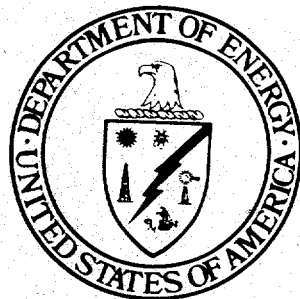


ANNUAL REPORT
NTS
TERMINAL WASTE
STORAGE PROJECT
FY 1978



UNITED STATES
DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE
LAS VEGAS, NEVADA

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ANNUAL REPORT
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INTRODUCTION AND EXECUTIVE SUMMARY

The primary thrust of the NTS Terminal Waste Storage Project during FY 1978 was to continue an evaluation of the suitability of the Nevada Test Site (NTS) for siting a commercial spent fuel or high-level waste repository. At the beginning of the year, three primary issues were identified. They are:

1. Is waste isolation at the NTS compatible with weapons testing?
2. Are there suitable geohydrologic settings available on the NTS?
3. Are there suitable disposal media available at NTS?

The NTS Terminal Waste Storage Project has been organized primarily to address these three issues. The southwestern area of the NTS has been identified as compatible with both current and future weapons testing. The NTS and adjacent areas of southern Nevada contain media which are probably suitable for waste isolation and which occur in a region characterized by long groundwater flow paths through sorptive media. However, utilization of the southwestern part of NTS requires that several geotechnical issues be addressed intensively. These are:

1. The potential for earthquakes at and near NTS.
2. The potential for future volcanism at possible repository sites.
3. The location and nature of faults.
4. The characterization of the groundwater flow system from possible repository sites to places of discharge.

Four potential disposal media available on the NTS were studied during FY 1978. Studies of one of these media, alluvium, were suspended due to the low near-field thermal conductivity. Studies of other potential media, granite, argillite, and tuff, will continue during FY 1979 since it appears that these media could be used for emplacement of commercial spent fuel or high-level waste. Geologic site investigations have and will continue to evaluate areas with these media.

FY 1978 program highlights are listed below:

WEAPON TESTING COMPATIBILITY

- FY 1978 analyses of weapons test-produced ground motion data have significantly reduced the previously predicted ground motion impacts on repository location or design.

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- The southwest portion of NTS has been established by the weapons testing community as an area where waste isolation would be compatible with both current and future known testing requirements.
- Initial estimates indicate that the cost increments to design repository facilities to withstand various levels (below 1 g) of predicted weapons testing ground motion are small.
- The Climax Stock, Twinridge Hill, and the Syncline Ridge area were eliminated from further consideration as possible repository sites because of their proximity to a weapons testing area.

AVAILABILITY OF SUITABLE GEOHYDROLOGIC SETTINGS

- A programmatic decision was made to suspend further geologic evaluation of the central block of Syncline Ridge due to the structural complexity identified by geophysical techniques.
- The geologic site evaluation program was redirected at midyear, and effort was concentrated on the southwest portion of the NTS. At the end of FY 1978, two areas were being evaluated: Yucca Mountain and Calico Hills. Other potential areas suitable for evaluation exist in the southwest portion of the NTS. These other areas were not evaluated during FY 1978 due to programmatic resource limitations.

AVAILABILITY OF SUITABLE DISPOSAL MEDIA

- Granite--Completed laboratory studies and the field experiment portion of an at-depth, small-scale heater test. FY 1978 results indicate that this medium can accept the thermal load imposed by high-level wastes.
- Argillite--Preliminary laboratory studies were completed and a near-surface, full-scale heater test was turned on and is continuing. No information has been identified which would disqualify argillite from consideration for spent fuel or high-level waste isolation.
- Tuff--The results of an initial scoping study were presented to a National Academy of Sciences Committee in September 1978. Based on this scoping effort, an expanded evaluation program is being planned for FY 1979.
- Alluvium--Based on a scoping study, the near-field thermal properties of alluvium appear to limit its utility as an emplacement medium for high-level wastes. However, its high sorptive properties enhance the suitability of disposal sites up the groundwater flow path from alluvial deposits. Further evaluation of alluvium as a disposal medium for high-level waste was suspended.

OTHER MAJOR PROJECT HIGHLIGHTS

- A quality assurance program has been started, including the preparation of an overall Quality Assurance Plan. Audits were started in September 1978.
- A spent fuel test in granite has been planned and construction started.
- Completion of inventory of granitic rocks in southern Nevada and the partial completion of inventories of shale/argillite and tuff rocks.

