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TITLE: Prototype Testing for the Yucca Mountain Project

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PROTOTYPE TESTING FOR THE YUCCA MOUNTAIN PROJECT

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ABSTRACT

The U.S. Department of Energy, through its Yucca Mountain Project Office (YMPO), has been conducting prototype activities in welded and non-welded tuff. These activities are in preparation for characterization of the Yucca Mountain area, which is under consideration as a site for a geologic repository in which high-level nuclear waste could be safely stored. Investigators from organizations that will conduct the site investigation have been afforded opportunity, through the prototype program, to test, evaluate, and develop instruments, equipment, and methods. The Exploratory Shaft Facility (ESF) will be used to collect significant amounts of underground site characterization data. The prototype tests are conducted under similar conditions.

INTRODUCTION

The U.S. Department of Energy (DOE) plans to conduct an investigation of the Yucca Mountain area, located approximately 100 miles northwest of Las Vegas, Nevada, to assess its suitability as a site to safely isolate nuclear waste in a proposed geologic repository in welded tuff (Fig. 1). The Yucca Mountain Project (YMP) Site Characterization Plan[1] calls for an assessment of the waste isolation capabilities of the site by obtaining geologic, hydrologic, geochemical, constructability, and other pertinent geotechnical information through a number of ESF and surface-based testing activities. Of particular importance is the determination of hydrologic properties of the thick sequence of unsaturated rocks that underlie Yucca Mountain and in which the potential repository would be constructed should the site be found suitable.

Site characterization activities will largely depend on scientific instruments, equipment, methods, and procedures that are commonly taken for granted in many other geotechnical applications. Stringent demonstration that testing techniques will yield acceptable data and can be effectively accomplished is necessary under the licensing environment associated with the Yucca Mountain site characterization. In anticipation and preparation for conducting site characterization tests under stringent quality assurance standards, the YMP has been conducting prototype testing activities in a number of technical areas including geologic mapping, air drilling, rock mechanics, hydrology, and geochemistry. Prototype activities were first conducted for the YMP around 1980. These early activities consisted largely of equipment development and measurements related to rock mechanics and were conducted in G-Tunnel by Sandia National Laboratories' staff. A more formalized program, initiated in late 1987, prescribed specific requirements whereby tests approved for implementation followed administrative and operational procedures similar to ones anticipated for use during site characterization of Yucca Mountain.

Although prototype testing has been conducted in support of both surface-based and underground site characterization activities, this presentation focuses on an overview of those tests conducted in preparation for implementing the underground testing program planned for the ESF. Specific detailed results of selected tests are presented by others elsewhere in these proceedings or in previous publications[2, 3].

OBJECTIVES

It is expected that lessons learned from the YMP prototype testing program will help ensure that experiments in the ESF will produce representative site characterization data and will also contribute significantly to ensuring that these data will be correct, well documented, and defensible during the licensing process. Primary technical objectives of the prototype testing program include the following:
(1) evaluate and/or develop test instrumentation,
(2) evaluate and/or formulate methodologies, and

(3) develop technical and administrative procedures for use in site characterization based on knowledge gained from prototype testing.

A secondary objective is for principal investigators, as well as YMP management staff, to significantly benefit from conducting the prototype work under administrative and operational practices employed at the Nevada Test Site (NTS). This requires interfacing and coordination with multiple support organizations which is similar to practices to be used during site characterization.

LOCATION OF TESTING FACILITIES

The prototype testing activities have been conducted at a number of locations that are located on and off the NTS and in principal investigators' home facilities, but the majority of tests addressed here have been conducted at the G-Tunnel Underground Facility (GTUF) on the NTS. The test facility is situated at Rainier Mesa, approximately one mile from the G-Tunnel portal and about 1430 feet below the surface where investigators have access to both non-welded and fractured welded tuffs (Fig. 2). Rocks in which the experiments are conducted are lithologically similar to those that underlie Yucca Mountain and are under a lithostatic load comparable to that expected at the conceptual repository location. The Experiment Drift, Rock Mechanics Drift, Thermal Stress Test Alcove, and Laser Drift provide access to welded tuffs. The facility tunnel and other drifts are in non-welded tuffs (Fig. 3).

