QA:QA

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

MOISTURE STUDIES IN THE ESF

REVISION 6

FIELD WORK PACKAGE FWP-ESF-96-004

WM-11
WM3507

UNITED STATES DEPARTMENT OF ENERGY

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
FWP/LWP APPROVAL

QA: QA

SECTION I (Project Engineer completes)

FWP/LWP Title:

Moisture Studies in the ESF

FWP/LWP Identifier:	Assigned Project Engineer:
FWP-ESF-96-004	Alan J. Mitchell

Affected Organizations in FWP/LWP:

LANL, USGS, LBNL, BSC

HISTORY OF REVISIONS

Revision Number	Effective Date	Reason for Change
0	07/23/96	Initial issue.
1	3/13/97	Inclusion of tracer gas injection tasks, additional affected organizations, and ES&H responsible. Various updates also included.
2	04/29/98	Update scope to include new moisture related tests and testing locations.
3	09/24/98	Update DIE references, controls, points of contact list, and ES&H review. Added attachment 12 and made various editorial changes.
4	04/07/99	Clarify organizational responsibilities and update scope of work.
5	02/08/00	Additional workscope.
6	04/18/01 ~~04/16/01~~	Bn 04/16/01 Change of work scope to include Batwing construction and testing.

SECTION II (Project Engineer obtains signatures) (N/A for expedited changes)

The following signatures authorize work to commence in accordance with this FWP/LWP and within the constraints identified in the Planning and Control System approved by the Office of Civilian Radioactive Waste Management.

Manager Name:	Organization:	Signature:	Date:
Mark Peters	S&ET	Ron Calvin for M P	4/12/01
Manager Name:	Organization:	Signature:	Date:
Dennis Sorensen	S&H	Jayne Andrews for CDS	4/13/01
Manager Name:	Organization:	Signature:	Date:
Mark Sparks	SS/FS	for CMS	4/12/01
Manager Name:	Organization:	Signature: QQA?	Date:
Manager Name:	Organization:	Signature:	Date:

SECTION III (Project Engineer obtains signatures) (N/A for non-expedited changes)

Work approved in the previous revision of this FWP/LWP may continue with the expedited changes identified in this revision. A full review of this expedited change should be initiated within 3 working days of the effective date of this revision.

TCO Manager:	Signature:	Date:

INTRODUCTION

This Field Work Package (FWP) developed in accordance with AP- 5.2Q provides both administrative guidance and instructions which implement the Quality Assurance Requirements and Description (QARD) DOE/RW-0333P, and Integrated Safety Management (ISM) Program principles/functions related to Moisture Studies in the Exploratory Studies Facility (ESF).

Affected organizations are responsible for conducting field work in accordance with this controlled FWP. It is the affected organization's responsibility to determine the Quality Assurance (QA) program applicability for related activities in accordance with the Office of Civilian Radioactive Waste Management approved QA program. This FWP is neither a design document, nor a Yucca Mountain Site Characterization Project (YMP) baseline document.

1.0 SCOPE AND DESCRIPTION

1.1 GENERAL SCOPE DESCRIPTION

This FWP provides the process controls utilized by the Test Coordination Office (TCO) to manage and coordinate the activities for this study, which include the configuration, installation, and implementation of Moisture Studies in the ESF. This testing FWP will address testing criteria, Project controls, Environmental, Safety, and Health (ES&H) requirements, and identify roles and responsibilities specific to this testing workscope. This FWP applies to Moisture Studies in underground excavations in the ESF, including but not limited to the ESF, Enhanced Characterization of the Repository Block (ECRB), and other locations as activities are budgeted and planned.

1.1.1 General Test Description and Objectives

This FWP describes the interfaces and controls used to coordinate Moisture Studies in the ESF. The objective of this task is to ensure information collected is suitable for use on the YMP. Moisture Studies in the ESF will consist of many different types of moisture measurements and moisture/water determinations which will be conducted throughout the ESF from the North Ramp portal along the Main Drift, continuing to the South Portal and throughout the entire ECRB Cross-Drift and extensions utilizing exposed ribs of alcoves as well as niches constructed specifically for this study.

The purpose of Moisture Studies in the ESF is to; (1) document tunnel baseline conditions and effects of various construction and operating activities; (2) conduct hydrologic testing, infiltration, percolation, seepage flux measurements, and data collection of the unsaturated stratigraphic zones exposed in the ESF; (3) utilize the information gathered from these studies to continue the development of process models to support system performance, site recommendation, and license application; (4) determine a mass water balance for material excavated during construction; (5) provide information for hydrologic imbibition with consideration to airborne industrial hygiene issues; (6) fracture flow and transport; and (7) associate information and technical skills used for moisture studies to help correlate and bring together additional information, which could tie to the activities needed to provide data required for performance assessment.

The Site Services and Field Support (SS/FS) implements ESF niche and alcove construction based on location criteria from the Principal Investigator (PI) transmitted through the TCO and design information from the Architect/Engineer (A&E).

Niche and alcove design and construction is the responsibility of the A&E and SS/FS.

Each niche will be constructed by the respective department within the SS/FS according to drawings and criteria. References to drawings may be called out for items including alteration of ground support utility requirements and construction configurations. The design process for these excavations will be coordinated by the TCO Design Coordinator. The design is concurrent with Repository Design planning in regards to the potential repository design. Prior to niche or alcove excavation, a series of boreholes may be drilled to allow for gaseous and/or aqueous tracer testing. During mechanical excavation processes, the PIs or their designees may collect bulk rock samples and map in-situ fractures. Upon completion of excavation, additional boreholes will be drilled laterally from each niche. These holes will be instrumented as quickly as possible, then bulkhead doors will be installed at each niche. Datalogging equipment will be set in or near the niches or alcoves. Opening of a niche bulkhead door must be coordinated by the TCO in order not to compromise the test and be concurrent with all access procedures.

Specific measurements planned may include: (1) the determinations of flux and humidity gradients across the boundary layers near the wall or invert surfaces; (2) installation of instrumentation into boreholes and or bench cuts to gain direct measurement of water potential, temperatures, rock permeability, and porosity; (3) determination of the air flow velocity, temperature, relative humidity, and barometric pressures within the various locations (approximately one sensor station every 500 meters to 1000 meters, and supplemented by mobile surveys along tunnel segments, and at major interfaces and fault intersections); and (4) the use of infrared imaging and other techniques to evaluate the evaporative processes near the ESF tunnel surfaces.

Measurements which are currently required by the Science & Engineering Testing (S&ET) scientists are: (1) electrical power consumption (as available); (2) air flow measurements inside the ESF/ECRB; and (3) volumes of traced water used inside the ESF/ECRB, dust control, construction, drilling operations, and other construction/testing activities. This information shall be supplied by the departments within the SS/FS.

Globally, the objectives of Moisture Studies in the ESF are to provide determinations of moisture conditions in the tunnel rock as well as the excavated areas in order to supply information to supplement hydrologic modeling calculations for the entire Yucca Mountain area and provide input to effective hydrologic, transport, flow, and integrated site models.

1.1.2 Regulatory Basis for Moisture Studies in the ESF

The following are controlled or published YMP documents that describe Moisture Studies in the ESF. These documents, together with related plans, include:

- Site Characterization Plan (DOE/RW-0199), Date: December 1988
  - Section 8.3.1.2.2.8 Fluid Flow in Unsaturated Zone Fractured Rock
  - Section 8.3.1.2.2.9 Site Unsaturated Zone Modeling and Synthesis
  - Section 8.3.1.2.2.1.2 Unsaturated Zone Infiltration
  - Section 8.3.1.2.2.3.1 Percolation in the Unsaturated Zone
- Characterization of the Yucca Mountain Unsaturated Zone
- Aqueous-Phase Chemical Investigations Unsaturated Zone Hydrochemistry
- Multi-Year Planning System (MYPS) Fiscal Year (FY) 01 at http://ympcs1.ymp.gov

1.2 SPECIFIC SCOPE DESCRIPTION

1.2.1 Organizational Responsibilities

The organizations described in the following section provide services in support of Moisture Studies in the ESF. A brief scope of responsibilities for each organization is provided including interface responsibilities. Specific ES&H responsibilities, processes, and controls are included in Section 4.1. In general, the TCO acts as the interface and coordinator between the PI Organization(s) and all other organizations listed in the following paragraphs. The TCO monitors all test-related construction and testing activities associated with this activity, also ensures and enacts the appropriate controls, as necessary, through the relevant organization(s).

TEST COORDINATION OFFICE - The TCO is responsible for overall field management, coordination, and monitoring of test activities as defined in this FWP. Specific responsibilities will include: planning and coordination of field testing activities, specifically coordination between the PIs and Construction Management; preparation and maintenance of working schedules based on annual budget allocations; assignment of a FWP Records Coordinator (FWPRC) to monitor the FWP records, assignment of a Data Manager for the data management activities described in FWP-ESF-96-001, "Exploratory Studies Facility Data Collection Systems"; preparation of requests for field work scope modification for activities that fall within the approved scope of this activity; and preparation and control of changes to this FWP. These responsibilities, when shared with the supporting PIs, will ensure that data processes and information gathered from the test activities described herein will meet requirements. The TCO is on site whenever construction or test-related activities are occurring. The TCO will provide ESF access for scientific staff, support staff, and Data Collection Systems (DCS) support personnel as required. The TCO is responsible for coordinating all aspects of field test implementation. The TCO will coordinate all requests specific to testing that are included in this FWP, as well as additional requests when supplied to the Responsible Engineer (RE) assigned to the test or the Field Test Manager. To remain consistent with other TCO FWPs and Organizations, the term TCO RE

will be used to represent the term RE in this document. Field activities that are not coordinated through the TCO may cause delays to field implementation or result in changes that may directly affect field test objectives. The TCO has the responsibility of maintaining the anticipated work location of each PI or designee while working in the field.

PRINCIPAL INVESTIGATORS - The PIs will provide the scientific staff, instrumentation, and equipment necessary for maintaining and calibrating all required scientific equipment and instrumentation utilized for conducting Moisture Studies in the ESF. Moisture Studies activities include deployment of testing components, instrumentation, and interactions with the established data collection services in the ESF. The PIs are responsible for ensuring that the data and information collected during test activities associated with Moisture Studies in the ESF are acceptable to meet requirements for site characterization and are qualified in accordance with QA requirements. The PIs are responsible for ensuring that each of their field staff has been provided an opportunity to read and understand the contents of this FWP. It is the responsibility of each PI or designee performing work covered within this FWP to report to the assigned PE, as well as the Field Test Manager each time they plan to conduct field activities. Field activities that are not coordinated through the TCO may cause delays to field implementation or result in changes that may directly affect field test objectives.

The PI is responsible for ensuring that each of their field staff have been provided an opportunity to read and understand this FWP and associated Work Instructions.

SITE SERVICES AND FIELD SUPPORT SS/FS - The SS/FS Department is comprised of multiple departments, which provide overall management of all tunnel operations. These SS/FS departments include, Field Engineering Department (FED), and Site Construction Management Department (CMD). The SS/FS will provide an interface to the TCO. The SS/FS will ensure that criteria transmitted through design documents and FWPs will be adhered to, unless communicated to the TCO. The TCO will coordinate testing field activities with the SS/FS who will ensure departmental support in providing underground labor, materials, and equipment to facilitate testing activities as requested by the PIs, and transmitted through the TCO. This support for testing activities may, at a minimum, include drilling activities, survey support, and the transportation of equipment and samples inside the ESF and on the ESF Pad. The SS/FS has the responsibility of ensuring safe working conditions and safe constructor operated equipment. Personnel entering the ESF will comply with the Safety and Health Plan.

WIRELINE MEASUREMENT SUPPORT (WMS) - WMS personnel will provide instrumentation and equipment, geophysical logging, and support for testing activities associated with this FWP. Call out for this support, as defined by the PI, will be coordinated through the responsible Moisture Studies TCO PE and TCO Field Test Manager. Work will be conducted for these activities through FWP-ESF-96-013, "Borehole Wireline Measurements for ESF Testing Activities."

SAMPLE MANAGEMENT FACILITY (SMF) will provide sample collection, handling, packaging, archiving, and shipping support for samples or core as requested by the TCO.

1.2.2 Field Testing Equipment

The PI testing organizations shall provide the test equipment required to perform field activities associated with Moisture Studies in the ESF. The PIs shall have approved procedures and/or scientific notebooks to follow when using this equipment. Field data collection equipment may be supplied by the PI testing organizations or provided to the PI testing organizations by the ESF DCS program. Currently identified PI provided instrumentation is outlined in Attachment 3.

1.2.3 Computer Software

Software (excluding that which is an integral part of measuring and test equipment) that uses numerical methods for complex scientific, engineering, or mathematical calculations will be controlled in accordance with appropriate QA procedures. The DCS uses manufactured software in order to allow the devices to perform the functions required. No manipulation of raw data will occur in the field during data collection, unless performed by the PI under approved procedures or documented in the PI's scientific notebook. No data manipulation software is identified at this time.

Personnel who use electronic methods to control data, used as sources for Quality Affecting work, must determine if requirements from the QARD Supplement V apply.

1.3 IMPLEMENTING FIELD DOCUMENTS

FWP-ESF-96-001 will provide the process controls utilized by the TCO to manage the configuration, procurement, installation, calibration, operation, and maintenance of the DCS specific to site characterization activities conducted in the ESF. FWP-ESF-96-001 will implement the installation and operation of data collection equipment and instrumentation to meet the data requirements identified for Moisture Studies in the ESF requiring electronic data collection support.

The following procedures or equivalents will be utilized to conduct work within the scope of this FWP. The roles and responsibilities by which these procedures are applied in executing the work are presented in Section 3.0. The sequence in which these documents are applied in executing the work is presented in Section 3.0. The decision to implement these procedures or apply them to QA controlled activities is under the direction of the implementing organization. This list identifies procedures and processes currently planned to implement activities. ISM principles and functions are administrative in nature and are implemented using the Work Instruction Process. This process is outlined in Attachment 15. These procedures may be revised, replaced, or added to, as needed, without revising this FWP.

Procedure Number	Title
AP-12.1Q	Control of Measuring and Test Equipment and Calibration Standards
AP-15.2Q	Control of Nonconformances
AP-17.1Q	Records Source Responsibilities for Inclusionary Records
AP-2.17Q	Tracers, Fluids, and Materials Data Reporting and Management
AP-2.21Q	Quality Determinations and Planning for Scientific, Engineering, and Regulatory Compliance Activities
AP-3.14Q	Transmittal of Input
AP-EM-002	Land Access and Environmental Compliance
AP-EM-003	Nonhazardous Waste Management
AP-EM-004*	Spill Management
AP-ESH-006*	Airborne Radiation Protection Program for Naturally Occurring
AP-ESH-008*	Hazards Analysis System
AP-OM-005	Underground Access Control Process
AP-OM-006Q	Work Request/Work Order Process
AP-REG-001*	Managing Lessons Learned
AP-SIII.1Q	Scientific Notebooks
AP-SIII.3Q	Submittal and Incorporation of Data to the Technical Data Management System
AP-SV.1Q	Control of the Electronic Management of Data
LANL-EES-13-DP-612	Identification, Collection, and Handling of Non-Required Assigned Core in the ESF
LANL-EES-13-DP-613	Borehole Wireline Measurements
LP-ESH-010-M&O*	Emergency Management
LP-ESH-012-M&O*	Compliance with the Occupational Safety and Health Administration Hazard Communication Standard
NWI-DS-002Q	Field Drilling Support Activities
NWI-DS-004Q	Logging, Handling, and Documenting Exploratory Studies Facility Non-Required Assigned Core Samples
NWI-ESF-007Q	Water Use and Control-Subsorface
NWI-ESF-008Q	Surveying
PRO-EP-003*	Authorization to Purchase Regulated Materials
PRO-MG-004*	Integrated Safety Management System
PRO-SH-001*	Accident Investigation, Reporting and Recordkeeping
PRO-SH-004*	Hearing Conservation Program
PRO-SH-014*	Silica Protection Program
USGS-YMP-HP 97	Measurement of Temperature and Relative Humidity Using a Temperature and Relative Humidity Probe
USGS-YMP-HP177	Operation of a Barometric Pressure Transducer
YAP-SII.1Q	Submittal, Review, and Approval of Requests for Yucca Mountain Site Characterization Project Geological Specimens
YAP-SII.4Q	Collection, Submission, and Documentation of Non-Core and Non-Cuttings Samples to the Sample Management Facility for Site Characterization
YMP-LBNL.TIP/AFT-4.0	In Situ Constant Mass Flux air Permeability Testing Using Pneumatic Packers
YMP-LBNLII-TIP/TT-5.0	Calibration of Inferred Camera
YMP-LBNL-QIP-4.3	Procurement Report Initiation and Acceptance of Quality Products and Services
YMP-LBNL-QIP-5.2	Preparing Development Plans and Quality Technical Implementing Procedures
YMP-LBNL-QIP-SII.0	Documenting Sample Control
YMP-LBNL-QIP-SV.0	Control of the Electronic Management of Data
YMP-LBNL-TIP/AFT-10.0	Field Checks for the Mettler Toledo Model PG-s and SG Series Balances
YMP-LBNL-TIP/AFT-2.0	Drift Scale Test Gas Tracer Testing in Hydrology Boreholes using Balzer's Mass Spectrometer
YMP-LBNL-TIP/AFT-3.0	Preparation of Standards for Ageous Tracer Concentration Measurements
YMP-LBNL-TIP/AFT-3.0	Calibration and Tuning of the Balzer's Mass Spectrometer for Tracer Tests Performed in the DST Using Reference Calibration Bags
YMP-LBNL-TIP/AFT-5.0	Borehole Scanner Survey
YMP-LBNL-TIP/AFT-6.0	Psychrometer Measurements
YMP-LBNL-TIP/AFT-7.0	Use of a Spectrometer of Fluorometer to Determine Aqueous Constituent
YMP-LBNL-TIP/AFT-8.0	Use of an Ion-Selective Electrode to Determine Ion Concentrations in Solution
YMP-LBNL-TIP/AFT-9.0	Chromatographic Determination of Aqueous Constituent Concentration
YMP-LBNL-TIP/TT-3.0	Calibration and Tuning of the Balzer's Mass Spectrometer for Tracer Tests in the DST Using Reference Calibration Bags

Note: all procedures identified with an asterisk can be found in the ES&H Electronic Manual available through Lotus Notes on server YMLN1.

