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YMP/CM-0019

U.S. DEPARTMENT OF ENERGY

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YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

PROJECT BASELINE DOCUMENT

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EXPLORATORY STUDIES FACILITY DESIGN REQUIREMENTS VOLUME 2

CHANGES TO THIS DOCUMENT REQUIRE PREPARATION AND APPROVAL OF A CHANGE REQUEST IN ACCORDANCE WITH PROJECT AP-3.3Q

DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

UNITED STATES DEPARTMENT OF ENERGY
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT OFFICE 102.6

9208240140 - Part 2

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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

EXPLORATORY STUDIES FACILITY (ESF)

DESIGN REQUIREMENTS

(ESFDR)

VOLUME 2

Prepared by Yucca Mountain Site Characterization Project (YMP) Participants as part of the Civilian Radioactive Waste Management Program. The YMP is managed by the Yucca Mountain Site Characterization Project Office (YMPO) of the U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

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REPOSITORY/EXPLORATORY STUDIES FACILITY (ESF) INTERFACE CONSTRAINTS

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REPOSITORY/ESF INTERFACE CONSTRAINTS

Constraints imposed upon the ESF by the repository shall be as follows:

1. The reference Repository/ESF configuration in the ESF Title I Design Summary Report, Revision 1 shall form the basis for the final ESF configuration to be developed during Title II design.

2. Design and construction of the ESF main test level shall not preclude construction of the repository emplacement level at the highest elevation possible compatible with the contact between the TSw1 and TSw2.

3. Design and construction of the ESF main test level shall not preclude design and construction of the repository so that waste emplacement drifts do not cross major faults, such as the Ghost Dance Fault.

4. Refer also to YMP MGDS Repository Design Requirements (RDR) (YMP/CC-0011) for additional constraints.

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APPENDIX A.2

ESF-REPOSITORY INTERFACE DRAWINGS

The information referenced in this Appendix consists of drawings illustrating spatial relationships between ESF and potential Repository drifts. The drawings show how ESF drifts will be incorporated into the layout of the potential repository. The layouts are based on the reference ESF/Repository configuration (referenced in Appendix A.1, ESF/Repository Interface Constraints). The drawings are preliminary. As the ESF and Repository designs evolve, the interface drawings will be revised to reflect changes in concept and include greater detail.

Drawing No.	Title
MND-A201-100	Repository General Layout and Plan
MND-A201-101	TS North Ramp/Main Drift Plan & Section
MND-A201-102	TS South Ramp/Main Drift Plan & Section
MND-A201-103	Repository Main Drifts & TS East/West Drifts - Plan View
MND-A201-104	Repository Main Drifts & TS East/West Drifts - Cross Sections
MND-A201-105	Repository/Main Test Area Boundary Interface - Plans and Cross Sections

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APPENDIX A.3

ESF SEALING REQUIREMENTS IMPOSED BY REPOSITORY SEALING PLAN

[TBD]

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APPENDIX A.4

THERMAL DESIGN BASIS LOADS FOR THE ESF

[TBD]

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SEISMIC DESIGN BASIS LOADS FOR THE ESF

[TBD]

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APPENDIX B

ESF TESTING REQUIREMENTS FOR FACILITY DESIGN

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INTRODUCTION

APPENDIX B

EXPLORATORY STUDIES FACILITY DESIGN REQUIREMENTS

FACILITY DESIGN REQUIREMENTS FOR EXPLORATORY STUDIES FACILITY TESTING

These Underground Testing Requirements for Facility Design (Appendix B) were previously incorporated into the Subsystems Design Requirements Document (SDRD) as Appendices B and C. This Appendix B presents testing support requirements which reflect changes to the testing program necessary to facilitate the new Exploratory Studies Facility (ESF) configuration, mechanical excavation methods, and exploratory drifting and testing in the nonwelded Calico Hills unit. The Underground Testing Program covered in this appendix is a flowdown of activities identified in the Site Characterization Program Baseline (SCPB) and defined in preliminary ESF test planning. The testing information, as provided, is deemed adequate to initiate ESF Title II Design.

The testing requirements will be revised by Los Alamos National Laboratory, as necessary to support design development, using inputs from the Test Organizations and Principal Investigators. Revisions will be based on prioritized needs to support Title II Design phases as identified by the Regulatory and Site Evaluation Division and the Engineering and Development Division, and will provide changes consistent with the SCPB and with selected facility configuration and construction methods. As developed, test-related design requirement inputs will be submitted for inclusion in formal revisions of the ESF Design Requirements (ESFDR). These revisions will include results of integration studies to define common and specific testing program schedules and networks, manpower requirements, storage/lab space requirements, utility and communication requirements, and common sampling requirements for the ESF Test Program.

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ACRONYM
TABLE

A/E	Architect/Engineer
AE	Acoustic Emission
BDG	Borehole Deformation Gage
BSM	Borehole Stress Meter
CHn	Calico Hills Nonwelded Unit
CTA	Core Test Area (in MTL)
DAS	Data Acquisition Station
DBR	Demonstration Breakout Room
DCU	Data Collection Unit
EDD	Engineering And Development Division
ESF	Exploratory Studies Facility (includes accesses and drifts)
ESFDR	ESF Design Requirements (document)
HPC	Hydraulic Pressure Cell
ICWG	Interface Control Working Group
IDAS	Integrated Data Acquisition System (participant)
IDS	Integrated Data System (Project)
kVA (also KVA)	Kilovolt-amperes
LANL	Los Alamos National Laboratory
LBL	Lawrence Berkeley Laboratory
LLNL	Lawrence Livermore National Laboratory
M&O	Management and Operations Contractor (TESS)
MPBH	Multipurpose Borehole
MPBX	Multiple-Point Borehole Extensometer
MTL	Main Test Level
PI	Principal Investigator, Experimentalist
PTn	Paintbrush Tuff Nonwelded (bedded) Unit
RBLC	Rock Bolt Load Cell
RBT	Radial Borehole Test
REECo	Reynolds Electrical & Engineering Co., Inc.
RSED	Regulatory And Site Evaluation Division
RSN	Raytheon Services Nevada
SCPB	Site Characterization Program Baseline (document)
SMF	Sample Management Facility
SNL	Sandia National Laboratories
T&MSS	Technical and Management Support Services Contractor
TCO	Los Alamos ESF Test Coordinator's Office
TCw	Tiva Canyon Welded Unit
TESS	TRW Environmental Safety Systems, Inc.
TSw1	Topopah Spring Welded Unit 1
TSw2	Topopah Spring Welded Unit 2
UDBR	Upper Demonstration Breakout Room
UPS	Uninterruptible Power Supply
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
VAC	Volts, Alternating Current
VSP	Vertical Seismic Profiling
YM	Yucca Mountain
YMP	Yucca Mountain Site Characterization Project
YMPO	Yucca Mountain Site Characterization Project Office

EXPLORATORY STUDIES FACILITY DESIGN REQUIREMENTS
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EXPLORATORY STUDIES FACILITY TEST LIST

Title	SCPB Section Reference	Lead Organization	ESFDR Appendix B Page
Chloride & Chlorine-36 Measurements of Percolation at YM	8.3.1.2.2.2.1	LANL	B-2.2.1-1
Matrix Hydrologic Properties Testing	8.3.1.2.2.3.1	USGS	B-2.2.2-1
Intact-Fracture Test in the ESF	8.3.1.2.2.4.1	USGS	B-2.2.3-1
Percolation Tests in the ESF	8.3.1.2.2.4.2	USGS	B-2.2.4-1
Bulk Permeability Test in the ESF	8.3.1.2.2.4.3	USGS	B-2.2.5-1
Radial Borehole Tests in the ESF	8.3.1.2.2.4.4	USGS	B-2.2.6-1
Excavation Effects Test in the ESF	8.3.1.2.2.4.5	USGS	B-2.2.7-1
Calico Hills Test in the ESF	8.3.1.2.2.4.6	USGS	B-2.2.8-1
Perched-Water Testing in the ESF	8.3.1.2.2.4.7	USGS	B-2.2.9-1
Hydrochemistry Tests in the ESF	8.3.1.2.2.4.8	USGS	B-2.2.10-1
Multipurpose-Boreholes Testing Near the Exploratory Shafts	8.3.1.2.2.4.9	USGS	B-2.2.11-1
Hydrologic Properties of Major Faults Encountered in the ESF	8.3.1.2.2.4.10	USGS	B-2.2.12-1

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EXPLORATORY STUDIES FACILITY TEST LIST (cont.)

Title	SCPB Section Reference	Lead Organization	ESFDR Appendix B Page
Diffusion Tests in the ESF	8.3.1.2.2.5.1	LANL	B-2.2.13-1
Petrologic Stratigraphy of the Topopah Spring Member	8.3.1.3.2.1.1	LANL	B-2.2.14-1
Mineral Distributions Between Host Rock And Accessible Environment	8.3.1.3.2.1.2	LANL	B-2.2.15-1
Fracture Mineralogy	8.3.1.3.2.1.3	LANL	B-2.2.16-1
History of Mineralogic and Geochemical Alteration of YM	8.3.1.3.2.2.1	LANL	B-2.2.17-1
Biological Sorption and Transport	8.3.1.3.4.2	LANL	B-2.2.18-1
Field-Scale Experiments to Study Radionuclide Transport at YM	8.3.1.3.7.2.2	LANL	B-2.2.19-1
Underground Geologic Mapping	8.3.1.4.2.2.4	USGS	B-2.2.20-1
Seismic Tomography/Vertical Seismic Profiling at the ESF	8.3.1.4.2.2.5	USGS	B-2.2.21-1
Laboratory Tests (Thermal & Mechanical) Using Samples Obtained from the ESF	8.3.1.15.1.1 8.3.1.15.1.2 8.3.1.15.1.3 8.3.1.15.1.4	SNL	B-2.2.22-1

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EXPLORATORY STUDIES FACILITY TEST LIST (cont.)

Title	SCPB Section Reference	Lead Organization	ESFDR Appendix B Page
Access Convergence Measurements	8.3.1.15.1.5.1	SNL	B-2.2.23-1
Demonstration Breakout Room	8.3.1.15.1.5.2	SNL	B-2.2.24-1
Sequential Drift Mining	8.3.1.15.1.5.3	SNL	B-2.2.25-1
Heater Experiment in TSw1	8.3.1.15.1.6.1	SNL	B-2.2.26-1
Canister-Scale Heater Experiment	8.3.1.15.1.6.2	SNL	B-2.2.27-1
Heated Block Experiment	8.3.1.15.1.6.3	SNL	B-2.2.28-1
Thermal Stress Test	8.3.1.15.1.6.4	SNL	B-2.2.29-1
Heated Room Experiment	8.3.1.15.1.6.5	SNL	B-2.2.30-1
Plate Loading Tests	8.3.1.15.1.7.1	SNL	B-2.2.31-1
Rock-Mass Strength Experiment	8.3.1.15.1.7.2	SNL	B-2.2.32-1
Evaluation of Mining Methods	8.3.1.15.1.8.1	SNL	B-2.2.33-1
Monitoring of Ground Support Systems	8.3.1.15.1.8.2	SNL	B-2.2.34-1
Monitoring Drift Stability	8.3.1.15.1.8.3	SNL	B-2.2.35-1

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EXPLORATORY STUDIES FACILITY TEST LIST (cont.)

Title	SCPB Section Reference	Lead Organization	ESFDR Appendix B Page
Air Quality and Ventilation Experiment	8.3.1.15.1.8.4	SNL	B-2.2.36-1
Overcore Stress Experiments in the ESF	8.3.1.15.2.1.2	USGS	B-2.2.37-1
Development and Demonstration of Required Equipment	8.3.2.5.6	SNL	B-2.2.38-1
In Situ Testing of Seal Components	8.3.3.2.2.3	SNL	B-2.2.39-1
Geomechanical Attributes of the Waste Package Environment	8.3.4.2.4.3	LLNL	B-2.2.40-1
Repository Horizon Near-Field Hydrologic Properties	8.3.4.2.4.4.1	LLNL	B-2.2.41-1
Repository Horizon Rock-Water Interaction	8.3.4.2.4.4.2	LLNL	B-2.2.42-1

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EXPLORATORY STUDIES FACILITY DESIGN REQUIREMENTS

SECTION 2.2

Description of Tests and Requirements
(Listed By Test)

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Chloride & Chlorine-36 Measurements of Percolation at Yucca Mountain

Definition of Test

The activity, Chloride and Chlorine-36 Measurements of Percolation at Yucca Mountain, is discussed in Section 8.3.1.2.2.2.1 of the Site Characterization Program Baseline (SCPB). This activity involves measurements of chlorine-36, chloride and bromide made at various locations in order to determine the residence time of water in the unsaturated-zone tuffs based on the chlorine-36/chlorine ratio of meteoric chloride. Large bulk samples from various locations throughout the Exploratory Studies Facility (ESF) will be collected, packaged, and labelled for laboratory analysis as described in SCPB Section 8.3.1.2.2.2.1. Because of the requirement to extract sufficient meteoric chloride to analyze each sample for chlorine-36 and to provide for the potential for replicate analyses of a given sample, large samples will be needed from each sampling location. In the event that perched water is encountered, perched water samples will also be collected as part of this activity.

Functional Requirements

1. Provide the facility design and operational flexibility to perform this activity, Chloride and Chlorine-36 Measurements of Percolation at Yucca Mountain.

Performance Criteria

1a. Ability to collect samples of about 100kg quantity from each sampling location must be provided.

1b. Ability to access any given sample location for resampling, if judged necessary, must be maintained.

1c. Provide the ability to take samples concurrently with construction, either by core, as rubble from drill and blast, or as chips from mechanical excavators. Individual fragments of any given sample must be chip size or larger, i.e., not rock flour.

1d. Provide the ability to collect several samples from each geologic unit encountered in both the North and South ramps and in drifts in the Calico Hills and Topopah Spring units.

1e. Provide the ability to collect samples from selected fracture zones, fault and breccia zones, lithologic contacts, and wet zones.

1f. If coring is required to collect samples, coring must be conducted dry. Any use of tracer must be approved by the principal investigator prior to use.

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1g. If coring is required to collect samples, the depth of the core shall be sufficient to ensure pristine samples and to avoid interference from contaminants which may be introduced by excavation or other activities. Contaminants of concern include water, chloride, and bromide or materials containing any of these constituents.

1h. Standard ESF utilities, including power, lighting, water, compressed air, communications, and ventilation are required. No special requirements have been identified.

Constraints

A. Sampling from documented locations will follow completion of geologic mapping activities.

B. The timing of this test will vary according to the construction method used in the ESF. In general, sampling can be conducted during facility construction without impact to construction activities. In some instances, samples may have to be deferred until completion of some construction activities in order to avoid interference with the construction schedule. However, wet zones and perched water require immediate sampling in order to protect the integrity of these samples.

C. Sampling of wet zones and occurrences of perched water must be coordinated with the Perched Water Test.

D. No water shall be used in the immediate vicinity of any sampling location (zone of potential interference to be determined).

E. No tracer shall be used in the vicinity of any sampling location without approval from the principal investigator of this activity (zone of potential interference to be determined).

F. Any drilling necessary to obtain samples shall be done dry.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

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Assumptions

1. A common integrated sampling program for the ESF will be available. Components of this program will include: provisions for locating, collecting, and storing samples following criteria supplied by the principal investigator; coordination of efforts to sample wet zones and occurrences of perched water; the potential for co-utilization of dry-drilled core holes; and short-term storage facility for samples.

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Matrix Hydrologic Properties Testing

Definition of Test

The Matrix Hydrologic Properties Testing is discussed in Section 8.3.1.2.2.3.1 of the Site Characterization Program Baseline (SCPB). The purpose of the matrix hydrologic properties test is to develop a comprehensive data base on matrix flux properties in the unsaturated-zone tuffs at Yucca Mountain. This activity includes collecting bulk and/or core samples from the ESF. Bulk samples may be collected from exposed areas in the ESF or from rubble created during drill-and-blast mining operations. Core samples may be obtained either from boreholes drilled for other tests (drilled for other principal investigators) or from boreholes drilled specifically for the collection of core samples for matrix properties testing. The bulk samples and core samples will be packaged, labeled, and sent to a laboratory for various analyses.

