RHO-BWI-80-100 2Q

Basalt Waste Isolation Project Quarterly Report

January 1, 1980 through March 31, 1980

MASTER

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Prepared for the United States Department of Energy
Under Contract DE-AC06-77RL01030

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ABSTRACT

This report addresses the technical progress for the Basalt Waste Isolation Project for the second quarter of fiscal year 1980. The organization of the report follows the current work breakdown structure for the technical areas of the project. The major highlights for the quarter are provided below.

Seismic design values were developed for preliminary repository design purposes; 0.25 g horizontal and 0.125 g vertical maximum accelerations for surface, zero-period conditions.

Preliminary seismic data indicate broad, smooth areas exist in the bedrock surface in the western portion of the Cold Creek syncline and a gently undulating bedrock surface in the eastern portion. The Umtanum flow, a prime candidate for the repository host rock, is interpreted as a tiered flow in boreholes DH-5, DC-8, and possibly in DC-6 with alternating zones of entablature and colonnade. Other boreholes penetrated an apparently thick, uniform entablature. Continuing studies include tectonics, surficial processes, geothermal survey, groundwater and mineral resources, and surficial mapping.

Hydraulic property determinations were completed for selected horizons at boreholes DB-15, DC-6, DC-12, DC-14, and DC-15. Test results indicate hydraulic property values fall within the range previously reported for sedimentary and interflow zones in basalt formations at the Hanford Site.

Preliminary results of available hydrochemical data obtained from several borehole sites indicate a significant difference in chemical composition of groundwater within lower Saddle Mountains Basalt in comparison to groundwater within the upper Wanapum Basalt. The presence of this abrupt hydrochemical change suggests that little, if any, vertical mixing of groundwaters is taking place across this stratigraphic boundary.

Multiple barrier studies indicate that the primary candidate canister/overpack alloys are TiCode-12, Inconel 625, Incoloy 825, and Zircaloy 2. Low-carbon steel and cast iron are among the list of secondary candidate canister alloys. Steel and cast iron are inexpensive (compared to other candidate alloys), strong, and do not involve the commitment of scarce natural resources. They would require protection by other engineered barrier system components to achieve mandated performance requirements.

Laboratory tests of borehole plug designs have shown that it is feasible to design a composite plug system that will satisfactorily seal a nuclear waste repository in Columbia River basalt. The plug designed for tunnels employs zones of concrete and mortared basalt blocks, interrupted at intervals by cutoff collars of a clay/sand slurry. The borehole plug employs a zone of gravel and unhydrated bentonite and a zone of cement grout.

The National Lead Industries, Inc. NLI-1/2 Universal Spent Fuel Shipping Cask was selected for use in Phase II operations. Phase II operations at the Near-Surface Test Facility consist of very limited testing with spent nuclear fuel and vitrified waste form materials. This cask will allow legal-weight truck shipments and meets all shielding and thermal performance requirements of the Near-Surface Test Facility program. A demonstration slot for a jointed block test was successfully drilled in the south wall of Transfer Room #2 as part of the Phase I qualification tests at the Near-Surface Test Facility.

Creep test results of samples of Umtanum basalt from borehole DC-6 were plotted and show the day-to-day variation in deformation versus time. The 20°C test of one sample had much less scatter in the data than a 300°C test of another sample. It was concluded that longer test durations may help to identify time-dependent deformation behavior factors. Near-Surface Test Facility Jointed Block Test #1 heater controllers and voltage regulators were tested and calibrated. The heater controllers were accurate within 0.02 kilowatt and the voltage regulators within 2 volts at their rated loads. The Near-Surface Test Facility data acquisition system power supply was acceptance tested for input rejection, ripple and noise, and long-term stability. Input rejection test output varied less than 0.4% for a 17% input voltage variation. Ripple and noise were less than 0.010 volt at 10 volts output and 2 amps. Long-term stability output drift over a 72-hour period was less than 0.030 volt at 10 volts and 2 amps.

The concept selection phase of repository conceptual design was completed in March 1980. The conceptual design for the repository in basalt will use five shafts ranging from 3.35 to 6.71 meters (inside diameter) constructed by drill-and-blast techniques based on current technology. The storage geometry is based upon single-row vertical storage holes on a 3.66-meter pitch. The storage panel thermal loading is 122 kilowatts per hectare. A test plan for the Exploratory Shaft Test Facility was developed and is scheduled for submittal to the U.S. Department of Energy in May 1980.

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INTRODUCTION

In February 1976, the U.S. Energy Research and Development Administration (currently the U.S. Department of Energy) expanded the commercial radioactive waste management programs and established the National Waste Terminal Storage Program. Its mission was to provide multiple facilities in various deep geologic formations within the United States. The Office of Waste Isolation was established within the Union Carbide Corporation-Nuclear Division to provide program management of the National Waste Terminal Storage Program. The overall program consisted of investigating a number of geologic rock types to determine their suitability for terminal storage of radioactive waste. Basalts, such as the Columbia Plateau basalts, which underlie a large portion of the Pacific Northwest and the Hanford Site, were selected for initial geologic reconnaissance. Atlantic Richfield Hanford Company was asked in May 1976, by the Office of Waste Isolation, to plan and execute a geologic exploration of Columbia Plateau basalts to determine the feasibility of utilizing those formations as a site for terminal storage of commercial nuclear waste.

In September 1977, the National Waste Terminal Storage Program was restructured. Additional funds were given to support investigations of two U.S. Department of Energy sites--Hanford and Nevada. The Hanford program is presently the responsibility of the U.S. Department of Energy-Richland Operations Office. Rockwell Hanford Operations (successor to Atlantic Richfield Hanford Company) is the prime contractor responsible for this work. The Basalt Waste Isolation Project within Rockwell Hanford Operations has been chartered with the responsibility of conducting these investigations. The investigations are presently aimed at assessing the feasibility of utilizing basalts as a possible rock medium for nuclear waste storage. These investigations are part of a national program being integrated for the U.S. Department of Energy by the Office of Nuclear Waste Isolation of Battelle Memorial Institute.

The overall Basalt Waste Isolation Project is divided into the following principal work breakdown areas:

- Systems Integration
- Geosciences
- Hydrology
- Engineered Barriers
- Near-Surface Test Facility
- Engineering Testing
- Office of Repository Studies.

Summaries of major accomplishments for each of these areas are reported in the following sections.

SYSTEMS INTEGRATION

The objective of Systems Integration is to consolidate all research activities leading to the identification, characterization, and licensing of a site for potential use as a nuclear waste repository in basalt within the Hanford Site. The scope of work includes reviewing research, test, and design activities, providing thermomechanical computer models, conducting trade-off studies, performing data analyses and interpretation, and establishing the technical basis and criteria for site selection, licensing, and design of the repository and ancillary facilities.

The Systems Integration end function is divided into three major activities:

- Project Management
- Systems Integration
- Safety and Environmental Documentation.

During the second quarter of fiscal year 1980, work has progressed in all three activities.

PROJECT MANAGEMENT

The project management activity is concerned with the management of the Systems Integration end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

SYSTEMS INTEGRATION

Technical Criteria

A scoping study to identify major environmental issues for a nuclear waste repository in basalt is under way. The study outlines those issues which must be addressed to comply with the National Environmental Policy Act. It will discuss the role of various Basalt Waste Isolation Project studies in responding to the National Environmental Policy Act issues.

Site Evaluation

The site evaluation program was established to evaluate the Hanford Site for possible development of a nuclear waste repository in basalt. The program is designed to reduce the area of study to an approximately 26-kilometer area that can be characterized by means of detailed site investigations. The work accomplished during the quarter included screening of the original nine candidate sites to determine those sites most likely to contain suitable geologic conditions for a repository. Seven contiguous sites within the Cold Creek syncline were selected as successful candidate sites because of the uniformity of geologic and hydrologic conditions.

The site evaluation process developed to determine the primary candidate site utilizes a criteria matrix based on the criteria imposed by 10 CFR 60 (Draft). The criteria matrix was prepared to identify specific values with a sufficiently narrow distribution range to allow classification of the seven sites. The process of evaluation was started at the end of the quarter.

Preliminary seismic design parameters were developed to provide values for analysis of certain components of the conceptual repository design. The parameters included were vertical and horizontal acceleration, frequency content of the motion, and the seismic response spectra at three levels of damping. The acceleration and frequency values are provided in Table 1.

TABLE 1. Preliminary Seismic Design Parameters.

Depth (m)	Acceleration, Gravity "g"	Frequency (Hz) at 2% Damping*
Maximum, zero period, horizontal (ground surface)	0.25	2 - 10
Maximum, zero period, vertical (ground surface)	0.125	2 - 10
168, Base of sediments	0.24	2.1 - 4.8
564, Top of Frenchman Springs flow	0.238	2.8 - 3.6
732, Top of Grande Ronde Basalt	0.19	2.1 - 3.7
914, Mid-Grande Ronde Basalt	0.32	4.4 - 5.2
1,082, Top of Umtanum flow	0.23	3.0 - 3.8

*Percent damping is degree of constraint imposed on rock mass by the confining system.

It is anticipated that these preliminary data will be used to provide estimates for tunnel and shaft-rock-stability and support requirements for a repository under dynamic loading. Use of these data is not recommended for advanced design of surface structures or electrical/mechanical facilities within the underground workings, because major changes are possible as the Basalt Waste Isolation Project's tectonic investigations and in-depth seismic design analyses proceed.

The reported maximum, zero period, horizontal acceleration is that used by the Washington Public Power Supply System, Inc. for the major surface reactor structures at the Hanford Site. This value will be used pending analyses established specifically for the repository structures.

The scope of the study undertaken to develop these preliminary parameters consisted of:

- Review of the regional seismicity of the Hanford Site
- Use of Washington Public Power Supply System, Inc. zero-period, horizontal ground acceleration and response spectra
- Evaluation of response at repository level using a one-dimensional computer model.

The results of the preliminary analyses confirm a shift toward higher frequencies with increasing depth. The horizontal acceleration attenuates with depth with the exception of an amplification at the 914-meter level.

The seismic data are based on the assumption that the design horizontal acceleration used to satisfy licensing criteria by the Washington Public Power Supply System, Inc. at Hanford will be the accepted-design acceleration for surface facilities of the repository in basalt. This assumption will be validated by planned research studies.

Development of this information has not taken into consideration the effects of near-field microseismic activity or rock-burst phenomena. Displacement along pre-existing faults as a result of seismic disturbance has not been evaluated. These elements will be investigated in detail in the next stage of the study.

Systems and Test Analysis

A member of the rock mechanics staff was selected to represent the National Waste Terminal Storage Program's interests in the area of rock mechanics in support of the Joint Technical Committee on the Swedish-American Cooperative Program on Radioactive Waste Storage in Mined Caverns. In this capacity, he visited Stockholm and Stripa, Sweden, March 4-6, 1980. A paper, "A Technical Approach to Resolving Issues on Rock Mechanics as Applied to Development of a Nuclear Waste Repository in a Crystalline Rock Formation," was prepared and is available as

RHO-BWI-SA-51. The rock mechanics issues discussed in this paper are those identified as major earth science technical issues by the Earth Sciences Technical Plan Working Group, a joint U.S. Department of Energy and U.S. Department of the Interior group. These major issues are:

- Are thermomechanical effects adequately understood?
- Are the effects of coupling the thermal-hydraulic and thermal-mechanical phenomena adequately understood?
- Are fractures induced by mining adequately understood?
- Are the effects of seismic events on the operational repository adequately understood?
- Are mine-stability issues adequately understood?

A multi-faceted approach involving site characterization, laboratory testing, numerical modeling and analysis, in situ testing, and monitoring was suggested. This technical approach is intended to further scientific understanding and quantification of rock mass response accompanying the thermal heating of rock from nuclear waste and to develop the repository design basis.

An accelerated room-scale test at the Near-Surface Test Facility at Gable Mountain on the Hanford Site has been proposed to increase the data base by testing at the room scale. The present test program approved for the Near-Surface Test Facility consists of a series of canister or smaller scale experiments. These tests, Full-Scale Heater Tests #1 and 2, the jointed block tests, and the nuclear materials tests which involve individual canisters of spent fuel or vitrified waste, will provide geomechanical strength and deformational data when coupled with the laboratory test program.

In the proposed accelerated room-scale test, a portion of the test room in the Near-Surface Test Facility will have electric heaters installed in drill holes in the floor, walls, and roof of the test room. The accelerated room-scale test will thermally load the test room at a higher level than would be expected in a repository. This should produce temperatures and stresses in the rock over a 2- to 5-year time frame can be related to conditions in a 25- to 50-year time frame for an operating repository.

The reason that field data must be acquired at room scale is because of fundamental uncertainties in characterizing the geomechanical, deformational, and strength properties of the rock mass-discontinuity system from smaller scale laboratory and small-scale in situ tests. The idealized illustration in Figure 1 presents the fundamental problem in selecting constitutive relations between stress and strain and in assessing ultimate strength values of basalt; i.e., the change in deformational response from small-scale tests to the room-scale test. The stress-strain relationships shown in the diagram are indicative of the influence of discontinuities on rock behavior.

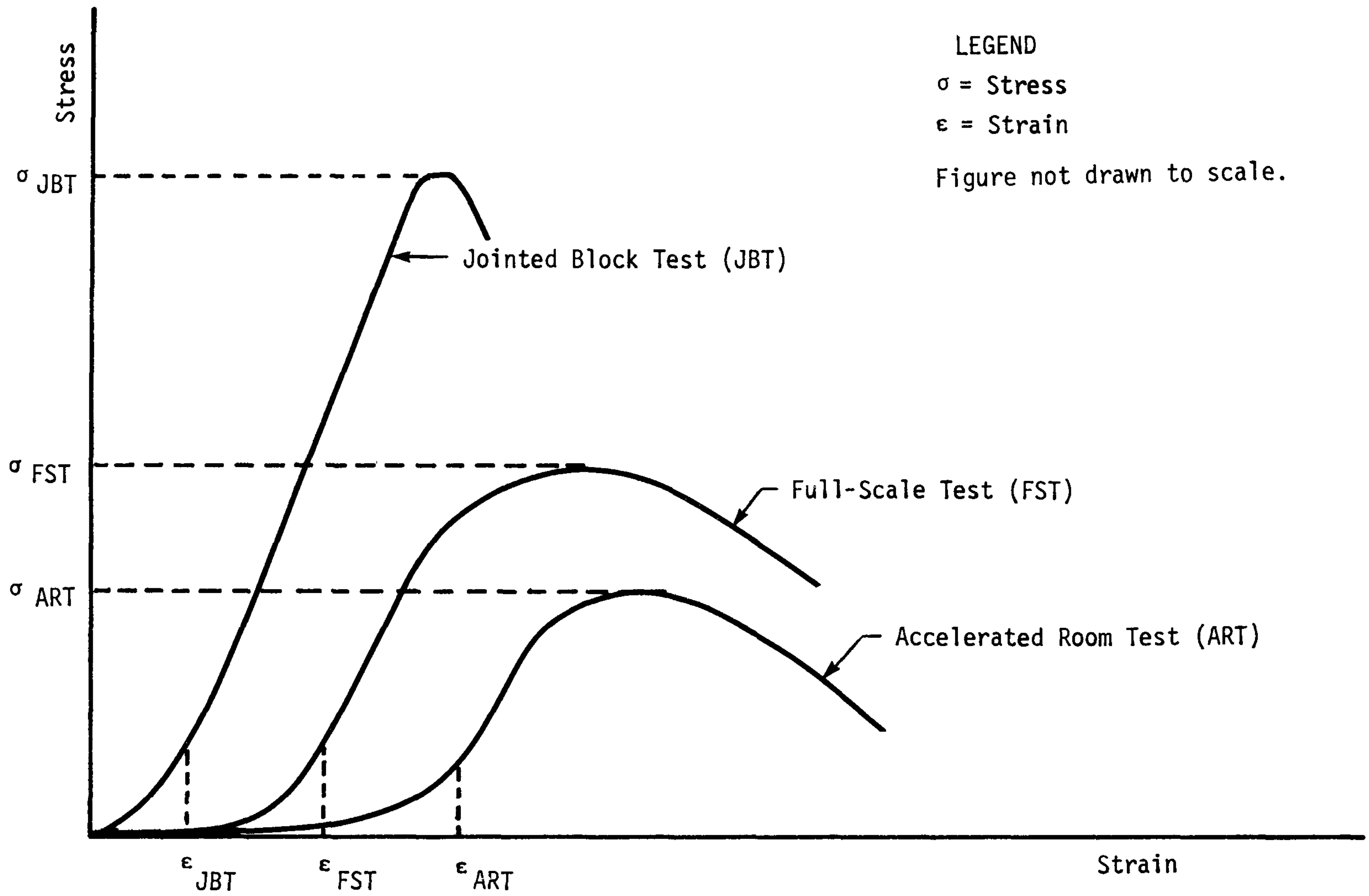

FIGURE 1. Influence of Scale on Constitutive Relations of Basalt.

Engineering Model Development

Documentation is being compiled of a series of computer codes which have been developed, modified, and used by the University of Minnesota's Department of Civil and Mineral Engineering and its subcontractor, Dames & Moore's, Advanced Technology Group, in support of the Basalt Waste Isolation Project during the current fiscal year. The status of this documentation activity is shown in Table 2. Documentation for all these codes is scheduled to be completed during fiscal year 1980.

SAFETY AND ENVIRONMENTAL DOCUMENTATION

An outline for the Detailed Site Characterization Plan was agreed to by the Basalt Waste Isolation Project, the Office of Nuclear Waste Isolation, and the Nevada Nuclear Waste Site Investigation. An annotated outline was received in early March 1980. The annotated outline is being revised based on the latest 10 CFR 60 (Draft).

The Regulatory Coordination Office of the Health, Safety and Environment Function has developed a detailed schedule and identified specific personnel who will be supporting the preparation of a Site Characterization Plan and associated environmental documentation for fiscal years 1980 and 1981. Efforts are currently under way to assure that the licensing and environmental documentation that is being identified in the U.S. Department of Energy's position on the U.S. Nuclear Regulatory Commission's confidence rulemaking will be prepared in a timely fashion. Outlines are being prepared for a Site Characterization Plan, an Environmental Impact Statement, and an Environmental Assessment. These outlines and forthcoming reports will be reviewed by members of the National Waste Terminal Storage Program to assure consistency in licensing efforts.

TABLE 2. Thermomechanical Modeling Codes--Documentation Status.

Code	Classification	Application	Status
SYM3D	Analytical; 3D Thermal; Linear, Elastic, Homogeneous	Parametric Studies; Preliminary Studies	Documentation nearing completion; to be completed in fiscal year 1980
TEMP3D	Analytical; 3D Thermal	Parametric Studies (a cheaper-to-run version of SYM3D)	Documentation nearing completion; to be completed in fiscal year 1980
DIFFUS2	Finite Difference (Explicit); 1D Thermal	Parametric Studies; Repository Scale	Documentation nearing completion; to be completed in fiscal year 1980
HEFF	Boundary Element and Analytical; 2D Thermal and Stress; Linear, Elastic, Homogeneous	Parametric Studies; Room Scale; Preliminary Design	Preliminary documentation under way; to be completed in fiscal year 1980
SALTY	Boundary Element and Analytical; 2D Thermal and Stress; Linear, Elastic, Homogeneous; Slip-On Joints	Parametric Studies; Room/Repository Scale	Preliminary documentation under way; to be completed in fiscal year 1980
SNEAKY	Finite Difference (Explicit); 1D Thermal and Stress; Dynamic or Static	Parametric Studies; Design Studies; Canister Scale	Documentation to be initiated; to be completed in fiscal year 1980
STEALTH	Finite Difference (Explicit); 2D Thermal, Stress; Fluid Flow; Dynamic or Static	Design Studies; All Scales	Documentation to be initiated; to be completed in fiscal year 1980

GEOSCIENCES

The purpose of the Geosciences' studies is to gather basic data on local and regional geology to support the identification of candidate repository sites in basalt. The studies emphasize reconnaissance field investigations in that portion of the Columbia Plateau underlain by Columbia River basalt and detailed field work within the Pasco Basin of the Columbia Plateau where the Hanford Site is located (Figure 2).

The Geosciences end function is divided into four major activities:

- Project Management
- Geology
- Geophysics
- Seismic Monitoring.

During the second quarter of fiscal year 1980, work has progressed in all four activities.

PROJECT MANAGEMENT

The project management activity is concerned with the management of the Geosciences end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

GEOLOGY

Activities reported in Geology for the quarter include the mapping program, geologic support studies, age dating, tectonic studies, and stratigraphic studies. Also, geologists of the Geosciences Group presented four papers at the Cordilleran Section meeting of the Geological Society of America in Corvallis, Oregon.

- Rate of Deformation in the Pasco Basin during the Miocene as Determined by Distribution of Columbia River Basalt Flows, RHO-BWI-SA-29
- Strain Distribution and Model for Formation of Eastern Umtanum Ridge Anticline, South-Central Washington, RHO-BWI-SA-30
- Chemical Stratigraphy of Grande Ronde Basalt, Pasco Basin, South-Central Washington, RHO-BWI-SA-32
- Compilation Geologic Map of the Pasco Basin, South-Central Washington, RHO-BWI-SA-46.

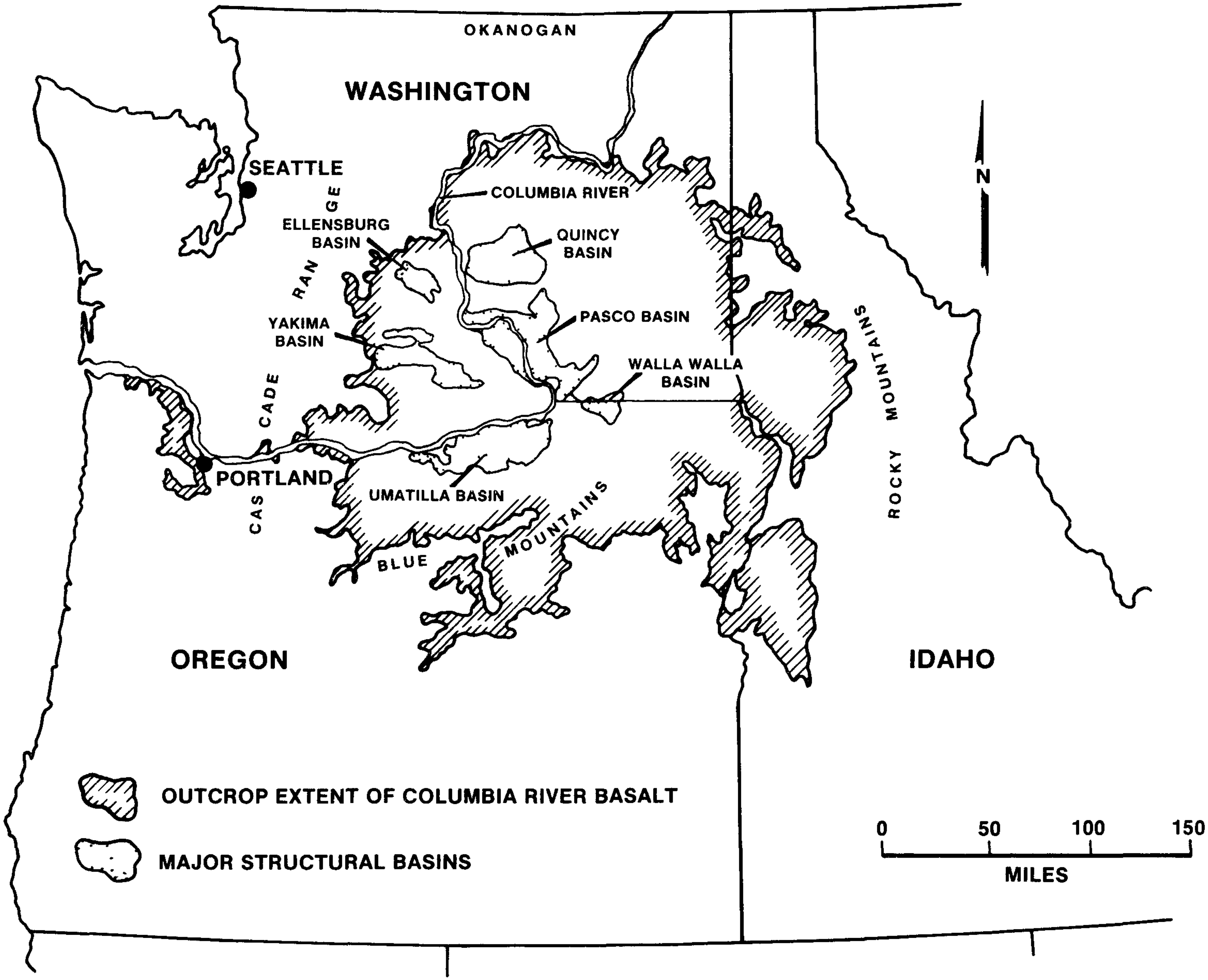

FIGURE 2. Regional Setting of the Columbia Plateau.

Regional studies to characterize and map the sediments and volcanic rocks overlying the Columbia River basalt in the State of Oregon were initiated. The first phase of this effort, production of a compilation geologic map at a scale of 1:250,000, was completed. The distribution of 16 sedimentary and three volcanic units was mapped. The results of the compilation effort indicate that little detailed sediment mapping has been completed in the Columbia Plateau in Oregon. Very few radiometric dates are available from the area and many correlations are tenuous. The compilation map is currently being used to identify areas where reconnaissance field mapping (scale of 1:24,000) will be carried out to clarify stratigraphic relationships.