ORGANIZATION AND MANAGEMENT OF THE PROTOTYPE TESTING

Because of a large number of organizations involved and the requirement to adhere to many administrative practices inherent in federal projects, management of the prototype testing program might be viewed as a prototype exercise. Ten organizations and dozens of individuals were involved in the program. Testing during site characterization of Yucca Mountain will be as complex as the prototype testing program. Therefore considerable attention was focused on identifying management practices that worked and those that inhibited progress.

The test program activities are coordinated for the Yucca Mountain Project Office (YMPO) by Los Alamos National Laboratory (LANL) through its Exploratory Shaft Facility Test Manager's Office (TMO) at Las Vegas. Principal Investigators (PIl), who conduct the prototype testing, represent the U.S. Geological Survey (USGS), LANL, Sandia National Laboratories (SNL), the U.S. Bureau of Reclamation (USBR), and Lawrence Livermore National Laboratory (LLNL). The responsibility of the TMO is to coordinate the PIs' test requirements with various support organizations that operate at the NTS, develop test schedules, conduct readiness reviews, track test progress, and report test status. Complexity of the process is illustrated in Figure 4.

One of the most effective management tools has been the readiness review. Such reviews are held prior to initiating a particular test. The readiness review process involves all participants in the test program. This ensures that the PI and operational support personnel are prepared to begin testing and that all instruments, equipment, and supplies are available.

TESTING PROGRAM

The prototype tests conducted in the G-Tunnel facility are described briefly below. Tests were initially identified by the organizations responsible for underground site characterization planned for the ESF and were subsequently reviewed and approved by the YMPO for implementation. The basis for prototype test approval was principally the extent to which a prototype test plan provided justification that the test work was needed in advance to prepare technical procedures for use in ESF testing.

DESCRIPTIONS OF G-TUNNEL PROTOTYPE TESTING ACTIVITIES

Drill Hole Instrumentation (USGS)

This work was conducted to develop methods for installing borehole instruments that measure and monitor hydrologic properties and to develop techniques for calibrating and testing instrument accuracy. Two boreholes were instrumented with

packer assemblies. Three isolated intervals in each borehole were instrumented with various sensors and were monitored over a 1-year period.

Intact Fracture Test (USGS)
The purposes of this work were to evaluate and modify equipment used to obtain intact fracture samples, to develop methods for preserving fracture integrity during sample collection, and to evaluate effectiveness of proposed laboratory testing for hydrologic characterization of the fractures.

Wet and Dry Drilling Test (USGS)
The objective of this work was to determine how air and water, when used as drilling fluids in tuffaceous rocks, affect the in-situ hydrologic conditions of the rock matrix surrounding a borehole.

Dry Coring of Rubble (USGS)
This prototype test was undertaken to demonstrate that the coring techniques to obtain rock samples will not adversely affect results of pore-water analyses. Comparisons were made between blast rubble samples and cores from unblasted rock for both welded and non-welded tuff.

Optimal Rubble Size Test (USGS)
This test involved the determination of the optimum size of blast rubble that can be successfully cored to produce an uncontaminated plug sample to be used for hydrochemical and isotopic pore-water analyses.

Perched Water Test (USGS)
This effort developed, tested, and evaluated methodology and equipment for measuring rates of seepage of perched water into a shaft or drift, for measuring hydraulic heads within a perched water zone, for collecting representative water samples, and for conducting aquifer tests within the perched zone.

In-Situ Stress Test (USGS)
This test evaluated field procedures and instruments and compared alternative methods of determining in-situ stresses under conditions similar to those expected in the ESF. Considerable effort was devoted to developing a dry overcoring method for instrument retrieval.

Excavation Effects Test (USGS)
This test was undertaken to develop, refine, and test methods and equipment for measuring stress changes (and resultant permeability changes), that occur in rock adjacent to a drift as it is being excavated.

Air Coring (LANL)
Feasibility of coring with air was investigated as a substitute for coring with water. Techniques for application to specific needs of the ESF testing program were evaluated.