FY 1978 PROJECT SUMMARY

The following is a description of progress and achievements of project subtasks. It is a project management summary and does not include technical details of the work performed. In-depth technical data and results are reported in topical reports prepared by project participants.

Task 1 Seismic Investigations

Subtask 1.1 Data Processing and Analysis

Objective: To define the ground motion environment from underground nuclear explosions as a function of yield and distance and at specific potential repository sites.

The Environmental Research Corporation's (ERC) equations relating peak ground motion acceleration to test yield and distance were derived using a wide range of yields and distances. Because of this broad data base, it was believed that the ERC prediction equation would overestimate the statistical variation in predicted peak acceleration. This subtask determined the availability of pre-FY 1978 ground motion data within restricted ranges of distance and yield and analyzed these restricted data sets. Subtask 1.1 has also analyzed a portion of the new ground motion data collected for this project by Subtask 1.2 during FY 1978. The FY 1978 results of these data analyses have indicated that within the parameter ranges of interest and for a 99.9 percent level of confidence (3σ), the predicted distance associated with a given test yield and peak ground motion acceleration is approximately one-half of the corresponding ERC distance prediction.

Subtask 1.2 Weapons Test Ground Motion Data Measurements

Objective: To make ground motion measurements at specified locations to provide the basis for determining how weapons test-induced ground motion changes with depth, distance, and yield; and to determine for candidate sites whether or not there are site specific ground motion anomalies.

The data acquired in this subtask are obtained on analog tape, digitized, and fed directly into the data analysis--Subtask 1.1. Surface stations and downhole instrumentation were installed at approximately twenty locations on and near the NTS, with each station measuring three components of acceleration. Numerous movements of these measuring stations throughout the NTS were necessary in FY 1978 to provide appropriate ranges of yields, distance from events, and media. In excess of 550 ground motion measurements were obtained from surface and downhole instruments during FY 1978.

Subtask 1.3 Facility Hardening Studies

Objective: To estimate the added costs required to protect a repository, at candidate NTS sites, against weapons test ground motion and to review the status of seismic design criteria.

This subtask provided a preliminary analysis for three candidate media (argillite, granite, and tuff) of ground motion effects on repository design and costs. In April 1978, a report entitled "Design Cost Scoping Studies," JAB-99-123, which estimated the added hardening cost as a function of media, surface and subsurface facilities, and peak ground acceleration, was published. Estimated cost increases, relative to a zero g static design, are less than 35 percent for all media considered and for a 1.0 g dynamic loading design.

The second portion of the subtask was to review seismic design criteria, summarize existing standards, guides, criteria, and analytical techniques for static and seismic design of nuclear facilities for their applicability to seismic design aspects of a repository. This preliminary work was included in a September draft report entitled "Progress Report, Seismic Design Criteria," currently being reviewed.

Subtask 1.4 Effect of Depth on Ground Motion

Objective: To develop an analytical prediction capability for subsurface ground motion when provided with the surface ground motion parameters and the necessary geological and physical description of the proposed site.

This subtask was initiated at midyear to review and catalog the available literature relating to the analysis of subsurface seismic motion necessary for design of underground openings and to review and evaluate all experimental data relating to the simultaneous recording of surface and subsurface seismic stations. An interim report entitled "Effect of Depth on Ground Motion" recommended continuation of this effort based on the results of literature surveys. Modeling efforts concentrated on the design and implementation of several digital filters for processing the measured at-depth data from Subtask 1.2. Analytical results obtained during FY 1978 show excellent agreement of spectral and peak amplitude values with those obtained independently by Subtask 1.1. This experimental at-depth data will be used to compare with the analytically predicted at-depth ground motion during FY 1979.

Task 2 Geological Investigations

Subtask 2.1 Tectonics, Seismicity, Volcanism, and Erosion

Objective: To assess the potential for damaging earthquakes, recurrence of volcanism, and acceleration of erosion in parts of the southern Great Basin.

The major seismologic effort in FY 1978 was deployment of a seismic net in an area of approximately 100-mile radius around the NTS. The net is presently about 95 percent complete, and full recording operations are expected by January 1979. A preliminary map of faults that offset Quaternary deposits on the NTS and nearby areas was compiled from aerial photographs and field reconnaissance. Three trenches were excavated, two across the Rock Valley Fault in upper Rock Valley and one in a pond deposit, probably fault-controlled, in western Yucca Flat. Carbonate samples from displacement zones and soils exposed in the trenches and along other faults were collected and dated by disequilibrium uranium series techniques.