1.4 DATA AND DELIVERABLES

Scientific and testing data and records related to the ESF are the result of the implementation of this FWP. The PIs have the responsibility for the collection, analysis, submittal, and reporting of data in compliance with Project and participant plans and procedures for their specific testing activities as described

in this FWP. The ESF Data Manager manages and facilitates the flow of ESF test-related data. Data record responsibility is addressed in Section 6.0 of this FWP.

Information needs, specific parameters, and instrumentation type yielding data are listed in Attachment 3.

Deliverables:

Analysis and Modeling Report (AMR) "In situ field testing of processes"
Process Modeling Report (PMR) "Unsaturated Zone Flow and Transport"

Data collected from Moisture Studies activities may feed the following models:

- Hydrogeologic Framework Model
- Infiltration Model
- Conceptual Numerical Model for UZ Flow and Transport
- Radionuclide Transport Model
- UZ Colloid Transport Model
- Analysis of Hydrologic Properties Data
- Abstract Drift Seepage and Scale Coupled Processes

1.5 PLANNED TRACERS, FLUIDS, AND MATERIALS USAGE

The use or removal of testing related Tracers, Fluids, and Materials (TFM) by affected organizations must be identified and reported to the TCO prior to use/removal. The TCO will report the use of test-related TFM in accordance with AP-2.17Q. The FED is responsible for reporting construction-related TFM usage in accordance with AP-2.17Q. The controls regarding the use of TFM are listed in the Determination of Importance Evaluations (DIE) specific to the field work, which are implemented and controlled under this FWP (Attachment 12).

Below is a list of planned TFM, which has been transmitted to the Safety Assurance Department (SAD) and evaluated through a DIE. This list of tracers does not signify approval by M&O Environmental Compliance Department (ECD) for the use of any of the tracers. Each individual tracer and associated tracer test shall be identified and approved in the land access and environmental approval letter as required by AP-EM-002.

Planned TFM include:

Silica Flour	Sodium Tungstate Dihydrate
Polycell Expanding Foam	Sodium Molybdate Dihydrate
Overton Type Sand (Washed Sand)	Sodium Fluoride
Sodium Chloride	Potassium Fluoride
Lithium Bromide	Magnesium Fluoride
Fluorescent Polystyrene Microspheres	Magnesium Iodide
Sulfur Hexafluoride (gas)	Helium
Nitrogen	Neon
SUVA Cold –MP (tetrafluoroethane) gas	Krypton
2,4,6-Trifluorobenzoic Acid	Xenon
2,4,5-Trifluorobenzoic Acid	Argon
2,3,4-Trifluorobenzoic Acid	Sodium Iodide

2,3,6-Trifluorobenzoic Acid	Sodium Bromide
2,3,4,5-Tetrafluorobenzoic Acid	Calcium Iodide
	Calcium Bromide
3,4,5-Trifluorobenzoic Acid	Potassium Iodide
2,3-Difluorobenzoic Acid	Potassium Bromide
2,4-Difluorobenzoic Acid	Sodium Hypochlorite
2,5-Difluorobenzoic Acid	Potato Starch (powdered)
2,6-Difluorobenzoic Acid	Pyranine
3,4-Difluorobenzoic Acid	Amino G Acid
3,5-Dilfuorobenzoic Acid	Rhodamine WT
Pentafluorobenzoic Acid	FD&C Blue No.1
Acid Yellow #7 (Lissamine FF)	FD&C Yellow No.5
Rhodamine B	FD&C Yellow No.6
Sulforhodamine B	Fluorescein
FD&C Red No. 40	

If additional TFM are required, separate requests for DIE evaluations and ECD approvals will be submitted by the TCO. Each tracer test must have appropriate ECD approvals prior to injection, except drilling using approved SF^6.

Attachment 12 lists the ECD approved tracers as well as the approved/pending tracers submitted to ECD and DIE for approvals/evaluations for each specific location and each test where testing activities will be conducted within the scope of this FWP.

Preliminary information specific to tracer usage and recovery shall be supplied to the TCO by the PIs, by the 5th day of each month.

2.0 SAMPLING PLAN

The PI or designee will select sample locations in the field. Samples shall be collected under the PI's scientific notebook procedure as identified in Section 1.3 or other applicable procedures. Core samples shall be collected under the current version of NWI-DS-001Q, NWI-DS-002Q, NWI-DS-004Q, and/or YAP-SII.1Q. Core determinations will be made by the TCO and concurred with by management in accordance with LANL-EES-13-DP-612.

Bulk Rock samples (if required) shall be collected under the PI's scientific notebook procedure as identified in Section 1.3. In addition, the current version of YAP-SII.4Q, shall be used to document collection and provide traceability of all underground bulk rock and water samples taken from the ESF. Particular samples collected in support of Moisture Studies in the ESF will be collected according to the sample collection criteria identified in, and under the control of Field Work Package FWP-ESF-96-009, Consolidated Sampling in the Exploratory Studies Facility. PI organizations will provide all non-standard sample packaging materials, transportation containers, and any associated equipment.

- All PIs who collect ESF samples shall coordinate underground access and sample collection support (including survey and photography) through the TCO.

- In instances where a sample location is identified, but the sample is not required immediately or sampling is constrained due to safety or construction considerations, the TCO may identify a construction or test exclusion zone to allow later sampling or testing.

3.0 WORK IMPLEMENTATION AND CONTROL

3.1 IMPLEMENTATION

The following list of activities provides instructions on how work associated with this testing will be conducted and controlled. The TCO generally acts as the interface and coordinator between the PI organization(s) and all other organizations involved in these activities. The TCO monitors all test-related construction and testing activities associated with construction monitoring to ensure the appropriate controls, as necessary, are implemented through the relevant organizations(s). All applicable DIE controls listed on Attachment 12 are incorporated into these instructions.

Safety requirements and procedures involved in these activities are addressed in Attachment 4.

The following list of activities includes both those that implement QARD requirements, and management guidance that does not implement QARD requirements. Grading is accomplished by AP 2.21Q or equivalent procedure. Items flagged with a **QA** are recognized as being quality affecting unless specifically graded out and documented by the organization performing the task. Items identified with a **QA: N/A** does not affect the sequence of the quality affecting work and do not implement QARD requirements and are therefore considered administrative in scope. The sequence of **QA** activities may be modified by the TCO FTC based on conditions in the field, provided affected organizations concur and those modifications are documented.

3.1.1 GENERAL ITEMS

3.1.1.1 **AFFECTED ORGANIZATIONS** who perform ESF testing activities specific to this FWP shall coordinate field activities through the ESF TCO. **QA: N/A**

3.1.1.2 The **TCO** will serve as point-of-contact for all testing activities defined in this FWP including drilling/coring operations, test installation, and DCS interactions. **QA: N/A**

3.1.1.3 Throughout the implementation of this FWP, the **TCO** will provide regular written reports to the U.S. Department of Energy (DOE) and the Contractor Manager addressing test specific progress. **QA: N/A**

3.1.1.4 **PIs** will provide necessary information to support TCO planning, management, and reporting requirements. **QA: N/A**

3.1.1.5 **SS/FS** will provide construction support, test support facilities, and operational flexibility to instrument, maintain, operate, and monitor Moisture Studies in the ESF and conduct post construction activity moisture-related activities. **QA: N/A**

3.1.1.6 **SS/FS** will maintain the ability to access any identified sample location for re-sampling, if necessary, as directed by the TCO. **QA: N/A**

3.1.1.7 **SS/FS** will provide administrative construction-related documentation necessary to support testing to the TCO which may include information specific to air flow measurements and electrical usage in the ESF. **QA: N/A**

3.1.1.8 **SMF** will provide a list of sample numbers and corresponding accession numbers to the records center with a copy to the TCO PE. **QA: N/A**

3.1.1.9 **SS/FS FED** will survey the sample locations of each bulk rock sample collected in accordance with NWI-ESF-008Q, as requested by the TCO and provide a list of accession or data tracking numbers. **QA**

3.1.1.10 The **PIs** and the **DATA MANAGER** will maintain the ability to tie into a centralized DCS when available and when necessary. **QA: N/A**

3.1.1.11 **PIs** are responsible for collection, management, and submittal of data, in compliance with Project and applicable PI plans and procedures. **QA**

3.1.1.12 **SS/FS FED** shall track, minimize, and report water use in accordance with NWI-ESF-007Q. **QA**

3.1.1.13 The **TCO** and **SS/FS** shall develop, with all affected organizations, Work Instructions/Work Orders for this particular work that specifically address detailed ES&H issues. All field work shall be done consistent with the activities described in the FWP and within the ES&H controls that specifically address identified job hazards in accordance with the specified ES&H requirements detailed in the approved work order. **QA: N/A**

3.1.1.14 The **TCO, PI**, and all scientific staff will participate in a daily Tool Box Safety Meeting that is held at YMP work sites at the start of each shift. **QA: N/A**

3.1.1.15 **SS/FS** shall provide labor, materials, and equipment necessary to construct or modify the sealed bulkhead doors at each location specific to this FWP, according to TCO instructions. **QA: N/A**

3.1.1.16 **SS/FS** and **A/E** shall coordinate the application of shotcrete in test support areas with the TCO prior to application. **QA: N/A**

3.1.1.17 The **TCO** will seek concurrence with PIs prior to SS/FS application of shotcrete, and will notify **SS/FS** and A/E of their approval in writing. **QA**

3.1.1.18 **SS/FS** and **SS/FS FED** will minimize, to the extent practical, the quantity of fluids used in and around borehole collars at all test areas. Quantities will be documented in accordance with AP-2.17Q. **QA**

3.1.1.19 **SS/FS** will dry-drill rockbolt holes and shall not use Swellex type bolts for ground support in areas identified by the TCO through SS/FS or A/E consistent with applicable drawings and specifications. **QA**

3.1.1.20 The **TCO** shall monitor water used in testing niches in the Topopah Spring Loop to ensure the total used does not exceed approximately 19.5m^3 (or about 5,150 gallons) per niche. Water use includes construction water in shotcrete, geologic mapping, and dyed testing water. Reporting will be done in accordance with AP-2.17Q. **QA**

3.1.1.21 **SS/FS** shall not use cementious materials for niche excavation-related ground support until the TCO provides written notification/concurrence that testing activities within the niches or alcoves have been completed. **QA**

3.1.1.22 **SS/FS** and **PI Organizations** shall limit the use of chlorides as practical. Only non-chloride-based ground enchancing materials may be used. Use of chlorides will be documented in accordance with AP-2.17Q. **QA**

3.1.1.23 The **TCO** shall evaluate and document concurrence of the use of chloride for applications other than potable water. **QA**

3.1.1.24 The **PIs** and **TCO** shall ensure the emplacement of committed organic substances related to niche testing is minimized. Use of committed organics will be documented in accordance with AP-2.17Q. **QA**

3.1.1.25 For the Batwing Slot Cut Testing, the **PIs** and **TCO** shall ensure the following tracers are limited as indicated unless an additional SAD evaluation is conducted. Organic tracers are limited to 6 grams, fluorinated tracers are limited to 18 grams, and non-fluorine halogenated salts are limited to 39 grams. TFM reporting will be done in accordance with AP-2.17Q. **QA**

3.1.1.26 For the ECRB systematic testing, the **PIs** and **TCO** shall ensure that the total quantity of water emplaced during drilling and testing of the ECRB Systematic Drilling boreholes shall not exceed 90 percent of the DIE Requirement 3 water loss limit, when combined with all other water losses (e.g., construction, dust control, drilling, testing), in the 10 meter section of the ECRB Cross Drift in which it is used. TFM reporting will be done in accordance with AP-2.17Q. **QA**

3.1.1.27 The **TCO** shall ensure that the quantity of water loss in the final 13 meters of Alcove 8 and all of Niche #3 (i.e., not subsequently recovered in the Niche #3 drip collection systems) shall not exceed a cumulative average of 3.785 m^3/m (approximately 1000 gal/m) without further SAD Evaluation. This water loss includes all water lost during construction of and testing in that section of Alcove 8 and all of Niche #3. Furthermore, the testing water released shall not exceed 37.85 m^3 (approximately 10,000 gallons) until an adequate recovery rate has been demonstrated and approved by SAD. TFM reporting will be done in accordance with AP-2.17Q. **QA**

3.1.1.28 **SS/FS FED** will ensure that water used for testing purposes in the Topopah Spring Loop and Cross Drift is traced in accordance with current DIE requirements. **QA**

3.1.1.29 The **TCO** and **PIs** shall ensure that specific TFM for the areas identified in Attachment 12 shall not exceed the specific concentrations and quantities without an additional SAD evaluation (Note: The maximum concentrations and quantities of all EPD approved/pending tracers for each specific test location and each test is listed in Attachment 12). **QA**

3.1.1.30 The **TCO** will report the use of test-related TFM in accordance with AP-2.17Q. **QA**

3.1.2 GENERAL GUIDELINES FOR DRILLING ACTIVITIES

3.1.2.1 The **PIs** will select and identify borehole locations and specify needs in writing to the TCO. Borehole locations shall include the North Ramp, South Ramp, Alcoves, and locations associated with Drift Scale niches along the ESF Main Drift, and ECRB. **QA: N/A**

3.1.2.2 The **TCO** shall identify, based on the PI's needs, the location of testing boreholes in the field prior to the installation of niche-related ground support. **QA: N/A**

3.1.2.3 **SS/FS** will supply the personnel and equipment to drill and core boreholes at identified locations. Boreholes will nominally be NQ-3 or HQ-3 sized, drilled utilizing dry drilling techniques. Expected approximate borehole depths will be from 2 meters to 20 meters deep. **QA: N/A**

3.1.2.4 The **TCO** shall notify SS/FS to use only dry drilling techniques. This notification will be documented. **QA: N/A**

3.1.2.5 **SS/FS** shall maintain a 300 mm distance between testing boreholes and niche-related ground support boreholes in the Topopah Spring Main Drift and ECRB consistent with applicable drawings and specifications. **QA**

3.1.2.6 **SS/FS FED** will layout the collar locations and backsites (if necessary) for boreholes associated with the niches and alcoves. **QA: N/A**

3.1.2.7 The **TCO** will define and document the disposition of core generated from drilling/coring activities associated with this FWP as outlined in procedure LANL-EES-13-DP-612. **QA**

3.1.2.8 The **PI** may drill short boreholes, nominally 2 meters (6.2 feet) in length by 2.5 cm (1 inch) in diameter, for instrumentation including, but not limited to, heat dissipation probes and tensiometers. **QA: N/A**

3.1.2.9 **SS/FS** shall monitor and document air pressure and flow rates during drilling operations. Any modifications to the compressed air supply lines shall be inspected and documented by the drilling foreman and a representative from FED. **QA: N/A**

3.1.2.10 **SMF** will support drilling operations by (1) maintaining footage drilled per drill bit; and (2) noting who is the driller on site during coring

operations. Reporting will be done in accordance with NWI-DS-002Q. **QA**

3.1.2.11 The **SMF** will support drilling operations by reporting line-of-sight measurements (as requested by the TCO) on the daily operations report in accordance with NWI-DS-002Q. **QA**

3.1.2.12 **SMF** or their designees will take custody of the core samples by operating the extruder to remove core from the core barrel, and processing the core in accordance with NWI-DS-002Q and/or NWI-DS-004Q. **QA**

3.1.2.13 The **SMF** will supply an administrative copy of all daily drilling reports to the TCO and submit a copy to the record center, in accordance with AP-17.1Q. **QA: N/A**

3.1.2.14 The **SMF** will collect core samples as requested by the PI in accordance with YAP-SII.1Q. **QA**

3.1.2.15 **SS/FS FED** will survey and document the borehole collar locations and orientation plan view of opening, and profile of Niche excavations in accordance with NWI-ESF-008Q. **QA**

3.1.2.16 The **SS/FS FED** shall put all test-related survey data into the TDMS according to AP-SIII.3Q, unless excluded by the TCO. **QA**

3.1.2.17 **SS/FS** will maintain the ability to collect bulk rock samples, water samples, and core samples from all Drifts, Niches, and Alcoves in the ESF. **QA: N/A**

3.1.2.18 The **PI** will document acceptance of each borehole (drilled with a drill rig) in writing or provide further direction to obtain a suitable hole. **QA**

3.1.3 GENERAL TEST INSTRUMENTATION GUIDELINES

3.1.3.1 The **PI** will install instrumentation in accordance with their QA technical procedures or scientific notebook identified in Section 1.3. **QA**

3.1.3.2 The **TCO** will coordinate the staging and installation of all test equipment with the PI. **QA: N/A**

3.1.3.3 The **PI** will maintain the ability to utilize or connect into a centralized DCS when applicable and where available. **QA: N/A**

3.1.4 GENERAL TESTING GUIDELINES

3.1.4.1 The **PIs**, **TCO**, and/or **TECHNICAL SUPPORT** personnel, shall collect acquired data in accordance with their scientific notebooks identified in Section 1.3 or other applicable QA procedures. **QA**

3.1.4.2 The **PI** will transmit initial and developed data in accordance with AP-SIII.3Q as identified in Section 6.1 of this FWP. **QA**