Functional Requirements

1. Provide the facility design and the operational flexibility to perform the sample collection.

Performance Criteria

1a. Samples will be required from all lithologic units penetrated by the ESF. Samples adjacent to lithologic contacts and from bedded intervals are of particular importance. Small alcoves, large enough for a core rig, may be required if boreholes are drilled specifically to collect samples for this test. If possible, core samples will be collected from boreholes drilled for other testing purposes (other PIs boreholes), provided that dry-drilling techniques are employed. Additional sampling may be required, either boreholes or block samples, to provide samples from all the lithologic units penetrated by the ESF.

1b. Boreholes cored specifically for this test should be HQ3-sized boreholes, deep enough to retrieve natural-state samples, oriented approximately horizontal (this is not critical), and drilled dry (air as the circulating fluid).

1c. There are currently no plans to instrument boreholes drilled specifically to collect samples for this test. No data collection equipment will be needed in the ESF.

1d. The placement of matrix hydrologic properties boreholes is flexible where thick, homogeneous units are being sampled. At lithologic contacts and in bedded units, there may be less sample flexibility. Orientation of the boreholes is flexible, to be determined by the type of units being sampled.

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1e. Standard ESF utilities are required for this test.

1f. Ramp and drift walls may need to be sampled as soon as they are excavated. The samples would be block samples or small core plugs, preferably taken by the USGS or designated representatives. Long-term access to drill boreholes and sample ramp and drift walls from 6 months to possibly years may be required.

Constraints

A. The matrix hydrologic properties testing will provide data on in situ hydrologic conditions to other PIs; providing background information for boreholes that are to be instrumented for monitoring changes in the rock surrounding the ESF. In some cases, the data provided from this test will be needed before instruments are placed in the monitoring boreholes.

B. Where practicable, core samples for this test shall be collected from boreholes drilled for other ESF tests, provided that the boreholes are drilled dry.

C. No IDS requirements are foreseen at this time.

D. This test requires in situ samples. The PI or his designated representative will determine where the samples should be collected from to mininmize the impact caused by any wet-drilling operation. This will ensure uncontaminated samples. No interference envelope is required.

E. Dry drilling is required for this test. Block samples, created by drill-and-blast methods, should be collected prior to significant use of water for dust control. Minimal water may be used in drilling the blast holes.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1 Scientific Manpower/Schedule Information
Section 2.3.2 Laboratory/Office/Storage Space Requirements
Section 2.3.3 Electrical Power Requirements
Section 2.3.4 Water System Requirements
Section 2.3.5 Compressed Air System Requirements
Section 2.3.6 Common Sampling Design Requirements
Section 2.3.7 Communications System Requirements
Section 3.0 Integrated Data System

Assumptions

1. The samples will be collected as part of the bulk sampling described in the Common Sampling Design Requirements (2.3.6). The USGS or designated representative will do all the sampling in the ESF.

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2. Core samples will be processed according to the PIs sample-handling procedures.

3. Facilities for handling samples collected from the ESF by the Principal Investigator will be provided by or through the Sample Management Facility.

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Intact-Fracture Test in the Exploratory Studies Facility

Definition of Test

The Intact-Fracture Test in the Exploratory Studies Facility is discussed in Section 8.3.1.2.2.4.1 of the Site Characterization Program Baseline (SCPB). The Intact-Fracture Test will be used to evaluate fluid-flow and chemical transport properties and mechanisms in relatively undisturbed and variably-stressed fractures to enhance the understanding of the physics of fluid flow and for flow modeling.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Intact-Fracture Test.

Performance Criteria

1a. Numerous core samples will be collected from various locations in the following five hydrogeologic units: 1) the Tiva Canyon welded (the North and/or South ramp), 2) the Paintbrush nonwelded (the North and/or South ramp), 3) the Topopah Spring welded (MTL), 4) the vitric Calico Hills nonwelded, and 5) the zeolitized Calico Hills nonwelded. Sample locations will be chosen by the PI using the detailed mapping information, if available.

1b. An alcove may be needed if the core samples are collected where a drill rig and dust collector may block through traffic. The PI will work with the ESF designer to identify and specify design requirements related to potential interferences with traffic in the ramps and/or drifts.

1c. Drilling and overcoring will be done using dry methods.

1d. Fractures of two orientations will be collected from various locations using dry drilling techniques. Both types of core will be collected a short distance (probably 620 to 1240mm) from the mined surface. This will be dependent on the type of excavation methods used. The preferred orientation shall be parallel to the excavated floor (i.e., on a rib). However, samples may be collected from the floor (invert) or roof of the excavation.

The first, radial fractures, are oriented approximately perpendicular to the core axis. A 19mm OD pilot hole is drilled beyond the fracture plane; anchors and a rock bolt are used to secure the fracture plane; the pilot hole is overcored; and a 254mm OD, 610mm long core is withdrawn.

The second fracture type, axial fractures, are oriented parallel to the core axis. The fracture plane is overcored; a 254mm OD, 610mm long core is banded; and the core is withdrawn.

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1e. Standard ESF power, lighting, ventilation, compressed air, and communications are adequate to conduct this test.

Constraints

A. The core samples do not have to be collected immediately following construction. However, these cores shall be collected as soon as possible so the lengthy laboratory tests to be conducted can be started. This test should be done before any lining material is installed in the ESF or the sample locations marked before any lining material is installed.

B. If other tests are to be conducted in the vicinity of the collection sites which may introduce thermal, mechanical, or chemical changes near these collection sites, the core samples shall be collected before the area is perturbed.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

None

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Percolation Tests in the Exploratory Studies Facility

Definition of Test

The Percolation Tests in the Exploratory Studies Facility (ESF) activity is discussed in Section 8.3.1.2.2.4.2 of the site Characterization Program Baseline (SCPB). These tests will be used to observe fluid flow and solute transport processes through variably saturated, fractured welded and nonwelded tuff under controlled, relatively undisturbed conditions. The tests plan to use large, isolated blocks of rock of about 2 meters on a side that have been excavated either within or at the contacts between selected hydrostratigraphic units. The blocks will be instrumented with thermocouple psychrometers, tensiometer-transducer systems and electrical resistivity probes to monitor fluid flow and tracer transport under fluid flow conditions that can be controlled and systematically varied. Tracer-tagged water will be introduced from a trickle system/sand bed on the surface of the block and effluent from the block collected and analyzed to determine transport behavior.

Functional Requirements

1. Provide the facility design and operation flexibility to perform the Percolation Tests.

Performance Criteria

1a. Two locations must be provided at the TCw-PTn and PTn-TSwl geologic contacts of the North Ramp, two locations in the MTL Core Test Area, and two locations (north and south) in the Calico Hills for performance of percolation testing.

1b. At each site, two parallel drifts, approximately 4m wide x 4m high x 7m deep, will be excavated as the test alcove. The final test geometry and dimensions are TBD.

1c. A support system consisting of plates and long bolts will be required to clamp the test block together. Jacks and a steel framework will be required to support the block. Details and design of these support components are to be determined.

1d. Tapered slabs will be cut with a diamond wire saw by drilling holes through the pillar at the intersections of the horizontal and vertical faces of the slabs.

1e. Flexibility in locating the block to be excavated is required because of the need for dense fracture spacing or stratigraphic contacts.

1f. A minimum one-meter air gap is required on the top and bottom of each block and a minimum two-meter air gap is required on each of the four vertical sides of the blocks.

1g. The bottom face will be exposed first, and a block support system must be installed before the pillar is excavated.

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Constraints

A. Alcove construction methods must prevent induced fractures in the test block.

B. Fractures on each of the six exposed block faces must be mapped prior to block instrumentation.

C. Provision for data collection and IDS connection must be available prior to beginning this test.

D. The test blocks will be cut by a wire saw using tagged water (tracer to be determined later) to cool the wire and control the dust.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 3.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. A ram can be used to push the tapered slabs cut from the pillar into an alcove and jack hammers will be adequate to break the slabs for removal.

2. A fluid effluent collection system designed and implemented by the USGS will be installed beneath the block prior to placement of the block on the block-support system.

3. The USGS will drill the approximately one-inch diameter boreholes used for instrument emplacement within the block.

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Bulk Permeability Test in the Exploratory Studies Facility

Definition of Test

The Bulk Permeability Test activity is discussed in Section 8.3.1.2.2.4.3 of the Site Characterization Program Baseline (SCPB). The tests will utilize single- and cross-hole air, and possibly water, injection to examine the effects of measurement scale on calculated permeability and to characterize media heterogeneity with respect to bulk permeability. Tracer testing using gaseous and possibly liquid tracers will help characterize media transport properties. Testing will be conducted at 5 locations within the Topopah Spring Main Test Level (MTL) and will require up to four 60 meter HQ coreholes at each location.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Bulk Permeability Tests.

Performance Criteria

1a. Three test locations must be distributed along MTL N-S main and E-W drifts, and two additional test locations must be provided in the MTL Core Test Area.

1b. The alcoves at each site must be of sufficient size to allow drilling of three 60-meter long HQ coreholes arranged in a frustum configuration, followed by a fourth HQ corehole drilled in the center of the three-hole frustum. Drilling of the fourth hole will follow the initial three holes by approximately 3 months. The initial three holes will start in an alcove, a minimum of one drift diameter off the drift, and be drilled at the corners of an equilateral triangle with 2-meter sides. The holes will be drilled at a 25 degree angle away from the centerline passing perpendicular through the center of the triangle. The fourth hole will be drilled on this center line. The holes will be a maximum of 60 meters in length. All holes will be dry-drilled and the core packaged for use in other tests. The preferred orientation of the holes is near horizontal and perpendicular to the drift, but flexibility exists in orienting the holes.

1c. The USGS will provide all equipment used in the Bulk-Permeability testing including the data acquisition equipment. No IDS connection or equipment is required.

1d. At this time the precise locations of the test sites are undefined. The precise locations will be selected only after the initial geologic fracture mapping is completed.

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1e. Standard power, lighting, and communications will be adequate.

1f. Testing will require 2 persons working in the alcove during normal working hours. The workers will be installing and removing packer systems and will therefore require sufficient space. Testing is expected to require up to 5 months per site.

Constraints

A. Location of the test sites will require information from the geologic fracture mapping.

B. Bulk Permeability testing could be postponed for up to one year after drift construction provided the alcove and coreholes are not constructed. Because of rock drying, testing must begin as soon as possible after corehole drilling.

C. Because the Bulk-Permeability Test program is designed to assess the undisturbed hydrologic characteristics of the Topopah Spring Unit, it is critical that no other tests alter these characteristics. Tests that might change the rock permeability, water content or temperature must be examined closely and probably restricted. Since air and water will be injected into the formation, other nearby tests might be adversely affected.

D. The Bulk Permeability Tests will require borehole geophysical and downhole TV logging information before testing can begin.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The alcove space required for drilling will also be sufficient for assembly and installation of the packer systems.

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Radial Borehole Tests in the Exploratory Studies Facility

Definition of Test

The Radial Borehole Tests in the Exploratory Studies Facility are discussed in Section 8.3.1.2.2.4.4 of the Site Characterization Program Baseline (SCPB). The tests will investigate vertical and lateral movement of gas, water, and vapor within the individual hydrogeologic units and across the hydrogeologic units contacts. The Radial Borehole Tests consist of three test programs: (1) anisotropy testing of the hydrogeologic units using a three-hole arrangement; (2) contact testing at the hydrogeologic units contacts using a four-hole arrangement; and (3) long-term monitoring at the contact test sites.

Functional Requirements

1. Provide the facility design and operation flexibility to perform the Radial Borehole Tests.

Performance Criteria

1a. Locations must be provided as follows:

(i). Asotropy Test Sites

North Ramp

Alcove in upper TCw
Alcove in lower TCw
Alcove in middle PTn
Alcove in TSw1

Calico Ramp off North Ramp

Alcove in TSw2

South Ramp

Alcove in upper TCw
Alcove in lower TCw
Alcove in PTn
Alcove in TSw1
Alcove in TSw2

Calico Ramp off South Ramp

Alcove in TSw3

Calico Hills Test Level

Three Alcoves in CHn (distributed along drifts)

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(ii). Contact Test Sites

North Ramp

Alcove at TCw-PTn contact
Alcove at PTn-TSw1 contact

Calico Ramp off North Ramp

Alcove at TSw2-TSw3 contact

South Ramp

Alcove at TCw-PTn contact
Alcove at PTn-TSw1 contact

Calico Ramp off South Ramp

Alcove at TSw3-CHn contact

Calico Hills Level

Three Alcoves at Vitric-Zeolitic contacts along CH drifts
Alcove at TSw3-CHn contact

1b. Alcoves

(i). Anisotropy Test Sites

The alcoves must be large enough to allow HQ drilling of three 30-meter coreholes. The coreholes will be horizontal, perpendicular to the ramp, parallel to each other and configured in an equilateral triangle with 3-meter sides. In addition, the holes must be a minimum of one ramp diameter off the ramp. The holes will be dry drilled and the core boxed and transported to the Sample Management Facility (SMF).

(ii). Contact Test Sites

The alcoves must be large enough to allow HQ drilling of four 30-meter coreholes parallel to the contact, perpendicular to the ramp and parallel to each other. These coreholes must be in a rectangular configuration with two coreholes located a maximum of 2 meters above the contact and separated by up to 3 meters and two coreholes located below the contact and separated by up to 3 meters. In addition, the coreholes must begin a minimum of one ramp diameter off the ramp. The coreholes will be dry drilled and the core boxed and transported to the SMF.

(iii). Long-term Monitoring

Following completion of contact testing, the long-term monitoring program will utilize the contact test-site coreholes with no additional modifications. The long-term monitoring program may last up to 5 years.

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1c. The USGS will supply all equipment used in the Radial Boreholes Tests including the data acquisition equipment. Data storage for the anisotropy and contact tests will be self-contained. However, the long-term monitoring will require an RS-232 connection from the IDS to the USGS data collection PC.

1d. The exact locations of the anisotropy test sites will be located only after the preliminary geologic mapping in the drifts have been conducted. The exact contact test sites will be known only when the ramp has intersected the contact. In addition, ramp construction may present geologic information that necessitates the addition of one or more test sites. Due to the many unknowns, it is imperative that a great deal of flexibility be maintained in the test site selection and development.

1e. Standard power, lighting, and communications will be adequate. Testing will require compressed air at 1000slpm and 1035kPa at the anisotropy and contact test sites during testing. Long-term monitoring will require standard power, lighting, and communications. After completion of long-term monitoring, the contact test sites will require water for water-injection testing. It is estimated the water-injection tests will require up to 3 months and require water at 100 liters per minute at 100kPa gauge pressure.

1f. Anisotropy Test Sites

Testing will require 3 people working the alcove during normal work hours. The workers will be installing and removing packer systems and will therefore require sufficient space. Testing is expected to take up to 3 months per site.

1g. Contact Test Sites

Testing will require 2 people working in the alcove during normal work hours. The workers will be removing and installing packers and will therefore require sufficient space. Testing is expected to take up to 3 months per site.

1h. Long-term Monitoring

This program will require weekly access for maintenance and equipment checks. Repair technicians will also require access in cases of equipment failure. Long-term monitoring may last up to 5 years. Upon completion of monitoring, a 2-person crew will require daily access during normal work hours to conduct water-injection tests. The water-injection tests may require up to 3 months.

Constraints

A. The Radial Borehole Tests will require borehole geophysical and downhole TV logging information before testing can begin.