The study of recurrence of volcanism was begun by radiometric dating of samples of relatively young basaltic and silicic rocks on and near the NTS. The silicic volcanic rocks of the NTS region are older than 5 million years and younger than 25 million years. Basaltic rocks in the NTS area are not voluminous, but have been erupted sporadically in the last 10 million years; the youngest eruption (near Lathrop Wells) occurred about 0.23 million years ago. Analysis was also begun of petrographic and chemical data of rocks from the youngest (7.5 m.y.) major silicic eruptive center and a similar center about 14 million years old. Erosional studies have concentrated on developing the Quaternary stratigraphy and tectonic framework of the alluvium-filled valleys on the NTS.

Subtask 2.2 Eleana Investigations

Objective: To characterize the candidate argillite mass located at Syncline Ridge with respect to its spatial dimensions, structural integrity, fluid permeability, and mineability.

During the first half of FY 1978, the mineability of argillite in the central block of Syncline Ridge was estimated and documented. Geophysical investigations of the middle block of Syncline Ridge indicated more structural complexity than originally anticipated. For this reason, further consideration of the Syncline Ridge area was suspended during April 1978, and the planned Syncline Ridge drilling activity was canceled. The remainder of the fiscal year was devoted to concluding the ongoing site evaluations and summarizing the available site information. Laboratory studies of Eleana argillite indicate very low matrix permeability values, typically about or less than 1.0 nanodarcy. Samples with induced through-going fractures were tested at confining pressures simulating

overburden depths of about 3,000 feet, with the results indicating permeabilities one to two orders of magnitude higher than those measured with intact samples.

Subtask 2.3 Low Test-Interference Areas

Objective: To evaluate the geologic and hydrologic factors affecting the waste isolation suitability of low-test interference areas of NTS and develop plans for site investigations of those areas that are potentially suitable.

This subtask accelerated its efforts following the project redirection subsequent to suspension of the Syncline Ridge evaluation. Geophysical surveys were conducted in the northern portion of Jackass Flats, Calico Hills, Climax Stock, and at Yucca Mountain. Two exploratory holes were sited, drilled, and continuously cored to 2,500 feet.

The Yucca Mountain drill hole, UE25a#1, encountered no major unexpected conditions. The partially welded upper part of the Crater Flat tuff, a potential emplacement unit, was reached at about 2,200 feet. Core from the drill hole in the densely welded sections (0-1,300 feet) showed extensive faulting and fracturing; only minor faulting and fracturing was observed in the deeper half (1,300-2,500 feet) of the hole.

The Calico Hills drill hole failed to penetrate a granitic body initially predicted to lie less than 2,500 feet below the surface based on interpretation of a large magnetic anomaly and of mineralogic alteration of rocks at the surface. The upper 1,300 feet of the drill hole penetrated argillite. At 1,300 feet, altered argillite was encountered. This rock is underlain by marble at about 2,350 feet. The core from the drill hole (UE25a#3) is highly fractured and brecciated throughout the total depth of the hole. Present estimates, based on newly obtained geophysical data, suggest that the intrusive is deeper than 4,000 feet beneath the surface. Preliminary electrical data indicate that an unfractured intrusive may not occur at a depth less than about 9,000 feet.

Paleohydrological studies emphasized a search for ancient spring deposits on and near the NTS. Preliminary results of the search indicate that Pleistocene groundwater discharge downgradient from the NTS was limited to elevations below about 2,500 feet, which is about 150 feet above the upper elevation of present springs. Initial studies of subsurface alluvial stratigraphy and paleopedology were begun to attempt to determine pluvial cycle water table levels in desert basins that are higher than the upper discharge elevation limit.

Subtask 2.4 Solute-Transport Model

Objective: To develop a digital hydraulic and solute-transport model to predict rates of movement of radioactive species and their concentrations in groundwater if they

should be released from a waste repository on or near the NTS.

Major effort in FY 1978 was placed on the collection and compilation of all available data on hydrologic conditions on and near the NTS. Drill hole records were compiled to obtain spot elevations which were then contoured by computer techniques to produce a first approximation water table map. Drill holes are very unevenly distributed throughout the region, with major concentrations in Yucca Flat, Pahute Mesa, Frenchman Flat, and Mercury Valley. Other areas have no or only sparse water table information. Hence, water table maps must presently be largely conjectural for significant areas of the southern Nevada region. Constructed water table maps were used to define nodal elevations on a 10- by 10-kilometer grid spacing for computer simulation of head potentials. From the hydrologic and geologic literature, estimates of transmissivity, saturated thickness, cross-sectional area of aquifers, and recharge-discharge flux were added to the matrix to define a model of factors that control regional groundwater flow. A standard USGS finite difference hydraulic computer code was chosen for first-run analysis of the two-dimensional model, and debugging was completed. Saturated thickness maps for alluvial, tuff, and carbonate aquifers were prepared from the geological and hydrological data base. The regional groundwater flow model is the first step toward creation of a radionuclide transport model for the NTS region.

