see pocket for enclosure

WM-11

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

WM Record File 102

WM Project 11
Docket No.
PDR ✓
LPDR ✓

OCT 22 1979

Distribution:

(Return to WM, 623-SS)

MEMORANDUM FOR: James C. Malaro, Branch Chief
High-Level Waste Licensing Management Branch

FROM: Regis R. Boyle
High-Level Waste Licensing Management Branch

SUBJECT: TRIP REPORT ON SEPTEMBER 24 AND 25 VISIT TO NEVADA TEST SITE

On Monday and Tuesday, September 24 and 25, 1979, Larry White and I visited the Nevada Test Site (NTS). The purpose of this trip was to initiate our critical assessment of the U.S. Department of Energy's (DOE) waste management program at NTS.

On Monday, we attended the first day of a two-day meeting between DOE and their consultants. The purpose of this meeting was to determine the information that needs to be acquired in the field of rock mechanics to assess the suitability of hard rock for the implacement of high-level radioactive waste. Enclosure 1 contains an agenda for the meeting and a listing of the invited participants. Enclosure 2 lists those individuals who attended the Monday session of the meeting.

Don Vieth (DOE-Headquarters) started the meeting by presenting a brief history of the waste management program in the U.S. He indicated that the Climax Test Facility at NTS will cost $18 million and the Near Surface Test Facility at Hanford will cost $31 million. He also outlined the pertinent points raised by the IRG. He was followed by W. A. Carbiener (ONWI). Mr. Carbiener summarized the current status of the rock mechanics activities in DOE. He indicated that a detailed plan for conducting rock mechanics programs will be available in the spring of 1980. This plan will provide recommendations on those rock mechanics activities which DOE should pursue in its waste management program. He identified several interim findings of the Earth Sciences Task Force working on this plan. These included: (1) a need for more testing facilities (laboratory equipment) for determining the physical and mechanical properties of rock; (2) more scientific analysis in rock mechanics experiments; (3) no further in-situ testing with spent fuel in generic rocks beyond the Climax Test Facility at NTS; (4) delaying the large scale granite heater tests until the Stripa in-situ experiments are evaluated; and (5) plan for in-situ heater tests in salt, tuff, shale, and other suitable media.

NV838269

original not rec'd.

00046

Mr. Carbiener then went on to discuss several questions regarding the in-situ testing program for gathering rock mechanics information. While many questions were raised, the fundamental issue was to determine the objectives of any in-situ test and the data that should be measured and collected during the tests. He further indicated that at this time, there is no consensus on the need for in-situ tests.

The next speaker was Larry Ramspott (LLL) who described a plan for: (1) defining the in-situ rock mechanics tests necessary to develop a waste repository in hard rock; (2) evaluating the suitability of the Climax granitic stock for rock mechanics tests; and (3) designing rock mechanics tests appropriate to the Climax site at NTS. A prime concern of some of the participants regarding the Climax Test Program had to do with the potential effect that weapons testing would have on the displacement measurements taken during an in-situ test. There was some concern that movement of the rock resulting from a weapons test would distort the readings on extensometers used to measure displacement.

Mr. Lynn Tyler (Sandia) described a program at NTS which has as its objective to evaluate tuffs and argillaceous rock as repository media. The current stategy of the program is to determine the thermal, mechanical, and chemical properties of these rocks by laboratory studies and in-situ testing. Mr. Tyler briefly described an in-situ experiment that will be conducted at the NTS site in tuffs. The goal of the in-situ test program will be primarily to assess the thermomechanical response of welded tuff to heat and water migration behavior in welded tuff under heat loads. These in-situ tests are expected to begin in the fall of 1980.

On Tuesday, September 25, 1979, we visited and observed activities at three separate facilities at NTS. These included: (1) the E-MAD Facility; (2) the G-Tunnel Complex; and (3) the Climax Site.

At the E-MAD Facility we observed the transfer of one PWR spent fuel assembly from a shipping cask to a storage canister. This operation took place within the hot cell at the E-MAD Facility. This fuel assembly will ultimately be placed in the Climax mine along with ten other assemblies for conducting in-situ tests. The fuel assembly had been taken from the Turkey Point Nuclear Station and had been in the spent fuel storage pool at the reactor site for about 2 years. The heat dissipation rate of the fuel assembly is about 2 kW (6800 Btu/hr).

While at the E-MAD Facility, we also viewed the drywell storage area and the above-ground sealed storage casks where two PWR fuel assemblies are being tested at each area.

Heat transfer data is being collected at each of these test areas and temperature profiles are being generated.

At the G-Tunnel Complex, the initial steps are being taken to perform in-situ heat transfer tests in welded tuffs. This test will also be used to assess the water migration behavior in tuffs. At the time of our visit, horizontal holes were being drilled in which electrical heaters would be placed at a later date. Tentative schedules indicate the start of the in-situ testing program to be the fall of 1980.

The Climax Site is the location where DOE intends to emplace 11 PWR spent fuel assemblies in granite. The emplacement is expected to begin in the early part of 1980.

At the time of our visit, construction was nearing completion. All of the underground excavation of the three tunnels was complete as was the canister access hole which had been drilled from the surface. The main canister storage holes (0.6m diameter x 6m deep) for spent fuel emplacement and electrical heaters completed. The only major construction related activities remaining were primarily related to instrumentation and materials handling. Personnel at NTS see no reason why the Climax in-situ testing program cannot start on schedule in January 1980.

It is recommended that the NRC waste management staff closely monitor the on-going activities at NTS because the programs being conducted there are on the forefront of technology in assessing hard rock for a radioactive waste repository. We should review all forecoming reports on the in-situ program in welded tuffs in order to assess its feasibility as a geologic disposal medium. And we should scrutinize the Climax Test Program because it represents the first in-situ experiment in the U.S. with spent fuel emplaced in hard rock. Results from these testing activities would provide substantial and substantive inputs into the NRC's regulatory program for waste management.

Regis R. Boyle

Regis R. Boyle
High-Level Waste Licensing
Management Branch

Enclosures:
As stated

AGENDA

ROCK MECHANICS

SEPTEMBER 24 & 25, 1979

Convene:	8:00 a.m.	DOE/NV Auditorium
Introduction & History:	D. L. Vieth	
Attendees:	DOE/HQ	D. L. Vieth
	DOE/NV	R. M. Nelson M. P. Kunich
	DOE/RL-C	R. Wunderlich
	ONWI	M. M. Lemcoe P. L. Hoffman W. A. Carbiener
	Texas A&M	J. Handin
	UNLV	R. V. Wyman
	RE/SPEC	P. Gnirk
	Sandia	L. D. Tyler B. Langkopf A. R. Lappin
	Sandia Overview	R. C. Lincoln A. E. Stephenson
	LASL	J. Blacic P. Halleck
	USGS	H. Smedes G. Olhofft
	LLL	L. D. Ramspott R. C. Carlson
	BWIP	To Be Named

I. Issues To Be Addressed:

- What is required in the field of rock mechanics to assess the suitability of emplacing high-level radioactive waste in hard rock?
- Do different hard rock media and sites have the same requirements?
- Wha facilities are available at NTS to perform rock mechanics ...?

II. Presentations:

. Introduction and History of the Rock Mechanics Issues.	D. L. Vieth (30 minutes)
. Topic to be determined.	W. A. Carbiener (1 hour)
. Present state of Rock Mechanics proposal for Climax. Representing LLL thinking on what should be done including description of facility.	L. D. Ramspott (1 Hour)
. Rock mechanics work required to evaluate tuff for use as a waste isolation media including description of facility.	L. D. Tyler (1 Hour)

III. Round Table Discussion

IV. Written commitments and agreements, if any, for follow-on action to be distributed prior to conclusion of the meeting.

ADJOURN - NOON - JULY 25, 1979

A PLAN FOR DESIGN OF AN IN SITU ROCK MECHANICS TESTING LABORATORY IN THE CLIMAX GRANITE

1. INTRODUCTION

This document describes a plan for defining the in situ rock mechanics tests necessary to achieve a waste repository in hardrock, for evaluating the suitability of the Climax granitic stock for rock mechanics tests, and for designing rock mechanics tests appropriate to the Climax site.

The Climax granitic stock is located at the north end of the U.S. Department of Energy (DOE) Nevada Test Site. It is the location of an ongoing test of the emplacement of spent fuel directly in granite (the Spent Fuel Test-Climax or SFT-C). There are, therefore, the advantages of an ongoing program, including an accessible site, utilities, shaft, ventilation, and a basic data acquisition system. There are other related advantages: a large amount of background data, ownership of the mine by DOE, and operation by integrated contractors. Because of these numerous advantages, it is desirable to evaluate the use of the Climax site for in situ rock mechanics testing needed to achieve a waste repository in hardrock.

Initial evaluations have been carried out by LLL staff and associated consultants and contractors. This proposal was prepared by LLL and RE/SPEC, Inc.

2. OBJECTIVES

1. Define relevant in situ rock mechanics tests necessary for a repository in hardrock.

The purpose of this objective is to establish a conceptual framework for in situ rock mechanics testing, either at the Climax site or elsewhere. The objective includes establishing the relation between in situ testing and modeling, including validation of models, and showing the relation between the test results and the design, construction, licensing, operation, and decommissioning of a repository.

2. Evaluate the Climax granite site for suitability for rock mechanics testing.

The purpose of this objective is to evaluate whether the Climax site is suitable for any or all of the tests defined in achieving objective (1), either (a) given or current knowledge or (b) given additional information. An additional, synergistic output of this evaluation will be to provide an after-the-fact analysis of the technical relevancy of the current spent fuel test to a repository in hardrock.

3. Prepare a conceptual design for tests appropriate to the Climax site.

The purpose of this objective is to prepare a plan for a series of inter-related tests from which the models necessary for a repository in granite could be tested and validated. This conceptual design would cover only those tests appropriate to the Climax granite.

3. BACKGROUND

The Climax granitic stock was the site of nuclear tests conducted by the Department of Defense in the 1960's. Facilities, including a shaft to 420 m depth, were developed in support of those tests, and were used during the early 1970's by the Lawrence Livermore Laboratory (LLL) for investigations of underground nuclear explosion effects in support the of the Plowshare Program. During 1975 an initial evaluation of the potential of the facility for a test storage of high level waste was conducted by LLL for DOE. In 1978 planning began for a test storage of spent nuclear fuel (SFT-C) which will be initiated early in 1980.

The use of nuclear material (spent fuel) in the SFT-C introduces many constraints into the test. The safe handling of the fuel is an overriding consideration both in test design and budget. In addition, the thermal output of spent fuel is relatively low on a per-canister basis and decays from an initial fixed value. These and other constraints limited the nature and extent of rock mechanics tests which could be performed in conjunction with the SFT-C. Thus, initial evaluations by LLL during FY 1978 (when granite was regarded as one of three equally possible media in terms of establishing an on-NTS waste repository) led to the conclusion that the SFT-C should be supplemented by adjacent rock mechanics tests in order to qualify granite as a waste isolation medium.

The LLL FY 1978 evaluation activity was summarized in a draft report by Joseph R. Hearst, "Technical Concept for Rock Mechanics Tests, Climax Granite, NTS." At the time this document was submitted, LLL was aware that the experiments described did not address in a comprehensive manner all tests needed to design, build, license, operate, and decommission a waste repository in granitic rock. However, the document did describe a major sub-set of such tests and initial testing could have been implemented while design continued for the rest of the tests required.

The draft technical concept was transmitted in November 1978 with a letter proposal from LLL to DOE-NV outlining a four to five year test program. The proposed program outlined four task elements: (1) an initial series of thermally overdriven field tests, (2) concurrent instrumentation development to increase the sensitivity and accuracy of currently available instrumentation, (3) a subsequent series of a priori (calculated and published before the fact) field tests under realistic (low heat-load) conditions, and (4) continuing computer model development and analysis. A prominent concept of the initial test series was that of an engineering overtest by loading the rock to failure to establish a margin of safety.

This letter proposal formed the basis for continuing dialogue during which a number of issues were raised. In response to some of these concerns, an informal modification of the proposal was presented to the Office of Nuclear Waste Isolation (ONWI) in February, 1979. This modification included four recommended activities: (1) extension of the mine taildrift to preserve capability for underground work adjacent to the SFT-C, (2) a laboratory program of systematic measurements of the effects of temperature, pressure and pore fluid on the elastic constants of brittle rocks from sites such as Climax and Stripa, (3) an in situ rock modulus measurement at the Climax site, and (4) a year-long effort to produce a conceptual plan for a comprehensive series of Rock Mechanics Tests in the Climax facility. Of these, (1) has been completed, (2) has been initiated but cut severely in funding for FY 1980, and (3) and (4) were not initiated.

Throughout discussions of the initial and subsequent proposals, certain issues have persisted as items of concern:

- In specific detail, how does a program of rock mechanics testing relate to the design, construction, licensing, operation and decommissioning of a repository.
- What is the validity of carrying out rock mechanics testing in a facility which is above the water table, such as the 420 m level at Climax.
- What is the transferability of testing done at a single generic granite site (such as Climax) to other hard crystalline rock types (such as basalt) or to a specific repository site in granite.

We believe the program outlined in this document will address the above concerns and produce a test plan for rock mechanics tests appropriate to the Climax granite.

4. PROJECT SCOPE

The scope of this project is limited to preparation of a test plan and does not include construction or operation of the tests defined in the plan. As part of the preparation of the test plan, certain field and laboratory investigations of the Climax granite will be conducted, as the test plan will be specifically directed to testing at the Climax site.

There are nine tasks defined for the project, as follows:

1. Development of a Generic <u>In Situ</u> Testing Plan
2. Application of State-of-the-art Modeling Techniques to Available <u>In Situ</u> Data
3. Laboratory Testing
4. Site Exploration
5. Geotechnical Field Data
6. Conceptual Design and Planning of Climax Experiments
7. Modeling of Experiments
8. Layout, Instrumentation, Costs, and Schedule of Experiments
9. Development of A Test Plan for Climax

Of the above tasks, Tasks 1 and 2 have output which is relevant whether or not additional testing at the Climax site is judged to be feasible.

Tasks 3 through 5 have output which is relevant to interpretation of the ongoing Spent Fuel Test-Climax (SFT-C).

Tasks 6 through 9 are directly related to preparation of a test plan for rock mechanics testing at the Climax granite site.

For clarity, we will specify the relation of certain items to the project scope. Rock-mechanics testing identified in Task 1 as having major impact on the design, construction, licensing, operation, and decommissioning of repositories but which is deemed inappropriate for the Climax site will be enumerated, together with suggested conditions under which it could be conducted. Design will be provided only for experiments to be conducted at the Climax site. In Task 1 the focus will be on a granite repository but many issues will be common to hardrocks such as basalt or welded tuff.

Although recommendations for instrument development may arise as a result of this project, instrumentation development is not included within the scope of this project. Work in the instrumentation area will be confined to evaluation of current or proposed designs and equipment.

The test plan to be furnished as a result of Task 9 (and the entire project) will include a preliminary (Title I) design adequate for estimating time and cost, but not for construction or procurement. Formal time and cost estimates will not be included in the plan, although they can readily be developed after submission of the plan. Throughout the project informal cost and time estimates will be generated and these will be available separate from the formal documentation. The plan will include logic network charts of the type used in the NNWSI program.