B. The anisotropy sites can be postponed up to one year after ramp construction, assuming that the alcoves and coreholes are not

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constructed. Construction of the alcoves and coreholes will cause changes in the rock water content, most notably in the nonwelded units, and therefore it is very important to begin testing as soon as possible after corehole construction.

The contact test sites have a long-term monitoring component. It is therefore important to get these tests started as soon as possible. It is necessary to get the early baseline data before changes due to ramp construction affect the contact test sites.

C. Long-term Monitoring

An IDAS RS-232 connection to the USGS data collection PC must be present at the start of monitoring at all sites.

D. Because the Radial Boreholes test programs measure the undisturbed (or minimally disturbed) characteristics of the rock, it is critical that no other tests alter the rock characteristics. Tests that might change the rock permeability, water content or temperature must be examined closely and probably restricted.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The USGS data acquisition and test control equipment will occupy a space of approximately 1 meter wide, 1 meter deep, and 2 meters in height, and can remain in the alcoves for long-term testing.

2. The alcove space required for drilling HQ coreholes should be sufficient for assembly and installation of packer systems.

3. Large air-pressure fluctuations in the ramp and alcove could adversely influence testing.

4. Fluctuations in the compressed-air supply or pressure could adversely influence testing.

5. Air-pressure fronts or water from other tests flowing into the test areas zone of influence could adversely affect testing.

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Excavation Effects Test in the Exploratory Studies Facility

Definition of Test

The Excavation Effects Test in the Exploratory Studies Facility is discussed in Section 8.3.1.2.2.4.5 of the Site Characterization Program Baseline (SCPB). This test is designed to measure permeability changes that result from stress redistribution around the underground excavations. The test is conducted in the Topopah Spring horizon to provide design information for the potential repository.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Excavation Effects Test.

Performance Criteria

1a. Locations must be provided at the CH ramp takeoff from the North Ramp, and at the MTL intersection of the N-S main and E-W drift, for performance of the tests.

1b. Enough space is required to, (a) accommodate a drilling rig that will be used to drill several holes up to 33m long; and (b) house data acquisition systems and packer strings and keep them off main traffic routes.

1c. The general geometry of the instrumentation holes is TBD.

1d. Approximately 26 horizontal boreholes of up to 33m long, 96 and 76mm in diameter that are dry-drilled will be needed.

1e. All instrument leads shall be protected from damage.

1f. Alcove dimensions must be adequate to support an overcore stress test, performed prior to initiating the excavation effects test.

1g. An organizational data collection area (or alcove) and an IDS connection must be provided near the instrumented face.

1h. Standard ESF electric power, lighting, ventilation, compressed air, and communications are adequate to perform this test.

1i. Nitrogen gas and associated tubing will be required for pressurizing packers and doing permeability tests.

Constraints

A. Overcore stress testing must be conducted in the alcove prior to initiating this test.

B. The instrumentation holes must be completed before the tested opening is excavated more than 1m beyond the instrumentation face.

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C. Test must be conducted during excavation of tested opening. No deferral is allowed.

D. At least 30m of excavated opening is required to obtain sufficient data.

E. No other drilling activities will be allowed in the alcove or in the tested opening during this test.

F. All instrumentation holes will be drilled using air as a drilling fluid.

G. Provision for data collection and IDS connection must be available prior to the beginning of this test.

H. Long-term permeability, temperature, and moisture measurements will be performed from the test holes. Access to instrumentation face must be maintained.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. Logging, surveying, and packer installation in the holes can be accommodated within the alcove provided.

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Calico Hills Test in the Exploratory Studies Facility

Definition of Test

The Calico Hills Test in the Exploratory Studies Facility is discussed in Section 8.3.1.2.2.4.6 of the Site Characterization Program Baseline (SCPB).

As the scope of testing in the Calico Hills nonwelded unit has increased dramatically with the current design of two ramp accesses and major drifting in both the Topopah Spring welded unit and Calico Hills nonwelded unit, current plans are to delete this activity from the SCPB and cover the testing descriptions and requirements as part of other test activities. Test descriptions and requirements for testing in the Calico Hills nonwelded unit can be found in other individual activities (Radial Boreholes, Intact Fracture, Hydrochemistry, etc.).

Functional Requirements

None

Performance Criteria

None

Constraints

None

Interface Requirements

None

Assumptions

None

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Perched-Water Testing in the Exploratory Studies Facility

Definition of Test

The Perched-Water Testing in the Exploratory Studies Facility activity is discussed in Section 8.3.1.2.2.4.7 of the Site Characterization Program Baseline (SCPB).

The purpose of the Perched-Water Test is to detect the occurrence, and delineate the lateral and vertical extent, of perched-water zones (if encountered) during excavation of the Exploratory Studies Facility (ESF), to identify perching mechanism(s), and to sample the perched-water for chemical analyses. Because there is significant uncertainty regarding the likelihood of encountering perched-water, the perched-water test is categorized as a "contingency test." The form and duration of the testing is dependent upon the nature of any encountered perched-water.

If perched-water is encountered during excavation, one or more small-diameter borehole(s) will be drilled to enhance drainage, facilitate collection of water samples, and allow flow and\or pressure measurements to be made. The borehole(s) may be instrumented for long-term testing and monitoring to obtain data on hydraulic pressure over time. Periodic water sampling may be required from perched-water boreholes.

Functional Requirements

1. Provide the facility design and the operational flexibility to perform perched-water sample collection.

Performance Criteria

1a. Space requirements for this test depend upon the type of perched-water zone encountered. Small perched-water zones (seeps, etc.) may require an opening in the ramp or drift wall large enough to contain water sampling equipment and a data logger (1m x 1m x 0.5m). In the event that boreholes are required for sampling, testing, and monitoring large volume perched-water zones, an alcove large enough to contain a coring rig may be needed to move the drilling operations out of heavy traffic areas in the ESF. Because of the nature of perched-water, the location of its occurrence cannot be predicted.

1b. Boreholes cored specifically for this test should be HQ3-sized boreholes, deep enough to retrieve natural state samples, oriented approximately horizontal (this is not critical), and drilled dry (air as the circulating fluid).

1c. Boreholes drilled to develop and concentrate the flow of perched-water will be instrumented to conduct hydraulic tests, to monitor pressure and temperature, and to collect water samples. Data loggers will be used to collect and store data from these boreholes.

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1d. The locations of perched-water tests will be controlled by the occurrence of perched-water. Access to ramp or drift faces may be required immediately after the detection of any perched-water. The orientation of boreholes drilled for this test will be controlled by the nature of the perched-water zone.

1e. Boreholes are drilled in the ESF for this test to concentrate and collect perched-water samples for laboratory testing. Additionally, the boreholes will be instrumented to test and monitor perched-water zones. Small flow perched-water zones may only require that water samples be collected along with an estimate of the flow rate and total volume of water produced.

1f. Standard ESF utilities are required for this test.

1g. Perched-water zones in the ramps and drifts need to be sampled and examined as soon as they are encountered. This activity may require that the tunnel boring machine be pulled back or driven forward to provide access to the perched-water, whichever is faster. After initial sampling, a determination as to the extent of the perched-water zone will be made. Based on this information, it will be decided whether to suspend excavation operations to allow for more complete testing and sampling or to allow excavation operations to continue. Long-term sampling and monitoring of perched-water zones, either in boreholes or along ESF walls, will continue until the nature of a perched-water zone is determined.

Constraints

A. Perched-water testing will be initiated as soon as any perched-water is encountered in the ESF. This test should not interfere with any other test. Core samples collected from boreholes drilled for this test will be provided to the matrix hydrologic properties test if necessary.

B. No IDS requirements are foreseen at this time. Perched-water data collected on data loggers may be transmitted and stored on the IDS system.

C. This test will be conducted wherever perched-water is encountered in the ESF. No interference envelope is required.

D. If boreholes are needed, dry drilling is required for this test. If grouting of the ramp and drift walls is required, a chemical tracer must be added to the grout. If alcoves are constructed for this test, minimal water may be used in drilling the blast holes.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

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Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The PI or his designated representative will determine what methods are needed to characterize the perched-water each time it is encountered.

2. The test organization (USGS) will provide all sampling, testing, and monitoring equipment.

3. Criteria will be developed by the test organization (USGS) to define what constitutes evidence of perched-water.

4. The USGS data collection system (data loggers) can be interfaced with the IDS for the storage of data collected during long-term monitoring.

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Hydrochemistry Tests in the Exploratory Studies Facility

Definition of Test

The Hydrochemistry Tests are discussed in Section 8.3.1.2.2.4.8 of the Site Characterization Program Baseline (SCPB). The Hydrochemistry tests will determine the chemical composition, reactive mechanisms, and age of water and gas in pores, fractures, and perched water zones within the unsaturated tuffs accessible from the ESF and/or affiliated coreholes. The ESF will provide access for the collection of gas, rock, and fracture-water samples.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Hydrochemistry Test.

Performance Criteria

1a. Core and gas samples will be required from the following locations:

(i). All Radial Borehole Test holes.

(ii). Many of the Bulk Permeability Test holes.

(iii). Many of the Major Faults Test holes.

(iv). From additional coreholes drilled specifically for the Hydrochemistry test to provide gas and core samples from locations not satisfied by the above tests locations. These may include 2 or 3 additional locations in the Tiva Canyon welded hydrogeologic unit, and 2 additional locations in the Topopah Spring hydrogeologic unit, the zeolitic and vitric facies of the Calico Hills nonwelded hydrogeologic units, and the bedded tuff of the Paintbrush hydrogeologic unit. This also may include any wet areas, any unanticipated geologic formation encountered during ESF construction, and coreholes cored in three different orientations from one alcove in each of the welded units. All of the coreholes will be 61mm in diameter (HQ), and dry drilled to a depth of about 30 meters.

1b. Long-term gas sampling will occur 2 times per year for a period of at least 3 years.

1c. Gas samples will be provided from short-term boreholes drilled from the drift in a minimum of 2 locations in each hydrogeologic unit as soon as possible after excavation. Additionally, it may be necessary to provide short-term boreholes from alcoves at each of the locations listed in 1a, 1b, 1c, and 1d (above). Information obtained from the short-term boreholes drilled from the drift will help determine the necessity for, and depth of, the alcove short-term boreholes.

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1d. Alcoves may be required at each gas sampling location as necessary to provide at least 1.8 by 2.4 meter space out of the traffic area for gas sampling equipment.

1e. Standard 110V power, lighting, and communications will be adequate. Testing will require that compressed air (345kPa) be available to inflate the packers.

1f. Samples of all traced water used at the ESF shall be provided for chemical analysis from all water system taps using procedures to be determined.

1g. Access must be provided to the test location collar on a continuing periodic basis for gas sample collection.

1h. A location must be provided for short-term core storage. The location should be at least 3 by 3 by 2.4 meters, out of traffic areas, and the temperature and humidity should not fluctuate by more than 11 degrees Celsius or 20% relative humidity.

1i. At this time the precise locations of the test sites are unknown. As the drifting progresses and contacts, faults, wet areas, etc. are determined the locations will be defined. Due to the many unknowns it is imperative that a great deal of flexibility be maintained in the test site selection.

1j. During the long-term gas sampling, no other hydrologic testing should be done within about 15 meters of the sampling intervals.

Constraints

A. Chemically trace all water used at the ESF.

B. Chemically trace all gas used for drilling or testing in the ESF.

C. Collect samples from all concrete, grouts, and other liquid construction materials as required by the ESF Fluid/Material/Tracer System Plan.

D. Long-term monitoring sites can be postponed up to one-half year after excavation as long as alcoves and coreholes are not constructed.

E. Short-term boreholes must be drilled within 4-5 days after excavation of a drift or alcove.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

   Section 2.3.1 Scientific Manpower/Schedule Information
   Section 2.3.2 Laboratory/Office/Storage Space Requirements
   Section 2.3.3 Electrical Power Requirements

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Section 2.3.4 Water System Requirements
Section 2.3.5 Compressed Air System Requirements
Section 2.3.6 Common Sampling Design Requirements
Section 2.3.7 Communications System Requirements
Section 3.0 Integrated Data System

Assumptions

1. No added gas tracer is required for the ventilation air. Freon 11 and 12 existing in environmental air will be used as the tracer.

2. Design, procurement, and operation of the air and water tracer systems will be by the YMP support organizations.

3. Tracer chemical specifications must take into account requirements from all tests, RCRA and other permitting requirements but will be the responsibility of the test organization.

4. The Universal water tracer will be sodium bromide.

5. Long term gas sampling will occur over a 2-4 week period and be performed every 6 months for 3 years at each gas sampling location.

6. The alcove space required for drilling HQ sized coreholes should be sufficient for assembly and installation of the packer system.

7. The short-term borehole construction and pumping will include: a) hammer drilling; b) insertion of a metal sleeve and grout; c) one hour of prepumping; and d) about a 1 day pumping period.

8. The packer system will be inserted by the investigators.

9. The sampling system (packers, pumps, and sampling vessels) will be transported to the sampling location and core samples will be transported to the drift portal by YMP contract personnel.

10. Core from all Radial Boreholes Tests, and some of the Bulk Permeability and Major Fault Tests will be available for Hydrochemistry Test use.

11. Cores will be sealed by YMP contract personnel according to procedures to be determined by the test organization.

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Multipurpose-Borehole Testing Near the Exploratory Shafts

Definition of Test

The Multipurpose-Borehole Testing near the Exploratory Shafts is discussed in Section 8.3.1.2.2.4.9 of the Site Characterization Program Baseline (SCPB).

One or more multipurpose boreholes may be constructed in conjunction with a possible vertical shaft using dry-drilling and coring techniques, to the extent practicable. The borehole(s) would be located such that they do not penetrate within a distance of two diameters, as appropriate, of any underground openings. The borehole(s) would be drilled to depths approximately equal to the corresponding opening, with walls as smooth as practical to maximize the quality of geophysical logging and provide adequate packers seats.

Under the current ESF design with two ramps, this activity will only be conducted in conjunction with the optional scientific shaft, and then only if testing is deemed necessary based on other prior testing results. Because the decision to construct a scientific shaft and conduct associated testing will be determined at some future date based on the results of prior testing in the ESF, it is premature to develop requirements or further descriptions for this activity.

Functional Requirements

To be determined, if required.

Performance Criteria

To be determined, if required.

Constraints

To be determined, if required.

Interface Requirements

1. Interface requirements to other systems, if applicable, are TBD.

Assumptions

None

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Hydrologic Properties of Major Faults Encountered in the Exploratory Studies Facility

Definition of Test

The Hydrologic Properties of Major Faults Encountered in the Exploratory Studies Facility test is discussed in Section 8.3.1.2.2.4.10 of the Site Characterization Program Baseline (SCPB).

This activity is designed to provide hydrologic information in conjunction with a portion of Activity 8.3.1.4.2.2.4 (Geologic Mapping of the Exploratory Shaft and Drifts). All faults encountered in the ESF will be characterized geologically under the geologic mapping activity. Hydraulic properties of major faults encountered in the ESF will also be determined in this activity. The major faults or fault zones expected to be tested are the Bow Ridge fault, the Boundary Ridge fault, the Imbricate fault zone, the Ghost Dance fault, a suspected fault in Drill Hole Wash, Solitario Canyon fault, the fault along Yucca Crest, and any major faults not previously identified, especially if fluid flow is observed.

A hydrologic testing program will be implemented based on the major faults identified by the geologic mapping activity. This program will consist primarily of tests conducted in boreholes drilled through or parallel to fault zones and tests on core collected from the boreholes. The first activity will be the drilling and testing of a geothermal borehole. Sensitive temperature measurements made in the borehole will indicate water movement in the fault zone. Air permeability tests will be conducted between other boreholes to determine the permeability to air of the fault zones. Some boreholes will be instrumented to determine in situ conditions of the rock mass and monitored for any changes in these conditions over time. Other sets of boreholes will be used for cross-hole water-injection tests. All water used for injection will be tagged with a tracer. Core recovered from the boreholes will be tested to provide a water-content profile across the fault zone. This profile may provide information regarding recent moisture changes in the fault zone.