3.1.4.3 The **PI**, scientific staff, and/or **WMS** personnel will conduct borehole wireline measurements in accordance with FWP-ESF-96-013. **QA**

3.1.5 MOBILE MOISTURE MONITORING SURVEY

3.1.5.1 The **TCO** will coordinate through CMD, times and durations of any moisture monitoring surveys conducted in the ESF. **QA: N/A**

3.1.5.2 The **PI** will transmit in writing to the TCO, methodology pertaining to the mobile moisture monitoring cart. This methodology will, at a minimum, include weight of the entire cart fully loaded, equipment to be installed on the cart, electrical power requirements for the cart, and expected rate of travel of the cart. **QA: N/A**

3.1.5.3 The **TCO** will provide escorts front and rear of the moisture monitoring cart as it travels through the ESF/ECRB. **QA: N/A**

3.1.6 LOCATION SPECIFIC GUIDELINES

3.1.6.1 Upper Paintbrush (non-welded) Contact Alcove (Alcove 3)

3.1.6.1.1 The PI will install moisture monitoring instrumentation which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes within the exposed surfaces of the alcove in accordance with approved procedures identified in Section1.3. **QA**

3.1.6.2 Lower Paintbrush (non-welded) Contact Alcove (Alcove 4)

3.1.6.2.1 The **PI** will install moisture monitoring instrumentation which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces of the alcoves, in accordance with approved procedures identified in Section 1.3. **QA**

3.1.6.2.2 The **PI** will install moisture monitoring instrumentation which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces, including the slot cut at the terminal end of the drift in accordance with approved procedures identified in Section 1.3. **QA**

3.1.6.2.3 The PI will conduct water release experiments in boreholes, in the terminal face of the alcove. **QA**

3.1.6.2.4 The PI will drill additional short boreholes with hand held tools into the terminal face of the alcove. **QA: N/A**

3.1.6.3 Southern Ghost Dance Fault Access Drift (Alcove 7)

3.1.6.3.1 The **TCO** shall follow the requirements identified in the Radon Protection Program prior to entering the areas behind the bulkheads or as identified by a potential airborne radioactive area. **QA: N/A**

3.1.6.3.2 **SS/FS** or **PI** shall drill small diameter boreholes (approximately 1 3/8 inch diameter x 2.0 meters deep) at locations identified by the PI through the TCO. **QA**

3.1.6.3.3 The **PI** will install moisture monitoring instrumentation which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces of the Alcove in accordance with approved procedures identified in Section 1.3. **QA**

3.1.6.3.4 The **PI** shall inform the TCO, prior to the injection and report the use of tracers as identified in Section 1.5 of this FWP. The reporting shall be made by the PI on a monthly basis. If new tracers are identified, the request shall be made to the assigned PE for this FWP. **QA**

3.1.6.4 Niche 35+66 (Niche #1)

3.1.6.4.1 The **PI** may install and/or remove/monitor moisture monitoring instrumentation including heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces of the Niche in accordance with approved procedures identified in Section 1.3. **QA**

3.1.6.5 Niche 36+50 (Niche #2)

3.1.6.5.1 The **PI** may install additional and/or remove/monitor moisture monitoring instrumentation including heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces of the Niche in accordance with approved procedures identified in Section 1.3. **QA**

3.1.6.6 Niche 31+07 (Niche #3) [see also Alcove 8]

3.1.6.6.1 The **PI** will install additional and/or remove/monitor moisture monitoring instrumentation which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces of the Niche in accordance with approved procedures identified in Section1.3. **QA**

3.1.6.7 Niche 47+88 (Niche #4)

3.1.6.7.1 The **PI** will install and monitor moisture monitoring instrumentation, which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces of the Niche. **QA**

3.1.6.8 Ramps and Main Drift

3.1.6.8.1 The **PI** will install and monitor moisture monitoring instrumentation including heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces in accordance with approved procedures identified in Section 1.3. **QA**

3.1.6.9 Enhanced Characterization of the Repository Block

3.1.6.9.1 **SS/FS** shall dry drill holes (approximately 2 to 4 meters deep) into the rib of the ECRB Cross Drift as requested by the TCO. **QA: N/A**

3.1.6.9.2 **SS/FS** shall supply individuals to assist in the collection of bulk samples and the installation of scientific monitoring instrumentation. **QA: N/A**

3.1.6.9.3 Air sampling instrumentation shall be installed by **PIs** at locations identified in association with M&O Industrial Hygiene monitoring stations. The TCO will coordinate locations for these instruments with **SS/FS**. **QA: N/A**

3.1.6.9.4 **SS/FS FED** shall provide labor, materials, and equipment necessary to construct, modify, and maintain bulkheads at approximately CS 17+63, 25+03, and 26+00 specific to this FWP and according to TCO instructions. **QA: N/A**

3.1.6.9.5 **SS/FS** shall provide labor, materials, and equipment necessary to support the installation of moisture monitoring instrumentation behind the bulkheaded areas in the ECRB. This may include drilling short holes and mounting hanger to attach drip collection material or instrumentation for the purposes collection ambient and in-situ moisture from the drift opening and rock matrix. **QA: N/A**

3.1.6.10 Cross Drift Drainage Benches

3.1.6.10.1 **SS/FS** shall supply individuals to excavate/construct approximately six 1 meter long by 1 meter wide by 0.5 meter high openings on the left rib. Each opening shall have a bottom surface of ± 1 inch smoothness from corner to corner. These openings can be line drilled and split or excavated with pneumatic tools. Minimized use of LiBr traced construction water may be used during excavation/ construction of these benches. The final locations will be determined by the PI and transmitted to the **SS/FS** by the TCO. **QA: N/A**

3.1.6.10.2 **S/FS** shall supply individuals to erect a small platform, at the same elevation as the bench, for testing equipment to be placed on. **QA: N/A**

3.1.6. 10.3 **SS/FS** will supply individuals to cut a kerf, the same diameter as the testing disk infiltrometer, (approximately 24" diameter) into the bench floor approximately 1 inch deep (depending on the flatness of the bench). **QA: N/A**

3.1.6.10.4 The **TCO** will post these locations as "Test Exclusion Areas" with signage. **QA: N/A**

3.1.16.11 ECRB Systematic Borehole Drilling

3.1.16.11.1 **SS/FS** shall drill/core a series (approximately 19) of NQ3 size boreholes (approximately 20 meters deep) at locations in the crown

and left rib. These boreholes will be used for air permeability and liquid release testing for percolation and seepage testing (Attachments 13 and 14). Phase 1 of this activity is from approximately CS 14+44 to approximately CS 17+63. Every 30 meters, one low angle (~15° from drift axis) shall be dry drilled into the crown. Every 90 meters, one near vertical (~75° from drift axis) will be dry drilled into the crown. Every 90 meters, one pair of horizontal to invert (2 to 3 meter separation) will be dry drilled into the left rib. **QA: N/A**

3.1.16.11.2 **SS/FS** shall provide for the use of an elevated work platform that will be utilized by the PI for borehole testing for the boreholes drilled into the crown. Periodic movements of the work platform will be coordinated by the TCO at the request of the PI. **QA: N/A**

3.1.16.11.3 **SS/FS** shall provide electrical power to these locations for temporary testing activities. **QA: N/A**

3.1.16.12 Niche 16+20 (Niche #5)

3.1.16.12.1 The **PI** will continue to test the three (approximately 20 meters) NQ3 size boreholes at locations identified in Attachments 5-6 throughout excavation of the niche. These boreholes will be used to conduct air permeability testing for pre and post excavation effects testing. **QA: N/A**

3.1.16.12.2 **SS/FS** shall supply individuals to excavate the "Batwings" located behind the bulkhead, extending from approximately 1.5 meters on the left rib away from the bulkhead, across the terminal face, and on the right rib to a location approximately 1.5 meters from the bulkhead. The Niche "Batwings" are identified in approved drawings and an illustration is attached in attachment 15. The plan is to excavate the "Batwings" using a series on small diameter holes line-drilled around the perimeter. Then a series of small diameter holes will be drilled and filled with an expanding grout (already approved by the SAD) to provide a mechanism to break the rock away, thus leaving the slots (Batwings). The equipment utilized to drill the small diameter holes shall minimize to the extent practical the amount of water used. **QA: N/A**

3.1.16.12.3 Water use during Batwing excavation shall be kept to a minimum and reported by **SS/FS FED** in accordance with NWI-ESF-007Q. **QA**

3.1.16.12.4 **SS/FS** will limit to the extent practical, the use of water when drilling the holes for Williams Rockbolts, required for additional ground support prior to Batwing excavation. **QA: N/A**

3.1.16.12.5 The **PI** may install additional moisture monitoring instrumentation, which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on any of the exposed surfaces of the Niche in accordance with approved procedures identified in Section 1.3. **QA**

3.1.16.12.6 The **SS/FS** shall excavate a minimum of one 1 cubic foot block of bulk rock from the excavation of the Batwings. The block extraction will be overseen by the **TCO**, who will generate the appropriate bulk-rock sample collection forms and transfer custody to the **SMF** for subsequent transfer to the PI for further laboratory analysis. **QA**

3.1.16.12.7 **SS/FS** shall maintain the ability to clean a series (approximately 6) of NQ3 size boreholes (approximately 7 meters deep) at locations identified by the PI through the TCO and **SS/FS** (Attachments 10-12) **QA: N/A**

3.1.16.12.8 **SS/FS** shall maintain or modify the bulkhead door in the niche access drift as identified by the PI and transmitted to **SS/FS** by the TCO. Sodium Silicate or paged grout may be used to ensure an air tight (as possible) seal around the bulkhead. **QA: N/A**

3.1.16.12.9 **SS/FS** shall maintain a supply and an uninterrupted source of tunnel air and LiBr traced construction water and electrical service to the niche at all times. During planned outages, alternate sources shall be made available. **QA: N/A**

3.1.16.13 Cross Over Alcove (Alcove 8) Niche 31+07 (#3)

3.1.16.13.1 **SS/FS** maintain or modify the bulkhead door in the alcove as identified by the PI and transmitted to SS/FS by the TCO. **QA: N/A**

3.1.16.13.2 **SS/FS** shall maintain the ability to drill small diameter boreholes (approximately 1 ¾ inch diameter x 30 to 300 cm deep) at locations identified by the PI through the TCO and SS/FS. **QA: N/A**

3.1.16.13.3 **SS/FS** shall maintain the ability to drill/core HQ-3 size boreholes in the Alcove invert as specified by the PI and transmitted to the SS/FS through the TCO. **QA: N/A**

3.1.16.13.4 **SS/FS** shall maintain the ability to drill small diameter boreholes approximately 22 meters long from locations in the Alcove invert to the crown of Niche #3 for cable installation. The final location will be specified by the PI. **QA: N/A**

3.1.16.13.5 **SS/FS** shall maintain the ability to drill/core HQ-3 size boreholes approximately 13 meters long from the intersection of the ribs and crown in Niche 31+07 (#3) at locations to be specified by the PI. **QA: N/A**

3.1.16.13.6 The **PI** shall install and maintain an infiltration system on the invert of the Alcove in accordance with procedures identified in Section 1.3, capable of providing 1 to 2 cm of water per day, to an area not to exceed 1.5 times the area of the Niche 31+07. **QA**

3.1.16.13.7 **SS/FS** shall provide craft support and material to maintain/modify the approximate 3 meter by 3 meter metal frame to contain the water/tracer as it is applied to the invert of the alcove. The frame should be approximately 30 cm tall and coated with an approved rust inhibiting paint. The frame shall be anchored to the invert and

sealed with grout. (if invert smoothness is adequate, kerfs may be cut into the invert to allow for the metal frame to be installed). **QA: N/A**

3.1.16.13.8 **SS/FS** shall provide craft support and material to construct a movable metal platform over the top of the infiltration plot on the invert of the alcove, to allow personnel access to the entire plot area. **QA: N/A**

3.1.16.13.9 **SS/FS FED** shall provide approximately 50 cubic feet of well sorted, washed sand (Overton Type) and spread over the infiltration plot area. **QA: N/A**

3.1.16.13.10 The **PI** will ensure that the surface infiltration system shall be protected with a cover, sealed on all edges with appropriate material (i.e. sand bags), and maintained such that the liner is not impacted by tunnel conditions (i.e. ventilation, dust, and hydrocarbons). **QA: N/A**

3.1.16.13.11 The **PI** will install moisture monitoring instrumentation which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces of the Alcove in accordance with approved procedures identified in Section1.3. **QA**

3.1.16.13.12 **SS/FS** will provide a material (i.e. steel plate or concrete pad) capable of supporting a load cell. **QA: N/A**

3.1.16.13.13 **SS/FS** shall supply an uninterrupted source of tunnel air and LiBr traced construction water and electrical power to the alcove at all times. During planned outages, alternate sources shall be made available. **QA: N/A**

3.1.16.13.14 **SS/FS** will provide support to transport containers of collected tracers to the surface for evaporation or disposal based on ECD approval of handling and disposal methods. The schedule will be transmitted to the TCO by the PI, which will be conveyed to the **SS/FS**. **QA: N/A**

3.1.16.13.15 The **PI** will coordinate with the TCO each deployment of Acoustic Tomography, Ground Penetrating Radar, neutron logging, and other similar technical support activities. **QA: N/A**

3.1.16.13.16 The **PI** will report usage of environmental approved tracers for the previous month to the TCO by the 5th of each month. **QA: N/A**

3.1.16.13.17 The **PI** will report TFM usage of all tracers monthly to the TCO. **QA**

3.1.16.13.18 The **TCO** shall follow the requirements identified in Radon Protection Program prior to entering the areas behind the bulkheads or as identified by a potential airborne radioactive area. **QA: N/A**

3.1.16.13.19 **SS/FS** will provide support to install framework outside Niche 31+07 in the ESF Main Drift and move plastic trays in order to allow for sample collection. **QA: N/A**

3.1.16.13.20 **SS/FS** shall provide and maintain an invert surface that is level and smooth to provide a stable surface for drip collection system installation. **QA: N/A**

3.1.16.14 Crest Alcove (Alcove 9)

3.1.16.14.1 **SS/FS** shall construct bulkhead doors, to criteria identified by the TCO, at locations identified by the PI and transmitted to SS/FS FED by the TCO. **QA: N/A**

3.1.16.14.2 **SS/FS** shall drill approximately 50 small diameter boreholes (approximately 1 3/8 inch diameter x .75 meter deep) at locations identified by the PI through the TCO and SS/FS. **QA: N/A**

3.1.16.14.3 The **PI** will install moisture monitoring instrumentation which may include heat dissipation, tensiometers, temperature, humidity probes, psychrometers, ERT, and pneumatic packers in boreholes and/or on the exposed surfaces of the Alcove in accordance with approved procedures identified in Section 1.3. **QA**

3.1.16.14.4 The **TCO** shall follow the requirements identified in Radon Protection Program prior to entering the areas behind the bulkheads or as identified by a potential airborne radioactive area. **QA: N/A**

3.2 PREREQUISITES AND HOLD POINTS

The addition of new tracers or changes to tracer concentrations shall not be utilized until all DIE and ECD requirements have been resolved. The TCO is responsible for documenting and lifting this hold point.

3.3 STOP WORK

Affected organizations must inform the TCO if quality-related work elements cannot be conducted as described in this FWP. The TCO will, if applicable, issue a stop work on those elements. If FWP revisions are required, work on affected elements will be stopped until the modifications have been completed and controlled by the Project. The Safety and Health Department, ECD, or any employee may stop work for ES&H related issues if an imminent danger exists to the workers, public or the environment. Employee's rights relating to Safety and Health (S&H) are described in the Safety and Health Plan. Environmental conditions are described in the Environmental Management Plan.

3.4 SPECIAL INSTRUCTIONS

None identified.

4.0 ADMINISTRATIVE (NON-QA) INSTRUCTIONS

4.1 ENVIRONMENTAL, SAFETY, AND HEALTH

4.1.1 Environmental

Site disturbing work requires Yucca Mountain Site Characterization Office (YMSCO)/Assistant Manager, Office of Project Execution (AMOPE) approval transmitted by ECD. To establish and maintain a high degree of environmental awareness on the YMP, all organizations and employees involved with YMP activities must clearly understand their roles and responsibilities in maintaining compliance with all applicable environmental requirements. All work shall comply with environmental requirements as found in AP-EM-002 and associated approval letters. The TCO supplies said letters to the PI and ensures the PI works to requirements specified.

All work shall comply with applicable environmental stipulation letters as required by AP-EM-002. Use of Tracers, in excess of State approved levels, must be brought to the attention of the ECD by the TCO within two working days.

All tracers must be approved through the ECD prior to use, including concentration limits for each tracer.

A preliminary set of information shall be transmitted to the TCO from each PI regarding tracer usage and recovery by the 5th of each month.

Radiological Requirements
All applicable items, equipment, and materials that have been in use on the NTS, or will be used by Affected Organizations, shall be surveyed by NTS RSPC Radioactive Material Control prior to entering the YMP Site area. This is to identify potential radiological contamination, and such shall not be used if the survey results indicate the presence of contamination greater than levels established by the NV/YMP Radiological Control Manual for release of material for unrestricted use. A report of the survey results shall be sent within 10 working days to the Affected Organizations and the Radiological Control Manager. All surveys shall be completed prior to moving an item onto the YMP Site area. An indication of clearance is to accompany each item moved onto the YMP Site area.

All conditions mandated in the Radiation Protection Program, and an Radiation Work Permit (RWP), an authorization for the Use of Radioactive Materials or Ionizing Radiation Producing Equipment must be met. Requests for use of radioactive materials, including sealed sources, shall be made to the Radiological Control Manager.