For the purpose of this scope of work, rock mechanics includes the mechanical behavior of the rock in response to both mining and thermal/radiation loading, including the effects of pore and fracture water. Thus near-field hydraulic behavior is included. Issues such as backfill, shaft-sealing, and chemical or radiation effects on mechanical rock properties will be evaluated. Issues such as far-field hydrology and radionuclide migration are not included.

5. TASK DEFINITION

The project consists of nine tasks, extending over a period of twelve months. Brief descriptions of each task follow. The scheduling relations of the tasks are summarized in the attached bar chart and CPM charts.

TASK 1. DEVELOPMENT OF A GENERIC IN SITU TESTING PLAN

The objective of this task is to identify those issues, questions, unknowns, and technology deficiencies in rock mechanics (and closely related geotechnical areas) which must be resolved before a waste repository in granitic rock could be established; to identify ~~those issues which~~ can be addressed by generic in situ testing; and to outline the general features and conditions of those tests. This outline of required generic in situ tests then represents a very generalized program plan from which an overall testing strategy can be developed. This plan will be developed for granitic rocks, but a number of elements could apply to hard rock such as basalt or welded tuff.

A number of conceptual repository designs for granitic rocks have been completed (KBS, AECL, GEIS, INFCE) and a number of "issue" reviews in waste disposal (IRG, APS, USGS-779) have been recently released. From this available material, a list of the various questions, problem unknowns, and deficiencies of understanding will be compiled which should be fairly complete. This compilation of issues in itself would be of considerable usefulness in overall program planning, especially if the various issues can be ranked according to their importance, degree of difficulty, and the approach required for their resolution. At the least, those issues which can be resolved by generic in situ testing will be identified.

The subsequent definition of those generic in situ tests, their objectives, general features, requirements, and conditions then represents an overall (but very generalized) program plan for in situ testing. It is likely that some of the tests in this overall program can be performed in the Climax facility, while some cannot. Regardless of this breakdown, an overall in situ testing strategy should now be obvious as well as a testing program for Climax.

The development of this generic in situ testing plan would be coordinated with the ONWI program and will result in a published document approximately midway through the project, with DOE/NV peer review prior to publication.

TASK 2. APPLICATION OF STATE-OF-THE-ART MODELING TECHNIQUES TO AVAILABLE IN SITU DATA

The objective of this task is to establish a modeling tool which can be used in the simulation of conceptual experiments. Specifically, this model should be demonstrated to be reasonably *adequate in duplicating* existing results from in situ tests. Future tasks within this project will rely heavily upon the adequacy of such a numerical model.

Previous attempts to correlate numerical model predictions with in situ tests results in granite have employed a linear elastic constitutive relationship. These studies (those relating to Stripa and the Climax "mineby") have also assumed isotropic and homogeneous media.

The comparison between certain predicted results (specifically displacements) and the actual field tests have not been encouraging. With this in mind, we propose to simulate the Climax "mineby" experiment (and if possible data from Stripa) using a more sophisticated constitutive relationship and characterization of the media in an effort to assess whether the agreement between model and field results can be improved. As an example, the constitutive relationship could employ a Mohr Coulomb strength failure criterion for the intact rock, in addition to a separate Mohr Coulomb criterion for the discontinuities. In this regard, the deformation characteristics of the discontinuities prior to strength failure will be assumed to be equivalent to those of the rock mass. Recent results given by Pande and Sharma (1979)[1] indicate that this is probably quite reasonable for discontinuities with length to thickness ratios of greater than about 10^3.

These simulations of the "mineby" experiment will also incorporate the mining sequence, in addition to evaluating a range of pre-mining in situ stresses which can be reasonably expected to exist. This task will enable one to evaluate whether existing state-of-the-art numerical models are adequate in evaluating the response of a granite rock mass to excavation. Laboratory and field data, as they become available from the Task 3 and 5 efforts, will be incorporated into the simulations.

---

[1] G. N. Pande and K. G. Sharma, "On Joint/Interface Elements and Associated Problems on Numerical Ill-Conditioning", Intl. Journ. of Numerical Methods in Engineering, 1979.

TASK 3. LABORATORY TESTING

The purpose of the laboratory testing task is to obtain those rock properties data for Climax granite which do not now exist or are judged inadequate, and which are needed in the modeling task. In particular, we are concerned with the influence of elevated temperature and confining pressure on the quasi-static thermal/mechanical properties, for both the elastic and nonelastic realms of rock behavior. A more detailed characterization of the material behavior of the Climax granite by laboratory testing will enhance the reliability of the calculations for preliminary experiment design. In addition, these data will provide a basis for evaluation of certain scale effects between laboratory and in situ measurements (e.g., modulus of elastic deformation).

Immediate attention will be focused on obtaining Young's modulus of elasticity, Poisson's ratio, tensile strength, the failure envelope, and the post-failure deformation characteristics of Climax granite as functions of elevated temperature and confining pressure. By performing both triaxial compression and extension tests to failure, it is possible to define in at least a preliminary fashion the failure surface in stress space, as well as similar surfaces for the onset of dilation preceding fracture instability, and post-deformation behavior in the sense of "fractured" rock behavior.

This task will include an evaluation of all existing rock properties data for the Climax granite. However, it is our current judgement that the thermal conductivity, thermal diffusivity, and coefficient of thermal expansion of Climax granite have been determined adequately by previous testing, with attendant evaluation of temperature and pressure effects. Such is also the state of affairs for matrix air permeability. However, an assessment of the decrepitation characteristics of the granite is required, and will be performed as a part of this task.

The obvious deficiency of the proposed laboratory effort described above is the lack of attention paid to the influence of joints and other structural discontinuities on the thermal/mechanical behavior of the Climax granite. The previous heater experiments have, however, provided a preliminary means for assessing the "bulk" thermal properties of the rock as compared to those obtained in the laboratory for "intact" specimens. The significant uncertainty in rock properties lies with the deformational response of the joints. To evaluate this response in the laboratory is impractical during the next year due to both equipment and time constraints. In fact, relatively simplistic in situ tests under controlled conditions of stress and temperature may be more relevant (due to specimen size), as well as less costly than laboratory testing. Until the in situ testing option can be evaluated in more detail, the few data available in the literature and from other relevant efforts for granitic media can be collected, and evaluated with regard to their applicability as input to the modeling tasks.

TASK 4. SITE EXPLORATION

The overall objectives of the site exploration effort are to locate a site(s) within the Climax stock that will be suitable for conducting rock mechanics experiments in granitic rock relevant to nuclear waste isolation, and to obtain both core samples and data to be used in the design of those experiments. Specific objectives are:

1. To confirm that the geology beyond the current tail drift extension is as expected and contains no anomalies. This includes confirmation that the rock in the proposed test area is quartz monzonite, that no chill zones or anomalous mineral or rock types are present, that no major fault zones or other discontinuities are identified and that the rock and its geometry will be compatible with the tests to be planned.
2. To obtain core samples for laboratory testing of thermal, mechanical and hydrological and other properties related to rock mechanics.
3. To obtain information on joint attitudes and spacings for input to the rock mechanics models and understanding of the related phenomena.
4. To obtain core for petrophysical examination to determine mineral constituents and rock fabric as they relate to rock homogeneity and rock type.
5. To establish any relationships between the geology of the Spent Fuel Test-Climax and the planned rock mechanics tests which will allow interfacing of information between the tests with potential enhancement to both programs.

6. To identify any adverse mining conditions that might be encountered either in the test area or in drifts leading into the test area.
7. To provide drill holes for in situ borehole testing of modulus and state-of-stress.
8. To provide a drill hole for determination of the water table location.

The scope of the site exploration would include drilling of 2600 feet of NX core, geologic logging of the core including joint patterns, relating the geologic logging to previous knowledge of the Climax stock in the spent fuel test area, and performing limited petrophysical analysis of samples from the core. These activities, described as follows, will be joint efforts of construction contractors and LLL employees.

(1) Drilling. Four NX borings, totaling 1500 feet, will be needed to intersect the known joint sets and allow correlation of geologic features between borings and the spent fuel test area where possible. Descriptions and locations of the borings are given as follows:

Boring	Depth/ Orientation	Location and Purpose
1	350 ft horizontal	Location: In area between the spent fuel test and the projected tail drift. Purpose: To allow correlation of N64°W joint sets; to investigate the suitability of this area for rock mechanics testing; and to provide for testing of elastic properties in the general area of previous overcoring.
2	400 ft horizontal	Location: In area south of the projected tail drift. Purpose: To allow correlation of N32°W and N50°W joint sets, and to investigate the suitability of the likely rock mechanics test area that is south of the tail drift projection.
3	600 ft 60° inclination	Location: In area below the tail drift projection and parallel to tail drift. Purpose: To allow three dimensional correlation of joints so that attitudes can be assessed, to investigate the suitability of deeper levels for rock mechanics testing and to provide possible correlation with UG-2 of both geology and water data.
4	150 ft horizontal	Location: In area beyond tail drift extension. Purpose: To provide correlation with other borings and to provide for in situ stress measurements in central area of rock mechanics tests.
	Total 1500 ft	

In addition to the 1500 ft of borings for geologic site evaluation, 1100 ft of vertical NX core boring would be drilled to allow water level measurements and/or multiple piezometer installation. This boring will be located near the Spent Fuel Test to avoid conflicts with rock mechanics tests and to allow interfacing with the data acquisition system of the spent fuel test facility. The vertical bore hole will also provide for the investigation of suitability of the Climax stock granites for rock mechanics tests below the water table.

(2) Core logging. This is an activity in which the 2600 ft of core from the exploratory borings are geologically logged and joints described.

(3) Petrophysical analysis. This activity will involve making thin sections of select intervals of core and analyzing the mineral constituents and rock fabric through optical petrographic studies and possibly x-ray defraction studies.

(4) Geologic interpretation. This activity includes geologic interpretation and correlation of the jointing and geologic features identified during core logging, and relating these features to the extent possible with the information developed from the Spent Fuel Test and other Climax studies.

TASK 5. GEOTECHNICAL FIELD DATA

The objective of this task is to obtain and assemble the best possible geotechnical data for the Climax granite stock. Geotechnical data are required for at least the following three reasons:

1. Key items of geotechnical data will guide the selection of an appropriate set of experiments to be executed at the Climax site. For example, the location of the water table will influence the decision to perform hydrological studies at the site.
2. Geotechnical field data will be used to verify or to modify and scale laboratory data, as appropriate.
3. Since the accuracy of model predictions depends directly on the input data provided, the best possible geotechnical data is required for input to the computer models. This data is required both for assessing model adequacy and for making scoping calculations.

Data from laboratory and field studies on the Climax granite have been developed under previous weapons testing studies and the ongoing Spent Fuel Test. The initial step in this task is to survey the existing data. Since much of these data were generated using instruments and techniques behind the current state of the art, all data will be critically evaluated. The purpose of this evaluation will be twofold. First, it will eliminate erroneous data from the set and will draw attention to any additional data which are of questionable credibility. Second, it will bring to light omissions in the data set which need to be filled by additional testing.

The next step in this task is to perform those field measurements currently identified as necessary. These measurements will be discussed in some detail here.

The location of the ground water table must be known to assess the effects of pore water pressure, to determine radionuclide migration paths, and to assess any additional synergistic effects on the thermal/mechanical/hydrological system. The Climax stock is fractured but the fracture system is generally tight. This fact complicates locating the water table since pockets of water may be locally perched. Indeed, several areas of perched water have been identified at locations within the Climax stock but nearer the surface. The general approach planned here is to use a vertical hole (drilled as part of the site exploration) from the level of the spent fuel test (approximately 420 m below surface) and to instrument it at several locations with piezometers. The various locations in the hole will be isolated with packer, or similar, assemblies.

Permeability is another critical issue, particularly as it relates to radionuclide migration. Both single and double packer tests are planned for one of the horizontal exploratory holes drilled during site exploration. Air permeability tests will be performed. The single-packer test will be used to determine the gross permeability of the drill hole which crosses several high-angle and low-angle joints of varying character. The packer assembly will be set near the collar of the hole and the test will be run. If the permeability is too small to measure, an additional hole will be tested. If a measurable permeability is encountered, as expected, a series of double-packer tests will be performed to develop a permeability profile for the hole. This profile may then be related to the number and character of fractures within the various zones tested.

The *in situ* state of stress has been found to be a controlling factor in the opening stability of underground excavations. This observation is founded on the results of both field and physical model studies as well as computer model calculations. *In situ* stress measurements were made in the early 1960's at Climax using a single-component borehole deformation gauge. Subsequent measurements in 1979 using a three-component gauge of similar design gave substantially different results. Additional measurements are needed at this point to resolve these discrepancies and, thus, to determine the *in situ* state of stress in the vicinity of the proposed tests. The concept is to use a different technique, namely borehole hydraulic fracturing, to determine the state of stress. Exploratory drill holes will be used.

The final measurement currently planned is an *in situ* deformation modulus determination. The purpose is to obtain a rock-mass modulus which more accurately reflects the response of the rock to applied load than does the laboratory modulus which is obtained from a small core. Although a complete modulus determination as a function of pressure and temperature would be most desirable, such a test is prohibitively expensive in the context of this project. Borehole tests, using available exploratory drill holes, present a viable alternative. The Goodman Jack and fluid-pressurized borehole techniques will both be considered. Once again, holes drilled during the site exploration phase will be utilized.

TASK 6. CONCEPTUAL DESIGN AND PLANNING OF CLIMAX EXPERIMENTS

The objective of this task is to design and plan the suite of experiments and tests which can be performed at Climax to most appropriately address the issues identified in Task 1, but within the constraints of the geological and geotechnical features of the Climax granite.

The output of this task will be a series of experiment definitions including objective; rationale; proposed geometrical configuration; suggested operational equipment (i.e., heaters, etc.); suggested instrumentation types, amounts, and locations; and a tentative test plan (e.g., operate heaters at constant power for two years). These experiment definitions will be sufficiently detailed to serve as input for scoping calculations (Task 7).

The appropriate tests to address certain issues can be designed in a relatively straightforward manner. For example, borehole decrepitation can obviously be addressed in a heated borehole test. However, other tests which more appropriately answer phenomenological questions relating to borehole decrepitation may require novel experiment design. It is the latter type of test which will occupy the majority of the effort within this task. Another example of a phenomenon which may require novel experiment design relates to the determination of thermally induced permeability changes. It is expected that several other issues identified in Task 1 will require novel experiment design. The conceptual design of all these tests will then be evaluated for expected responses in Task 7 and practical feasibility in Task 8.

Task 6, Task 7 (modeling of experiments), and Task 8 (experiment layout/costing) will be highly interactive. Initial interaction will be informal, with increasing formality as plans are finalized.

Of the nine months allotted for design of the experiments through test plan preparation, the first four months in Task 6 will be devoted to preparing a package of initial concepts. The next four months will be devoted to revision and improvement based on interactions with Tasks 7-9 and the NV Peer Review process (at month 7).

TASK 7. MODELING OF EXPERIMENTS

The objective of this task will be to perform a series of simulations of the conceptual experiment designs developed in Task 6 using the numerical model established in Task 2. These simulations will extend the conceptual design of each experiment identified as being plausible for the Climax stock to a state where the geometry, dimensions, power requirements and instrumentation requirements can be established. This modeling effort will incorporate the most contemporary characterization of the rock properties and conditions in the Climax stock as developed during this project and from previous investigations of the Climax stock.