Functional Requirements

1. Provide the facility design and operation flexibility to perform the Hydrologic Properties of Faults Test.

Performance Criteria

1a. Special L-shaped alcoves are required at each fault testing location. The maximum dimensions for an alcove shall be 15m x 18m. The dimensions will vary depending on excavation effects.

The major faults or fault zones expected to be tested are the Bow Ridge fault, the Boundary Ridge fault, the Imbricate fault zone, the Ghost Dance fault, a suspected fault in Drill Hole Wash, the Solitario Canyon fault, the fault along Yucca Crest, and any major faults not

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previously identified, especially if fluid flow is observed. The exact location of these geologic features in the ESF can not be determined at this time. Each ramp or drift intersection with a major fault or fault zone will be tested.

1b(i). A geothermal borehole will be dry drilled, approximately horizontal, at each location at about a 45 degree angle to the ramp\drift wall as soon as possible after the fault is identified. Geothermal boreholes will be HQ3-sized and a minimum of 60m long.

(ii). The facility design and operations shall allow access to these boreholes for temperature logging soon after drilling and at intervals of one or two days initially and weekly thereafter until the effects of drilling have subsided and the effects of ventilation of the drift are detected.

1c. The planned IDS may be utilitized for long-term monitoring requirements.

1d. Access to the geothermal boreholes is required for the entire duration of site characterization.

1e(i). Four boreholes parallel to the fault, and three boreholes perpendicular to the fault will be dry drilled at each location. These boreholes will not be drilled until directed to do so by the PI or his designated representative. These boreholes will be approximately 15m long.

(ii). The facility design and operations shall allow access to these boreholes to replace faulty packers, to repair and calibrate instrumentation, to handle the nitrogen gas bottles and associated hardware for trouble shooting, to test the instrumentation, and to test the data collection and IDS equipment.

(iii). Each location will require a space for organizational data collection and IDS equipment.

(iv). Access to the hydrologic boreholes is required for the entire duration of site characterization.

1f. Standard ESF power, lighting, water, compressed air, ventilation, and communications are adequate to conduct these tests.

Constraints

A. The alcoves or the hydrologic boreholes shall not be started until the PI has determined that effects of ventilation in the drift have been detected in the geothermal borehole. After this has occurred, alcove construction and borehole drilling can proceed.

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B. These boreholes will not be drilled until the PI has determined that the effects of ventilation in the ESF have been detected in geothermal borehole.

C. The IDS will be used for data acquisition and storage from the long-term monitoring operations.

D. The interference envelope for air-permeability testing is uncertain. Excavation effects evaluation and prototype testing are required to assess potential interference problems. The use of water in the final stages of testing is also problematic even though tracers will be used to tag the water. By-passing effects of drifts near the fault-testing location may pose a serious problem. It is desirable to locate fault testing locations as far as possible from other underground openings. A conservative minimum distance from other openings would be three-to-four drift diameters. Test boreholes need to be placed such that stress relief effects of the ramp or drift alcove are minimized, and other tests will not interfere.

E. Dry drilling will be required using a tracer gas. Borehole(s) will not be drilled in an alcove until preliminary mapping of the structural geologic features is complete.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

None

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Diffusion Tests in the Exploratory Studies Facility

Definition of Test

The Diffusion Tests in the Exploratory Studies Facility are discussed in section 8.3.1.2.2.5.1 of the Site Characterization Program Baseline (SCPB). The diffusion tests in the ESF will be conducted in: 1) the bedded tuff between the Tiva Canyon and the Topopah Spring Member, 2) the Topopah Spring Member, and 3) the Calico Hills unit. These tests will determine *in situ* the extent to which tracers diffuse into the Yucca Mountain tuffs penetrated by the ESF. Tracers will be introduced into boreholes in the tuffs and permitted to diffuse. The emplacement locations will be overcored and tracer concentrations will be measured as a function of the distance from emplacement. The tracer concentration data will be used to obtain the effective diffusion coefficients of the tracers in the tuffs.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the diffusion tests in the ESF.

Performance Criteria

1a. The following alcoves must be provided for the diffusion tests: a) an alcove in the nonwelded bedded Paintbrush tuff unit below the Tiva, b) two alcoves in the Core Test Area of the MTL (Topopah Spring Main Test Level), and c) four alcoves in the Calico Hills component of the ESF (two in the zeolitic units and two in the vitric units).

1b. Alcoves must be able to accommodate the equipment required to conduct the diffusion tests, such as dry-drilling equipment to emplace boreholes vertically or subhorizontally, sample injection apparatus, and dry-overcoring equipment.

1c. Dry-drilling of boreholes and dry-overcoring is required for the success of the diffusion tests.

1d. Test parameters such as temperature, humidity, atmospheric pressure and packer performance must be collected by the Integrated Data System.

1e. Flexibility is required to find suitable locations for the diffusion tests to avoid highly fractured zones.

1f. Two boreholes (drilled vertically or subhorizontally) are required in each alcove to perform two diffusion tests of different time duration. Each borehole will be approximately 10cm in diameter for the upper 10m and about 4cm in diameter for the bottom 45cm. The 4cm diameter hole must be centered with respect to the 10cm diameter hole.

1g. Standard utilities are required for power, lighting, water,

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ventilation, compressed air, and communications.

1h. Access to the alcoves throughout the duration of the diffusion tests is required to allow accessibility to the test locations for overcoring equipment and personnel.

Constraints

A. The diffusion tests must be initiated four years prior to the completion of milestone R537 entitled "Significant Physical Processes Affecting Transport" being conducted under the Retardation Sensitivity Study (WBS 1.2.3.4.1.5.1).

B. The IDS must be in place before initiation of the diffusion tests.

C. No other activities may be conducted in the alcoves after the initiation of the diffusion tests; simulations will be utilized to specify standoff distances.

D. Dry-drilling of boreholes and dry-overcoring is required for the success of the diffusion tests; the introduction of substances that can interfere with the diffusion tests must be minimized during construction and drilling.

E. Location of diffusion tests must be surveyed and geologic mapping must be completed prior to test initiation.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

None Identified.

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Petrologic Stratigraphy of the Topopah Spring Member

Definition of Test

Studies of the petrologic stratigraphy of the Topopah Spring Member are discussed in Section 8.3.1.3.2.1.1 of the Site Characterization Program Baseline (SCPB). The goal of this activity is to determine the petrologic variability within the devitrified Topopah Spring Member at Yucca Mountain, and to define the stratigraphic and lateral distribution of this variability using samples taken from locations throughout the Topopah Spring member in the ESF. Studies of the distribution of phenocryst and rock matrix textures in this member have been shown to be useful for defining stratigraphic position. Mineralogic analysis will be conducted with X-ray diffraction. Chemical analyses will also be used to determine variability.

Functional Requirements

1. Provide the facility design and operational flexibility necessary to perform sampling for studies of petrologic Stratigraphy of the devitrified Topopah Spring Member.

Performance Criteria

1a. Samples will be collected from the rock exposures created by underground workings.

1b. It may be necessary to revisit and resample mapped workings after completion of excavation and construction.

1c. Any drilled sample will require hand-held drills only.

1d. Oriented samples may be required.

1e. Standard ESF power, lighting, water, ventilation, compressed air, and communications are adequate.

Constraints

A. Geologic mapping should be completed prior to sample collection, or sample collection may be done concurrently with geologic mapping.

B. Because of the small scale of sampling, this activity can proceed without impacting construction.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

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Section 2.3.1 Scientific Manpower/Schedule Information
Section 2.3.2 Laboratory/Office/Storage Space Requirements
Section 2.3.3 Electrical Power Requirements
Section 2.3.4 Water System Requirements
Section 2.3.5 Compressed Air System Requirements
Section 2.3.6 Common Sampling Design Requirements
Section 2.3.7 Communications System Requirements
Section 3.0 Integrated Data System

Assumptions

1. Sample collection from exposures will normally be accomplished by mapping geologists during the same time period as geologic mapping is performed.

2. Ability to revisit and resample mapped workings is assumed.

3. A common sampling and sample shipping program will be developed to accommodate the sampling needs of related activities.

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Mineral Distributions Between Host Rock And Accessible Environment

Definition of Test

Studies of mineral distributions between the host rock and the accessible environment are discussed in Section 8.3.1.3.2.1.2 of the Site Characterization Program Baseline (SCPB). This activity will provide a three-dimensional description of the distribution and abundances of minerals along potential flow paths between a potential repository and the accessible environment. Statistical evaluation of the three-dimensional distribution models will be part of this activity, to estimate natural variability and sample density requirements. Data collected by this activity are quantitative X-ray diffraction determinations of mineral abundances, X-ray fluorescence and/or other chemical methods to determine major and trace element abundances in bulk rock, and microbeam analysis of samples. Sampling density is dependent on statistical considerations, but also dependent on needs of other studies such as sorption (SCPB 8.3.1.3.4) and results of studies such as History of Mineralogic and Geochemical Alteration of Yucca Mountain (SCPB Section 8.3.1.3.2.2).

Functional Requirements

1. Provide the facility design and operational flexibility necessary to perform sampling for studies of mineral distributions between the host rock and the accessible environment.

Performance Criteria

1a. Samples will be collected from the rock exposures created by underground workings.

1b. It may be necessary to revisit and resample mapped workings after completion of excavation and construction.

1c. Any drilled sample will require hand-held drills only.

1d. Oriented samples may be required.

1e. Standard ESF power, lighting, water, ventilation, compressed air, and communications are adequate.

Constraints

A. Geologic mapping should be completed prior to sample collection, or sample collection may be done concurrently with geologic mapping.

B. Because of the small scale of sampling, this activity can proceed without impacting construction.

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Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

   Section 2.3.1 Scientific Manpower/Schedule Information
   Section 2.3.2 Laboratory/Office/Storage Space Requirements
   Section 2.3.3 Electrical Power Requirements
   Section 2.3.4 Water System Requirements
   Section 2.3.5 Compressed Air System Requirements
   Section 2.3.6 Common Sampling Design Requirements
   Section 2.3.7 Communications System Requirements
   Section 3.0 Integrated Data System

Assumptions

1. Sample collection from exposures will normally be accomplished by mapping geologists during the same time period as geologic mapping is performed.

2. Ability to revisit and resample mapped workings is assumed.

3. A common sampling and sample shipping program will be developed to accommodate the sampling needs of related activities.

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Fracture Mineralogy

Definition of Test

Fracture Mineralogy studies of the Exploratory Studies Facility (ESF) are discussed in Section 8.3.1.3.2.1.3 of the Site Characterization Program Baseline (SCPB). The fracture mineralogy studies will be conducted to determine the mineralogic variability in fractures and faults throughout the ESF. Coatings in fractures and faults will be examined using a binocular microscope, petrographic microscope, scanning electron microscope, x-ray diffraction, and electron microprobe. Other techniques such as neutron activation analysis and cathodoluminescence may be employed. Information obtained will be used in determining mineralogy along potential transport pathways for both sorption and hydrologic calculations, to assess health hazard potential of fibrous zeolites, and to establish limits on the time and condition of fracture mineral deposition.

Functional Requirements

1. Provide the facility design and operational flexibility necessary to perform the sampling for fracture mineralogy studies.

Performance Criteria

1a. Hand samples approximately 5x10-15cm and cores of up to 30cm length will be required along selected fractures and fault zones throughout the ESF (accesses, drifts, and available alcoves).

1b. Oriented samples may be required.

1c. Additional sampling (hand samples and/or short cores) of fractures or faults exposed in the walls or roof of accesses, drifts and alcoves may be required after construction and mapping are completed. This may be some years after completion of excavation and may require temporary removal of small areas of mesh.

1d. Standard ESF power, lighting, water, ventilation, compressed air, and communications will be adequate to perform sampling.

Constraints

A. Sampling will be done during or after geologic mapping.

B. Samples must be free of hydrochloric acid (HCl). Exposure of fracture to other materials that could be deposited on fracture surface should be minimized.

C. Sampling should not impact construction activities.

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Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. Sample collection from walls and roof (where required) will normally be accomplished by mapping geologists during the same time period as geologic mapping of the accesses, drifts and alcoves is performed.

2. Ability to revisit selected features after (possibly 1-2 years after) mapping and to collect samples (either hand samples or short core) tied to the survey and mapping is assumed.

3. A common sampling program and shipping procedure will be developed.

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History of Mineralogic and Geochemical Alteration of Yucca Mountain

Definition of Test

History of Mineralogic and Geochemical Alteration of Yucca Mountain studies in the Exploratory Studies Facility (ESF) are discussed in Section 8.3.1.3.2.2.1 of the Site Characterization Program Baseline (SCPB). This activity will include petrologic analysis of natural alteration features in the ESF wall rock. Mineralogic alteration products will be studied by petrographic microscope, scanning electron microscope, x-ray diffraction, electron microprobe, and other techniques. Ages of alteration events will be estimated by textural study, potassium-argon dating of clays and zeolites, electron spin resonance dating of quartz and calcite, or other techniques. Any alteration features encountered in the ESF wall rock may be sampled and studied as part of this activity. Natural gels (semiliquids) found in the ESF will also be sampled.

Functional Requirements

1. Provide the facility design and operational flexibility necessary to perform sampling for the studies of the History of Mineralogic and Geochemical Alteration of Yucca Mountain.

Performance Criteria

1a. Wall-rock samples will be collected by the Alteration History PI (or designee) from the north and south ramps, from the main Topopah Spring test level, from the drifts in the tuff of Calico Hills, and from any other drifts. A safe method of collecting and transporting samples to the surface will be provided.

1b. Small-scale hand drilling may be required to collect samples. No other drilling will be required.

1c. For the most part, this test can be conducted during facility construction without impact to construction activities. The activity will be conducted in two phases. An early phase of sampling and spot-detail mapping during construction will be followed by more sampling as needed. Accessibility for sampling on a long-term basis is desired. Gels must be sampled as soon as possible after exposure by excavation. If fault zones or other features requiring surface treatment for stabilization (e.g., shotcrete) are encountered during excavation, then the ability to examine them before they are covered is desired, provided that safety considerations permit.

1d. Standard requirements for power, lighting, water, ventilation, compressed air, and communications are adequate.

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Constraints

A. Sample collection for this test will generally follow the geologic mapping test.

B. There are no expected standoff requirements for this test because wall-rock sampling can be accomplished before most other tests begin. Sampling activities for this test are not expected to interfere with other tests.

C. Procedures for sample collection and control will be developed by the PI with consultation from the constructor and the geologic-mapping activity personnel.

D. The gel-collection part of this test requires integration with the perched-water test and the geologic-mapping test.

E. Sampling should not be done in locations where chemicals have already been deliberately or accidentally applied to rock surfaces during other tests.

F. Samples will generally be 1 to 5kg and will be separated from the excavation walls by hammer and chisel if possible.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. Geologic mapping test will provide copies of wall maps/photos, adequate to function as general guide to mapped units, to PI of Alteration History activity in a timely manner.

2. Alteration History wall-rock sampling will not be part of a common sampling program, but will share some procedures with the common sampling program and may participate on a special-case basis, as for gel collection.

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3. Geologic mapping test will establish a sample location coordinate system for use by Alteration History test.

4. On-site storage facility for rock samples and a means to transport rock samples from the underground to the surface will be available.

5. Locations where chemicals have been deliberately or accidentally applied to wall-rock surfaces will be tagged, labelled, and recorded to prevent inadvertent sampling.

6. Prior notification will be given regarding experiments that will involve introduction of chemicals into the wall-rock so that any necessary sampling can be completed before the experiments begin.

7. Apparatus for access to upper walls and ceiling of excavations will be available on a part-time basis.

8. Small portions of the excavation that have been covered with shotcrete or wire mesh may be re-exposed if this study requires examination or sampling of important features.

