MASTER

OFFICE OF WASTE ISOLATION
PROGRESS REPORT

NOVEMBER 1977

**UNION
CARBIDE**

OFFICE OF WASTE ISOLATION
OAK RIDGE, TENNESSEE

*prepared for the U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
under U.S. GOVERNMENT Contract W-7405 eng 26*

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OFFICE OF WASTE ISOLATION
PROGRESS REPORT

NOVEMBER 1977

C. D. Zerby, Director

Issued December 28, 1977

Edited by R. C. Rhines
and J. M. Asher

OFFICE OF WASTE ISOLATION
Union Carbide Corporation-Nuclear Division
Oak Ridge, Tennessee 37830

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HIGHLIGHTS

- . . . The Geologic Review Group meeting was held in New Orleans, November 16-17 1
- . . . Start-up of the near-surface heater experiment in the Conasauga Shale Formation is under way at Oak Ridge 34
- . . . The first shipment of experimental equipment from Oak Ridge to Avery Island, Louisiana, for the dome salt in situ test was successfully completed 35
- . . . On November 9-10, a design status review on the spent fuel repository conceptual design was held with Kaiser Engineers, Inc., in Oakland, California 39
- . . . On November 2, OWI personnel reviewed the progress on the Economic Studies with TRW representatives 44

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FOREWORD

As in the past, the format of this report generally follows the organizational structure of the Office of Waste Isolation (OWI) and the programmatic structure of the National Waste Terminal Storage (NWTs) Program. The report contains project reports on work performed by commercial and/or nonprofit organizations under subcontract to OWI, by Department of Energy (DOE) contractors (including UCC-ND), by OWI consultants, and by other federal agencies supporting and participating in the NWTs Program. Each project report identifies the OWI staff member responsible for managing the project, as well as the names of the consultants, subcontractors, or DOE facilities conducting the work.

1. TECHNICAL PROJECTS

W. C. McClain

1.1 Geologic Evaluation

R. B. Laughon

1.1.1 GULF COAST INTERIOR SALT DOME BASIN . . . R. B. Laughon

1.1.1.1 An Investigation of the Utility of Gulf Coast Salt Domes for the Storage and/or Disposal of Radioactive Wastes . . . J. D. Martinez, Louisiana State University (LSU)

General

Representatives of the project team attended the meeting of the Geologic Review Group in New Orleans, November 17-18. Each of the senior investigators presented the results of his work to date, along with the program for future work in his area of activity. Planning for the New Orleans meeting was discussed during an earlier meeting at LSU (November 1) with W. C. McClain and R. B. Laughon of OWI.

Geomechanics

Alternating current was installed at the recording seismograph site over Vacherie dome. Routine tiltmeter data collection is proceeding over Vacherie and Rayburn's domes. A site-specific finite-element numerical model of Vacherie dome is nearing completion. This model will be used to assist in interpreting the field instrumentation data currently being collected over Vacherie dome. A similar numerical model is planned for Rayburn's dome.

Planning is under way to coordinate with James Dorman, a geophysicist of the University of Texas Marine Geophysics Laboratory in Galveston, Texas, in the use of a liquid-level tiltmeter over one of the North Louisiana study domes.

Geohydrology

The description of well cuttings and the detailed correlation and analysis of the geophysical logs of the wells drilled at Rayburn's salt dome were begun. Cross sections of the sediment near the flanks of the dome are being prepared to establish the local dip and to locate discontinuities such as erosional surfaces and faults that might affect the hydrology near the dome. The Cane River Formation is being correlated in electric logs between Vacherie and Rayburn's domes.

Planning for the proposed thermal infrared survey progressed. A. J. Lewis, LSU, is reviewing and revising existing specifications in preparation for anticipated subcontracting during early CY 1978. Law Engineering Testing Company, the Geologic Project Manager (GPM), was informed about this work and will be coordinating with other investigatory agencies

in Texas and Mississippi to assure maximum efficiency in performing this survey. The GPM was also advised of future subcontracting requirements for water wells at Vacherie and Rayburn's domes. The results of existing wells are being evaluated in order to determine specific well locations and specifications at each dome.

Regional geology

Geochemical analyses were completed on 28 crushed rock-salt samples from the Cote Blanche salt mine in St. Mary Parish, Louisiana. The atomic absorption spectrophotometer was used for the determination of Na, K, Sr, Ca, and Mg. Sulfate was determined by a colorimetric method, and chloride values were obtained by silver nitrate titration. In addition, the compilation and reduction of analytical data for all salt samples continued.

Efforts are being made to locate additional existing seismic data in the vicinities of Vacherie and Rayburn's domes. Inquiries have been made of various companies concerning existing seismic data. Teledyne indicated that they have new multichannel data available on a north-south line between the two domes. Other companies will also be contacted in the coming month.

Gravity data were obtained from Exploration Services and Texaco, and reduction of the data was begun. Gravity data have now been obtained from five independent sources.

Quaternary geology

The principal effort during the reporting period involved the processing of cored samples from Vacherie. Grain-size analyses, hydrometer and Atterberg limits data from the LSU Soils Laboratory are being processed and used in classifying and correlating soil units within the Quaternary. Based on this data, preliminary subsurface sections included in the 1977 report are being revised, and the final sections are being drafted.

A specially devised pitcher-type sampler was used to obtain samples from an unusual, and abnormally deep, fine sand encountered beneath gravel-bearing Quaternary sediments at the western end of the dome. These materials were examined microscopically and compared with cored samples obtained from the Tertiary Sparta sands that cap the hills surrounding the dome. Thirty thin clayey and silty strata within this sand unit were also selected for pollen analysis. Processing of samples and isolation of possible pollen spores are being done by the LSU Geology Department. If spores are found, they will be sent to an expert in Gulf Coast pollen studies for dating. The deep sand is believed to fill ancient surface depressions formed because of dissolution and collapse of the underlying salt. It is hoped that the origin of the material can be determined as well as its age of formation.

Carboniferous deposits have not been found in sufficient quantity within the Quaternary at Vacherie to permit ^{14}C dating. The two samples obtained in sufficient quantity dated beyond the 40,000-year range of the radiocarbon dating method. With the aid of experts from Florida State University, the possibility of using the ionium-thorium method to date

the Quaternary at Vacherie is being investigated. Iron-cemented terrace materials have been dated between 100,000 and 2,000,000 years in Alabama using this method, and iron-cemented strata are fairly common at Vacherie.

Final field surveying of boring locations and elevations and of seismic traverse positions and elevations at Rayburn's dome was accomplished during this reporting period. Seismic refraction surveys were also made with the LSU Nimbus equipment along the three lines of borings. Preliminary subsurface sections were prepared based on logs taken in the field by the LSU supervisory geologist. Results of the network of seismic traverses made by Harding-Lawson of Livermore, California, were also received, and these data are being studied and correlated. Harding-Lawson also sent their computer program for use in the computer processing of the returns being obtained with the Nimbus equipment.

1.1.1.2 Hydrologic Studies of Louisiana Salt Domes . . . R. L. Hosman, U.S. Geological Survey (USGS)

The base-of-freshwater map of northern Louisiana is essentially complete, and work on data compilations for regional geohydrologic mapping is continuing.

Continuous water-level recorders were installed on the four test wells drilled in the vicinity of Vacherie dome by the LSU Institute for Environmental Studies. (Two of the wells are completed in Wilcox Group sands, and the other two are screened in the caprock.)

A reconnaissance trip was made through the study area to determine whether any of the 13 proposed test drilling sites could be located on highway rights-of-way. The USGS in Louisiana has a working agreement with the Louisiana Office of Highways whereby permits may be readily obtained for drilling on a state highway right-of-way. Only two locations were identified where sufficient open, level land is available. One location is on the Interstate 20 right-of-way, and some question exists whether permission can be obtained to drill there.

On November 3 and 4, Hosman met with GPM personnel in Atlanta to discuss test drilling needs and approaches to site acquisition. A sample set of specifications was reviewed and can serve as a model with appropriate modifications for the anticipated test drilling. The USGS does not have manpower available for site acquisition. However, a suggested workable alternative might involve a local agent under contract to the GPM and trained by a USGS representative.

On November 11, Hosman met with Jim Wallace and David Pauls of Law Engineering in Baton Rouge, Louisiana; he also met with Jerry Carr and Charles Spiers, USGS, in Houston, Texas, and Jackson, Mississippi, respectively. The Gulf Coast salt dome studies were discussed, with special emphasis on the assurance of a uniform approach in the three states involved.

On November 16 and 17, Gary Ryals, accompanied by J. J. Musser and G. T. Cardwell of the district staff, attended a meeting with OWI personnel, the GPM, and the Geologic Review Group. Ryals presented a review of past work and future plans.

1.1.1.3 Northeast Texas Salt Dome Basin Study . . . J. E. Carr, U.S. Geological Survey

This one-year study by the Water Resources Division of the USGS is concerned with describing the regional geohydrology of the Northeast Texas salt dome basin. This effort is part of a larger program to provide background information on several possible types of radioactive waste repository sites in order to evaluate the hydrostability characteristics of each site. Although this study is of a regional nature, special consideration will be given to the ground-water conditions within the vicinity of three particular salt domes - Keechi, Whitehouse, and Bullard.

The description of the regional geohydrology will be primarily concerned with geologic units of Upper Cretaceous (and younger) age. These units will be described mainly by a series of maps showing (1) structural contours on all major units, (2) net sand thickness and potentiometric surfaces of aquifer units, (3) confining bed thicknesses, and (4) water-quality variations. These maps and additional information will be used to interpret the regional hydrology.

Current progress on the study area includes completion of structural contour maps on the top of the Wilcox Group, Reklaw Formation, and the Queen City Sand.

Planned accomplishments for the next report period are construction of potentiometric surface maps on the following aquifers: Wilcox, Carrizo, Queen City, and Sparta.

1.1.2 SALINA BASIN . . . R. B. Laughon

1.1.2.1 Appalachian Basin Remote Sensing . . . L. C. Rowan, U.S. Geological Survey

Two field trips were conducted to west-central New York to begin field evaluation of lineaments delineated on Landsat MSS images. The area being evaluated lies generally between Cortland and Watkins Glen on the north, and Elmira and Binghamton on the south. This area includes the thickest bedded salt deposits and some of the most prominent lineaments.

Most of the lineaments represent linear segments of streams, but a few are escarpments. Some of the stream segments owe their linearity to their flow down steep gradients. These are typically less than 10 km long and appear to lack structural control except where joints cause minor deviations in flow direction. Many of the long linear segments lie in major stream valleys with low gradients. Outcrops are generally sparse and confined to valley walls, where the widespread glacial debris has been stripped by erosion.

Measurements of the attitude, spacing, and continuity of joints in shales and siltstones were made along the valley walls and away from them as outcrops permit. Preliminary evaluation of these measurements suggests that joints are more numerous and less planar in shales than in siltstones; this suggestion is consistent with the results of earlier studies. Near Van Etten, where three long linear streams intersect, low-dipping joints appear to be more common locally than elsewhere, but more data are needed to test the consistency of this observation.

1.2 Geological Studies

T. F. Lomenick

1.2.1 PARADOX BASIN . . . T. F. Lomenick

1.2.1.1 Paradox Basin Waste Emplacement Studies . . . R. P. Snyder, U.S. Geological Survey

At a meeting in Denver on November 2, personnel of OWI, Woodward-Clyde Consultants, USGS, and consultants for OWI discussed plans and requirements for drilling in Salt Valley, Utah. A copy of the amended minutes of the meeting, describing responsibilities as understood by the USGS, was sent to all organizations with personnel in attendance at the meeting.

R. J. Hite, USGS coordinator for the Paradox Basin project, visited the Salt Valley area and staked locations for three drill sites. Location descriptions were sent to OWI.

Horst Albrecht of the West German Bundesanstalt für Geowissenschaften und Rohstoffe, Hanover, West Germany, visited the Special Projects and Engineering Branches in Denver to discuss radioactive waste storage in salt and other rocks.

1.2.1.2 Paradox Basin Remote Sensing . . . L. C. Rowan, U.S. Geological Survey

Tenmile Canyon lineament, identified on Landsat frames that include E-5165-17030 (taken October 10, 1975) and reported in the October monthly report, is not shown on any geological, geophysical, or remote-sensing maps of the region. A detailed analysis was made in preparation for field reconnaissance during the last part of October. A literature review plus image and map analysis revealed the following significant information:

1. Tenmile Canyon lineament extends on the Landsat frames from Thompson, Utah (Moab 2° sheet), Township 21 South, Range 20 East to the Green River, where it controls an incised meander near the northwest corner of Township 25 South, Range 17 East. The lineament follows a linear alluvial pattern and aligned drainage courses of Thompson Wash and Tenmile Wash. The lineament continues for 47 km or more. Its southwesterly extension has not yet been investigated in detail.
2. Tenmile Canyon lineament cuts Salt Valley anticline where a change in trend is shown by dotted lines on structural maps in Township 22 South, Range 19 East. The change in trend of Salt Valley anticline (partially concealed by alluvium) at this locality could be explained by a right lateral offset along Tenmile Canyon lineament.

3. An apparent right-lateral offset along Tenmile Canyon lineament, similar to that above, affects the plunging Courthouse syncline to the southwest of Salt Valley anticline.
4. The eastern edge of Tenmile graben abuts against Tenmile Canyon lineament in Township 23 South, Range 18 East. Tenmile graben may be an extension of the Moab fault system underlain by a diapiric salt core. Gravity mapping reveals a 10-12 mGal anomaly below Tenmile graben, suggesting the presence of a salt core at depth. The gravity anomaly begins to taper out to the southeast near the Tenmile Canyon alignment and shows complete closure a short distance to the southeast. Tenmile graben appears to have been severed or offset (right-lateral) from Moab anticline to the southeast, almost exactly along the Tenmile Canyon alignment.
5. To the northeast, the Tenmile Canyon lineament generally aligns with a segment of the fault scarp bounding the Uncompahgre horst block.
6. Along the Tenmile Canyon lineament at Township 23 South, Range 18 East, Section 32, an outlier of Entrada sandstone saturated with hydrocarbons occurs; also, a few springs occur here. In a recent conversation, R. J. Hite pointed out the existence of skarns of copper mineralization along the Tenmile Canyon alignment as well.
7. The possibility of a seismic discontinuity along the Tenmile Canyon lineament has also been suggested by R. J. Hite.

During the reporting period, image-processing programs for scale change of the Landsat images were completed. A comparison with photographically adjusted scales is under way.

1.2.2 PERMIAN BASIN . . . T. F. Lomenick

1.2.2.1 Texas Panhandle Studies . . . T. C. Gustavson and W. C. Galloway, Texas Bureau of Economic Geology

Remote sensing and shallow stratigraphy . . . T. S. Gustavson, Texas Bureau of Economic Geology

Environmental geologic mapping is under way, and 40 quadrangles have been completed. Ten map units defined in terms of geologic processes, materials, and morphology were identified. The areal distribution of these units must be understood in order to recognize areas of different geologic processes and rates of erosion.

A generalized regional soils map from south of the Canadian River to 1st 33°N has been compiled. The map covers 31 Texas and New Mexico counties.

Linear features were mapped on seven Landsat scenes covering the High Plains of Texas and eastern New Mexico. One of the scenes was an enhanced false-color composite that proved particularly useful for mapping linear features. Black and white photomosaics (scale 1:24,000) were also analyzed for linear elements. Understanding the distribution

of linear elements and their preferred orientations may influence understanding the development of drainage networks in the High Plains. This correlation may be especially true if a relationship between deep structure, surface joint patterns, and linear elements can be established. All linear element data will be digitized for statistical analysis.

The Texas Water-Oriented Data Bank will provide for all recording stations on the High Plains precipitation, stream flow, and sediment load data along with length of record and estimates of data quality. Additional references concerning climate, stream flow, and Quaternary environments of the southwest have been located.

Preliminary contact with land owners in areas of proposed instrument stations is 75% complete.