Subtasks 2.5 and 2.7 Off-Site Investigations

Objectives: To identify and systematically appraise large masses of granite, argillaceous rocks, and tuff near the NTS.

Geological investigations outside the NTS during FY 1978 were primarily literature surveys, reconnaissance geological field studies, and map compilations of geologic, geophysical, and hydrologic data. These investigations resulted in completion of a draft report, "Preliminary Inventory of Granitic Masses in the State of Nevada," presently in review, and partial completion of reports on the distribution of clay-rich rocks in eastern Nevada, and on the distribution of tuffaceous rocks in southern Nevada. The granite inventory report includes 1:500,000-scale maps of the state of Nevada: aeromagnetic, generalized tectonic, groundwater recharge-discharge and general flow direction, and granite outcrop areas. The narrative describes the very general petrographic, geological, and hydrological settings of the exposed plutons in Nevada. The off-NTS studies will be used as base data for preliminary screening of geological settings with regard to their suitability for high-level waste isolation.

Subtask 2.6 Timber Mountain Wrap-Up

Objective: To complete preliminary definition of the subsurface geology and structure of the Timber Mountain area.

Electrical, gravity, and aeromagnetic geophysical surveys of the Timber Mountain area were completed during FY 1978. Results of these surveys were matched with existing data and evaluated. Interpretations generally indicated that a higher porosity, higher water content zone overlies a dense, relatively impermeable zone beneath the resurgent dome. The lower, dense zone is inferred to be a silicic-type intrusion associated with resurgence and offers potential for effective isolation of high-level waste. Based on weapons testing compatibility and project guidance, major exploration effort was directed to other areas on NTS.

Task 3 Media Investigations

Subtask 3.1 Argillaceous Experiments

Objective: To characterize the response of Eleana argillite to the thermal and structural loadings imposed by the emplacement of high-level waste sufficiently to permit a preliminary assessment of the suitability of Eleana argillite (or any argillite) for isolation of spent fuel or high-level waste.

Both field and laboratory activities were conducted in this subtask during FY 1978. A near-surface Eleana argillite full-scale heater test was fielded and operated for approximately the last half of the year. The design of the heater test was initiated during FY 1977, as was site selection and some preliminary site preparation. During the second quarter of FY 1978, scaled heater tests were initiated and completed. The data from these tests agreed with pretest modeling and supported the feasibility of a long-term, full-scale heater test.

Near-field thermal modeling of the full-scale heater experiment was performed both before and during the test operation. During initial operation of the full-scale test, water entered the heater hole. Modifications were made to measure and collect this water, and the experiment was restarted in mid-May. Full power, 3.8 kw, was attained in early June. No water has appeared in the heater hole since June, and temperature profile predictions based on conductive heat transfer along the strike compare well with the in situ field data. The source of the water is currently an unresolved issue.

Laboratory measurements were made of thermal, mechanical, sorptive, and mineralogical properties of various argillite samples. Some preliminary thermal and mechanical modeling was done for a hypothetical repository located in Eleana argillite using an assumed stratigraphy and media

properties measured in the laboratory. This modeling included near-canister effects as well as far-field thermal (repository modeled as a thin disk smeared heat source) and mechanical response. Based on these thermal and linear elastic stress calculations, no known near-canister or far-field thermal or stress limits were exceeded with 10-year-old high-level or spent fuel wastes emplaced at 150 kw/acre at a depth of 600 meters in the assumed stratigraphy.

Subtask 3.2 Tuff Experiments

Objective: To provide an initial evaluation of tuffs as media for nuclear waste isolation.

This subtask initially concentrated on a literature review and laboratory measurements of existing core to define ranges for the mineralogical, thermal, mechanical, and sorptive properties of tuffs.