Photolineament maps of the Oregon State portions of the Pendleton and The Dalles one- by two-degree quadrangles were completed. LANDSAT imagery, U-2 photography, and Skylab photography formed the basis of the photolineament map. The results of the photolineament mapping study show that the Blue Mountains area is very densely lineated. Maximum density of lineaments is found west of Ukiah and the Lehman Springs area. These two areas appear to have a conjugate pattern of northwest- and north-northwest-trending lineaments. The northwest-trending lineaments appear somewhat longer and have a better expression than the north-northwest set. The pattern of the lineaments suggests joint control; however, known faults with similar trends do occur in these areas. Photolineament maps will be checked by regional reconnaissance geologic surveys during the third quarter of this fiscal year. This mapping will determine which photolineaments may be structurally significant.

A sample of granite from Bald Butte near Pullman was potassium-argon dated at 69.8 ±2.6 million years. Another granite, located about 24 kilometers northeast of Bald Butte, gave a potassium-argon age of 67.8 ±2.5 million years. These dates suggest that the isolated pre-Columbia River basalt igneous bodies represent one intrusive event and might be the prime intrusion.

Field mapping is continuing in the Pasco Basin. Remapping of basalt outcrops on the eastern end of Yakima Ridge at a scale of 1:12,000 has been completed. This mapping has shown the existence of two north-dipping thrust faults that trend east-west along the south flank of the ridge. A left-lateral strike-slip fault offsets the ridge along a north-south trend. Offset is not more than 500 meters. In addition, remapping of the Rattlesnake Mountain fault zone at a scale of 1:12,000 is also in progress. Mapping there indicates that the Rattlesnake Mountain fault is a complex structure consisting of two parallel faults striking northwest-southeast with a complexly folded zone between the two faults.

Results of Pasco Basin mapping of basalt outcrops are being combined with the results of sediment mapping. Collection of 95% of all available samples from wells and core holes that penetrate into the top-of-basalt in the Hanford Site has been completed. These samples have been chemically analyzed, stratigraphic member identifications have been made, results have been plotted, and updated distribution maps of the Ice

Harbor Member, Elephant Mountain Member, and Pomona Member have been prepared. This information is being used to prepare a revision of the top-of-basalt structure contour map.

Tectonic studies have included the completion of a preliminary investigation of in situ stress in the Pasco Basin and the beginning of work on a geodetic survey. A bid has been received to perform a two-color, laser, interferometer, geodetic survey of 12 points selected for placement across known faults; negotiations are being conducted on this bid.

Geologic support studies for the mapping and tectonic studies consist of the granulometric sediment analyses, analyses of Ringold core holes, and field checking and review of existing maps. Granulometric data and paleomagnetic data will be used to interpret the stratigraphy of the sediments overlying basalt in the Pasco Basin. Granulometric analysis was completed on approximately 7,000 sediment samples from Hanford wells and $CaCO_3$ determinations were made on approximately 4,000 of these samples. Ringold core hole DH-19 was completed at a depth of 236 meters and Ringold core hole DH-18 was completed at a depth of 187 meters. The locations of boreholes are shown in Figure 3. Paleomagnetic determinations have been completed on 162 samples from DH-19. The samples exhibit good magnetic stability and their magnetic signature is not complex. Approximately 440 additional samples will be analyzed from DH-18 and DH-19 to determine the paleomagnetic stratigraphy of the Ringold Formation.

Studies concerning surficial geologic processes, geothermal energy resources, and groundwater and mineral resources are continuing. Data on the surficial geologic processes operating in the Pasco Basin during Quaternary time are being reviewed. Results of these studies will emphasize the distinction of endogenic and exogenic geologic processes and the fact that glaciation of the Pasco Basin has not occurred. Data establishing rates of denudation and sedimentation for flat-lying and tectonically folded areas in the Pasco Basin are scheduled to be received during the next quarter. Data on geothermal energy resource potential have been received and reviewed.

A test well is being planned by Shell Oil Corporation to a depth range of 6,100 to 9,150 meters at a location north-northwest of Yakima on the Umtanum Ridge structure. Rockwell Hanford Operations is negotiating to share geologic information from this well to determine the thickness of the Columbia Plateau basalt, lateral variation of the basalt flows from the Hanford Site, and the potential for new mineral resources beneath the Columbia River basalt.

Continued progress has been made in determining detailed stratigraphic relationships among various chemical types and subtypes in the Pasco Basin. It is now recognized that the Umtanum flow is not everywhere overlain by a high-magnesium flow, but in core hole DH-4, for example, a low-magnesium flow overlies the Umtanum flow. Moreover, in the southern part of the Pasco Basin, a single, high-magnesium flow underlies the Umtanum flow. This clearly demonstrates a limited

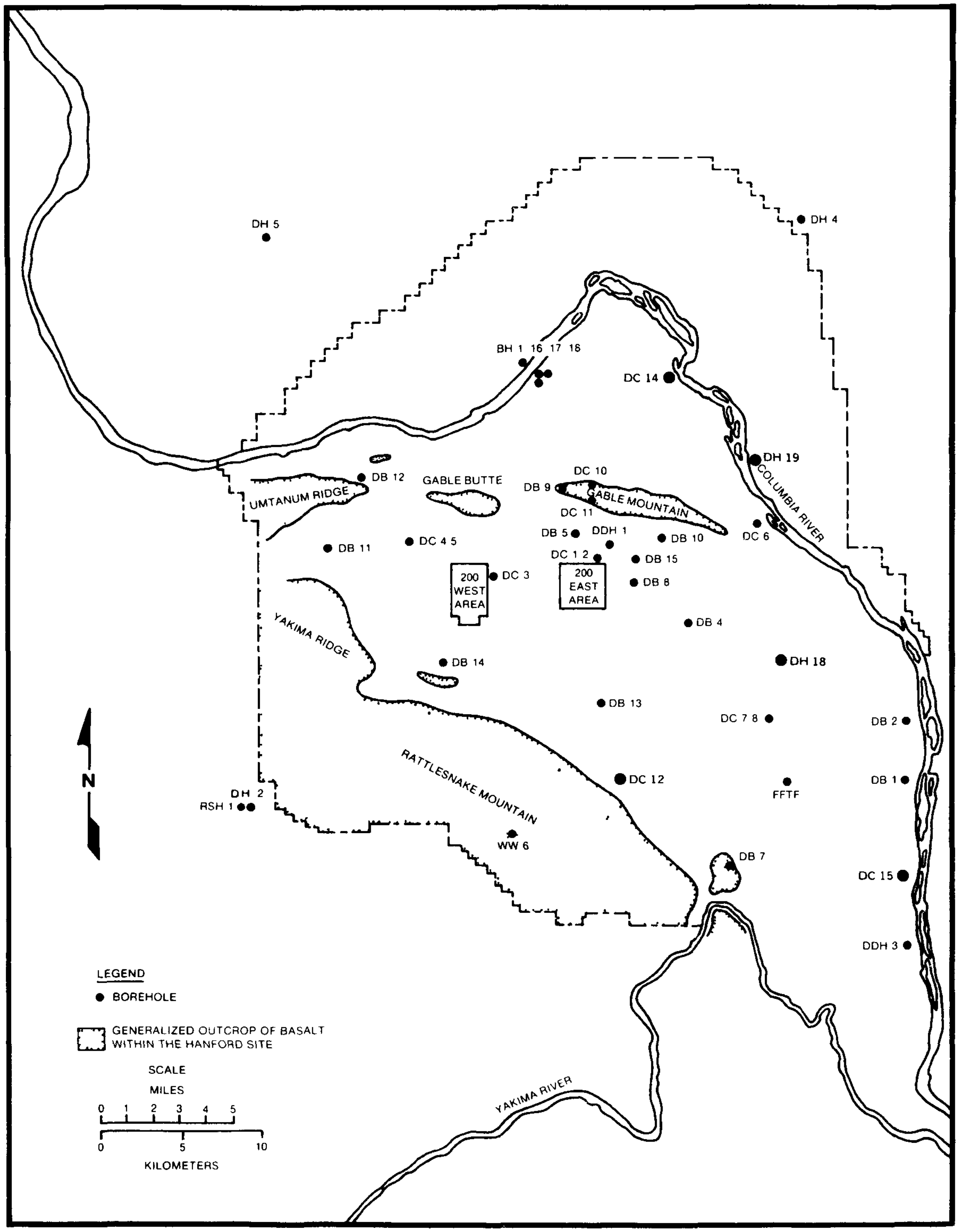

FIGURE 3. Pasco Basin and Vicinity Boreholes.

interfingering of the high- and low-magnesium flows near the magnesium horizon. A knowledge of flow-by-flow stratigraphic relationships among flows near the magnesium break has allowed the completion of isopachs for several flows. These isopachs show that the Pasco Basin did not exist as such during late Grande Ronde time, but rather broad south-, southwest-, or west-dipping paleoslopes did exist. These paleoslopes appear to have been progressively deformed and tilted during extrusion of the late Grande Ronde Basalt flows and controlled the distribution of lava. Estimates of the minimum rate of differential uplift or tilting suggest that deformation rates during late Grande Ronde time were the same order of magnitude as those during late Wanapum and Saddle Mountains time. Furthermore, an isopach of the entire thickness of the high-magnesium section indicates that the Yakima Ridges in the Pasco Basin began forming in very late Grande Ronde time.

Preliminary results from a study of the lateral variations of intraflow structures of Grande Ronde Basalt flows suggest that intraflow structures in these flows do change laterally, but that change may be in part related to flow thickness. The single flow studied in detail to date thins markedly at a location about 40 kilometers north of the Pasco Basin and this thinning is accompanied by a loss of the basal pillowed zone and by a gradual change in intraflow structure. These data are interpreted to mean that thick (greater than 50 meters) flows typically will either exhibit a sharp entablature-colonnade contact or they will be tiered with alternating entablature and colonnade-type structures. They probably will not show large-diameter columns throughout most of their thickness, as is common for some thinner flows.

A spin-off of the lateral variation study has been a test of chemical homogeneity within what is known to be a single flow of Grande Ronde Basalt. This test has shown very slight differences vertically in the flow and no discernible lateral chemical trends from one part of the flow to another over a distance of about 21 kilometers. This confirms, by comparing exposed surface flow samples, previous conclusions based on correlations of subsurface flows from borehole samples.

A detailed study of the Umtanum flow in the Pasco Basin subsurface shows that it is a tiered flow in boreholes DH-5, DC-8, and possibly in DC-6. Table 3 is a summary of thickness variation of intraflow structures in the Umtanum flow observed in Pasco Basin boreholes. In the other boreholes, the Umtanum flow is a Type III flow with a thick, uniform entablature. These intraflow structure differences in the Umtanum flow within the Pasco Basin probably will influence site identification should a repository be constructed in the Umtanum flow, because repository design, construction, and performance may depend in part on whether the repository is constructed in a tiered or non-tiered part of the Umtanum flow.

Utilization of a triple-tube core barrel for coring in the Umtanum flow and selected zones of Grande Ronde Basalt flows has been recommended. This will better preserve the in situ rock properties and fracture characteristics of the recovered core. In addition, it has been

TABLE 3. Umtanum Flow Thickness in the Pasco Basin.

Borehole	Total Flow (m)	Flow Top (m)	Flow Interior (m)	Basal Colonnade (m)	Comments
DC-2	66.0	9.9	43.3	14.0	Upper 10 meters possible flow lobe; uniform entablature (Type III)
DC-4	61.5	16.8	41.2	4.6	Thick, uniform entablature (Type III); possible upper colonnade
DC-6	66.6	8.2	54.3	5.2	Possible tiered flow (Type II)
DC-8	79.2	28.8	48.8	4.9	15 meters of flow-top breccia, 12 meters of angular breccia with 30% intercalated solid basalt; tiered flow (Type II)
DH-4	39.6	13.1	24.7	2.4	Uniform entablature (Type III); possible upper colonnade
DH-5	63.0	9.5	48.8	5.8	Tiered flow (Type II)
DDH-3	86.4	29.3	37.2	21.3	16 meters flow-top breccia, 13 meters of welded flow-top breccia intercalated with 15% solid basalt; possible upper colonnade
Average Total Flow	67.1				
Surface Sections					
Schwana	78.6	3.0	49.4	27.4	Maximum basal colonnade thickness; possibly a tiered flow with lower entablature concealed
Emerson Nipple	78.6	38.4	27.7	13.7	Thick, uniform entablature (Type III)

Type I Flow--Thin flow 0 to 5 meters thick. Irregular tapering columns, no distinct entablature, poorly developed flow top (not shown here).

Type II Flow--Alternating entablature and colonnade, vesicular flow top consisting of up to one-third of the flow thickness.

Type III Flow--Approximately 60 meters thick. Sharp boundaries between entablature and colonnade, frequently an upper colonnade within the entablature.

recommended that geomechanical logging of these zones be initiated to provide fracture data needed for characterization of the Umtanum flow and other Grande Ronde Basalt flows.

Input for the geotechnical testing portion of the exploratory shaft test plan has been prepared. The proposed exploratory shaft test will be a facility test at the proposed repository horizon to confirm geology, hydrology, and design data. The geotechnical test input provided for in situ rock mechanics testing and measuring of lateral variations in basalt lithologic properties. Specific tests recommended for the exploratory shaft include lithologic and geomechanical logs, tunnel wall and borehole mapping; geophysical testing to include cross-hole and surface-to-core hole and in situ seismic reflection surveys, as well as overcoring, jointed block, and other rock deformation tests.

GEOPHYSICS

Geophysics results reported for the quarter include seismic reflection, magnetotelluric survey, aeromagnetic survey, and related work.

The data-collection phase of the fiscal year 1980 seismic reflection survey was completed on February 7, 1980. A total of 54 line kilometers, distributed along six profiles, was collected using the Vibroseis method (lines 9-14 on Figure 4). Fiscal year 1979 survey locations are shown in Figure 5. The processing phase of the survey is in progress. Some preliminary processed sections have been delivered to Rockwell Hanford Operations for evaluation.

Results of drilling and geophysical surveys near the east end of Gable Mountain have been used to revise the top-of-basalt map. In addition, preliminary seismic data confirm a smooth, broad area in the western portion of the Cold Creek syncline and reveal a gently undulating basalt surface toward the eastern portion of the Cold Creek syncline. Work will be in progress next quarter to convert the fiscal year 1980 seismic reflection data to more accurately depict subsurface features. This and proposed seismic modeling in one and two dimensions will be utilized to better evaluate the seismic data collected in this fiscal year.

Fiscal year 1980 magnetotelluric data collection is complete. Nine stations were added to the original 25 stations to bring the total number of stations to 34 for fiscal year 1980. As of this writing, no data were available for evaluation; they are being reduced for interpretation. A two-dimensional, finite-element, magnetotelluric data-modeling program will be modeled on local computer facilities. This program (obtained from the University of Utah) will allow interactive modeling for a better evaluation of the data collected during fiscal year 1979 and during the first quarter of fiscal year 1980. In the past, the data have been modeled one-dimensionally by subcontractors to Rockwell Hanford Operations.

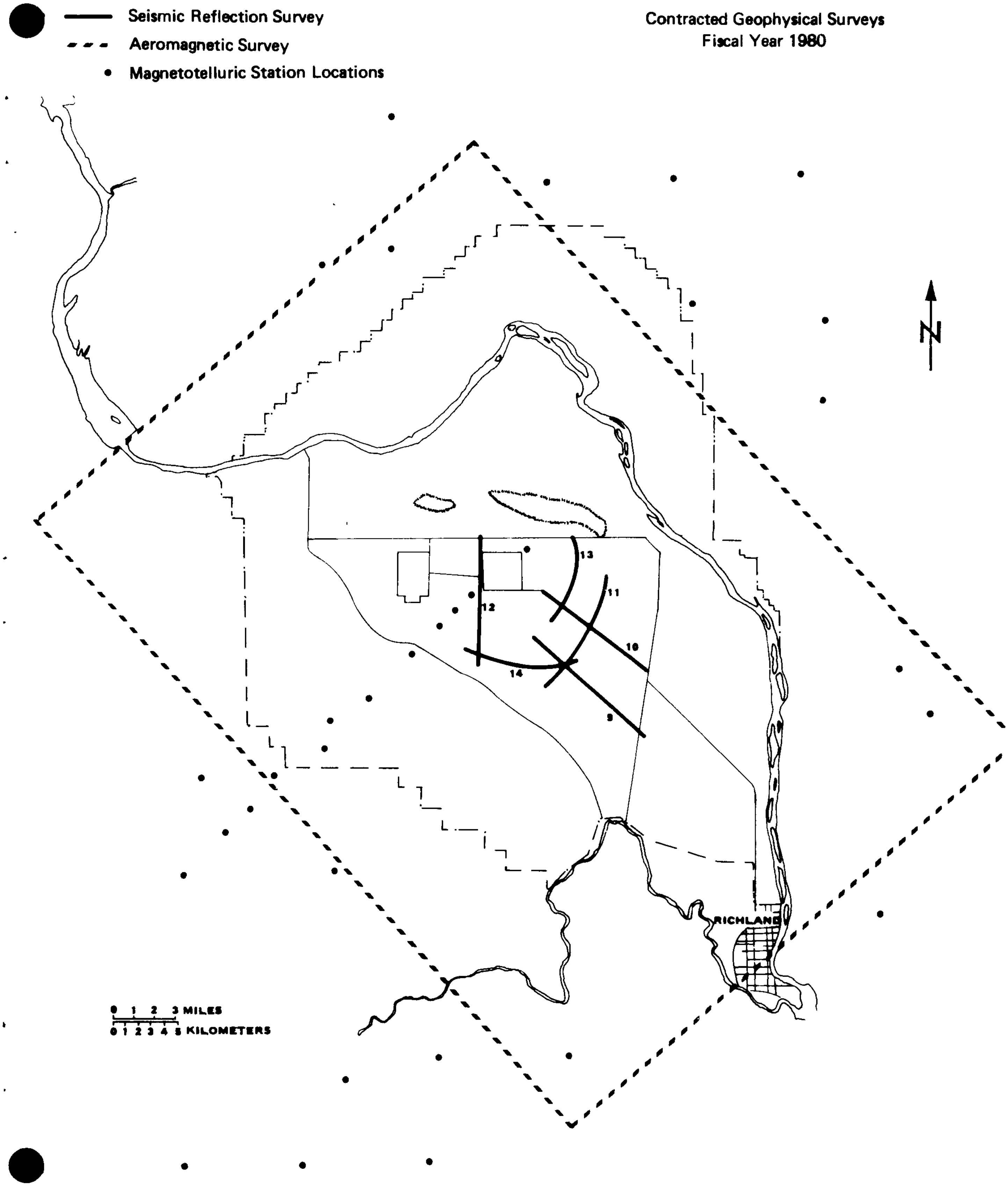

FIGURE 4. Contracted Geophysical Surveys--Fiscal Year 1980.

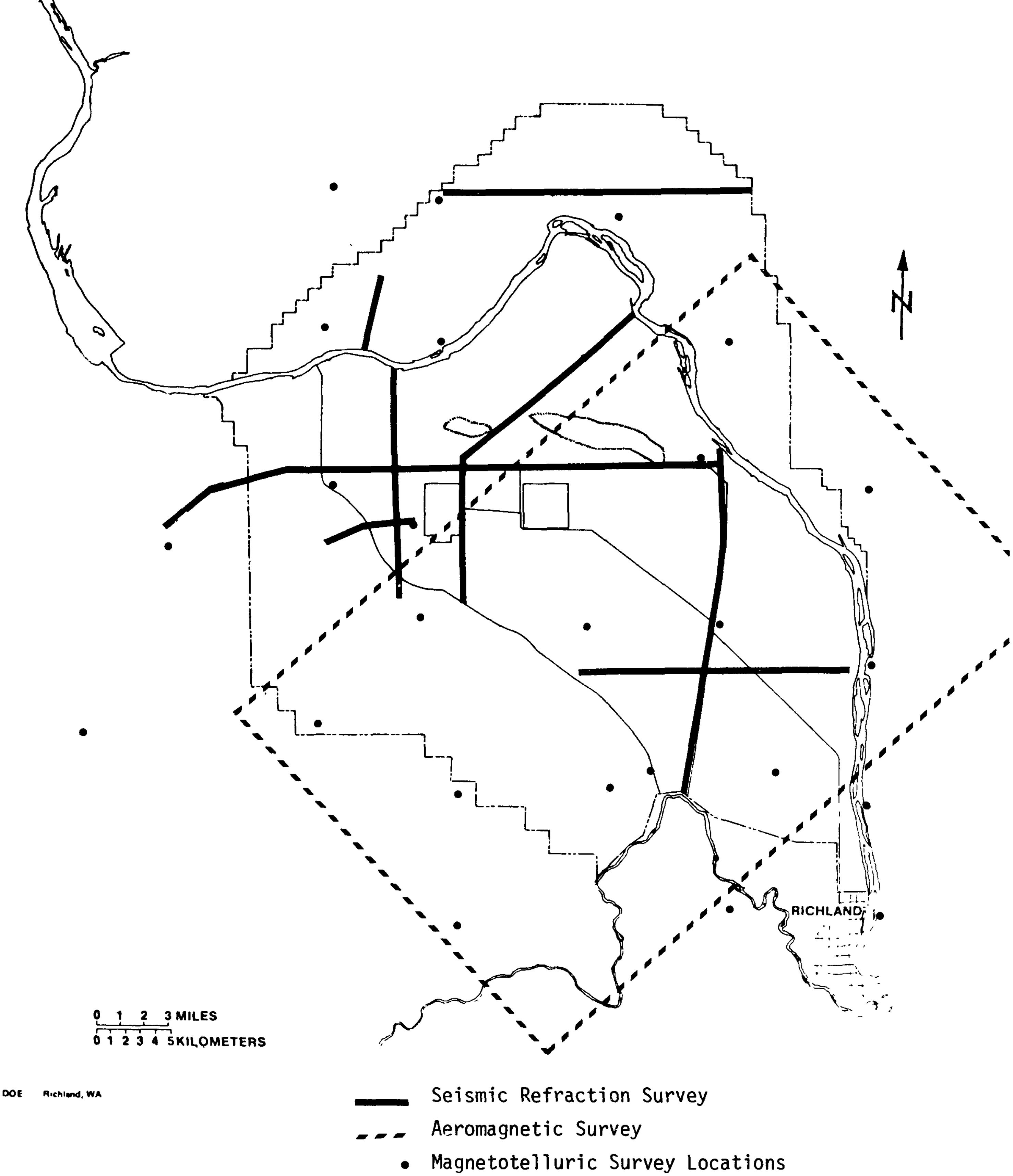

FIGURE 5. Contracted Geophysical Surveys--Fiscal Year 1979.

The fiscal year 1980 aeromagnetic investigation consists of a multi-level aeromagnetic survey covering approximately 3,100 square kilometers over the central Pasco Basin using a rectangular (0.5- by 0.8-kilometer) gridded technique. The gridded survey technique reduces flightline bias usually found in most aeromagnetic surveys for computerized map compilation procedures. A data compilation procedure flowchart is given in Figure 6. The first processing steps of editing the data, map positioning, and magnetic adjustment are used in quality control and development of an evenly sampled grid. This grid of X, Y coordinates (latitude, longitude) and Z (magnetic) values is then fed into a computer-contouring program to present the data in map form at the desired scale. Interpretations of the location of magnetic anomaly-producing structures, such as faults, folds, basalt flow terminations (erosional or depositional), and similar features will then be made.

Internal documentation and communication of results were completed on all completed in-house geophysical work. This includes surveys conducted on Rattlesnake Mountain, Gable Mountain, Gable Butte-Gable Gap area, and the Wahluke Slope area. The documentation and distribution of findings represent the completion of a major geophysical effort started in fiscal year 1979. Locations of the general survey areas are shown in Figure 7. Specific survey results will be incorporated into geologic documentation which is in progress.

In general, the in-house surveys (Figure 7) have shown the existence of buried basalt flows and possible channel fills on Wahluke Slope, faulting at DB-10, and faulting along the north flank of Rattlesnake Mountain. Although the surveys show previously undisclosed geologic features in some areas, these geologic features do not display conditions which would obviously affect the integrity of the proposed repository.

Additional in-house geophysical work was started during the quarter. These areas include 200 West, Gable Gap-Gable Butte, Finley Quarry, and the Yakima Ridge structure. Field work and preliminary interpretation are 95% complete for the 200 West surveys and Gable Gap-Gable Butte surveys and will be reported in the third quarter.

SEISMIC MONITORING

Seismic monitoring continued by the University of Washington in eastern Washington State. No unusual activity that originated in eastern Washington was reported. However, earthquakes associated with volcanic activity at Mount St. Helens were recorded by many of the stations in eastern Washington.

Equipment for the Rockwell Hanford Operations' portable seismic array is onsite and is in the process of being checked out and deployed. A temporary station on Rattlesnake Mountain has recorded the larger events of the Mount St. Helens activity. Phone lines at Gable Mountain should be available in the third quarter and will permit deployment of the net at intended field stations.

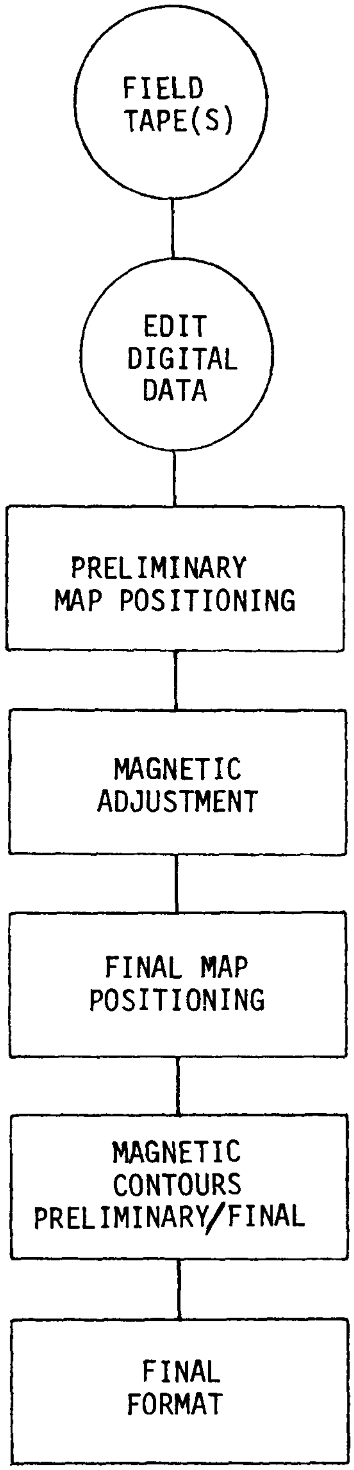

FIGURE 6. Data Compilation Procedure Flowchart.