In the coming month, the selection of final instrument station locations and the leasing of these plots will be initiated. Environmental geologic mapping will be field-checked. Mapping of joint systems and areas of slope failure or mass movement within the Palo Duro Canyon was initiated.

Basin analysis . . . W. E. Galloway, Texas Bureau of Economic Geology

Acquisition of the primary data base for basin analysis is essentially complete, and geologic synthesis is under way. Regional cross sections, combined with published information, indicate that the stratigraphic sequence of the Palo Duro/Dalhart basins may be logically subdivided into six genetically related units, including (1) pre-Pennsylvanian carbonates, (2) Pennsylvanian mixed clastics and carbonates, (3) Lower Permian carbonate, clastic, and evaporite facies, (4) Upper Permian carbonate, evaporite, and clastic facies, (5) Triassic clastics, and (6) Plio-Pleistocene clastics. Facies architecture, potential resources, and hydrologic parameters vary significantly between these units, which both include and vertically bracket potential isolation sites.

Pre-Pennsylvanian. Correlation of Precambrian, Ellenburger, and Mississippian units within the Palo Duro basin is complete. Six east-west cross sections of the pre-Pennsylvanian sequence are complete, and a structure map on the top of the Mississippian as defined by sample logs and filled out by correlation of geophysical logs is complete.

Pennsylvanian. Seven cross sections illustrating facies patterns within the Pennsylvanian section were constructed. Sample logs provide basic data on lithologic type and can be used to calibrate geophysical log response. The Pennsylvanian section consists of a narrow, northward-trending, central basinal sequence surrounded by fringing shelf-margin carbonates. Shelf facies include interbedded limestone and clastics that grade into coarse granite wash and mudstone toward the surrounding granitic uplands. Sections detailing the geometry of the granite wash are in progress, and isopach maps are planned. A structure map on a top Pennsylvanian datum is complete.

Lower Permian. Regional sections designed to illustrate facies relationships within the Lower Permian section are under construction.

Upper Permian. Eight lithologic cross sections are complete, and a structure map on the top of the Tubb sand in the Palo Duro basin is under construction. Details of the Tubb, one of several widespread terrigenous clastic beds within the carbonate- and evaporite-dominated sequence, are under examination. A preliminary isopach map of the Tubb was drawn, and sections show that the Tubb can be further subdivided into three units using widespread salt beds that occur within the dominantly mudstone unit. An isopach map of the San Andres Formation is in progress; further subdivision of the San Andres will follow.

Triassic. Stratigraphic and sedimentologic studies of the Dockum Group already under way are being extended northward into the Panhandle. Comparison of the Dockum of the Palo Duro/Dalhart basins with the better known section to the south indicates depositional continuity within a major lacustrine basin.

1.2.3 BASIC GEOLOGIC STUDIES . . . T. F. Lomenick

1.2.3.1 Pierre Shale . . . T. F. Lomenick

No activity has been reported for November.

1.2.3.2 Crystalline Rocks . . . L. B. Cobb and R. B. Laughon

New England and Canadian Shield crystalline rocks . . . H. W. Smedes, U.S. Geological Survey; L. B. Cobb, OWI

Rock mechanics. Results of preliminary measurements of rock stress at three sites in the Mt. Waldo Granite in south-central Maine showed that near-surface horizontal stresses are compressive and unequal. Initial magnitudes are as high as 14.5 MN/m^2 .^{*} Creep stabilized about 20 days after excavation, having attained additional stresses of as much as 48 MN/m^2 . Stresses of that magnitude may exceed the shear strength of the granite and may account for the observed deformed drill holes and recent near-surface horizontal shear fractures that accompanied the formation of the fault gouge.

A violent quarry rock burst was described in 1907 which occurred near the site of the present measurement locations. That burst produced a north-trending vertical fault extending the length of the quarry, further attesting to the rock-breaking magnitudes of the in situ stresses.

These new data indicate that excavations in the upper several meters in this granite could be subject to damage from abrupt brittle failure in addition to long-term deformations.

In order to determine the integrity of large excavations at greater depths, the ratio of horizontal-to-vertical stresses must be determined as well as stresses associated with faults and joints.

^{*} MN/m^2 = Mega newton per square meter, which is the metric equivalent of about 145 psi.

Isotope studies. Z. E. Peterman completed a review of the geochronology of the Archean of the United States for presentation at the Geological Society of America meeting in Seattle. Analytical work continued on the Precambrian rocks of northern Michigan and Wisconsin. New samples collected this summer by P. K. Sims were evaluated for subsequent isotopic studies. Z. E. Peterman, R. E. Zartman, and P. K. Sims completed a manuscript, "Ancient Archean Totalitic Gneiss from Northern Michigan, U.S.A.," and submitted it for technical review. Considerable time was devoted to learning to operate the new energy-dispersive x-ray fluorescence unit for rubidium and strontium analyses.

S. S. Goldich continued work on the preparation of manuscripts dealing with the geochronology and geochemistry of Precambrian crystalline rocks of the Minnesota River Valley.

Coordination and other activities. On November 2, B. E. Doe, S. S. Goldich, and Z. E. Peterman met with Tom Lomenick of OWI to discuss present and future directions of the waste disposal program with particular reference to crystalline rocks.

During November, twelve USGS specialists in seismicity, hydrology, remote sensing, earthquake hazards, isotope geology, geophysics, rock mechanics, and regional geology participated in a committee review of efforts directed toward nuclear waste disposal in crystalline rocks. The committee was assembled and chaired by Smedes, who is preparing a draft summary of that review.

On November 8, Smedes, Peterman, and Goldich attended the Nuclear Waste Disposal Symposium at the Geological Society of America meeting in Seattle and talked with several people concerned with waste containment in crystalline rocks.

1.2.3.3 Studies for Geologic Storage of Radioactive Waste in the Southeast . . . I. W. Marine, Savannah River Laboratory (SRL)

The SRL studies for the storage of radioactive waste fall into the following two categories: (I) those with the aim of ultimately designating a suitable site and host rock for initial-phase repository operations and (II) those concerned with research applicable to storage in the rock types of interest irrespective of the specific location.

Category I studies

The literature and existing knowledge of host rocks of the southeastern United States are to be reviewed by geologic consulting firms. Because several of the subregions were enlarged, new requests for proposals (RFP) for these studies were issued. The states now include Maryland, Virginia, North Carolina, South Carolina, and Georgia in both the Piedmont and Coastal Plains studies. The area involved in the Triassic basin studies remains the same.

Category II studies

During November, the following progress was made in the research applicable to radioactive waste storage in rock types of interest irrespective of the specific site.

1. In the Parametric Study of Geologic and Hydrologic Performance Characteristics, most calculations were complete; however, additional effort will be necessary to develop the graphs directly from the computer.
 2. On the contract to Document and Evaluate the Damage to Mines, Wells, and Underground Facilities Due to Earthquakes, SRL personnel attending the Rockstore 77 meeting in Sweden during September learned of a thesis that contained extensive data on tunnel response to earthquake loading. A copy of the thesis was requested and was received at the beginning of October. This thesis was included in the draft report and has consequently delayed completion of the report.
 3. In the Study of Membrane Phenomena, the layout of the room to house the membrane testing machine was completed. A clay sample used in USGS membrane tests was received at SRL from Everett Jenne of the USGS.
- 1.2.3.4 Cooperative Work Program with the Swedish State Power Board on Waste Storage in Mined Caverns* . . . P. A. Witherspoon, Lawrence Berkeley Laboratory (LBL)

Part I

Task 1 - Full-scale heaters. The photomosaics of the walls in the full-scale drift were completed. The detailed mapping and fracture evaluation were started and will continue in November.

Thirty holes were drilled, and the core has been logged, photographed, and stored. Nine holes remain to be drilled in November. Excavation of the extensometer drift was completed. Roof scaling and installation of anchor bolts were also completed.

The computer room has been insulated, and wall and ceiling lighting panels have been installed. Work on the ventilation and sprinkler systems is under way. Photographs of the walls and floors were taken, and work on the photomosaic is in progress.

Hot-testing of the first of three full-scale heater canisters was completed. Based on this test, the type of heater power wiring and electrical connection procedure for all remaining heaters was selected.

Design of heater power and monitoring modules is continuing, with the full-scale heater control chassis being in the prototype stage.

Nearly all instrumentation and data acquisition hardware is on hand. Detailed instrumentation channel assignments, installation of hardware in racks, and internal wiring will proceed through November and into December.

The performance testing of heater 1 was completed. The mechanical components were disassembled and examined, and the deficiencies were noted and corrected. Tests of each heater element were conducted at 5000 W output.

*This report contains two parts: Part I covers activities from October 1 through October 31, 1977. Part II covers activities from November 1 through November 15.

Task 2 - Time-scale heaters. The detailed mapping and fracture evaluation in the full-scale drift are partially completed and will continue in November. Heater holes H2-H8 have been drilled to 127 mm, and the core has been logged, photographed, and stored. The drilling in this drift was completed.

Heater power and monitoring module design has been started for the time-scaled heater units.

Nearly all instrumentation and data acquisition hardware is on hand. Detailed instrumentation, channel assignments, installation of hardware in racks, and internal wiring will proceed through November and into December.

Flange design was modified to allow for nonstraight boreholes.

Twenty-five percent of the detailed drawings have been completed, and the assembly drawing for the noninstrumented version of the time-scale heaters was completed.

Task 3 - Fracture hydrology. The inclined hole SBH-1 has been completed to a depth of 350 m and will be terminated in November at a depth of 385 m. The Reflex-Photobar measurements were taken at depths of 96 and 235 m to assure that the deviation does not exceed 1.9 m. Core reconstruction, logging, and photography are proceeding on schedule. Borehole television-camera tapes are being examined and correlated with the core logs.

Four water table wells have been completed to a depth of 50 m, and one has been drilled to a depth of 100 m. Two holes have been partially drilled and will be extended to 50 m during November.

Water sampling for the geochemistry program continued in the time-scale drift as well as in the private wells in the vicinity of the mine.

Task 4 - Geophysical assessment of fracture systems. The Mt. Sopris borehole logging unit was received, and electronics technicians were assigned to work on it full-time. Modification and checkout began and continued throughout October.

Task 5 - Material properties measurement. Detailed design on this task is under way.

Task 6 - Water, mass transfer experiment. No activity has been reported for October.

Task 7 - In Situ stress measurement. No activity has been reported for October.

Part II

Task 1 - Full-scale heaters. Six drill holes were completed in the full-scale drift. Heater hole H-9 was also completed. Additionally, the pilot hole for H-10 was drilled. Geographical hole K-8 was begun. The central part of the drift has been mapped.

Work is proceeding on schedule in the computer room. Research into the aspects of installing an alarm system in the computer room is in progress.

Testing of the second of three full-scale heaters is almost completed. The four individual heater elements were tested at 5 kW and are being collectively tested at a total power level of 7.2 kW. Peripheral heater tests are continuing.

Bolting of the roof is approximately two-thirds completed.

Fabrication of the full-scale heater control prototype chassis is continuing. Design of the remaining electronics chassis for the heater power racks is scheduled to be completed in the second week of December.

Lawrence Berkeley Laboratory and Terra Tek personnel completed the outline of final assignment of all instrumentation devices to computer and data logger channels. These assignments will be tabulated and cross-referenced at the LBL computer center with a formal documentation printout encompassing the approximately 800 full- and time-scale channels.

The second data logger was received at LBL and is being tested in conjunction with the full-scale and peripheral heater tests. Final cabling and testing of instrumentation continued throughout the reporting period and is expected to be completed in mid-December.

Extensometer tests at Terra Tek using low thermal expansion Superinvar are continuing.

Performance tests have been completed on heater assembly 2, and heater assembly 3 is completed and ready for installation in the test fixture.

Installation of peripheral heaters into the test fixtures is completed. The circuits were energized, and the instrumentation was checked out. Performance testing of the first unit has begun.

Task 2 - Time-scale heaters. Drilling in the time-scale drift was completed. All 127-mm and 76-mm holes were blown dry, and drilling has proceeded to 174 m in SBH-2.

Water inflow measurements were taken in the extensometer, monitor, and heater holes, and pressure measurements were done in the 76-mm holes. Intensive mapping effort has begun.

The floor was cleaned for VIAM photography; subsequently, the walls and floor were photographed. Also, television logging by Hagconsult of Sweden began.

Calculations are in progress on engineering for water intrusion.

The detailed design of the heater control chassis for the time-scaled heaters was started.

Instrumentation assignments to computer and data logger channels were made. These assignments will be tabulated and cross-referenced at the LBL computer center with a formal documentation printout encompassing the approximately 800 full- and time-scale instrumentation channels.

Final cabling and testing of the instrumentation data acquisition equipment is continuing.

Task 3 - Fracture hydrology. Drilling of hole SBH-1 was completed. Drilling of the water table wells is continuing. Pressure test measurements are being taken in SBH-1 at regular 15- to 20-m intervals. Two injection tests were run in hole SBH-2, and all equipment was found to be working well. Water sampling is continuing as planned.

A 2 BX packer system for SBH-2 was designed and fabricated in order to take pressure readings and run injection tests while drilling.

Task 4 - Geophysical assessment of fracture system. Checkout and calibration of the borehole logging system continued through the reporting period.

The neutron and gamma-gamma tools were calibrated in the sand-tank calibrator.

Task 5 - Material properties measurement. Detailed design on this task is under way.

Task 6 - Water, mass transfer experiment. No activity has been reported for November.

Task 7 - In Situ stress measurement. No activity has been reported for November.

1.2.4 GENERAL GEOLOGY AND GENERAL HYDROLOGY . . . T. F. Lomenick

1.2.4.1 Borehole Geophysics* . . . J. Daniels, U.S. Geological Survey

Work is continuing on computer modeling of hole-to-hole electrical data. Installation of a digital data acquisition system for hole-to-hole acoustic and electrical measurements was begun. Investigations are currently being conducted to determine the best methods of increasing the depth capability of the borehole radar system.

1.3 Technical Support Projects

W. C. McClain

1.3.1 HEAT TRANSFER/THERMAL ANALYSIS . . . W. A. Burnett

1.3.1.1 Thermal Conductivity Measurement Development . . . J. G. Moore, Chemical Technology Division, Oak Ridge National Laboratory

Thermal conductivities were measured on a U.S. Bureau of Mines standard basalt sample and two Conasauga Shale samples at temperatures ranging from 66° to 326°C (Table 1). The thermal conductivity of the basalt specimen was 2.8 W/m·°K at 66°C and varied indirectly with temperature. The shale specimens (4-34 and 3-86) had thermal conductivities of ~0.8 and ~2 W/m·°K, respectively. The values for specimen 4-34 increased slightly with increasing temperature whereas the conductivity of specimen 3-86 decreased on raising the temperature. In

*This report covers activities from October 15 through November 15, 1977.

both cases, the specimens were oriented so that conduction was perpendicular to the bedding plane. Density, porosity, and composition determinations will be made for the shale samples in an effort to explain the variations in conductivity. Specimen 4-34 was measured with Pyrex and Pyroceram as reference standards; however, the values with Pyrex should be more accurate since its conductivity more closely matches that of the shales.

The reported thermal conductivities were measured with imbedded thermocouples. In addition, 31 measurements were determined using nickel temperature sensing disks. The maximum difference in the values obtained between the two methods was 16%, with 21 of the measurements having a difference of <7%. The maximum error using imbedded thermocouples as determined on standards compared with other standards was 5% at 322°C.

Table 1. Effect of Temperature on the Thermal Conductivity of Shale and Basalt

Sample	Reference	Temperature (°C)	Thermal conductivity (W/m·°K)
Shale No. 4-34	Pyroceram	67	0.786
		106	0.804
		213	0.835
	Pyrex	67	0.715
		105	0.784
		212	0.815
		324	0.845
Shale No. 3-86	Pyrex	66	2.20
		105	2.15
		214	1.97
		326	1.83
Basalt	Pyroceram	66	2.84
		105	2.77
		211	2.58
		321	2.45

1.3.1.2 Thermal Properties of Rocks . . . E. C. Robertson, U.S. Geological Survey

No activity has been reported for November.