Dust Hazards Assessments (LANL)
This effort, accomplished in conjunction with the air drilling and coring tests, evaluated the potential exposure of personnel to airborne silica, zeolite fibers, and nuisance dusts. Effectiveness of commercial dust control equipment attached to the drilling apparatus was also assessed.

Diffusion Test (LANL)
This experiment included the development and test of a system for injecting downhole tracers, the development of techniques for overcore sampling of the test zone, and the measurement of diffusion rates in unsaturated, welded and nonwelded tuff.

Engineered Barrier Test (LLNL)
This heater test simulated thermal response and produced movement of moisture similar to a waste package environment. Horizontal emplacement was simulated.

Geologic Mapping (USBR)
Photogrammetric mapping equipment was tested in a drift so that methodology and techniques could be perfected and technical procedures developed.

Blast Effects Test (SNL/USBR)
This test assessed the impact of controlled blast effects on instruments to be used for hydrologic investigations. These instruments may be installed in close proximity to underground construction and therefore, appropriate changes might be made to instrument design or test strategies.

Thermal Stress Test (SNL)
The purpose of this work is to develop and to

refine methods, equipment, and techniques for measuring thermally induced stress in rocks that enclose waste canisters.

Equipment Development and Evaluation (SNL)
This test developed and evaluated equipment for use in rock mechanics and related investigations in the ESF. A significant task was the development of a special "chain saw" for cutting slots in rock. These slots are used for installation of flatjacks that can be emplaced for use in stress measurements.

HIGHLIGHTS AND BENEFITS OF THE PROTOTYPE TESTING

The prototype testing program has provided the opportunity to try out equipment, to test instrumentation, to develop methodology, and to explore new ideas in a work environment similar to that anticipated at underground investigations in the ESF. Moreover, because the prototype testing is remote from Yucca Mountain, it does not produce data for use in site characterization. Therefore the investigators have been free to use trial-and-error and iterative methods to select or to develop acceptable equipment, instruments, and methodology that will produce the best site characterization data. From the prototype test experience, PIs can prepare technical procedures required for the ESF testing program with confidence that the procedures will have a high degree of success. This prototype effort has demonstrated the difficulties in performing some tasks considered to be standard. The test related drilling and coring was found to be unique to particular tests and to require specific engineering design and operational procedures. For example, maintaining the precision required for dry drilling of holes in welded tuff was considerably more difficult than expected. Dry drilling techniques and dust control mechanisms had to be modified. Significant difficulties were encountered in dry overcoring to recover test instruments emplaced in boreholes, and drilling direction was also difficult to control. These kinds of problems have demonstrated the importance of instituting a rigorous equipment acceptance program and operator training for testing activities during ESF investigations.

The most valuable lessons from G-Tunnel prototype testing relate not so much to the tests themselves or the data obtained from the tests but from the realization that there were false expectations that equipment and operational support for the tests would be routine. However, both specific testing results and operational realities are being factored into the development of realistic testing schedules, instrumentation specifications, equipment lists, training needs, and preparation of technical and field operations procedures.

CURRENT STATUS

In late November 1989, a decision was made by the YMPO to cease further prototype testing activities at G-Tunnel in support of the ESF testing program. This was due to severe budgetary restraints and deferral of ESF construction until 1991. All YMP activities in G-tunnel are suspended at this time, but it is anticipated that prototype work may be resumed either in G-Tunnel or elsewhere at an appropriate future time. Currently, PIs are preparing reports on the results of completed tests and writing technical procedures based on information gained from these prototype tests.