4.1.2 Safety and Health

Specific ES&H requirements are implemented through work instructions particular to individual activities. The work instructions acknowledge a person-in-charge, identify work scope, equipment requirements, hazard identification, and task steps. These work instructions are maintained in the field TCO offices on the ESF pad.

Safety and Health Roles and Responsibilities: The TCO and the SS/FS for the YMP regards the safety and health of all employees to be of paramount importance. To establish and maintain a high degree of safety and health awareness on the YMP, all organizations and employees involved with the scientific characterization activities must clearly understand their roles and responsibilities in maintaining a safe and healthful workplace.

The Project strives to work within the ISM process implemented within the YMP. This process identifies five core functions. They are (1) define the scope of work, (2) analyze the hazards, (3) develop and implement hazard controls, (4) perform work within controls, and (5) provide feedback and continuous improvement. Roles and responsibilities are defined within this FWP and the attachments of this document.

The responsibility for safety and health on the YMP begins with the Contractor, flows down through the SS/FS, then to the TCO and the testing staff. From these organizations, responsibility flows down to the respective organizations conducting work on the YMP, including scientific characterization organizations, through the umbrella of the Safety and Health Plan. The Safety and Health Plan establishes implementing guidance through written YMP safety and health programs and procedures.

An ES&H Review is an attachment to this FWP and has been compiled by the TCO S&H Specialist in order to evaluate and transmit information on the potential hazards that may be encountered while installing, operating, and/or maintaining scientific investigation equipment or instrumentation on the YMP. In the event discrepancies are found between the ES&H Review and this FWP on roles and responsibilities, the FWP language prevails. Each organization's line management and supervision should read the ES&H Review and use it as a guideline for informing, educating, and implementing protective measures for the identified hazards.

4.2 POINTS OF CONTACT

FOC Visitor Control	L. Camp	295-5915
TCO Responsible Engineer	A. Mitchell	295-6539
FWPRC	A. Mitchell	295-6539
ESF Testing TFM	A. Mitchell	295-6539
ESF Data Management Lead	F. Homuth	295-4900
Field Test Management Lead	R. Kovach	295-6180
TCO Manager	R. Oliver	295-3578
TCO Safety Coordinator	M. Taylor	295-3647
SS/FS Manager	J. Broom	295-1692
SS/FS Site Construction Manager	M. Sparks	295-7560
SS/FS FED	R. Dresel	295-4250
Borehole Wireline Measurement Support	D. Neubauer	295-5022
SMF	C. Lewis	295-6105
Safety Assurance Department	J. Hollins	295-6370
Science & Engineering Testing Manager	M. Peters	295-3644
BSC Environmental	T. Pysto	295-5082
LBNL Principal Co-Investigator	J. Wang	(510) 486-6753

LBNL Principal Co-Investigator	R. Trautz	(510) 486-7954
USGS Principal Co-Investigator	D. Hudson	295-5973

4.3 SCHEDULE

The working QA: N/A schedule, included as Attachment 1 is expressly limited to this FWP and record development for Yucca Mountain site field activities associated with this FWP. Task dates and estimated durations are based on construction schedules and current construction strategies. The tasks, dates, and durations are subject to change.

4.4 SUMMARY ACCOUNTS

A QA: N/A summary account associated with the activities described in this FWP and related information is included as Attachment 2.

5.0 FIELD VERIFICATIONS AND SCOPE COMPLETION

5.1 FIELD VERIFICATION

No field verifications have been identified at this point.

5.2 SCOPE COMPLETION

The scope of this FWP will be completed when each PI has notified the TCO in writing that all testing activities associated with this FWP have been completed and no further data will be collected. Scope completion will be documented by the PI. The RE for Moisture Studies in the ESF will forward a copy of the completion notification record to the FWPRC.

6.0 RECORDS

6.1 LIST OF RECORDS

PIs are responsible for collection, management, and submittal of data, in compliance with Project and applicable PI plans and procedures. All transfers of data between YMP Participants, submittal of data to the YMP database, and transfer of data to outside parties shall be conducted in accordance with AP-SIII.3Q, and other applicable plans and procedures.

All records shall be submitted to the Records Processing Center (RPC) within 60 days of their completion. Records will be submitted to a Project approved records center. An information copy of any records submitted to the RPC should be sent to the TCO RE assigned to the activity.

The FWPRC will coordinate and monitor the development of the FWP records package. The records package shall contain documents that demonstrate compliance with YMP procedures. The completed records package for this test may contain (or reference) the following:

Record	Participant	QA Designator
Revisions/Changes to this FWP	TCO	QA: QA
DIEs related to the FWP	TCO	QA: QA
Regular Reports Addressing Test Status	TCO	QA: N/A
ES&H Review/Job Safety Analysis	TCO	QA: N/A
ESF Drilling Reports and Related Information	SMF	QA: QA
Sample Numbers, Corresponding Accession Numbers Supporting Test Activities	SMF	QA: QA
As-Builts Borehole and Sample Collection Survey Coordinates	SS/FS FED	QA: QA
Construction/Testing Related Use of TFM	SS/FS FED/TCO	QA: QA
Safety Assessment Reviews	TCO	QA: N/A
Instrumentation Locations	PI Organizations	QA: QA
Borehole Locations and Needs	PI Organizations	QA: N/A
Documentation Identifying Work as Complete	PI Organizations – TCO	QA: QA
Modifications to Quality-Related Work Sequence	TCO	QA: QA
Borehole Wireline Measurements and Video	Wireline Support	QA: QA
TCO Concurrence Regarding the Use of Chlorides	TCO	QA: QA
TCO Notification/Concurrence to Constructor that Testing Activities are Complete	TCO	QA: QA
Borehole Acceptance	PI Organizations	QA: QA
Monthly Information Specific to Tracer Usage and Recovery	PI Organizations	QA: N/A
Monthly and Quarterly Transmittal of UIC State Approved Tracers Used During Testing Activities Specific to this FWP	TCO	QA: N/A
Calibration Documentation	PI	QA: N/A
Lifting of Hold Points	TCO	QA: QA
Scientific Work Instructions	TCO/PI	QA: N/A
TCO Notification to SS/FS to Use Dry Drilling	TCO	QA: QA

6.2 RECORDS GENERATION

Activities within the scope of this FWP will be documented in accordance with AP-17.1Q, see Section 6.1 above. All personnel associated with this testing activity are responsible for ensuring that documents associated with this FWP shall meet the legibility and indexing requirements established in AP-17.1Q. If a scientific notebook is utilized, it shall be stored in accordance with the procedures.

7.0 ATTACHMENTS

1. Summary Schedule Information (QA: N/A)
2. Summary Account Information (QA: N/A)
3. Expected Information Needs, Parameters, and Instrumentation (QA: N/A)
4. Operational Preliminary Hazard Analysis Checklist and Environmental, Safety, and Health Review (QA: N/A)
5. Access Drift Boreholes (Niche 1620) – End View Figure 3 (QA: N/A)
6. Access Drift Boreholes (Niche 1620) – Plan View Figure 4 (QA: N/A)
7. Niche 1620 – Borehole End View Figure 5 (QA: N/A)
8. Plan View – Niche 1620 Layout of Pre-Niche Boreholes Figure 6 (QA: N/A)
9. Side View – Niche 1620 Layout of Pre-Niche Boreholes Figure 7 (QA: N/A)

10. Post-Niche 1620 Construction Radial Boreholes – End View Figure 8 (QA: N/A)
11. Plan View – Niche 1620 Layout of Post-Niche Construction Radial Boreholes Figure 9 (QA: N/A)
12. Maximum Tracer Concentrations and Quantities (QA: N/A)
13. Borehole Layout of Systematic Characterization of Topopah Spring Lower Lithophysal Unit (QA: N/A)
14. Close Up View of Three Categories of Systematic Boreholes (QA: N/A)
15. Niche 5 "Batwing" General Layout (QA: N/A)
16. Niche 5 "Batwing" General Ground Support Layout (QA: N/A)

8.0 REFERENCES

1. "Site Characterization Plan", 8.3.1.2.2.1.2, Evaluation of Natural Infiltration.

2. "Site Characterization Plan", 8.3.1.2.2.3.1, Matrix Hydrologic Properties Testing.

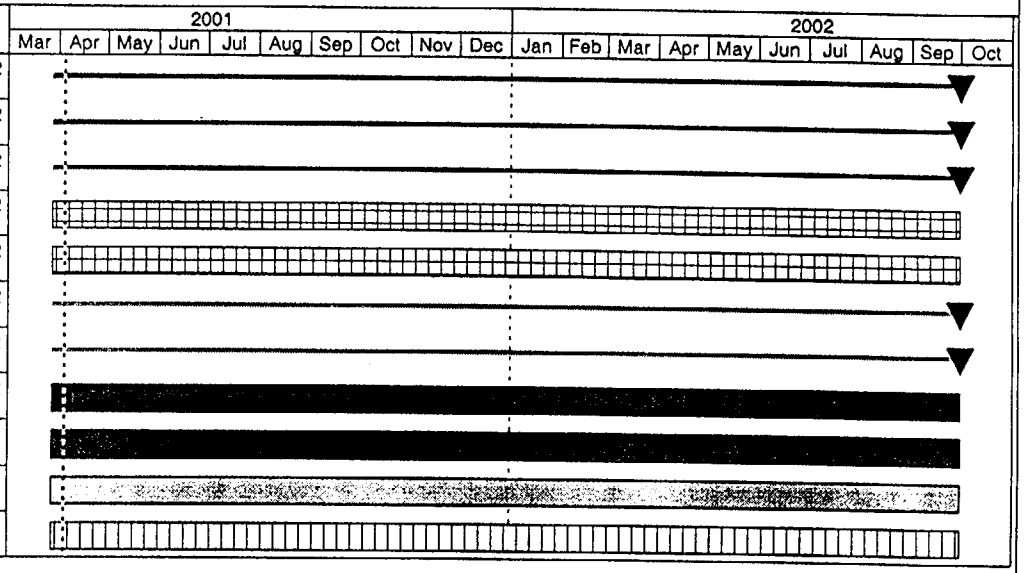
3. "Site Characterization Plan", 8.3.1.2.2.8, Fluid Flow in the Unsaturated Zone Fractured Rock.

4. "Site Characterization Plan", 8.3.1.2.2.9, Site Unsaturated-Zone Modeling and Synthesis.

MOISTURE STUDIE HE ESF
FWP-ESF-96-004, R6
SUMMARY SCHEDULE INFORMATION (QA;N/A)

Note: Years are represented in fiscal years.

ID	Task Name	Dur	Start	Finish
1	Moisture Testing in the ESF	394 days	3/28/01	9/30/02
2	Field implementation	394 days	3/28/01	9/30/02
3	Discrete	394 days	3/28/01	9/30/02
4	Moisture Studies in the ESF (8191224UU3)	394 days	3/28/01	9/30/02
5	Moisture Studies in the ESF (4201224UMG)	394 days	3/28/01	9/30/02
6	Field Support Implementation	394 days	3/28/01	9/30/02
7	Matrix Support	394 days	3/28/01	9/30/02
8	Test Coordination	394 days	3/28/01	9/30/02
9	Field Surveying for Site Characterization	394 days	3/28/01	9/30/02
10	SMF Support	394 days	3/28/01	9/30/02
11	ECRB Testing Support	394 days	3/28/01	9/30/02



Project: MoisStudyrev6
Date: 4/4/01

Task
Split
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Split
Rolled Up Milestone
Rolled Up Progress
External Tasks
Project Summary

Summary Account Information

	Moisture Studies in the ESF	WBS#	Lead Matrix Org.	Start Date	FY01 Work Package Number	FY01 WP Funding ($K)
Field Implementation						
	Discrete					
	Moisture Studies in the ESF & Cross Drift	1.2.21.3.U	USGS	10/1/00	8191224003	689K
	Moisture Studies in the ESF & Cross Drift	1.2.21.5.T	LBNL	10/1/00	42012240MG	1,784K
Field Support Implementation						
	Matrix Support					
	Test Coordination	1.2.21.5.T	LANL	10/1/00	4201215TMF	$1258K
	Niche 5 Batwing Exc.	1.2.21.5.T	BSC	10/1/009	6401215TN5	154K
	Subtotal- Discrete					2,473K
	Subtotal-Matrix Support					1,258 K
	Totals					3,731K

EXPECTED INFORMATION NEEDS, PARAMETERS, AND INSTRUMENTATION

Data regarding the following parameters are expected to be collected as part of the Moisture Studies. This list is subject to change as Scientific Investigations Proceed.

Primary Technical Data Parameters

Fracture Connectivity
Fracture Frequency
Water Content
Saturation
Temperature
Rock Displacement
Permeability

INFORMATION NEEDS	INSTRUMENTATION TYPES
Changes in Rock Saturation	• Humicaps • Electrical Resistivity Tomography (ERT) • High Frequency Electromagnetic Tompography (HFEM) • Tensiometers • Heat Dissipation Probes • Psycrometers
Water Chemistry	• Borehole Fluid Sampling & Monitoring
Drainage/Reflux of Liquid by Fracture Flow	• Infrared Imaging (IR Camera) • Detailed Fracture Mapping • Fluid Sampling
Bulk Rock Samples Core Samples	• Pore Water Extraction Matrix Properties Measurements
Rock-Mass and Fracture Permeability Changes	• Fluid Sampling • Mass Flow Controllers • Pressure Transducers

Operational Preliminary Hazard Analysis Checklist

Review the Hazard Identification Checklist and provide a "YES" or "NO" answer. The work/activity check list addresses potential hazards to personnel, property, or the environment. The Safety Basis checklist is used to determine impacts to existing systems.

1. WP/FWP/Laboratory Work Package (LWP) Title and Number: FWP-ESF-96-004, R6, Moisture Studies in the ESF and ECRB

2. Date of Analysis: 3/19/01

3. Scope of Work Description: See Section 1.1 of FWP-ESF-96-004,R6

4. Will the work involve any of the following activities?

Work Activity	Yes	No
Trenching/Excavation	X	
Geophysical Investigation		X
Subsurface Construction	X	
Surface Construction		X
Dry Drilling	X	
Wet Drilling	X	
Modification to existing structures	X	
Sample Collection	X	
Decontamination		X
Work outside in inclement weather		X
Exposure to temperature extremes		X
Work on off-normal hours or in remote locations		X
Maintenance activities		X
Operational activities	X	
Heavy Equipment	X	
Lasers or Laser systems		X
Material/soil containing Crystalline Silica	X	
Radioactive materials/logging tools		X
Biological hazards		X
Utility/Electrical Modifications		X
Exposure to high noise levels	X	
Confined Space entry & work		X
Equipment with exposed mechanical/moving parts	X	
Working at a height greater than 6 ft	X	
Welding, cutting, brazing		X
Working on uneven, slippery surfaces	X	
Use of any chemical that is Flammable/Ignitable, Corrosive, Reactive or Toxic	X	
Fire or explosive hazards		X
Generation, storage of Hazardous and Non-Hazardous Waste(s)	X	
Work with Explosives (Blasting)		X
Impacts to external Organizations/Facilities		X

5. Will the work impact any of the following YMP Systems?

Safety Basis System	Yes	No
Compressed Air (FCL2)		X
Other: Hazardous Material Inventory		X
6. Is the activity adding a system that has not been developed through the design process (A/E or Field Design)?		X

(FCL1) = Functional Classification Level 1(FCL2) = Functional Classification Level 2
(FCL3) = Functional Classification Level 3
(FCL4) = Functional Classification Level 4

7. All "Yes" responses in block 5 require additional documented hazard analysis and mitigating control development. A "Yes" response in block 6 requires the proposed activity to be subjected to the Section 5.2 screening process of AP-ENG-001.

8. Manager/Supervisor Signature:

Date: April 28, 2001

ENVIRONMENTAL, SAFETY, AND HEALTH REVIEW

1.0 INTRODUCTION

This Environmental, Safety, and Health (ES&H) Review of the Field Work Package (FWP) for Moisture Studies in the Exploratory Studies Facility (ESF) and the Enhanced Characterization of the Repository Block (ECRB) East-West Drift has been compiled by the Test Coordination Office (TCO) ES&H Specialist. The purpose of this ES&H Review is to: (1) provide a **Operational Preliminary Hazard Analysis (OPHA)** which identifies and lists hazards; and (2) recommends engineering, administrative, work practice, and personal protective equipment (PPE) control measures for coordinating and conducting Moisture Studies in the ESF and ECRB. This ES&H Review strives to incorporate the seven guiding principles and five core functions of Integrated Safety Management (ISM).

The hazard analysis was conducted in accordance with Bechtel/SAIC Company LLC (BSC) **Hazard Analysis System** (the latest version of the **Hazard Analysis System** can be found in the ES&H Electronic Manual available through Yucca Mountain Project Site Characterization Project [YMP] Lotus Notes on Server YMLN1). The **Hazard Analysis System** also requires incorporation of subordinate hazard analysis processes such as Design Hazard Analysis, Work Package Hazard Analysis, Work Order Hazard Analysis, Job Safety Analysis (JSA), Medical Needs Analysis (MNA), Occupational Exposure Assessment (OEA) and Personal Protective Equipment Hazard Analysis (PPEHA). All JSAs must be conducted and documented in accordance with Section 5.4 of the **Hazard Analysis System**. All MNA must be conducted and documented in accordance with Section 5.7 of **Hazard Analysis System**.

This review has been conducted to ensure ES&H functions have been integrated into the activities described by the FWP. This ES&H Review does not address all environmental permit compliance stipulations. Line managers and supervisors should contact the Environmental Compliance Department (ECD) to ensure that necessary environmental permits have been applied for and approved in accordance with BSC Procedure for **Environmental Permit Compliance**. This includes compliance with the BSC Procedure for **Land Access and Environmental Compliance**. (The latest version of the procedures for **Environmental Permit Compliance** and **Land Access and Environmental Compliance** can be found in the ES&H Electronic Manual.