9. Apparatus for measuring sampling orientation will be available on a part-time basis.

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Biological Sorption and Transport

Definition of Test

Biological Sorption and Transport is discussed in Section 8.3.1.3.4.2 of the Site Characterization Program Baseline (SCPB). This activity involves determining the effects of microorganisms on the transport (either positive or negative) of radionuclides to the accessible environment. This study will determine the numbers, types, and metabolic activities of microorganisms present in Yucca Mountain. Samples from various locations through the Exploratory Studies Facility (ESF) will be collected, packaged, and labelled for laboratory analysis.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Biological Sorption and Transport test.

Performance Criteria

1a. Must have the ability to collect aseptically a minimum of 1.0kg of pristine sample.

1b. Must have the ability to collect samples in line with construction, either by core, as rubble from drill and blast, or small scale hand drilling.

1c. Must have the ability to collect samples throughout the facility within all units and at contacts.

1d. If coring is required to collect samples, coring must be conducted dry.

1e. If coring is required to collect samples, the depth of the core shall be sufficient to ensure pristine samples, and to avoid interference from contaminants which may be introduced by excavation or other activities. Contaminants of concern include water and drilling fluids.

1f. Provision of standard ESF utilities (power, lighting, water, compressed air, communication, ventilation, etc.) will be adequate.

1g. Because sample integrity is the utmost requirement, samples will be collected immediately following the tunnel boring machine (TBM). Sample collection will not impact the progress of the TBM.

1h. Long-term accessibility will be required.

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Constraints

A. Sampling from documented locations will follow completion of geologic mapping activities.

B. Sampling can be conducted during facility construction (during the time that mapping is following the TBM) without impact to construction activities.

C. No water will be used in the immediate vicinity of any sampling location.

D. Any drilling used to obtain samples will be done dry.

E. All samples will be taken either by the principal investigator (PI) or by a personnel trained by the PI.

F. No IDS interface is required.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. A common sampling program for the ESF will be available. Components of this program will include provisions for locations of samples following criteria supplied by the principal investigator, sample labeling, the potential for co-utilization of samples, and short-term storage facility for samples.

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Field-Scale Experiments to Study Radionuclide Transport at Yucca Mountain

Definition of Test

The Field-Scale Experiments to Study Radionuclide Transport at Yucca Mountain is discussed in Section 8.3.1.3.7.2.2 of the Site Characterization Program Baseline (SCPB).

This study will provide data to validate laboratory estimated parameters and models for radionuclide transport calculations at Yucca Mountain. The tests will be conducted in the Calico Hills unit. Dual breakout rooms will be required for these tests. The upper room is where sampling instruments and equipment to apply water and tracers to the test block will be located. Access will need to be maintained to this room in order to service equipment and make measurements. The lower alcove will provide information on the nature of the water and tracer breakthrough relative to the total area of the alcove, and serve as a sump to collect water for removal from the Exploratory Studies Facility (ESF). During room excavation, samples will be collected from the alcove area for laboratory characterization of hydrologic and chemical properties.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Field Scale Experiments to Study Radionuclide Transport in the Exploratory Studies Facility (ESF).

Performance Criteria

1a. A total of eight sites will be selected for tests. Two tests will be conducted in each of the following geologic units: zeolitic unit of the Calico Hills, vitric unit of the Calico Hills, the vitric/zeolitic interface in the Calico Hills, and the Topopah Spring/Calico Hills contact.

(i). Each test location has the following configuration. There will be two alcoves designated upper and lower separated by the test block. The upper alcove will be constructed off the ESF drift at a location designated by the principal investigator.

(ii). Preliminary dimensions for the plan view of the upper alcove have been determined to be 10m x 10m. These dimensions are based on the experimental plan.

(iii). The height for the upper alcove must be as small as possible for environmental control but the height should be sufficient to allow drilling equipment to be used.

(iv). Access to the upper alcove should be as small as possible to allow for a controlled environment, but sufficient access must be maintained for drilling equipment.

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(v). The lower alcove will be approximately 10m beneath the upper alcove. The plan view dimensions of the lower alcove will be the same as the dimensions used for the upper alcove.

(vi). The lower alcove will be constructed after the upper alcove. Possible construction timing for the lower alcove is 1 to 10 years after the test at that location has been initiated.

(vii). The lower alcove will not have a controlled environment. Access to the lower alcove should permit equipment required to support the roof of the lower alcove and equipment that may be needed to mine the test block between the upper and lower alcoves.

(viii). All drilling will be conducted and all sampling equipment, water and tracer distribution system, and instrumentation will be placed in the upper alcove.

1b. All drilling will be vertically downward through the floor of the upper alcove. Drilling must be done dry. The approximate borehole diameter is 5 - 7.5cm. All holes must be cored.

1c. An Integrated Data System (IDS) interface is required. The IDS interface should be located to minimize access to the upper alcove during servicing of the IDS.

1d. The upper alcove for those tests conducted at the contacts between the Topopah Spring/Calico Hills units and the vitric/zeolitic Calico Hills units is to be located 5m above the contact, and the lower alcove will be located below the contact. There are no flexibility requirements for those tests located in the vitric and zeolitic Calico Hills units.

1e. Standard ESF utilities for power, lighting, water, compressed air and communications is adequate.

1f. Once tests are initiated continuous access to the upper alcove must be assured. If lower alcove is deferred, then access to the lower alcove must be provided during construction.

Constraints

A. Samples will be collected from the upper alcove for hydrologic and chemical characterization. Geologic mapping of the floor of the upper alcove is required.

B. Each test is expected to last from 1 to 10 years, and because these tests support the resolution of Issue 1.1, these tests should be initiated whenever construction permits.

C. The IDS and IDS interface must be available prior to test initiation.

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D (i). These tests will introduce water so locations should be off the potential repository block.

(ii). Alcoves should be located away from ramps/shafts a sufficient distance to avoid excavation effects on the test block.

(iii). A distance of 10m is proposed as a preliminary standoff for locating other tests in relation to this test. This estimate will be refined by calculations and this requirement updated.

(iv). Once the test has been initiated no other activities will be permitted in the upper alcove.

(v). There are no additional requirements for the lower alcove.

E (i). All drilling and excavation should be conducted dry.

(ii). Efforts are needed to minimize the introduction of fluids and materials during construction.

(iii). Rock bolts will not be used for roof support of the lower alcove.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. There will be no organizational computer. The IDS will provide primary data collection.

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Underground Geologic Mapping

Definition of Test

Geologic Mapping of the Exploratory Shaft and Drifts Test is discussed in Section 8.3.1.4.2.2.4 of the Site Characterization Program Baseline (SCPB). Geologic mapping and photogrammetry will be used to document lithologic and fracture variability throughout the vertical and horizontal extent of the underground excavations, to investigate structural features, and to provide siting data to confirm (or modify) planned test locations within the underground excavations. Geologists will take stereo-photographs of exposed rock surfaces of all openings in the ESF. These photographs will be analyzed off-site using a computer-driven analytical plotter. Detail line surveys will be performed continuously along one wall of each drift or ramp (or at 2m intervals if in a shaft).

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Underground Geologic Mapping Test.

Performance Criteria

1a. The test organization will map all ESF excavations, on a daily basis, usually mapping the extent of daily progress, up to an expected maximum of 75m in TBM drifts. Mapping will generally be done prior to installation of any chain-link, mesh, or shotcrete. Where ground conditions require fabric or shotcrete, the excavation and mapping sequence will need to be modified to permit mapping near the heading.

In roadheader and/or mobile miner excavations, mapping will be done as near the heading as possible. The machines will need to pull back from the face while mapping is being done.

If a shaft is excavated as part of the ESF, mapping will be either from the bottom deck of the galloway (if drill/blast) or from platform designed for the purpose of mapping (machine excavation). In both cases, the walls must be mapped prior to any wire mesh, shotcrete, or permanent utilities are installed.

1b. Survey accuracy for the Underground Geologic Mapping Test shall be ± 1cm for the benchmarks. The ability should be retained to resurvey and upgrade the initial mapping survey and reference points.

1c. A securable, underground space of about 5 X 6m with a height at least 2.5m is required for storage of mapping equipment. If the North and South ramps are developed separately, a storage room is required in each one.

1d. A geological storage and staging trailer or building of at least 18 m^2 (200-sq-ft) area shall be provided at the ESF surface facility in Midway Valley. This building shall be equipped with heating, air

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conditioning, electricity, running water at a sink, smoke detectors, first aid kit, and shelving.

1e. If the optional shaft is required, the shaft sinking galloway must be provided with equipment to assure a stable platform for photography. In drifts other than those excavated by full-face tunnel boring machine, a collapsible platform must be provided to allow geologists access to all surfaces of the excavations.

1f. The construction contractor will clean the walls using compressed air/water following procedures developed during prototype testing.

1g. A light-tight photography laboratory (in a trailer or building) approximately 2.5m by 4m (8 ft by 14 ft, with a minimum of 100 sq ft) shall be provided at the ESF surface facility, adjacent to or in the geological storage and staging trailer or building. This laboratory shall be equipped with heating, air conditioning, and the following: (1) sink with hot and cold running water and (2) two 110-V, 20-A circuits and one 220-V, 30-A circuit.

Constraints

A. In TBM drifts and ramps, a distance of at least 75m must be left directly behind the trailing gear, where utilities are confined to one quadrant of the circumference of the excavation. This confinement is necessary to allow unobstructed view of as much of the exposed rock as possible for photogrammetric mapping.

In roadheader/mobile miner drifts, utilities (including permanent fan line) must not be installed until an area has been mapped and photographed. Generally, mapping will keep up with the daily excavation progress.

B. Ground support in the form of rock bolts and anchors may be installed as near the working face as necessary without detriment to mapping. The installation of chain-link fabric, wire mesh, or application of shotcrete may not take place until mapping is completed.

C. Mapping in the TBM drifts will require construction of a mapping platform which will allow access to all portions of the crown and walls for sampling and detailed mapping. The platform may also be used for installation of ground support, surveying, installation of utilities, etc., as long as these operations are coordinated with the mapping effort.

Mapping in the roadheader/mobile miner drifts may be done from a collapsible platform (i.e. scissor lift).

D. During drift wall mapping, all unnecessary equipment will be removed from the section of the drift being mapped.

E. If a shaft is constructed as part of the ESF, provision must be made to allow unobstructed mapping of the shaft walls prior to the installation

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of wire mesh, shotcrete, or permanent utilities. Specific requirements will depend on the excavation method (machine vs. drill-blast).

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communication System Requirements
Section 3.0	Integrated Data System

2. If required, the shaft sinking equipment must accommodate the shaft mapping equipment.

Assumptions

1. Mapping equipment will be provided by the testing organization. This includes strobe lighting for stereophotography, pyramid beam splitter (for deflecting the laser and setting survey control points), and sampling equipment for hand and block samples.

2. The excavation contractor will provide a miner for cleaning of the excavation walls, moving the mapping platform, hooking up utilities, and assistance in sample acquisition and handling.

3. Shaft and drift mapping will be sequenced with construction to minimize interference with construction progress. In the TBM ramps, where advance rates may approach 75m/day, we expect that mapping may require 2 shifts on a daily basis to keep up with excavation. This arrangement will require mapping and mining concurrently.

4. In general, hand sampling of exposed rock by geologists will be performed during the period that mapping is being done.

5. Voice communications from the surface will be provided to a station near each heading during mapping.

6. Office and laboratory space will be provided at the Field Operations Center Building and the Technical Services Building in Area 25.

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Seismic Tomography/Vertical Seismic Profiling at the Exploratory Studies Facility

Definition of Test

The Seismic Tomography/Vertical Seismic Profiling test is discussed in Section 8.3.1.4.2.2.5 of the Site Characterization Program Baseline (SCPB). The purpose of these tests is to apply seismic imaging methods (cross hole, cross drift, cross ramp, surface to subsurface, and Vertical Seismic Profiling (VSP)) to provide a means for detecting and characterizing the subsurface fault and fracture patterns, lithologic features, and zones of perched water in regions between and ahead of tunnels, drifts, ramps, boreholes, and between the surface and subsurface workings. Another purpose is to characterize and quantify the damage associated with tunneling activities as a function of space and time through high resolution seismic imaging. Thirdly, passive seismic monitoring will be used to provide data to predict ground motion and its effects on repository integrity from near by seismic events that may cause strong ground motion. The results of this work will be used to calibrate and relate the seismic characteristics of the host rock to the fracture patterns and lithology observed directly in the underground workings, and to select and define structural, lithologic, and fracture domains with similar properties within the ESF for future application over the entire potential repository. Successful seismic results will provide constraints for the 3-D rock properties models of the potential repository volume at a variety of scales. This work will also provide baseline measurements for performance confirmation and post closure studies. The tests will be performed in a staged manner to assess their applicability and functionality for the stated purpose.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Seismic Tomography/Vertical Seismic Profiling tests.

Performance Criteria

1a. There are no alcoves or dedicated rooms required for these tests. The work will be performed in, and from the presently available underground workings on a non-interference basis with the other work. The exception will be space required for the strong motion monitors. These can be located in any out of the way area near the designated zone of monitoring. Approximately one cubic meter of space will be necessary for each strong motion instrument. A maximum of ten are envisioned for the entire ESF.

1b. Two shallow, parallel, 85 to 90mm diameter drill holes (5 meters deep, 2 meters apart) with a three degree dip will be required for the damage zone. These can be either air or water drilled, water is the preferred method but air drilling will be acceptable. Ideally, boreholes will be filled with fluid during the survey, but dry boreholes can also be used. Other drill holes may be necessary in zones of loose rock to emplace a sensor, but these can be hand drilled using a hand-held drill. Open boreholes drilled for other tests can

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also be used for this activity, dedicated boreholes are not necessary. For the larger scale borehole to borehole, or drift to borehole work, any horizontal or near horizontal borehole can be used for this purpose as long as it is at least 85mm in diameter. It may be necessary to drill horizontal holes (water drilled, but air is also acceptable) to map fracture or fault zones of interest that have been identified by the cross drift, the surface to drift seismic or VSP surveys.

1c. The investigator's office responsible for this test will supply all data collection equipment for this work. All equipment is temporary and will not need IDS. The exception is that the strong motion recorders will be connected to IDS.

1d. The seismic imaging tests will be used at several different scales, meter size, 10's of meters, and 100's of meters. The meter size tests will be used to infer the damage zone associated with the tunneling and mining activities. These tests will be performed at various locations along the ramps where perched water zones, significant fracturing, and lithologic changes are encountered. Therefore these tests will not be at equal spacing. The number and location will be dictated to a large degree by the geology and structure encountered in the subsurface workings. Other tests will be run between relatively larger spaced bore-holes (and tunnel to borehole, tunnel to tunnel, surface to tunnel, etc.) than for the damage zone studies. The spacing of the boreholes will depend upon the feature being mapped but typical spacing of the boreholes will most likely be on the order of 50 to 100 meters apart. The 100's of meter scale tests will be carried out between the drifts to map the location and characteristics of the features in and around the emplacement drifts that may affect potential repository integrity and ground water travel time from the surface all the way to the Calico Hills workings.

1e. The general test configuration is placing a seismic source in one location and recording the seismic energy from this source at another location. This may be in a borehole to borehole, mine working to borehole, surface to borehole, surface to mine working, or mine working to mine working, or any combination there of.

1f. No special utility requirements beyond the already planned power, air, and water services will be needed for this test.