1.3.1.3 Hybrid Computer Heat Transfer Program . . . R. S. Stone and O. W. Burke, Instrumentation and Controls Division, Oak Ridge National Laboratory

No activity has been reported for November.

1.3.1.4 Thermophysical Property Measurements of Conasauga Shale and Jefferson Island Dome Salt . . . D. D. Smith, Y-12 Development Laboratory, UCC-ND

No activity has been reported for November.

1.3.1.5 Computing Support on Thermal Analysis Work for OWI . . . D. C. Elrod, G. E. Giles, and W. D. Turner, Computer Sciences Division, UCC-ND

HEATING5A code . . . G. E. Giles

The documentation on the HEATING5A computer code was completed. Additional test cases were developed and run on the code.

HEATPLOT code . . . D. C. Elrod

Additional development work was done on the HEATPLOT computer code. The contour plotting package HOLES3 was replaced by the more efficient HOLES4. The new package requires less core and also handles saddle points more accurately. Some additional work was expended in preparing HEATPLOT for submission to the Argonne Code Center. Some routine maintenance was performed on HEATPLOT.

THAC-SIP-3D code . . . W. D. Turner

Work on adding refinements to the three-dimensional heat conduction code THAC-SIP-3D continued. Features added to the code were more general external boundary conditions, including forced and natural convection, radiation, and prescribed heat fluxes. Work is continuing on the addition of output features to THAC-SIP-3D which are available in the HEATING5 computer code.

1.3.1.6 Spent Fuel Disposal . . . G. H. Llewellyn, Engineering Division, UCC-ND

Corrections were made in ORNL/ENG/TM-7, "Temperature Increases in a Salt Repository Incurred from the Storage of Spent Fuel or High-Level Waste," incorporating changes suggested by both in-house and OWI reviewers. The revised draft will soon be released for comment.

1.3.1.7 Heat Transfer Studies in Salt and Granite . . . R. A. Just,
Engineering Division, UCC-ND

Two-dimensional cylindrical far-field heat transfer analysis models have been developed for the burial of either high-level waste (HLW) or spent fuel in a salt repository. Models were developed for both single and multilayer storage. A transient calculation for the time interval 0 to 2500 years was calculated for each model.

A conservative thermal uplift model was developed and incorporated into the HEATING5 code for comparison between the different burial schemes. The maximum thermal uplift for burial of HLW in salt occurs at 600 to 800 years, while the thermal uplift for the burial of spent fuel in salt has not yet peaked at 2500 years. The spent fuel transient analysis will be continued until the thermal uplift has reached its maximum value.

In order to compare the analysis of OWI subcontractor RE/SPEC Inc. with the analysis undertaken in this study, the stratigraphy, boundary conditions, thermal properties, and initial temperature profile used by RE/SPEC in their far-field analysis of an 883-acre dome salt repository for HLW was used to develop a HEATING5 model. This model predicts a maximum uplift of 81 in. at 250 years and a maximum centerline temperature of 333°F. As expected, the HEATING5 uplift model predicted a larger thermal uplift than the RE/SPEC model because the HEATING5 model is highly conservative. Therefore, this model should be used for qualitative comparison only. Also, notice should be taken that both uplift models predict a maximum uplift at 200 to 250 years.

1.3.2 WASTE/ROCK INTERACTION . . . G. H. Jenks and L. R. Dole

1.3.2.1 Nuclide Transport Data* . . . L. R. Dole, OWI; R. J. Serne,
Battelle Pacific Northwest Laboratories (PNL)

Technical progress summary[†]

I. General - R. J. Serne. One-hundred-pound samples of Sentinel Gap Basalt, Westerly Granite, oolitic limestone, and argillaceous shale were obtained to start the controlled sample program. Culebra Dolomite, Cowden Anhydrite, Climax (granitic) stock, and Eleana Shale samples have been promised when available.

Negotiations continue with subcontractors to finalize FY 1978 priorities and milestones. A contract with Adaptronics, Inc., has been finalized.

Near-term plans. Rock samples will be dispensed to all subcontractors, and appropriate ground-water compositions will be formulated for each rock sample.

Final contract negotiations with subcontractors will be completed, as well as final FY 1977 progress reports.

*This report covers activities from October 15 through November 15, 1977.

[†]A detailed report may be requested.

II. PNL Internal Research - J. Relyea, D. Rai, and R. J. Serne, "Collection and Generation of Transport Data." Batch adsorption-desorption K_d 's for Cs, Sr, and Tc were completed for four solutions and 12 minerals. Desorption experiments for Am, Np, and I were initiated. Preliminary desorption results show batch methods unacceptable for species having low K_d 's such as TcO_4^- and I^- ; column experiments would be preferable. Erratic Eh readings obtained using very small platinum wire electrodes have been reconciled through the use of commercial electrodes.

Dissolution of plutonium compounds continued. Variable results of plutonium in solution after 21 days' contact was found to be caused by fine plutonium particles present after centrifugation at 6000 rpm for 40 min. The particles retained on the filters were crystalline PuO_2 or amorphous $Pu(OH)_y$ depending on which solid was supporting the solution. There was no difference in solution activity for samples filtered through 0.1- or 0.015- μm filters.

Further plutonium adsorption experiments under controlled Eh and pH conditions were planned. Experiments were performed to assess the feasibility of using two cells on each potentiostat in order to double the work output. The experiments demonstrated the feasibility; consequently, more cells are being fabricated to allow greater work output.

III. Argonne National Laboratory (ANL) - P. Ricket, M. G. Seitz, A. Friedman, and S. Fried, "Transport Properties of Nuclear Waste in Geologic Media." Batch adsorption experiments using americium and plutonium were performed on anhydrite and limestone for variable NaCl solutions. The chlorine concentration was varied from 10^1 to 10^5 ppm. For either rock, the K_d of plutonium was not affected by the chlorine concentration. For the limestone, the K_d of americium dropped significantly when the chlorine content was increased from 10^4 to 10^5 ppm. Below 10^4 ppm of chlorine, no significant changes were found. No chlorine effects for americium sorption on anhydrite were observed for concentrations below 10^4 ppm.

Near-term plans. Analysis of rock mineralogy and solution composition for materials used in FY 1977 will be synthesized.

IV. Oak Ridge National Laboratory - R. E. Meyer, K. A. Kraus, and J. Johnson, "Systematic Study of Nuclide Adsorption on Selected Geologic Media." Work is continuing on the investigation of $Sr(II)/Na(I)$ exchange on montmorillonite using batch, column, and axial filtration experimental designs. Temperature and strontium concentration are being varied to determine their effects on observed distribution coefficients. The contacting solution is NaCl between 0.5 and 4 M. The final FY 1977 progress report was nearly completed.

Near-term plans. Experiments on nonhydrolyzable cations will continue.

V. Lawrence Livermore Laboratory - L. D. Ramspott, Homer Weed, David Coles, and Don Jackson, "Studies of Radionuclide Availability and Migration at the Nevada Test Site." No activity has been reported for November.

VI. Rockwell Hanford Operations - G. S. Barney, M. Brutzeck, and R. A. Deju, "Kinetics and Reversibility of Radionuclide Sorption Reactions with Geologic Media." Batch K_d experiments investigating sorption-desorption and their time dependency are continuing for ^{137}Cs , ^{90}Sr , ^{106}Ru , ^{239}Pu , and ^{241}Am . Accelerated "weathering" experiments on rocks continue. A final FY 1977 progress report was finished.

Near-term plans. The experimental program previously described will continue.

VII. Adaptronics, Inc. - A. N. Mucciardi and Elsie Orre, "Statistical Investigation of the Mechanics Controlling Radionuclide Sorption." A final FY 1977 progress report was submitted comparing adaptive learning network and regression techniques for predicting K_d data from water and rock characteristics.

Near-term plans. An analysis of FY 1977 PNL data will be performed to evaluate whether the 12 minerals under study show redundancy and would then allow reduction in scope or substitution of other materials.

VIII. Lawrence Berkeley Laboratory - John Apps, Sidney Phillips, and John Neil, "Theoretical and Experimental Evaluation of Waste Transport in Selected Rocks." Conversion of FASTPATH to the CDC 7600 computer was not successful; however, the problem has been identified and is being corrected. An alternate code developed by Wolery (graduate student at Northwestern University) will be used for comparative testing. Core samples of Eleana Shale, Climax (granitic) stock, quartz monzonite, and Umtanum Basalt were obtained. Samples are being prepared for physical and chemical characterization. Isotopes of U, Np, Pu, Am, and Cm have been obtained. Preliminary results show the neptunium and americium are contaminated with other actinides and will need to be purified.

Near-term plans. A detailed comparison will be made of the chemical mechanisms acting during distribution experiments with the mechanisms acting in natural geochemical systems. A review of basalt alteration products will be completed. Tracer isotopes will be purified.

IX. Oak Ridge National Laboratory - C. W. Francis, M. Reeves, and E. A. Bondiotti, "Soil Chromatograph K_d Values." A computer model combining unsaturated hydraulics and binary chemical interactions (exchange) has been coded. Using Fuquay Sand and Consauga Shale, the model is being verified for Na, Ni, and Sr competing against Ca. Soil chromatographic data are being compared against the computer predictions and the saturated column and batch methods. The FY 1977 final progress report was completed.

Near-term plans. Computer model verification studies will be performed using sand and silt soils and crushed shale. Emphasis will shift to laboratory studies on rock materials once the model is verified.

X. Sandia Laboratories - T. E. Hinkebein, R. L. Schwoebel, R. G. Dosch, and R. E. Cohen, "Microstructural Interactions of Geologic Media with Waste Radionuclides." This contract has not been reinstated in FY 1978.

XI. Los Alamos Scientific Laboratory - D. C. Hoffman, K. Wolfsberg, B. Erdal, R. Vidale, and E. Norris, "Laboratory Measurements of Radionuclide Distributions." Polypropylene columns, pumps, and fraction collectors have been ordered or obtained to start column K_d experiments. Climax (granitic) stock and Eleana Shale are on hand. Chemical, mineralogic, and surface area characterization of rock are in progress. Microautoradiography facilities are being set up. A final FY 1977 progress report was prepared.

Near-term plans. Sample characterization will continue, and batch and column K_d experiments will be initiated.

1.3.2.2 Criticality Study of Nuclear Waste . . . G. H. Jenks, OWI; E. J. Allen, Engineering Technology Division, Oak Ridge National Laboratory

The criticality survey calculations have been completed for combinations of brine and water mixtures, five actinide compounds, five waste types, and four waste ages. The actinide compounds considered were oxides of U, Pu, Am, Cm, and a mixture of these four oxides. The five waste types treated were pressurized-water reactor (PWR) spent fuel, HLW from plutonium-recycled fuel, HLW from fresh uranium fuel, HLW resulting from a mixture of fresh uranium fuel and plutonium-recycled fuel, and HLW with all the plutonium remaining in the waste. The four waste ages selected were 10, 100, 1000, and 10,000 years. Minimum critical masses were calculated for each mixture, actinide compound, waste type, and waste age. The calculated results are being analyzed and will be summarized in a forthcoming report.

1.3.2.3 Natural Fission Reactor Program (NFRP) . . . K. E. Apt, Los Alamos Scientific Laboratory (LASL)

Preliminary neodymium analyses of Oklo samples from regions peripheral to the reactor zones show remarkably less fission-product neodymium than fission-product ruthenium. The fission-product ruthenium concentrations (previously determined) range from ~1 to 1500 ng/g, essentially all of which is from thermal-neutron-induced fission of ^{235}U . By contrast, fission-product neodymium concentrations did not exceed ~0.1 ng/g. All of the fission-product ruthenium and neodymium in the peripheral samples apparently migrated from the reactor zones (typically 2 to 10 m distant from the sample locations) because uranium isotopic analyses gave no indication of fission at these locations. These data suggest that the fixation in the reactor zones of neodymium was better than ruthenium or perhaps that the small amount of neodymium that was hydrochemically released from the reactor zones was more mobile than ruthenium. Samarium isotopic analyses are planned for these peripheral samples, and interpretation of the results is continuing.

Petrographic thin sections were made for a suite of eight OKLO samples which represents a traverse across reactor zone 2. Preliminary examination of textural relationships and phase assemblages suggests that a higher metamorphic grade was achieved in the reactor zone than in the adjacent rock only a few meters away. The reactor apparently experienced "autometamorphism," which may relate to the question of

radionuclide behavior. Subsequent microprobe studies are planned to better establish the temperature gradient and perhaps the pressure of the reactor system. Also, isotopic analyses are planned for these samples which may determine how radionuclides behaved in this thermally perturbed setting.

For the UO_2 solubility studies, progress is being made on the assembly of apparatus with which to equilibrate water and solid material. The technician working on the project is becoming proficient with hot-gas welding techniques and has begun some of the polypropylene welding for fabrication. The need for additional equipment for this apparatus is being studied, and future work on uraninite solubility and dissolution rates is being planned.

During November, G. A. Cowan of LASL was the guest lecturer at the University of Arkansas, the University of Missouri-Columbia, South Central Missouri, Quincy College, and Kansas State University. The lectures, sponsored by the scientific lecture tour program of the American Chemical Society, were on natural fission reactors and their relevance to geologic disposal of radioactive waste. D. G. Brookins, of the University of New Mexico, presented a paper entitled "Prediction of Radioactive Element Behavior in Aqueous Systems from Eh-pH Diagrams" at the annual meeting of the Geological Society of America in Seattle. The studies were supported in part by this program.

1.3.2.4 Near-Field Waste/Rock Interaction . . . D. M. Roy, G. W. Brindley, J. V. Biggers, G. H. McCarthy, W. B. White, S. Komarneni, and B. Scheetz, Pennsylvania State University

Salt consolidation and brine migration

Sintered cores of "pure" sodium chloride crystals were produced of two distinct grain sizes in order to investigate the flexural strength as a function of grain size at constant porosity. At a variety of temperatures and pressures, the sintering characteristics have been observed by scanning electron microscope (SEM) techniques. A number of strength tests were made, and additional samples are being tested in a four-point bending apparatus on an Instron machine. Several crystal etching techniques are being perfected which will reveal the dislocation network of the samples in an effort to obtain a better understanding of the deformation mechanisms.

Experiments are currently being designed that will test the effects of high gamma irradiation on the physical, mechanical, and thermal properties of Morton evaporite salt. The irradiation will be performed at the Pennsylvania State Reactor Facility with additional cooperative interaction with P. Levy of Brookhaven National Laboratory.

The theory of deformation of NaCl at various temperatures and stress levels has been reviewed, and equations of state have been selected or are being derived for the low stress conditions that will be used for the preparation of deformation maps of several salt samples.

Shale-waste compatibility

Effort during the report period was focused on reconnaissance experiments in which spent unprocessed fuel (SURF) was the waste form and on experiments designed to clarify SURF-shale interactions. The products from experiments in which granular SURF was reacted with water at approximately 200 and 400°C and 300 bars showed no apparent interaction between the UO_2 and water. The x-ray diffractograms showed no significant differences between the starting material and the reaction products. However, careful SEM examination revealed a small proportion of extraneous crystalline phases in the products. Only cesium and molybdenum were detected in the reaction products. A tentative phase identification is Cs_2MoO_4 , which has been shown to be the predominant Cs-Mo phase in SURF.

A group of experiments is now being initiated to explore any interaction between the major constituents of SURF and the reference shales. During the coming month, other planned experiments include (1) a test for interaction of the likely Sr-phase, $SrZrO_3$, and reference clays and (2) a study of the stability of pollucite, $CsAlSi_2O_6$, in a variety of solutions and under several relevant pressure-temperature conditions.