The very good sorptive properties of tuff measured indicate that a repository located in a tuff setting could provide excellent multiple barriers to radionuclide transport. The thermal and mechanical data, combined with preliminary modeling, indicated that, with appropriate repository design, tuffs could dissipate the heat produced by spent fuel or high-level waste. The scoping data and conclusions drawn from them, combined with discussions of the origins, occurrences, and typical geohydrologic settings of tuff, were presented to the National Academy of Sciences Committee on Radioactive Waste Management in September 1978. The presentation identified favorable aspects, unfavorable aspects, and unresolved issues associated with tuffs and their geohydrologic setting in the Basin and Range Province.

Plans for experiments designed to provide an understanding of the major media-related unresolved issue, impact of the water content, were nearing completion by the end of FY 1978.

Subtask 3.3 Granitic Experiments

Objective: To provide a basic characterization of the Climax granite's response to thermal and structural loading.

Included in this subtask was the operation of an at-depth heater test designed and constructed in FY 1977, laboratory studies of the sorption characteristics of the Climax granite, and modeling for the initial design of the Spent Fuel Test (Task 7). The heater test was designed to measure the bulk thermal conductivity both parallel and perpendicular to the principal local fractures. Preliminary results indicate a net thermal conductivity of approximately 3 W/m²-K both parallel and perpendicular to fracture directions. During operation of the second of the two heaters used in this initial test, a localized hot spot required decreasing the heater power. The temperature rise was accomplished by

excursions of both temperature and fluid pressure at 0.5 meter from the heater hole. This phenomenon did not occur during operation of the first heater. It is hypothesized that the local temperature excursion was caused by drilling dust which accumulated around the lower thermocouple.

After completion of the thermal conductivity tests, the experimental setup was used to measure the granite matrix permeability and its variation with temperature. Preliminary data analysis of this second phase of the heater test indicates a matrix permeability of 200 to 600 picodarcies at 32° C., decreasing to less than 20 picodarcies at 75° C.

Subtask 3.4 Alluvium Studies

Objective: To provide a preliminary evaluation of the waste isolation potential of alluvium.

The occurrences; geologic and hydrologic characteristics; and thermal, mechanical, and mineralogical properties of alluvium-filled valleys within the NTS region were summarized in a draft report entitled "Preliminary Evaluation of the Radioactive Waste Isolation Potential of the Alluvium-Filled Valleys of the Great Basin." Based on data and thermal calculations presented in this draft report, alluvium appears to rank behind other media (for high-level waste isolation) in all properties examined except radionuclide sorption properties. It was recommended that alluvium be considered a secondary barrier to radionuclide migration for a high-level waste repository. This study concluded the subtask effort.

Task 4 NTS Engineering and Technical Support

Objective: To provide technical support requirements of the project by the NV prime A-E support contractors and the NV prime operating contractor.

This task provided technical support (such as surface facility engineering, drilling and mining cost estimating, aerial photographic services, core library, field geology support, etc.) to the project. FY 1978 activities of this task are implicitly included in the reports of all other tasks or subtasks.

Task 5 Quality Assurance

Objective: To develop and implement the NTS Terminal Waste Storage Project Quality Assurance Plan.

The Quality Assurance Overview contractor, reporting directly to the Project Manager, provided guidance to all project participants concerning quality assurance policy and requirements for the NTS Terminal Waste Storage Project. Using this guidance, laboratories and agencies participating in the project have initiated development of individual Quality

Assurance Plans utilizing their own Quality Assurance organizations or appropriate subcontractors.

The Quality Assurance Overview contractor also initiated the preparation of the overall NTS Terminal Waste Storage Project Quality Assurance Plan. This overall Quality Assurance Plan will be completed during FY 1979, and audits will continue.

Task 6 Project Management

Objective: To provide technical management support to the NV project manager.

This task provides technical guidance to the NV Project Manager, including project planning, integration and evaluation, and related technical and administrative support. The Technical Overview contractor, working with Technical Project Officers, other project participants, and the NV Project Manager:

- Defined critical issues associated with evaluating the waste isolation potential of the NTS, formulated a conceptual plan to address these issues, and prepared a formal project plan.
- Documented the criteria for the recommendation to suspend exploration of the central block of Syncline Ridge.
- Presented technical briefings to representatives of DOE/HQ, NRC, the State of Nevada, and the Air Force.
- Working with tuff project participants, prepared and presented to NAS an evaluation of tuffs as disposal media.

Task 7 Spent Fuel Test

Objective: To emplace safely, store for a 3- to 5-year period, monitor, and retrieve approximately 11 spent fuel canisters.

