAM PLAN DIAGRAM
PILOT PLANT NO. 3, 4, 5, 6

Figure 29



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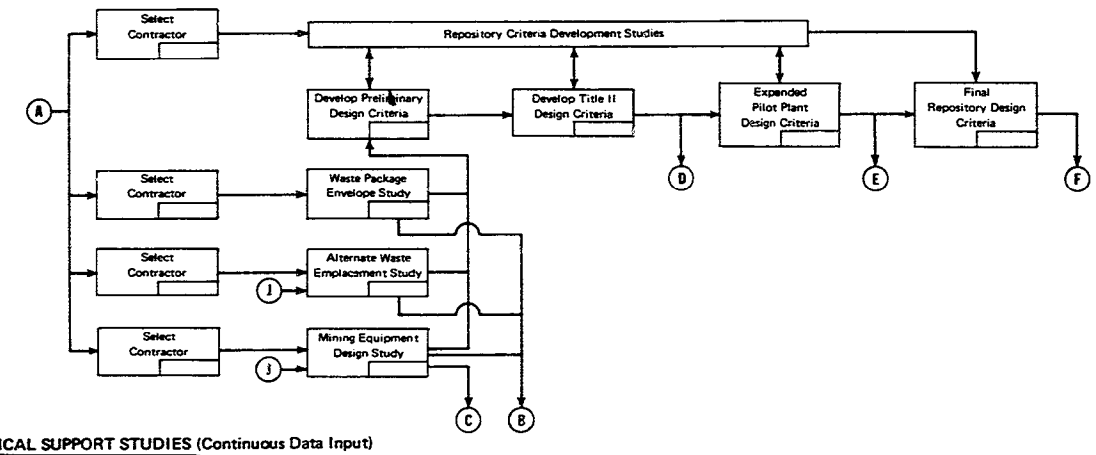

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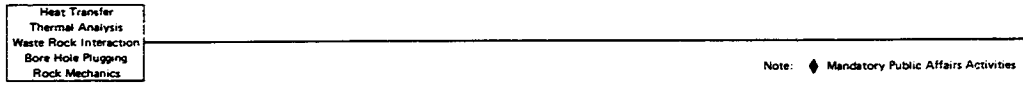
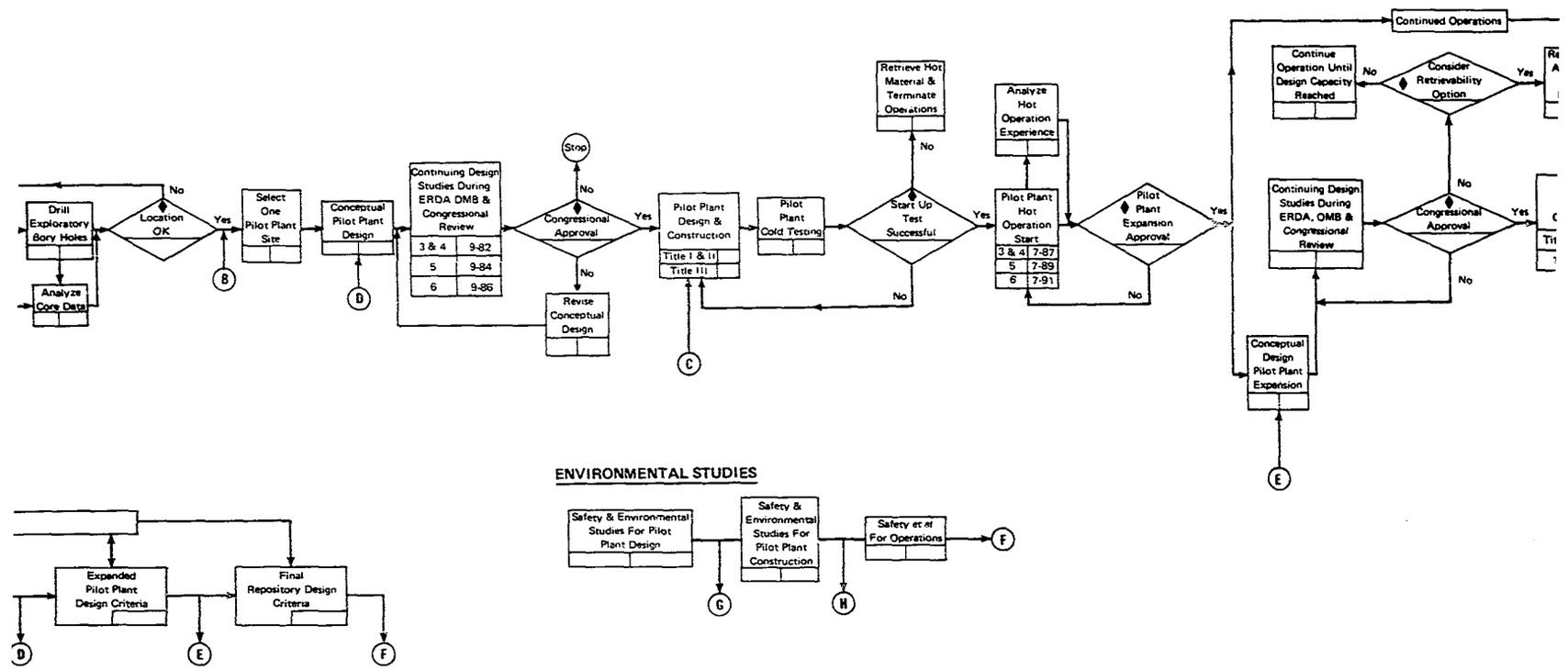