1.3.2.5 Strain-Related Radiation Damage Measurements on Rock Salt for Waste Disposal Applications . . . K. J. Swyler and P. W. Levy, Brookhaven National Laboratory (BNL)

The radiation effects studies on natural rock salt and synthetic NaCl continue. Emphasis is being placed on measurements of defect (F-center) and colloid particle formation as a function of sample temperature and dose rate in synthetic NaCl. To some extent, these second-generation measurements provide additional quantitative data on effects previously studied. With sufficient data, the theoretical model of Jain and Lidiard* for defect formation in NaCl can be tested. Also, these additional studies on synthetic NaCl can be compared with similar data on natural rock salt, to indicate the reasons for differences in radiation damage kinetics between the two. Lastly, these additional studies will provide insight into translating laboratory dose rate data to waste disposal purposes.

Synthetic crystals were irradiated with 1.5-MeV electrons at 75, 100, 125, 150, 175, 200, 250, and 300°C at dose rates approximately 2.5×10^8 rads/hr. After 9000 sec of irradiation, the dose rate was abruptly decreased to one-half of this rate. Often the beam was maintained at the one-half level for 1200 sec and then reduced to one-quarter of the original rate. At the end of one, two, or three intervals, the beam was increased to its original level. With the use of varying rates, these measurements indicate that the F-center colloid "equilibrium" is dose-rate dependent. Accompanying the reduction in beam current, a decrease in F-center absorption is paralleled by an increase in colloid absorption. Conversely, an increase in beam current rapidly increases the F-centers and temporarily reduces the colloid formation rate. Thus, the F-center-to-colloid reaction appears reversible.

*Jain, Uma and Lidiard, A. B., "The Growth of Colloidal Centres in Irradiated Alkali Halides," Phil. Mag., 35: 245-259 (1977).

The following are additional results:

1. The temperature at which colloid formation is most efficient is in the 100 to 150°C range, agreeing with recent data from Harwell of UK. The available data may be sufficient to determine the optimum temperature of colloid formation and to determine if the temperature depends on dose rate and strain.
2. Some samples did not color uniformly, often showing enhanced colloid formation along the crystal directions associated with slip systems.

Much of the above-described qualitative data can be quantified; extensive computations are planned and will be reported next month.

1.3.2.6 Geochemical Interactions and Characterizations . . . D. B. Stewart, U.S. Geological Survey

Solubility measurements to 100°C were made on the systems KCl-NaCl-H₂O, CaCl₂-NaCl-H₂O, and MgCl₂-NaCl-H₂O to determine three-phase curves (two solids plus brine). The measurements give the position and slope of the curve on the T-X diagram representing the composition of the brine, and, together with data for the anhydrous eutectics for these systems, allow the entire curve to be loosely estimated. The proportion of brine to solids at constant H₂O content, temperature, and pressure is greatly increased over that in a simple NaCl-H₂O system. Because the rock strength is dependent on the proportion of brine to solids, a limit of permissible H₂O contents may be determinable.

Calculations were begun to estimate the density, vapor pressure, and enthalpy of various brines and bitterns in order to assess the sensitivity of these physical properties to variations in composition. These estimates will be available for engineering and rock mechanics purposes.

In addition to preparing reports for OWI, Stewart attended the following meetings during the reporting period: (1) a meeting with USGS and Sandia personnel in Albuquerque, October 27-28, to discuss the application of experimental results; (2) a conference with Potter and Clynne, USGS-Menlo Park, in Seattle, November 6-7, about the solubility experimental program; and (3) program reviews for PNL's WISAP* and the in situ heater program at DOE-HQ, November 8-11.

1.3.2.7 Geothermometry Methods for Determining the Thermal History of Shale . . . C. E. Weaver, Georgia Institute of Technology

Measurements of the crystallinity index and the sharpness ratio of the illitic material in the Conasauga Shale show a regional trend in the southern Appalachians indicating that temperatures increased toward the south and east. The amount of mixed-layer illite-montmorillonite in the <0.2-μm fraction shows a similar pattern. Values of illite-montmorillonite range from 0 in the southeast to 63% in the western portion. Potassium/argon apparent ages have been completed for all size fractions of a set of six Conasauga samples collected in Tennessee. Apparent ages

*WISAP = Waste Isolation Safety Assessment Program.

for the 0.2- to 2- μ m fractions, ranging from 350 to 544 million years, indicate that the trends toward increasing apparent ages for progressively more northern and western sample locations (observed in earlier analyses) are not continued into the northernmost sample areas. Apparent ages of 99 to 768 million years were obtained for the <0.2- μ m fractions. The wide variability observed is in contrast to values determined previously for samples in this size range; therefore, repeat analyses of the anomalous samples are being performed. Using conventional mineral separation techniques, work is under way to obtain purified clay and other mineral separates from the silt-sized fractions of several samples.

Using x-ray diffraction and optical methods, work continued on the characterization of narrow-size fractions obtained by elutriation.

1.3.2.8 The Effects of Water in Salt Repositories* . . . G. H. Jenks, OWI; C. F. Baes, Jr., H. F. Holmes, and R. E. Mesmer, Oak Ridge National Laboratory

Water is present as brine inclusions in bedded salt and may move, under thermal gradients, into the open spaces within a repository in salt. Also, water from water aquifers might conceivably gain access to the storage cavities during the operational period and during the subsequent period of reconsolidation of the backfilled salt. Determinations need to be made, for each stage in the history of the repository, of the nature and extent of possible exposure to water and the resulting effects on

1. the mechanical properties of the salt and the structural integrity of the mine;
2. the rate of consolidation of backfilled salt;
3. the corrosion of the canister and the resulting gas production;
4. the interaction with the radioactive waste and the resulting transport of activity.

A program has been initiated within the Chemistry Division of ORNL with the objective of examining, as fully as possible, the various effects of water exposure in salt repositories. The effects to be examined are those in situations that include (1) the migration and fate of brine inclusions present initially, (2) the episodic floodings of open or backfilled mines, and (3) the exposure of sealed mines to a flowing aquifer. The goal is to gain sufficient information to credibly predict the consequences of any plausible form of water ingress to a salt repository that might compromise the integrity of that repository.

Baes is the principal investigator in this program, which was initiated during October 1977. The following activities have been planned for the program:

1. A review of the literature on the migration of brine and gas inclusions in salt crystals and aggregates as a function of water content, thermal gradients, gravitational gradient, and mechanical stress.

*This report covers activities from October through November 1977.

2. The fabrication of an apparatus to study such water and gas migration on a microscopic scale.
3. A review of the information available on the mechanical properties of salt as a function of moisture content and temperature.
4. Experimental studies of the mechanical behavior of mixtures of brine and salt as a function of water content, particle size, configuration, temperature, and pressure.

Preliminary experiments were performed to investigate the consolidation of salt in flowing brine. Saturated brine was passed downward through a column of approximately 70 g of salt (250- to 400- μ m crystals) at a constant head. Over a period of 24 hr, about 3 kg of brine flowed through the salt without a detectable decrease in flow rate.

In a second experiment, a similar column (150- to 250- μ m crystals) was fitted with two water jackets, one above the other. Water at 35°C was passed through the upper jacket, and water at 22.4°C was passed through the lower one. At a constant head, the first 350 g of saturated brine passed downward through the column at a constant flow rate of 2.0 g/min. Thereafter, the flow rate decreased until it was 0.002 g/min after 1800 g of brine had passed through the column. The data are summarized in the following table:

Elapsed Time, t (min)	Total Brine Passed, G (g)	Flow Rate, dG/dt (g/min)	Interval Descriptions
0	0	2.0	Flow constant
180	360	2.0	
400	600	0.4	Rapid change in flow
7,700	1,730	0.03	$dG/dt = 3.43 \cdot 10^{-4} [G(\infty) - G(t)]$
16,750	1,800	0.002	$dG/dt = 1.62 \cdot 10^{-4} [G(\infty) - G(t)]$
∞	(1,825)	(0)	Extrapolation

Over the range 600 to 1730 g of brine passed through the column, the flow rate decreased in proportion to the amount remaining to be passed. For the next 80 g of brine, a similar proportionality was found, but the rate of decrease in flow was about one-half that of the previous period.

From the dependence of NaCl solubility on temperature, calculations were made that revealed that over the course of the run 4.96 g of salt had been dissolved at the top of the column and deposited in the middle

of the column. The location of the resulting plug was marked at its lower boundary by a narrow break in the salt column, which was caused by settling of the loose salt below it. The volume of the plug was about 5 cm³, indicating that little porosity remained.

This technique will be further developed as a means of studying the kinetics of salt consolidation.

1.3.3 ROCK MECHANICS . . . J. E. Russell

1.3.3.1 RE/SPEC Studies* . . . G. D. Callahan, RE/SPEC Inc.

Phase 1: Repository concept analysis and evaluations

Task 3A: Continuation of quasi-static and creep tests on bedded and dome salt. An experimental effort is continuing to determine the strength and deformational properties of Avery Island (AI) salt. To date, a total of seven room-temperature quasi-static compression experiments have been performed at confining pressures ranging from 0 to 3000 psi. In addition, seven creep experiments have been performed on four specimens; two of these were multistage tests. The material properties resulting from the room-temperature tests were evaluated, and a failure envelope was developed. Additional creep experimentation is necessary to adequately evaluate the creep response. Further, additional quasi-static compression tests at elevated temperature are necessary for a priori numerical simulation of the in situ heater experiments. Completion of this testing program will probably be delayed until adequate core specimens are available. Several experiments are presently planned which will use core from an unoriented block from AI.

During the last 40 days, three simultaneous creep experiments have been conducted. Jefferson Island (JI) salt specimens were used for these experiments to evaluate relatively long-term (1000 hr) creep response. The tests were conducted at room temperature at differential stress levels of 4500, 4500, and 3000 psi under confining pressures of 2000, 1000, and 500 psi, respectively.

Task 4: Design, fabrication, and implementation of additional creep apparatus. Fabrication of additional creep apparatuses is progressing; the four mainframes were delivered on November 1. Since that date, considerable attention has been directed toward the design and fabrication of the hydraulic control panels. As designed, the basic control panel will control two machines with independent digital panel meters for each transducer. Fabrication of the hydraulic control panels is estimated to take 12 weeks. Simultaneously, the data logging system is being checked and appears to function properly. Complete on-line status of the data acquisition system will probably precede that of the testing apparatus.

*This report covers activities from October 16 through November 15, 1977.

Task 5: Parametric scoping study of the global temperature fields around high-level repository facilities and Task 6: Parametric scoping of the potential for global thermal fracturing and global plastic flow around high-level repository facilities. A report concerning the parametric analysis of the far-field thermoelastic behavior of a granitic repository is nearing completion and will be submitted to OWI for review during December 1977.

1.3.3.2 Displacement Discontinuity Modeling* . . . C. M. St. John,
University of Minnesota

Development of the displacement-discontinuity-based model intended for use to simulate experimental, or test-scale, sites for underground disposal of heat generating waste is now complete. The revised treatment of pillar creep was incorporated in this computer code that is referred to as EXPAREA; also, a restart capacity permitting the breakdown of long simulations into shorter parts was added. Previously prepared documentation of this program is being revised to include these recent changes.

Also during the reporting period, the first of several computer runs with the MARC-CDC Structural Analysis Program were initiated. The results from these runs are anticipated to be compared with solutions obtained using the two-dimensional displacement discontinuity model SALT2.

Methods of improving the temperature distributions used in the displacement discontinuity models are being investigated. Currently, the models use analytical expressions for heat sources in a continuous elastic material and therefore do not consider the presence of excavations or of the thermal boundary conditions associated with them. To overcome this limitation, a boundary element method of calculating temperature distributions around excavations of arbitrary shape is being developed. Initial results have been obtained for cases when the excavation is maintained at a constant temperature.

1.3.3.3 Explicit Finite-Difference Modeling . . . Ronald Hofmann,
Science Applications, Inc.

No activity has been reported for November.

1.3.3.4 Bench-Scale Creep Testing . . . W. H. Grams, South Dakota
School of Mines and Technology

No activity has been reported for November.

1.3.3.5 Thermal Properties and Thermal-Mechanical Behavior of Rocks Under Pressure . . . Hugh Heard and A. E. Abey, Lawrence
Livermore Laboratory

No activity has been reported for November.

*This report covers activities from October 16 through November 15, 1977.

1.3.3.6 Handbook of Salt Properties* . . . L. H. Gevantman, National Bureau of Standards

Proposals for assembling a Salt Properties Data Handbook have now been received from the three data centers (the National Center for Thermodynamic Data of Minerals, USGS; the Rensselaer Molten Salts Data Center; and the Purdue Center for Information and Numerical Data Analysis) previously designated as principals by the Office of Standard Reference Data. The Office issued authorizations to these centers to initiate the effort, the first task of which will be to peruse and compile the data from the literature.

1.3.4 BOREHOLE PLUGGING . . . G. D. Brunton

1.3.4.1 Characteristics of Cement and Concrete . . . J. G. Moore, Chemical Technology Division, Oak Ridge National Laboratory

Compressive strength measurements were completed on 7- and 28-day-cured mortars and 7-day type I Portland cement/Cencron fly-ash pastes. In both cases, the samples had a water-to-solids (w/s) ratio of 0.485, with 10 to 40% of the cement replaced with either sand or fly ash. The specimens were cured at ambient temperature after being coated with Protexo Cote. Correlations will be made after measurements are completed on the 28- and 91-day-cured specimens.

Permeability measurements were made on the aforementioned mortar specimens after curing 28 days in saturated lime water. No apparent correlation between sand content and permeability was observed. The values ranged from 5.6×10^{-5} darcy to 1.3×10^{-4} darcy. These results are almost identical to those reported last month for cement/fly-ash pastes. In each case, the measurements were made using the Hassler Cell technique with nitrogen gas as the permeability fluid. All samples were run in triplicate after drying 24 hr at 110°C. The standard deviations ranged from 16 to 43%. An attempt will be made to improve the precision in future measurements by drying the specimens to a constant weight (i.e., <0.05% wt change on heating at 110°C for 24 hr) rather than for a specified time period.

E. W. McDaniel, ORNL, attended the Seventh Annual Technical Meeting of the National Ash Association in Kansas City, November 1-3. The emphasis of the meeting was on the characteristics and use of western (lignite) fly ash. These materials have a high lime content (5 to 30% CaO) and thus cementitious properties that are completely different from the eastern fly ashes. Scouting tests are in progress to determine the effect of these lignite fly ashes on cement/fly-ash pastes.

Meetings were held with Della Roy and her staff at Pennsylvania State University on November 3-4 to discuss the progress of the borehole plugging studies and to decide on a future course of action.

*This report covers activities from October 16 through November 15, 1977.

1.3.4.2 Preparation, Properties, and Optimization of Characteristics of Cements for Radioactive Waste Isolation . . . D. M. Roy and B. Scheetz, Pennsylvania State University

Investigation of the effect of water-reducing admixtures upon the properties of cement slurries and hardened pastes is continuing. Additional measurements of weight loss (to determine the degree of hydration) and compressive strength measurements as a function of time are being conducted with several different admixtures. In addition, the surface potential developed at the solid-liquid interface is being investigated as to how it affects the properties of slurries; zeta potential measurements have been completed on β -wollastonite in order to serve as calibration for measurements with cement samples. Two kinds of water-reducing additives, M-1 and MY-2, and two different purity waters were used to determine the streaming potentials at 20 min and 20 hr. A parallel determination of the zeta potential by microelectrophoresis techniques produces results that have a smaller zeta potential than those attained by the streaming potential technique. This difference may be explained by the larger distance between the solid surface and the plane-of-shear in the streaming potential determinations where the liquid phase flows very rapidly. Another reason is that the sample used in the electrophoresis technique contains very fine particles, and therefore, soluble phases, if present in the original β -wollastonite clinker, would dissolve to a greater extent.

Permeability measurements continue at high pressures, and the validity of the use of average pressure, $\Delta P/2$, in the Darcy equation has been investigated up to pressures of 600 psi. Data obtained at these pressures continue to observe Darcy's Law and can be fitted to a straight line with a typical correlation coefficient of 0.998. Preliminary measurements of permeability have also been made with the Hoek-Franklin cell.