1g. Access will be needed in the drifts and tunnels to emplace the instrumentation. But once in place access is not needed to the sensors. The source will be moving every few minutes (or less) in boreholes or the tunnels. In all of the subsurface activities (all activities are considered primarily subsurface except VSP and the surface to tunnel imaging) space is required along the tunnel walls to attach a seismic sensor, 0.5 square meter, at the above specified scales, and room enough for the associated cabling running to a portable central recording system. The central recording system can be located in a small alcove on a table top of a few square meters. The seismic source will be moved along the tunnels and ramps and only access to the tunnel floor or wall is necessary at five or ten meter intervals. Only the strong motion recording devices are permanent,

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all other equipment will be removed after each survey. Approximately one cubic meter of space is needed for each strong motion accelerometer and associated electronics. Once installed access is required only to replace faulty equipment

Constraints

A. The sequence of the tests will largely depend upon the sequence of the tunneling activities, but the overall sequence is to carry out the VSP work before tunneling begins in order to map large scale features, obtain data for designing future seismic tests, and to provide input relating to variation in the general rock properties at Yucca Mountain for the site scale modeling activities. The next tests will be the damage zone studies which will be carried out as soon as there is access to the tunnel walls. These tests will be repeated periodically to examine damage zone growth as a function of time. The cross hole, surface to ramp, ramp to ramp, etc., class of studies will be carried out as boreholes become available and as the need to map critical features away from the workings are encountered as the excavation activities proceed. The schedule will also be driven by the success of the technique and its ability to provide input to the 3-D rock characteristics models.

B. The only permanent cable will be a twisted pair from each strong motion device to the surface recording, it is assumed IDS will provide this capability. Recording data from the strong motion devices will only be done when a strong earthquake or Underground Nuclear Explosion (UNE) occurs. No other IDS requirements are needed.

C. These tests are not anticipated to interfere with other activities. The drill holes used for this work should be in competent rock.

D. The only significant constraint is that the best seismic data are collected in conditions where there is small vibration noise. In most cases this will not be a problem because the frequency band of interest will not be in the cultural noise band. However, in the cases where it is not, then the work can be scheduled during quiet times at night, off shift, or during down time for other experiments when mining activities are low. The survey setup can be done at any time.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1 Scientific Manpower/Schedule Information
Section 2.3.2 Laboratory/Office/Storage Space Requirements
Section 2.3.3 Electrical Power Requirements
Section 2.3.4 Water System Requirements
Section 2.3.5 Compressed Air System Requirements
Section 2.3.6 Common Sampling Design Requirements
Section 2.3.7 Communications System Requirements
Section 3.0 Integrated Data System

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Assumptions

1. Geophones, analog cables, connections, energy source, and recording and storing equipment will be furnished by the office of the scientist in charge.

2. It is anticipated that the geophone installation for each of the tests will require 2 shifts (probably 2 days).

3. Each measurement will take approximately 30 seconds after the source, receivers, and recorder are in place. Depending upon signal-to-noise ratio, there could be as many as 50 measurements taken in succession at each source site.

4. Once the geophones are installed in a tunnel or drift, it is anticipated that a 5- to 10-hour time period will be required to collect data.

5. Storage space will not be required at the ESF. The minimal office and storage space needed for these tests will be provided by the Underground Geologic Mapping Group.

6. Geophones will be clamped into the holes during the periods of seismic measurements. In the drifts, geophones will be attached to the walls directly by clamping to plates installed at 5m intervals (± 0.3 m).

7. Geophones will be secured (without grout) by the seismic-test team in such a way that signals from each phone can be transmitted separately to the recording equipment via an instrumentation link via an analog cable. The analog cable will be installed after completion of the geophone installation. The instrumentation cable will connect all geophones so that the signals from all phones can be recorded simultaneously. This cable is connected to the geophone cables via "takeouts."

8. At the completion of the data collection from each test, all geophones and portable recording equipment will be removed.

9. The IDS will not be used in these tests. The seismic data will be recorded on an industry standard (SEFY or SEGB) recording device.

10. Water is not required for these tests, but a small amount of traced water used in each hole will aid in tamping material to secure the geophone.

11. Compressed air may be required to blow out the holes prior to the installation of geophones.

12. The in-tunnel cable will be "Seiscord" brand or equivalent. This cord has 128 pairs of wire in a cable 0.845 inch diameter and a weight of 357#/MFT.

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13. Where geophones attach to the in-tunnel cable, the diameter of the junction will expand the cable diameter to about 2 inches for a length of about 2 feet. If the cable is placed in a conduit, access for junctions must be provided at each measurement station.

14. This test is a short duration test, and the PI requests that the cable may be better accessed if it is not placed in a conduit. The cable can be removed after the test is complete (reference assumption #8).

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Laboratory Tests (Thermal & Mechanical) Using Samples Obtained from the Exploratory Studies Facility

Definition of Test

The laboratory tests (thermal and mechanical) using samples obtained from the ESF are discussed in Section 8.3.1.15.1 of the Site Characterization Program Baseline (SCPB).

The laboratory geoengineering properties test will provide bulk, thermal and mechanical properties data for evaluations of opening stability and related design and performance studies and/or modeling. Data from the laboratory test will also support analyses of the geomechanical and thermomechanical field tests planned in the Exploratory Studies Facility (ESF). For this test, the ESF activities consist of the collection, packaging, and labeling of the selected bulk samples or core taken from the ramps, drifts, or shafts. The laboratory test activities are described individually in SCPB Section 8.3.1.15.1.

Functional Requirements

1. Provide the operational flexibility to perform the sample collection.

Performance Criteria

1a. No special room or alcove is required. The tests entail sampling throughout the ESF, in each of the thermomechanical units encountered, with an emphasis in the TSw2.

1b. No need for data collection by the Integrated Data System has been identified.

1c. No flexibility requirements for test location or orientation have yet been identified.

1d. Standard underground facilities for water, air, and electricity for drilling will be used for this test. Capability should exist to extract cores of various sizes up to 15 inches in diameter, to collect samples and to transport them to the surface for shipment to laboratories.

1e. Access to locations throughout the ESF will be required in order to take samples.

Constraints

A. This test can be scheduled independently of the scheduling of the other tests.

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B. Test preparation can be performed at any time after the test location is exposed. The use of underground resources (men and equipment) will be based on scheduled availability and preferably coincide with scheduled TBM shut down. Slow down of excavation progress will be avoided. Construction progress impact (far behind face) will be limited to minor interference with support forces (maintenance crews, ramp transportation vehicles, priority testing support, etc.)

C. No interference envelope exists. Samples should be taken from rock that has not been disturbed by excavation or other testing. Dry coring may be required in some cases.

D. No other constraints or controls have been yet identified for this test.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

   Section 2.3.1 Scientific Manpower/Schedule Information
   Section 2.3.2 Laboratory/Office/Storage Space Requirements
   Section 2.3.3 Electrical Power Requirements
   Section 2.3.4 Water System Requirements
   Section 2.3.5 Compressed Air System Requirements
   Section 2.3.6 Common Sampling Design Requirements
   Section 2.3.7 Communications System Requirements
   Section 3.0 Integrated Data System

2. Detailed interface requirements will be identified and documented through the normal change control process.

Assumptions

1. Samples collected as described in the mineralogy and petrology sampling tests (Sections 2.2.14-17) will be divided at the SMF to supply samples for this testing.

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Access Convergence Measurements

Definition of Test

The Access Convergence Measurements test is discussed in Section 8.3.1.15.1.5.1 of the Site Characterization Program Baseline (SCPB).

Access convergence tests are required to monitor rock-mass deformation around the accesses and measure in situ stress at the stations where convergence is being measured.

Rock-mass deformation around the access will be monitored at measurement stations using multiple-point borehole extensometers (MPBXs) placed at 120 degree intervals around the opening. The MPBXs primarily consist of anchors installed at predesigned depths. Movement in the rock mass is recorded as the anchors move. Deformations will be measured across the ramp diameter and as a function of distance from the access portal at multiple locations in the access using rod extensometers. Extensometer measurements will be made along diameters in the same plane as the MPBXs at 60 degrees from the MPBX heads. Stress meters will be used at stations located near faults.

If a liner is used at the portals, the portal stations will also include hydraulic pressure cells in the liner to measure radial and hoop stress changes over time as construction continues beyond the test location.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Access Convergence Test.

Performance Criteria

1a. No special room or alcove is needed.

The tests will be located in each thermomechanical unit encountered (one in each unit), preferably more than 100 meters from major thermomechanical contacts and faults. Additional stations may be installed near major structural features. The tests will be performed in both ramps, in order to investigate the different faults that will be encountered and to study the effect of spatial separation. Stress meters will be installed about the faults that are encountered. At a minimum, the tests should be performed within the TSw1, TSw2, Tsw3, and in the different thermomechanical units in the ramps to the Calico Hills. Testing will be performed in the ramps to the Calico Hills in order to validate that the openings will remain stable throughout the testing period in that region.

1b. The test will require drilling holes approximately 15m long, of sufficient diameter to install the MPBXs, and shallow holes to install anchors for the extensometer measurements.

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1c. It is preferable that the tests be more than 400 meters from major thermomechanical contacts and faults. Additional stations may be installed near major structural features. Stress meters will be installed about faults that are encountered.

1d. Each access convergence measurement station will consist of two sets on instruments installed in adjacent planes, separated by approximately 1m.

1e. Standard underground facilities for water, air and electricity for drilling will be used for this test. Access to the back (roof) will be required. An uninterrupted power supply (UPS) for the Integrated Data System will be needed.

1f. Access to the measurement stations will be needed during the test period. It is necessary to maintain access to the monitoring stations over a period of years.

Constraints

A. This test can be scheduled independently of the scheduling of other tests.

B. The very early time access convergence occurring immediately after excavation will not be measured. Instead, the long term opening stability will be monitored. It is not necessary that the stations be instrumented immediately after the face has been exposed, but test instrumentation should be installed as close to the working face as possible without impacting the progress of the excavation. The use of underground resources (men and equipment) will be based on scheduled availability and preferably coincide with scheduled TBM shut down. Slow down of excavation progress will be avoided. Construction impact will be limited to minor interference with support forces (maintenance crews, ramp transportation vehicles, priority testing, etc.).

C. Provision for data collection by the IDS must exist prior to the beginning of the test.

D. The tests will sense rock mass displacements on a line approximately 15 meters from and perpendicular to the drift wall, floor, and ceiling. Other tests, which in any way affect the thermomechanical response in this region, should be avoided.

E. No constraint on construction is imposed by this test. The purpose of the test is to obtain deformation, in situ stress, and the stress change due to excavation activities. No drilling will be allowed near the MPBX and the pressure cell stations.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

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Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communication Systems Requirements
Section 3.0	Integrated Data System

Assumptions

1. None.

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Demonstration Breakout Room

Definition of Test

The Upper Demonstration Breakout Room (UDBR) Test is discussed in Section 8.3.1.15.1.5.2 of the Site Characterization Program Baseline (SCPB).

This test will be used to demonstrate constructability and stability of underground openings in the high lithophysal zone of the Topopah Spring member. A lower demonstration breakout room in welded fractured tuff (TSw2) on the Main Test Level is not necessary because of the experience that will be gained in building the ESF.

Functional Requirement

1. Provide the facility design and operational flexibility to perform the Upper Demonstration Breakout Room test.

Performance Criteria

1a. The test itself includes excavating a separate room off the main access. The size and cross-section of the UDBR opening will be consistent with the maximum width planned for potential repository openings. The excavation techniques to be used for the UDBR should be similar to the excavation techniques to be used for potential repository openings. This test will evaluate excavation techniques and rock support requirements. Rock mass response will also be measured in the UDBR excavations by using extensometers and convergence measurements.

The test will be located in the high lithophysal zone of the TSw1 encountered in the North Ramp. The exact location and orientation will be determined at the time the test is initiated.

1b. The test will require drilling holes 15m in length and of sufficient diameter to accommodate the MPBXs, and shallow holes to accommodate the anchors for the extensometer measurements.

1c. The instrument heads (MPBX and convergence anchors) will be placed in a recess at the walls of the excavation.

1d. Flexibility in the orientation of the room is required to ensure that desired alignment relative to local geological features, such as the prevailing joint structure, is achieved.

1e. The layout and dimensions of the demonstration breakout room are TBD.

1f. Standard underground facilities for water, air, and electricity for drilling will be used for this test. An uninterrupted power supply (UPS) for the Integrated Data System will be needed.

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1g. It will be necessary to access the Upper Demonstration Breakout Room while it is being constructed.

Constraints

A. The Heater Experiment in TSw1 (SCPB Section 8.3.1.15.1.6.1) will take place in the UDBR and therefore the UDBR must be constructed before the Heater Experiment in TSw1 can be performed.

B. The test should be performed (the excavation of the UDBR) before non-TBM excavations are performed on the Main Test Level. This test is to be used as a prototype for non-TBM excavations.

The test instruments and anchors must be installed as close to the working face as practical. It is preferable that these be installed within one meter of the face, and that time be allotted for these anchors to be set before excavation continues.

C. Provision for data collection by the IDS must exist prior to the beginning of the test.

D. The test will sense rock mass displacements on a line approximately 15 meters from and perpendicular to the drift wall, floor, and ceiling. Tests which in any way affect the thermomechanical response in this region should be avoided until baseline data are gathered.

E. No other excavation should be performed within a distance of approximately 15m from the deepest multi-point borehole extensometer installed in the walls of the opening while the test is in progress.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The UDBR will be used for the Heater Experiment in TSw1 (SCPB Section 8.3.1.15.1.6.1).

2. The UDBR will be used to carry out other testing; it will therefore not be put to other facility uses such as storage.

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Sequential Drift Mining

Definition of Test

The Sequential Drift Mining test is discussed in Section 8.3.1.15.1.5.3 of the Site Characterization Program Baseline (SCPB).

The purpose of this activity is to measure the deformational response of a repository size opening as the opening is being excavated. This is accomplished by installing instruments from adjacent drifts into a rock mass and subsequently excavating the instrumented rock mass.

Instruments installed in boreholes will monitor stress change caused by excavation. Tests of bulk permeability changes will be conducted and deformation will be measured. To measure rock mass response to excavation, data will be obtained before excavation of the center parallel drift. Air and water permeability in boreholes adjacent to the new drift opening will be measured after excavation.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Sequential Drift Mining Test.

Performance Criteria

1a. Two parallel drifts approximately 4.3m high, 4.9m wide and 55m long are required to install the instruments. Center-to-center distance between the two drifts should be 34m. After the instruments have been installed, a central drift 55m long with the same cross-sectional dimensions as those expected for potential repository emplacement drifts will be excavated using the same technique that is expected to be used to excavate the potential repository.

The test will be performed in the Core Test Area of the Topopah Spring Main Test Level.

1b. The test will require drilling holes for MPBXs, borehole deflectometers, borehole permeability measurements, borehole stressmeters, and anchors for the extensometer measurements. The longest hole will be approximately 15m.

1c. A 3m by 4.6m alcove, located off one of the instrumented drifts, should be provided for the Integrated Data System. The center pillar between the instrument drifts must not be affected by this alcove.

1d. The orientation of the rooms is to be decided. Flexibility regarding drift orientation is needed so that the room orientation will match the orientation to be used in the potential repository. The decision on orientation will be based upon early test data.

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1e. The cross-sections, dimensions, and test layout are TBD.

1f. Standard underground facilities for water, air, and electricity for drilling will be used for this test. An uninterrupted power supply for the Integrated Data System will be needed.

1g. Test instrumentation must be accessible during the test.

Constraints

A. It is expected that the Heated Room Test will also be conducted in these drifts. Therefore early construction is required to assure that the Heated Room Test can be started early enough to allow data to be collected for the License Application. It is estimated that one year will elapse between the Sequential Drift Mining test and the beginning of the Heated Room Test.

B. This is the first major test that should be performed in the Core Test Area of the Main Test Level in order to minimize effects of rock disturbance from unrelated excavations. The test should be performed as soon as two means of egress exist. This test will take place near the time of the mining of the exploratory drift to the imbricate faults. It is anticipated that instrumentation holes in the outer drifts will be drilled as soon as practical behind the excavation machine.