The ES&H Review is also being compiled to ensure that information about potential hazards and control measures will be transmitted to all affected organizations on the YMP and within the BSC Organization in order to integrate ES&H into all activities, processes, work requests, work orders, work instructions, and operations described by the FWP.

All work requests, work orders (work instructions) must be written in accordance the BSC Procedure for **Work Requests/Work Order Process** (the latest version of the procedure for **Work Requests/Work Order Process** can be found in the ES&H Electronic Manual.

Line managers and supervisors should read/review this document and work with Safety and Health (S&H) in order to evaluate work processes and operations where further hazard analysis will need to be conducted and documented.

1.1 OBJECTIVES, TEST SCOPE AND DESCRIPTION

This revision of the FWP for conducting Moisture Studies in the ESF and the ECRB involves revising the wording to incorporate the revised workscope.

2.0 HAZARDS

2.1 OPERATIONAL PRELIMINARY HAZARD ANALYSIS:

See attached OPHA.

3.0 HAZARD CONTROLS

ACTIVITY #1:
Excavation, Subsurface Construction, "Dry" Drilling, Wet Drilling, Modification to existing structures, and Sample Collection Activities.

POTENTIAL HAZARD 1A: Exposure to material/soil containing Crystalline Silica. Exposure to Respirable Silica Dust.

Moisture Studies in the ESF and ECRB may require YMP personnel to perform excavations, subsurface construction, "dry" drilling, wet drilling, and modifications to existing underground structures and sample collection activities. Water use during some of these activities could be limited or restricted. Some boreholes may be "dry" drilled using compressed air as the drilling fluid. Respirable dust containing crystalline silica could be produced as a result of these types of operations.

Any drilling or excavation/construction activity should only be conducted according to the Work Practices as outlined in the BSC Program for **Silica Protection.** (The latest version of the **Silica Protection Program** can be found in the ES&H Electronic Manual).

The **Silica Protection Program** requires line managers and supervisors to implement effective engineering controls, such as atomizing water spray, highly efficient particulates and aerosols/air (HEPA) filtration system, dust diverter, torit dust collector and/or administrative controls (rotation of personnel), and work practices to control silica dust.

The **Silica Protection Program** requires employees to attend a training course on the hazards and control measures for Silica exposure. The **Silica Protection Program** recommends that workers exposed to high dust levels in work areas receive a chest x-ray and "uniforms" to wear. In addition, as part of this program, employees may be required to wear a respirator as a secondary line of defense.

Employees will follow the guidance/requirements that can be found in the BSC **Respiratory Protection Program** should respiratory protection be required as part of moisture studies activities. (The latest version of the **Respirator Protection Program** can be found in the ES&H Electronic Manual). Supervisors and employees wearing respirators have several specific responsibilities/actions under this procedure. Employees must have completed a physical examination within the past year and have no facial hair that interferes with the sealing surface of the respirator, or facial hair that interferes with the valve function of the respirator.

Currently, employees are required to wear occupational respiratory protection, i.e., at a minimum, 1/2 mask HEPA Filtered Air Purifying Respirator whenever excavation activities, subsurface construction, dry drilling activities or sample collection activities, are

being conducted and dust generation is above the Action Level (AL). Smoking and chewing of tobacco is not allowed in areas of the ESF or the ECRB where respirators are required. Approved respiratory protection shall be worn in posted areas and whenever so directed by supervision.

An ongoing Industrial Hygiene (IH) sampling and monitoring program which includes both the sampling of employees' breathing zones and work areas is being conducted by BSC IH. Control measures are being constantly evaluated and additional engineering, administrative and work practice control measures will be recommended/implemented when they are required.

ACTIVITY #2:
Operational Activities: Working in inadequately ventilated drifts, alcoves and niches. Working in temperature and humidity extremes.

POTENTIAL HAZARD 2A:
Exposure to radon, dust, and diesel emissions. Exposure to hot temperature extremes and high humidity. Heat cramps, heat exhaustion, and heat stroke.

Exposure to radon, dust, and diesel emissions:
During daily operation in the ESF and ECRB, BSC IH will conduct air quality and air quantity inspections, and on an as needed basis. Test alcoves and niches that have been closed will need to be monitored by IH and Health Physics (HP) personnel before anyone can re-enter. Contact the TCO to arrange to provide IH and HP support. Exemptions are identified on specific Work Instructions generated by the TCO.

An inadequate supply of fresh air could result in an increased breathing rate, headache, and dizziness. Diesel emissions contain Carbon Monoxide (CO) and Nitrogen Dioxide (NO2). Exposure to low levels of NO2 could result in eye and respiratory tract irritation; exposure to low levels of CO could cause an increased respiration rate. Exposure to CO inhibits the bloods ability to absorb Oxygen (O2). Exposure to very high levels of CO and NO2 could result in serious health effects, including death. Working inside the ESF and the ECRB could also expose personnel to elevated levels of Radon. Continued chronic exposure to high levels of these gases has been linked to the incidence of lung cancer. Radon is a colorless, odorless, and tasteless gas. Radon daughters are of particular concern, because they adhere to respirable dust and once inhaled, they become deposited in the lungs where they continue to decay, giving off radiation and damaging the lung tissue.

The **Protection Program for Radon** provides guidance/requirements to moisture studies personnel and other YMP personnel in order to limit exposure to Radon. (The latest version of the **Protection Program for Radon** can be found in the ES&H Electronic Manual). The **Protection Program for Radon** requires the implementation of the requirements listed below for Naturally Occurring Radon that may be encountered during Moisture Studies Activities:

Posting and Entry Training Requirements for Radiological Areas: (The latest version of the BSC Procedure for **Posting and Entry Training Requirements for Radiological Areas** can be found in the ES&H Electronic Manual). **Posting and Entry Training Requirements for Radiological Areas** identifies the posting and entry requirements for areas that are managed for the purpose of radiological control.

Personal Protective Equipment: Determination of respiratory PPE is determined in the field for actual job conditions as determined by HP personnel.

Exposure to hot temperature extremes and high humidity. Personnel conducting Moisture Studies Activities in the ESF or the ECRB could encounter certain areas of the tunnel where elevated temperatures and humidity are routinely found. The combination of wearing respiratory equipment and working in an environment with elevated temperatures and humidity could produce heat stress.

ACTIVITY #3:
Working around drilling and heavy equipment. Working with equipment with exposed mechanical/moving parts. Working with high pressure equipment.

POTENTIAL HAZARD #3A:
Being struck by, contact with equipment, or equipment components.

Working around drilling and heavy equipment. Working with equipment with exposed mechanical/moving parts. When moisture studies activities require personnel to conduct work on any form of equipment with stored energy (i.e., mechanical systems/components, drilling systems monitoring devices), the systems/components must first be de-energized, isolated, and rendered inoperative before employees can begin work. This process of de-energizing, isolating, and rendering inoperative is known as **Lockout/Tagout**. (The latest version of the BSC **Lockout/Tagout Process** can be found in the ES&H Electronic Manual).

The **Lockout/Tagout** process is not required for working around mobile in-use equipment (i.e., automobiles, pickup trucks, front-end loaders, forklifts). Contact the ESF TCO FTR to arrange for **Lockout/Tagout** assistance through the Site Services and Field Support (SS/FS) Lockout/Tagout Coordinator.

Compressed air will be used as the "dry" drilling fluid on Moisture Studies Boreholes. Air compressors and air receivers (storage tanks) must be equipped with pressure relief valve/apparatus. Air hoses must be equipped with whip checks, to prevent accidentally separated hoses from thrashing about, injuring employees.

Large K bottles or cylinders, which contain 200 cubic feet of compressed gas may be used at moisture studies locations. These cylinders are used for tracer gas injection. Any compressed gas cylinder that is not being used must be stored in an upright position, secured to a rack with a chain, and have the protective cap on the cylinder valve. Cylinders should be transported using a cart that is designed for this purpose.

ACTIVITY #4:
Working in high noise levels.

POTENTIAL HAZARD 4A:
Physical hazard; exposure to high noise levels, hearing impairment, hearing loss.

Personnel conducting moisture studies activities need to be aware that the core drill, jack-leg drill, drill jumbo, and related equipment that will be used could produce high noise levels. Hearing protection (ear plugs and/or earmuffs) must be used, during core drilling operations.

Contact the ES&H Lead for information on moisture studies areas where dual protection may be required. Approved hearing protection shall be worn in posted areas and whenever so directed by supervision.

The BSC **Hearing Conservation Program** specifies the requirements for employees working in high noise areas. (The latest version of the BSC **Hearing Conservation Program** can be found in the ES&H Electronic Manual). All employees working in high noise level areas must be in the hearing conservation program and, among other things, obtain a baseline and annual audiogram which is usually conducted during annual physical examinations.

ACTIVITY #5:
Working with chemical/hazardous materials. Working with Flammable/Ignitable, Corrosive, Reactive or Toxic Materials.

POTENTIAL HAZARD 5A:
Exposure to and contract with chemicals. Generation of Nonhazardous Waste(s).

A majority of the chemicals and materials used in Moisture Studies Activities will be provided by the Tool Crib.

The use or removal of testing related TFM by affected organizations must be identified and reported to the TCO prior to such use or removal. The affected organization must know the location of the **Material Safety Data Sheets (MSDS)**, and the proper storage, use, transportation, and PPE requirements for all the hazardous chemicals they use. The MSDS should always be reviewed before using any product/material underground. Contact M. F. Taylor, ESF TCO ES&H Specialist, if there are questions regarding TFM usage in the ESF and/or ECRB.

ACTIVITY #6:
Working at a height greater than 6 feet.

POTENTIAL HAZARD 6A:
Fall to below or fall to ground level.

Scientific characterization personnel conducting Moisture Studies Activities who have to work at a height greater than 6 feet off the ground must either use approved fall protection equipment (i.e., **body harness, lifelines, sala block, and/or lanyards**), or they must use approved ladders or approved scaffolding. Approved scaffolding must have guard rails, mid rails, and toeboards.

Guidance for fall protection equipment can be found in the BSC **Fall Protection Procedure.** (The latest version of the BSC **Fall Protection Procedure** can be found in the ES&H Electronic Manual).

Guidance for using ladders and working from scaffolding can be found in the BSC **Ladders and Scaffolding** Procedure. (The latest version of the BSC **Ladders and Scaffolding** Procedure can be found in the ES&H Electronic Manual).

OSHA approved ladders (set at an angle of between 75 and 90 degrees from vertical) must always be used. OSHA approved ladders are available through the ESF Pad Tool Crib. Approved fall protection equipment is available at the ESF Pad from the Rigging Loft. Contact the Area 25 ES&H Lead for assistance in making arrangements for getting proper fall protection equipment.

ACTIVITY #7:
Walking and working on uneven surfaces:

POTENTIAL HAZARD 7A:
Slips, trips, and falls.

A pre-cast concrete invert section system has been chosen for installation in the main ESF Tunnel. Railroad lines for the equipment and man-trains have been attached/secured to these invert sections. The invert sections have gaps and irregularities on the walking surface. Slips, trips, and falls could be hazardous.

The ECRB has treated wood ties to which the railroad lines are attached/secured. These ties will have gaps and irregularities. A metal grate walkway has been installed in the ECRB for pedestrians.

When accessing the main drift in the ESF to conduct moisture studies activities, always walk on the rib that has the lights strung on it.

Orange reflective safety vests are required to be worn by all personnel working, walking, or visiting the ECRB East-West Cross Drift.

Follow all directions of the TCO FTR, the Person-In-Charge (PIC), or SS/FS craft personnel while accessing underground work areas.

4.0 ROLES AND RESPONSIBILITIES - SAFETY AND HEALTH

4.1 Safety and Health Roles and Responsibilities: BSC controls all work activities on the YMP and has the responsibility for S&H for all organizations, employees, visitors, and personnel from other organizations when they are on BSC controlled worksites. Clear roles and lines of responsibility, authority, and accountability are established at all levels of the organization to ensure protection of workers, the public, the environment, and property.

4.2 Specific Group and Individual Safety and Health Roles and Responsibilities: The following groups and individuals are responsible for:

Site Services and Field Support Organization: The SS/FS and the TCO are responsible for jointly selecting the PIC. The SS/FS is responsible for implementing the requirements of this FWP during the construction/test support and scientific testing processes. SS/FS provides construction/test support services to the organizations conducting scientific testing activities work on the YMP. SS/FS is responsible for oversight and management of all construction/test support activities on the YMP. The SS/FS has S&H responsibility for all persons (employees and visitors) inside YMP construction/test support and scientific testing work areas and locations. SS/FS is responsible for maintaining YMP construction/test support and scientific testing work areas and locations in a safe and healthful condition, for maintaining mobile and stationary equipment, S&H training, and training in the safe operation of some pieces of equipment.

Test Coordination Office: is responsible for jointly, selecting (with the SS/FS) the PIC. The TCO is responsible for coordinating scientific testing activities on the YMP. The TCO is responsible for the implementation of the requirements of this FWP and for coordinating all scientific testing activities requirements with construction/testing support activities. The TCO and other scientific organizations are responsible for the S&H of their employees and conducting scientific testing activities in compliance with BSC S&H policy and procedures.

Person-In-Charge: is responsible for ensuring the specific work (construction/testing support or scientific testing) activity is conducted in accordance with BSC established S&H procedures. The PIC is responsible for ensuring that the Tool Box Safety Meeting is conducted at the beginning of each shift, on a daily basis. The PIC will determine if the workers present have the training, experience, knowledge, skills, and abilities needed to perform their work safely and competently. The PIC will be a point of contact for all visitors to the specific work area, i.e., all workers in the specific work area should be able to immediately identify the PIC. If the PIC needs to leave his/her assigned specific work area, a new PIC will be selected and the change will be communicated to all individual workers in the specific work area. If an issue arises, the PIC will be responsible for notifying the appropriate manager(s) within the SS/FS and TCO and serve as the focal point of contact of issue resolution.

4.3 Written Safety and Health Roles and Responsibilities - TCO ES&H Review

The ES&H Review is an attachment to this FWP and contains both an OPHA and a section recommending control measures for all identified hazards. The ES&H Review is specific to the construction/testing support and scientific testing activities found in this FWP. Each organization's line management and supervision shall read the ES&H Review and use it as both guidelines and minimum requirements for informing, educating, and implementing protective measures, i.e., engineering, administrative, PPE controls training to a JSA, or environmental controls, for the identified hazards.

The BSC **Occupational Safety and Health Program** establishes implementing guidance/requirements through S&H procedures and applicable Environmental Plans that can be found in the FWP. (The latest version of the written BSC **Occupational Safety and Health Program** can be found in the ES&H Electronic Manual).

5.0 NEAREST POTABLE WATER

Orange "Gott" Drinking Water Coolers are located throughout the ESF and the ECRB.

5.1 SUGGESTED EMERGENCY EVACUATION ROUTE AND MEETING AREA(S)

Underground, situations may occur that will require immediate evacuation of an operation or area. These situations may include but are not limited to uncontrollable fire, explosions, collapse, hazardous chemical release, or chemical spill.

If such a situation(s) occurs, the Mine Service Phones are equipped with a speaker, which will serve as an underground paging system to announce any emergency condition. Follow the direction given by the announcement, the SFO Supervisor Personnel, or the PIC handling the emergency.

Should access to the portal be cut off or evacuation routes become questionable, all personnel in the tunnel should report to the SFO Supervisory Personnel or the PIC in their work area and follow the instructions provided.

6.0 TCO PERSONNEL

Some TCO Personnel carry hand held radios and are available on the surface through YMP NET #1.