The output of this task will be calculations which show that the proposed experiment will in fact be technically feasible. The effects predicted in the calculations should be measureable by the proposed instrumentation, and the proposed test durations and protocols should be appropriate to the calculated rock behavior.

This series of numerical simulations will constitute an a priori prediction of expected in situ results, and as such will be useful in validation of the numerical model should the tests actually be performed at a later date. However, for the purposes of this project, the simulations will have greatest value in rationally determining the engineering design aspects of each of the experiments, such as instrumentation and excavation requirements.

As discussed under Task 6, Tasks 6, 7, and 8 are all highly interactive. Task 7 will establish the technical validity of the designs generated in Task 6.

TASK 8. LAYOUT, INSTRUMENTATION, COSTS, AND SCHEDULE OF EXPERIMENTS

The objectives of this task will be to establish the overall layout of the Rock Mechanics Tests at Climax and to evaluate total instrumentation requirements in terms of costs and emplacement scheduling.

The output of this task will be a design layout sufficiently detailed to (1) evaluate feasibility of the conceptual design and (2) provide a basis for cost estimating and scheduling. This task will also address the interrelations of the experiments and establish the location of experiments within the area with regard to minimum proximity to one another. It will also evaluate total instrumentation and data acquisition requirements. Information obtained from designing previous in situ tests will be invaluable in the selection and costing of instrumentation and data acquisition systems.

Task 8 will establish the practical feasibility of the designs generated in Task 6 and modeled in Task 7.

TASK 9. DEVELOPMENT OF A TEST PLAN FOR CLIMAX

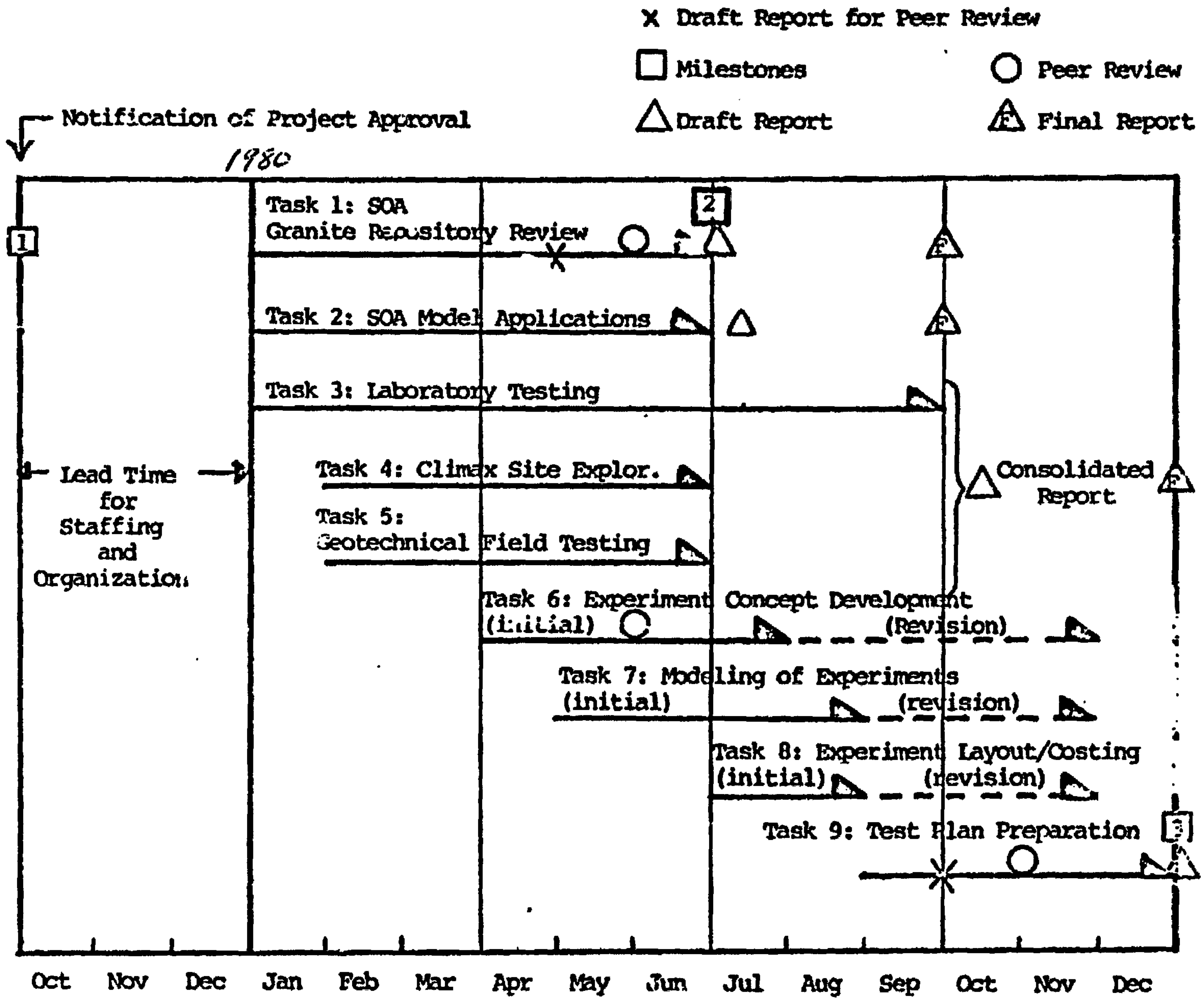
The purpose of this task is to develop a test plan for experiments appropriate to the Climax granite in sufficient detail such that long-term cost and schedule requirements can be reasonably estimated. The plan, which is the output of this task, will contain the necessary justification of each proposed experiment in the context of relevancy to the network of tasks that are required to establish a repository in granitic rock, which will be established in Task 1. The identification of those tasks appropriate to the Climax granite will be established in Task 6 based on input from Tasks 3-5, which will define the characteristics of the site. Finally, Tasks 6,7, and 8 will provide conceptual design, scoping calculations, and preliminary engineering design. Task 9 is therefore an integration of all previous effort in the project.

A draft test plan will be circulated for comment and presented for peer review by the NV peer review panel. All comments will be addressed for a final revision for the final project milestone: issuance of a test plan.

6. SCHEDULE AND COST

The schedule and cost to execute this plan are shown in the attached figures and tables. They have been prepared assuming notification of project approval early in October 1980. The costs shown for REECo field activities are an internal LLL estimate and have not been confirmed by DOE-NV. FY 1981 costs were estimated using FY 1980 manpower cost information without inflation.

On separate network charts, the relationship of this project to subsequent testing is shown. If the test plan submitted in December 1980 is reviewed and approved by March, detailed design would continue throughout FY 1981 and construction of the test laboratory could begin in FY 1982, with testing initiated in FY 1983. As noted earlier, cost estimates beyond the test plan submission are not included in this plan.


X Draft Report for Peer Review
Milestones
Peer Review
Draft Report
Final Report
Notification of Project Approval
1980
Task 1: SOA
Granite Repository Review
Task 2: SOA Model Applications
Task 3: Laboratory Testing
Lead Time
for
Staffing
and
Organization
Task 4: Climax Site Explor.
Task 5:
Geotechnical Field Testing
Consolidated
Report
Task 6: Experiment Concept Development
(initial)
(Revision)
Task 7: Modeling of Experiments
(initial)
(revision)
Task 8: Experiment Layout/Costing
(initial)
(revision)
Task 9: Test Plan Preparation
1
2
3
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

MILESTONE AND COST PLANS

SUBTASK NUMBER AND TITLE: <u>x.x</u> Planning for Rock Mechanics Tests-Climax Granite

PRINCIPAL INVESTIGATOR: L. B. Ballou, LLL, FTS: 532-4911

FY 1980

MILESTONE PLAN	O	N	D	J	F	M	A	M	J	J	A	S
MILESTONE LISTING:	1									2		

1. Project Approved
2. Completed Revised Draft Report for Task 1
   (Development of a Generic <u>In</u> <u>Situ</u> Testing Plan for Granitic Rock)

COST PLAN ($K)	O	N	D	J	F	M	A	M	J	J	A	S
LLL	0	5	15	40	90	150	220	310	400	475	550	630
REECO	0	0	0	0	75	150	220	300	370	370	370	370
Total Cost Plan	0	5	15	40	165	300	440	610	770	845	920	1000

FY 1981

	O	N	D	J	F	M	A	M	J	J	A	S
MILESTONE PLAN				3								

MILESTONE LISTING

3. Completed Revised Draft of Test Plan

COST PLAN ($K)	O	N	D	J	F	M	A	M	J	J	A	S
LLL	70	130	160	175	190	200	200	200	200	200	200	200

ROCK MECHANICS MEETING

DOE/NV

LAS VEGAS

SEPTEMBER 24-25, 1979

STATUS OF ROCK MECHANICS ACTIVITIES

- **ESTP SUBGROUP ON ROCK MECHANICS**
  - INTERIM RECOMMENDATIONS LATE JULY
  - PROJECT REVIEWS SEPTEMBER AND OCTOBER
  - NO "SPONSOR" AFTER NOVEMBER 1
  - PROPOSED SCHEDULE TO COMPLETE DETAILED PLAN IN MARCH - APRIL

- **DRAFT ESTP**
  - RECOMMENDED STEERING COMMITTEE COMPOSED OF DOE, DOE CONTRACTORS, AND USGS

- **ONWI**
  - FORMED COMMITTEE IN RESPONSE TO DRAFT ESTP
  - HELD WORKSHOP IN JUNE, FIRST ANNUAL

- **PEER REVIEWS**
  - NNWSI RECOMMENDED CLIMAX UPGRADING
  - EXPANDED CLIMAX TEST BEING IMPLEMENTED
  - NSTF (BWIP) SPENT FUEL EMPLACEMENT BEING REVIEWED

- **DOE**
  - PLACED FY 80 MONIES ON HOLD PENDING RECOMMENDATION
  - DEFERRED NSTF SPENT FUEL EMPLACEMENT

WAC:9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

ESTP ROCK MECHANICS SUBGROUP

GENERAL

- COMMUNICATION AND COORDINATION BETWEEN PROGRAMS
- WIDER INVOLVEMENT OF "TECHNICAL COMMUNITY"--
  ESPECIALLY EARLY IN PLANNING
- INTERNATIONAL INVOLVEMENT URGED

ROCK PHYSICS AND FUNDAMENTAL MECHANISMS

- STUDY NEED AND FEASIBILITY OF LARGE TRIAXIAL MACHINE
- MORE LAB TESTS FOR CONSTITUTIVE LAWS FOR FAILURE,
  RADIATION EFFECTS ON SILICATE MINERAL AND ROCKS
- ADDITIONAL ROCK PHYSICS TESTING CAPABILITY

IN SITU TESTING

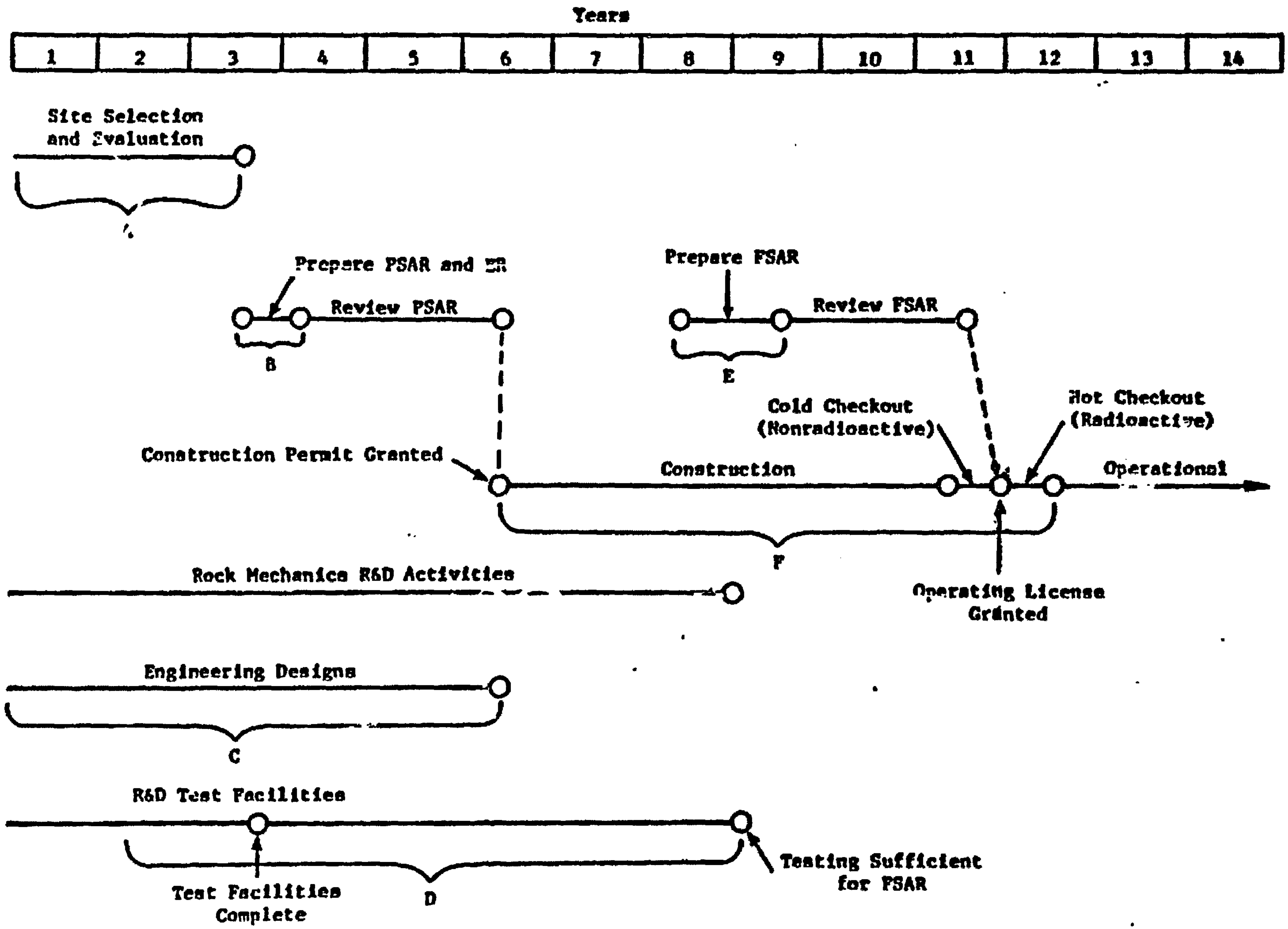
- MORE "SCIENCE" IN TESTS
- * NO CLEAR ADVANTAGE FOR FURTHER SPENT FUEL DEMONSTRATIONS
  IN GENERIC ROCKS BEYOND CLIMAX
- UPGRADE CLIMAX MEASUREMENTS AND SCIENCE
- REVIEW ROCK MECHANICS AND SCIENCE IN BASALT HEATER
  TESTS AND UPGRADE
- DELAY LARGE SCALE GRANITE HEATER TESTS UNTIL STRIPA
  EVALUATED AND UNDERSTOOD
- PURSUE VIGOROUS PLANNING FOR SUBSURFACE HEATER TESTS
  IN TUFF, PALEOZOIC SHALE, AND OTHER SUITABLE MEDIA
- PLAN IN SITU SALT TESTS TO ADDRESS CIRCULAR 779.