C. The Integrated Data System must be available when the test begins.

D. No excavation, except to excavate the central drift, should be allowed within 15m of any multi-point borehole extensometer (MPBX) anchor until MPBX measurements are no longer being taken. Since MPBX anchors can be 15m from the central drift rib, this effectively excludes a region 30m from the central drift ribs. No other drifts should be mined within two drift diameters of the outside ribs of the instrumentation drifts.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1 Scientific Manpower/Schedule Information
Section 2.3.2 Laboratory/Office/Storage Space Requirements
Section 2.3.3 Electrical Power Requirements
Section 2.3.4 Water System Requirements
Section 2.3.5 Compressed Air System Requirements
Section 2.3.6 Common Sampling Design Requirements
Section 2.3.7 Communications System Requirements
Section 3.0 Integrated Data System

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Assumptions

1. **The test alcove and the test instruments installed from the adjacent drifts from the Sequential Drift Mining experiment will also be used for the Heated Room Test (SCPB 8.3.1.15.1.6.5).**

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Heater Experiment in TSw1

Definition of Test

The TSw1 heater test is discussed in Section 8.3.1.15.1.6.1 of the Site Characterization Program Baseline (SCPB).

The Heater Experiment in TSw1 will monitor thermomechanical and hydrothermal response in the potential repository host rock for design and performance modeling, for assessment of retrievability, and for monitoring radon emanation as a function of heating. During the tests, heat fluxes will be increased so that the temperatures near the heater will exceed design limits, to aid in determining limits on waste-emplacement borehole stability.

At a location within the Upper Demonstration Breakout Room (UDBR), a vertical heater hole and parallel small-diameter instrumentation holes will be drilled. A small instrumentation decline will also be constructed to provide radial access to the heater. Baseline moisture data in neutron probe holes will be recorded. A heater and instrumentation (thermocouples, multi-point borehole extensometers, borehole deformation gages, and radon monitors) will be installed. Finally, heating in incremented steps will be initiated, and thermal, thermomechanical, and hydrothermal phenomena, and radon release rates, will be monitored at increasing heat loads.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the TSw1 Heater Test.

Performance Criteria

1a. The test will be conducted in the TSw1 unit within the UDBR, away from contacts and faults.

1b. The test will require drilling a vertical hole for the heater canister and horizontal and vertical holes for test instrumentation (thermocouples, MPBXs, borehole deformation gages, neutron probes, moisture sensing gages, and radon monitoring gages). The drilled holes may be as long as 15m, in order to install the MPBXs. The radon monitoring holes will have the largest diameter of the instrument holes, at this time estimated to be 160mm. The canister heater hole will be approximately 740mm in diameter.

1c. Provision for the Integrated Data System must be available prior to beginning the test.

1d. The instrument heads will be placed in a recess at the walls of the excavation.

1e. A small decline approximately 10m from the heater hole will be required to install instruments on a radial line from the heater.

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1f. Flexibility is required to ensure that the test is located away from contacts and faults. The exact test location will be based, in part, on the results of mapping and other observations after the UDBR has been constructed.

1g. Layout, dimensions, and configuration of test instrumentation are TBD.

1h. Standard underground facilities for water, air, and electricity for drilling will be used for this test. An uninterrupted power supply for the heater and the Integrated Data System will be needed.

1i. Accessibility to the test is required during its duration.

Constraints

A. This test can only be performed after the Upper Demonstration Room (SCPB 8.3.1.15.1.5.2) is constructed.

B. The test will help assess the viability of storing waste in, or in the vicinity of, the high lithophysal zones of the Topopah Spring member. The test should begin 36 months before license application. Except for this condition, the test can be scheduled as convenient.

C. Provision for data collection by the Integrated Data System must exist before this test can start.

D. To limit the influence of drift openings on the stresses near the heater and on the temperatures produced in the rock mass, the heater should be located 10m from other drifts or alcoves. The zone of influence of this test was calculated to extend 15m radially and 20m axially from the heater. However, the above constraints and zones of influence are being re-evaluated because of NRC comments related to the duration of the test. It is expected that the zone of influence may increase substantially as a result of the new analyses.

E. The experiment needs to be located in a low traffic area. Water usage and spillage must be controlled within a 14m radial distance from the test centerline. These controls will be determined by Performance Assessment analyses of the quantity of water that can be used and not appreciably change the state of saturation in the 14m radial vicinity of the test.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   Section 2.3.1 Scientific Manpower/Schedule Information
   Section 2.3.2 Laboratory/Office/Storage Space Requirements
   Section 2.3.3 Electrical Power Requirements
   Section 2.3.4 Water System Requirements
   Section 2.3.5 Compressed Air System Requirements
   Section 2.3.6 Common Sampling Design Requirements
   Section 2.3.7 Communications System Requirements
   Section 3.0 Integrated Data System

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Assumptions

1. Test instruments and IDS computer linkages from the UDBR test will be available for this test.

2. Interference zones calculated for this test will change if heater output or the duration of heating for this test is changed.

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Canister-Scale Heater Experiment

Definition of Test

The Canister-Scale Heater Experiment is discussed in Section 8.3.1.15.1.6.2 of the Site Characterization Program Baseline (SCPB).

The Canister Scale Heater Experiment will monitor thermomechanical and hydrothermal response in the potential repository host rock for design and performance modeling, for assessment of retrievability, and for monitoring radon emanation as a function of heating. During the tests, heat fluxes will be increased so that the temperatures near the heater will exceed design limits to aid in determining limits on waste-emplacement borehole stability.

At a location within the Core Test Area of the Main Test Level, a vertical heater hole and parallel small-diameter instrumentation holes will be drilled. A small instrumentation decline will also be constructed to provide radial access to the heater. Baseline moisture data in neutron probe holes will be recorded. A heater and instrumentation (thermocouples, multi-point borehole extensometers, borehole deformation gages, and radon monitors) will be installed. Finally, heating in incremented steps will be initiated, and thermal, thermomechanical, and hydrothermal phenomena, and radon release rates, will be monitored at increasing heat loads.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Canister Scale Heater Experiment.

Performance Criteria

1a. The test will be conducted in the TSw2 unit in a separate room within the Core Test Area of the Main Test Level, away from contacts and faults.

1b. The test will require drilling a vertical hole for the heater canister and vertical and horizontal holes for test instrumentation (thermocouples, MPBXs, borehole deformation gages, neutron probes, moisture sensing gages, and radon monitoring gages). The drilled holes may be as long as 15m, in order to install the MPBXs. The radon monitoring holes will have the largest diameter of the instrument holes, at this time estimated to be 160mm. The heater hole will be approximately 740mm in diameter.

1c. The instrument heads will be placed in a recess at the walls of the excavation. A small decline approximately 10m from the heater hole will be required to install instruments on a radial line from the heater.

1d. Flexibility is required to ensure that the test is located away from contacts and faults.

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1e. Layout, dimensions, and test instrument configuration are TBD.

1f. Standard underground facilities for water, air, and electricity for drilling will be used for this test. An uninterrupted power supply for the heater and the Integrated Data System will be needed.

1g. Accessibility to the test is required during its duration.

Constraints

A. This test can be scheduled independently of the scheduling of other tests.

B. The test will help assess the viability of storing waste in the welded fractured tuff of the TSw2 thermomechanical unit. The test should begin 36 months before license application. Except for this condition, the test can be scheduled as convenient for all involved.

C. Integrated Data System support for this test must be operational and provision for data collection by the IDS must be available before this test can start.

D. To limit the influence of drift openings on the stresses near the heater and on the temperatures produced in the rock mass, the heater should be located 10m from other drifts or alcoves. The zone of influence of this test was calculated to extend 15m radially and 20m axially from the heater. However, the above constraints and zones of influence are being re-evaluated because of NRC comments related to the duration of the test. It is expected that the zone of influence may increase substantially as a result of the new analyses.

E. The experiment needs to be located in a low traffic area because surface temperatures may reach 200 degrees C and may pose a hazard to personnel in the area. Water usage and spillage must be controlled within a 14m radial distance from the test centerline. These controls will be determined by Performance Assessment analyses of the quantity of water that can be used and not appreciably change the state of saturation in the 14m radial vicinity of the test.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   Section 2.3.1 Scientific Manpower/Schedule Information
   Section 2.3.2 Laboratory/Office/Storage Space Requirements
   Section 2.3.3 Electrical Power Requirements
   Section 2.3.4 Water System Requirements
   Section 2.3.5 Compressed Air System Requirements
   Section 2.3.6 Common Sampling Design Requirements
   Section 2.3.7 Communications System Requirements
   Section 3.0 Integrated Data System

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Assumptions

1. **The interference zone for this test will change if the heater output or the duration of heating used for this test is changed.**

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Heated Block Experiment

Definition of Test

The Yucca Mountain Heated Block Experiment is discussed in Section 8.3.1.15.1.6.3 of the Site Characterization Program Baseline (SCPB).

The heated block experiment will provide intermediate scale field measurements of three dimensional deformation and temperature changes in a rock mass. Results of this test will be used for model validation as well as determining rock mass response under a variety of loading conditions.

In an alcove of the Core Test Area of the Main Test Level, a 2m by 2m area of rock will be defined. Reference survey pins will be established, and crosshole ultrasonic measurements will be made. Next, slots will be cut on each side of the block, approximately 2m deep, and flatjacks will be inserted. An array of heaters will be installed in holes on opposite sides of the block. Additional holes will be drilled and instrumented with thermocouples, multi-point borehole extensometers, and deformation gages. Cyclic thermal and mechanical tests will be conducted using the flatjacks and the heaters. The rock responses will be monitored under the induced loads.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Heated Block Experiment.

Performance Criteria

1a. An experimental alcove with nominal dimensions of 9m by 9m and a height of 4.3m is required in the Core Test Area of the Main Test Level in TSw2.

1b. The test will require drilling holes for test instrumentation (MPBXs, surface extensometers, stressmeters, permeability gages, thermocouples, neutron probes) and for heaters. The largest drilled hole is estimated to be 4m long and 76mm in diameter.

1c. Flexibility in location of the test alcove is required to ensure that the block contains a joint spacing and orientation that is reasonably representative of the potential repository horizon.

1d. Test layout, dimensions, and instrument configuration are TBD.

1e. Standard underground facilities for water, air, and electricity for drilling will be used for this test. An uninterrupted power supply for the heaters and the Integrated Data System will be needed.

1f. Access to the test area is required while the test is underway.

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Constraints

A. This test can be scheduled independently of the scheduling of the other tests.

B. The test should be scheduled to begin 24 months before license application and one year before the Heated Room Experiment (SCPB Section 8.3.1.15.1.6.5) begins. Otherwise, the test can be conducted any time after the test alcove has been constructed.

C. Provision for data collection by the Integrated Data System must exist prior to beginning this test.

D. The test should be 10 meters from the nearest test which altered the thermomechanical properties of the rock. As a result of this test, a hydrologically and chemically altered region may extend as much as 11 meters from the line of heaters.

E. The experiment should be located in a low traffic area so that dust and vibrations from other construction and testing do not interfere with sensitive displacement measurements being made as the block is loaded.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The test organization will provide the chain saw for slot cutting.

2. The interference zone for this test will change if the power output of the heaters or the duration of heating changes.

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Thermal Stress Test

Definition of Test

The Thermal Stress Test is discussed in Section 8.3.1.15.1.6.4 of the Site Characterization Program Baseline (SCPB).

This test will measure thermal stresses in a relatively large volume of jointed rock and relate the stress changes to thermomechanical displacement for numerical modeling. This test will also be used to establish criteria for rock mass failure. The test will be conducted at one or two locations on the Main Test Level (MTL). The primary location will be in an alcove that was planned for the Lower Demonstration Breakout Room (LDBR). All other activities planned for the LDBR in the old configuration are currently planned for other locations in the MTL, eliminating the need for a separate LDBR.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Thermal Stress Test.

Performance Criteria

1a. The test will be in a separate room of the Core Test Area of the Main Test Level. Additional space should be reserved on the Main Test Level for a second test, if required. The cross-section of the room should be similar to that of a potential repository emplacement drift, however the room does not need to be full-scale, and can be excavated by any method.

1b. Drilling is required for instrumentation holes (thermocouples, stress gages, MPBXs, extensometers) and for heater holes, with the largest drilled hole estimated to be 12m long and 76mm in diameter.

1c. Flexibility in location of the test room is required to ensure that the joint spacing and orientation is reasonably representative of the potential repository horizon. The test location will be selected after observing rock conditions and joint orientation.

1d. Test layout, dimensions, and instrumentation configuration are TBD.

1e. Standard underground facilities for water, air, and electricity for drilling will be used for these tests. An uninterrupted power supply for the heaters and the Integrated Data System will be needed.

1f. The test room should be accessible during the performance of the test.

Constraints

A. It will be necessary to complete this test before the heating of the

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Heated Room Test (SCPB 8.3.1.15.1.6.5).

B. The tests should be performed in a timely manner as they will help assess the failure and stability criteria for potential repository drifts.

C. Provision for data collection by the Integrated Data System must exist prior to beginning this test.

D. No excavation should be conducted within a two drift diameter standoff region until the test is completed. The test should be conducted in a drift that can be isolated from normal mine traffic. The zone of influence of this test was calculated to be less than the standoff region. However, the above constraints and zones of influence are being re-evaluated because of NRC comments related to the duration of the test. It is expected that the zone of influence may increase substantially as a result of the new analyses. Rock falls in the test room are likely during the test.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The test interference zone will change if the output of the heaters, or the duration of heating changes.

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Heated Room Experiment

Definition of Test

The Heated Room Test is discussed in Section 8.3.1.15.1.6.5 of the Site Characterization Program Baseline (SCPB).

Upon completion of the Sequential Drift Mining experiment (SCPB Section 8.3.1.15.1.5.3), the rock around the central drift will be heated to temperatures representative of those expected in the potential repository. The heated room experiment is intended to measure thermomechanical responses in fractured welded tuff at a drift size scale to acquire data for evaluating both pre- and post-closure design. Measurements will also be used to support the validation phase of both empirical and numerical design methods. The two flanking drifts will be used as access drifts for installation of heaters and instrumentation. Instrumentation installed for the Sequential Drift Mining experiment will remain in use during at least part of the Heated Room Test.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Heated Room Test.

Performance Criteria

1a. The test will be located in the drifts mined during the Sequential Drift Mining Experiment.

Upon completion of the Sequential Drift Mining Experiment in the Core Test Area of Main Test Level, the rock around the central drift will be heated to temperatures representative of those expected in the repository.

1b. Drilling will be required to install the heaters to be used in this experiment. Current dimensions for these holes are 160mm in diameter and 11m long.

1c. The Integrated Data System (IDS) alcove used previously for the Sequential Drift Mining experiment will be reused for this test.

1d. The orientation of the rooms is to be decided. Flexibility regarding room orientation is needed so that the geologic conditions are representative of those expected in the potential repository. The decision on orientation will be based upon early test data before the Sequential Drift Mining experiment.

1e. Test layout and instrument configuration are TBD.

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1f. Standard underground facilities for water, air, and electricity for drilling will be used for these tests. An uninterrupted power supply for the heaters and the Integrated Data System will be needed.

1g. Accessibility to test instrumentation will be needed throughout the test duration.

Constraints

A. The experiment will be conducted following the Sequential Drift Mining experiment and the Thermal Stress Test (SCPB 8.3.1.15.1.6.4).

B. Heating will begin during the site characterization phase and will continue into the confirmation period. The test will need to begin approximately 3 years before license application in order to collect data for the application. The test should begin within a year after the Sequential Drift Mining experiment has ended. Outside of these considerations, the test can be scheduled as convenient.

C. Provision for data collection by the IDS must be available prior to beginning the test.

D. No mining, except to excavate the central room, should be allowed within 15m of any multi-point borehole extensometer (MBPX) anchor until MPBX measurements are no longer being taken. Since MPBX anchors can be 15m from the central room rib, this effectively excludes a region 30m from the central room ribs. Based on consideration of the zone of influence of this test, a standoff distance of 46m laterally from the centerline of the center drift and 15m longitudinally beyond the ends of the center drift is needed. However, the zone of influence is being re-evaluated because of NRC comments related to the duration of this test. It is expected that the zone of influence may increase substantially as a result of the new analyses.