Further studies are being performed to determine the lowest standard deviation that can be obtained with strength measurements on small cylinders of paste currently at 28 days' curing time; these standard deviations are about 6%. Microhardness measurements on similar samples are also being made. In addition, steps are being taken to maximize the precision of weight loss data measurements, which show some variability in the loss of water at 110°C. Concurrent weight loss measurements will be made by thermogravimetric analysis, which will have the advantage of giving more complete, but less precise, data. Density measurements on types I and V cement pastes have been completed in addition to surface area measurements for a series of samples that have been cured at elevated temperatures under a series of conditions for 3, 7, and 28 days.

Tobermorite is presently being synthesized hydrothermally over a range of stoichiometries and at several temperatures and pressures. The resulting crystalline product will be used to seed cement pastes. Additional studies are in process to examine the structure continuity developed across the interface of the cement paste and aggregate.

The influence of the addition of fly ash to cement pastes on bulk chemical shrinkage was investigated. Results of this study indicate that pastes containing fly ash show slightly higher shrinkage than neat pastes with the same w/s ratio.

1.3.5 SAFETY AND RELIABILITY . . . H. C. Claiborne

1.3.5.1 Long-Term Safety Assessment (WISAP,* Tasks 1-3)[†] . . . H. C. Burkholder, Battelle Pacific Northwest Laboratories

Program management

A summary of technical progress for the NWTs Program annual progress report was submitted to OWI.

Task 1: Release scenario analysis - Jess Greenborg and J. A. Stottlemire. Task 1 has been divided into three subtasks for FY 1978: (1) characterization of dynamic earth processes and events, (2) development of the repository simulation analysis computer code, and (3) the development of a geologic/geophysical data base. Contracts have been initiated for four members of the geologic consultants group; several others are in preparation. The draft of a report describing the proposed WISAP release scenario analysis method was completed and is under internal review.

Task 2: Waste Form release rate data - D. J. Bradley and R. P. Turcotte. The proposal for temperature and flow-rate studies at Lawrence Livermore Laboratory has been received, and final technical review has been completed.

The proposal for leaching of low-level transuranic (LL-TRU) wastes was received from Brookhaven National Laboratory and is being reviewed.

Bids have been received for the glove-box/open-face hood, and the purchase should be made within a week. The specifications for four autoclaves have been prepared, with scheduling for the equipment to be operational by the end of March 1978.

Arrangements have been completed for the analysis of the leach solutions generated by the actinide-doped waste glasses. Approximately 1500 samples are being started through the analysis sequence. Final preparation of in-cell waste disposal techniques has been completed, and the spent fuel studies will be started by the end of the month.

Task 3: Release consequence analysis - J. R. Raymond and J. K. Soldat. Conversion and testing of the Davis Three-Dimensional Finite-Element Hydrologic Model were completed. The converted model was verified with various test problems as well as the data set for the Long Island ground-water system. A user's manual has been prepared.

*WISAP = Waste Isolation Safety Assessment Program.

[†]This report covers activities from October 15 through November 15, 1977.

Conversion of the PATHS Hydrologic Model and the water-dose codes, ARRRG and FOOD, to the Univac 1100/44 computer (the new Hanford Project computer) was initiated. During conversion, all dose codes will be modified slightly to use common data libraries. This change will enable parametric studies to be performed with greater efficiency.

The desirability of formulating a computer code to perform the direct conversion of radiation dose to health effects was evaluated. Because such a conversion would require modification of all dose codes in order to monitor dose rate vs time and because the conversion relationship is being reevaluated and modified for the commercial waste management environmental impact statement, the decision was made not to formulate a computer code at the present time.

1.3.5.2 Operational-Phase Safety Assessment

This phase is currently inactive.

1.3.6 DATA MANAGEMENT . . . L. B. Cobb

1.3.6.1 Geologic Data Management . . . R. C. Durfee, Computing Applications Department, Computer Sciences Division, UCC-ND

Software

I. Spatial analysis software. Work on siting-factor maps and suitability maps for the northeast Michigan area have now been completed. Different siting factors generated from the raw digitized data were combined in the suitability analysis.

II. Borehole plotting package. Software development continued on the borehole plotting package design for the Versatec electrostatic plotter. Several major improvements are being made, including the capability to plot multiple boreholes corresponding to their occurrence along predetermined cross-sectional lines. The distance between these boreholes on the plot will be scaled and made proportional to the projected distance along the actual cross-sectional line. Each individual borehole is displayed as a lithologic column with the different strata shaded according to standard rock symbols. Approximately 25 to 30 different shading patterns are currently provided. In addition, the name of the geologic formation can be plotted within each shaded section. A borehole of any depth can be plotted by this program. Test runs have been made using the borehole data for northern Louisiana extracted from magnetic tapes compiled by M. B. Kumar of Louisiana State University (LSU). This program, which is being implemented by C. A. Dillard, is presently in the debugging stages.

III. Geologic cross sections. R. G. Mashburn is continuing development of a geologic cross section program to display geological strata as a cross-sectional cut through the earth's surface. The basic input information consists of all borehole data within a study area; the data are then spatially interpolated to determine strata elevations

and thicknesses along a user-defined cross-sectional line. The interpolation procedure used a new technique involving the construction of Thiessen networks among boreholes to determine the adjacent influencing neighbors along the cross-section line. This technique provides for a quick and efficient calculation of adjacency relationships. At present, a planar interpolation is being used in the cross section program although a second technique using a quadratic-least-squares fit is also operational for regions in which a large number of boreholes are available. The cross-sectional cut line may consist of a single plane passing across the study region, or it may consist of multiple intersecting planes across the study area. In this way, the user can choose a cross-section line that travels from borehole to borehole. Once the interpolation along this plane has been completed for all strata within the boreholes, the user may then choose any viewing plane onto which the cross-section plane is projected. These last three steps of defining the cross-section cutting plane, projecting the data onto the viewing plane, and actually plotting the information are currently being programmed. The borehole data compiled by M. B. Kumar will also be used as test data for this project. A problem in defining the spatial location of these boreholes is described in the section below on the North Louisiana borehole data base.

IV. Oak Ridge Interactive Digitization System (ORIDS) assembly language software. The assembly language software to allow the Tektronix Digitization System to be connected to the Modcomp II minicomputer is approximately 60% complete. This software will allow the Tektronix to communicate with the Modcomp II as well as allowing the Modcomp II to communicate with the PDP-10. The software for the first link has been completed, and the spooler program for the second link is presently under development. This transition will significantly reduce the computer charges on the PDP-10.

The test software has now been written for the video projection system to drive the beam from the Modcomp II minicomputer. The interface portion of the software between the Modcomp II and the video display generator is presently being debugged. This software is being written by R. G. LeBlanc.

V. Documentation. Documentation has begun on the U.S. county mapping program that is used in conjunction with the display of digitized geological data. A generalized version of this program is being loaded onto an on-line disk for immediate access by various users. The documentation will be in the form of a user's manual describing the input, output, user options, etc. Documentation is also being planned for the borehole and geological cross-section programs.

Data bases

I. U.S. major salt dome regions. The major salt dome basins of the continental United States have been digitized and edited to allow for textual labeling of each salt dome region. Overlay maps have been produced on the Calcomp plotter, in color, with the state outlines superimposed.

II. North Louisiana salt dome data base. The salt dome within the North Louisiana basin has been digitized from a variety of different maps at three different scales: (1) on a regional basis for the Texas-Louisiana area as a whole; (2) on a USGS 1:250,000 scale basis; and (3) on a 1:62,500 scale basis (15-min maps). These three data bases were plotted for the North Louisiana area at the same scale so that the maps might be overlayed and so that a visual correlation could be made to determine the spatial accuracy and consistency of the individual salt domes. The regional tectonic data was slightly in error when compared with the other two data sources; therefore, the three data bases will be edited and corrected so that they will all be consistent. A log system is being established to keep track of and monitor the large number of data bases being digitized for OWI.

III. North Louisiana borehole data base. Processing is continuing on the borehole data compiled by M. B. Kumar, LSU, to extract and analyze three files of borehole data for northern Louisiana. These files have been read, and appropriate formats have been set up to handle the different types of data. An inconsistency between the file formats caused some initial problems, but it has now been resolved. The order of occurrence of the different geological structures was tested for consistency between the different boreholes and found to be satisfactory. However, some missing data, such as the total depth of the boreholes and missing Kelly bushings, are causing a problem. These missing data prevent the calculation of depth (in feet above sea level) in comparing boreholes. Approximately 25 boreholes have been eliminated from the study because of the missing data. The most serious problem encountered in analyzing this data base was the determination of the actual latitude and longitude of the borehole location. The spatial coordinates given on the tape files consist of northings and eastings based on the township-range coordinate system in North Louisiana. Each individual file has its own origin and uses a different system. Since the township-range system is not a true linear cartesian coordinate system (the grid lines traversed the map at odd angles with intermittent shifts in different directions), no universal method of transforming the borehole northings and eastings into latitude and longitude was found. A possibility is to divide the area into local subareas in which the grid lines are approximately cartesian and then perform an approximate transformation into true map coordinates. However, attempts are being made to acquire the original maps on which the boreholes were plotted so that the locations may be digitized directly in latitude-longitude. When new coordinates are obtained, the original data files will be updated.

IV. Vacherie site. Most of the detailed data on the Vacherie salt dome area has been digitized to create a data base containing detailed information on topography and land use features. The digitized data include schools, churches, access roads (with right-of-entry), streams, water well sites, tiltmeter sites, corehole sites, and areas with right-of-entry and refused right-of-entry tracks. Overlay plots

will be made to determine the accuracy of the digitized data since the original map was not in a known map projection and empirical ground truth rectification points were used for digitization.

V. Petroleum information well history data base. Information is being gathered to determine the best mechanism for accessing the Petroleum Information Corporation (Denver) Well History Control System data. Preliminary contact has also been made with the National Uranium Resource Evaluation (NURE) program concerning their interest and access of this data base. Because of the vast amount of information in this data base, the NURE program may be obtaining access to the information through another group in Colorado. Borehole data on selected regions may possibly be retrieved and provided for OWI analysis through coordination with the NURE program.

Hardware

The computer equipment delivered in September 1977 (magnetic tape drive, large disk, printer interface, and extra memory) has been installed on ORIDS and is currently operational. The card reader was delivered in October 1977, has been installed, and is operational for both local Modcomp development and as part of the HASP (Houston Automatic Spooling Priority System) input station to the IBM/360. Approximately 30-40 computer jobs per day are being processed through the HASP system. The video projector has been improved and was returned from the factory (Aydin Controls, Inc.) in November. The projector and display generator are currently undergoing acceptance tests, and the resolution and accuracy of the beam movement have been greatly improved. A small problem may still exist with the electronic stability in the system. A new high-resolution digitizer table has been delivered and assembled. Initial off-line tests have been made, and the equipment appears to be satisfactory. This equipment will also be connected to the Modcomp II for use with the video projection system.

2. FACILITY PROJECTS

A. L. Boch

2.1 Engineering Projects

2.1.1 FIELD TESTING . . . P. D. Fairchild

2.1.1.1 Shale In Situ Tests

During November, field installation of the Conasauga near-surface heater experiment progressed toward conclusion, and start-up is under way at site S-1. On November 28, the heater at S-1 was turned on, and the temperature is being increased in 100°C increments (with strict monitoring of the pressures and temperatures in the heater hole and the thermocouple readings in the adjacent rock). Heater installation at site S-2 will be completed as soon as sufficient experience is gained at S-1 to verify that significant modifications in experimental procedures are not necessary. (S-2 start-up should begin by mid-December 1977.)

Field experiments . . . J. L. Krumhansl, Sandia Laboratories

During the month, central heater holes at both sites were cored and reamed to a diameter of 15 in. Each hole was pumped empty and found to refill at a rate of several inches per hour. Through use of a downhole television camera, the recharge in the S-2 heater hole was found to take place primarily through a single fracture at a depth of about 54 ft. However, application of air pressure to adjacent instrumentation holes was also found to cause bubbling over a region extending approximately 10 ft downward from the casing of the central heater hole. At site S-1, pressurization of instrumentation holes caused intense bubbling in the bottom of the heater hole, thus confirming the presence of an open fracture system at depth. Krypton-85 transmissivity measurements were also made at both sites. At S-1, the bulk of the rock is apparently quite impervious, and apparently S-1 contains domains of both permeable and fairly impervious rock.

The heater was installed at S-1, and the data acquisition instrumentation was connected. The heater at this site will be turned on within the next week. At the second site, S-2, the heater is suspended over the heater hole and will be emplaced as soon as experience from S-1 indicates that no modifications in experimental procedure are necessary.

Laboratory studies . . . J. L. Krumhansl, Sandia Laboratories

Core from last summer's drilling program arrived in Albuquerque. Unfortunately, the coring of the large-diameter heater holes yielded insufficient material for the machining of oriented samples for mechanical testing. Therefore, the only possible measurements will be directional variations in thermal expansion and perhaps thermal conductivity.

2.1.1.2 Dome Salt In Situ Tests

Activities on the Avery Island Heater experiment in Louisiana continued on schedule both in the field and on equipment fabrication at Oak Ridge. The first shipment from Oak Ridge to Avery Island, consisting of all major electrical equipment needed to tie in to the mine feeder system, was successfully completed during the week of November 14; installation work by the local electrical sub-subcontractor was approximately 50% complete at the end of the month. Drilling is scheduled to begin in early December on one of the NX (3-in. diam) extensometer coreholes (depth of 36 ft), both to confirm the site suitability at depth and to provide core specimens for the laboratory support testing. A meeting is scheduled at Oak Ridge on December 8, 1977, with RE/SPEC and UCC-ND Engineering to review the proposed installation procedures and to firm up the drilling/installation sequencing and the schedule for January 1978.

Field operations* . . . G. D. Callahan, RE/SPEC Inc.

Efforts in relation to the installation of the heater experiment at Avery Island were primarily directed toward the installation of electrical power by the sub-subcontractor Ernest P. Breaux Co. of New Iberia, Louisiana. The electrical subcontractor began work the week of November 14 and will require approximately four weeks to complete the wiring. Initial electrical wiring should provide the power required for drilling by December 1, 1977. The initial shipment of hardware from OWI was received at the mine, and items such as transformers, electrical lights, switches, circuit breakers, and panelboards are currently being installed. The control shack is approximately 90% constructed and is being wired.

During the week of November 8, Paul Gnirk, Joe Ratigen, and Leo Van Sambeek attended the in situ heater experiment review sponsored by DOE in Germantown, Maryland. Van Sambeek presented a description of the physical aspects of the experiment as well as the objectives and rationale for performing the experiment.

On November 16, P. D. Fairchild of OWI met with Lester Jay of the International Salt Company (ISC) and inspected the underground site.

Equipment design and fabrication . . . E. G. St. Clair, Engineering Division, UCC-ND

Equipment fabrication continued in the ORNL shops. A thorough inventory and check of all electrical, mechanical, and instrumentation items in ORNL stores was conducted, and all electrical materials to be furnished to Breaux were shipped to Avery Island on November 14. All heater canisters have been completed and packaged for shipment, as well as the peripheral heater sleeves, peripheral heaters, and the closure measuring tools. The second sleeve was completed at the Y-12 Engineering Technology Division shop, and the third sleeve should be finished December 9, 1977.

*This report covers activities from October 16 through November 15, 1977.

The pressure relief valves were received and calibrated, and the long-awaited meter relay was received and installed. Also, the electrical control panels were checked out.

The data loggers returned to Accurex for interfacing were not returned by mid-November, as scheduled, which continues to cause a delay in the completion of the instrumentation panel. Although completion of this item is not critical, a potential problem has been recognized, and steps are being taken to expedite resolution with the manufacturer.

After the time-consuming slitting and deburring process was completed, progress was made on the peripheral thermocouple sleeves. These sleeves are nearly complete and will soon be available for thermocouple installation. The corrosion samples were delivered to the Metals and Ceramics Division for cataloging before being installed on the sleeves prior to packaging. A list of items that can best be purchased locally by RE/SPEC was developed and forwarded to OWI.