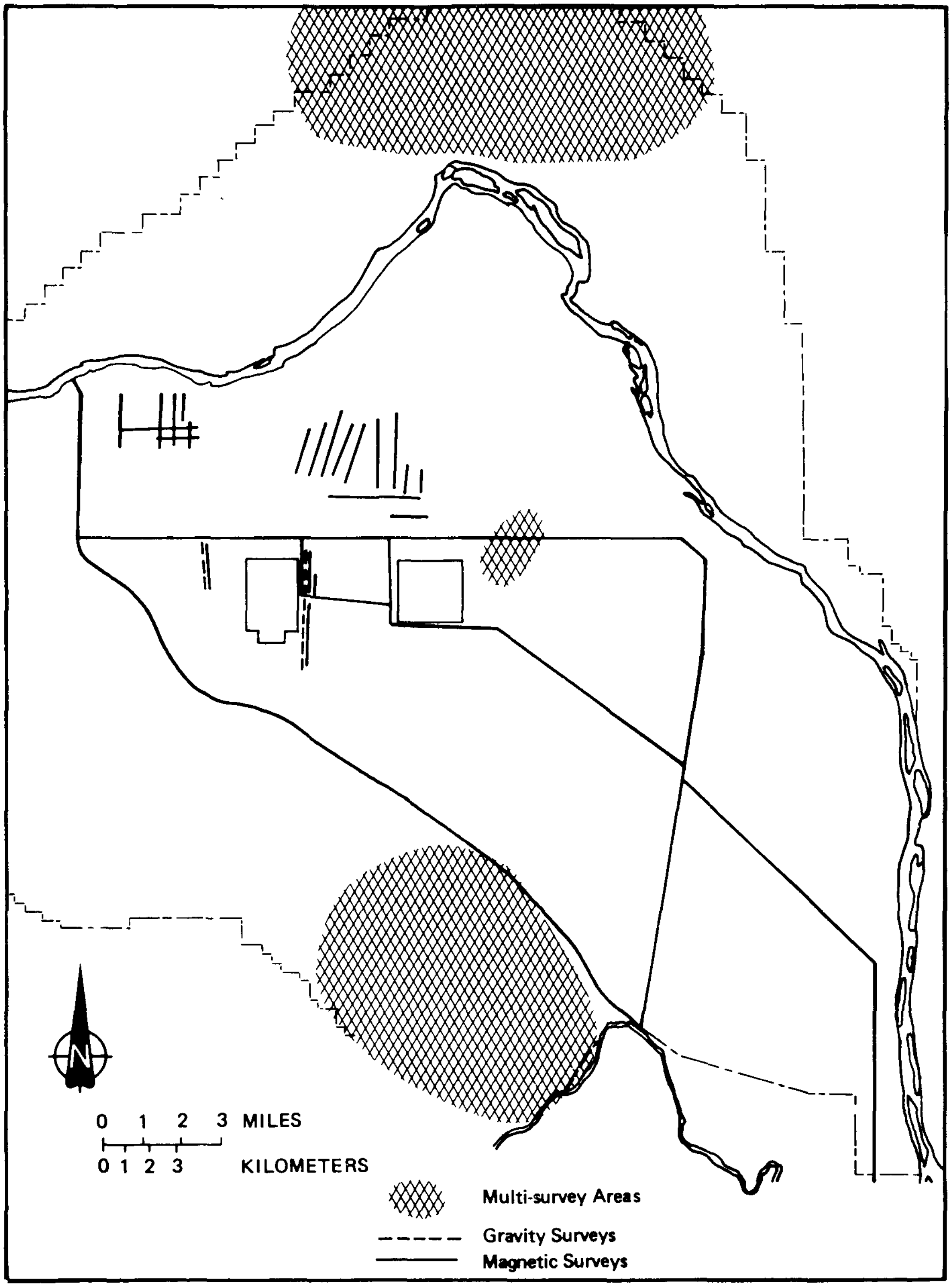

FIGURE 7. Location of In-House Rockwell Hanford Operations' Geophysical Surveys.

Modification of the generic plan for baseline seismic monitoring has been proposed because of changes in the requirements of the site identification effort and recent changes in 10 CFR 60 (Draft). This work is on schedule for submission of the plan to the U.S. Department of Energy by July 1, 1980.

HYDROLOGY

Hydrology is responsible for collecting, recording, evaluating, analyzing, and reporting data on the hydrologic conditions within the Columbia River Basalt Group. These data will be used to assess the effects of a proposed deep geologic repository for radioactive waste in basalt. A proper understanding of the natural and disturbed groundwater regimes is essential, considering that (in the absence of a disruptive event) groundwater pathways probably represent the fastest avenue between repository-stored wastes and the biosphere.

In view of this need, the Hydrology end function is involved with reconnaissance studies on regional (Columbia Plateau) and local (Pasco Basin and Hanford Site) scales. The Hydrology end function is divided into four major activities:

- Project Management
- Hydrology
- Testing Support
- Drilling Support.

During the second quarter of fiscal year 1980, work has progressed in all four activities.

PROJECT MANAGEMENT

The project management activity is concerned with the management of the Hydrology end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and the overall project guidance of the technical activities.

HYDROLOGY

Modeling studies of three-dimensional groundwater flow simulations were initiated for the Pasco Basin as part of a parametric and sensitivity analysis. A three-layer, finite-element network model is being used to characterize the Saddle Mountains, Wanapum, and Grande Ronde Basalts. Current results indicate that the flow regime is particularly sensitive to the boundary conditions set for the recharge areas and the bottom of the Grande Ronde Basalt. Sparse data on the physical boundaries of the Pasco Basin could be a limiting factor in fully calibrating the simulation model to the actual flow regime.

A two-dimensional, finite-element network representing the stratigraphic units in the Sentinel Bluffs and upper Schwana sequences of the Grande Ronde Basalt within the Pasco Basin has been prepared for the near-field model.

A mathematical analysis was performed to evaluate the type of fracture flow and transport models applicable to the Columbia River basalt. A double-porosity method used extensively in the petroleum industry appears to be the best-suited approach. Mathematical models were derived for a fractured/porous rock system. Three partial differential equations were obtained for heat transport, flow through the fractures, and groundwater storage in the secondary pores.

Rockwell Hanford Operations has placed into operation the U.S. Geological Survey-Trescott Groundwater Flow Model. This is the same model used by the district office of the U.S. Geological Survey in Tacoma for their regional studies.

Input was completed for building a Basalt Waste Isolation Project Hydrologic Data Dictionary/Directory System. Such a data dictionary/ directory system is used to document data procedures, users, and their interactions. It also will assist in defining the optimum data base structure and format for the basalt environment.

Hydrologic and geologic data were assembled for use in modeling studies of a hypothetical repository site at Hanford. The repository is assumed to be located in the Cold Creek syncline; the host rock is assumed to be the Umtanum flow. The data are based on information documented in the hydrology and geology integration reports. (RHO-BWI-ST-5 and RHO-BWI-ST-4, respectively.) These studies will consider heat transport, groundwater flow, and nuclide transport in fractured/porous media; principal focus will be on simulation of the hydrologic processes produced by possible disruptive events.

TESTING SUPPORT

During the quarter, emphasis was primarily placed on acquiring new downhole hydraulic parameters and hydrochemical data for groundwater horizons within new and existing boreholes on the Hanford Site. These data were acquired by the Hydrology Group of Rockwell Hanford Operations.

Hydraulic parameters were obtained in selected horizons in boreholes DB-15, DC-6, DC-12, DC-14, and DC-15. At borehole DC-6, testing was conducted in two zones directly below the Umtanum flow: (1) between the 990- and 1,075-meter depths; and (2) between the depths of 1,075 and 1,165 meters. Preliminary results indicate transmissivity values ranging from 10 to 100 square meters per day in these zones. These values are within the upper range of data previously obtained for interflow zones at this site.

Several test methods were used to examine the zones. Generally, close agreement was attained between all test methods used. The test results for Zone 2, DC-6 are listed in Table 4.

TABLE 4. Test Results in Zone 2, DC-6.

Test Type	Transmissivity (m^2/day)	Storage Coefficient
Constant Discharge (Recovery)	8.1	-
Constant Drawdown	6.8	4.8×10^{-5}
Constant Drawdown (Recovery)	9.6	-
Instantaneous Slug Withdrawal	4.9-8.8	-

Hydraulic tests in borehole DC-14 within the Selah interbed at a depth of 214 to 231 meters indicate a mean hydraulic conductivity of 0.1 meter per day. This value falls within the upper range previously reported for the sedimentary horizons within the Saddle Mountains Basalt. Three additional interflows (test interval depths of 270 to 275, 277 to 281, and 282 to 295 meters) within the Umatilla Member were also hydrologically tested. Preliminary analyses indicate hydraulic conductivities for the zones, ranging from 1 to 1,000 meters per day (Figure 8).

At borehole DC-12, hydrologic testing and groundwater sampling have been completed for two interflow zones within the Priest Rapids Member at depth intervals of 372 to 382 and 405 to 416 meters and three interflow zones within the Frenchman Springs Member at depth intervals of 460 to 468, 493 to 513, and 514 to 522 meters. Hydraulic head measurements taken in these zones at DC-12 indicate no significant gradient with depth (Figure 9).

Hydraulic head measurements at DC-14 at four intervals in the borehole indicate a significant increase with depth (Figure 10). This head increase with depth differs considerably when compared with intervals below the Rattlesnake Ridge interbed at borehole DC-15 (Figure 11).

At borehole DC-15, hydrologic testing has been completed for the Rattlesnake Ridge interbed at a depth of 127 to 151 meters, for two interflows at a depth of 183 to 192 meters (Pomona-Esquatzel Members), 192 to 201 meters (Esquatzel Member), and for the Cold Creek interbed at a depth of 220 to 234 meters. Preliminary analyses for these zones

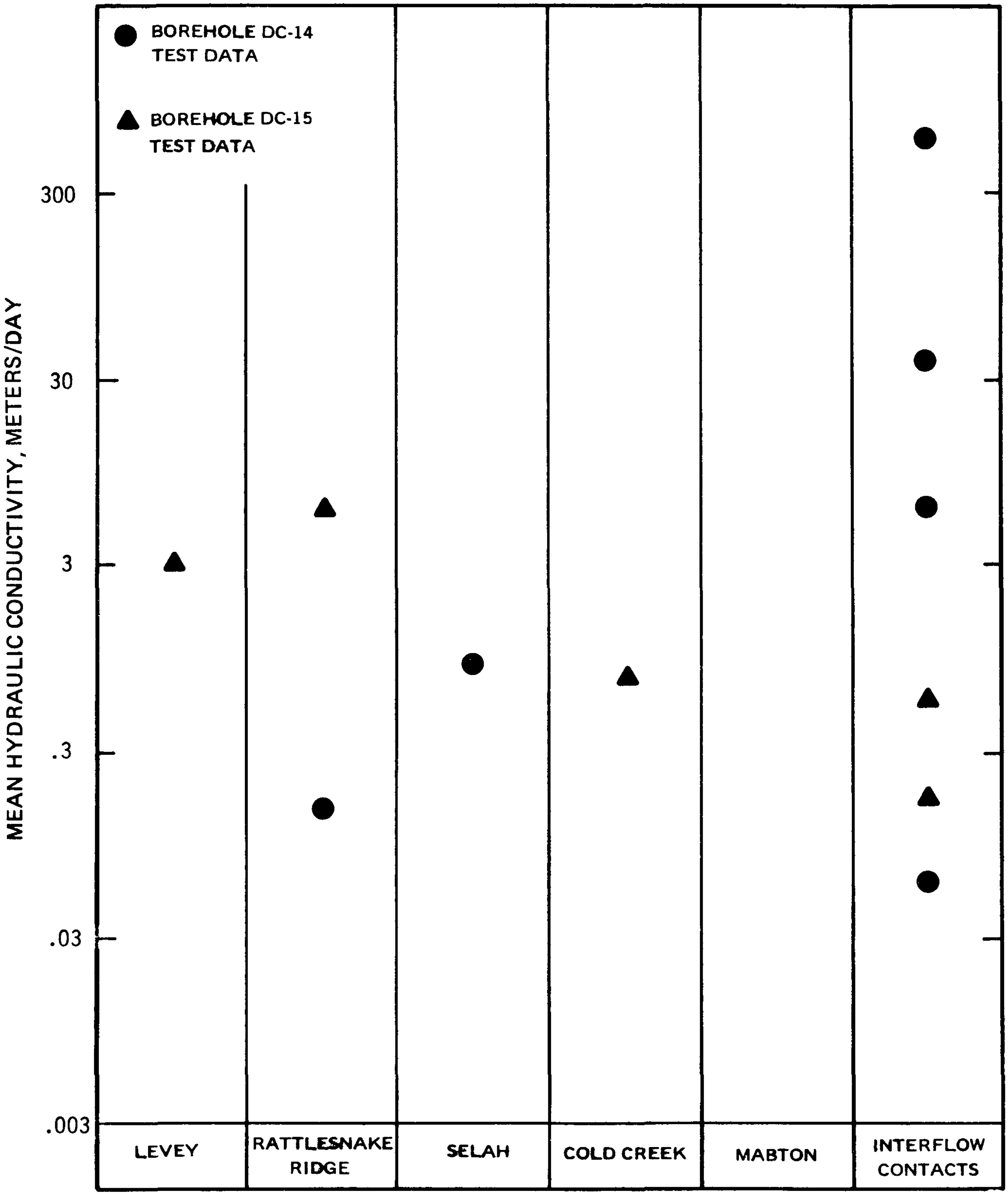

FIGURE 8. Mean Hydraulic Conductivity Values for Saddle Mountains Basalt Intervals at Boreholes DC-14 and DC-15.

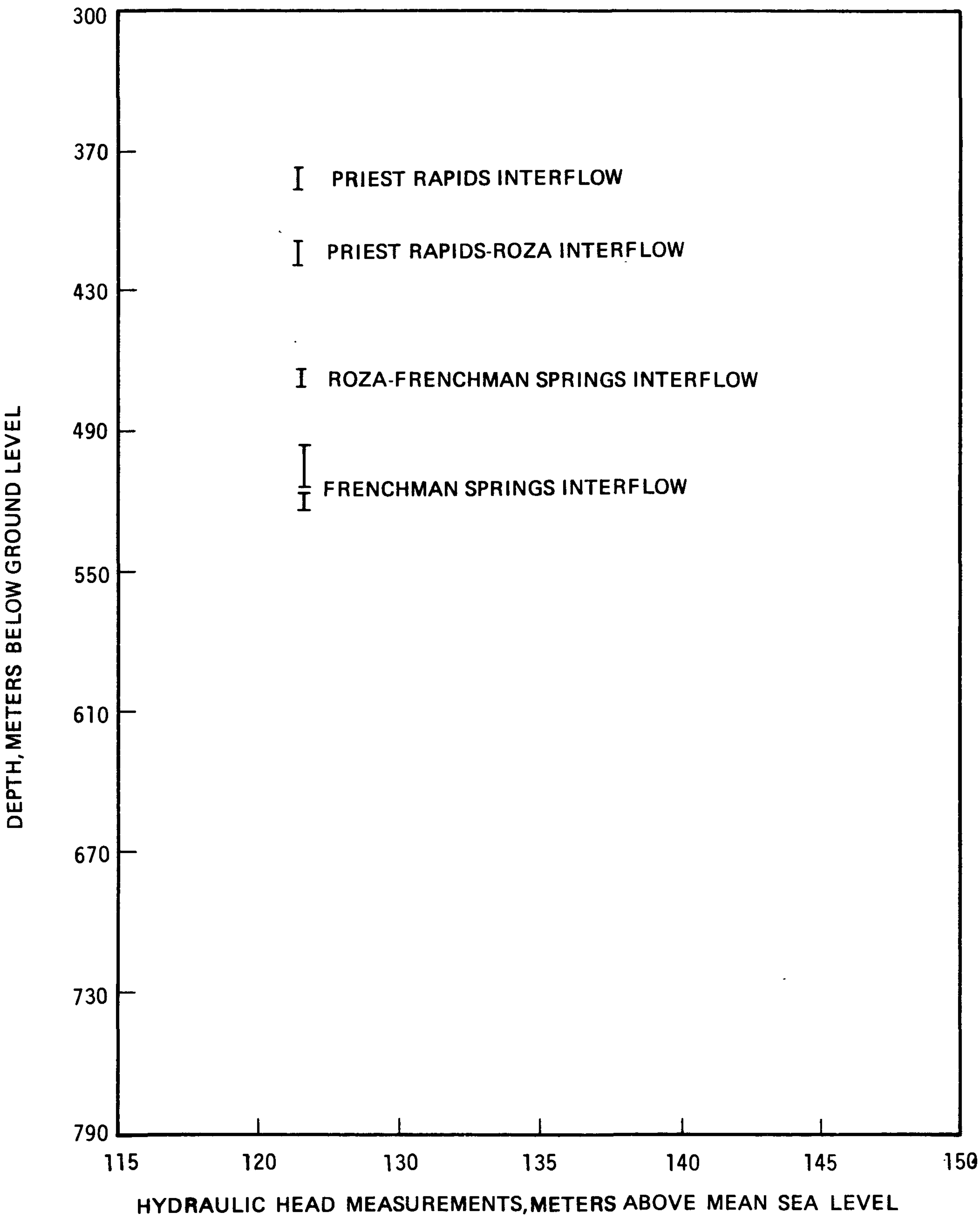

FIGURE 9. Hydraulic Head Measurement within the Wanapum Basalt at Borehole DC-12.

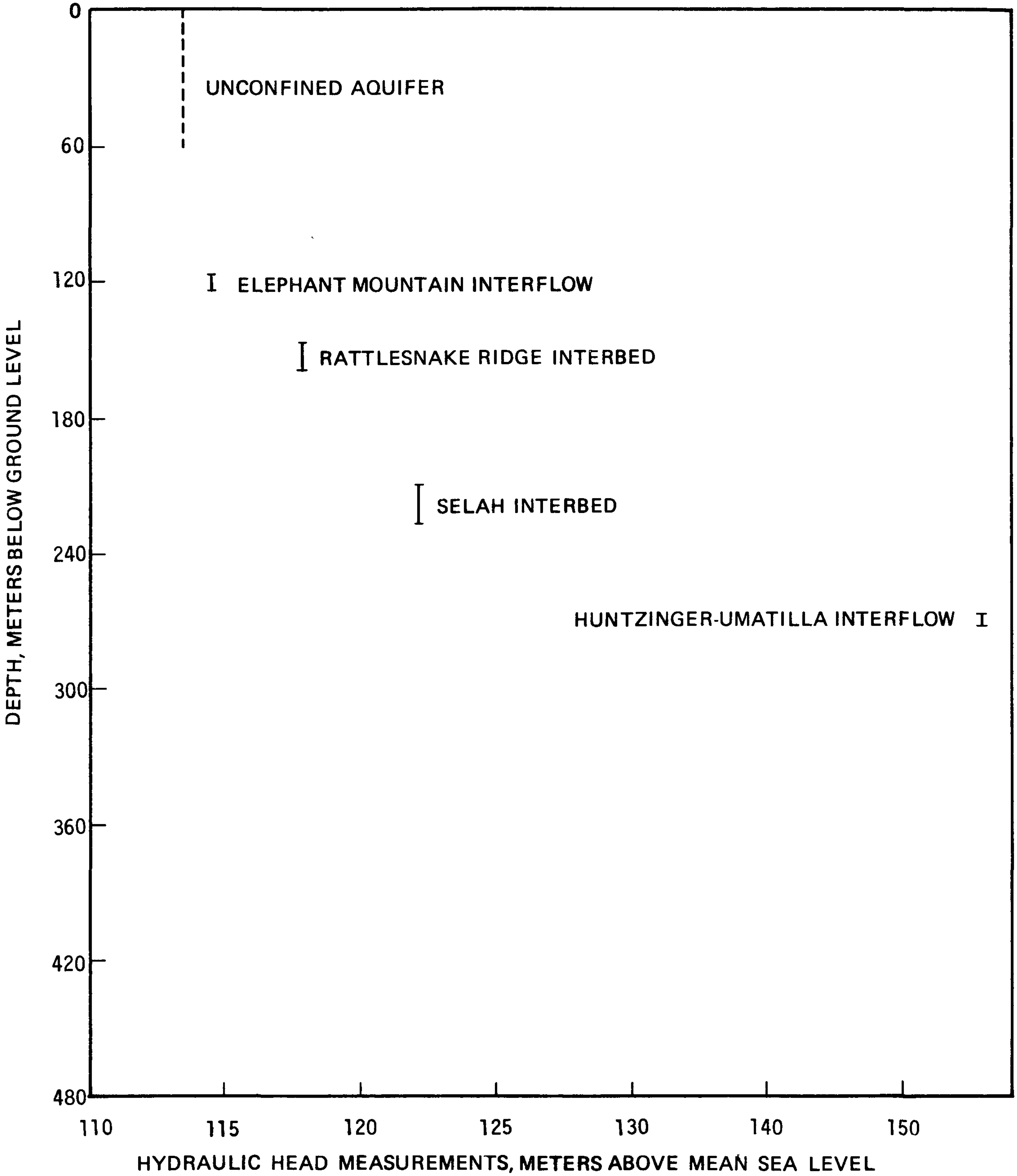

FIGURE 10. Hydraulic Head Measurements within the Saddle Mountains Basalt at Borehole DC-14.

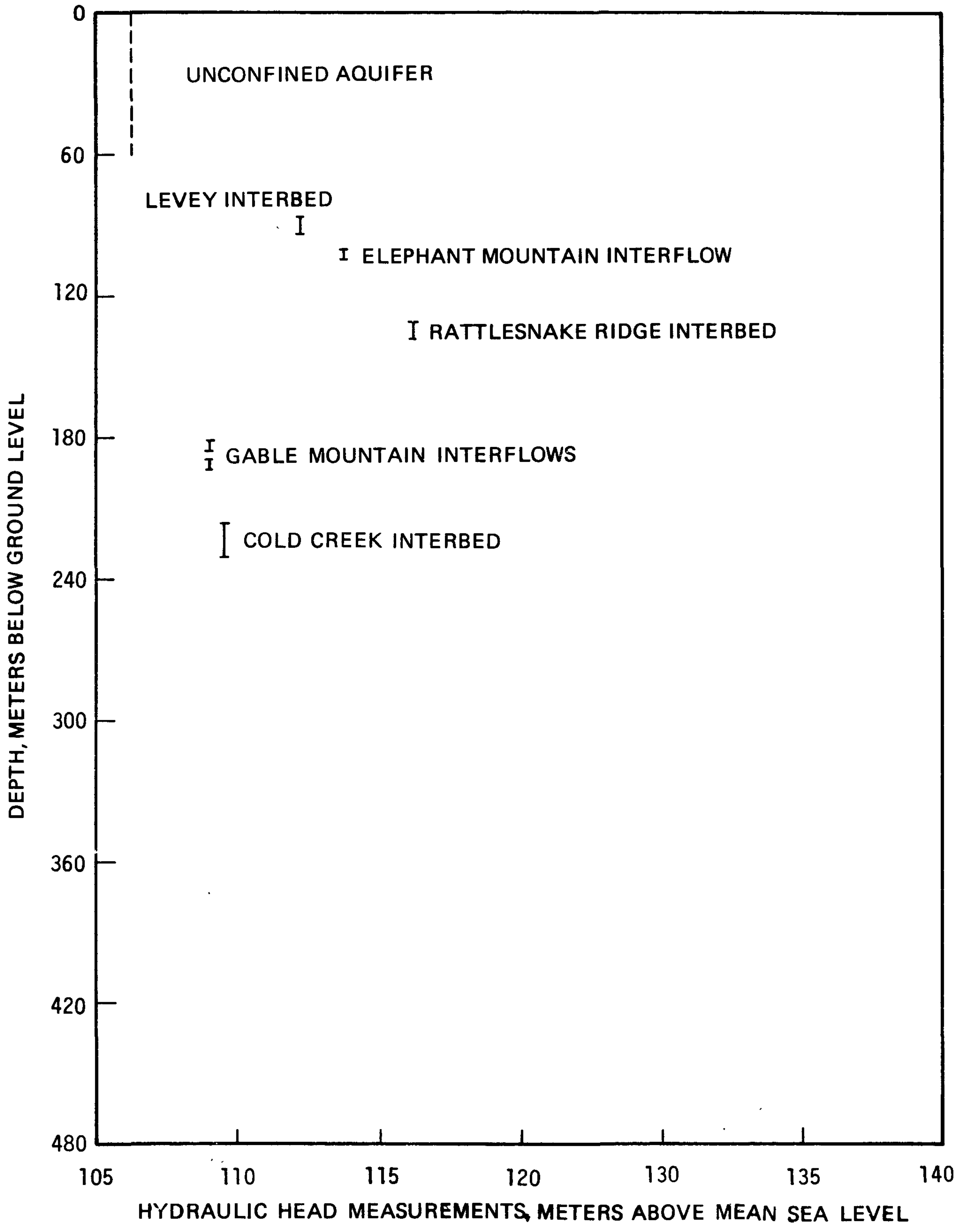

FIGURE 11. Hydraulic Head Measurements within the Saddle Mountains Basalt at Borehole DC-15.

indicate a hydraulic conductivity of about 1 meter per day for the Rattlesnake Ridge interbed. This falls within the range of previously reported values for the sedimentary horizons within the Saddle Mountains Basalt. Both interflow zones had hydraulic conductivities ranging between 0.5 and 10 meters per day. These values are below the range previously reported on interflow zones in the Saddle Mountains Basalt.