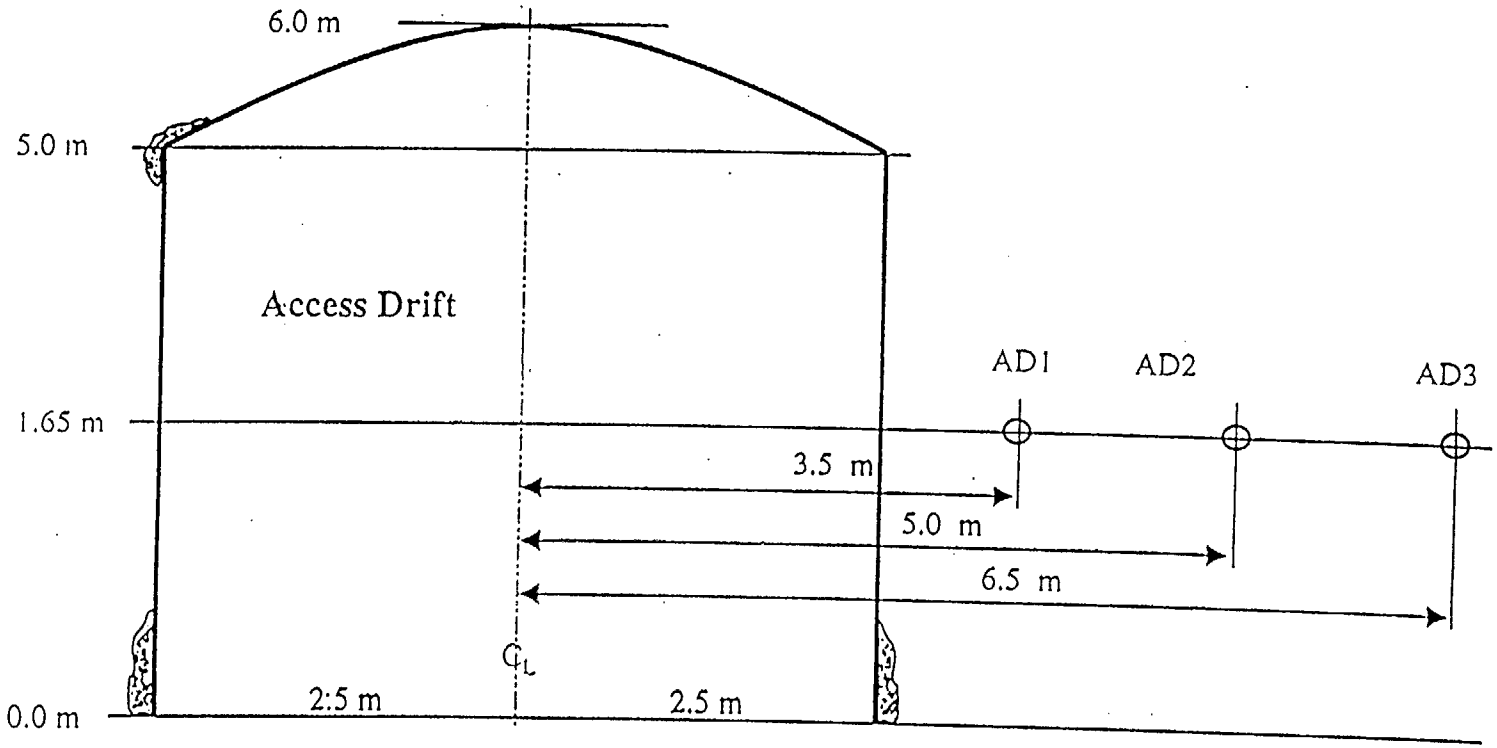
6.1 TCO FIELD TEST COORDINATION PERSONNEL AND PHONE NUMBERS

Dick Kovach	FTM	295-6180
Kitty Longhouser	Secretary	295-3483
Gene Griego	FTR	295-1804
Joe Spoeneman	FTR	295-6189
John Dinsmoor	FTR	295-3727
Mike Taylor	ES&H Specialist	295-3647
	Beeper -	794-6676

FIGURE 3

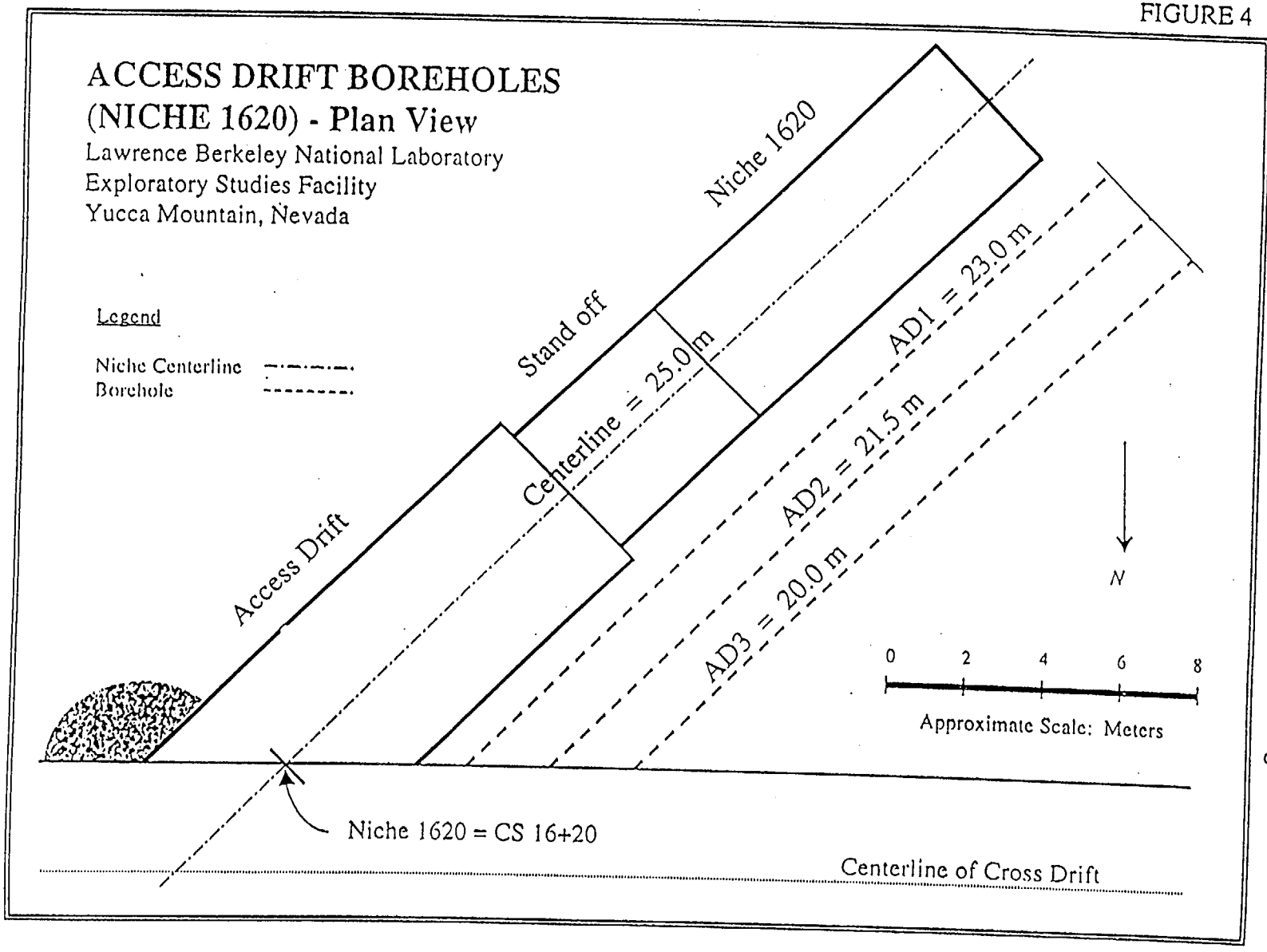
ACCESS DRIFT BOREHOLES (NICHE 1620) - End View

Lawrence Berkeley National Laboratory
Exploratory Studies Facility
Yucca Mountain, Nevada



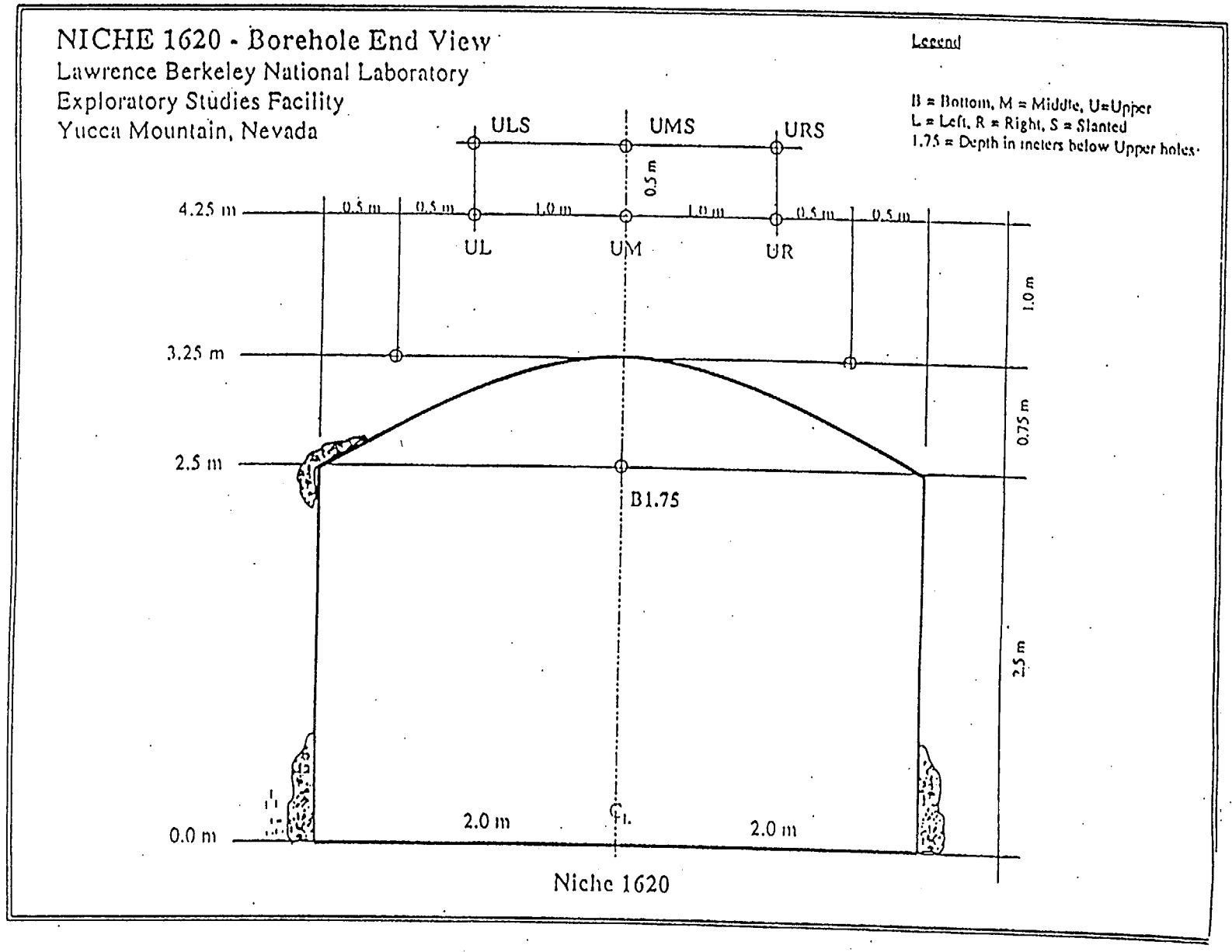
Access Drift Boreholes (Niche 1620) – End View Figure 3

FIGURE 4



Access Drift Boreholes (Niche 1620) – End View Figure 4

FIGURE 5



Niche 1620 – Borehole End View Figure 5

Plan View – Niche 1620 Layout of Pre-Niche Boreholes Figure 6

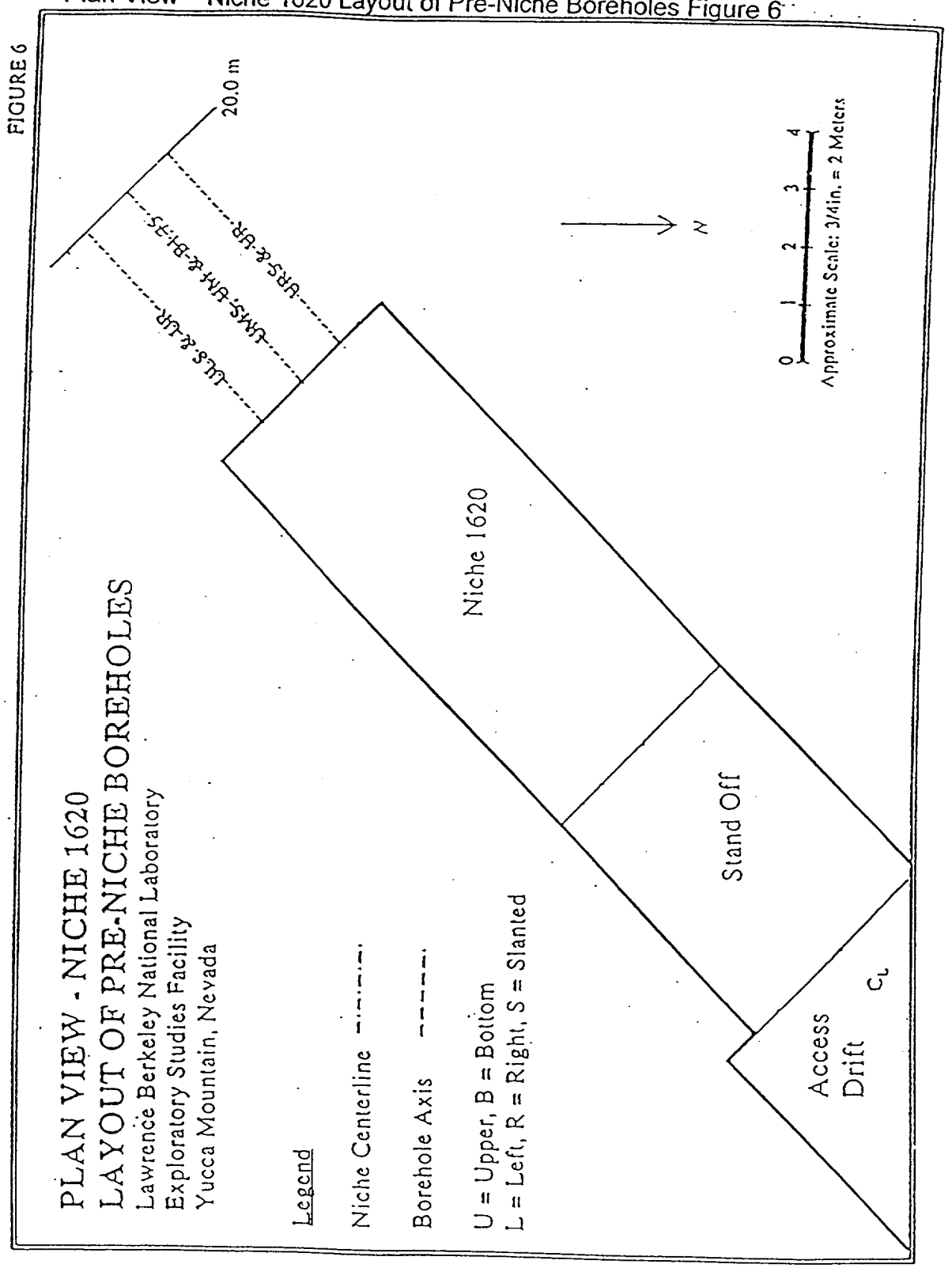
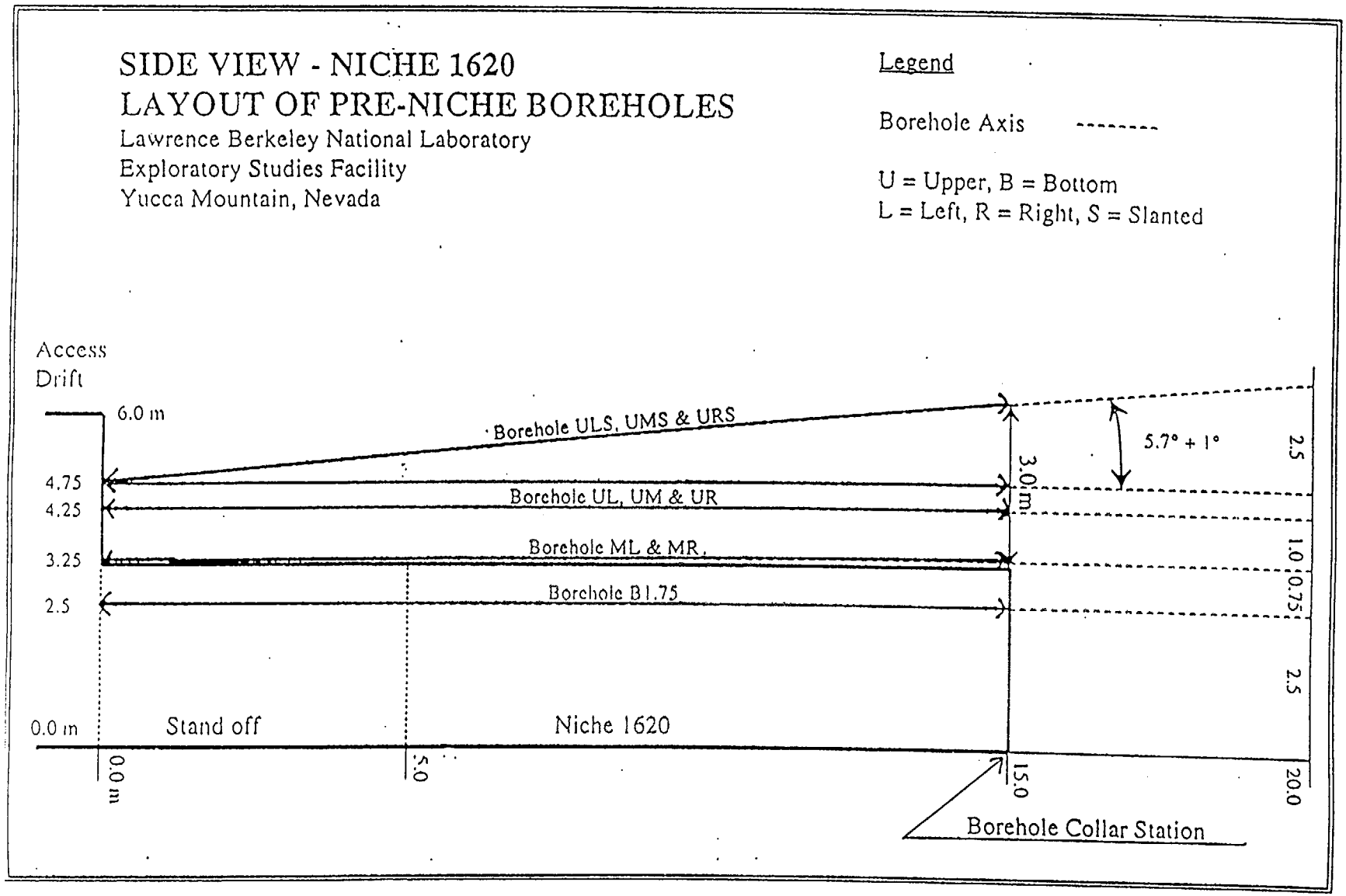