2.1.2 DESIGN STUDIES . . . P. D. Fairchild

In November, considerable progress was made on the Canister Transporter Design Study, and a draft of the FMC final report is expected at OWI for review in early December. Also, an oral presentation is scheduled for December 13, 1977, at Oak Ridge. The Cask Scoping Study is near conclusion, and Sandia Laboratories is placing primary emphasis on drafting the final report.

2.1.2.1 Canister Transporter . . . M. Wallis, FMC Corporation

Los Alamos Technical Associates (LATA) revised the shielding calculations for spent fuel, high-level waste (HLW), cladding waste (CW), and intermediate-level waste (ILW) as follows:

1. Spent fuel - (3-year-old pressurized-water reactor spent fuel) 10.2 cm depleted uranium, 10 cm borated polyethylene, plus 2½ in. of steel liners and sleeves, and some aluminum heat paths.
2. High-level waste - (based on reprocessing 5-year-old spent fuel) 11 cm depleted uranium, 20 cm borated polyethylene, plus 2½ in. of steel liners and sleeves, and some aluminum heat paths.
3. Cladding waste - 10.2 cm depleted uranium; no neutron shielding required.
4. Intermediate-level waste - 5.2 cm lead or 12.5 cm of steel; no neutron shielding required.

These revised shielding requirements are being incorporated into the transporter concepts. The greatest changes occurred in the spent fuel cask, the revision of which is 90% complete. The spent fuel transporter revisions are also 90% complete.

The HLW cask for vertical installation has been revised, and a net weight decrease allowed the selection of a smaller forklift unit. The concept drawing is being revised to show the smaller vehicle, the cask, and a cask turntable to lower the overall transporter height to less than 11 ft during travel.

An HLW transporter can also handle the CW, and because the gamma shielding requirements for HLW are 11 cm vs 10.2 cm for CW, the shielding requirements are well matched.

The drawings for the horizontal HLW/CW transporter are complete, and a sequence of operating events is being prepared. This sequence will be similar to that already prepared for the spent fuel transporter.

An artist's concept has been completed which illustrates modifications of the horizontal HLW/CW transporter for inclined installation in a plane perpendicular to the longitudinal axis of the vehicle.

Calculations for the ILW cask are complete, and a forklift has been selected. Drawings will be prepared shortly.

The economic analysis for the spent fuel transporter has been revised to reflect the latest concept.

The draft of the final report is under way and approximately 90% complete (including text, drawings, and tables.)

2.1.2.2 Cask Scoping Study . . . J. M. Freedman, Sandia Laboratories

Sandia Laboratories is currently drafting their final report on the Cask Scoping Study. A review meeting was held at OWI on November 2 to discuss the contents of the final report and to discuss the implication of cask design variations on the receipt/unloading interface at the repository. As a follow-up to that interface discussion, a meeting has been arranged with representatives of Stearns-Roger and Kaiser Engineers at OWI on December 14, 1977. The draft of Sandia's final report is due at OWI in January 1978.

2.2 Repository Projects

S. C. Matthews

2.2.1 CONCEPTUAL DESIGN OF NWTS REPOSITORIES 1 AND 2

Conceptual design efforts continued, with Stearns-Roger (SRENCO) working on NWTS Repository 1 and Kaiser Engineers (KE) working on NWTS Repository 2.

SRENCO has forwarded all current conceptual design materials for the formal 50% design review by UCC-ND/DOE. The comments are planned to be internally resolved and consolidated by December 9, 1977, so that they can be covered in depth with SRENCO on December 14 and 15. On November 15, a UCC-ND environmental control engineering specialist met with SRENCO engineers for an in-depth discussion and review of their confinement, filtration, and ventilation concepts for the surface facilities and the mine.

A conceptual design status review meeting was held at Kaiser, November 9-11, and in-depth reviews were made of the mine design and of the mechanical handling systems.

An intensive indoctrination for KE and SRENCO on the required DOE cost-estimating procedures, formats, etc., was held on November 30-December 1. Special emphasis was placed on the use of a standard cost code of accounts and on the UCC-ND cost-estimating computer software. The approximate percentage of completion for Repository 1 (SRENCO) is 49%, and for Repository 2 (KE), is 55%.

2.2.1.1 NWTS Repository 1 . . . S. C. Matthews, OWI; J. H. Jones,
Stearns-Roger Engineering Company

The general design effort continues with emphasis on reviewing schedules for completion of final Cost Estimate and the Conceptual Design Report. Considerable time was spent on assembling material for the 50% design review. This required collection of data, drawings, and evaluations, which were made by SRENCO, has been submitted to DOE for review prior to the review meeting in December 1977.

Detailed drafting of drawings for the final conceptual design of the Underground Facilities was started during the month. Woodward-Clyde Consultants continued to support the design efforts of the Underground Facilities and have issued preliminary drafts of reports describing backfilling techniques and filtration systems. These preliminary drafts are being reviewed by SRENCO before final reports are issued.

In the canistered waste area, SRENCO is evaluating surface effect vehicles (SEV) to transport shielding casks. Also in the canistered waste area, work is continuing on the structural design of the Canistered Waste Facilities.

Energy Incorporated, in support of SRENCO, initiated efforts to proceed on the Occupational Exposure and Health Physics Studies and is also continuing efforts in shielding calculations.

The 50-year far-field thermal analysis run was completed. The results are being tabulated and evaluated, and graphs are being plotted showing the results.

SRENCO is preparing an artist's perspective of the Underground Facilities. Several different arrangements have been reviewed in developing the final approved sketch.

The Planning Study was issued in final approved form, and copies have been transmitted to DOE.

UCC-ND personnel visited the SRENCO offices on November 14-16 to review the conceptual designs for ventilation systems. A meeting with Energy Incorporated personnel was held in Denver on November 22 to initiate the Occupational Exposure and Health Physics Studies.

A SRENCO estimator and computer programmer met with UCC-ND personnel in Oak Ridge on November 30-December 1 to review the computer code to be used in the preparation of the final Cost Estimate. This computer code will be operated on SRENCO computer facilities.

General conceptual design efforts will continue during the next month with emphasis on systems descriptions and final drawings in the Underground Facilities and on structural evaluations and design in the Canistered Waste Facilities.

2.2.1.2 NWTS Repository 2 . . . S. C. Matthews, OWI; J. S. Ritchie,
Kaiser Engineers, Inc.

Kaiser Engineers' technical effort continued in the areas of thermal and nuclear analyses, mining studies for the conceptual design preliminary site layouts, and documenting design decisions.

A design status review meeting with KE, DOE, and OWI personnel was held in Oakland on November 9 and 10. This meeting resulted in agreement on deleting some elements of engineering from the KE work to comply with the OWI fiscal 1978 budget. Design status was reviewed on all aspects of in-progress work; conclusions to studies that were made by KE were summarized on individual Conceptual Design Decisions (CDD's) and used as documentation of the design decisions reached. Major decisions reviewed at this meeting include (1) consolidation of mine shaft functions resulting in four shafts; (2) a mine configuration using a shaft pillar on one side; (3) surface salt pile location over the last areas mined; (4) onsite steam generation using rental boilers for Phase I and onsite turbine generators for power and steam generation for Phase II; (5) use of 18-ft-high burial rooms for the 5-year retrieval period; (6) use of an electrically powered boring-type continuous miner and extensible conveyors for salt removal in burial rooms; (7) use of a shielded transfer cask (the cask is loaded with canisters in a surface hot cell and then transferred to the burial location); (8) transfer casks that will carry one canister rather than two; (9) use of dual lines in the spent fuel surface handling facility; (10) electromagnetic pickup for canisters and shield plugs; and (11) the development of a minimum safeguards security design basis that will meet Nuclear Regulatory Commission (NRC) requirements.

Other major items of in-progress design on which CDD's have been prepared during the reporting period include (1) storing two boiling-water reactor (BWR) assemblies in a canister rather than three or four; (2) filtration and ion-exchange for liquid radioactive waste rather than evaporation; (3) use of stainless steel etched disk filters for liquid radioactive waste; (4) use of a normally by-passed caustic scrubber for iodine removal in the gaseous radioactive waste system; (5) incineration of ion-exchange resins rather than regeneration; (6) advance mining plan rather than retreat mining plan; (7) selection of a "secondary selective" electrical distribution system; (8) underground electrical distribution; and (9) use of a fluidized bed incinerator for in-plant radioactive waste.

A study entitled "The Effects of Earthquakes on Underground Openings" was completed, and the general conclusion reached was that seismic effects below the top of bedrock are relatively insignificant.

Contracts for four individual heat transfer consultants were finalized during this reporting period.

The next design status review is scheduled for February 7, 1978, at Oak Ridge.

2.3 OWI Facilities

S. C. Matthews

No activity has been reported for November on any of the general plant projects or line-item projects submitted as support facilities for OWI.

2.4 Generic Preconceptual Facility Studies

R. K. Kibbe

In a meeting on February 7-8, 1977, between representatives of OWI, ERDA-OR, ERDA-RL, ERDA-HQ, and Battelle Pacific Northwest Laboratories (PNL), OWI was requested to perform an accelerated series of preconceptual repository design studies considering alternative fuel cycles and alternative rock formations. This work is intended to generate baseline information on a systematic basis which will allow a comparison of both the technical and economic impacts of the various alternatives. The results would also be available for inclusion in the generic environmental impact statement (GEIS) on radioactive waste disposal, which is being prepared by PNL.

To accomplish this work, UCC-ND has contracted with three firms: (1) the A-E firm of Parsons, Brinckerhoff, Quade & Douglas, Inc. (PBQ&D), to generate preconceptual repository designs and to analyze the costs associated with the various alternatives; (2) the geotechnical firm of Dames & Moore (D&M), to analyze the geophysical properties of the various salt, granite, and shale formations of interest for potential geologic isolation of commercial waste; and (3) the multidisciplinary firm of Science Applications, Inc. (SAI), to analyze the nuclear, thermal, and effluent releases that may be associated with these facilities under normal operations or accident conditions. In addition, SAI is assisting OWI in program planning and organization and in the generation of the OWI GEIS submittal, in which the results of these studies will be included. Contracts with each of these firms were effective June 3. All work under the initial contract scope was completed by September 30, 1977.

During this month, contract negotiations for a second phase of work on an expanded work scope were completed, and UCC-ND Purchasing submitted two of the three contract extensions to DOE for final approval. Final approvals to proceed on all three contracts are anticipated during the next month, with the final results from the expanded studies expected within 4½ months of the receipt of the necessary approvals.

3. PLANNING AND ANALYSIS

J. M. Morrison

3.1 Schedule and Control System Development

J. R. Palmer

3.1.1 PROGRAM CONTROL SYSTEM . . . M. L. Bennett, J. R. Palmer, D. G. Shaner, and W. R. Musick

The baseline Program Control System (PCS) planning data were modified during the month to reflect continuing changes to the program, most notably in the area of budgets and schedules. The second Program Review Meeting was held November 30.

A slide presentation explaining the concept of the OWI PCS with actual case data was prepared and also reproduced for a handout booklet. One presentation was given to UCC-ND top management. Another presentation was made to the Operating Contractors Project Office staff, and a third, to staff members of the Separations Systems, Y-12 Development Division, and the Operations Analysis and Planning Division.

A decision was made not to extend the Boeing contract, and steps were taken to effectively complete the existing contract by December 30, 1977. Boeing supplied the formal documentation for the PCS and Integrated Cost/Schedule Subsystem Operating Instructions.

3.2 Program Planning

J. E. Vath

3.2.1 GENERAL PROGRAM PLANNING ACTIVITIES . . . J. E. Vath and R. S. Lowrie

The OWI Program Plan was issued for limited distribution in notebook format on November 1. All scheduled report deadlines were met.

3.2.2 WASTE PROJECTIONS STUDY . . . R. A. Kisner, OWI; J. R. Marshall and J. A. Nowicki, Operations Analysis and Planning Division, UCC-ND

The second draft of the report Y/OWI/TM-34, entitled "OWI Waste Projection and Source-Term Data for FY 1977," by R. A. Kisner, J. R. Marshall, D. W. Turner, and J. E. Vath, was released for internal review this month. Publication is expected in about a month.

A major effort was directed toward the development and documentation of the source-term data/library recovery code named PLOTLIB. The

OWI source-term library currently consists of 16 ORIGEN runs incorporating a variety of differing light-water reactor (LWR) fuel cycles and waste streams. The typical isotopic source-term data consist of information on watts, curies, grams, etc.; all data are compiled as a function of time after reactor discharge and unitized on a per metric ton heavy metal (MTHM) basis. The computer recovery system is designed to provide computer plots and/or user-specified output tables. PLOTLIB is also user-oriented and extremely versatile. A free-form read package incorporated within the code allows the user to input the necessary code parameters without regard to strict format requirements. Further, the code uses a modular concept; that is, the data recovery, tabulation, and plotting modulars are separate entities and require little or no interfacing between one another. The PLOTLIB user's manual will be available early in CY 1978.

3.2.3 WASTE INVENTORY STUDY . . . H. N. Rosenberg

The Pricing Proposal for the Waste Inventory Study was submitted to UCC-ND for review. Technical and audit reviews were completed, and the contract is being prepared for signature.

3.2.4 CURRENT ACTIVITY ON ALTERNATIVE FUEL CYCLES . . . R. A. Kisner and W. H. Pechin

No activity has been reported for November.

3.3 Systems Studies

R. S. Lowrie

3.3.1 WASTE CONTAINER STUDIES , . . W. H. Pechin

The nature of the waste container studies is such that they interface with, and to a certain extent overlap, numerous other activities sponsored by OWI, for instance, the Transportation/Logistics Study. The objective of the Rockwell Hanford Operations (RHO) canister envelope and waste packaging studies (Sects. 3.3.1.1 and 3.3.1.2) is to develop sufficient information to determine the limitations imposed by the rest of the repository system on the high-level-waste (HLW) canister and other waste packages.

Work is continuing at RHO on the preparation of a long-range program plan covering work on HLW canisters, spent unprocessed fuel (SURF) canisters (for both geologic and surface storage), and the packaging of other radioactive wastes for geologic disposal. This plan and the draft report on HLW canisters (Sect. 3.3.1.1) will be discussed at a meeting at OWI on December 8, 1977.

3.3.1.1 High-Level-Waste Canister Envelope Study - Task 2 . . . E. L. Moore, Rockwell Hanford Operations

An objective of the High-Level-Waste Canister Envelope Study is to establish canister acceptance criteria that will assure that the waste canisters are compatible with all handling equipment and environments from the waste solidification process until emplacement in the federal geologic repository. To accomplish the objective, all constraints (size, weight, waste heat density, etc.) imposed by the handling equipment and environments must be identified for their impact on waste canister design. Five firms have been engaged to provide technical assistance in the development of canister acceptance criteria.

Four of the firms (Science Applications, Inc., Battelle Columbus Laboratories, Kaiser Engineers, Inc., and TRW Defense and Space Systems Group) have completed their initial three-month studies and submitted their final reports. A draft interim report covering the results of these studies is being written for transmittal to OWI by November 30. The draft interim report will also contain preliminary HLW canister criteria and bases for the criteria.

The fifth firm, Nuclear Services Corporation (NSC), is conducting a study to identify applicable codes and standards for the design and fabrication of the HLW canister. A preliminary draft of the report covering the study is to be submitted to Rockwell for review by December 19, 1977. This information will be incorporated in the final HLW canister report to be issued in February 1978.

3.3.1.2 Radioactive Waste Packaging Study . . . D. B. Calmus, Rockwell Hanford Operations

Contracts for the Transportation Study (Science Applications, Inc.) and the Corrosion Study (Battelle Columbus Laboratories) were procured, and work was scheduled to begin the week of November 21.

During the reporting period, a visit was made to the Allied General Nuclear Services (AGNS) facility to tour the reprocessing plant and familiarize AGNS personnel with the RHO Radioactive Waste Packaging Study.