STRUCTURAL DISCONTINUITIES

DEVELOP ROCK BEHAVIOR MODELS, STRESS INTERRELATIONSHIP BETWEEN THERMO-MECHANICAL AND HYDROLOGIC PHENOMENA

NUMERICAL MODELS FOR DISCRETE STRUCTURAL DISCONTINUITIES

CHARACTERIZATION OF DISCONTINUITIES, REMOTE METHODS IF POSSIBLE.


Years
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Site Selection and Evaluation
Prepare PSAR and ER
Review PSAR
B
Prepare FSAR
Review FSAR
E
Cold Checkout (Nonradioactive)
Hot Checkout (Radioactive)
Construction Permit Granted
Construction
Operational
F
Rock Mechanics R&D Activities
Operating License Granted
Engineering Designs
C
R&D Test Facilities
Testing Sufficient for FSAR
Test Facilities Complete
D

A. Site Selection and Evaluation

Rock mechanics technology input will be minimal. It will primarily consist of the application of rock mechanics codes for determination of repository behavior at alternative sties and in alternative mediums.

B. PSAR

Prior to the PSAR, ONWI will prepare a PIR. The rock mechanics input will be substantial, and will include (a) structural calculations of mine stability, (b) room and hole closure, (c) uplift and subsidence, (d) prediction of the impact of backfill on temperature, and the impact of thermal-mechanical loading on ground water flow, and (e) addressing questions raised during review of both documents, utilizing input from the rock mechanics program, as required.

C. Engineering Designs

Rock mechanics will provide considerable input to those activities relating to the development of design criteria with respect to extraction ratios, mine layout, and waste loadings. This input will primarily be in the form of rock mechanics analyses.

D. Test Facilities

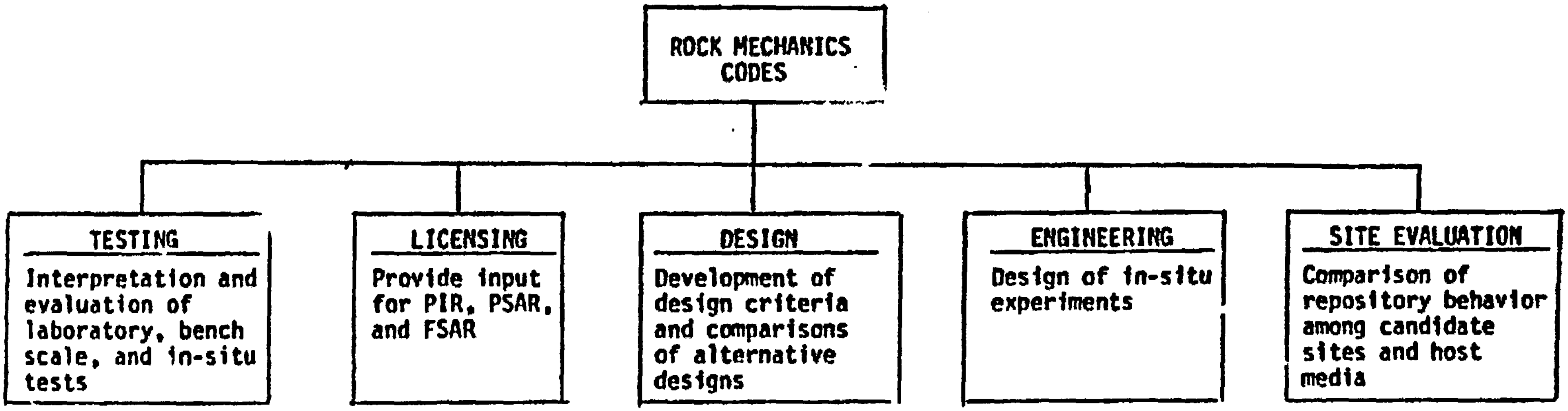
Codes developed under the rock mechanics program will be used for the planning and design of in-situ tests which will be carried out in these facilities. Predicted results of in-situ tests will be compared to actual results as a means of verification of the rock mechanics codes.

E. Input to the FSAR

The input from rock mechanics modeling will be similar to that in the PSAR. However, models will be further developed and verified than they were at the time of the PSAR. Again rock models will be used to develop input for addressing questions that may arise during review of the FSAR.

F. Construction

During construction, rock mechanics codes will be further refined by comparison of predictions with data from the following sources: response of the host rock to mining the repository and in-situ experiments conducted during both the cold and hot checkout periods. Verification will continue through the operational period by comparing predicted and actual repository behavior.



SCOPE OF APPLICATION OF ROCK MECHANICS CODES

ONWI ROCK MECHANICS PROGRAM

ROCK PHYSICS

- LABORATORY TESTS TO DEVELOP CONSTITUTIVE LAWS
- SIZE EFFECTS ON DATA
- TEMPERATURE-PRESSURE EFFECTS ON PERMEABILITY
- ROCK SALT CREEP DATA
- ROUTINE PROPERTY MEASUREMENTS

MODELING

- DISPLACEMENT DISCONTINUITY
- FINITE ELEMENT
- FINITE DIFFERENCE

TECHNIQUES

- STRESS AND DISPLACEMENT MEASUREMENTS
- BOREHOLE DEVICES

IN SITU TESTS

- STRIPA
- SALT TEST FACILITY (PLANNED)
- HARD ROCK FACILITY FEASIBILITY
- HEATED BLOCK TEST
- AVERY ISLAND

WAC: 9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

CRUCIAL PLANNING DATES

NOVEMBER 1 -- ESTP TO AGENCIES FOR REVIEW AND RELEASE

~JANUARY 1 -- RECOMMENDATION TO HQ REGARDING FY 80 ROCK MECHANICS EMPHASIS

~MARCH -- DETAILED LONG TERM ROCK MECHANICS PLAN FOR NWTS BEGINNING IN FY 81

WAC:9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

APPROACH FOR PROCEEDING

- NEED - REEXAMINE THRUSTS AND DIRECTIONS OF ROCK MECHANICS ACTIVITIES - MUST BE BROAD BASED AND SUPPORTED BY SCIENTIFIC COMMUNITY

  - BROADEN ESTP SUBGROUP REPRESENTATION BY ADDING MORE CONTRACTORS AND STRENGTHENING HYDROLOGIC EXPERTISE, PLANNING AND WORKING GROUP

  - DEFINE NEW CHARTER, GROUP TO REPORT TO STEERING COMMITTEE

  - ESTABLISH STEERING COMMITTEE VIA COGNIZANT FIELD OFFICES

  - USE PLANNING AND WORKING GROUP TC ASSIST IN PREPARING FY 80 BUDGET RECOMMENDATIONS

  - USE GROUP AND COMMITTEE TO DEVELOP COMPREHENSIVE DRAFT PLAN.

WAC:9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

PURPOSES OF APPROACH

(1) FACILITATES BROAD TECHNICAL PEER INPUT AT THE EARLIEST OR PLANNING STAGES OF PROJECTS (AN ESTP SUBGROUP RECOMMENDATION).

(2) ESTABLISHES A STEERING COMMITTEE TO ASSIST IN ALLOCATING SPARSE MANPOWER RESOURCES (A DRAFT ESTP RECOMMENDATION).

(3) PROVIDES A WAY TO USE NATIONAL LABORATORY EXPERTISE MORE EFFICIENTLY IN PLANNING (AN ONWM SUGGESTION).

(4) PROVIDES FOR TECHNICAL INTERCHANGE AND PLANNING IN ORDER TO HAVE AN INTEGRATED, COHESIVE NWTS ROCK MECHANICS PROGRAM.

(5) MAINTAINS THE CONTINUITY AND MOMENTUM OF ROCK MECHANICS EXPERTS CURRENTLY REVIEWING THE PROJECTS AS PART OF THE ESTP COMPLETION AND FY 80 BUDGET REVIEW PROCESSES.

WAC:9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

FUNDAMENTAL QUESTIONS

- CAN OR SHOULD THERMO-MECHANICAL PHENOMENA BE DECOUPLED FROM HYDROLOGIC PHENOMENA IN TESTS?
- HOW WILL "SCIENCE" BE APPLIED?
- WHAT IS THE LEVEL OF TRANSFERABILITY OF DATA AND/OR METHODS FROM IN SITU TESTS? (SITE TO SITE AND ROCK TYPE TO ROCK TYPE)
- SHOULD ROCK MECHANICS PROGRAM BE FOCUSSED ON OPERATIONAL PERIOD OR POST CLOSURE PERIOD?
- IS CHARACTERIZATION OF THE FRACTURES IN THE VERY NEAR FIELD OR THE EXTENT OF THERMALLY INDUCED FRACTURING MOST IMPORTANT TO REPOSITORY PERFORMANCE?
- CAN THE MINE STABILITY PROBLEMS BE "ENGINEERED"?
- WHAT IMPACT, IF ANY, SHOULD THE USE OF A LONG LIVED, HIGH INTEGRITY WASTE PACKAGE HAVE ON THE ROCK MECHANICS PROGRAM?

WAC:9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

SPECIFIC QUESTIONS

- HOW MANY IN SITU TESTS ARE REQUIRED AT WHAT PACE?
- WHAT ARE THE "BEST" TESTS TO SHOW SUITABILITY OF HOST ROCKS?
- IS IT SUFFICIENT TO DEVELOP A STANDARD SUITE OF TESTS TO BE CONDUCTED AS PART OF REPOSITORY DEVELOPMENT FOR SITE CONFIRMATION?
- CAN MODELS BE VERIFIED ON A GENERIC BASIS?

WAC:9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

MINIMUM IN SITU TEST JUSTIFICATION

- SPECIFIC OBJECTIVE OF TEST(S)
- EXPECTED APPLICATION OF RESULTS TO SITE SELECTION AND/OR PERFORMANCE ASSESSMENT
- WHAT WILL BE MEASURED AND WHY
- STATE OF THE ART OF MEASUREMENT TECHNIQUES
- IMPACT OF NOT DOING TESTS
- ALTERNATE APPROACHES FOR ATTAINING OBJECTIVE
- POTENTIAL USE OF "SITE" FOR OTHER TYPES OF TESTS
- SUPPORTING ANALYSES SHOULD BE PRESENTED

WAC:9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

ASSERTIONS

- A CONCENTRATED PLANNING PERIOD IS WARRANTED LEADING TO "5-YEAR" PLAN WITH ENGINEERING BASES FOR PROPOSED IN SITU TESTS
- EARLY TESTS SHOULD BE AIMED AT DETERMINING THE THERMO-MECHANICAL-HYDRAULIC COUPLING IMPORTANCE OR NECESSITY
- A PROGRAM TO DEVELOP A "CONFIRMATION" SUITE OF TESTS FOR INDIVIDUAL SITE APPLICATION SHOULD BE PURSUED
- SENSITIVITY ANALYSES SHOULD BE USED EXTENSIVELY IN DEVELOPING TEST PLANS
- THE THRUSTS AND DIRECTIONS OF ROCK MECHANICS PROGRAMS NEED TO BE THOROUGHLY REEXAMINED.

WAC:9/24/79

ONWI
Office of Nuclear Waste Isolation
Battelle

MEDIA INVESTIGATIONS

Objectives

- Evaluate tuffs and argillaceous rocks as repository media for high level waste
- Prepare an Interim Tuff Assessment Report for the National Academy of Sciences (FY 80)