FIGURE 7



Side View – Niche 1620 Layout of Pre-Niche Boreholes Figure 7

FIGURE 8

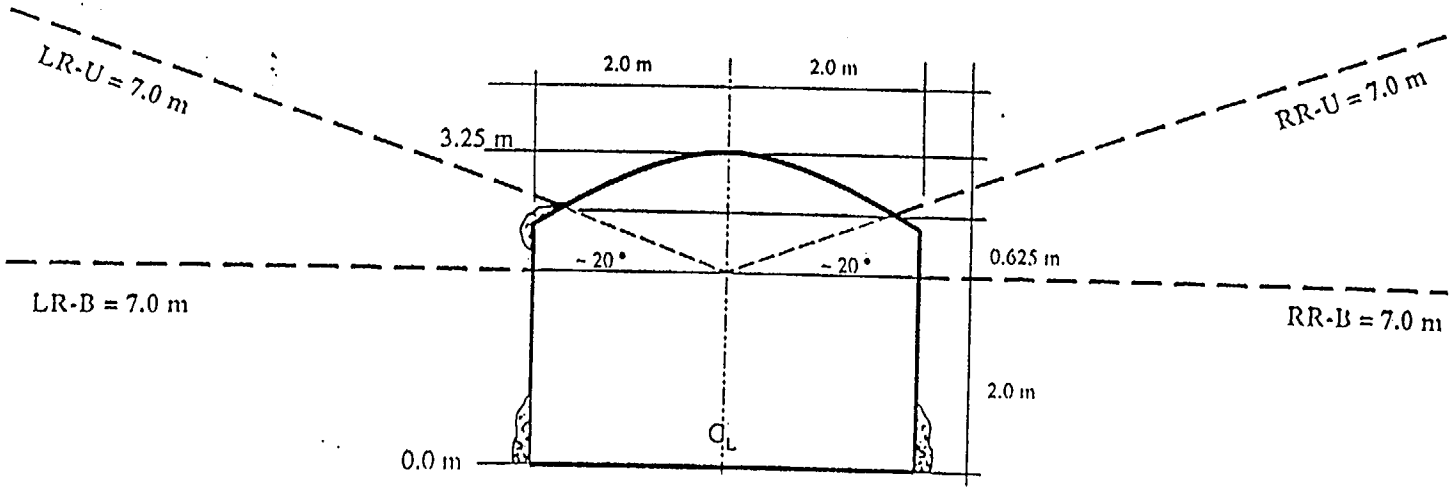
POST-NICHE 1620 CONSTRUCTION RADIAL BOREHOLES - END VIEW

Lawrence Berkeley National Laboratory
Exploratory Studies Facility
Yucca Mountain, Nevada

Legend

ML Borehole designation
M = Middle
L = Left, R = Right
RR = Right Rib
LR = Left Rib
U = Upper, B = Bottom

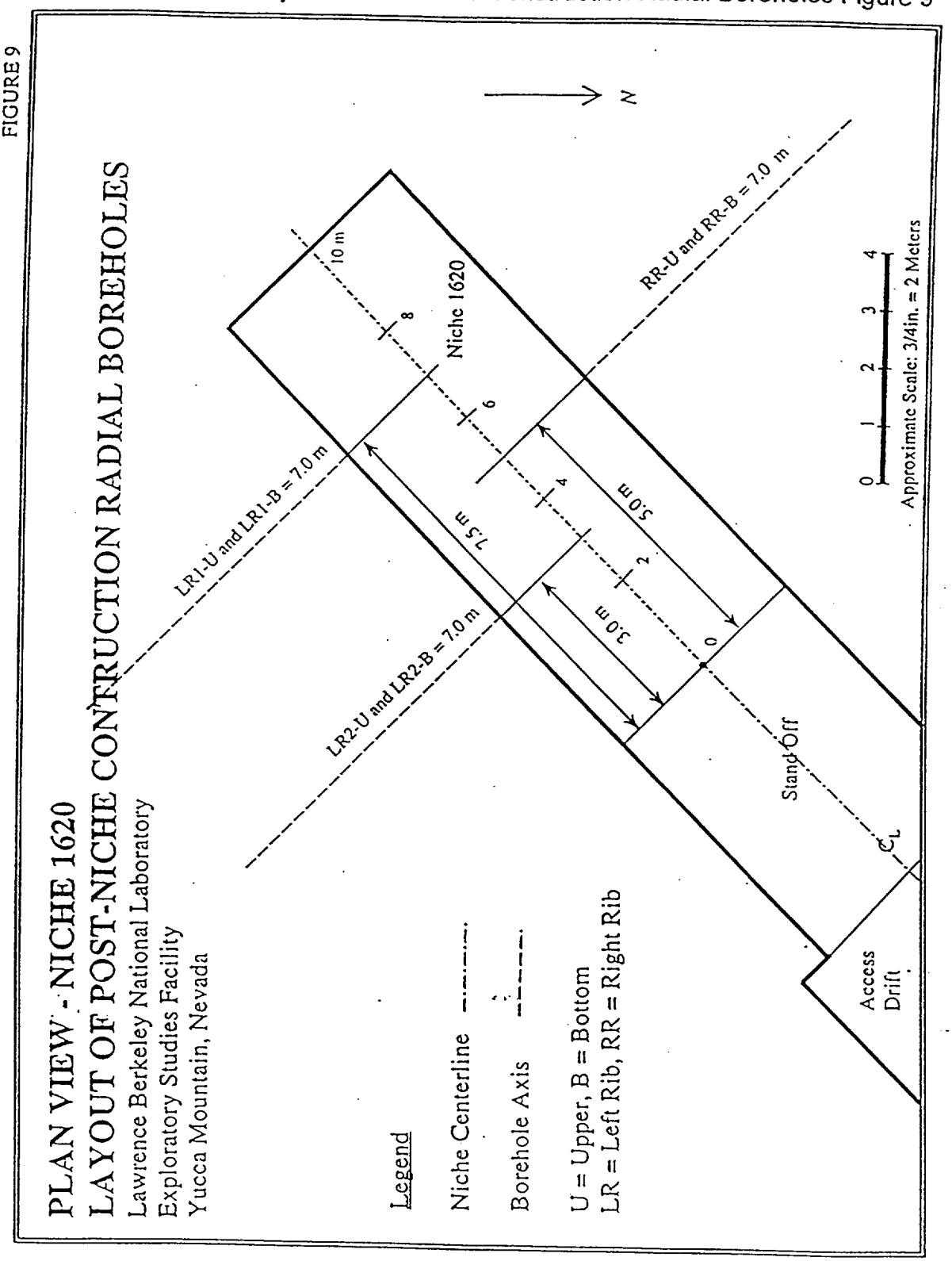
Note: A total of six boreholes will be drilled into the Left Rib (LR) and Right Rib (RR) of Niche 1620 as shown on the Plan View of Figure 9. Three of the 7.0-meter long boreholes (LR-B-1, LR-B-2, and RR-B) will be drilled along a near-horizontal plane located approximately 2.0 meters above the invert as shown in the diagram below. The remaining holes should be sloped upward about 20 degrees with a collar elevation of approximately 2.625 meters above the invert.



Niche 1620

Post-Niche 1620 Construction Radial Boreholes – End View Figure 8

Plan View – Niche 1620 Layout of Post-Niche Construction Radial Boreholes Figure 9



Maximum Tracer Concentrations and Quantities

Alcove 1		
Tracer	**Maximum Quantity (grams or liters)**	**Maximum Concentration (ppm)**
Calcium Bromide	151.4 kg	500
Calcium Iodide	3.0 kg	10
Lithium Bromide	151.4 kg	600
Sodium Chloride	605.6 kg	2,000
Magnesium Fluoride	26.3 kg	87
Sodium Iodide	3.0 kg	10
Fluorescein	0.3 kg	1
Pyranine	0.3 kg	1
Rhodamine WT	0.3 kg	1
FD&C Blue No. 1	6.1 kg	20
Alcove 4		
Tracer	**Maximum Quantity (grams or liters)**	**Maximum Concentration (ppm)**
Sodium Chloride	60 g	3,000
Lithium Bromide	4,000 g	2,000
2,4,6-Trifluorobenzoic Acid	0.5 g	20
2,3,4-Trifluorobenzoic Acid	0.5 g	20
2,3,6-Trifluorobenzoic Acid	0.5 g	20
2,3,4,5-Tetrafluorobenzoic Acid	0.5 g	20
2,4,5-Trifluorobenzoic Acid	0.5 g	20
3,4,5-Trifluorobenzoic Acid	0.5 g	20
2,3-Difluorobenzoic Acid	0.5 g	20
2,4-Difluorobenzoic Acid	0.5 g	20
2,5-Difluorobenzoic Acid	0.5 g	20
2,6-Difluorobenzoic Acid	0.5 g	20
3,4-Difluorobenzoic Acid	0.5 g	20
3,5-Difluorobenzoic Acid	0.5 g	20
Pentafluorobenzoic Acid	0.5 g	20
Fluorescein	4 g	4,000
Acid Yellow #7 (Lissamine FF)	4 g	4,000
Pyranine	240 g	4,000
Amino G Acid	4 g	4,000
Rhodamine B	4 g	900
Rhodamine WT	420 g	4,000
Sulforhodamine B	4 g	4,000
FD&C Blue No. 1	516 g	10,000
FD&C Red No. 40	50 g	10,000
FD&C Yellow No. 5	50 g	10,000
FD&C Yellow No. 6	50 g	10,000
Sodium Tungstate Dihydrate	50 g	5,000
Sodium Molybdate Dihydrate	50 g	5,000
Sodium Fluoride	50 g	5,000
Potassium Fluoride	50 g	5,000
Magnesium Fluoride	50 g	5,000
Helium	1,440 L	1,000
Neon	1,440 L	1,000
Krypton	1,440 L	1,000
Xenon	1,440 L	1,000
Argon	1,440 L	1,000
Magnesium Iodide	50 g	5,000
Sodium Iodide	50 g	5,000
Sodium Bromide	50 g	5,000
Potassium Iodide	50 g	5,000
Potassium Bromide	50 g	5,000

Alcove 6		
Tracer	**Maximum Quantity (grams or liters)**	**Maximum Concentration (ppm)**
Sodium Chloride	60 g	3,000
Lithium Bromide	4,000 g	2,000
2,4,6-Trifluorobenzoic Acid	0.5 g	20
2,3,4-Trifluorobenzoic Acid	0.5 g	20
2,3,6-Trifluorobenzoic Acid	0.5 g	20
2,3,4,5-Tetrafluorobenzoic Acid	0.5 g	20
Sulfur Hexafluoride	0.5 cubic meters	104,000
Helium	0.5 cubic meters	104,000
2,4,5-Trifluorobenzoic Acid	0.5 g	20
3,4,5-Trifluorobenzoic Acid	0.5 g	20
2,3-Difluorobenzoic Acid	0.5 g	20
2,4-Difluorobenzoic Acid	0.5 g	20
2,5-Difluorobenzoic Acid	0.5 g	20
2,6-Difluorobenzoic Acid	0.5 g	20
3,4-Difluorobenzoic Acid	0.5 g	20
3,5-Difluorobenzoic Acid	0.5 g	20
Pentafluorobenzoic Acid	0.5 g	20
Fluorescein	64 g	4,000
Acid Yellow #7 (Lissamine FF)	64 g	4,000
Pyranine	240 g	4,000
Amino G Acid	64 g	4,000
Rhodamine B	64 g	900
Rhodamine WT	420 g	4,000
Sulforhodamine B	64 g	4,000
FD&C Blue No. 1	816 g	10,000
FD&C Red No. 40	160 g	10,000
FD&C Yellow No. 5	160 g	10,000
FD&C Yellow No. 6	160 g	10,000
Sodium Tungstate Dihydrate	80 g	5,000
Sodium Molybdate Dihydrate	80 g	5,000
Sodium Fluoride	80 g	5,000
Potassium Fluoride	80 g	5,000
Magnesium Fluoride	80 g	5,000
Helium	1,440 L	1,000
Neon	1,440 L	1,000
Krypton	1,440 L	1,000
Xenon	1,440 L	1,000
Argon	1,440 L	1,000
Magnesium Iodide	80 g	5,000
Sodium Iodide	80 g	5,000
Sodium Bromide	80 g	5,000
Potassium Iodide	80 g	5,000
Potassium Bromide	80 g	5,000
Alcove 8		
Tracer	**Maximum Quantity (grams or liters)***	**Maximum Concentration (ppm)**
Calcium Bromide	140 g*	500
Calcium Iodide	2 g*	10
Lithium Bromide	140 *g	600
Sodium Chloride	550 g*	2000
Magnesium Fluoride	20 g*	87
Sodium Iodide	2 g*	10
Fluorescein	0.2 g*	1
Pyranine	0.2 g*	1
Rhodamine WT	0.2 g*	1

Niche #1		
Tracer	**Maximum Quantity (grams or liters)**	**Maximum Concentration (ppm)**
Sulfur Hexafluoride and Noble Gases (Helium, Neon, Krypton, Xenon, Argon)	Total of all Noble gases and SF6 not to exceed 1,000 L per tracer	1,000
Fluorescein	14 L**	2,000
Pyranine	14 L**	2,000
Acid Yellow #7 (Lissamine FF)	14 L**	2,000
Rhodamine WT	14 L**	2,000
Rhodamine B	14 L**	2,000
Sulforhodamine B	14 L**	2,000
FD&C Blue #1	14 L**	10,000
FD&C Red #40	14 L**	10,000
FD&C Yellow #5	14 L**	10,000
FD&C Yellow #6	14 L**	10,000
LiBr Water (tracer make-up water)	NA	30
Amino G Acid	14L**	2,000
Niche #2		
Tracer	**Maximum Quantity (grams or liters)**	**Maximum Concentration (ppm)**
Sulfur Hexafluoride and Noble Gases (Helium, Neon, Krypton, Xenon, Argon)	Total of all Noble gases and SF6 not to exceed 1,000 L per tracer	1,000
Fluorescein	84 L**	2,000
Pyranine	84 L**	2,000
Acid Yellow #7 (Lissamine FF)	84 L**	2,000
Rhodamine WT	84 L**	2,000
Rhodamine B	84 L**	2,000
Sulforhodamine B	42 L**	2,000
FD&C Blue #1	42 L**	10,000
FD&C Red #40	42 L**	10,000
FD&C Yellow #5	42 L**	10,000
FD&C Yellow #6	42 L**	10,000
2,3-Difluorobenzoic Acid	0.4 g	20
Pentafluorobenzoic Acid	0.4 g	20
Sodium Iodide	100 g	5,000
Calcium Bromide	100 g	5,000
Calcium Iodide	100 g	5,000
LiBr Water (tracer make-up water)	NA	30
Amino G Acid	84 L**	2,000
	Niches #3 & #4	
Tracer	**Maximum Quantity (grams or liters)**	**Maximum Concentration (ppm)**
Nitrogen	20 L	20
SUVA Cold-MP	20 L	20
Sulfur Hexafluoride	1,000 L	1,000
Helium	1,000 L	1,000
Neon	1,000 L	1,000
Krypton	1,000 L	1,000
Xenon	1,000 L	1,000
Argon	1,000 L	1,000
Sodium Chloride	60 g	3,000
Lithium Bromide	40 g	2,000
Fluorescent Polystyrene Microspheres	40 g	--
2,4,6-Trifluorobenzoic Acid	0.5 g	20
2,3,4-Trifluorobenzoic Acid	0.5 g	20
2,3,6-Trifluorobenzoic Acid	0.5 g	20
2,3,4,5-Tetrafluorobenzoic Acid	0.5 g	20

2,4,5-Trifluorobenzoic Acid	0.5 g	20
3,4,5-Trifluorobenzoic Acid	0.5 g	20
2,3-Difluorobenzoic Acid	0.5 g	20
2,4-Difluorobenzoic Acid	0.5 g	20
2,5-Difluorobenzoic Acid	0.5 g	20
2,6-Difluorobenzoic Acid	0.5 g	20
3,4-Difluorobenzoic Acid	0.5 g	20
3,5-Difluorobenzoic Acid	0.5 g	20
Pentafluorobenzoic Acid	0.5 g	20
Fluorescein	4 g	4,000
Acid Yellow #7 (Lissamine FF)	8 g	4,000
Pyranine	20 g	4,000
Amino G Acid	4 g	4,000
Rhodamine B	1 g	900
Rhodamine WT	4 g	4,000
Sulforhodamine B	48 g	4,000
FD&C Blue No. 1	300 g	10,000
FD&C Red No. 40	160 g	10,000
FD&C Yellow #5	50 g	10,000
FD&C Yellow #6	50 g	10,000
Sodium Tungstate Dihydrate	50 g	5,000
Sodium Molybdate Dihydrate	50 g	5,000
Sodium Fluoride	50 g	5,000
Potassium Fluoride	50 g	5,000
Magnesium Fluoride	50 g	5,000
Magnesium Iodide	50 g	5,000
Sodium Iodide	25 g	5,000
Sodium Bromide	50 g	5,000
Potassium Iodide	50 g	5,000
Potassium Bromide	50 g	5,000
Potato Starch (powdered)	500 g	--
Sodium Hypochlorite	100 g	1,000
LiBr Water (tracer make-up water)	NA	30