REFERENCES

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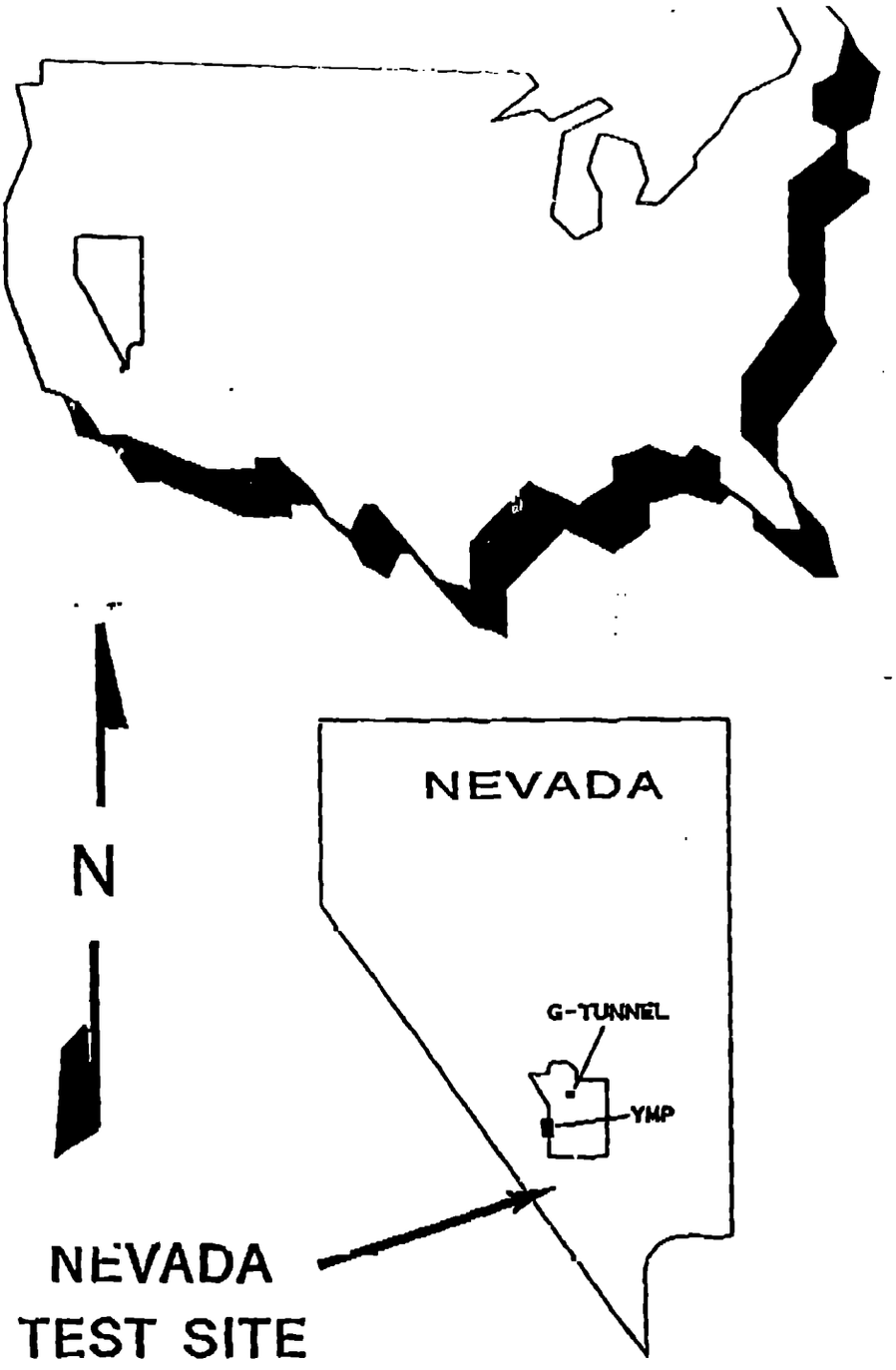
3. J. M. Ray and J. C. Newsom, "The Yucca Mountain Project Prototype Air Coring Test, U12g Tunnel, Nevada Test Site", Sept, 1988. Los Alamos, Draft (1989) LA-To Be Published.