Preliminary analyses of hydrologic tests for the Cold Creek interbed indicate a mean hydraulic conductivity of about 1 meter per day. This falls within the range previously reported for sedimentary horizons within the Saddle Mountains Basalt.

Hydraulic head measurements at DC-15 display a pronounced decrease with depth below the Rattlesnake Ridge interbed. The decline in hydraulic head over this depth interval was not evident in measurements taken at boreholes DB-1 and DB-2 during the early 1970s (Figure 12).

At DB-15, hydrologic testing has been completed for two interflow zones within the Frenchman Springs Member at depths of 532 to 536 and 560 to 578 meters. Preliminary analyses indicate hydraulic conductivities fall within the lower range of 10^{-2} to 10^{-6} meters per day reported for interflow zones within the Wanapum Basalt.

Preliminary analyses of groundwater chemistry in DC-6 at depths of 990 to 1,076 and 1,076 to 1,166 meters suggest that these horizons are chemically dissimilar from an underlying groundwater zone located between 1,271 and 1,322 meters. Qualitative comparison indicates that the upper zone has less total dissolved solids content (electrical conductivity equals 1,125 versus 1,250 micromhos per centimeter) and significantly less sulfate concentration (84 versus 180 milligrams per liter).

Hydrologic test results at DC-12 indicate a multiphase condition within the aquifer and/or gas separation within the borehole. Samples of gas from selected zones in the Wanapum Basalt have been collected and sent to the U.S. Geological Survey for carbon isotopic analysis of contained methane. Carbon isotopic ratios of the methane will be useful for determining the source of methane gas present in the Wanapum Basalt.

Preliminary analysis of hydrochemical data available for groundwater horizons in the upper Wanapum Basalt at DC-12 indicates a significant difference in chemical composition in comparison to groundwater within the Mabton interbed at nearby DB-13 (Figures 13 and 14). This hydrochemical break is consistent with hydrochemical findings at DB-15 for the Mabton interbed and upper Wanapum Basalt. The presence of an abrupt hydrochemical change over a relatively short distance (24 to 30 meters) suggests that little, if any, vertical mixing of groundwaters is taking place across this boundary at these three locations.

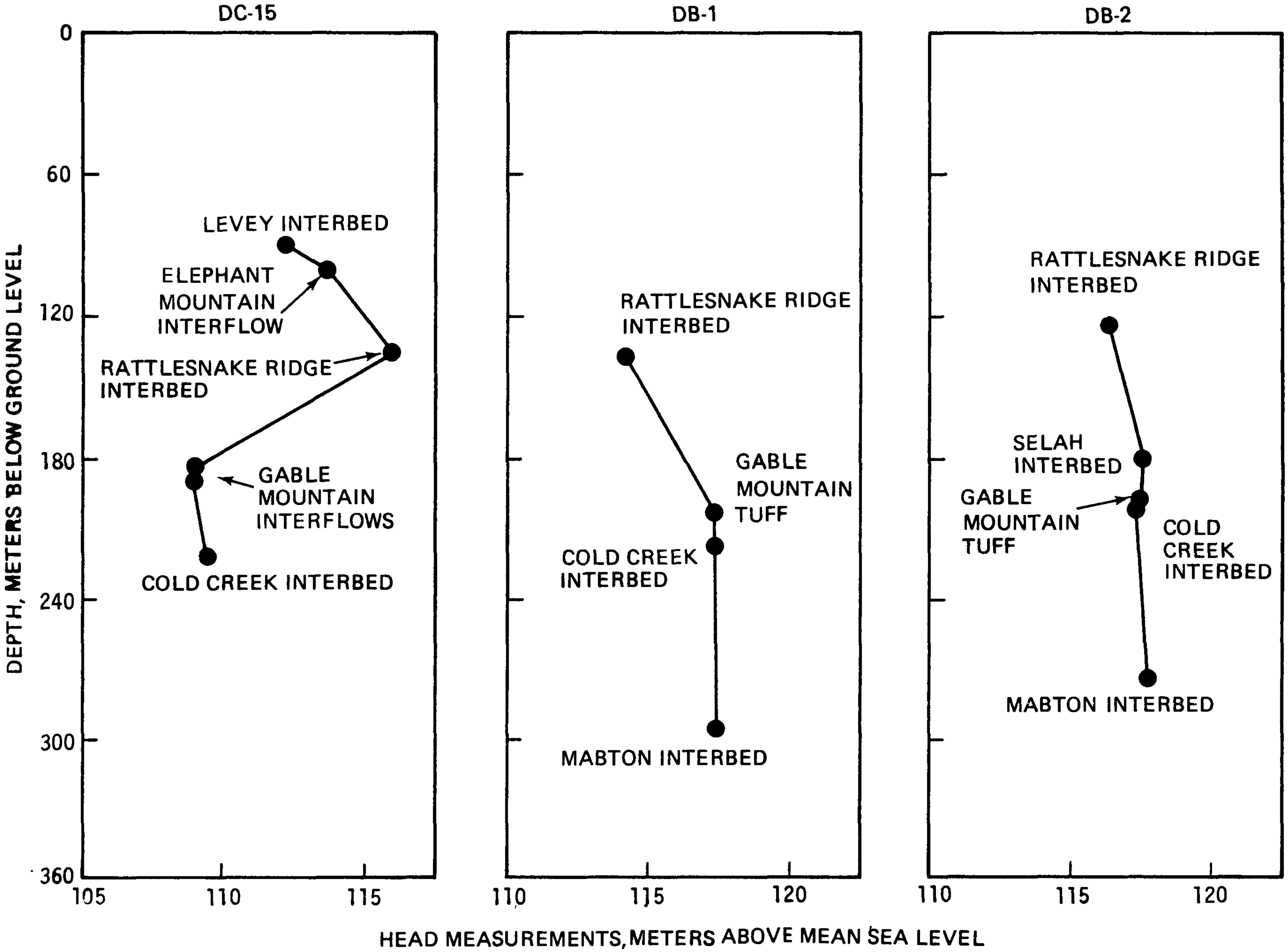

FIGURE 12. Comparison of Hydraulic Head Measurements within the Saddle Mountains Basalt at Boreholes DC-15, DB-1, and DB-2.

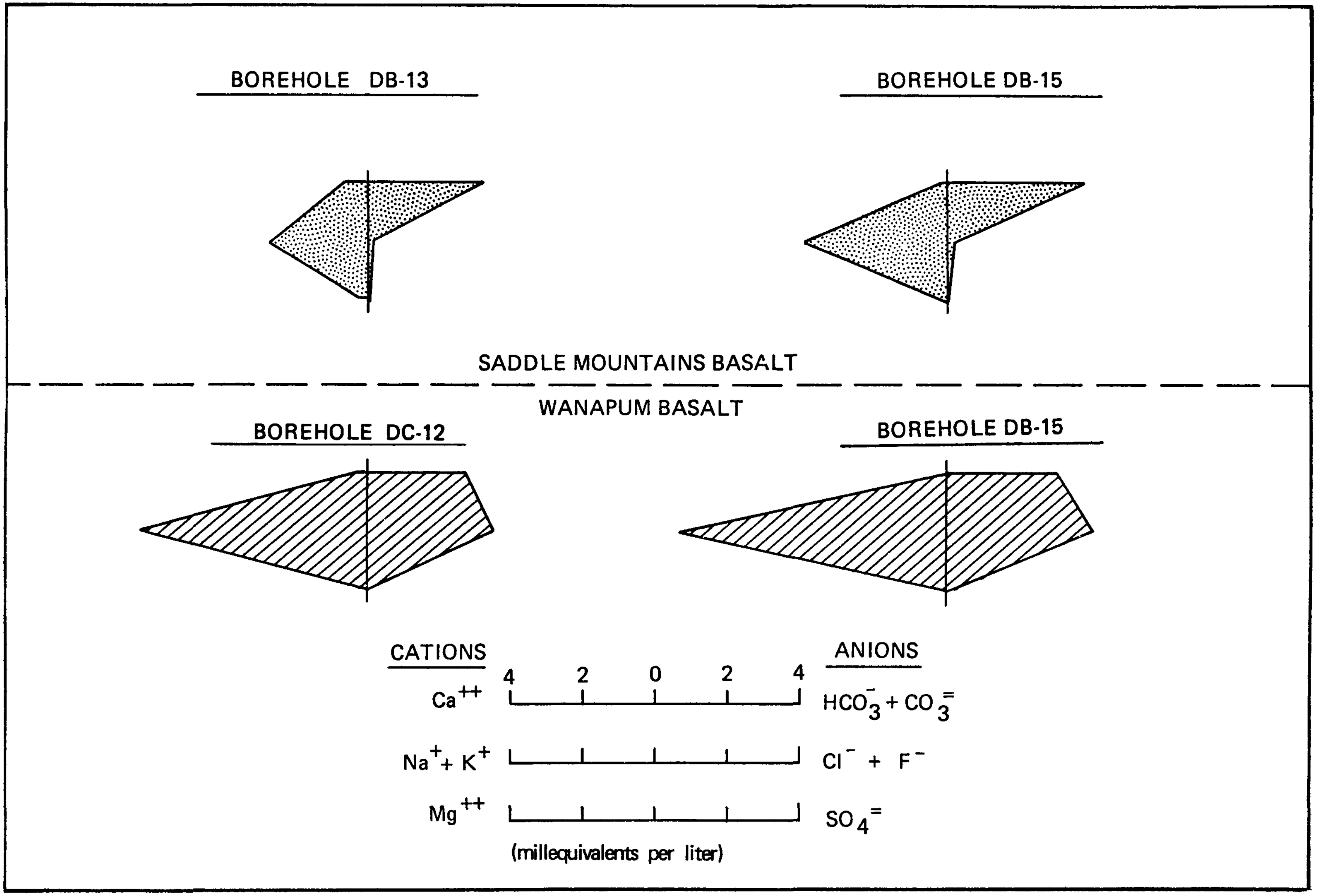

FIGURE 13. Comparison of Hydrochemical Facies for Groundwater within the Lower Saddle Mountains and Upper Wanapum Basalts at Selected Borehole Sites.

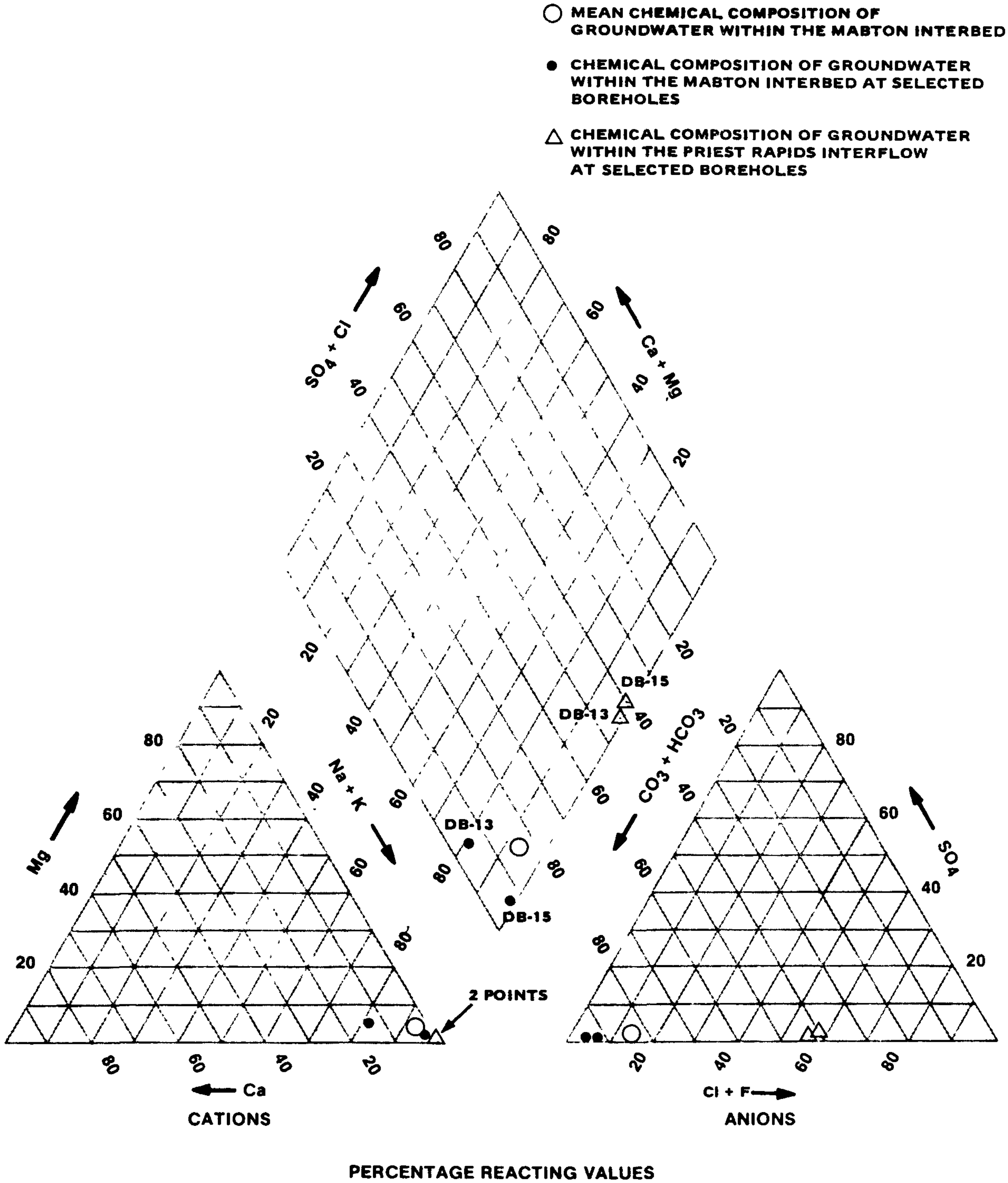

FIGURE 14. Comparison of Chemical Composition for Groundwater within the Mabton Interbed and Priest Rapids Interflow at Selected Boreholes.

DRILLING SUPPORT

Drilling support provides the boreholes necessary to investigate the subsurface geologic, hydrologic, and engineering properties of the Columbia River basalt.

Drilling accomplished during this quarter is shown in Table 5; also see Figure 3 for borehole locations.

TABLE 5. Status of Borehole Drilling--End of Second Quarter, Fiscal Year 1980.

Well #	Actual Depth (m)	Planned Depth (m)	% Completion		Depth at Completion (m)
			Actual	Planned	
DH-18	165	84	120	61	137
DH-19	237[a]				
DC-7 (Deepen hole; was 1,250 m)	1,312	1,387	23	50	1,524 (274[b])
DC-12	544	533	41	40	1,326
DC-14	297	347	44	52	671
DC-15	245	594	18	45	1,326

[a]Total depth completed on March 5, 1980.
[b]Net meters drilled--1,524-1,250 = 274 meters.

ENGINEERED BARRIERS

The objective of the Engineered Barriers end function is to specify the engineered and natural barriers which will ensure that nuclear and nonradioactive hazardous materials emplaced in a repository in basalt do not exceed acceptable rates of release to the biosphere. Key activities are the definition of repository conditions under planned operating and potential accident scenarios, review and development of information relevant to radionuclide transport, development and engineering of barrier materials and assemblages, and the acquisition of data necessary to define safe disposal of wastes in a repository in basalt. Program activities have concentrated on specifying and testing natural and man-made materials which can be used to plug boreholes in basalt and which can be used as multiple barriers to surround nuclear waste forms and containers.

The Engineered Barriers end function is divided into three major activities:

- Project Management
- Multiple Barrier Studies
- Borehole Plugging.

During the second quarter of fiscal year 1980, work has progressed in all three activities.

PROJECT MANAGEMENT

The project management activity is concerned with the management of the Engineered Barriers end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

MULTIPLE BARRIERS

Emplacement of nuclear wastes in a deep geologic repository may cause both physical and chemical changes in the existing geologic environment. These changes may, in turn, promote detrimental reactions between waste package components, repository host minerals, and the groundwater. Studies of potential interactions between candidate waste forms, container, overpack, backfill materials, and the rock in contact with groundwater continued in order to design and develop site-specific engineered barrier systems. These studies deal with potential chemical reactions both in the near-field zone (phase transformations, dissolution) and in the far-field zone (solution/precipitation).

Studies of potential nuclear waste canister materials and their response to physical conditions which will exist in a repository in basalt have continued. The resistance of such canister materials to degradation in such an environment will influence what types of protection (overpacks) must be provided, if any, to allow the canister to achieve mandated performance requirements. The composition of the canister alloy may also influence the types of radionuclide-sorbent backfill materials which may be used in the repository.

Based upon the data taken from the literature and a knowledge of the general geochemical environment in basalt, a preliminary list of candidate canister/overpack alloys was developed as shown in Table 6. Testing of these alloys in a simulated basalt environment is required to identify those alloys from the table that are suitable as reference alloys for conceptual engineered barrier systems. Low-carbon steel and the cast irons are considered prime candidates for canisters, since they offer many advantages to a repository system. They are inexpensive (compared to the other candidate alloys), strong, and do not involve the commitment of scarce natural resources. However, because their corrosion resistance is considerably lower than the remaining candidate alloys, such canisters would require protection by other components of an engineered barrier system.

TABLE 6. Preliminary List of Candidate Canister/Overpack Alloys for a Repository Located in Basalt.

Prime Candidates	Backup Candidates
TiCode-12	SS 20Cb3
Inconel 625	Ebrite 26-1
Incoloy 825	Inconel 600
Zircaloy 2	Hastelloy C-276
	90-10 Cupronickel
	Low-Carbon Steel
	Cast Iron

Testing of the alloys listed in Table 6 was initiated at Pacific Northwest Laboratory during the quarter. The initial effort will be to fully characterize the corrosion resistance and mechanical properties of TiCode-12, low-carbon steel, and selected members of the family of cast irons, while corrosion-screening tests will be conducted on the remaining candidate alloys. Particular care will be taken during the tests to simulate the environment expected in a repository located in basalt.

Groundwater composition, pH, and oxygen content will significantly influence reactions which may occur between emplaced nuclear waste and barrier materials, both natural and man-made. The pH of Grande Ronde groundwater has been measured in the field at 45 C and in laboratory experiments at 100° to 200°C. A comparison of pH values at these temperatures with dissociation constants for specific reactions suggests that the pH in this system is buffered by the carbonate-bicarbonate equilibrium reaction ($HCO_3^- \rightleftarrows CO_3^{-2} + H$) at 45°C and at lower temperatures. The measured pH at 45°C is 10.1, and the dissociation constant for the carbonate-bicarbonate dissociation reaction is 10.16 at the same temperature. At 100° to 200°C, however, pH is apparently buffered by the dissociation of silicic acid. Values of pH at these temperatures were obtained from solutions produced by the reaction of Hanford groundwater and basalt. An empirical formula derived from these experiments yields pH as a function of temperature. Close agreement has been obtained between measured (or calculated) pH and the dissociation constant for the breakdown of silicic acid ($H_4SiO_4 \rightarrow H_3SiO_3^- + H^+$) at these temperatures. For example, at 100°C, the pH of basalt groundwater is 8.7, while the dissociation constant for silicic acid breakdown is 8.9.

The results of these calculations imply that the pH buffer changes from carbonate-bicarbonate control to silicic acid dissociation control between 45° and 100°C. At 65°C, which is considered the ambient temperature of the proposed repository site, a range of pH values can be predicted by using the dissociation constant for the carbonate-bicarbonate equilibrium as an upper pH limit and the dissociation constant for silicic acid decomposition as a lower limit. These considerations yield an estimated pH range of 9.4 to 9.9 for the Grande Ronde groundwater at a depth of approximately 1,000 meters. Presumably, the low-carbonate content of the groundwater, coupled with the high-dissolved silica content, is responsible for the switch in the primary buffering reaction. The estimated concentrations of major ionic species in the Grande Ronde groundwater are listed in Table 7.

A variety of reference secondary minerals and interbed materials has been collected in large quantities for use in sorption experiments. These minerals, which possess large sorptive capacities for many radionuclides, comprise an important barrier to radionuclide migration from a breached repository. These materials, some of which have already been characterized, are in various stages of preparation for experimental use.

Approximately 9 kilograms of secondary minerals were obtained from a large Pomona basalt vug in Tunnel #2 of the Near-Surface Test Facility. A large fraction of this material has been sieved, homogenized, and freeze-dried. Characterization of the vug material revealed that it is a mixed-phase smectite clay, which contains no other mineral types. Basalt fragments originally present in the vug were removed during the preparation. This material is being tested in sorption experiments.

TABLE 7. Estimated Species Concentrations Computed from Grande Ronde Groundwater.

Anionic Concentrations	Composition at 25°C		Composition at 45°C	
	mg/ℓ	epm*	mg/ℓ	epm*
CO_3^{-2}	30	1.003	21	0.704
HCO_3^-	36	0.589	25	0.414
OH^-	3	0.182	10	0.575
$H_3SiO_4^-$	137	1.438	145	1.519
Cl^-	148	4.174	148	4.174
SO_4^{-2}	108	2.249	108	2.249
F^-	37	1.947	37	1.947
	TOTAL	11.582	TOTAL	11.022
Cation Concentrations	mg/ℓ	epm	mg/ℓ	epm
Na	250	10.875	250	10.875
K	1.9	0.049	1.9	0.049
Ca	1.3	0.065	1.3	0.065
Mg	0.04	0.033	0.04	0.033
SiO_2	121		211	
	TOTAL	11.022	TOTAL	11.022

*Equivalents per million.

Three varieties of interbed material have also been collected. The specimens include 90 kilograms of tuff and 50 kilograms of sandstone from the Beverly interbed at Sentinel Bluffs. About 200 kilograms of arkosic sand and sandstone from the Rattlesnake Ridge interbed have also been collected. The Beverly tuff has been coarsely crushed, with a 10-kilogram split carefully sieved and prepared for sorption experiments. Characterization of the Beverly tuff and sandstone has been initiated. Preliminary characterization of the Rattlesnake Ridge interbed samples has revealed that the bulk samples contain smectite, quartz, and plagioclase in varying amounts, along with traces of pyroxene and potassium feldspar. The finer fractions contain mainly smectite clay with smaller fractions of quartz and plagioclase. Materials such as these are likely to be encountered in the more distant parts of potential radionuclide migration pathways from a repository in basalt.

Sorption experiments designed to test the barrier potential of basalt, basalt secondary minerals, and interbed minerals have also continued. These experiments provide vital information for determining the quantity of radionuclides which could reach the biosphere from a failed repository in basalt. One of the major parameters which can affect radionuclide sorption on geologic materials is concentration of the ion in solution. Experiments have been conducted at 23° and 60°C with strontium and cesium solutions in contact with Pomona basalt and the smectite vug-filling described above. Distribution coefficients (K_d) for cesium and strontium were constant for both materials at solution concentrations $\leq 10^{-7}$ moles per liter at both temperatures. At higher concentrations, measured K_d values decrease as a function of radionuclide concentration. Such results are indicative of saturation of the available sorption sites in the quantity of geologic material undergoing testing.

BOREHOLE PLUGGING

The objective of the borehole plugging activity is to devise a plugging system to seal boreholes, shafts, and tunnels associated with a repository in basalt. Several types of plugging materials, plug emplacement machinery types and techniques, and monitoring instrumentation are undergoing study to fulfill this goal. Current work has included: (1) review of plug material (or system) emplacement methods; (2) laboratory tests (physical and chemical) of selected materials; and (3) preconceptual design of plug systems for boreholes, shafts, and tunnels excavated during repository construction. The primary goal of these plug design activities is to assure containment of radioactive and non-radioactive hazardous waste products after closure of the repository.

The most recently completed work in this task has been the development of preconceptual designs for borehole, tunnel, and shaft-plugging systems. These designs have been based upon the following criteria:

- Plugs must possess a design life of 10,000 years.

- Plugs must restrict total seepage to less than 1 cubic meter per year through the plug after saturation.

- Plugs must reduce waste leakage to below permissible levels assuming maximum credible amounts of radionuclides in solution in the repository.

- Plugs must sustain a thermomechanical loading cycle from a 50°C change in temperature without compromising other performance objectives.

- The plug must produce a suitable bond with tunnel or borehole walls to resist maximum credible axial forces.

In order to fulfill these criteria, plug designs must take into account the depth of disturbance of the wall rock created by borehole or tunnel excavation. This disturbance alters the permeability of the wall rock and affects the permeability of the plug-wall rock interface. Idealized models based on the conditions such plugs are expected to encounter were used to analyze the performance of monolithic plug elements for a variety of designs and conditions. Based on such calculations, combinations of plug elements (creating multiple-zone plug schemes) were devised to provide plugs which exceeded performance objectives over a wide range of repository environment conditions. A suite of "optimum" multiple-zone plug designs was chosen from those which were tested. Because many variables such as repository design, site location, exact hydrologic conditions, and so forth are yet to be determined, these designs are, for the present, being considered as preconceptual.

The plug designed for tunnels employs zones of concrete and mortared basalt blocks, interrupted at intervals along its length by seepage-cutoff collars of a clay/sand slurry. The cutoff collars extend across the entire plug section and into the wall rock extending through the disturbed and into the undisturbed rock zone. Envisioned in the shaft plug design are zones of concrete and compacted clay/sand mixtures; sections of the plug where the concrete zones occur include the use of cutoff collars for the control of seepage.

The borehole plug scheme shown in Figure 15 includes alternately: (1) a zone of gravel and unhydrated, compressed bentonite pellets in a hydrated bentonite originally introduced as a slurry; and (2) a zone of cement grout. The nominal length of tunnel and shaft plugs is 300 meters based upon required performance parameters derived from modeling results.