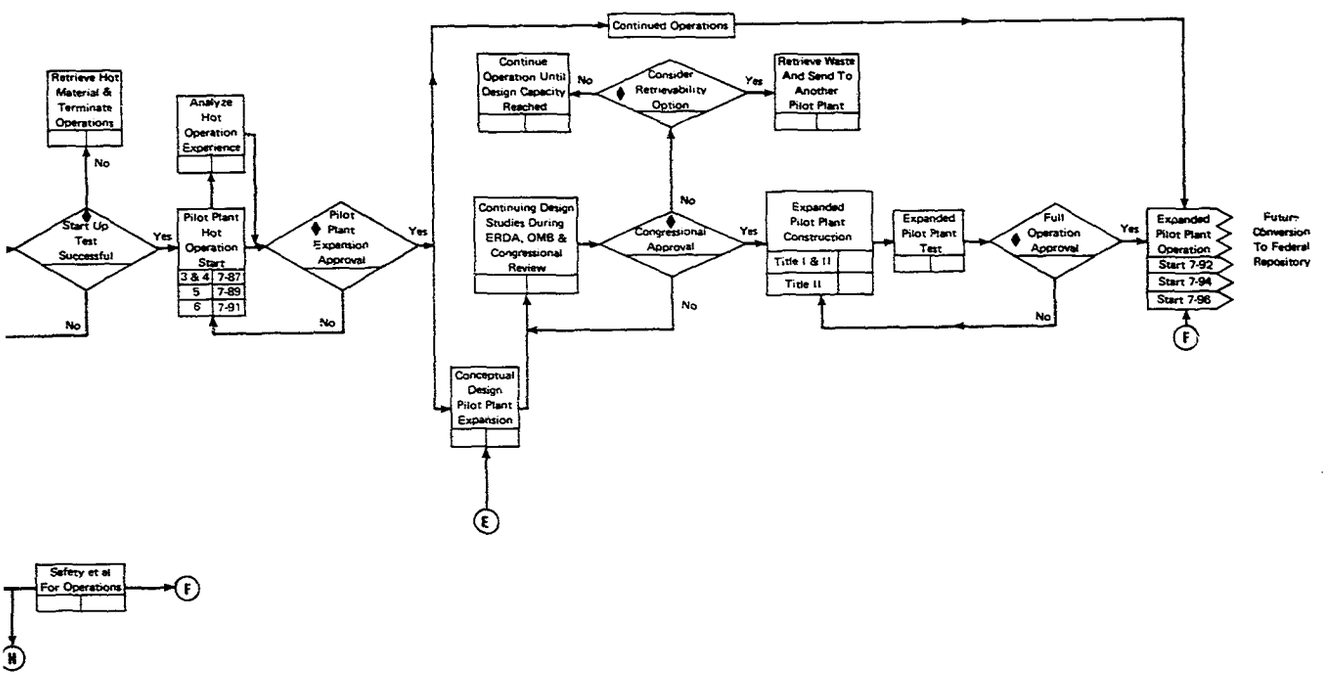


ENVIRONMENTAL STUDIES

Continuous Data Input To All Pilot Plant Activities

Note: ♦ Mandatory Public Affairs Activities

Note: All Dates Are Activity Completion Dates Unless Otherwise Stated.



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C. C. Hopkins

Technical

W. J. Wilcox, Jr.

Y-12 Plant

J. M. Case
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J. D. Griffin
R. F. Hibbs
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P. R. Vanstrum