Collation of information relating to the generation, packaging, and storage of low-level transuranic (TRU) waste, intermediate-level TRU waste, and cladding waste was initiated. Topics covered in the collated information will discuss current practices for the following areas:

1. Source of commercial TRU waste.
2. Treatment of TRU waste.
3. Immobilization of TRU waste.
4. Containerization of solid TRU waste.
5. Transportation of TRU waste containers.
6. Interim storage of TRU waste.
7. Final disposal of TRU waste.

A status report on the Radioactive Waste Packaging Study is scheduled to be sent to OWI in December 1977.

3.3.2 TRANSPORTATION/LOGISTICS STUDY . . . D. W. Turner, OWI;
L. B. Shappert, Chemical Technology Division, Oak Ridge
National Laboratory

The draft report documenting the Transportation/Logistics systems analysis and program plan was transmitted to OWI for review and comment. The final draft of the Pacific Northwest Laboratories (PNL) information on generic waste transportation system problems and concerns was received and reviewed. Comments were discussed with J. G. De Steese of PNL during his visit to OWI on November 17, and a letter containing this information is expected in December 1977. Preliminary drafts of twelve sections of the AGNS report entitled "Current Status and Future Considerations for a Transportation System for Spent Fuel and Radioactive Waste" (Y/OWI/SUB-77/42513) were received and reviewed. Comments were discussed with AGNS personnel during a visit to their facility in Barnwell, South Carolina, by ORNL and OWI personnel on November 9 and 10. Also, a tour of the AGNS facility and a discussion on facility-equipment interface problems were included in the visit.

The first request for shipping rates was submitted to the General Services Administration (GSA) on November 8. Rates from 23 regions to three destinations were requested for rail, truck, and overweight truck. These rates will be used in logistics calculations to provide supporting information for the Economic Study (see Sect. 3.3.4). A parametric study of the effects of canister size on HLW shipping costs was submitted to OWI by ORNL.

Developmental work on the Spent Fuel Shipping Logistics program was concluded, and the model is now operational at ORNL. This model calculates the optimal transportation policy for shipping spent fuel from reactor to away-from-reactor (AFR) facilities and subsequent shipment to the federal repository.

3.3.3 SPENT FUEL DISPOSAL SYSTEM STUDY . . . H. M. Noritake, OWI

The Statement of Work for this study was completed and accepted by the successful bidder. A review of the Pricing Proposal was conducted. This project is currently awaiting completion of the sub-contractor audit.

3.3.4 ECONOMIC STUDY . . . H. N. Rosenberg

On November 2, a review meeting with TRW Energy Systems was held at OWI. During this meeting, progress on the tasks discussed below was reviewed. In addition, a copy of the cost estimation computer model specification was delivered to OWI for review and comment. During the month of November, the TRW effort was expended on the following items:

1. Definition of quantitative physical flow model - Comments from OWI were incorporated into draft papers, and detailed calculations were made of the number and type of fuel elements to be delivered for each of the cost estimation scenarios.
2. Definition of set of cost elements - The list of cost elements proposed by TRW at the October review meeting was slightly revised in order to incorporate additional levels of detail in the research and development cost element.
3. Engineering cost estimates - Effort continued on this task using the review comments provided from OWI in the earlier cost collection effort. Detailed annual costs for the TRW cost center breakdown structure were prepared and documented for the geologic disposal of spent fuel in bedded salt, with 5-year retrievability and onsite encapsulation. Additionally, detailed annual costs for geologic disposal of spent fuel in bedded salt with 25-year retrievability and onsite encapsulation were derived and documented.
4. Development of cost estimation model specification data - A validation test plan for the computer model was prepared for inclusion as an appendix within the model specification. The validation plan contained a sample case and a sample hand-calculated output for validation of the computer coding.
5. Computer programming - Work was initiated on this task. Because programming personnel were diverted to other efforts, programming is slightly behind schedule but within budget. Sufficient allowance was planned in the PERT analysis presented in the program plan so that completion of the project on schedule is not affected.

On November 29, DOE-ORO approved an extension of the TRW contract to June 1978, which provides for the completion of three additional major tasks beyond the original work scope. This additional work is directed toward support of the recently proposed National Spent Fuel Policy* and will provide basic pricing data to aid in the establishment of a one-time charge for spent fuel storage and disposal. The additional tasks are as follows:

1. Expanded cost data - Two additional fuel cycle options (beyond the two identified in the original work scope) will examine cases in which the government will take title to spent fuel from utilities for a fixed fee. The cases to be considered will use some combinations of cost centers developed for options defined in the original scope of work plus cost centers associated with AFR, SURF, and 25-year retrievable geologic storage options.

*DOE Press Release No. 77-017, October 18, 1977.

2. Development of pricing algorithms - Pricing concepts will be identified and developed and will include the concept of governmental full cost recovery for disposal of nuclear wastes via one-time charges to waste generators (utilities or reprocessors). Pricing concepts, in the form of algorithms, and the assumptions/implications inherent in each will be documented with preliminary results and transmitted to OWI as available.
3. Development of pricing data - The algorithms developed will be used to calculate the approximate charge for government acceptance of spent fuel. For each of two fuel cycle options to be considered, two sets of charges will be calculated. The variation in charges will be consistent with assumption of specific values for variables contained in the pricing algorithms. Fuel cycles to be considered will be selected from those for which costs were previously collected. Estimated charges will be documented with preliminary results and transmitted to OWI as available.

3.3.5 WASTE ACCEPTANCE CRITERIA . . . W. H. Pechin

Proposals were received from five companies in response to the request for proposals (RFP) for a Waste Acceptance Criteria Study. Based on analyses of these proposals, three companies were selected and visited during the week of November 28.

3.3.6 INTERNATIONAL WASTE REPOSITORY STUDY . . . R. A. Kisner and H. M. Noritake

The Statement of Work was reviewed and accepted by the successful bidder after minor changes were made.

The Pricing Proposal was received by UCC-ND on schedule and is undergoing review. An audit of the bidder has been requested by UCC-ND Purchasing.

4. REGULATORY AFFAIRS

A. S. Quist

4.1 Environmental Studies

4.1.1 ENVIRONMENTAL STUDY PLANS . . . A. S. Quist, OWI; R. J. Davis, NUS Corporation

Draft regional and study area plans, along with an extensive introduction and a synopsis of regulatory requirements, were published as Volume I of the environmental survey plans for the states of Utah, Louisiana, and Texas (one document for the Permian region and one for the Gulf Interior region). NUS personnel orally presented the plans to state agency personnel (with the exception of Louisiana), and copies were provided to the responsible contact person in each state so that state agency review could begin. As reported last month, oral presentations and plan transmittals were made in Mississippi, New York, and Ohio during October. NUS and OWI staff presented the Utah and Texas documents to state agency personnel in those states on November 2 and 3, respectively. As requested by the Louisiana contact, the proposed oral presentation was assembled in written form and transmitted to state agency personnel along with copies of the plans on November 21. Comments from state agency reviews are expected within 30 to 60 days after their receipt of the plans.

The public review process was initiated in Mississippi, Ohio, Utah, and Texas and will be initiated in New York and Louisiana as soon as the determination is made that state legislators are informed of the planning activities in those states. Letters to introduce the program and solicit participation as a reviewer were sent to approximately 20-25 technical experts in one or more of the environmental disciplines in each of the four states noted. Follow-up telephone conversations will determine the availability and willingness of these experts to participate in the review; thereafter, plans will be sent to those participating. The plans will be sent to a regional environmental coalition in each state and to two national organizations (i.e., the National Resources Council of America and the Atomic Industrial Forum) immediately after the transmittals are made to the regional experts. These coalitions and national organizations will be requested to provide reviews of the plans and/or to coordinate reviews by member groups. All transmittals are expected to be completed in December 1977.

Volume II of the environmental survey plans for each state will contain the plan for the locational survey (a location is an area of approximately 30 sq miles identified within the study area). Volume II for the Texas (Permian region) study area was provided to the NUS Technical Advisory Board (TAB) in edited rough draft form on November 21 and is to be sent to OWI for review in December 1977.

Draft outlines of environmental considerations relative to site selection and to the draft environmental impact statements are being reviewed by TAB. These outlines will be developed according to TAB comments.

4.1.2 DRAFT GENERIC ENVIRONMENTAL IMPACT STATEMENT FOR MANAGING RADIO-ACTIVE WASTE FROM COMMERCIAL REACTORS AND POST-FISSION OPERATIONS IN THE LWR FUEL CYCLE . . . A. S. Quist

Activities for November are reported in Sect. 2.4.

4.1.3 REGULATORY PROJECT MANAGERS

4.1.3.1 Bedded Salt Formations . . . R. L. Shoup, OWI; J. J. DiNunno, NUS Corporation

NUS, as Regulatory Project Manager (RPM) for bedded salt formations (Permian and Salina basins), and OWI personnel participated in a meeting with key state agencies in Austin, Texas, on November 8. The purpose of the meeting was (1) to introduce the RPM project and personnel to the state agencies and (2) to establish lines of communication for subsequent environmental data gathering using the state files as necessary.

Progress continued in the preparation of regional reconnaissance reports characterizing the environmental setting of the Permian and Salina basins. Detailed work plans for each subtask were finalized and approved. The primary activity in all technical tasks was the acquisition, review, and documentation of available information on the regions. Standardized base maps are in preparation. Task reports were started for background radiation, aquatic ecology, and terrestrial ecology. Initial draft texts of the regional reports were completed for land use, demography, socio-economics, and meteorology. Drafts of all regional reconnaissance report sections, except hydrology and geology, will be completed for project manager review during December 1977.

4.1.3.2 Dome Salt Formations . . . W. A. Goldsmith, OWI; N. A. Norman, Bechtel Corporation

Gulf Coast Interior salt dome region

Data collection in Louisiana was initiated after a meeting with state officials at Baton Rouge on October 11, 1977; this effort has been completed. The Bechtel environmental and geologic staff are presently preparing the maps required for the regional characterization report. Data collection for Texas was initiated after a meeting with state officials at Austin on November 8 and has been completed. Review of regional data and preparation of maps are currently in progress for the states of Louisiana and Texas.

An initial meeting with Mississippi state officials was held in Jackson, Mississippi, on October 26, 1977. The coordination of plans by Mississippi executive and legislative branches has not been completed; therefore, initiation of data collection will be delayed until specific permission to proceed is granted. However, based on discussions with Mississippi officials, the collection of this regional data is anticipated to be conducted during December 1977. Since the overall regional characterization report for the Gulf Coast salt dome region must include Mississippi, this report will be completed later than the presently scheduled date of February 1978. However, work will proceed on portions of the report based on Texas and Louisiana data.

The geologic and hydrologic characterization of the Gulf Coast Interior salt dome region has been proceeding at an accelerated pace since October 11, 1977. This characterization will be presented using maps and narrative descriptions and will form a portion of the regional characterization report.

Bechtel has evaluated several potential sub-subcontractors for environmental baseline surveys, and negotiations will begin shortly. The work to be performed by the sub-subcontractor will include a 52-week environmental baseline survey of aquatic and terrestrial biology, surface water hydrology, meteorology, air quality, background radiation, and archaeology. Present activities are proceeding according to the existing OWI Program schedule.

Paradox basin region

Regional data collection in Utah was initiated after a public meeting with state officials in Salt Lake City on November 2; regional data collection in Utah is 95% complete. Environmental, geologic, and hydrologic staff are presently preparing the maps and associated narrative descriptions required for the regional characterization report. Submittal of the report to OWI is expected by February 1978.

4.1.4 ENVIRONS MONITORING PROGRAM . . . W. A. Goldsmith, OWI; J. J. DiNunno, NUS Corporation

This project was completed in November. The final report provides a generic design of the radiological and meteorological portions of an environs monitoring program for a nuclear waste repository. The final report was received by OWI on November 9.*

4.1.5 ENVIRONMENTAL IMPACTS OF DISPOSAL OF MINED ROCK . . . W. A. Goldsmith, OWI; J. J. DiNunno, NUS Corporation

This project was completed in November. The final report describes the expected environmental impacts of waste-mined rock disposition techniques at seven reference locations. The final report was received by OWI on November 9.[†]

4.1.6 EVALUATION OF ENVIRONMENTAL DOSE MODELS . . . W. A. Goldsmith, OWI; J. A. Franco, Envirosphere Company

J. A. Franco and J. Mauro of Envirosphere Company visited OWI on November 4 to review OWI comments on their draft report received and reviewed by OWI in October. The comments were resolved; a final report will be issued in early December 1977.

*NUS Corporation, Generic Description of Radiological and Meteorological Monitoring Program for Federal Repositories for Radioactive Wastes, prepared for Union Carbide Corporation, Nuclear Division, Office of Waste Isolation, Y/OWI/SUB-77/42502 (September 1977).

[†]NUS Corporation, Preliminary Environmental Assessments of Disposal of Rock Mined During Excavation of a Federal Repository for Radioactive Waste, prepared for Union Carbide Corporation, Nuclear Division, Office of Waste Isolation, Y/OWI/SUB-77/42503 (September 1977).

4.1.7 POSTDECOMMISSIONING MONITORING OF A REPOSITORY . . . A. S. Quist, OWI; J. A. Franco, EnviroSphere Company

A preliminary evaluation of the postdecommissioning monitoring of a waste repository located in rock salt was performed. A wide range of presently available instrumentation could be deployed in surface, borehole, or buried locations to monitor key radiological, geological, and hydrological properties of the repository and its surroundings after decommissioning. Although some general conclusions as to monitoring feasibility can be made, any detailed evaluation of the monitoring program effectiveness must be based on evaluations performed for a specific site. The draft report is under review by OWI.

4.2 Safety, Risk, and Hazard Studies

4.2.1 OUTLINES OF CONTENTS OF SAFETY ANALYSIS REPORTS FOR REPOSITORIES . . . C. S. Sims, OWI; J. A. Franco, EnviroSphere Company

In FY 1977, SRI, International, and Battelle Columbus Laboratories prepared two format guides for the contents of the safety analysis report (SAR) for a waste repository. EnviroSphere reviewed these guides in light of licensing requirements and current NRC regulations and prepared a single format guide incorporating some features of each of the previous guides. They also proposed a schedule for the development of the SAR and made recommendations for work needed to meet the schedule. The final report was received by OWI near the end of November.

4.2.2 RISK ASSESSMENT BIBLIOGRAPHY STUDIES . . . R. L. Shoup, OWI; B. Suta, SRI, International

The purpose of this bibliography is to provide part of a data base for preparation of safety analysis reports and environmental reports. B. Suta and R. White of SRI, International, visited OWI on October 21 to review OWI comments on the SRI draft report entitled "Annotated Risk Assessment Bibliography for Geologic Isolation of Nuclear Wastes." The final report is complete and will be delivered to OWI in early December.

4.2.3 SAFETY ANALYSIS REPORT PREPARATION ACTIVITY

4.2.3.1 Regulatory Project Manager for Bedded Salt Formations . . . R. L. Shoup, OWI; J. J. DiNunno, NUS Corporation

No activity has been reported for November.

4.2.3.2 Regulatory Project Manager for Dome Salt Formations . . . W. A. Goldsmith, OWI; N. A. Norman, Bechtel Corporation

To prepare the SAR properly, effectively, and efficiently, close coordination must be maintained between the RPM and the other subcontractors participating in the OWI Program. To help maintain this

coordination, Bechtel has developed and is maintaining a list of OWI sub-contractors and other contacts that can or will provide input to the Bechtel SAR. The coordination effort will involve both written contacts and attendance at suitable review meetings. On November 16 and 17, E. M. Miholits, the RPM Project Engineer, and D. G. Campbell, geologist, attended the GPM review meeting in New Orleans. On November 9, the RPM SAR Task Manager, H. G. Wills, attended the Kaiser Engineers Facility Design Review at Oakland, California. At OWI request, RPM representatives will continue to coordinate with OWI subcontractors for purposes of SAR data collection.

4.3 Nuclear Regulatory Commission Licensing Requirements

A. S. Quist

No activity has been reported for November.