Based upon the results to date, it appears feasible to design a composite plug system which employs natural and manufactured materials that will satisfactorily seal a nuclear waste repository in Columbia River basalts.

GROUT FOR LOW TEMPERATURE LOCATION T < 100°C	
Mix Design per m3	
Portland Type V	. 602 kg
Lassenite	: 241 kg
Sand	. 723 kg
Water	447 ℓ
W R A.	1 25 ℓ
Al powder	180 g
Grout Properties	
Unit weight	2,013 kg/m^2
Porosity	: 33 %
Flow	: 16 Acc
28 days strength	29 MPa
Permeability	: 1x10 ^{9}cm/sec

SOIL BENTONITE BACKFILL	
Mix Design per m3	
Crushed basalt gravel	1,358 kg
Bentonite pellets	: 137 kg
Shurgel	. 31 kg
Water	436 ℓ
Initial density	1 93
Porosity	: 47 %

GROUT FOR HIGH-TEMPERATURE LOCATION T > 100°C	
Mix Design per m3	
Portland Type V	: 586 kg
Silica flour	: 315 kg
Glaciofluvial sand	: 772 kg
Water	: 414 ℓ
W R A.	. 1 22 ℓ
Al powder	: 176 g
Grout Properties	
Unit weight	. 2,087 kg/m^3
Porosity	: 33 %
Flow	: 16 2 Acc
28 days strength	: 24 8 MPa
Permeability	: 9 6 x 10 ^{9} cm/sec

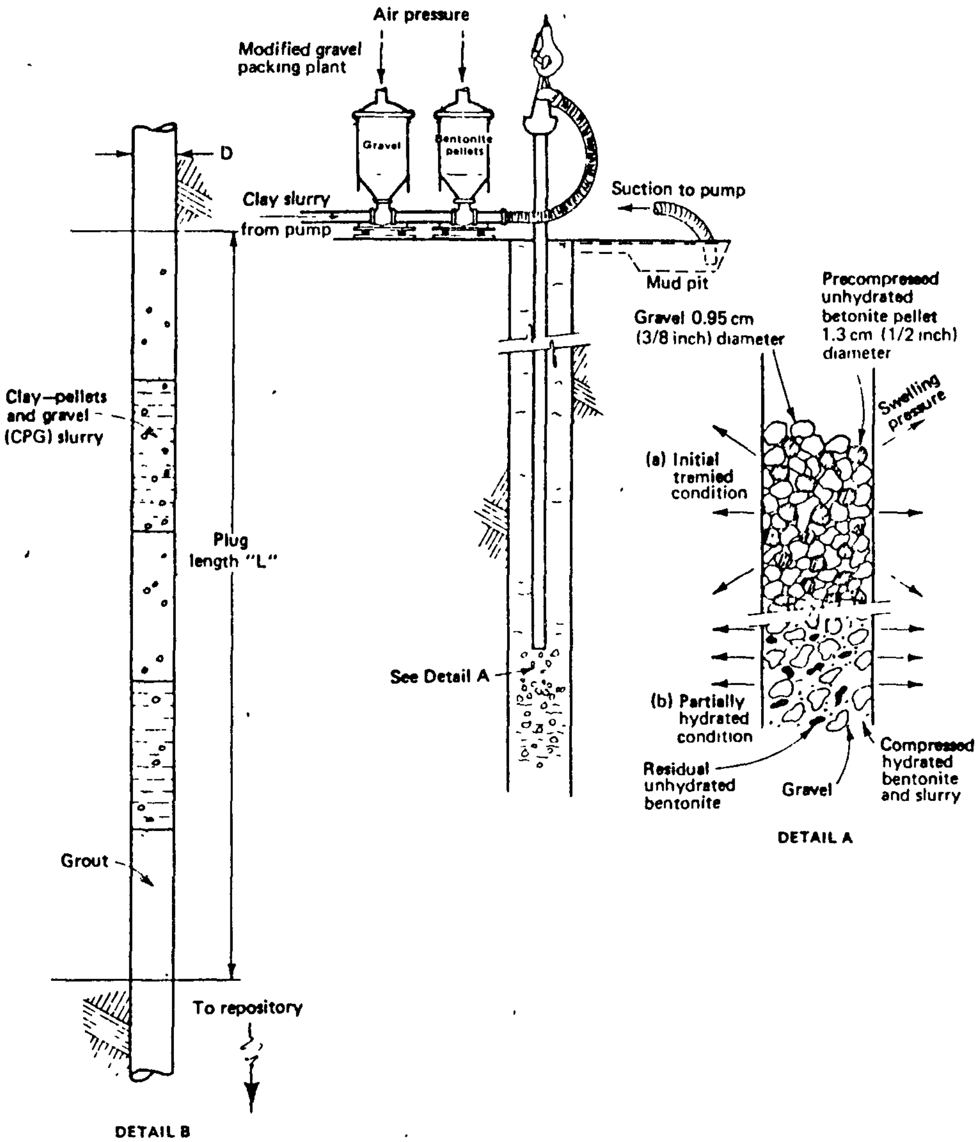

FIGURE 15. Preconceptual Design for Borehole Plugs.

NEAR-SURFACE TEST FACILITY

The Near-Surface Test Facility is a multipurpose test facility for in situ testing in basalt. The Phase I (electric heater) and Phase II (nuclear waste) tests to be conducted in the facility are designed to:

- Qualify basalt as a repository medium
- Provide the basis of design for key repository elements
- Demonstrate placement, storage, and retrieval of canisters containing radioactive material in an underground basalt environment
- Demonstrate capability of monitoring of radioactive material in an underground basalt environment.

The Near-Surface Test Facility is located on the west end of Gable Mountain on the Hanford Site. The facility consists of a computer room and approximately 1,000 meters of underground workings, including access tunnels and test rooms. Work under Phase I will develop the electric heater test portion of the facility so that testing may begin in fiscal year 1980. Work in preparation for Phase II testing is scheduled for completion in fiscal year 1982.

The Near-Surface Test Facility end function is divided into nine major activities:

- Project Management
- Design--Phase I
- Construction--Phase I
- Safety and Environmental Analysis--Phase I
- Decommissioning--Phase I
- Design--Phase II
- Construction--Phase II
- Safety and Environmental Analysis--Phase II
- Decommissioning--Phase II.

During the second quarter of fiscal year 1980, work has progressed in four of these activities: project management; construction--Phase I; design--Phase II; and construction-Phase II.

PROJECT MANAGEMENT

The project management activity is concerned with the management of the Near-Surface Test Facility end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

DESIGN--PHASE II

The shipping cask to be used for transporting spent fuel canisters from the source to the transfer pit in the Near-Surface Test Facility has been specified. The canisters will be shipped from the Nevada Test Site in a National Lead Industries, Inc. NLI-1/2 Universal Spent Fuel Shipping Cask. This cask has been designed to accommodate either one pressurized water reactor or two boiling water reactor spent fuel assemblies. The cask design is based on fuel decay heat and radiation source terms, which were derived from certain, limiting, operating values of fuel exposure, specific power, initial enrichment, and axial peaking factor. Therefore, shipment of any pressurized water or boiling water reactor fuel assemblies whose parameters do not exceed the design basis fuel values is permissible.

Cask size and capacity are limited to permit legal-weight truck shipment (33,234 kilograms gross vehicle weight) of the fully loaded cask. To achieve this objective, it was necessary to consider the shipping cask, tractor, and trailer as a system, with primary consideration being given to the shipping cask integrity and reliability. The trailer is specially designed to accommodate the cask. For the purpose of package evaluation, the shipping cask with impact structures attached to each end is to be considered as the configuration of the package as presented for shipment.

The NLI-1/2 Universal Spent Fuel Shipping Cask has been designed to provide maximum safety for the shipment of spent fuel by providing double containment of the fuel assemblies in a dry environment. Decay heat is dissipated from the fuel to the cask by thermal radiation and conduction through a helium-filled cavity and then through the cask sides and ends by a combination of conduction, natural convection in the water-filled neutron shield, and natural convection and radiation from the surfaces of the cask. Thermal radiation augments the conduction heat transfer across well-established air gaps within the cask. Being entirely passive, this means of heat dissipation is highly reliable.

The NLI-1/2 Universal Spent Fuel Shipping Cask has been designed to meet all applicable requirements of 10 CFR 71, 46 CFR 146-149, and 49 CFR 170-189.

CONSTRUCTION--PHASE I AND PHASE II

A demonstration slot was successfully drilled to verify feasibility of a method of constructing slots in basalt for jointed block tests. The slot was drilled in the south wall of transfer room #2 using an Ingersol-Rand Air-Trac drill which had been converted to accommodate a downhole hammer. A template was mounted on the wall and the hammer guide was bolted to the template for stabilization. The first hole was drilled without the use of a guide. After the first hole was drilled, a 12.7-centimeter pipe guide was placed in the first hole and the second hole was drilled. This system was used for the first four holes, but the pipe guide repeatedly became wedged at the back of the hole, which made it difficult to remove. Thereafter, every other hole was drilled without the pipe guide, then the pipe guide was placed in the drilled holes, and the areas in between were drilled out. Webs left in the slot had to be removed to accommodate a dummy flatjack; a chisel-head reamer was fabricated to remove the webs.

ENGINEERING TESTING

The objectives of the Engineering Testing end function are to design, procure, fabricate, and install equipment and instrumentation to obtain in situ test data during the Near-Surface Test Facility operations. Phase I tests consist of Full-Scale Heater Tests #1 and #2 and Jointed Block Tests #1 and #2. Phase II (nuclear waste) tests consist of Spent Fuel Tests #1 and #2 and a Vitrified Waste Form Test. The test data will be used to establish the engineering feasibility of constructing a repository in basalt and repository design. Rock testing and other miscellaneous special studies are also included as part of this program to assist in meeting the Near-Surface Test Facility objectives.

The Engineering Testing end function is divided into four major activities:

- Project Management
- Engineering Studies
- Phase I
- Phase II.

During the second quarter of fiscal year 1980, work has progressed in all four of the activities.

PROJECT MANAGEMENT

The project management activity is responsible for the management of the Engineering Testing end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

ENGINEERING STUDIES

During the second quarter of fiscal year 1980, the final report on the characterization of the Umtanum flow by the Colorado School of Mines was received. This report included results of creep tests conducted on samples from boreholes DC-4, DC-6, and DC-8, as well as results of a characterization effort that involved a detailed petrographic and X-ray mineralogical analysis of selected samples. Samples from both dry and fully saturated conditions were loaded under steady-state thermal conditions until a constant creep rate was achieved. Temperature conditions varied from room temperature (20°C) to the highest anticipated temperature (500°C), with intermediate values of 150° and 300°C chosen to help develop the plotting routines. A loading rate of up to approximately 45% of the failure load was also maintained throughout the testing.

At the present time, the results of the creep tests are being further analyzed to determine if any trends are discernible. Numerous factors appeared to play significant roles in the fluctuations seen in the results. Several of these factors were fluctuations in temperature and humidity, differences in density as seen in samples from different parts of the flows, the presence or absence of jointing, and differences in joint angles in samples. These factors all contributed to the extreme variability in the creep test results. A typical example of these fluctuations is seen in Figures 16 and 17.

Figure 16 shows data from a room-temperature sample from a more vesiculated and clastic portion of the flow. In general, it displayed relatively little fluctuation over time. Figure 17 shows data from a sample from the dense portion of the flow, which was heated to 300°C and indicated a strong fluctuation in deformation. A probable explanation for the fluctuation was the presence of a major joint running the length of the sample. These results are tentative and suggest that further refinement of the independent variables, such as density, temperature, and humidity, is necessary. Wide day-to-day variations would seem to suggest that longer test durations may be required to conclusively identify time-dependent deformation behavior.

The characterization effort consisted mainly of X-ray analysis of thin-section samples of basalt that contained joints, samples heated to high temperatures, and samples that showed atypical behavior during the creep testing. Further X-ray mineralogical analysis was performed on selected samples from intervals that contained typical secondary minerals in the core. These were then used to confirm those features identified on a microscopic scale. The purpose of this effort was to broaden the background of information relating to samples that showed behavior during testing that might be related to a specific feature not explainable on a macroscopic scale. A typical lithologic and microscopic log description of an interval from DC-4 is shown in Table 8.

Pacific Northwest Laboratory is nearing completion of the fiscal year 1980 work on the thermal properties of Pomona flow samples from boreholes DB-5 and DB-15. A series of tests ranging from measuring thermal conductivity, specific heat, density, and thermal expansion on basalt core samples over a temperature range of 100° to 300°C is being conducted. The thermal diffusivities of these samples are also being calculated.

Thermal conductivity measurements were made utilizing a steady-state comparator apparatus and assuming a one-dimensional, steady-state heat conduction model. The thermal conductivity of a basalt sample is measured relative to the known conductivity of a standard material. Two National Bureau of Standards' silica glass standards, one 6.35 millimeters in thickness and the other 12.7 millimeters in thickness, were used in calibrating the comparator. Measurements of the basalt samples are now complete and the data are in the process of being reduced.

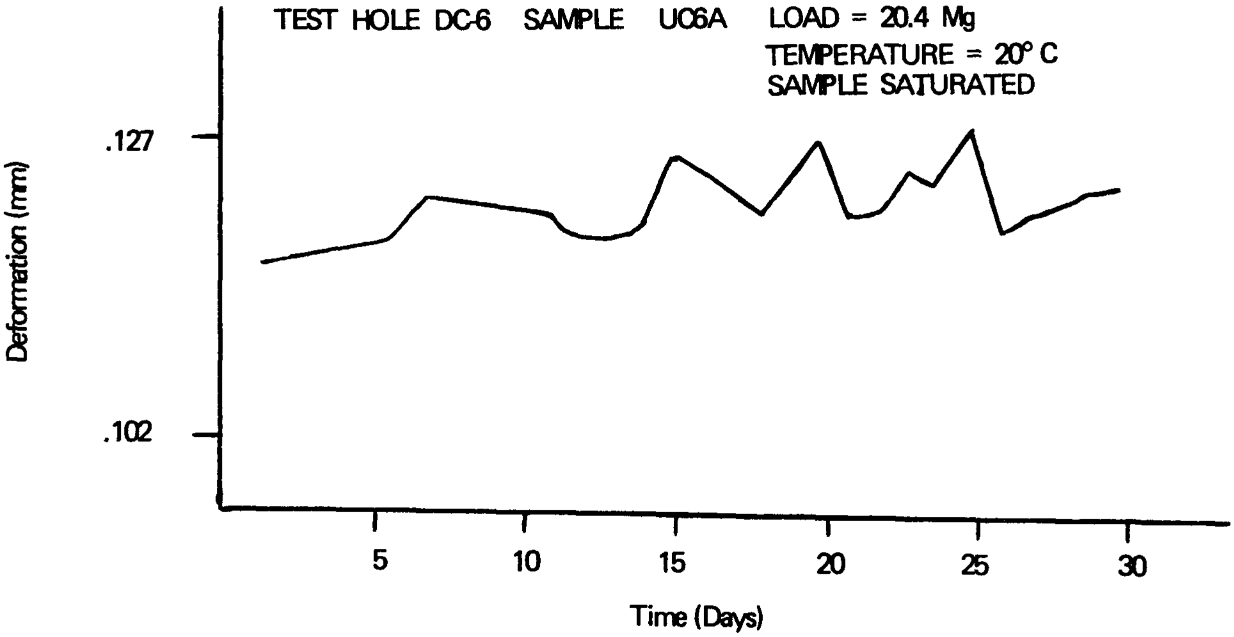

FIGURE 16. Creep Test Sample Results.

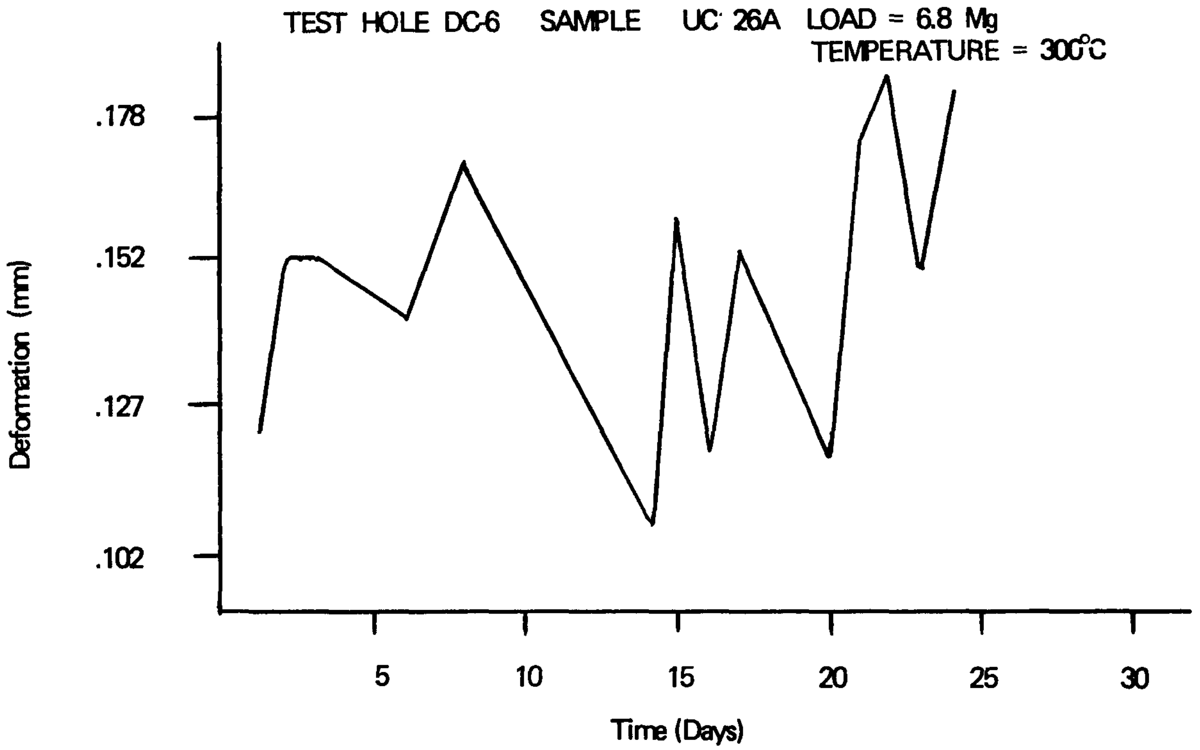

FIGURE 17. Creep Test Sample Results.

TABLE 8. Typical Lithologic and Microscopic Log Description.

Drill Hole	Formation	Depth	Description
		Lithologic Log	
DC-4	Umtanum Flow Top	1,227.7 m to 1,227.9 m	Basalt; greenish-gray; microcrystalline; non-porphyritic with scarce microphenocrysts of plagioclase; vesicular, with vesicles up to 9.9 mm long perpendicular to the core axis, and probably parallel to flow layering; vesicles lined and partially filled with amygdules of chalcedony, quartz, waxy, very dark smectite, and zeolite; several irregular fractures at various angles to the core axis; moderately microbrecciated and veined with secondary minerals listed above.
		Microscopic Log	
DC-4	Umtanum Flow Top	1,227.8 m	Weakly microporphyritic with sparse plagioclase phenocrysts up to 0.5 mm; groundmass aphanitic and intersertal to pilotaxitic with microcrystalline plagioclase and clinopyroxene set in nondescript, dark, cryptocrystalline material; moderately microbrecciated and autoclastic; zeolite and dark greenish brown smectite cementing fragments and locally replacing groundmass. Petrographic Designation: Smectitic, zeolitic, microbrecciated basalt.

Specific heat measurements utilize a microprocessor computer, controlled-drop calorimeter, which measures the enthalpy of a basalt sample relative to that of a National Bureau of Standards' sapphire standard. From a change in enthalpy versus temperature curve, the specific heat can be calculated. Thermal expansion measurements using a dilatometer also incorporate the microprocessor for data acquisition. The differences between the thermal expansion of a basalt sample and that of the material of the dilatometer are measured; the expansion of the apparatus is determined using a calibration procedure and a material with a known expansion, such as aluminum. Expansion values obtained will be used to estimate the change in density of basalt up to 300°C and will be important in the calculation of thermal diffusivity.

All of the above measurements being made by Pacific Northwest Laboratory are either nearing completion or the data are in the process of being analyzed. Results will be obtained during the third quarter of fiscal year 1980.

The fiscal year 1980 advanced rock testing contract was awarded on February 1, 1980. The present scope of work entails testing core from three test areas in the Near-Surface Test Facility: Full-Scale Heater Test #1; Full-Scale Heater Test #2; and the former Time-Scale Test area. The test currently under way uses core taken only from the area of Full-Scale Heater Test #1, with the succeeding tests using core from the remaining two test areas. Approximately 34 meters of NX size (7.6 centimeter) and 10 meters of AX size (4.8 centimeter) core were selected from available core and will be used for a suite of 11 mechanical and thermomechanical tests.

A list of the tests being conducted and the range of conditions at which tests will be run are shown in Table 9. The temperature range of 20° to 300°C and pressure range of 3,450 to 13,790 kilopascals was chosen to simulate the range of test conditions of the full-scale heater tests that will be conducted at the Near-Surface Test Facility. Each individual test will yield results that will further characterize each test area and yield information that will be utilized in the computer modeling (predictive data) effort. Tests such as uniaxial and triaxial compression tests will provide basic material properties such as Young's modulus, Poisson's ratio, and failure stress versus a range of temperatures and confining pressures, as well as sample conditions (jointed versus intact).

At the present time, approximately 40% of the core-testing work has been completed in Full-Scale Heater Test #1 area. One hundred-thirty bulk density and 73 dynamic elastic measurements have been made, and eight triaxial and eight thermal expansion measurements have been completed. The remainder of the core-testing work in the Full-Scale Heater Test #1 area will be completed in the third quarter of fiscal year 1980. Following successful completion of this testing work, samples from the remaining two areas will be tested throughout the remainder of fiscal year 1980 and into portions of fiscal year 1981.

TABLE 9. Matrix of Samples and Tests for Total Testing Program.

Tests	No. of Samples	No. of Test Runs	No. of Measurements	No. of Sets of Samples	Total Tests
1. Uniaxial Compressive	10	1	1	6	60
2. Brazilian Tensile	6	1	1	6	36
3. Triaxial Compressive					
(a) High Pressure	10 (5 jointed; 5 intact)	3	3 (3,450, 6,895, and 13,790 kP)	6	360
(b) High Temperature	5	2	3 (20°, 150°, and 300°C)	6	180
4. Modulus of Rupture	6	1	1	6	36
5. Density	69	1	2 (Bulk and Grain)	6	828
6. Porosity	6	1	1	6	36
7. Thermal Expansion	4	1	3 (20°, 150°, and 300°C)	6	72
8. Thermal Conductivity	4	1	3 (20°, 150°, and 300°C)	6	72
9. Specific Heat	4	1	3 (20°, 150°, and 300°C)	6	72
10. Thermal Diffusivity	6	2	3 (20°, 150°, and 300°C)	6	216
11. Dynamic Elastic	33	1	1	6	198

PHASE I

The Phase I tests provide the design, procurement, fabrication, calibration, installation, checkout, operation, and analysis of heater test equipment in the Near-Surface Test Facility.

The Phase I tests are subdivided into the following subactivities:

- Heaters and Controllers
- Rock Instrumentation
- Data Acquisition System
- Site Characterization
- Test Engineering Support
- Equipment Installation
- Operation.

Heaters and Controllers

The main-heater borescope, as specified in the full-scale heater test plan, will be used to view borehole walls for evidence of decrepitation in the area adjacent to the heated portion of the main heaters and to allow recording of decrepitation progress. Borescope insertion tubes are provided at 90-degree intervals around the main heater. The borescope dimensions and capabilities are:

- Diameter of 12.7 millimeters to ensure ease of insertion through the tubes and beyond the movable tube stopper and stopper wire
- Length of 6.4 meters, adjustable in 0.9-meter sections, to extend to the bottom of the 5.5-meter-deep borehole and allow viewing of the borehole wall from the bottom to 2.4 meters above the bottom
- Right-angle viewing to allow visual examination of the borehole wall
- Integral light source to illuminate the area viewed
- Capability of intermittent use in an ambient temperature of 204^{o}C and physical contact with metal at 427^{o}C. Intermittent use is defined as 30 minutes of viewing during one session succeeded by withdrawal to allow the borescope to cool prior to reinsertion.

Jointed Block Test #1 heater controllers regulate power to the heater elements. The controllers provide a digital readout of heater element power to allow accurate adjustment and transmit a signal to the data acquisition system to record heater element power levels during the tests. To ensure that the controllers function properly, they were operated, adjusted, and calibrated so that the digital readouts were accurate within $\pm$0.02 kilowatt using a variable load bank as the test load.

The voltage regulators provide voltage regulated at 208 $\pm$2 volts to the controllers. Voltage to the controllers must be regulated to ensure the power to the heater elements is accurately controlled, sensed, and recorded. To ensure proper performance, all voltage regulators were acceptance tested by connecting the regulators with a variable transformer (VARIAC) and a load bank. The voltage regulators were adjusted to provide an output voltage of 208 $\pm$2 volts and load-bank power was adjusted, in steps, from 0.0 to 7.5 kilowatts. During this time, the VARIAC output was varied from 185 to 220 volts. A calibrated voltmeter was utilized to read voltage regulator output and verify that the voltage from the voltage regulator remained at 208 $\pm$2 volts.

Rock Instrumentation

Goodman Jack testing was performed at the Near-Surface Test Facility to determine the in situ modulus of deformation at numerous points and orientations within the facility. The modulus of deformation of an elastic, homogeneous material is theoretically independent of sample size. Rock, however, is neither perfectly elastic nor homogeneous, and it has been found that the modulus of a large mass, in situ rock is generally different from the modulus of laboratory size samples of the same rock. When a sample is removed from the rock mass, the modulus changes. This difference can be attributed to:

- Existing state of stress in the rock
- Microcracks
- Fractures, joints, and the material that fills them in the large rock mass.