Location of Nevada Test Site in Southern Nevada

Figure 1

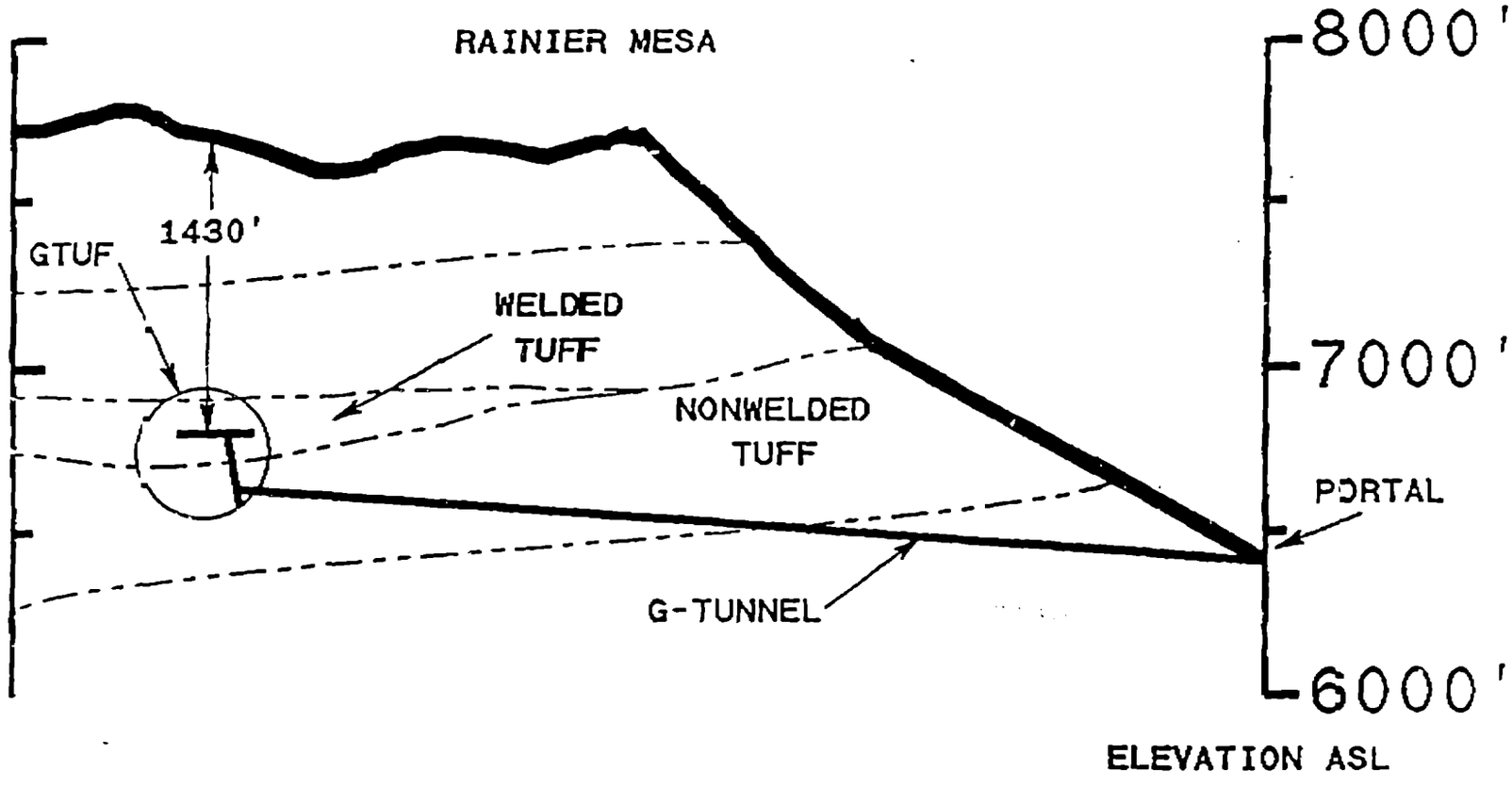

RAINIER MESA
8000'
1430'
GTUF
WELDED
TUFF
NONWELDED
TUFF
7000'
PORTAL
G-TUNNEL
6000'
ELEVATION ASL

Figure 2

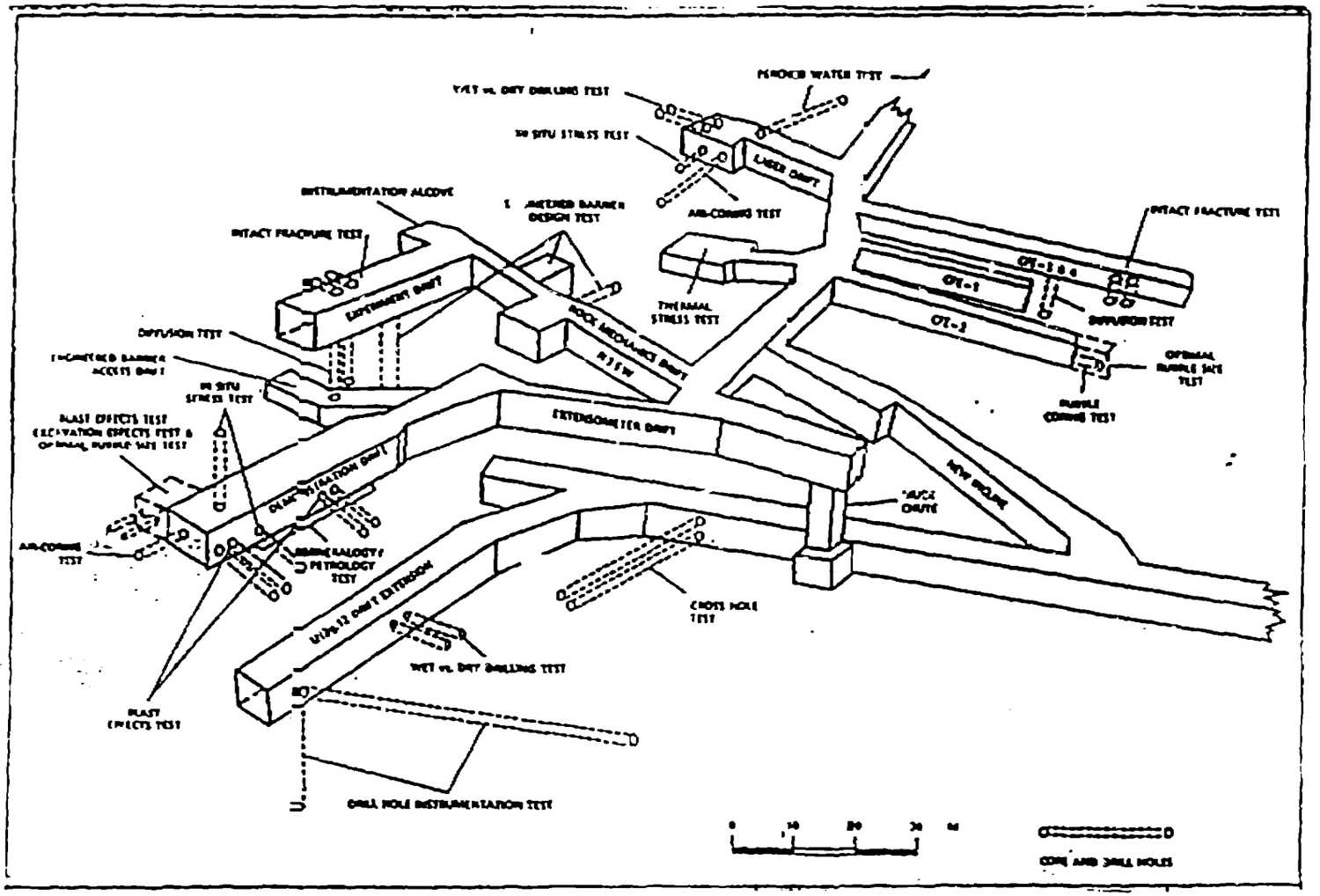

INTACT FRACTURE TEST
DIFFUSION TEST
BLAST EFFECTS TEST
EXCAVATION EFFECTS TEST &
OPTIMAL BUBBLE SIZE TEST
AIR-COMBS TEST
BLAST EFFECTS TEST
CROSS HOLE TEST
DRILL HOLE INSTRUMENTATION TEST
EXTENSOMETER DRIFT
ROCK MECHANICS DRIFT
THERMAL STRESS TEST
OPTIMAL BUBBLE SIZE TEST
BUBBLE CURTAIN TEST
0
30
60
90
M
CORE AND DRILL HOLES