Strategy

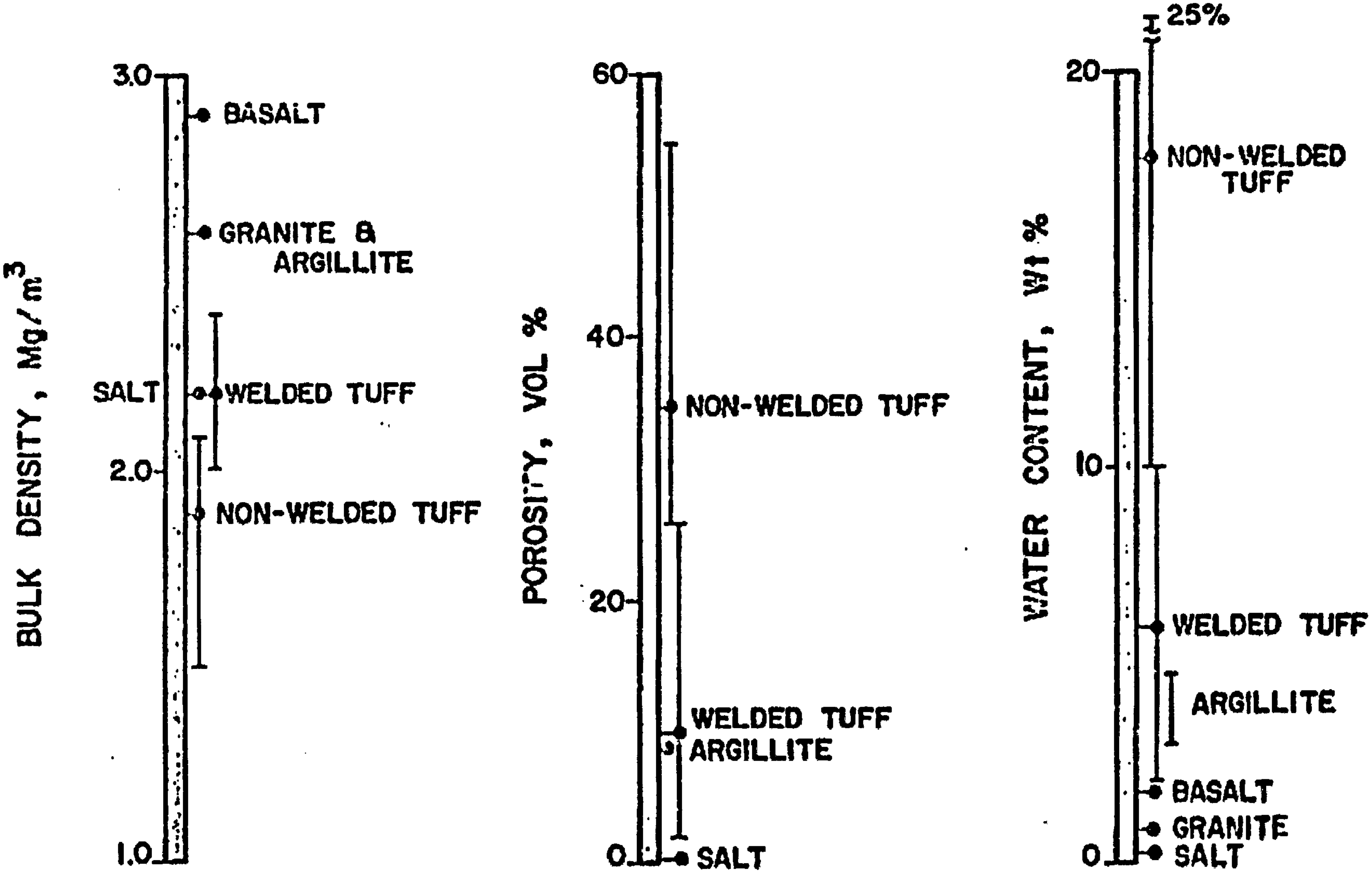
DETERMINE

- Thermal properties
- Mechanical properties
- Chemical properties

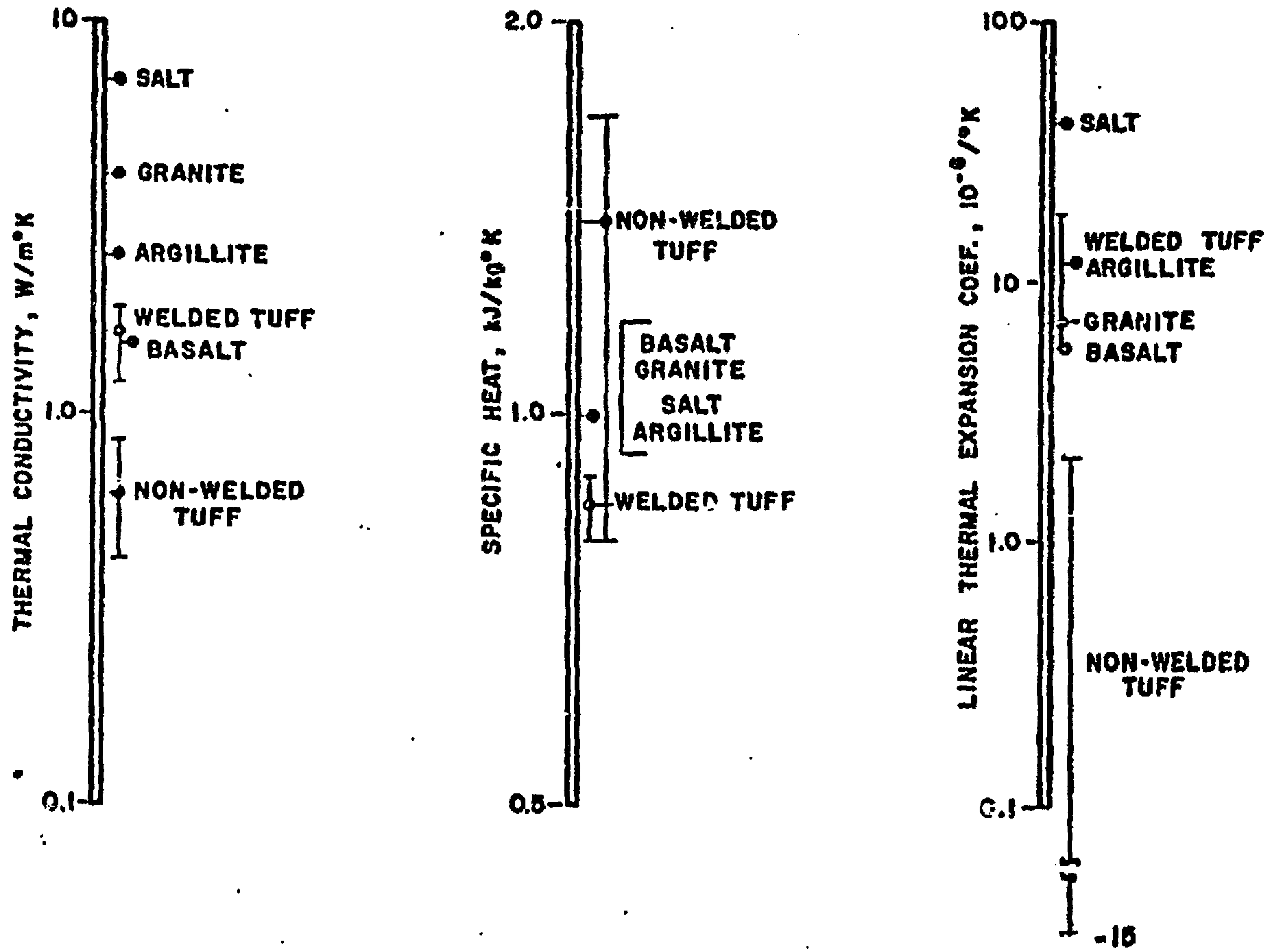
CONDUCT

- Laboratory studies
- Model development
- In situ experimentation
- Repository and experimental test bed design

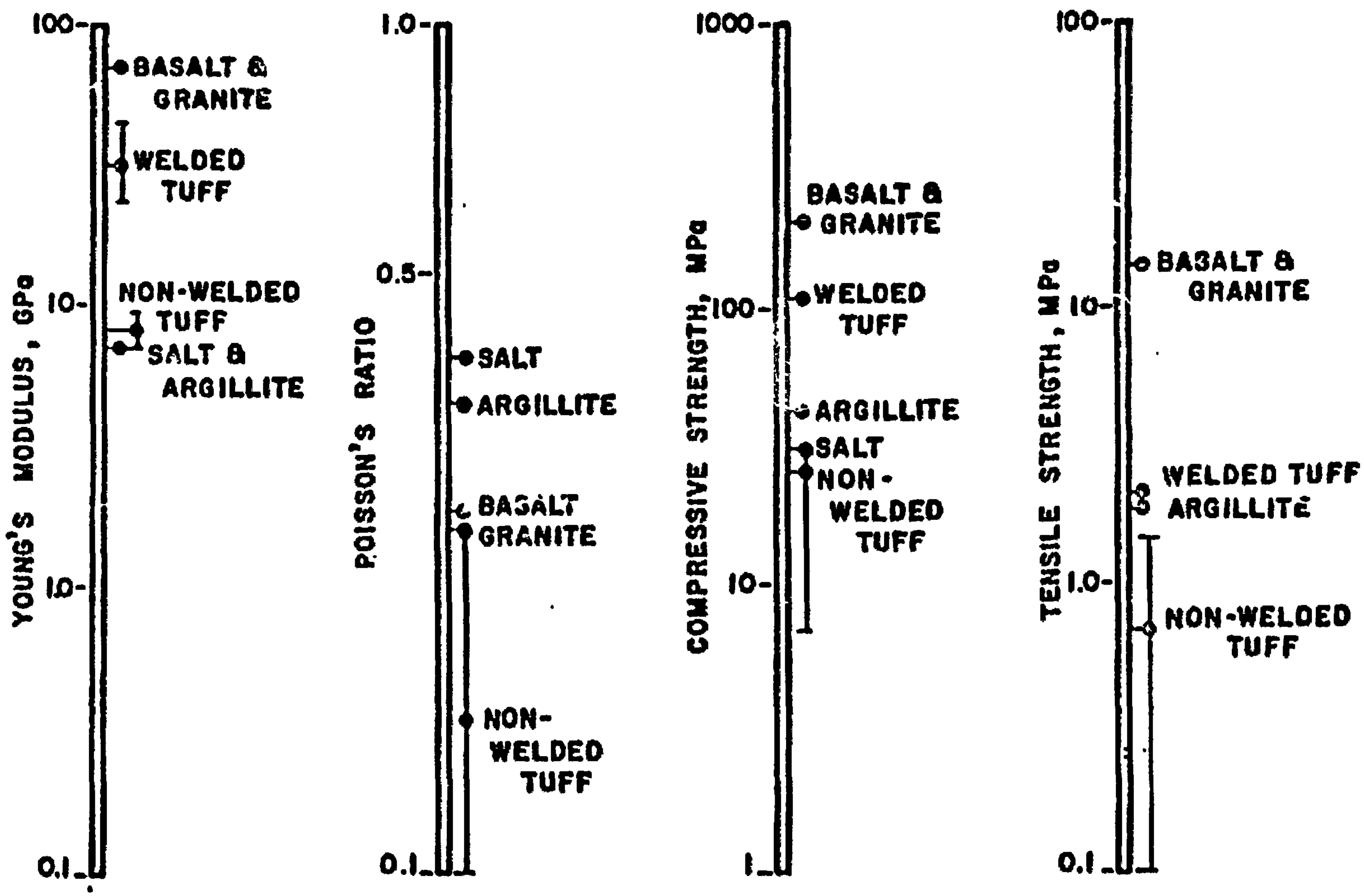
TYPICAL PHYSICAL PROPERTIES OF ROCK TYPES



TYPICAL THERMAL PROPERTIES OF ROCK TYPES



TYPICAL MECHANICAL PROPERTIES OF ROCK TYPES



TUFF PROPERTY STUDIES
RESULTS

THERMAL

- SCREENING DATA ON THERMAL EXPANSION

  1. MINERALOGICAL EFFECTS ARE SECONDARY ON DEVITRIFIED WELDED TUFFS

  2. BEHAVIOR OF GLASSY AND NON-WELDED TUFFS IS COMPLEX

- SCREENING DATA ON THERMAL CONDUCTIVITY

MECHANICAL

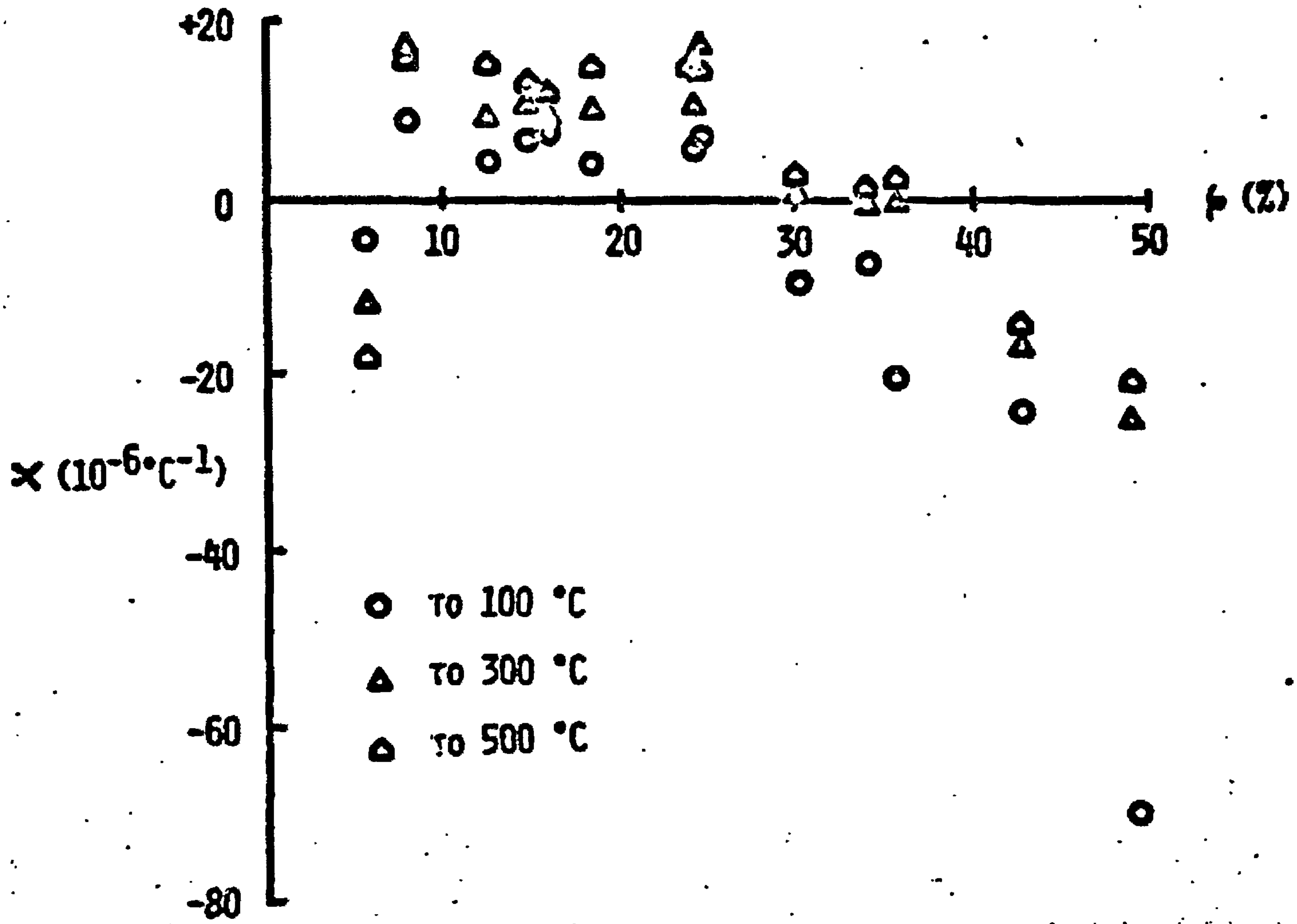
- SCREENING STUDIES OF MECHANICAL PROPERTIES OF TUFF

  1. CONFINING PRESSURE

  2. POROSITY DEPENDENCE

  3. FRICTIONAL EFFECTS

  4. MINERALOGY EFFECTS MINIMAL



LINEAR THERMAL EXPANSION COEFFICIENT OF TUFFS AS A FUNCTION OF FINAL POROSITY (UNCONFINED)

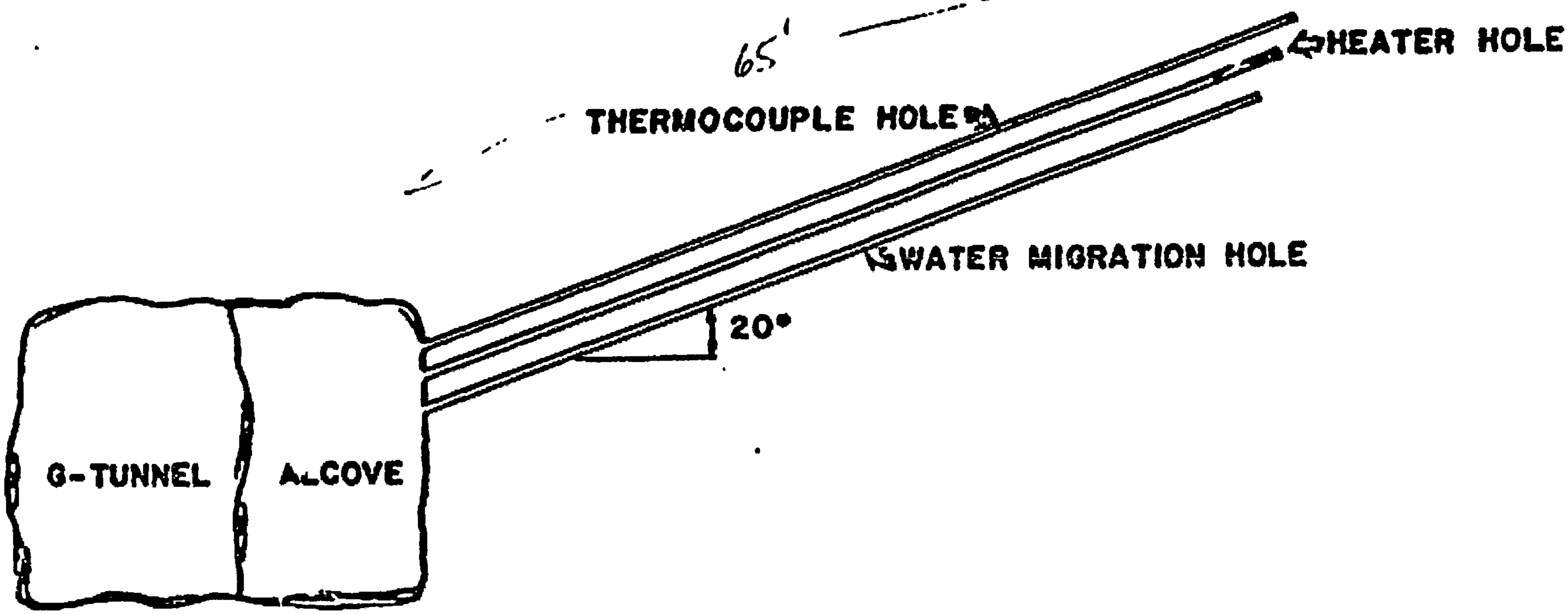
IN SITU TUFF WATER MIGRATION/ HEATER EXPERIMENT