Goodman Jack testing was completed in a total of six monitoring boreholes; four were vertical in the Heater Test Room and two were horizontal in the Extensometer Room. The horizontal boreholes were tested at 1.5-meter increments from a depth of 1.5 to 13.7 meters from the face of the tunnel wall. The vertical boreholes were tested at 1.5-meter increments from a depth of 1.5 to 7.6 meters from the tunnel floor.

Each borehole was tested at two orientations 90 degrees apart at each test station. This allowed the comparison of modulus of deformation for three perpendicular axes; one of which is parallel to the Heater Test Room tunnel, one perpendicular to the Heater Test Room tunnel, and the third perpendicular to the Heater Test Room tunnel floor (parallel to the vertical borehole axis tested).

The Goodman Jack is a borehole probe with movable rigid bearing plates for measuring wall deformation as a function of applied load. The probe is designed to operate in a 7.6-centimeter (NX) diameter borehole; the pressure plates can span diameters between 7.0 to 8.3 centimeters creating an effective working borehole size of approximately 7.4 to 7.9 centimeters to allow for average rock deformation during testing. Hydraulic pressure is transmitted to the rock through movable plates transmitting a maximum bearing plate pressure of 64,120 kilopascals to the rock surface (see Figure 18). Two linear variable differential transformers are mounted within the jack at each end of the movable plates allowing precision measurements (within 0.025 millimeter) of deformation to be made. The system also includes pressure gauges, a portable solid-state indicator for measuring displacement, a hydraulic hand pump, hydraulic hoses, and electrical cable.

Deformation values will be plotted for each station; the orientation will be determined, and, in addition, average deformation values will be calculated. Each station orientation will have a corresponding geologic write-up, which delineates the characteristics of the basalt at that location in the borehole. The above information will be collected from borehole logs and impression packer tracings.

The Goodman Jack test data will not be completed until the third quarter of fiscal year 1980.

Additional testing was carried out on several U.S. Bureau of Mines' gauges and IRAD Manufacturing Company gauges.

Additional testing on the U.S. Bureau of Mines' gauges involved thermal expansion to determine what portion of the U.S. Bureau of Mines' gauge readings are actually attributable to the thermal expansion of the gauge body itself as it heats up. The thermal expansion of the gauge body was assumed to be a linear function between 20°C (room temperature) and 200°C.

The test consisted of placing a U.S. Bureau of Mines' gauge in a machined, hollow steel cylinder that has an inner diameter hole of 4.8 centimeters, an outer diameter of 15.2 centimeters, and a length of 15.2 centimeters. The outer surface of the cylinder had several strain gauges adhesively bonded around the circumference to determine the thermal expansion of the steel cylinder. The test started with the cylinder at room temperature and the readings were taken of the U.S. Bureau of Mines gauge axis as well as the cylinder strain gauges. This assembly was then placed in a temperature-controlled oven and heated to 200°C. Once again, the readings of the U.S. Bureau of Mines' gauge axis and the cylinder

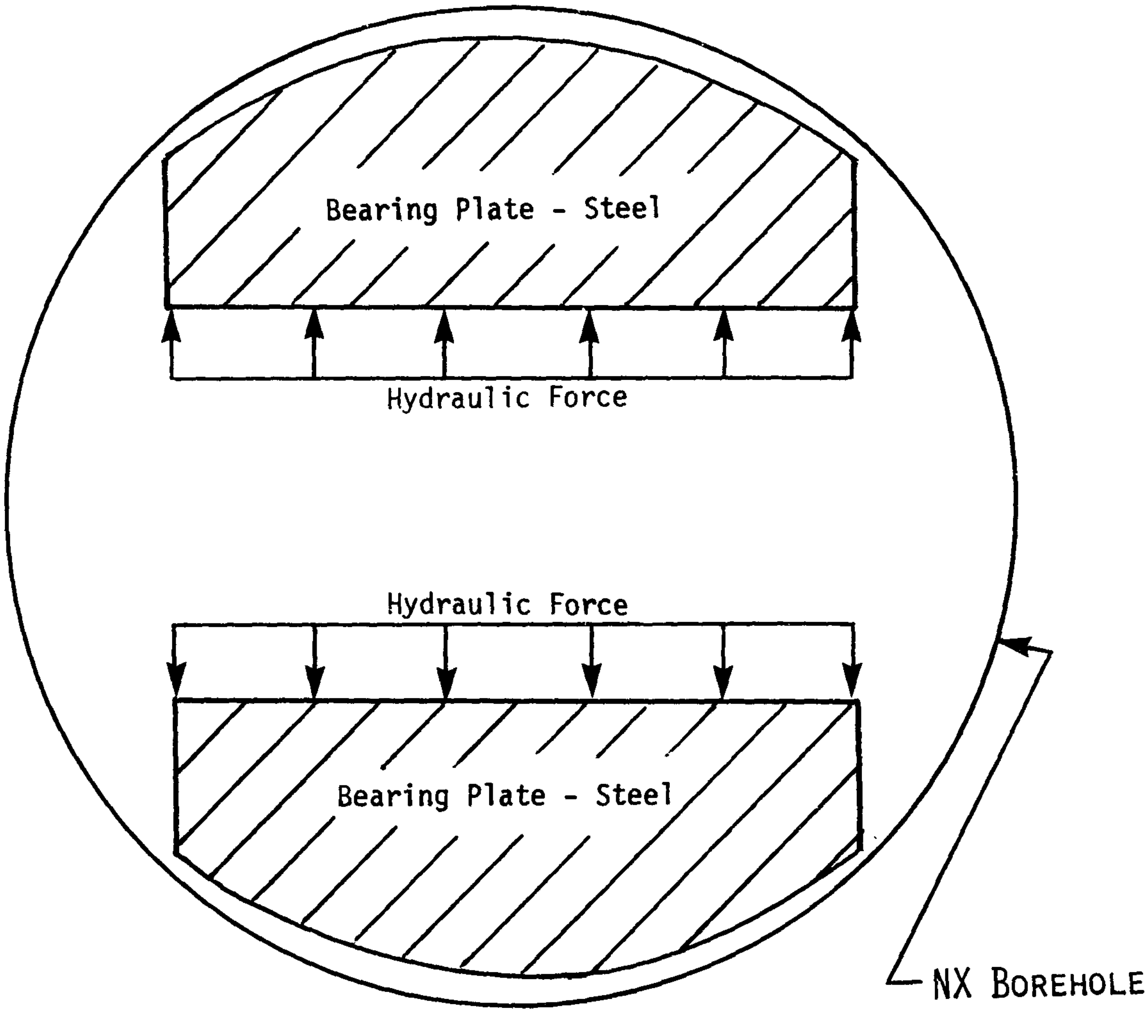

FIGURE 18. Simplified Cross Section, Goodman Jack Test.

strain gauges were observed and recorded. From these data, the actual thermal expansion of the U.S. Bureau of Mines' gauge could be determined by taking the difference in the gauge readings and correcting for the expansion of the cylinder by means of the strain gauge readings.

The additional testing on the IRAD Manufacturing Company gauges consisted of two types; one test consisted of the gauge being evaluated for thermal expansion between 20°C (room temperature) and 200°C, and the other consisted of "heat treating" the gauges. The first test consisted of applying strain gauges to the gauge body, wedge, and platen. These strain gauges were then read at room temperature and again at 200°C, when the gauge body, wedge, and platen were placed in a temperature-controlled oven. The purpose of this test was to determine the thermal expansion of the gauge in order to correct the reading to the actual stress measured after backing out the thermally induced stress portion.

The second test consisted of "heat treating" (to 200°C) all the IRAD Manufacturing Company gauges for Full-Scale Heater Tests #1 and #2. This was accomplished in a temperature-controlled oven in 50°C increments. The purpose of this test was to eliminate the thermal offset being experienced by these gauges. By heat treating all gauges one thermal cycle to 200°C, the thermal offset problem would be virtually eliminated from consideration in the data output from these units. The results of this test, as well as other additional testing described in this section, will be available in the third quarter of fiscal year 1980.

Data Acquisition System

The Near-Surface Test Facility program requires a data acquisition system to receive and process instrumentation data, as well as predictive data. The data acquisition system consists of hardware and software.

Instrumentation data loggers receive input analog voltages from test measurement instruments (thermocouples, U.S. Bureau of Mines' borehole gauges, extensometers, and IRAD Manufacturing Company gauges). The data loggers output information in the form of RS-232C ASCII data to a computer (Data General Model M600). RS-232C is a standard of the Electronic Industries Association for data communications. ASCII data are coded according to the American Standard Code for Information Interchange.

Figure 19, a simplified diagram of the hardware for the data acquisition system, is referenced when discussing hardware information. A data logger (block 1) receives analog data from U.S. Bureau of Mines' gauges, extensometers, and thermocouples, and digital data from IRAD Manufacturing Company gauges via a scanner (block 2). Whenever an instrument reading is out of limits, or when readings from all instruments are made by the data logger, the data logger writes this data onto a magnetic tape unit (block 3) and forwards it through the data transmission channel (block 4) to the computer (block 5). The computer

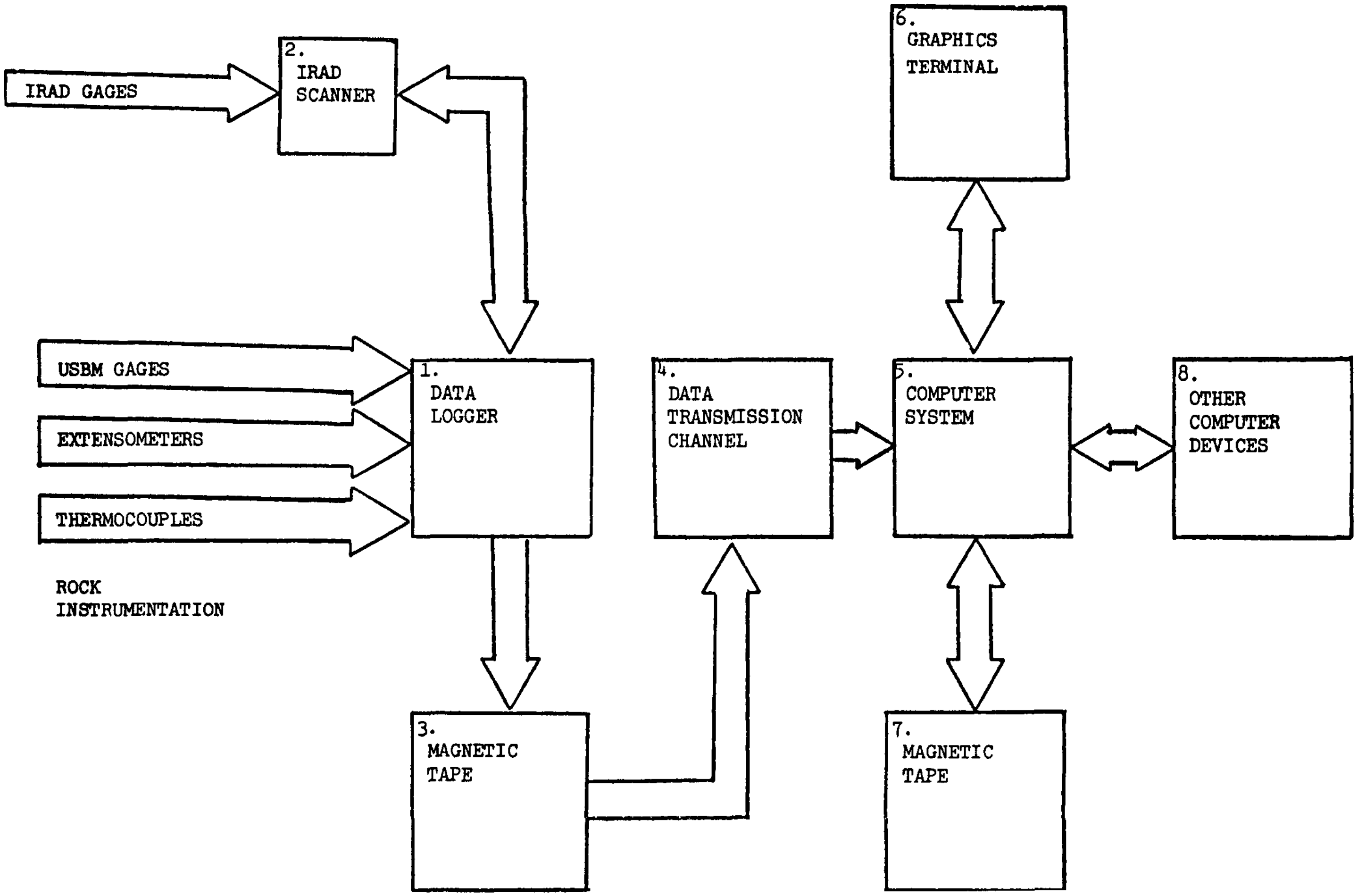

FIGURE 19. Simplified Diagram of Hardware for the Data Acquisition System.

processes the data to produce plots on the graphics terminal (block 6), data on magnetic tapes (block 7), and other outputs (block 8).

Figure 20, a simplified diagram of the software for the data acquisition system, is referenced when discussing software information. Figure 20 shows that the total software for the data acquisition system, which is represented by block 1, is divided into several categories. Thus, the total software (block 1) is composed of two categories of software; that started by the computer itself or by someone other than the programmer (block 2) and that started by the programmer (block 3). Software started by someone other than the programmer (block 2) is composed of software for in situ data acquisition (block 4), user-defined graphics (block 5), historical data tapes (block 6), or other software (block 7). Similarly, details of block 3 can be determined from blocks 8 and 9.

The transfer of data from the IRAD Manufacturing Company scanner (block 2, Figure 20) to the data logger (block 1) was erratic during data acquisition system checkout. A timing problem caused the data logger to miss data from the scanner. A design change by the manufacturer of the data logger corrected the problem, and the change was made to all data loggers in the system.

If the computer system (block 5, Figure 19) fails, in situ data are not lost, but are recorded on the magnetic tape (block 3). After the computer system is operational, information-recovery software (block 8, Figure 20) is started by a programmer to put any lost data into on-line data files. On-line data files allow the data to be examined by non-programmers, such as engineers, scientists, and operating technicians. The information-recovery software, CATCHUP (block 8, Figure 20), will provide the capability to restore the Near-Surface Test Facility to an updated state in the event of a complete or intermittent failure of the data acquisition system computer. Each data logger (Fluke Model 2240-B) is equipped with a magnetic tape cartridge recorder (Columbia Model 300-C) to record all scan data independent of the data acquisition system computer availability. The tape cartridges are removable and will be collected on a daily basis and retained until it is verified that the data acquisition system files contain all recorded scan data.

CATCHUP will read the collected tape cartridges and restore all appropriate data acquisition system data files to an updated state. The software will update all or a subset of the appropriate data acquisition system data files as required to meet the following conditions:

- Total Computer Failure: No data were acquired for a given time interval and, as a result, the appropriate data acquisition system data files were not updated.

- Intermittent Computer Failure and Insufficient Data: Intermittent data were acquired and the appropriate data acquisition system files updated. However, sufficient data were not acquired to provide meaningful information.

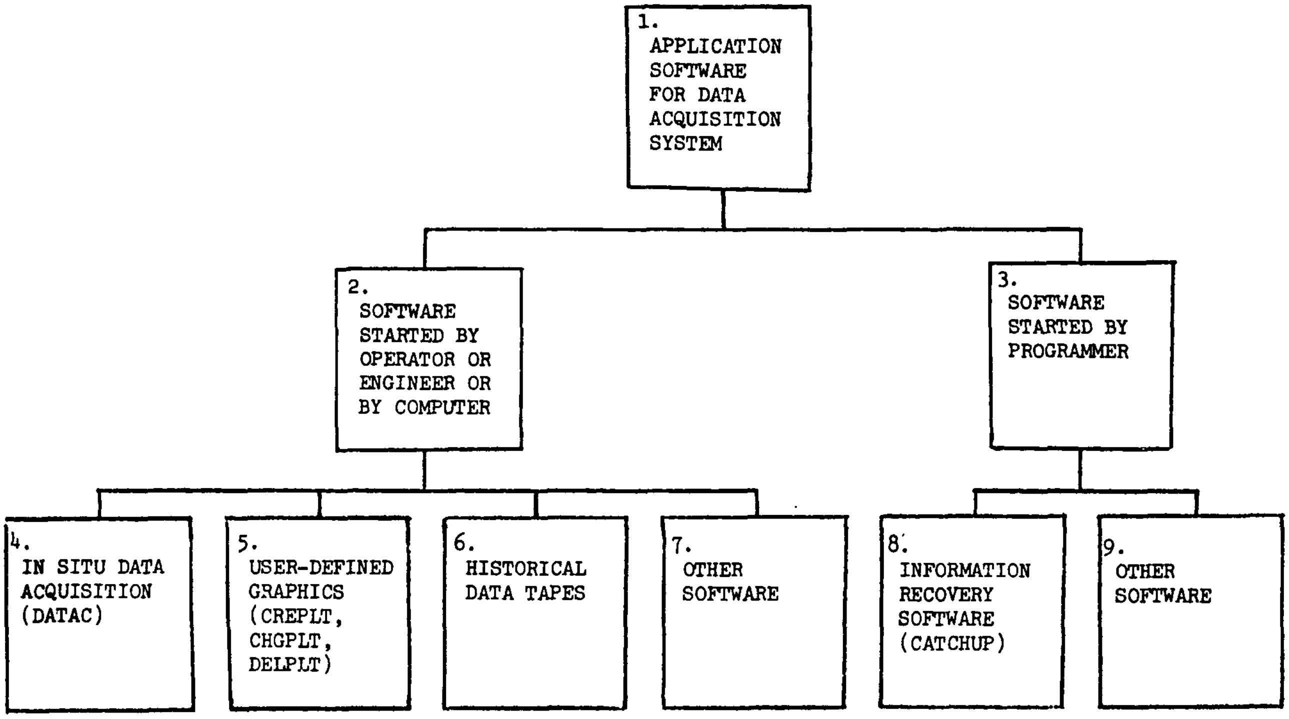

FIGURE 20. Simplified Diagram of Software for the Data Acquisition System.

- Intermittent Computer Failure and Sufficient Data: Intermittent data were acquired and the appropriate data acquisition system data files updated. Sufficient information was acquired to provide meaningful information; however, it is desired to provide the remainder of the data for historical purposes.

CATCHUP will simulate the acquisition of data through the normal scanning process. The system will provide the following features:

- Complete programmer control through prompted input parameters
- Simultaneous input of primary and secondary data logger tapes when required
- Ability to recover information spanning multiple tapes
- Ability to recover information up to 14 days old
- Editing to assure information and file integrity
- Complete updating of all appropriate data acquisition system data files
- Alarm, error, and status reporting to assist the operator in monitoring the recovery process.

While testing the information-recovery software and the associated magnetic cartridge recorders, problems were encountered. First, the data logger wrote data on the tape cartridges with a format that required so much time to read that the system could not read cartridges as fast as they were written. Second, the tape recorders failed too frequently to provide adequate backup in case of computer failure.

The data logger manufacturer has solved the first problem by providing a data format that speeds the data processing by the computer. This solution will be completely evaluated early in the third quarter; it is working very well now. Solutions to the second problem are being implemented by the data logger manufacturer and by staff personnel. Engineers from the manufacturer have improved operation of the recorders and have recommended a more reliable tape cartridge, which is being tested. Technicians will monitor the cartridge recorders to detect failures.

The user of the graphics system in the data acquisition system (block 5, Figure 20) can perform the following: list the code number and title for each plot that is stored in the system; display a particular plot on a graphics terminal by identifying its code number; create a new plot; change an existing plot; and delete a user-defined plot.

When the user is defining his own plot, he can select from the 14 different categories below:

1. Isotherm plots

2. Heater power/heater temperatures
3. Temperatures
4. Displacements (vertical)
5. Displacements (horizontal)
6. Stress tables
7. Stress scatter (U.S. Bureau of Mines)
8. Stress (U.S. Bureau of Mines) (vertical)
9. Stress (U.S. Bureau of Mines) (horizontal)
10. Stress scatter (IRAD Manufacturing Company)
11. Stress (IRAD Manufacturing Company) (vertical)
12. Stress (IRAD Manufacturing Company) (horizontal)
13. Stress ellipses
14. Temperatures for other boreholes.

The create-a-plot and change-a-plot routines give the user yes- or no-type questions, or menu selection, when possible. These routines do as much data checking as reasonable, considering that they must work for all tests. The questions assume that the user knows some of the following items:

1. The plane wanted for an isotherm plot
2. The temperature levels to be plotted
3. The quadrant to be displayed
4. Actual or predicted data
5. Differences between heater borehole, thermocouple borehole, extensometer borehole, U.S. Bureau of Mines' borehole, and IRAD Manufacturing Company borehole
6. U.S. Bureau of Mines' measurement type
7. IRAD Manufacturing Company measurement type
8. Plot parameters, such as grid, minimum to maximum Y axis range, major and minor tic marks.

The range for the time axis for the user-defined plots can be from 10 to 50 days and any starting day may be specified.

Specifications have been developed for the historical data tape description; design has been started on software to produce the historical data tapes for permanent storage in the secured storage facility (block 6, Figure 20). Two types of data will be archived:

- Processed data
- Configuration data.

Processed data are those data which are manipulated by the software in the data acquisition system. There is only sufficient storage to maintain this data on-line for a limited time, after which it must be stored on magnetic tape and sent to the secured storage facility. Adequate information is contained in these data for reproducing the original forms of output.

For the Near-Surface Test Facility data acquisition system, processed data are categorized as:

- Raw/converted data
- Smooth data
- Test analysis data
- Out-of-limits data.

Raw/converted data are raw data and reduced raw data converted to engineering units using programmed instrument algorithms. Smoothed data are calculated values of the converted data that represent a statistical sample of all individual readings over a 24-hour period. Test analysis data are selected subsets of the smoothed data, which are sent to the organization doing the test analyses. Out-of-limits data are those raw/converted readings which have gone outside predefined alarm bands on each interval.

Configuration data describe the data acquisition system software. These data consist of:

- Instrument data, such as instrument identification and data logger channel number
- Graphics data
- Other data, such as program software modules and system software.

The software to produce historical data tapes for storage is menu- and dialogue-controlled to reduce chances for operator error during the production of the historical data tapes.

In addition to a magnetic tape, a report is produced giving the catalog number and the dates of the data contained on the tape.

Data acquisition system acceptance test procedures were completed on the power supply and signal simulator drawers for the interface cabinets for Full-Scale Heater Tests #1 and #2. An acceptance test procedure was also completed on the instrumentation alarm system cabinet.

The acceptance test procedure for the power supply drawers consisted of three test sections:

- Input rejection test
- Ripple and noise output test
- Long-term stability test.

The input rejection test verified that, for a 17% input voltage variation, the output varied less than 0.4%.

The ripple and noise output test measured the peak-to-peak ripple on the direct current voltage output of the power supply and verified it was less than 0.010 volt at the 10-volt nominal output voltage with a load of 2 amps.

The long-term stability test verified that the output drift of the power supply was less than 0.030 volt/direct current over a 72-hour period, while operating at the 10-volt/direct current nominal output voltage and a load of 2 amps.

The acceptance test procedure for the signal simulator drawers was a series of tests designed to verify (by the use of indicator lights and simulator switch position configurations) that the wiring in the simulator was correct.

The acceptance test procedure for the instrumentation alarm system cabinet was a series of tests, similar to those done on the signal simulator drawers, which were designed to verify (by use of indicator lights and a switch module) that the wiring was correct.

Site Characterization

Pre-test geologic site characterization is required to characterize the structural and physical composition of the rock mass before testing, so that changes resulting from the heating and testing can be easily identified and to allow comparison of the Near-Surface Test Facility geologic conditions to those which prevail at a site picked for the repository.

This characterization will be accomplished by detailed geologic mapping, instrument borehole core logging, impression packer mapping of selected boreholes, and laboratory testing of the physical properties of the rock.

Geomechanical logs, with detailed descriptions of each discrete fracture, were prepared for the horizontal 7.6-centimeter holes and selected vertical 7.6-centimeter holes. Due to the number of the fractures measured (approximately 7,000), the use of a computer in data reduction was necessary. The reduction of data has been in two forms; the plotting of poles on an equal-area stereonet (Figures 21 and 22) and the plotting of histograms. The histograms (Figures 23, 24, and 25) are plots of fracture frequency versus the following parameters; dip angle, strike azimuth, aperture, in-filling material, and roughness. Using the dip angle versus frequency plots, the fractures can be divided into several populations. The data can then be divided into these populations and a new set of histograms and stereonets plotted. The blocks of rock in which the Full-Scale Heater Tests #1 and #2 will take place have each been divided into 12 smaller blocks. For each of these smaller blocks, fracture density, average and/or dominant strike and dip, average aperture, in-filling material, and a rock mass quality will be calculated. A major application of these data will be in the numerical modeling for the predictive analysis.

Test Engineering Support

Operating test procedures detailing the scope of work and functional responsibilities for Full-Scale Heater Tests #1 and #2 were completed and released in early February 1980. The full-scale heater tests utilize electric heaters in basalt to simulate and measure the effects of emplacement of nuclear waste in a repository located in basalt.

The operating test procedures define the responsibility for establishing test objectives, verifying and analyzing the data, and evaluating the impact of heater, power, instrument, and computer failures on the test, should they occur. Responsibility for the test development and control of the day-to-day activities associated with the testing are also identified. The schedule and procedures for the heaters and controllers are also included in the operating procedures. The heating schedules were reported in the first quarterly report for fiscal year 1980.