Figure 3

ESF PROTOTYPE TESTING

ACTIVITY FLOW

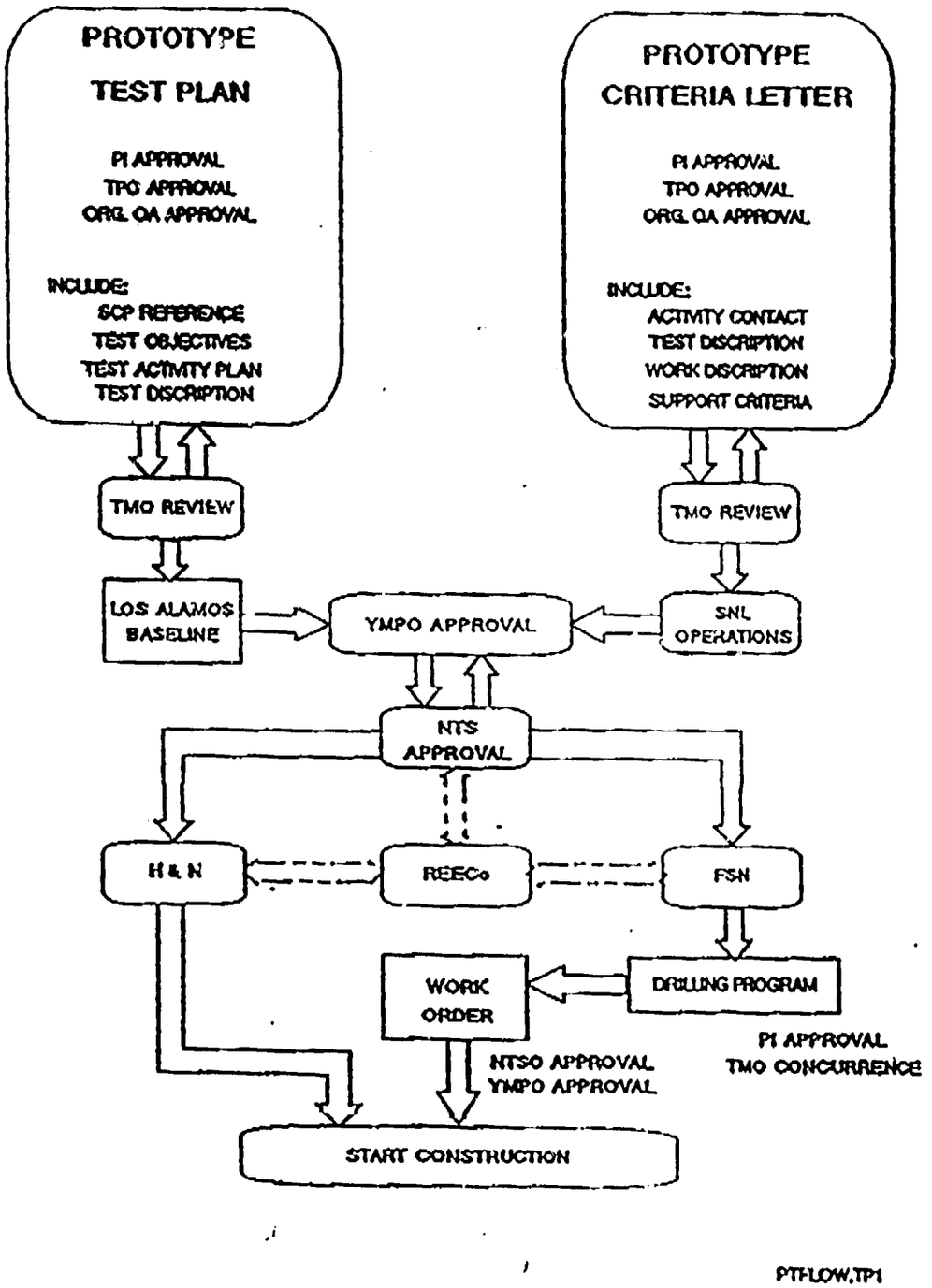


Figure 4