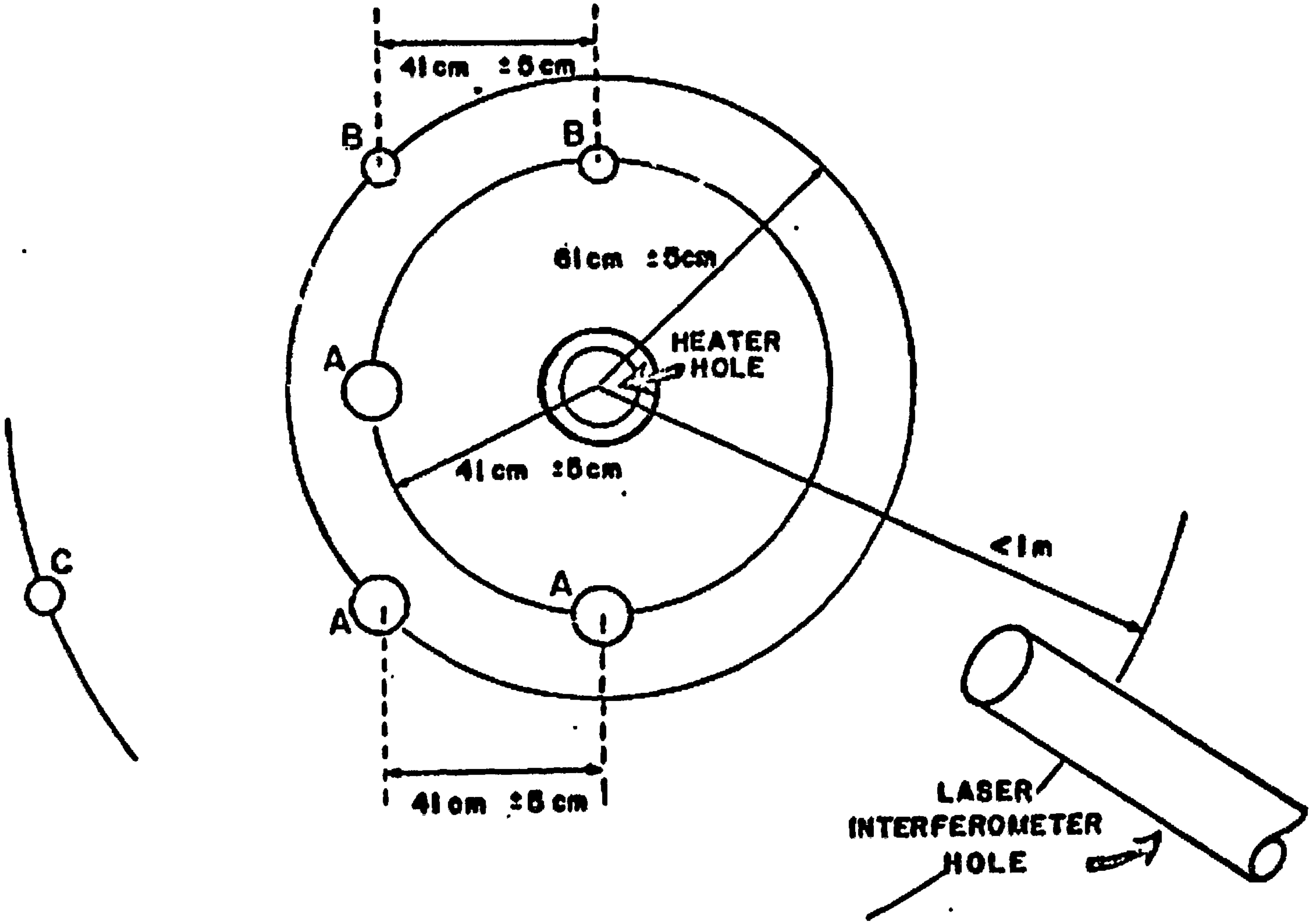
GOALS

- ASSESS WATER GENERATION/MIGRATION BEHAVIOR IN WELDED TUFF
- SUPPORT THERMAL/THERMOMECHANICAL CODE DEVELOPMENT
- SUPPORT INSTRUMENTATION DEVELOPMENT
- MEASURE IN SITU THERMAL CONDUCTIVITY

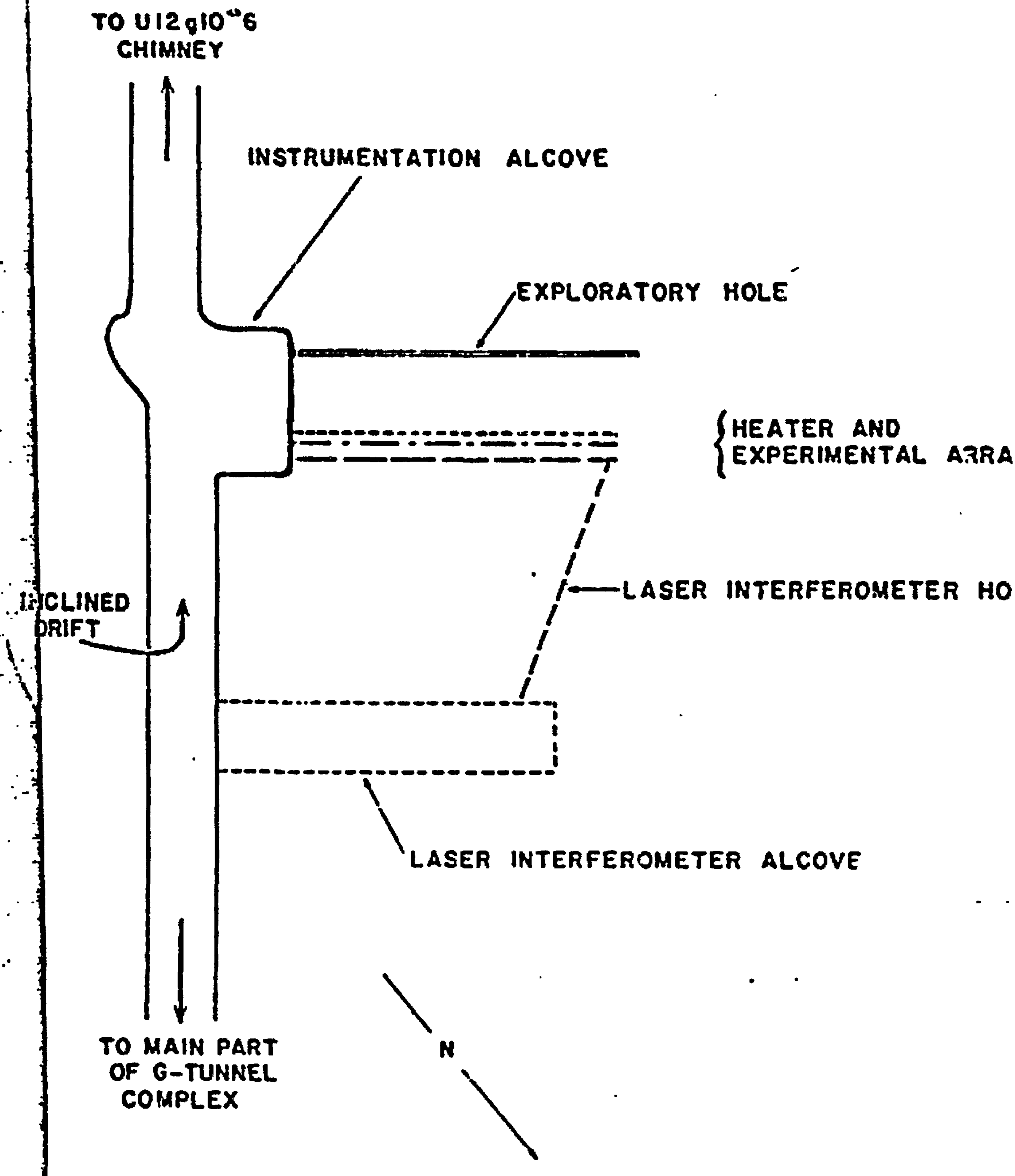
STATUS

- GEOLOGICAL SITE CHARACTERIZATION INITIATED
  --IDENTIFICATION OF TEST BED
  --FRACTURE CORRELATION (! ?)
- HEATER HOLE DRILLED
- DATA ACQUISITION SYSTEM ASSEMBLED
- INSTRUMENTATION DEVELOPMENT
  1. LASER INTERFEROMETER
  2. WATER DEPTH GAUGE
  3. RELATIVE HUMIDITY GAUGE
- HEATER DESIGNED AND IN FABRICATION
- EXPERIMENTAL PLAN IN REVIEW


65'
THERMOCOUPLE HOLE
HEATER HOLE
WATER MIGRATION HOLE
20°
G-TUNNEL
ALCOVE



41cm ±5cm
B
B
61cm ±5cm
HEATER
HOLE
A
41cm ±5cm
C
A
A
<1m
41cm ±5cm
LASER
INTERFEROMETER
HOLE



TO U12g10"6
CHIMNEY
INSTRUMENTATION ALCOVE
EXPLORATORY HOLE
HEATER AND
EXPERIMENTAL ARRA
LASER INTERFEROMETER HO
INCLINED
DRIFT
LASER INTERFEROMETER ALCOVE
TO MAIN PART
OF G-TUNNEL
COMPLEX
N

MEDIA INVESTIGATION (FY80)

Objectives

TUFF

- Yucca Mountain Site Analysis
  - Property determination
  - Modeling of thermomechanical response

- Tuff Assessment

  A. National Academy of Science Issues
  Research activity to address the two media issues of tuff for NAS assessment

  1. Joint effects study
  2. Water effects study

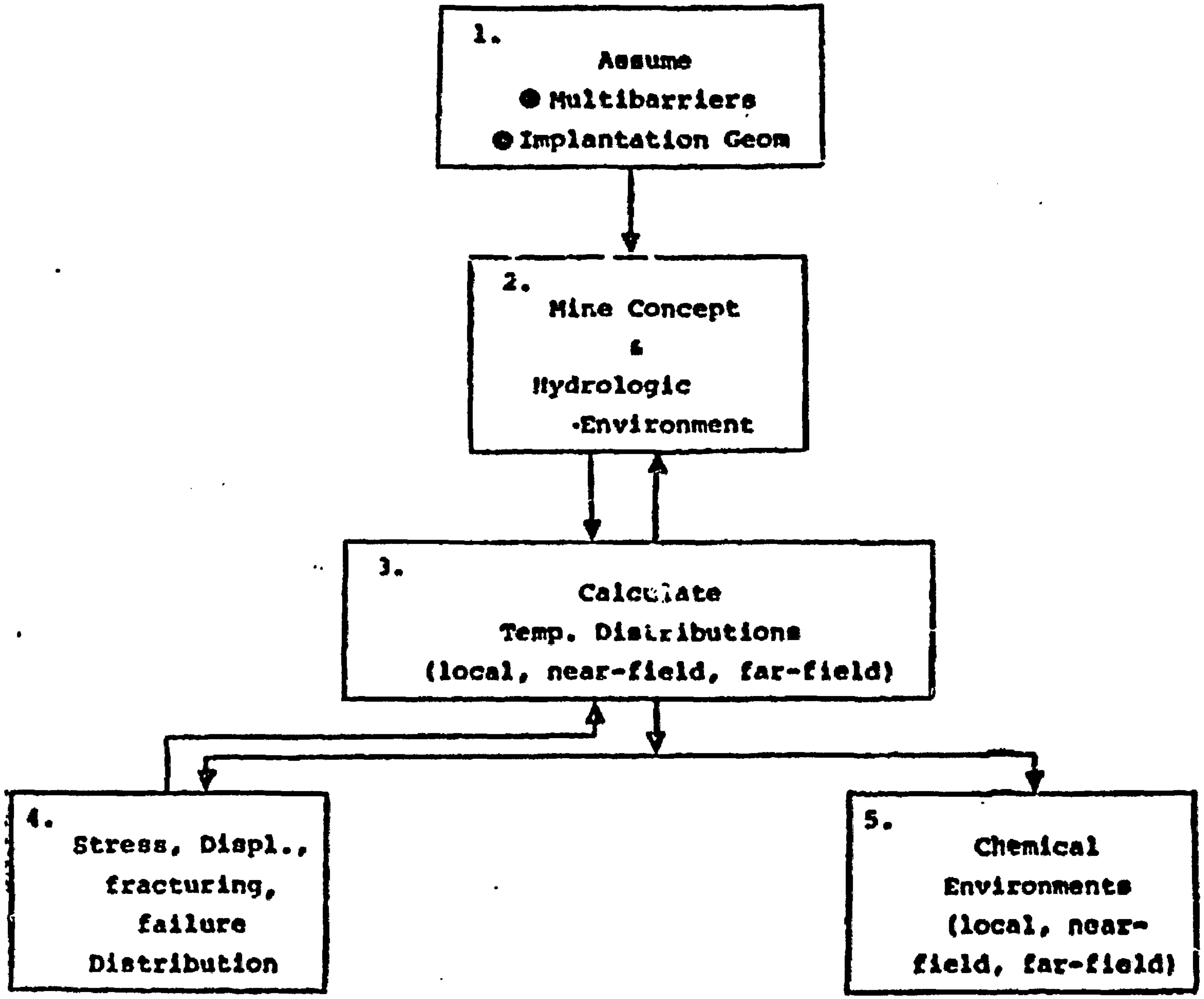
  B. Mine Design Study*

  1. Develop mine design concept
  2. Define problems
  3. Analyze problems
  4. Develop conceptual test plans

  * (Working group activity -- SL, LASL, RE / SPEC, Texas A & M, Terra Tek)

ARGILLITE

- Integrate all work done on Argillite into a final report



1.
Assume
Multibarriers
Implantation Geom
2.
Mine Concept
&
Hydrologic
Environment
3.
Calculate
Temp. Distributions
(local, near-field, far-field)
4.
Stress, Displ.,
fracturing,
failure
Distribution
5.
Chemical
Environments
(local, near-
field, far-field)

Example: Below Water Table; No Expandable Clay

1. First Cut Assumption

   - Fuel and s.s. canister only
   - Fuel full length
   - 100 kW/acre
   - Fuel in floor

2. Characterization of Mine

   - Identification of mining requirements
   - Ventilation
   - Estimation of water inflow (mine and emplacement holes)
   - Evaluation of stabilization methods

   * Mine layout with sufficient specification to allow subsequent thermal, mechanical, chemical characterization
   * Identification of uncertain assumptions and issues

3. Thermal Analysis

   - Local-convection (operational, post-decommissioning)
   - Near-field - conduction (operational, post-decommissioning)
   - Far-field - conduction

   * Temperature versus time at representative positions
   * Identification of uncertain assumptions and issues