Drilling feasibility investigations have been performed for the jointed block tests at the Near-Surface Test Facility (see section entitled Construction Phase I and Phase II). Each jointed block test utilizes an 18-cubic-meter block of in situ basalt, free on five sides from the basalt rock mass. Electric heaters, extensometers, borehole deformation gauges, flatjacks, and thermocouples are used to determine thermal conductivity, thermal expansion, and rock-mass deformability with respect to temperature, stress fields, and rock quality. These data will be used to evaluate thermomechanical properties of the in situ rock and will provide a basis for comparison between the Near-Surface Test Facility and repository conditions.

CORE HOLE 2E19
Equal area stereonet - scatter diagram
number of poles = 144

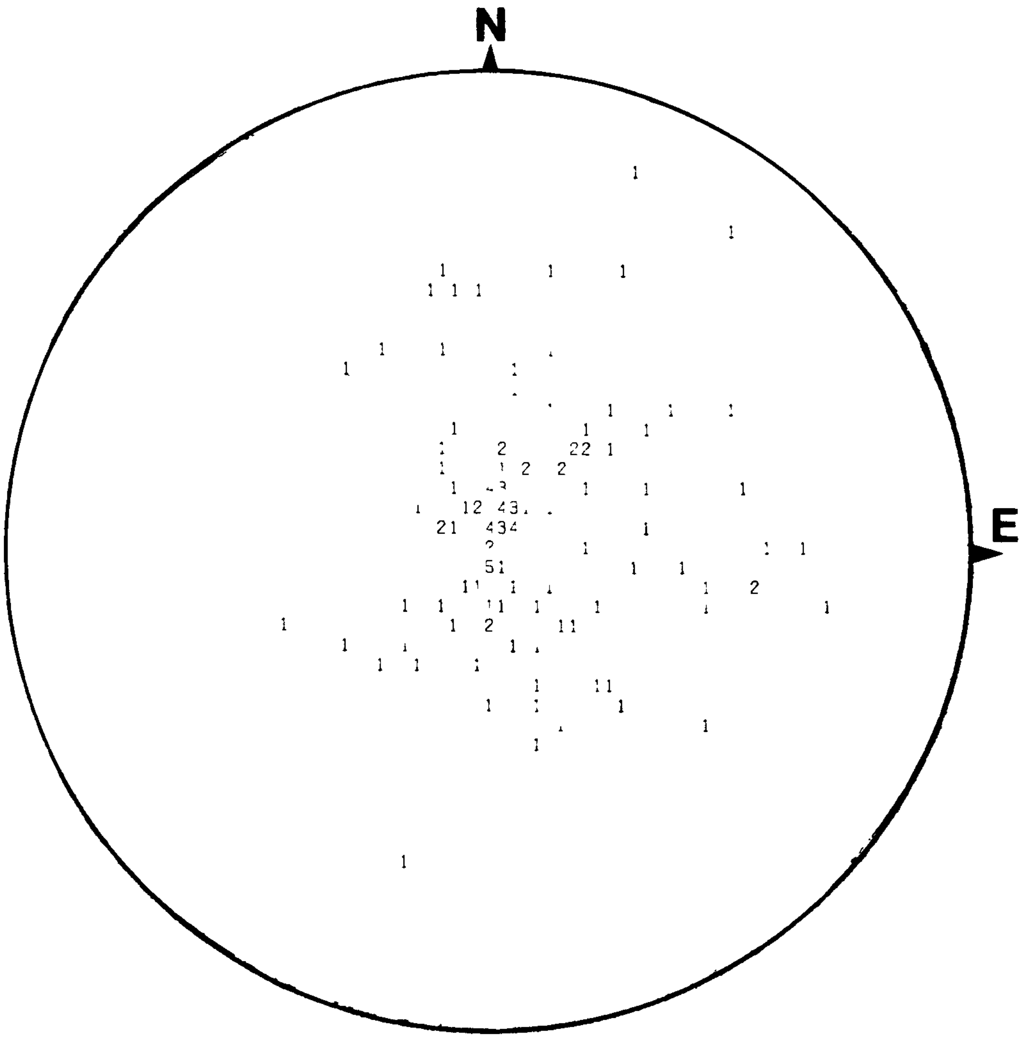

FIGURE 21. Scatter Diagram, Core Hole 2E19.

CORE HOLE 2E19

Equal area stereonet - contour plots indicate percentage of poles in an area of approximately 1 percent area

number of poles = 144

Contour Number	Percent
1	2.0
2	10.0
3	18.0
4	26.0
5	34.0

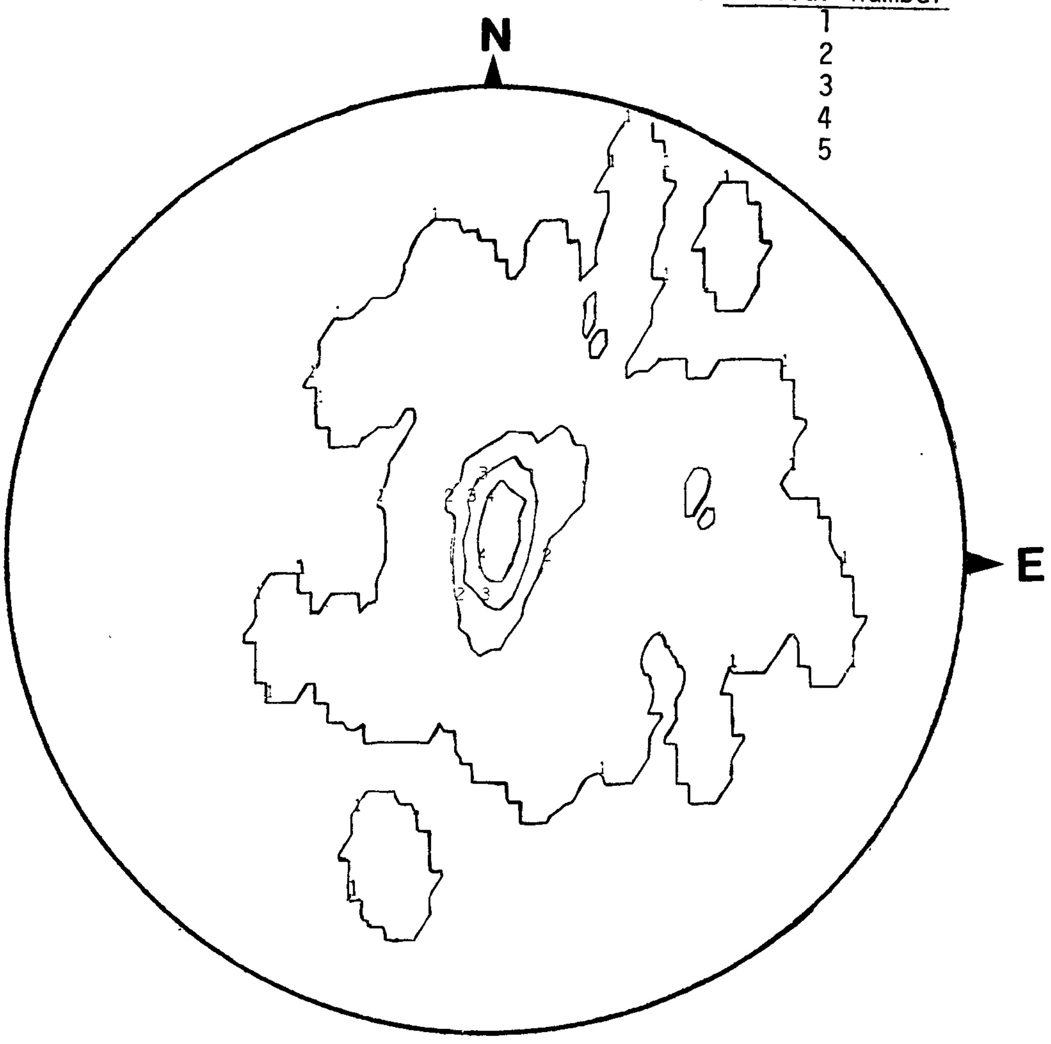

FIGURE 22. Contour Plots, Core Hole 2E19.

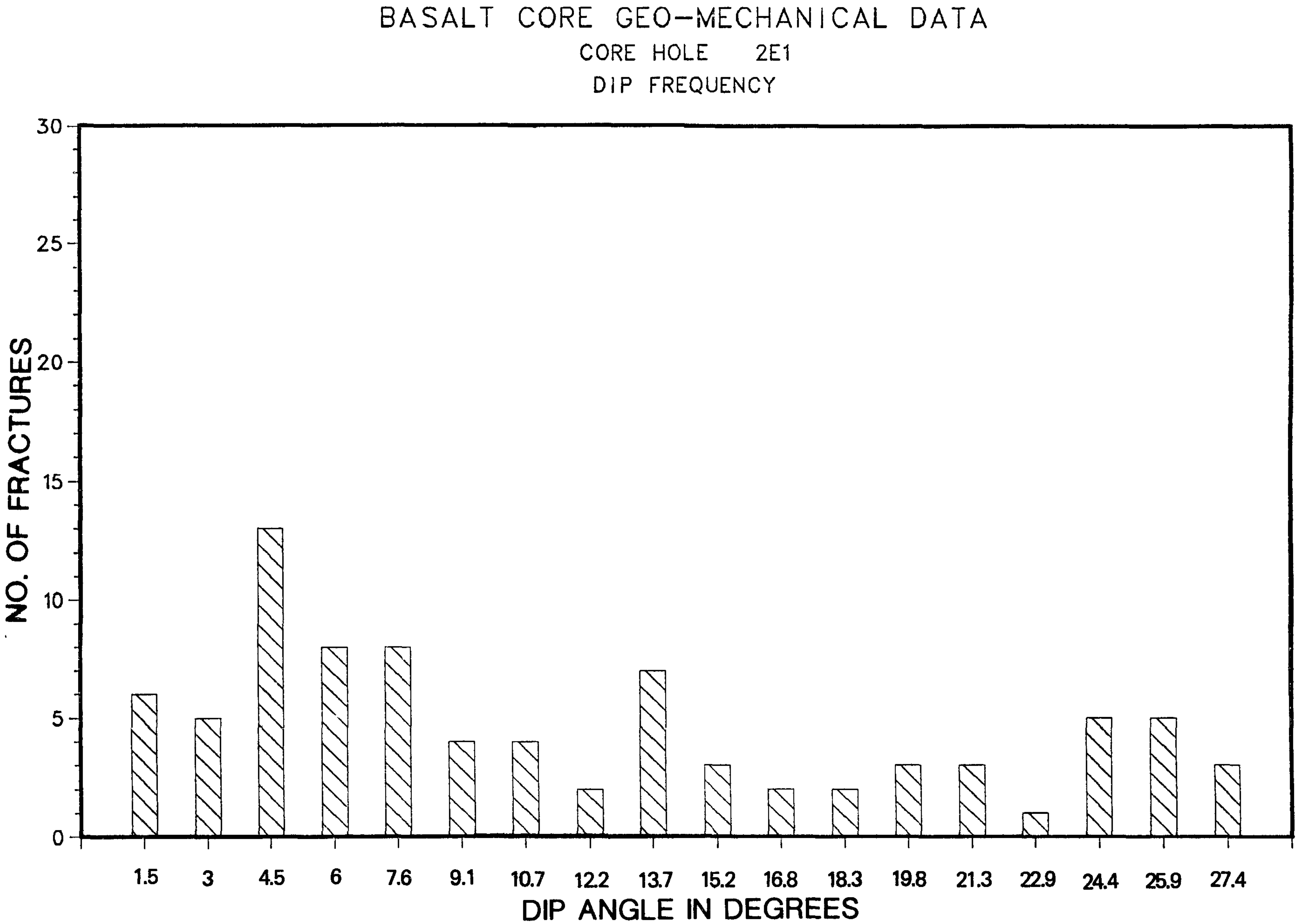

FIGURE 23. Basalt Core Geo-Mechanical Data, Core Hole 2E1; Fracture Frequency Versus Dip Angle.

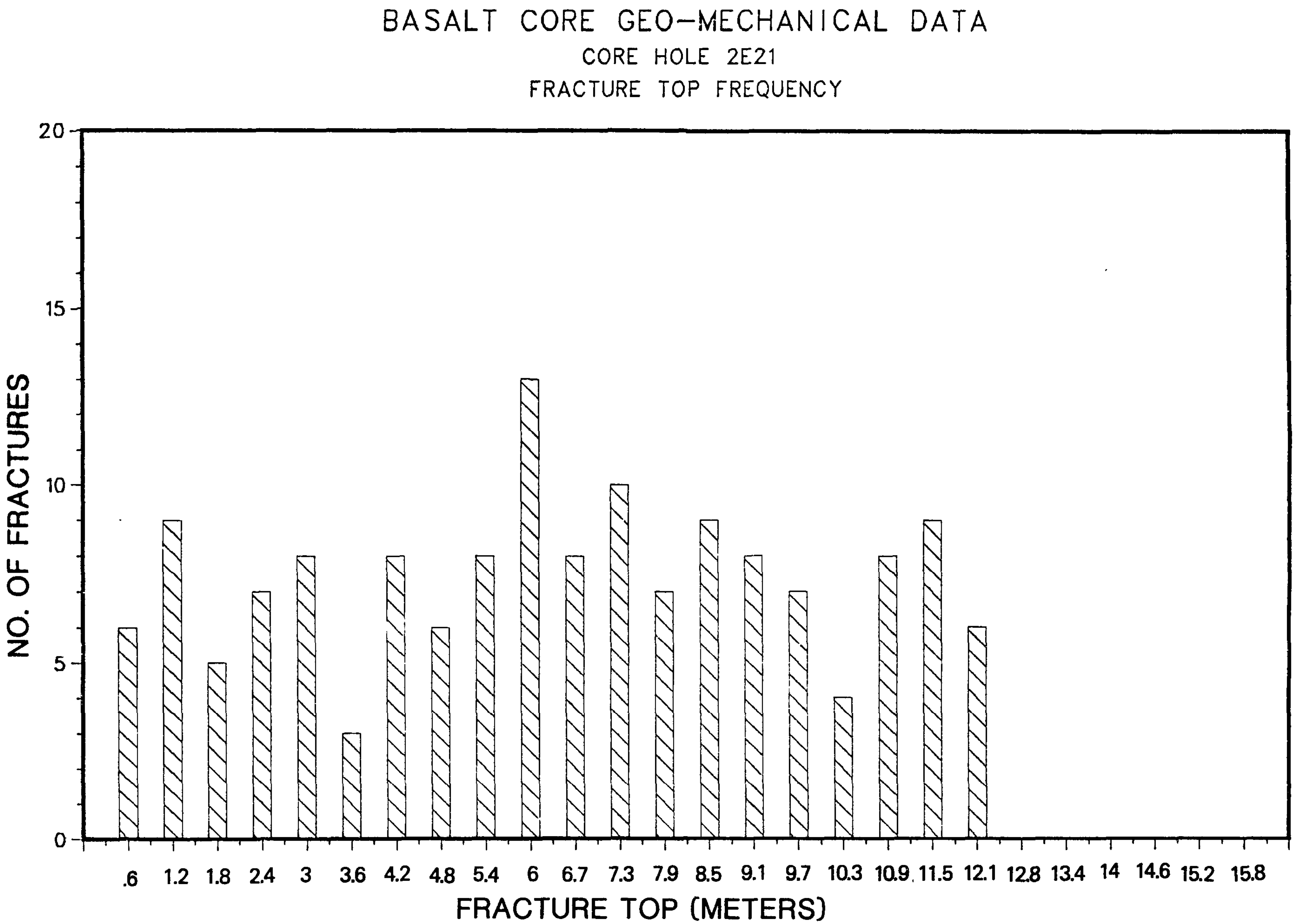

FIGURE 24. Basalt Core Geo-Mechanical Data, Core Hole 2E21; Fracture Frequency Versus Fracture Top.

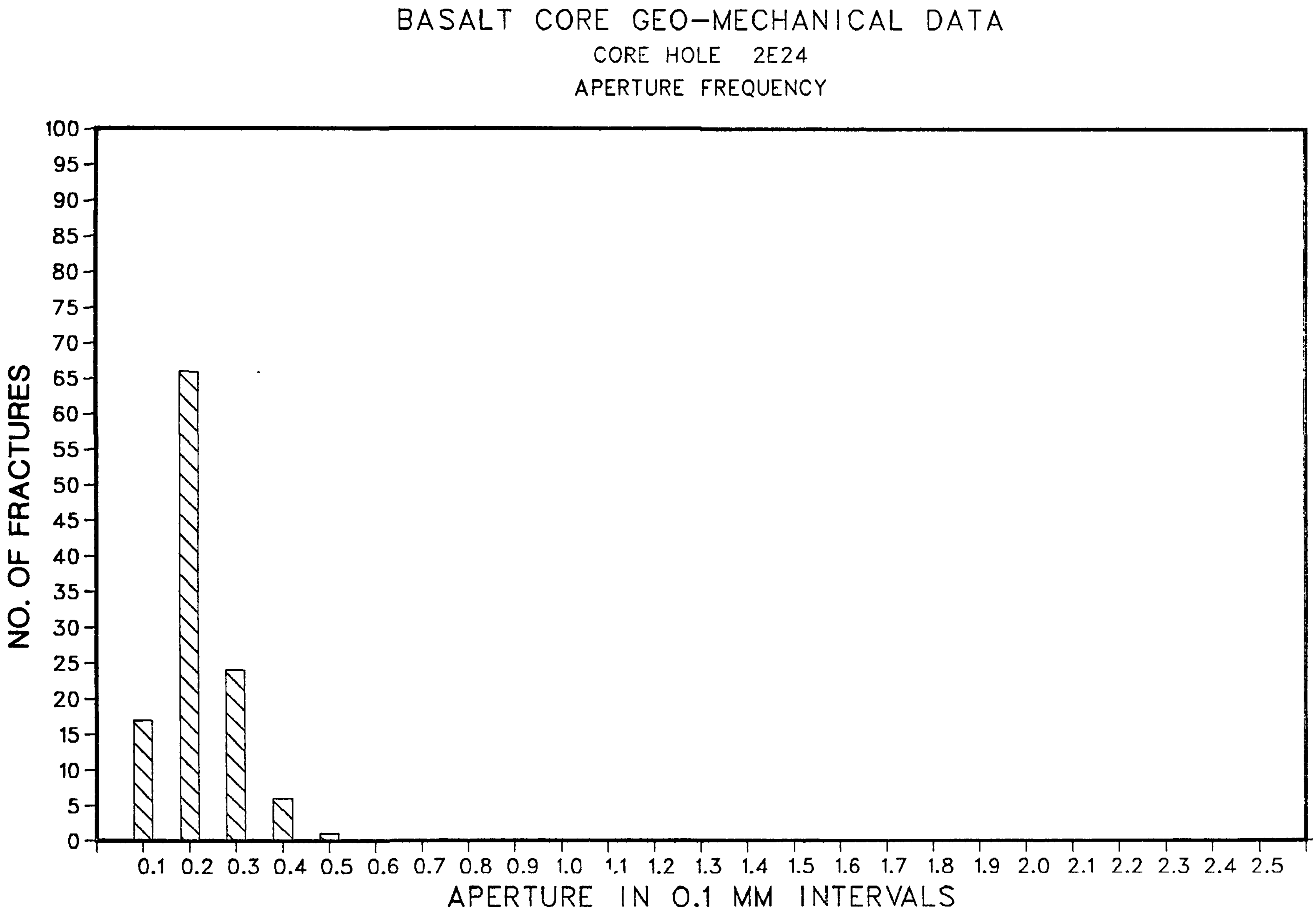

FIGURE 25. Basalt Core Geo-Mechanical Data, Core Hole 2E24; Fracture Frequency Versus Aperture.

Equipment Installation

Equipment installation accomplishments for the quarter included surveillance, inspection, and acceptance testing of: instrumentation assemblies; borehole extensometers; borehole deformation gauges; thermocouples; and heater assemblies. The installation of the rock instrumentation system required trained personnel to properly install the specialized assemblies. A 2-week training class on the installation procedures for the various types of rock instrumentation assemblies was conducted. An installation sequence was established that permitted concurrent installations at different locations within the Extensometer and Heater Test Rooms to reduce the installation time. Each borehole was cleaned and prepared ahead of the anticipated instrument insertion date to allow for a final inspection prior to the scheduled installation.

The location and orientation of the borehole and the location of the collar position relative to the borehole were recorded in borehole logs. These borehole logs were reviewed before the instrument sensor depths from the borehole collar were selected. The placement positions were identified prior to installation and all instruments were successfully placed at their specified depths to within the ±15.2-centimeter accuracy required.

Extensive laboratory tests and analyses were made to determine the need to grout the extensometer anchors; the results of these tests showed that grouting was not necessary. In some cases, grouting could actually degrade the accuracy of the instrument, since extensometer rod binding could result in introducing mechanical hysteresis errors in the extensometer readouts. Anchor grouting was deleted, with a subsequent reduction in installation complexity.

Two installation teams were selected; one to install the multiple-position borehole extensometer assemblies and the thermocouple assemblies, and the other team to install the U.S. Bureau of Mines' borehole deformation and IRAD Manufacturing Company gauge assemblies.

Surveillance of the installation was performed and daily logs were used to record progress. Notations representing as-built instrument sensor placements were entered onto a set of master control prints to update the prints upon completion of installation. An inspection record is maintained of the current status of the installation.

Acceptance test procedures have been written for use in determining the operability of the instruments. The acceptance test procedures call for exercising the completed rock instrumentation system and the Full-Scale Heater Tests #1 and #2 data acquisition system. Each instrument assembly will be monitored by the data acquisition system and appropriate sensor voltage outputs recorded and printed. This rock instrumentation/data acquisition systems checkout approach will provide a test of the interconnections within the system.

Rock instrumentation system assemblies have been installed for Full-Scale Heater Tests #1 and #2 and are presently being electrically connected to the data acquisition system. The following assemblies were installed:

- Full-Scale Heater Test #1

  Multiple Position Borehole Extensometer (22 assemblies)

  Nine vertical borehole assemblies

  Thirteen horizontal borehole assemblies

  U.S. Bureau of Mines' Borehole Deformation Gauges (12 assemblies)

  Six vertical borehole assemblies

  Six horizontal borehole assemblies

  NOTE: Eight of the 12 Full-Scale Heater Tests #1 U.S. Bureau of Mines' assembly boreholes also contained two IRAD Manufacturing Company gauges.

  IRAD Manufacturing Company Vibrating Wire Stressmeter Gauges

  One vertical borehole assembly

  Thermocouple Assemblies

  Seven vertical assemblies

- Full-Scale Heater Test #2

  Multiple-Position Borehole Extensometer (29 assemblies)

  Thirteen vertical borehole assemblies

  Sixteen horizontal borehole assemblies

  U.S. Bureau of Mines' Borehole Deformation gauges (16 assemblies)

  Ten vertical borehole assemblies

  Six horizontal borehole assemblies

  NOTE: Ten of the Full-Scale Heater Test #2 U.S. Bureau of Mines' borehole assemblies also contained two IRAD Manufacturing Company assemblies.

IRAD Manufacturing Company Vibrating Wire Stressmeter Gauges

One vertical borehole assembly

Thermocouple Assemblies

Nine vertical borehole assemblies

The unassembled, multiple-position borehole extensometers were shipped to the Near-Surface Test Facility. The packaged constituent parts were uncrated and inspected in the Extensometer Room buildup area. Each multiple-position borehole extensometer assembly consists of the following parts (see Figure 26):

- One set of hydraulic (bladder) anchors (three or four anchors as required)
- One set of anchor rods (as required)
- One set of hydraulic lines (as required)
- Five thermocouples with leads
- Silicone rubber-sheathed conduit
- One head assembly with supportive hardware and direct current linear variable differential transformers (as required)
- One set of instrument leads
- One set of hydraulic pressure gauges
- One hydraulic manifold.