Niche #5

Tracer	Maximum Quantity (grams or liters)	Maximum Concentration (ppm)*
Sodium Chloride	60 g	3,000*
Lithium Bromide	40 g	2,000*
Fluorescent Microspheres	40 g	--
Polystyrene Microspheres	40 g	--
Sulfur Hexafluoride (gas)	1,000 L	1,000*
Nitrogen	20 L	20*
SUVA Cold – MP	20 L	20*
2,4,6-Trifluorobenzoic Acid	0.5 g	20*
2,3,4-Trifluorobenzoic Acid	0.5 g	20*
2,3,6-Trifluorobenzoic Acid	0.5 g	20*
2,3,4,5-Tetrafluorobenzoic Acid	0.5 g	20*
2,4,5-Trifluorobenzoic Acid	0.5 g	20*
3,4,5-Trifluorobenzoic Acid	0.5 g	20*
2,3-Difluorobenzoic Acid	0.5 g	20*
2,4-Difluorobenzoic Acid	0.5 g	20*
2,5-Difluorobenzoic Acid	0.5 g	20*
2,6-Difluorobenzoic Acid	0.5 g	20*
3,4-Difluorobenzoic Acid	0.5 g	20*
3,5-Difluorobenzoic Acid	0.5 g	20*
Pentafluorobenzoic Acid	0.5 g	20*
Fluorescein	16 g	4,000*
Acid Yellow #7 (Lissamine FF)	16 g	4,000*
Pyranine	20 g	4,000*
Amino G Acid	4 g	4,000*
Helium	1,000 L	1,000*
Neon	1,000 L	1,000*
Krypton	1,000 L	1,000*
Xenon	1,000 L	1,000*
Argon	1,000 L	1,000*
Rhodamine B	4 g	900*

Rhodamine B	4 g	900*
Rhodamine WT	4 g	4,000*
Sulforhodamine B	48 g	4,000*
FD&C Blue No. 1	280 g	10,000*
FD&C Red No. 40	160 g	10,000*
FD&C Yellow No. 5	50 g	10,000*
FD&C Yellow No. 6	50 g	10,000*
Sodium Tungstate Dihydrate	50 g	5,000*
Sodium Molybdate Dihydrate	50 g	5,000*
Sodium Fluoride	50 g	5,000*
Potassium Fluoride	50 g	5,000*
Magnesium Fluoride	50 g	5,000*
Magnesium Iodide	50 g	5,000*
Sodium Iodide	25 g	5,000*
Sodium Bromide	50 g	5,000*
Potassium Iodide	50 g	5,000*
Potassium Bromide	50 g	5,000*
Calcium Iodide	100 g	5,000*
Calcium Bromide	100 g	5,000*
Sodium Hypochlorite	100 g	1,000*
Potato Starch (powdered)	500 g	--
ECRB Systematic Drilling		
Tracer	**Maximum Quantity Injected (grams or liters)**	**Maximum Concentration (ppm or mg/L)***
FD&C Blue No. 1	10 g***	2 mg/L
FD&C Red No. 40	100 g***	20 mg/L
FD&C Yellow No. 5	100 g***	20 mg/L
FD&C Yellow No. 6	100 g***	20 mg/L
FD&C Acid Yellow No. 7	1 g***	0.2 mg/L
Fluorecein	0.05 g***	0.01 mg/L
Pyramine	0.3 g***	0.06 mg/L
Sulfur Hexafluoride	540,000 L***	1000 ppm
Xenon	540,000 L***	1000 ppm
Neon	540,000 L***	1000 ppm
Krypton	540,000 L***	1000 ppm
2,4,6-Trifluorobenzoic Acid	100 g***	20 mg/L
2,3,4-Trifluorobenzoic Acid	100 g***	20 mg/L
2,3,5-Trifluorobenzoic Acid	100 g***	20 mg/L
2,3,4,5-Tetrafluorobenzoic Acid	100 g***	20 mg/L
2,3-Difluorobenzoic Acid	100 g***	20 mg/L
2,4-Difluorobenzoic Acid	100 g***	20 mg/L
2,5-Difluorobenzoic Acid	100 g***	20 mg/L
2,6-Difluorobenzoic Acid	100 g***	20 mg/L
3,4-Difluorobenzoic Acid	100 g***	20 mg/L
3,5-Difluorobenzoic Acid	100 g***	20 mg/L
Pentafluorobenzoic Acid	100 g***	20 mg/L
Sodium Iodide	25 g***	5 mg/L
Lithium Bromide	5000 g***	1000 mg/L
Sodium Chloride	2000 g***	400 mg/L
Sulforhodamine B	0.1 g***	0.02 mg/L
Amino G Acid	2 g***	0.4. mg/L

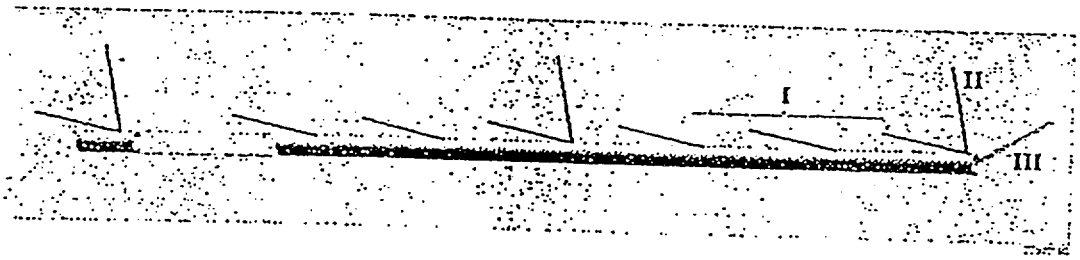
* The quantity of tracers (in excess of the 20+/-10 ppm of LiBr allowed for tracing of construction water) applied with the Alcove #8 water injection testing water shall not exceed the following limits without further SAD evaluation: Total quantity of halogenated salts (excluding LiBr and Fluorine) shall not exceed 2 g/m^2 of injection test area; total quantity of committed Fluorine shall not exceed 1 g/m^2 of injection test area; and total quantity of committed organics shall not exceed 0.3 g/m^2 of injection test area

** The maximum volumes of dyed water in Niches 1# & #2 testing activities shall not exceed 42 liters (11.1 gallons) for food color dyes and 84 liters (22.2 gallons) for fluorescent dyes.

*** Tracers and water loss (i.e., not subsequently recovered) during ECRB Systematic Drilling boreholes shall not exceed the following quantities, as averaged over the 10 m section of the ECRB Cross Drift in which they are released, without further evaluation by the SAD: The emplaced quantity of fluorinated tracers shall not exceed 7.6 grams per meter; the emplaced quantity of non-fluorine, halogenated salt tracers shall not exceed 16 grams per meter; the emplaced quantity of non-fluorescent, organic tracers shall not exceed 2.9 grams per meter; and the concentration of fluorescent tracers used shall not exceed 1 ppm (i.e, 0.001 gram per liter).

BOREHOLE LAYOUT OF SYSTEMATIC CHARACTERIZATION OF TOPOPAH SPRING LOWER LITHOPHYSAL UNIT

Three Categories of ~20 meter long boreholes for performing air permeability, liquid seepage and gas tracer tests



I One low angle (~15° from drift axis), every 30 meters along ECRB Cross Drift

II One near vertical (~75° from drift axis), every 90 meters along Cross Drift

III One horizontal pair (2 to 3 meter separation) collared on rib, every 90 meters along Cross Drift

Figure 1 Borehole configuration for systematic characterization of the East-West Cross Drift from station 14+44 m to 17+63 m.

CLOSE UP VIEW OF THREE CATEGORIES OF SYSTEMATIC BOREHOLES

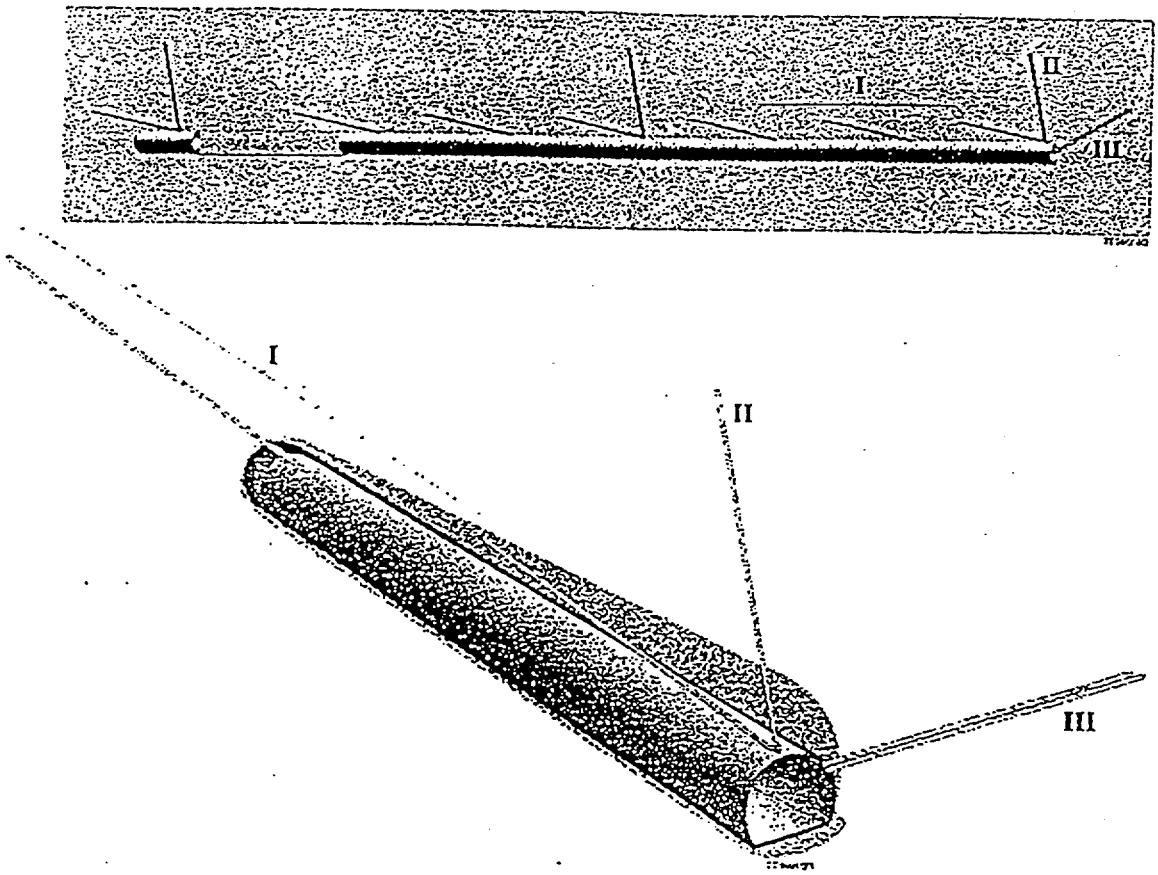
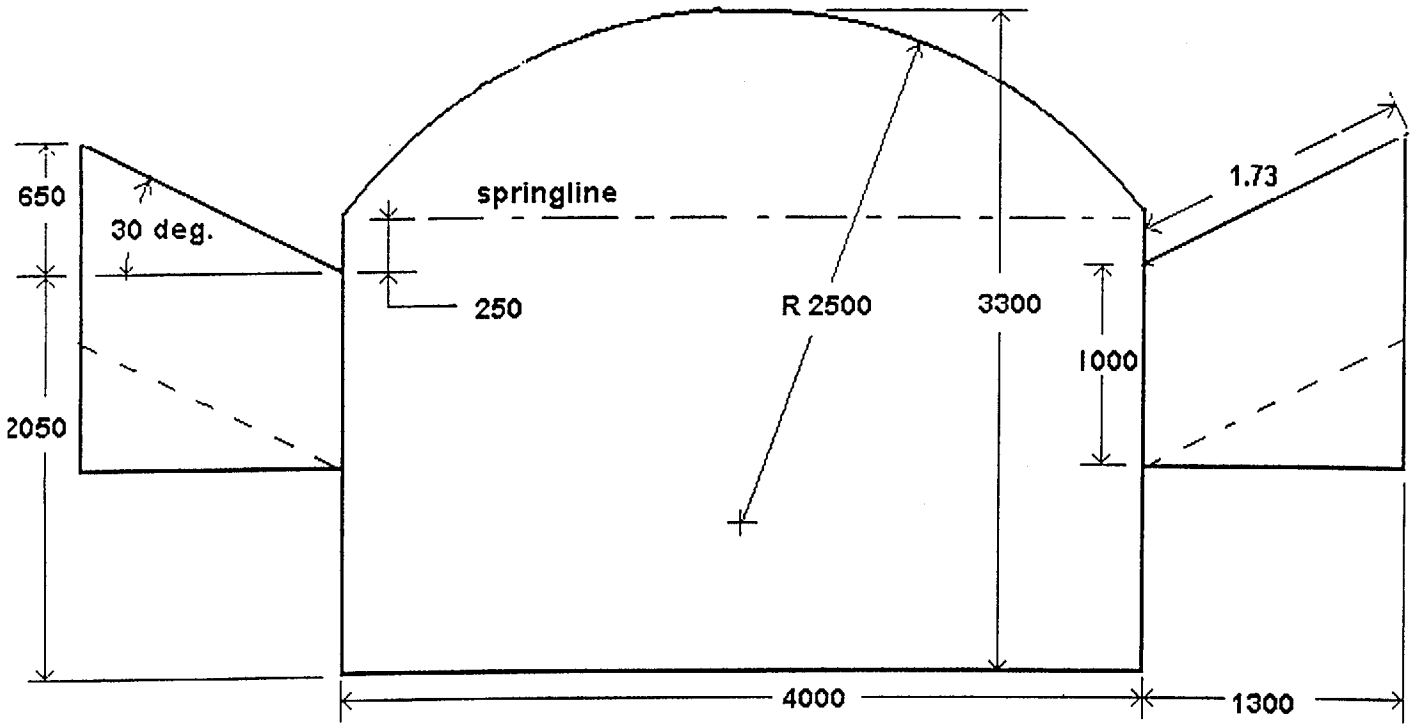


Figure 2 A close-up view of three categories of boreholes between stations 14+44 and 17+63 in the Cross Drift for systematic characterization of flow and transport properties of the lower lithophysal unit.

Niche 5 "Batwing" General Layout.

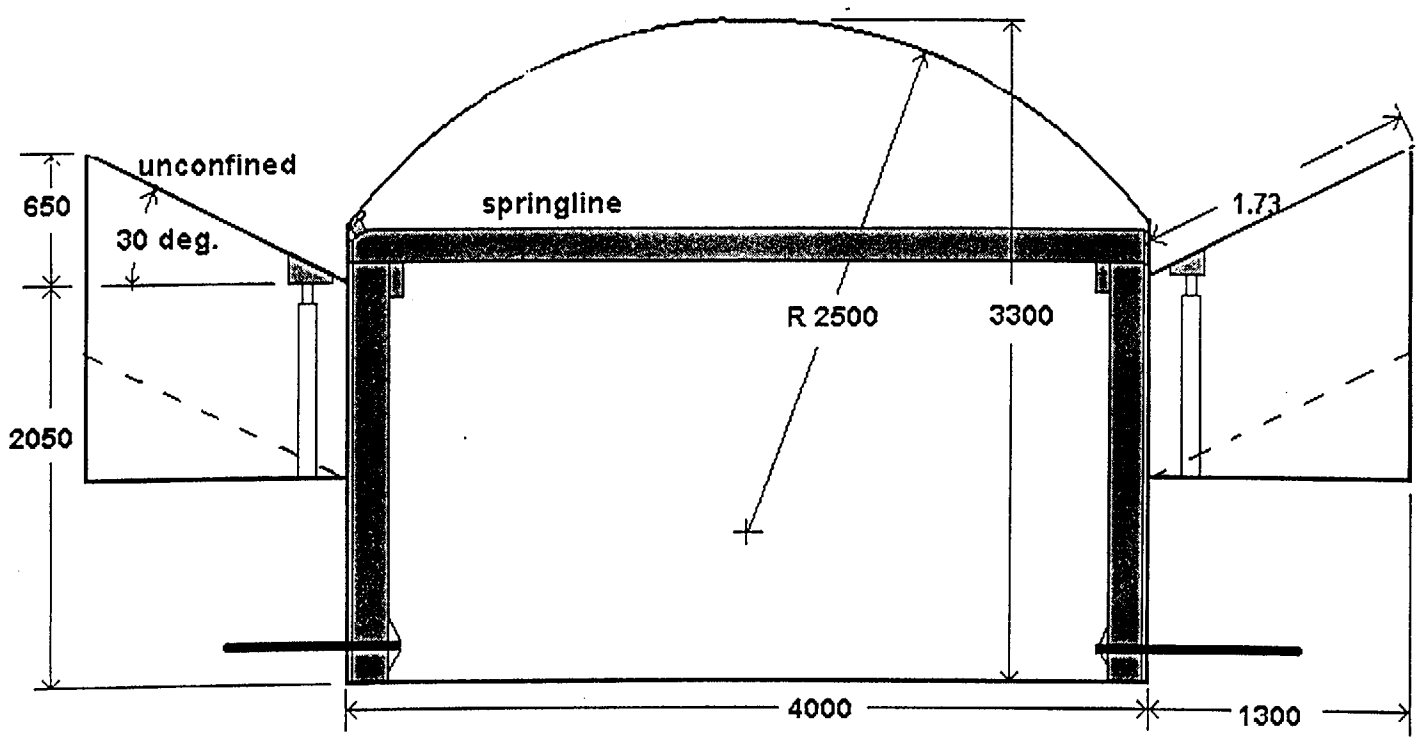


Niche 5 test excavation.

General Criteria:

The angle of Batwings (slot) shall be approximately 30 degrees from horizontal upward (+- 10 degrees).
The depth of Batwing (slot) excavation shall be 1.5 m.
The height of the Batwing (slot) shall be 1.0 m (+- 300cm)
The bottom of the Batwing (slot) shall be horizontal to the invert.
Top of excavation at 250 mm below designed spring line.
Excavation will be accomplished by line drilling with subsequent use of currently approved expanding grout, with minimal hand spading.
(NOTE: Dimensions are for illustration only, final dimensions will be shown on final design submittal drawing)

Niche 5 "Batwing" General Ground Support layout.



Niche 5 test excavation.

(NOTE: Dimensions are for illustration only, final dimensions will be shown on final design submittal drawing)