4. Mechanical/Structural Analysis

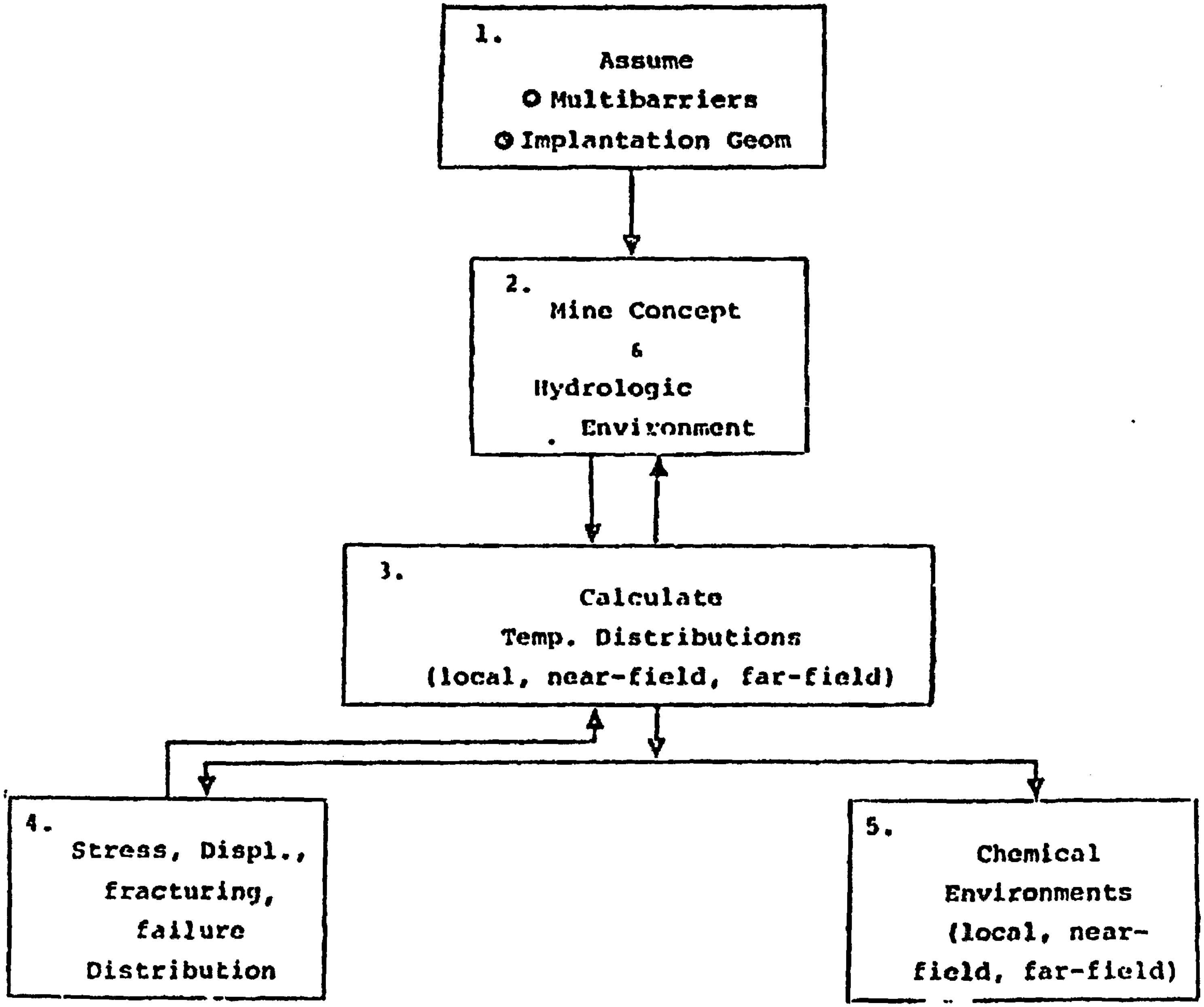
   - Using calculated temperatures, positive thermal expansion, and available constitutive relations (probably elastic/plastic behavior) calculate stress and displacement
   - Using available strength data calculate failure

   * Displacement and failure vs. time at representative positions
   * Identification of uncertain assumptions and issues

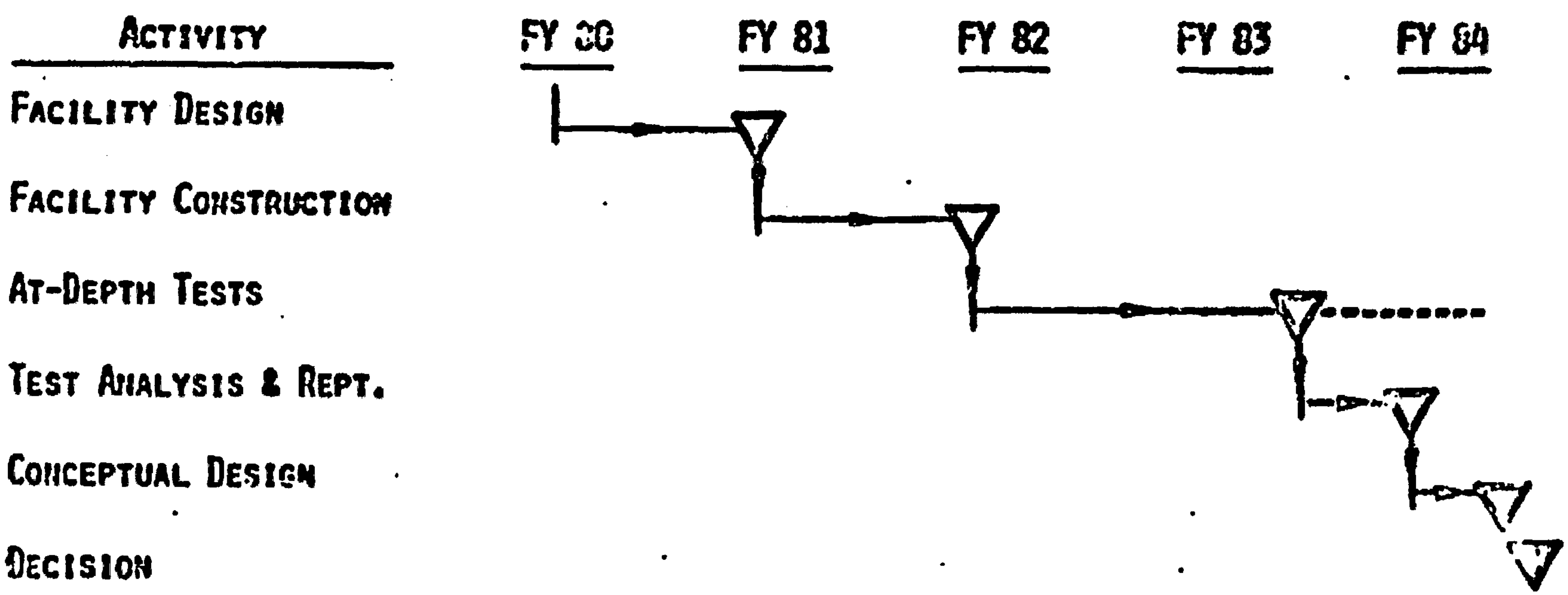
5. Chemical Analysis

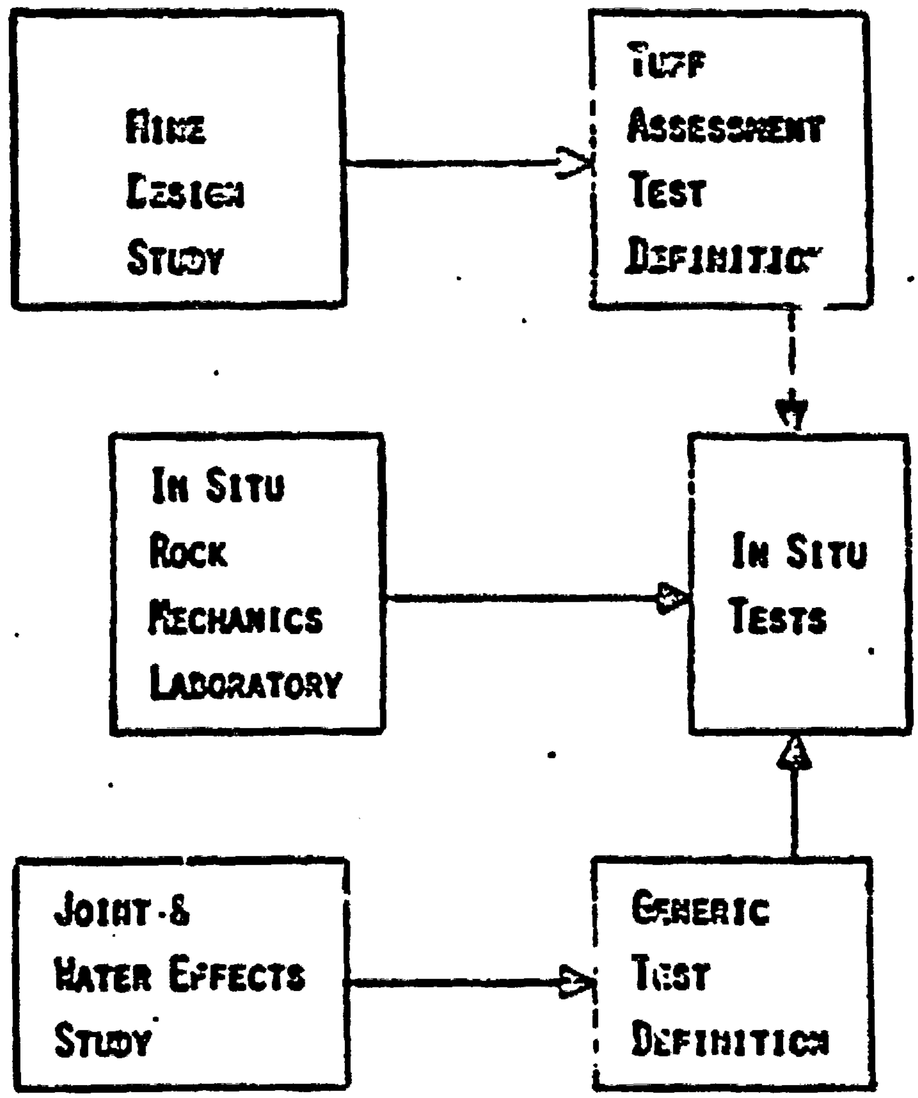
   - Calculate radiation environment at representative points

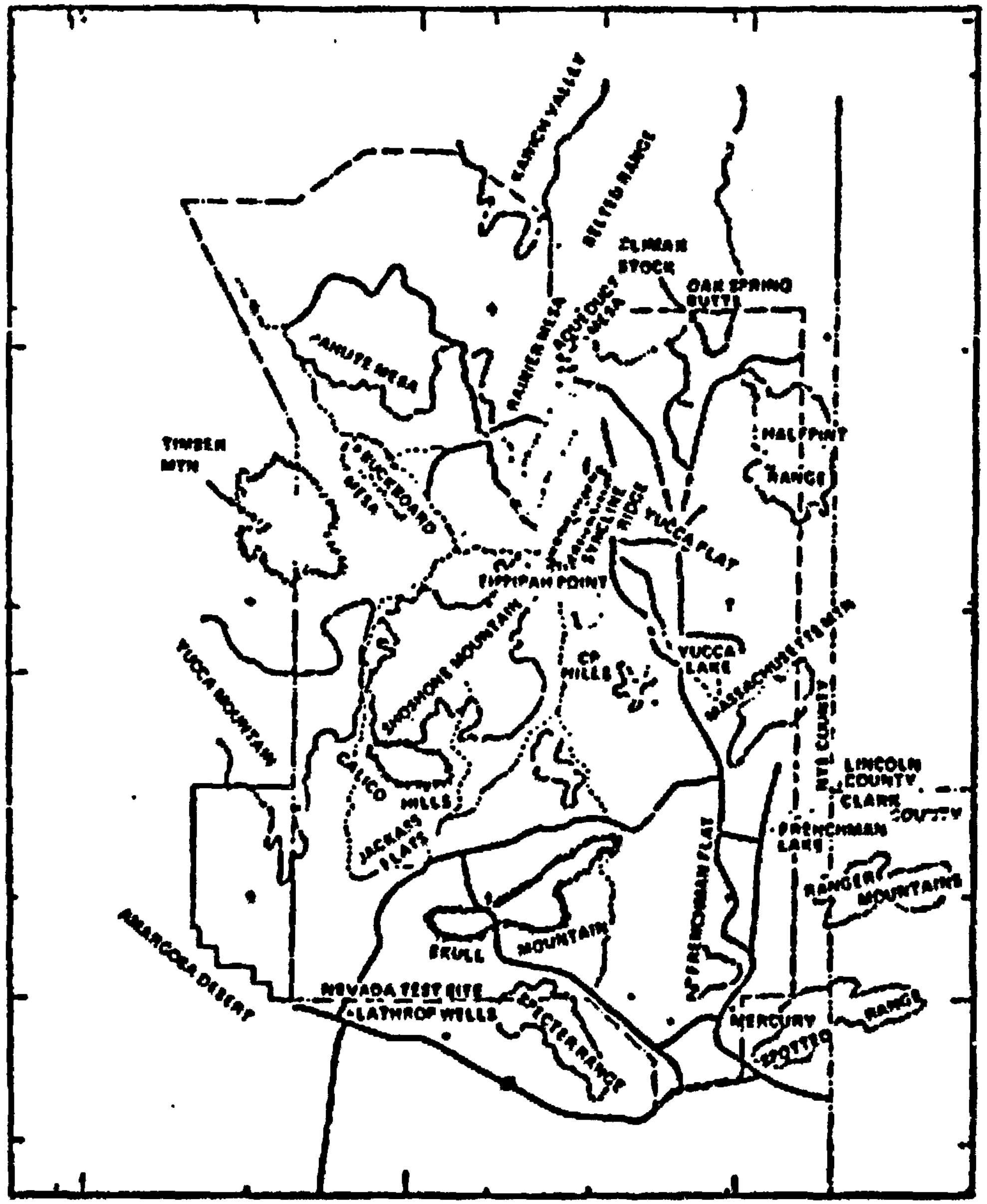
   * Specify temperatures, pressures, radiation field and material at representative points


1.
Assume
O Multibarriers
O Implantation Geom
2.
Mine Concept
&
Hydrologic
Environment
3.
Calculate
Temp. Distributions
(local, near-field, far-field)
4.
Stress, Displ.,
fracturing,
failure
Distribution
5.
Chemical
Environments
(local, near-
field, far-field)