This task, initiated at midyear, started with a conceptual design of the Spent Fuel Test planned for the Climax Stock. The test was designed to simulate, with supplementary heaters, an accelerated thermal history of a "module" of a spent fuel repository in granite. Data and models from Subtask 3.3 were used in this design process. Exploratory core drilling to investigate the area planned for the test was conducted during the last quarter of FY 1978. Drilling of the vertical access hole, which will be used to transfer spent fuel to the 425 m level of the test in the Climax Stock, was also started. The existing service and entry shaft was rehabilitated in preparation for FY 1979 mining operations.

Spent fuel canister design, handling, transportation, transfer systems, drift design, and instrumentation definition comprised the major engineering efforts conducted during FY 1978.

A draft of the "Technical Concept for Test of Geologic Storage of Spent Reactor Fuel in the Climax Stock, NTS" was issued at the end of the fiscal year.

Distribution for NTS Terminal Waste Storage Project Annual Report

DOE/HQ Personnel

S. Meyers, ETW
R. G. Romatowski, ETW
C. W. Kuhlman, ETW
C. A. Heath, ETW
C. H. George, ETW
C. R. Cooley, ETW
D. L. Vieth, ETW
R. Stein, DWM
M. W. Frei, DWM
R. H. Campbell, ETW
E. C. Hardin, ETW

DOE Field Offices

D. Squires, RL
F. Standerfer, RL
D. T. Schueler, AL

U.S. Department of Energy
c/o Battelle Office of
Nuclear Waste Isolation
505 King Avenue
Columbus, OH 43201
Jeff O. Neff

DOE/NV

M. E. Gates/T. E. Wade, MGR/DMGR
R. D. Duncan, AMA
R. W. Newman, AMO
R. W. Taft, AMPE&B
J. B. Cotter, Dir., E&EAD
A. J. Roberts, P&BD
J. R. Gilpin, Dir., P&BD
R. D. Betteridge, P&BD
R. M. Nelson, Jr., E&EAD
H. L. Melancon, E&EAD
M. P. Kunich, E&EAD
NV Technical Library (2)
P. J. Mudra, OSD
R. H. Marks, OCC, CP-1

DOE/NTSSO

J. H. Dryden, Dir., NTSSO
C. P. Bromley
F. R. Huckabee

NRC

W. Bishop, M/S SS-604
Washington, DC 20555

J. Malaro, M/S SS-674
Washington, DC 20555

Rockwell-Hanford Operations
Richland, WA 99352

R. Deju
B. Dietz

LASL

K. Wolfsberg, Los Alamos, NM, M/S 514 (2)
L. Lanham, Los Alamos, NM, M/S 755
J. R. Smyth, Los Alamos, NM, M/S 978
L. Germain, Los Alamos, NM, M/S 570
B. Crowe, Los Alamos, NM, M/S 978

LLL

L. D. Ramspott, Livermore, CA (2)
L. Ballou, Livermore, CA

Sandia

E. H. Beckner, 4500
W. D. Weart, 4510
R. W. Lynch, 4530
L. D. Tyler, 4537
G. F. Rudolfo, 1417
F. A. Donath, 5413
R. C. Lincoln, 4538
A. E. Stephenson, 4538, SL/NV (25)

USGS

U.S. Geological Survey
National Center, M/S 410
Reston, VA 22092
G. D. DeBuchananne
P. R. Stevens

USGS

U.S. Geological Survey
Post Office Box 25046, M/S 416
Denver, CO 80225

W. W. Dudley, Jr. (6)
W. S. Twenhofel

Geological Society of America
3300 Penrose Place
Boulder, CO 80301

J. C. Frye

Kansas State Geological Survey
University of Kansas
Lawrence, KS 66044

W. W. Hambleton

Battelle Office of Nuclear
Waste Isolation
500 King Avenue
Columbus, OH 43201

J. M. Batch
S. Basham
W. Carbiner
R. Robinson

State of Nevada
Capitol Complex
Carson City, NV 89710
Bruce Arkell, Nevada State
Planning Coordinator
Noel Clark, Director,
Nevada Department of Energy

John A. Blume Engineers
Sheraton Palace Hotel
130 Jessie Street
San Francisco, CA 94105

Peter Yanev

Computer Sciences Corporation
6565 Arlington Boulevard
Falls Church, VA 22046

J. A. LaHoud

Woodward-Clyde Consultants
Western Region Library
No. 3 Embarcadero Center
San Francisco, CA 94111

Western Region Library

Westinghouse AESD
J. B. Wright
D. C. Durrill