Assembly of the multiple-position borehole extensometer included the following steps:

1. Trimming the interconnection rods to fit within the head assembly to allow free movement of the rods
2. Laying out the anchors at specified locations and attaching the interconnecting rods
3. Attaching the thermocouples at specified locations along the rods
4. Concurrent with steps (2) and (3), interconnecting the sheathed conduit
5. Attaching the transition flange (part of the head assembly) and mounting the pressure gauges and manifold

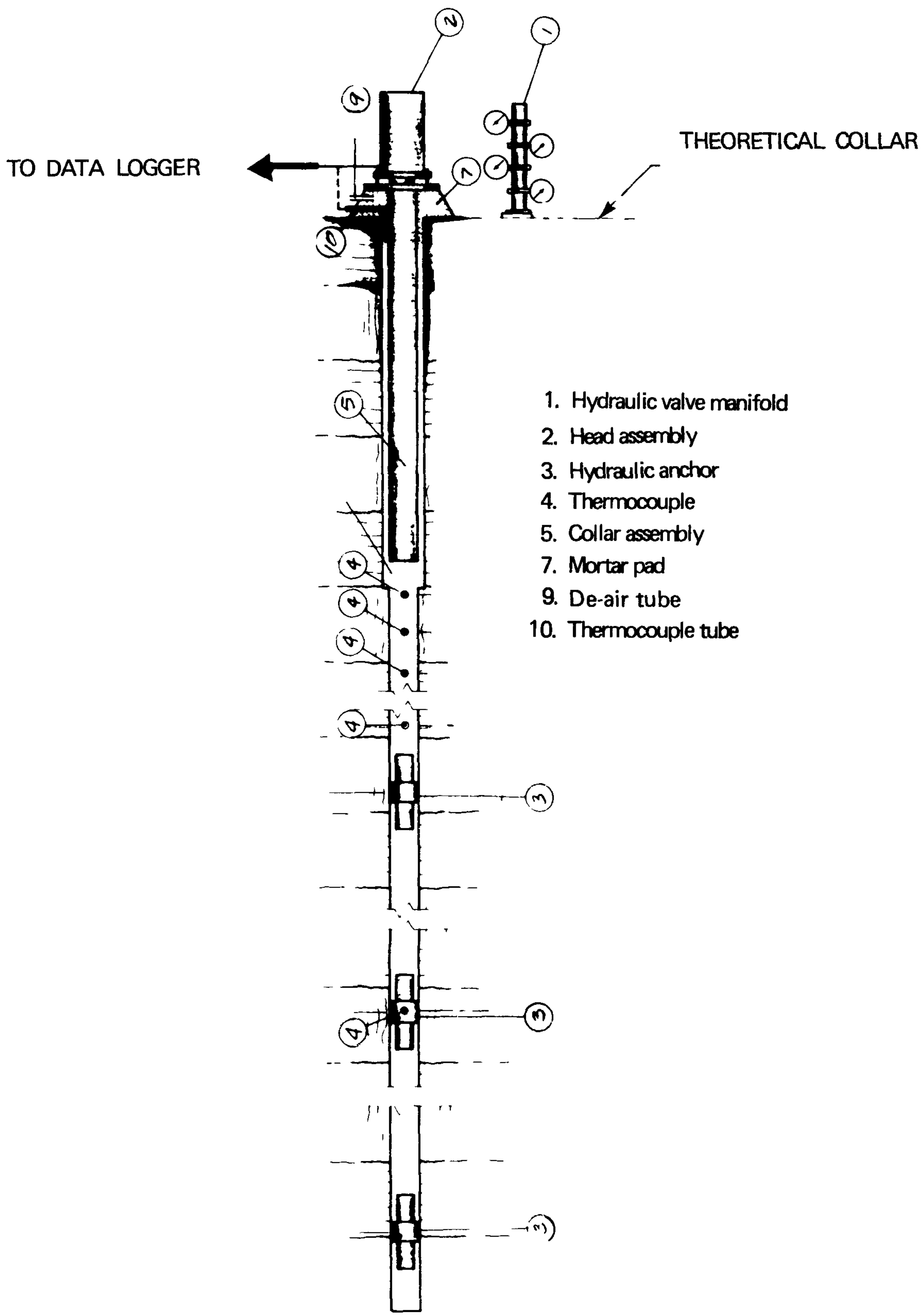

FIGURE 26. Multiple-Position Borehole Extensometer (Horizontal).

6. Connecting the hydraulic lines between the anchors and the hydraulic manifold.

After these initial steps, the anchor bladders were clamped and the hydraulic system tested to 13,790 kilopascals. This pressure was maintained for approximately 1 hour and a detailed inspection made for any leaks or drops in pressure. If the hydraulic system was found to be intact, pressure was released and the restraining clamps removed. The partially assembled, multiple-position borehole extensometer was then inserted into the borehole and the anchors set at their specified depths.

The transition flange was then mortared in place and allowed to set for about 24 hours. After the concrete set, the interconnecting rods were spring loaded to 500 newtons tension.

The final step of assembly consisted of attaching the head assembly electronics hardware, including the direct current linear variable differential transformers.

The multiple-position borehole extensometer assembly was then calibrated by moving the head assembly in calibrated distances and recording the direct current linear variable differential transformers output. Once calibrated, the multiple-position borehole extensometer was ready for connection to the data acquisition system.

All multiple-position borehole extensometer assemblies have been calibrated and the in situ anchor locations have been documented.

The U.S. Bureau of Mines' and IRAD Manufacturing Company gauges are used to measure radial deformation of the borehole. The U.S. Bureau of Mines' gauge provides a measure of the change in the borehole diameter along three radial axes, separated 120 degrees from each other, using cantilevered stressmeter bridges. The IRAD Manufacturing Company gauge measures the change in the borehole diameter using a vibrating wire suspended across a supporting cylinder. As the borehole diameter changes, the wire tension is adjusted causing the resonant frequency of the wire to change.

Three types of borehole deformation instrument assemblies were installed: (1) IRAD Manufacturing Company gauge only, containing two vibrating wire stressmeters mounted parallel to and perpendicular to selected axes; (2) one 3-axis U.S. Bureau of Mines' gauge only; and (3) one 3-axis U.S. Bureau of Mines' gauge and two IRAD Manufacturing Company gauges.

Installation began with cleaning the borehole and installing a borehole collar. The collar was aligned and the reference axis orientation scribed. It was then mortised in place and allowed to set.

After a setting and curing period, installation proceeded as follows:

- Level borehole collar plate and mark axis

- Shim the U.S. Bureau of Mines' gauge (adjust deflection for the borehole)
- Use borehole GO and NO-GO gauges to verify borehole diameter (nominal 4.80 centimeters)
- Place IRAD Manufacturing Company gauges in position in the borehole and anchor the gauge using the specially designed, hydraulically actuated platen (wedge) (This step applies only to the IRAD Manufacturing Company gauge.)
- Place U.S. Bureau of Mines' gauge in position in the borehole
- Perform electrical checks on the completed assembly.

The thermocouple assemblies were received with the thermocouples pre-mounted along the assembly at specified locations (Figure 33). Installation consisted of inserting the assembly and grouting in place. All thermocouple assemblies are installed and documented.

One main and eight peripheral heaters were installed in the Full-Scale Heater Test #1 room, and one main heater was installed in the Full-Scale Heater Test #1 room. Each main heater consists of a four-element heater assembly with 12 thermocouples. Installation consisted of building up segments of the heater assembly and lowering them into the 45.7-centimeter-diameter main heater borehole.

Each of the eight peripheral heaters consists of one heater element and six thermocouples. Installation consisted of building up two segments of the heater assembly and lowering them into the peripheral heater boreholes.

Depth, radial distance, and angular orientation records were completed to identify the thermocouple locations within the heater boreholes.

Operation

Chief Operation activities included training, facility readiness preparation, maintenance support, and startup team efforts. Training of personnel on the Near-Surface Test Facility operational procedures is on schedule and has included 10 administrative procedures and 26 of the 45 critical function alarm panel procedures. Training has also included instruction on the operation of the manual extensometer and adjustment of the anchor pressure on installed extensometers that are to be used during Full-Scale Heater Tests #1 and #2.

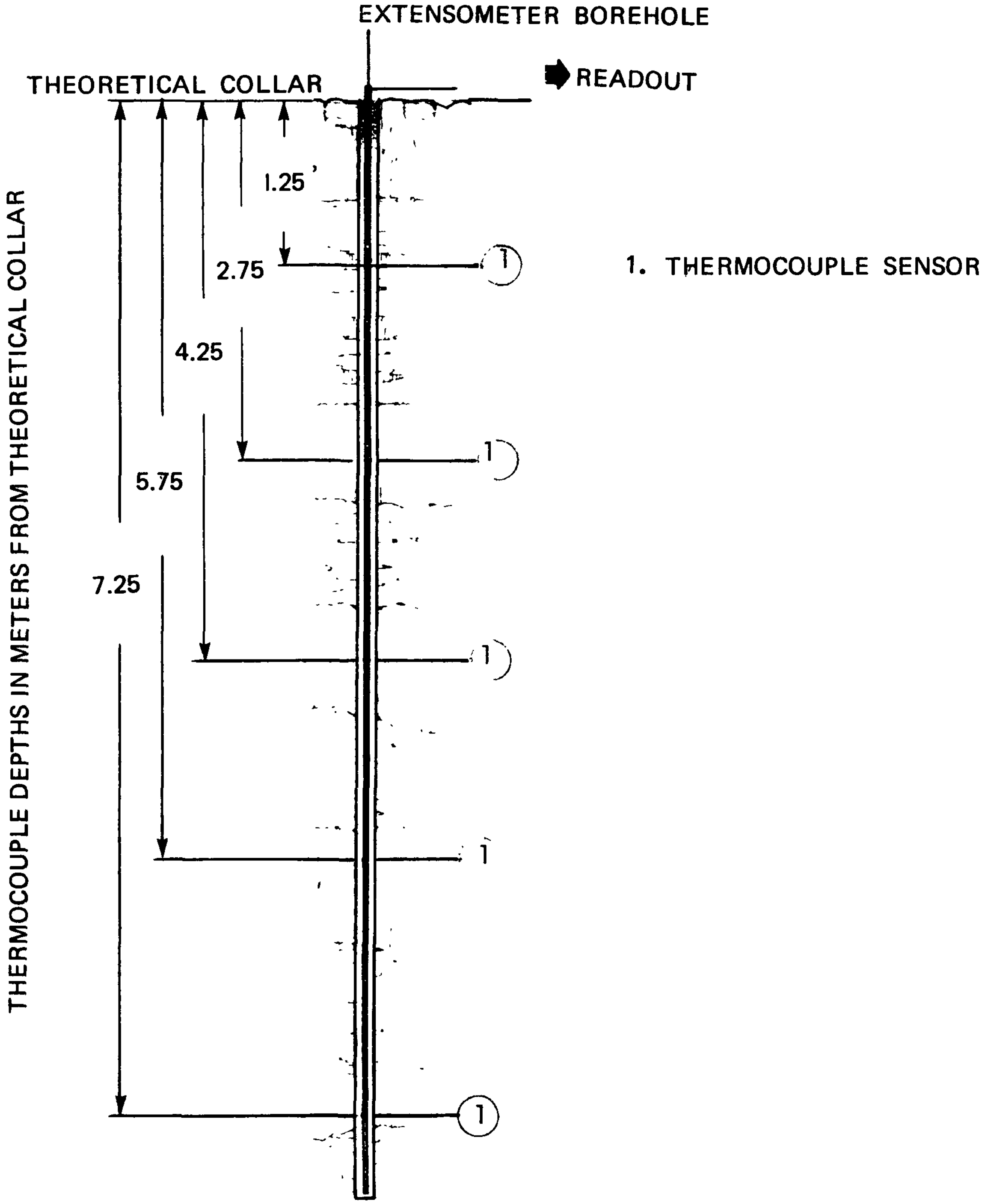

FIGURE 27. Thermocouple Assemblies.

Equipping of the facility for testing operations has included ordering a diesel-powered, self-propelled, mobile lift to be used in the tunnel area for examining ceiling areas and/or related maintenance functions in the heater and spent fuel test rooms, transfer rooms, and Tunnels #1 and #2. A diesel-powered, mine-tender vehicle for utility uses has also been ordered with delivery expected in July 1980. A display board of the tunnel areas showing fire zone and intercommunication system component locations was completed. The display board will be used to train operating personnel and to easily locate fire zones, communication points, and work locations of personnel in the tunnels if an emergency occurs during operation of the facility.

Maintenance personnel have been assigned to Gable Mountain, work areas have been designated, and maintenance responsibilities have been assumed for those portions of the facility that have been completed. Special tools for the repair of in situ instruments were obtained after completing the installation of rock instrumentation for Full-Scale Heater Tests #1 and #2.

The briefing (visitor) center trailer was delivered, facilities and furnishings were installed, and the facility is ready for beneficial use.

A startup plan was drafted by the Near-Surface Test Facility startup team for Full-Scale Heater Tests #1 and #2. The plan has been approved by the Readiness Review Board and work is under way by the startup team to provide the specified documentation required by the plan. A management oversight risk tree analysis for Phase I of the Near-Surface Test Facility has also been scheduled.

PHASE II

Demonstration tests will employ canistered spent fuel and vitrified waste to evaluate emplacement of canisters and the thermomechanical response of basalt. The demonstration tests are subdivided into the same activities as listed in the qualification tests, plus the spent fuel preparation activity. Efforts for this quarter were directed at spent fuel preparation.

Spent Fuel Preparation

As a part of the Phase II demonstration testing, the feasibility of using vitrified nuclear wastes (from spent fuel reprocessing) in the Near-Surface Test Facility was investigated and a conceptual design was started. Some of the technical considerations for this design are given in this section.

The source of the vitrified waste form was identified as Pacific Northwest Laboratory, since they have two canisters of vitrified waste from a past project. The Pacific Northwest Laboratory canisters exhibit two major differences from the spent fuel canisters to be used in the other demonstration tests:

- The size of the Pacific Northwest Laboratory canister is smaller than a spent fuel canister
- The radiation spectra and heat loading are different than that of the spent fuel canister.

Relative to the size difference between the canisters, the following options were considered:

- Modify the handling equipment and emplacement design to accommodate the Pacific Northwest Laboratory canister
- Place the Pacific Northwest Laboratory canister in the spent fuel canister.

Leaving the Pacific Northwest Laboratory canister the same size would necessitate extensive redesign of the canister-handling equipment including the bottom loading transporter; therefore, based on both cost and time factors, this option was rejected.

Placing the Pacific Northwest Laboratory canister in the spent fuel canister would have the advantage of using the same handling equipment, but would have the disadvantages of: (1) requiring encapsulation of the Pacific Northwest Laboratory canister in the spent fuel canister; (2) requiring a "cage" assembly to prevent the Pacific Northwest Laboratory canister from moving within the spent fuel canister (movement within the spent fuel canister could significantly damage the vitrified waste form and also could lead to uneven heating, since portions of the spent fuel canister would be in contact with the Pacific Northwest Laboratory canister resulting in directional heat loading); and (3) requiring modifications to the Pacific Northwest Laboratory canister to allow it to be loaded in the spent fuel canister.

The modifications to the Pacific Northwest Laboratory canister to allow it to fit in the spent fuel canister and the cage assembly were defined. These include removing the external thermocouples, removing the thermocouple connector pipe, removing the lifting bail, attaching the lid, and seal welding all openings to reduce the potential for contamination spread during the encapsulation. The Pacific Northwest Laboratory canister is shown in Figure 28.

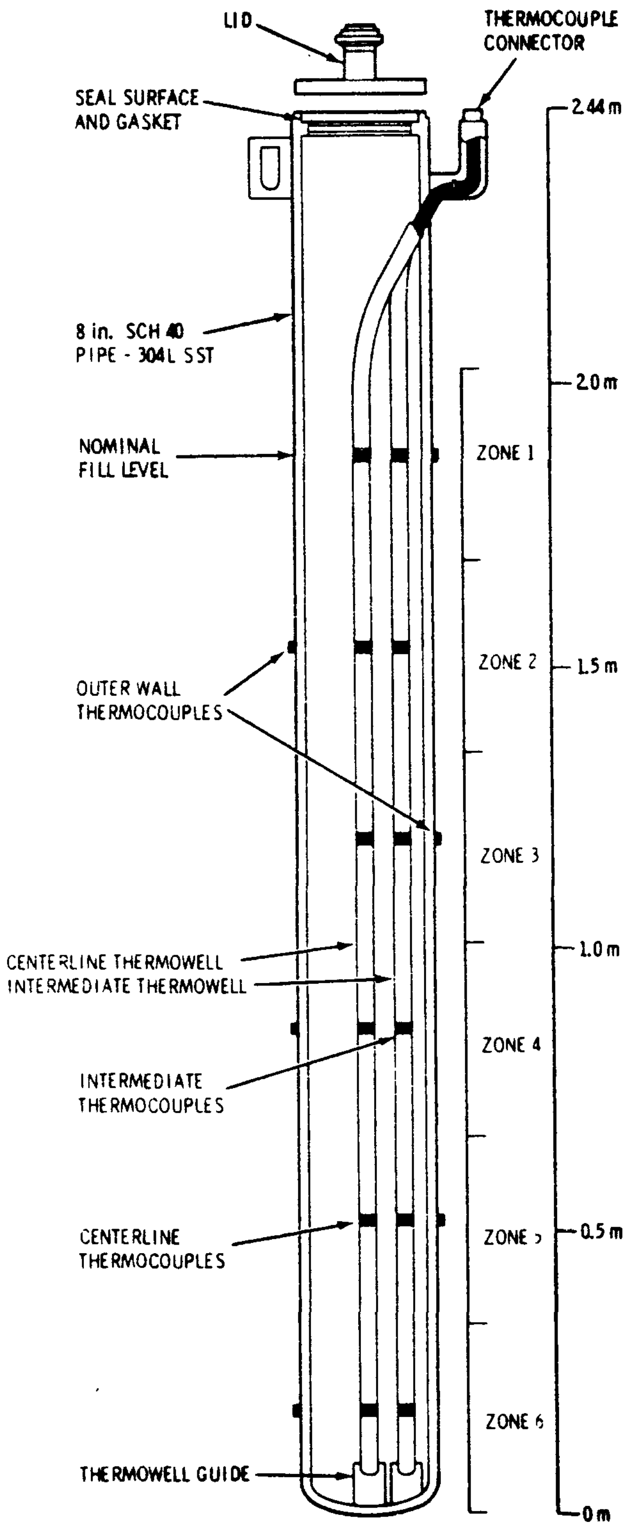

FIGURE 28. Schematic View of the Pacific Northwest Laboratory Vitrified Waste Canister.

OFFICE OF REPOSITORY STUDIES

The objective of the Office of Repository Studies is to design and construct a repository in Columbia River basalt for the storage and eventual disposal of nuclear waste. A supporting goal is to design and construct an Exploratory Shaft Test Facility on the repository site for detailed site characterization.

The Office Repository Studies end function is divided into seven major activities:

- Project Management
- Engineering Support
- Repository Design
- Long-Lead Procurement Support
- Construction Manager Selection Support
- Construction
- Site-Specific Tests.

During the second quarter of fiscal year 1980, work has progressed in four of these activities: project management; engineering support, repository design; and site-specific tests.

PROJECT MANAGEMENT

The project management activity is responsible for the management of the Office of Repository Studies end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

A Rockwell Hanford Operations' site representative was transferred to the architect-engineer's office during January 1980. The site representative is acting in a liaison capacity on a full-time basis to assure the cost-effective coordination and control of design work by the architect-engineer.

Monthly repository conceptual design review meetings were conducted with U.S. Department of Energy, Office of Nuclear Waste Isolation, Rockwell Hanford Operations, and Kaiser Engineers/Parsons Brinckerhoff representatives in attendance. A quarterly review meeting was held during January 1980.

Kaiser Engineers/Parsons Brinckerhoff has started preparation of a detailed tabulation of the information required for repository Title I design, preparation of an environmental report/license application, and preparation of a Schedule 44 for repository design and long-lead procurement.

The tabulation will include:

- A listing of the specific information items required to support each of the above activities
- Identification of the end use of each item
- An estimate of the acceptable range of uncertainty associated with required numerical values
- Identification of the source of information (referenced to specific program activities and test plans)
- A schedule indicating when each information item is required.

The completed tabulation will be used to assess program plans to ensure that information required to support these activities will be available when required, and to eliminate any work that does not directly support program needs. These data will be completed by April 15, 1980; the final report incorporating U.S. Department of Energy, Office of Nuclear Waste Isolation, and Rockwell Hanford Operations' comments will be available by June 1980.

ENGINEERING SUPPORT

Limited work was conducted in this activity during the quarter. A meteorological data report for the repository site, prepared in compliance with Regulatory Guide 1.23 (Onsite Meteorological Programs), was to be issued by February 1983 to support preparation of an environmental report. During fiscal year 1980, technical specifications for a meteorological station and a data collection plan were to be completed. Work on these tasks was started and subsequently terminated during the reporting period due to changes in the program schedule related to the recent U.S. Nuclear Regulatory Commission confidence rulemaking. Work in the meteorological area has been deferred until fiscal year 1983.

REPOSITORY DESIGN

The repository preconceptual design report will be issued during the next reporting period.

Repository conceptual design work by Kaiser Engineers/Parsons Brinckerhoff continued during the quarter with emphasis on the completion of the engineering studies supporting concept selection. During the

March 1980 design review meeting, a tentative selection of design concepts was made with the objective of accelerating the start of concept development work from August 1980 to June 1980. Although all engineering studies are not finalized, it was judged that concept selection could be completed at this time without significantly increasing the feasibility uncertainties of the selected concepts.

Tables 10, 11, and 12 summarize the major features of concepts selected for access shafts, subsurface facilities, and the waste-handling system.

SITE-SPECIFIC TESTS

The objectives of the Exploratory Shaft Test Facility related to the site characterization test program are:

- Measure rock properties and lateral variations within the proposed repository flow; define envelope of expected repository geotechnical conditions
- Measure rock properties and lateral variations in basalt flows surrounding the repository horizon
- Determine horizontal variations of hydrologic properties in a single, deep basalt layer and describe the bounding envelope of these properties
- Determine near-field hydrologic parameters that characterize the repository horizon
- Determine near-field hydrologic parameters that characterize the layers surrounding the repository
- Determine age of groundwater (if any) at proposed repository level and in surrounding horizons
- Evaluate the water-inflow potential into the repository layer and the surrounding horizons
- Establish the hydrologic baseline
- Assess the transport potential of the groundwater flow system.

TABLE 10. Concept Selections for Access Shafts and Related Service Systems.

Facility Component or Feature	Preferred Concept	Reasons for Preference
Shafts, Number	5	Prefer one for each function
Shaft 1, Confinement Air Intake 153 std. m^3/s	3.35 m I.D.	Retrievability and backfill cooling requirements
Shaft 2, Confinement Air Exhaust 153 std. m^3/s	3.35 m I.D.	Exhaust of heated air
Shaft 3, Men-And-Materials and Working Air Inlet 194 std. m^3/s	6.71 m I.D.*	Mining air intake and equipment size
Shaft 4, Basalt Hoist and Working Air Exhaust 175 std. m^3/s	5.49 m I.D.	Skip size and mine exhaust
Shaft 5, Waste Transport	3.66 m I.D.	Cage and counterweight
Shaft Lining	Concrete plus steel lining in aquifer zones	Waiting results of hydrologic studies
Shaft Sinking Method	Conventional drill-and-blast	Boring equipment not available
Water Control During Shaft Sinking	Freezing	Conservative approach to uncertainties associated with shaft sinking
Shaft Hoisting	Tower-mounted friction hoists	Cost, ease of operation, and safety
Ventilation	Complete separate air supply for confinement and mining work	Safety

*Possible size reduction later after study of equipment disassembly options.

TABLE 11. Subsurface Facilities and Related Service Systems.

Facility Component or Feature	Preferred Concept	Reasons for Preference
Storage Geometry	Single row vertical	Least basalt removed per spent fuel package (including engineered barriers)
Storage Pitch	3.66 m	Satifies criteria for maximum fuel clad temperature of 300°C
Storage Room Cross Section	4.27 m wide by 6.10 m high	Equipment and canister handling
Main Access Cross Section	5.49 m wide by 5.18 m high	Equipment and ventilation
Main Airways Cross Section Mining Side	5.49 m wide by 5.18 m high	Cooling flow requirements and equipment
Main Airways Cross Section Confinement Side	4.57 m wide by 4.88 m high	Cooling flow requirements and equipment
Room Length	4 equal 266-m long segments separated by cross cuts; 1,095 m total	Length compatible with ventilation requirements and waste receipt rate
Panel Dimensions	1,095 m by 219 m 6 rooms/panel	Annual receipt of 1,747 canisters
Subsurface Separation Distances--Shaft Pillar	305 m each side (610 m total)	Isolation barrier consideration
Separation Distance--Panel to Entries	30.5 m	Thermal, rock mechanics, and operating considerations
Rate of Storage	1,747 canisters per year	Average annual design receipt rate
Mining Method	Conventional drill-and-blast	Available proven technology
Ground Support	Rockbolts and shotcrete	Standard practice
Ventilation	Working level heat exchangers; exchange heat to working fluid which comes from and returns to central refrigeration plant at surface	Economic considerations
	106 std m^3/s of 27°C air sequentially pre-cools room segments prior to backfill or retrieval	Cool perimeter to 52°C in nine days prior to initiating backfill or retrieval at the same rate as storage
Mining Layout	In two directions from shaft pillar with rooms on both sides of main entrance	Rate of mining, rate of implantation, mining method, and ventilation

TABLE 12. Concept Selections for Waste Handling System.

Facility Component or Feature	Preferred Concept	Reasons for Preference
Shipping Cask/Hot Cell Interface	Integral cask-car, with movable sleeve at hot cell inlet port	Maximum safety and equipment simplicity, plus ease of registration
Hot Cell--Welding Method for Waste Package	Laser	Superior quality and location of almost all welding equipment outside hot cell
Hot Cell--Transfer Machine Type	Powered, rectilinear manipulator, similar to NWTS R2	Reliability (reduces reliance on operator capability); inherent greater through-put capability provides capability to handle high-level waste
Transfer Cask	Single-ended, bottom loading	Permits handling canister from a single end
Transfer Cask Mover, Hot Cell to Waste Cage to Transporter	Overhead rail machine with X and Z motion	Safety and simplicity
Transporter	Similar to NWTS R2	System simplicity and control of registration between cask and storage hole
Handling Method (Grapple Design) for Canister and Waste Package	Can be left open	Present concepts permit mechanical or magnetic handling
Waste Package Length	Different lengths for pressurized and boiling water reactor	Economics of waste package and mining excavation
Non-Standard Cask Handling	113-metric-ton crane before hot cell	Contingency equipment to provide flexibility
Pressure-Resistant Handling	Design for hydrostatic pressure	Hydrostatic pressure may be developed after backfill

The shaft for the Exploratory Shaft Test facility will be drilled to an expected depth of 1,130 meters, with a finished inside diameter of 1.8 meters. About 140 meters of tunnel drifts will be provided at the base of the shaft for testing space. While the Exploratory Shaft Test Facility has been sized to accommodate only those tests needed for in situ characterization, consideration will be included for performance of later engineering tests to support repository design, licensing, and operation.

A by-product of the installation of this facility will be information obtained on shaft-sinking rates for extrapolation to larger shaft sizes, integrity of shaft-grouting provisions for aquifer isolation, and tunnel-support requirements in the host flow.

During the quarter, work continued on preparation of the test plan for in situ characterization tests in basalt (Exploratory Shaft Test Facility). This test plan will form the basis for preparation of the functional design criteria document for the Exploratory Shaft Test Facility and for ultimate preparation of test procedures.

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