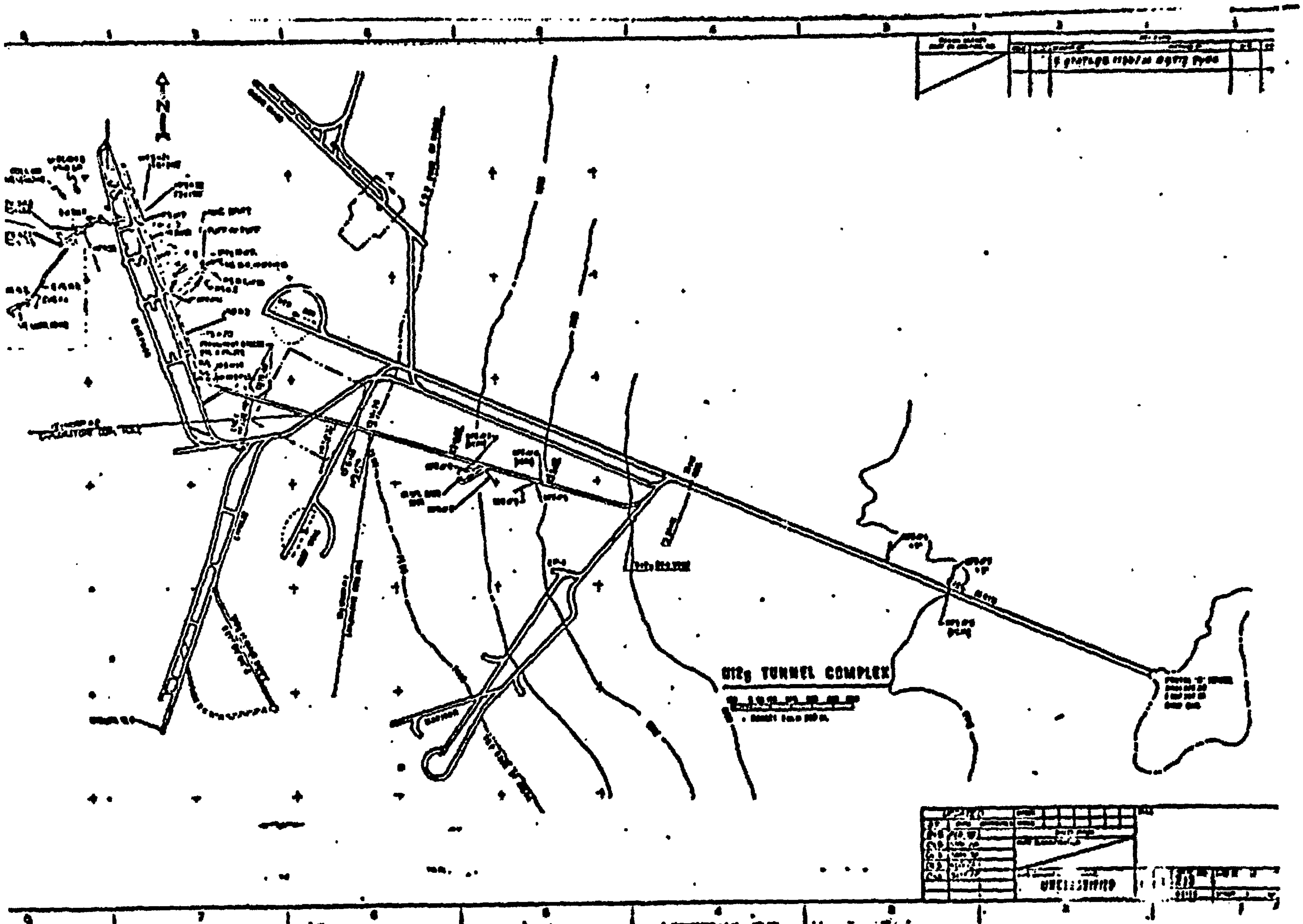
FY 84 SITE SELECTION DECISION
STRATEGY III (TUFF)

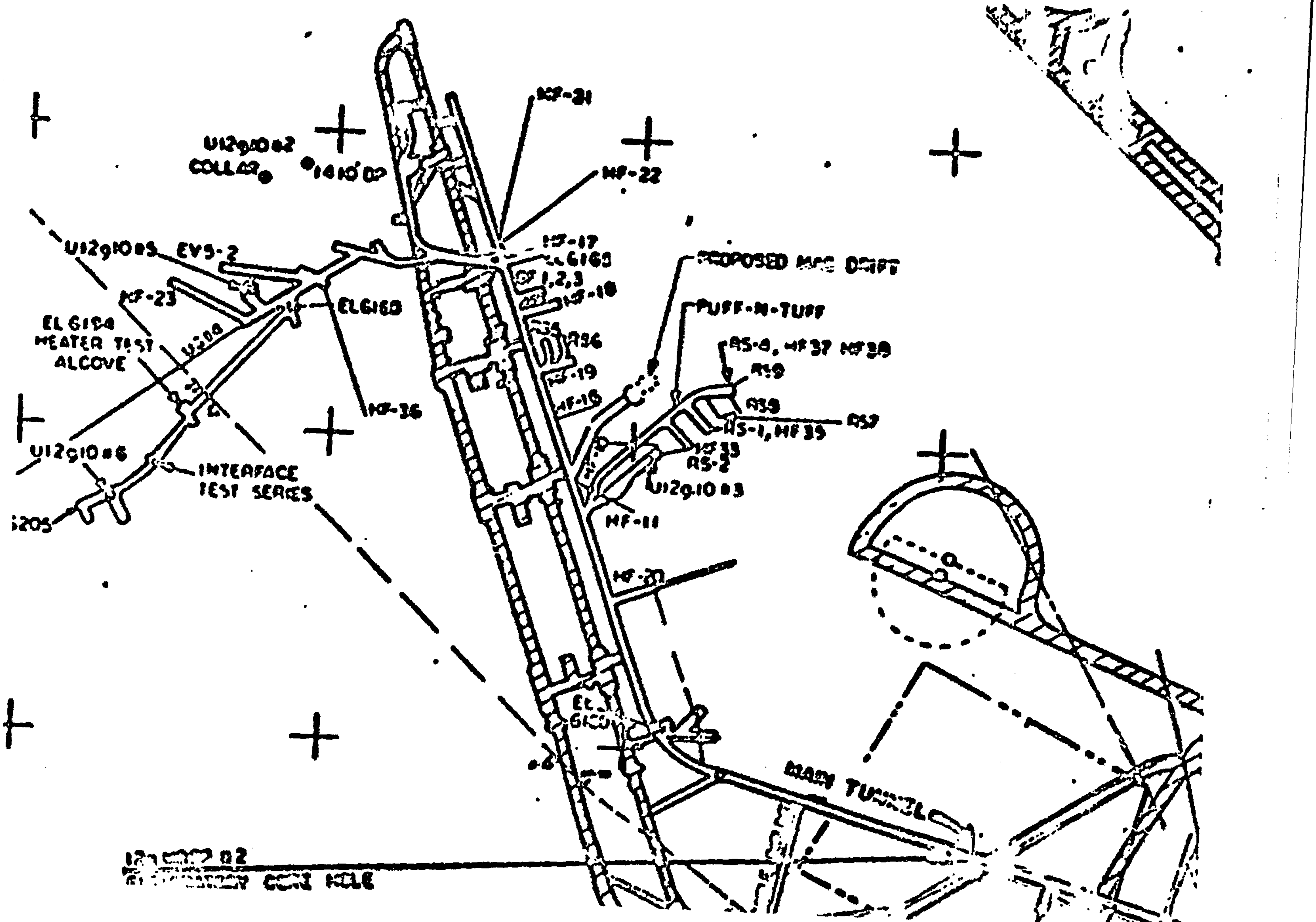



Mine Design Study
Tuff Assessment Test Definition
In Situ Rock Mechanics Laboratory
In Situ Tests
Joint & Water Effects Study
Generic Test Definition



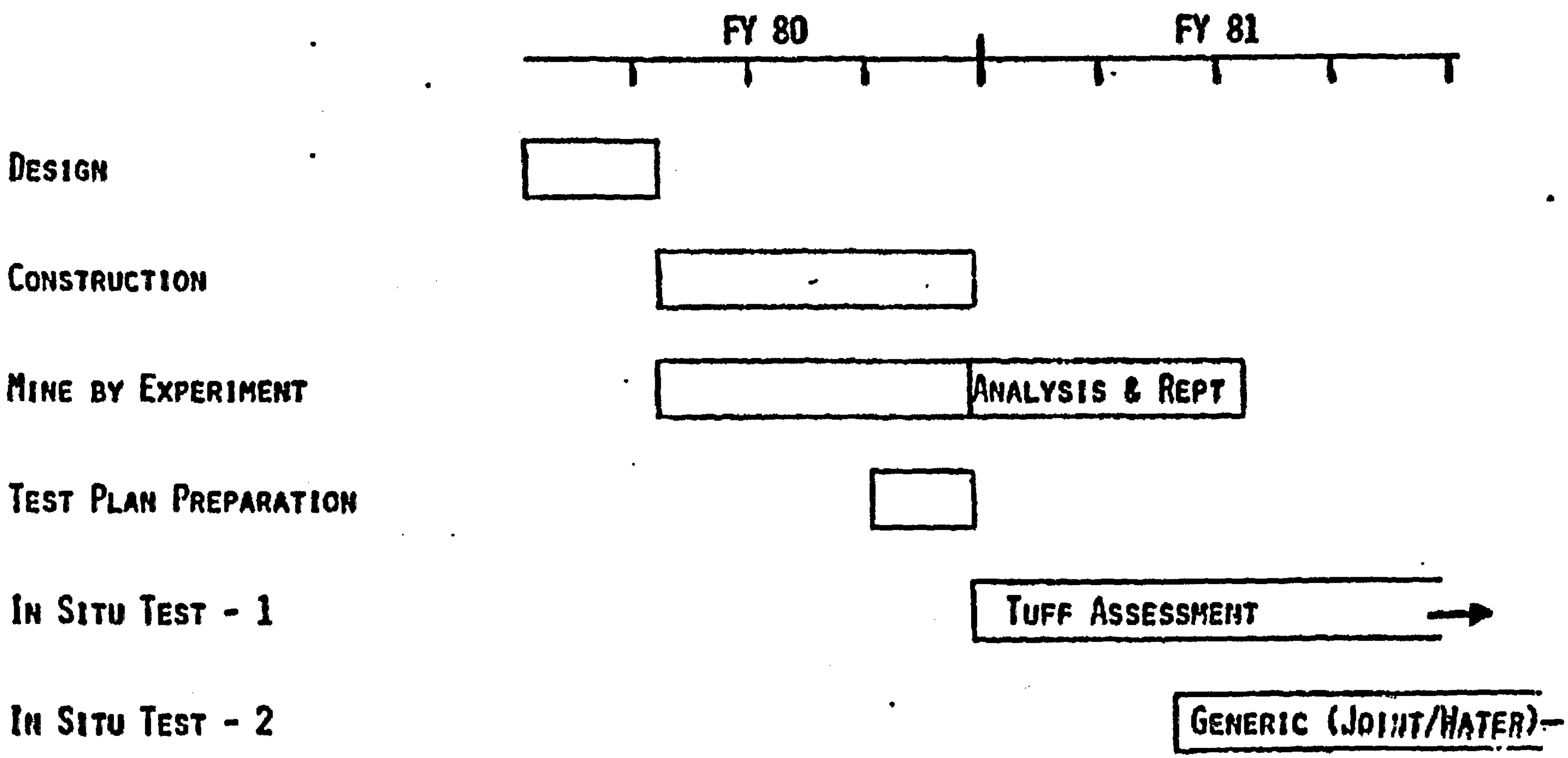
MAP OF THE NEVADA TEST SITE SHOWING PRINCIPAL TOPOGRAPHIC FEATURES

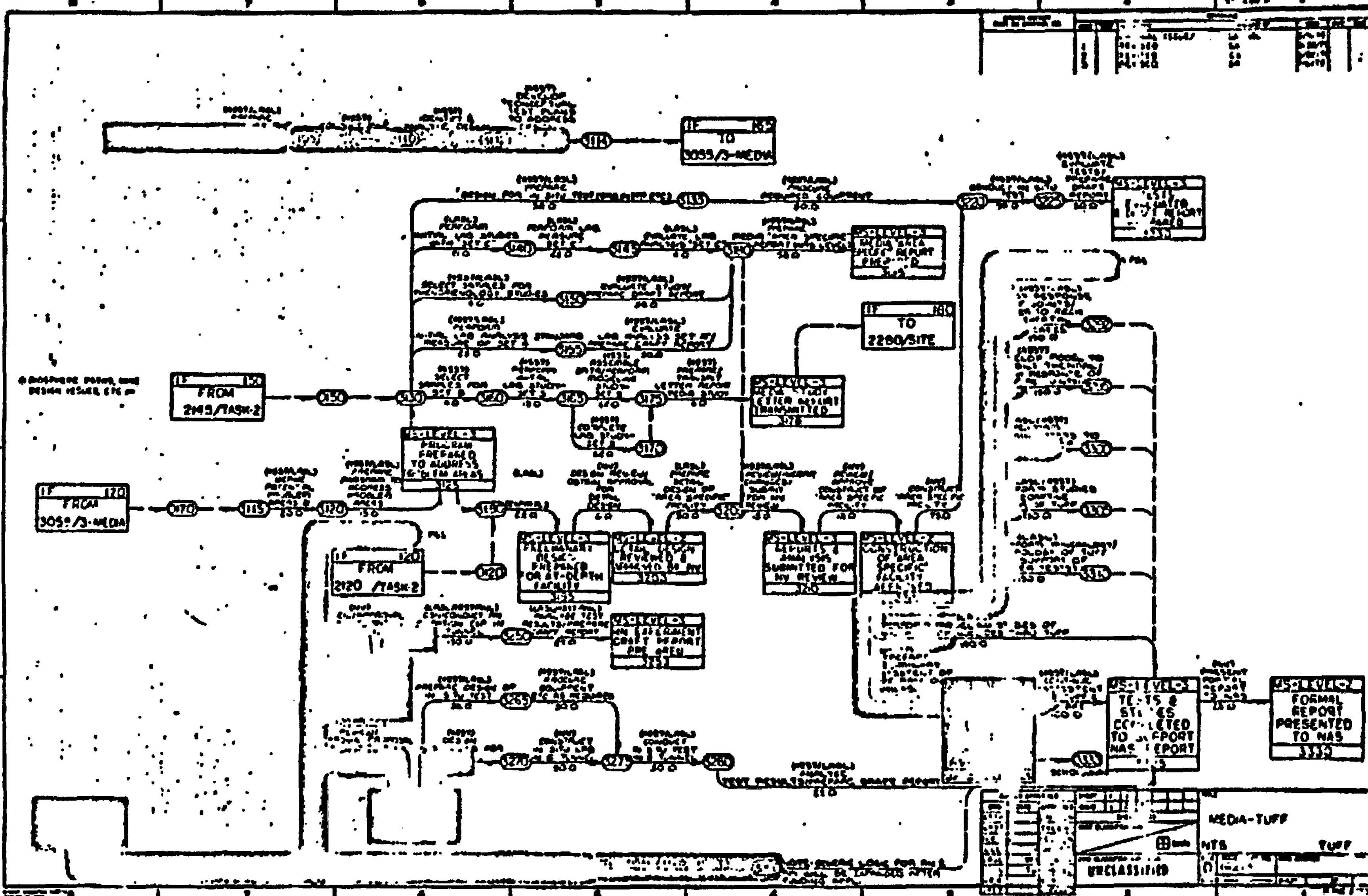

U12g TUNNEL COMPLEX



HF-21
U12g.10 #2
COLLAR
1410' DP
HF-22
U12g.10 #5
EVS-2
HF-17
EL6165
HF-23
EL6165
HF-18
EL 6194
HEATER TEST
ALCOVE
RS6
HF-19
HF-16
HF-36
PROPOSED
PUFF-N-TUFF
RS-4, HF37 HF38
RS9
RS8
RS7
RS-1, HF35
HF33
RS-2
U12g.10 #3
U12g10 #6
INTERFACE
TEST SERIES
HF-11
HF-20
MAIN TUNNEL

IN SITU ROCK MECHANICS SCHEDULE





TO
3055/3-MEDIA
TO
2260/SITE
FROM
2145/TASK-2
FROM
3055/3-MEDIA
FROM
2120 /TASK-2
FORMAL REPORT PRESENTED TO NAS
3330
MEDIA-TUFF
NTS
TUFF
UNCLASSIFIED