4.4 Socioeconomic Impacts of Repository Construction and Operation

4.4.1 SOCIOECONOMIC IMPACT ASSESSMENT AND SOCIETAL ACCEPTANCE . . . A. S. Quist, OWI; A. H. Schilling, Battelle Human Affairs Research Centers (HARC)

A paper analyzing the issues involved in providing compensation to states and local communities for the costs incurred by them because of the construction and operation of waste repositories was prepared in outline form. Internal HARC review is proceeding on the following three items: (1) a report on socioeconomic impact management techniques; (2) an analysis of the ability of state and local officials to manage adverse socioeconomic impacts that could accompany repository development; and (3) a paper on public issues in nuclear waste management that reviews the waste management literature to identify the existing public issues and to apply clustering techniques to define categories and provide discussion of relationships among various issues. The socioeconomic impact forecasting model, which projects both population changes and resulting increases in demand for social services attributable to the development of a repository, has been completed and is available for general use.

4.4.2 REPOSITORY BENEFITS, CONSEQUENCES, AND EFFECTS STUDY . . . A. S. Quist, OWI; R. D. Brenner, Princeton University

Work on preconstruction impacts was postponed in order to complete a draft paper describing the probable initial economic impacts of repository construction on nearby communities. Continuing effort was devoted to developing a series of papers describing the politics of energy facility siting. This work will aid in analyzing the social and political impacts that occur between the designation of candidate sites and the start of repository construction.

4.4.3 ANNOTATED BIBLIOGRAPHY ON CONFLICT RESOLUTION . . . A. S. Quist, OWI; R. S. Burt, University of California, Berkeley

A draft report entitled "Resolving Community Conflict in the Nuclear Power Issue: A Report and Annotated Bibliography" was completed and transmitted to OWI for review and comment.

4.4.4 PUBLIC CONSULTATION IN POLICY FORMATION . . . A. S. Quist, OWI; A. Bruce Bishop, Intermountain Consultants and Planners, Inc.

Progress on the state-of-the-art report and bibliography continued; the survey of the literature and the selection of the works for annotation were completed. Some draft sections of the state-of-the-art report have been completed and transmitted to OWI for review.

4.4.5 COMMUNICATION OF TECHNICAL INFORMATION TO LAY AUDIENCES . . . A. S. Quist, OWI; J. E. Bowes, University of Washington, Seattle

Effort continued in searching, abstracting, and reviewing pertinent literature concerning the use, or nonuse, by nonexperts of technologically complex information. A large part of the information and literature reviewed is in the process of being organized.

APPENDIX A
VISITORS TO THE OFFICE OF WASTE ISOLATION
DURING NOVEMBER 1977

Company	Visitor	Date	Principal contact
Battelle Pacific Northwest Laboratories P. O. Box 999 Richland, WA 99352	J. G. De Steese	11/17	D. W. Turner
Bechtel Corporation 50 Beale Street San Francisco, CA 94119	W. L. Cady	11/3	W. A. Goldsmith
	N. A. Norman	11/3	W. A. Goldsmith
	D. M. Rockey	11/3	W. A. Goldsmith
Boeing Engineering & Construction Company 102 Tulsa Road Oak Ridge, TN 37830	C. P. Black	11/22	D. G. Shaner
		11/3	D. G. Shaner
	R. B. Dixon	11/4	J. R. Palmer
		11/11	D. G. Shaner
	H. G. Stocking	11/15	J. R. Palmer
		11/22	D. G. Shaner
		11/1	M. L. Bennett
		11/3	M. L. Bennett
		11/8	M. L. Bennett
		11/11	D. G. Shaner
		11/17	W. R. Musick
		11/18	W. R. Musick
Control Data Corporation 901 South Highland Arlington, VA 22204	R. F. Kuechenberg	11/11	J. R. Palmer
Dames & Moore 134 Fairbanks Road Oak Ridge, TN 37830	T. M. Gates	11/3	R. K. Kibbe
		11/10	R. K. Kibbe
		11/21	R. K. Kibbe
		11/30	R. K. Kibbe
	J. R. Swaisgood	11/15	R. K. Kibbe
Envirosphere Company A Division of Ebasco Services, Inc. 19 Rector Street New York, NY 10006	J. A. Franco	11/4	A. S. Quist
	T. L. Gould	11/4	A. S. Quist
	J. J. Mauro	11/4	A. S. Quist
Gilbert Commonwealth P. O. Box 1498 Reading, PA 19603	C. A. Layland	11/29	A. L. Boch

APPENDIX A (continued)

Company	Visitor	Date	Principal contact
Goodyear Atomic Chillicothe, OH 45601	E. M. Dougherty	11/18	J. M. Morrison
Harwell Environmental Safety Group AERE Harwell Oxfordshire, U. K.	J. Bromley	11/21	G. H. Jenks
Kaiser Engineers Kaiser Center 300 Lakeside Drive Oakland, CA 94606	J. H. Bocks F. V. Kahle	11/30 11/30	C. E. Oldham C. E. Oldham
Law Engineering Testing Company 2749 Delk Road S. E. Marietta, GA 30067	C. O. Durham, Jr. J. G. LaBastie	11/22 11/22	R. B. Laughon R. B. Laughon
Louisiana State University Baton Rouge, LA 70808	R. E. Miles	11/21	P. D. Fairchild
National Forge Company Irvine, PA 16329	V. F. Oberhofer	11/17	W. H. Pechin
Oak Ridge Associated Universities P. O. Box 117 Oak Ridge, TN 37830	C. V. Hill	11/10	C. D. Zerby
Parsons Brinckerhoff Quade & Douglas Inc. One Penn Plaza New York, NY 10001	A. J. Angiola A. Gursoy T. E. Hoover K. Von Dobeneck	11/15 11/15 11/15 11/15	R. K. Kibbe R. K. Kibbe R. K. Kibbe R. K. Kibbe
Sandia Laboratories P. O. Box 5800 Albuquerque, NM 87115	G. C. Allen, Jr. J. M. Freedman J. H. Renken A. R. Sattler	11/12 11/2 11/2 11/14-15	P. D. Fairchild P. D. Fairchild P. D. Fairchild S. C. Matthews
Savannah River Laboratory E. I. du Pont de Nemours & Company Aiken, SC 29801	J. L. Crandall	11/1	J. M. Morrison
Science Applications, Inc. 114 Tulsa Road Oak Ridge, TN 37830	J. G. Arbital	11/1 11/15-16 11/23 11/28	R. K. Kibbe R. K. Kibbe R. K. Kibbe R. K. Kibbe

APPENDIX A (continued)

Company	Visitor	Date	Principal contact
Science Applications, Inc. 114 Tulsa Road Oak Ridge, TN 37830	J. N. Baird, Jr.	11/7	L. L. McCauley
		11/8	R. K. Kibbe
	G. R. Bray	11/4	R. K. Kibbe
	L. D. Rickertsen	11/10-11	R. K. Kibbe
	R. E. Wilems	11/3	R. K. Kibbe
		11/8	R. K. Kibbe
		11/15	R. K. Kibbe
		11/17	R. K. Kibbe
		11/30	R. K. Kibbe
Stearns-Roger Engineering Company 700 South Ash Street Denver, CO 80217	J. L. Brock	11/30	C. E. Oldham
	J. R. Smith	11/30	C. E. Oldham
Sundstrand Corporation 1005 Courtney Drive Dayton, OH 45431	L. R. Hardy	11/10	A. L. Boch
Sundstrand Corporation 4747 Harrison Rockford, IL 61101	D. C. Morgan	11/10	A. L. Boch
Tera Corporation 2150 Shattuck Berkeley, CA 94704	B. G. Kniazewycz	11/16	H. C. Claiborne
TRW Energy Systems 7600 Colshire Drive McLean, VA 22101	H. L. Bell, Jr.	11/2	H. N. Rosenberg
	E. R. Christie	11/2	H. N. Rosenberg
		11/11-12	H. N. Rosenberg
	J. D. Forster	11/2	J. E. Vath
	J. R. Gauthier	11/2	J. E. Vath
	L. M. Green	11/2	J. E. Vath
	F. P. Mertes, Jr.	11/2	H. N. Rosenberg
	C. W. Pittman	11/2	J. M. Morrison
University of Texas at Austin P. O. Box 7726 Austin, TX 78712	E. C. Jonas	11/18	G. D. Brunton

APPENDIX B
TRIPS TAKEN BY OWI STAFF MEMBERS DURING NOVEMBER 1977

Date	Place visited	OWI staff member	Purpose of visit
11/2	Denver, CO	L. B. Cobb T. F. Lomenick	To discuss drilling in the Paradox basin with USGS and Woodward-Clyde, Consultants.
	Salt Lake City, UT	W. A. Goldsmith A. S. Quist	To attend a state agency meeting with OWI, NUS, and Bechtel personnel.
	Baton Rouge, LA	R. B. Laughon W. C. McClain	To review plans for the evaluation of Gulf Coast salt domes with Louisiana State University.
11/3	Atlanta, GA	R. B. Laughon W. C. McClain	To review plans for the evaluation of Gulf Coast salt domes with Law Engineering Testing Company.
11/7-8	Seattle, WA	R. B. Laughon T. F. Lomenick	To attend the Geological Society of America meeting. (Lomenick presented a paper.)
11/8	Austin, TX	W. A. Goldsmith A. S. Quist R. L. Shoup	To attend a state agency meeting with OWI, NUS, and Bechtel personnel.
11/8-9	Germantown, MD	H. C. Claiborne L. R. Dole W. C. McClain C. S. Sims	To attend a Safety Assessment meeting at DOE-HQ.
11/9	Berkeley, CA	T. F. Lomenick	To discuss and inspect heater assembly for Sweden tests.
	Germantown, MD	A. S. Quist	To attend a Safety Assessment meeting at DOE-HQ.

APPENDIX B (continued)

Date	Place visited	OWI staff member	Purpose of visit
11/9-10	Barnwell, SC	R. S. Lowrie D. W. Turner	To discuss the Allied-General Nuclear Services subcontract status, and to receive preliminary information on transportation costs for use in logistics models.
	Oakland, CA	S. C. Matthews J. E. Russell	To review Kaiser Engineers progress on conceptual design.
11/10-11	Washington, DC	H. C. Claiborne L. R. Dole W. C. McClain	To attend an In Situ Testing meeting.
11/13-15	Atlanta, GA	W. H. Pechin	To attend American Society for Testing and Materials Committee Week.
11/15	New York, NY	J. E. Russell	To present a paper at the American Institute of Chemical Engineers meeting.
11/16	Avery Island, LA	P. D. Fairchild	To inspect the Avery Island mine and meet with International Salt Company personnel.
11/16-18	Washington, DC	K. K. Aydelotte M. L. Bennett	To attend the American Institute of Industrial Engineers' seminar on "Design to Cost/Life Cycle Costing."
11/17-18	New Orleans, LA	P. D. Fairchild R. B. Laughon W. C. McClain	To attend the Geologic Review Group meeting.
11/22	Rockville, MD	A. S. Quist	To review NUS progress on the environmental survey plans.

APPENDIX B (continued)

Date	Place visited	OWI staff member	Purpose of visit
11/28- 12/2	Vienna, Austria	W. C. McClain	To assist, as consultant for International Atomic Energy Agency, in the preparation of a detailed program concerning the development of guides on site confirmatory investigations for repositories of radioactive waste in geological formations.
	San Francisco, CA	J. R. Palmer	To attend the Atomic Industrial Forum, Inc., Annual Conference.
11/29- 12/1	Columbus, OH	R. S. Lowrie	To evaluate potential vendors for the Waste Acceptance Criteria Study.
	San Francisco, CA Seattle, WA	W. H. Pechin	

APPENDIX C
REPORTS GENERATED

The following reports were forwarded to DOE during November 1977:

Y/OWI/SUB-4310/4

Supplemental Field and Literature Investigation of the Upper Cretaceous Austin Group (Chalk) of Texas with Regard to Its Potential for Radioactive Waste Isolation, prepared by S. Gonzales under consultant subcontract 4310 with Union Carbide Corporation, Nuclear Division (June 1977).

Y/OWI/SUB-7009/4

Fine-Grained Sheet Silicate Rocks, prepared by C. E. Weaver under subcontract 7009 with Union Carbide Corporation, Nuclear Division (September 1977).

Y/OWI/SUB-77/16543

Waste Isolation Facility Description for the Spent Fuel Cycle, Bedded Salt, prepared by Parsons, Brinckerhoff, Quade & Douglas, Inc., under subcontract 86Y-16543V with Union Carbide Corporation, Nuclear Division.

Y/OWI/SUB-77/42509

As-Low-As-Reasonably-Achievable (ALARA) Studies Relative to the NWTs Program, prepared by the NUS Corporation under subcontract 864-42509V with Union Carbide Corporation, Nuclear Division (October 1977).

Y/OWI/SUB-77/45706

Review of Proposed Formats for Safety Analysis Reports for Radioactive Waste Repositories in Deep Geologic Formations, prepared by Enviro-sphere Company, EBASCO Services, Inc., under subcontract 62Y-45706V with Union Carbide Corporation, Nuclear Division (September 1977).

APPENDIX C (continued)

Y/OWI/TM-43/1

Office of Waste Isolation Progress Report,
October 1977, Office of Waste Isolation,
Union Carbide Corporation, Nuclear Division
(November 18, 1977).

Y/OWI/TM-46

Selected Charts: National Waste Terminal
Storage Program, Office of Waste Isolation,
Union Carbide Corporation, Nuclear Division,
presented to Commissioner E. E. Varanini, III,
State of California, Energy Resources Conser-
vation and Development Commission (October 21,
1977).

APPENDIX D
FUTURE ACTIVITIES

Date	Activity
December 8	OWI, RE/SPEC Inc., and UCC-ND Engineering to meet at Oak Ridge to firm up installation procedures/drilling sequence for the Avery Island in situ test.
December 8-9	W. C. McClain and J. E. Russell to attend a Rock Mechanics Review meeting at the University of Minnesota.
December 13	FMC Corporation to make a presentation at OWI on canister transporter design studies for DOE-ORO, OWI, UCC-ND Engineering, and representatives of Stearns-Roger Engineering Company and Kaiser Engineers.
December 13-15	A 50% formal review of the high-level waste repository conceptual design (Stearns-Roger Engineering Company) to be held in Oak Ridge.
December 14	Sandia Laboratories, Kaiser Engineers, and Stearns-Roger Engineering Company to meet at OWI to discuss potential cask/repository interface issues.
December 19	DOE-ORO and NRC staff to visit OWI (tentative date) regarding NRC preliminary review of GEIS. This review meeting to be coordinated by R. K. Kibbe, OWI.

APPENDIX E
SUBCONTRACTS NEGOTIATED DURING NOVEMBER 1977

Subcontractor/Consultant	Subcontract Number	General Scope of Work
Pennsylvania State University	4091	Borehole Cement Rock Property Studies (Supplement 8).
D. W. Byerly	4251	Consultant for Technical Projects (renewal).
C. E. Weaver	7009	Consultant for Technical Projects (renewal).
University of Minnesota	7118	Rock Mechanics Computational Models (Supplement 1).
A. L. Brokaw	7210	Consultant for Technical Projects (renewal).
E. D. Goebel	7219	Consultant for Technical Projects (renewal).
T. Stauffer	7220	Consultant for Technical Projects (renewal).
L. F. Dellwig	7242	Consultant for Technical Projects (renewal).
R. E. Grim	7245	Consultant for Technical Projects (renewal).
J. M. Kellberg	7248	Consultant for Technical Projects (renewal).

APPENDIX F

EMPLOYMENT LEVELS AS OF NOVEMBER 30, 1977

	<u>Exempt</u>	<u>Non-Exempt</u>	<u>Total</u>
Technical Projects	9	4	13
Facility Projects	4	2	6
Planning and Analysis	11	4	15
Regulatory Affairs	4	1	5
Administration	4	5	9
Director's Office	1	2	3
Total	33	18	51

PERSONNEL CHANGES

<u>Name</u>	<u>Type</u>	<u>Department</u>	<u>Effective Date</u>
<u>Transfers</u>			
I. N. Kaplan	Transfer	Public Affairs	November 30

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