E. Because it will take approximately 3 years after heating begins before needed data is obtained, the test should begin early enough to obtain the data. Special doors and thermal barriers may be required to control the ventilation and heat flow from the area. No traffic will be allowed in the test drift during the experiment.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1 Scientific Manpower/Schedule Information
Section 2.3.2 Laboratory/Office/Storage Space Requirements
Section 2.3.3 Electrical Power Requirements
Section 2.3.4 Water System Requirements
Section 2.3.5 Compressed Air System Requirements
Section 2.3.6 Common Sampling Design Requirements

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Section 2.3.7 Communications System Requirements
Section 3.0 Integrated Data System

Assumptions

1. The data collection space and facilities used for the Sequential Drift Mining experiment will also be used for this test.

2. The zone of influence for this test is based on present plans for the heater power. If the heater power is increased to accelerate the heating rate, or if the duration of heating is increased, the standoff zone will need to be re-evaluated.

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Plate Loading Tests

Definition of Test

The Plate Loading Test is discussed in Section 8.3.1.15.1.7.1 of the Site Characterization Program Baseline (SCPB).

The plate loading test loads diametrically opposed surfaces of rock for the purpose of deformation measurements. Experimental results can be used to calculate rock mass modulus and interpret the depth of the disturbed zone. This test will follow International Society for Rock Mechanics (ISRM) and American Society of Testing and Materials (ASTM) standard testing procedures.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Plate Loading Tests.

Performance Criteria

1a. The tests will be conducted in alcoves extending from the accesses or main drifts. The alcoves will be approximately 4.6m wide by 2m tall by 18m long. The actual cross-section of the alcoves will depend upon the location, excavation machinery available and the test apparatus to be used. The height of the alcoves will most likely be the minimum that can be successfully excavated and will be determined by the PI and the A/E. Five or more tests may be performed in each alcove. The excavations should be mechanically excavated such that the surface damage created approximates the excavation damage expected in the potential repository.

The tests will be conducted in each of the thermomechanical units encountered in the North and South Ramps. Testing will be performed in the South Ramp in order to test the unique thermomechanical units encountered there. Most tests should be away from geological contacts or structure; some locations proximal to faults will be acceptable. In the Main Test Level and in the Calico Hills, tests will be conducted at one or two locations, with at least one test on each of the two levels near a crossing with the Ghost Dance fault.

1b. Instrumentation holes for the MPBXs, extensometer anchors and acoustic emission microphones will require drilling. The largest holes will be for the MPBXs, which will be approximately 15m long and 76mm in diameter.

1c. Flexibility is required to insure that the joint spacing and orientation of the test alcoves are reasonably representative of the potential repository horizon and that the cross-section of the test alcoves is consistent with the test apparatus that will be used.

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1d. The test layout, dimensions, and instrument configuration are TBD.

1e. Standard underground facilities for water, air, and electricity for drilling will be used for this test. An uninterrupted power supply (UPS) for the Integrated Data System will be needed.

1f. The test alcoves must be accessible during the test duration.

Constraints

A. One test in the TSw2 unit should be completed before the Sequential Drift Mining test (SCPB Section 8.3.1.15.1.5.3).

B. The test should be performed in a timely manner as it will provide input to facility design and other Exploratory Studies Facilities Tests. Otherwise, test alcoves can be built at any time and will be scheduled as convenient for all involved. The tests will be performed as soon as the alcoves are finished.

C. Provision for data collection by the IDS is required prior to beginning this test.

D. The test should be a minimum of 10m from the nearest test which altered the thermomechanical properties of the rock. Only a small region of rock (approximately 1 to 3 cubic meters) will be directly loaded and the effects of the loading will likely extend a distance of only a few times the width of the area over which the load is applied. No permanent alteration to the local hydrological, chemical, or thermal conditions will result from this test.

E. Testing impedes traffic, therefore test alcoves should be provided.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The alcoves used in this test may also be used for the slot tests conducted in the Rock Mass Response Test (SCPB 8.3.1.15.1.7.2). Tests that are in shared alcoves, will share access to the Integrated Data System.

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Rock-Mass Response Test

Definition of Test

The Rock-Mass Response Test is discussed in Section 8.3.1.15.1.7.2 of the Site Characterization Program Baseline (SCPB).

This activity evaluates the mechanical behavior of the rock mass. Tests will obtain information on the mechanical response of multiply jointed volumes of rock. This test is composed of three different types of activities: uniaxial compression tests, ambient block tests, and slot tests; and will be conducted in several areas that are representative of the range of conditions encountered in the Main Test Level of TSw2 and in the Calico Hills. The information will be used to evaluate scale effects between laboratory and in situ conditions, provide data to evaluate empirical design criteria, and provide data to evaluate and validate jointed-rock models.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Rock Mass Response Test.

Performance Criteria

1a. Tests will be conducted in alcoves extending from the drifts. The alcoves will be approximately 3.7m wide by 3.7m long by 2.4m high. If the exposed floor is not suitable for the test, the alcoves will need to be enlarged.

Tests will be performed in alcoves at 2 or 3 selected areas within the Main Test Level (MTL) and in the Calico Hills. Specifically, in situ tests for strength and deformability would be conducted in the MTL if the rock mass is fractured or heterogeneous. Alcoves cannot be located until after excavation and mapping identify appropriate rock conditions. Tests will be conducted in the Calico Hills in order to verify the stability of the accesses for long term use.

1b. Drilling is required for test instrumentation (MPBXs and fracture deflection gages). The holes will be 38mm and 76mm in diameter and extend approximately 1 to 3m in length.

1c. Flexibility in location of the test alcoves on the Main Test Level and in the Calico Hills is required to ensure that the test is conducted in rock with the appropriate fracture spacings and quality. Alcoves cannot be located until after exploration and mapping identify appropriate rock conditions.

1d. Layouts, dimensions, and instrument configurations for uniaxial, ambient block, and slot tests are TBD.

1e. Standard underground facilities for water, air and electricity for drilling will be used for these tests.

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1f. Access to the test alcoves is needed while the tests are underway.

Constraints

A. Block tests will be conducted in the same alcoves as the compressive tests. Slot tests may be conducted in the same alcove, or in other selected locations, such as the alcoves used in the Plate Loading Tests (SCPB 8.3.1.15.1.7.1).

B. No conflict exists with facility construction. Tests will be conducted in alcoves developed after drift excavation is complete.

C. Provision for data collection by the IDS must be available prior to beginning this test.

D. This test must be performed in a location that has not been affected by other testing. This experiment will be conducted in alcoves along any access or drift where suitable rock conditions (in regions that have not been altered by other activities) exist. The location of the tests will be determined after the drifts are excavated. The experiment will be similar to the Plate Loading Test in that only a small region of rock (approximately 1 to 3 cubic meters) will be directly loaded and the effects of the loading will likely extend a distance of only a few times the width of the area over which the load is applied. No permanent alteration to the local hydrological, chemical, or thermal conditions will result from this test. No significant zone of influence will result from the rock-mass loading imposed in this activity.

E. Protection will be required from the high-pressure hydraulics used in this test.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

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Assumptions

1. **Tests that are in shared alcoves will share access to the Integrated Data System.**

2. **The slots required for the compressive strength, block tests, and slot tests will be cut using the hydraulic saws provided by the test organization. Construction of the test reaction frames will be done by the test organization.**

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Evaluation of Mining Methods

Definition of Test

The Evaluation of Mining Methods Test is discussed in Section 8.3.1.15.1.8.1 of the Site Characterization Program Baseline (SCPB).

These tests will monitor and evaluate excavation methods for ramp and drift openings, with an emphasis on rock responses in a variety of lithologic and structural settings that may be encountered in the ESF. This activity will be used to develop recommendations for excavation in the potential repository. Investigations will include excavation performance measurements, and examination of induced damage, as appropriate. This experiment will not monitor the machine performance (cutting heads, etc.).

Functional Requirements

1. Provide the operational flexibility to perform the Evaluation of Mining Methods tests.

Performance Criteria

1a. No special rooms or alcoves are required. The tests will be conducted in conjunction with excavation of all openings in the North Ramp, in the South Ramp, in the Main Test Level, and in the Calico Hills. Both ramps will be considered in this experiment, because of the different slopes, lithologies, and faults associated with each ramp. The experiment involves monitoring performance, is not invasive, and thus should not cause interference with excavation when performed in both ramps.

1b. No drilling is required for this test.

1c. It is expected that data collection will be performed by the ESF constructor as part of the construction process.

1d. No flexibility requirements have been identified.

1e. Because this is a monitoring activity, no sketch of the test configuration is needed.

1f. Because this is a monitoring activity, no utility requirements exist.

1g. No accessibility requirements have been identified.

Constraints

A. This test can be scheduled independently of the scheduling of the other tests.

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B. The test will be performed as the excavation proceeds, following the excavation equipment. The test will be performed near the face, in order to record movement of the mining equipment. However, face advance will not be affected, and underground resources will not be redirected, as the experiment involves only the recording of mining performance and is not invasive.

C. No need for the Integrated Data System has yet been identified.

D. No interference envelope exists; this test is observational only.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. No test-specific assumptions have yet been identified for this test.

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Monitoring of Ground Support Systems

Definition of Test

The monitoring of ground support systems is discussed in Section 8.3.1.15.1.8.2 of the Site Characterization Program Baseline (SCPB).

This activity will develop recommendations for ground support in drifts in the potential repository, based on evaluations of the ground-support techniques used in the underground excavations, and on experimentation with other ground-support configurations. This activity will be carried out in both ramps, on the Main Test Level, and in the Calico Hills. The selection, installation, and performance of the support systems used will be monitored. Experimentation with ground supports will include pull tests on rock bolts and installation of rock bolt load cells. Observation will be made of unsupported rock, strength measurements will be made on shotcrete cores, and trials of ground-support systems different from those prescribed for the ESF will be made. The effects of heat on ground support will be considered in the Heated Room Experiment (SCPB Section 8.3.1.15.1.6.5).

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Ground Support Test.

Performance Criteria

1a. No special room or alcove is required. The tests will be conducted in all of the thermomechanical units encountered in both ramps, in the Main Test Level and in the Calico Hills. The observational tests will be performed in both ramps because they are non-invasive, survey type tests and by examining the different lithologies and faults encountered in each, the data base may be increased. The tests will be performed in the Calico Hills in order to monitor the stability of the drifts in the Calico Hills to enhance safety over the time period in which access will be needed. The pull tests will be performed in the North Ramp and the Main Test Level only.

1b. No required drilling has been identified for this test.

1c. Provision for data collection by the Integrated Data System is required for the rock bolt load cells and the pull tests.

1d. Location will depend on ground conditions. Extra bolts, in addition to those required for safety, will be installed for this test. Where shotcrete is used, cores will be taken for laboratory testing of strength and bonding to the rock. For each location where steel sets are used, two will be instrumented with load cells.

1e. Because this is a monitoring activity, no sketch is given for this test.

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1f. Standard underground facilities for water, air, and electricity for drilling will be used for this test. No other special experimental needs exist.

1g. Accessibility to the rock bolts to be tested using pull tests is required. Accessibility to the rock bolt load cells will be needed only for repair activities.

Constraints

A. This test can be scheduled independently of the scheduling of the other tests.

B. In general, test preparation for this experiment can be initiated any time after the test location is exposed and will continue over a period of years. The use of underground resources (men and equipment) will be based on scheduled availability and preferably coincide with scheduled TBM shutdown. Slow down of excavation progress will be avoided. Construction progress impact (far behind the face) will be limited to minor interference with support forces (maintenance crews, ramp transportation vehicles, priority testing support, etc.). An exception is that the load cells must be placed when rock bolts are installed.

C. Monitoring must begin when the rock bolts are installed, and the Integrated Data System (IDS) must be available from the start of monitoring and continue over the term of the experiment. The pull tests will also need IDS support, but these tests are of short duration (on the order of a day).

D. No interference envelope exists for this experiment. However, pull tests may temporarily block movement of vehicles in the drifts.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. No test-specific assumptions have yet been identified for this test.

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Monitoring Drift Stability

Definition of Test

The Monitoring Drift Stability test is discussed in Section 8.3.1.15.1.8.3 of the Site Characterization Program Baseline (SCPB).

These tests will monitor drift convergence and drift maintenance activities throughout the ESF, along accesses, and in the Calico Hills. Convergence measurement stations will be selected by the Principal Investigator. In the ESF drifts on the Main Test Level, convergence measurements will be taken in a continuous manner. Rock-mass relaxation will be investigated in these drifts using multiple-point borehole extensometers (MPBXs). Rock falls and maintenance activities will be documented.

Functional Requirements

1. Provide the operational flexibility to perform the Monitoring of Drift Stability Test.

Performance Criteria

1a. No special room or alcove is required. The tests will be conducted at drift closure monitoring stations in the Tsw2 unit in the South Ramp access, on the Main Test Level, especially near the Ghost Dance Fault, and in the Calico Hills. Drift intersections will be monitored, and will be more heavily instrumented than the tests at locations away from drift intersections. The purpose of the tests in the Calico Hills is to monitor the long term stability of the drifts in order to enhance safety during the time that they are used.

1b. Drilling requirements for this test include holes for MPBXs that are approximately 15m long and 76mm in diameter and shallow holes for tape extensometer anchors (approximately 230mm long, 29mm diameter)

1c. Field observations of ground conditions will be necessary before final locations of measurement stations can be specified. The design of service hardware in the drifts (such as ventilation ducts, cable trays, etc.) must accommodate these measurements.

1d. Layouts, dimensions, and instrument configuration are TBD.

1e. Standard underground facilities for water, air, and electricity for drilling will be used for this test. No other special experimental needs exist.

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1f. Access to the monitoring stations will be required periodically during the test.

Constraints

A. This test can be scheduled independently of the scheduling of the other tests.

B. The experiment will look at both early time response and long term response. Test preparation should be initiated as soon as practical after the test location is exposed. The test instruments must be installed before the installation of permanent utilities, and permanent access to measurement heads will be required. The use of underground resources, (men and equipment) will be based on scheduled availability and preferably coincide with scheduled TBM shut down. Slow down of excavation progress will be avoided. Construction progress impact (far behind face) will be limited to minor interference with support forces (maintenance crews, ramp transportation vehicles, priority testing support, etc.). Monitoring of cross-drift convergence and borehole extensometers will continue beyond site characterization to help predict long-term stability.

C. Provision for data collection by the Integrated Data system is required prior to beginning this test.

D. No interference envelope exists for this test.

E. MPBXs and extensometer anchors should be installed as close to the advancing face as possible.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. No test-specific assumptions have yet been identified for this test.

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Air Quality and Ventilation Experiment

Definition of Test

The Air Quality and Ventilation test is discussed in Section 8.3.1.15.1.8.4 of the Site Characterization Program Baseline (SCPB).

The purpose of this test is to assess the impact of site characteristics on ventilation requirements to ensure a safe working environment. This activity consists of (1) measurements of radon emanation; (2) surveys of air-flow and pressure, temperature, and humidity; (3) determinations of air resistance factors; and (4) dust characterization. The radon emanation measurements will be made in a dead-end drift that has been sealed with a bulkhead and that will be repeatedly ventilated and then allowed to return to equilibrium. Radon concentrations may also be measured in a borehole. The air quality and ventilation measurements are not expected to interfere significantly with other underground activities.

Functional Requirements

1. Provide the operational flexibility to perform the Air Quality and Ventilation Test.

Performance Criteria

1a. A dead-end drift that can be sealed with a bulkhead is required for measurements of radon emanation. The sealed drift will be repeatedly ventilated and then allowed to reach equilibrium.

The tests will be conducted throughout the ESF after construction is completed. The end section of a drift or alcove on the Main Test Level will be sealed with a bulkhead to allow measurement of radon gas emanation. Surveys of air-flow and pressure, temperature, and humidity, determinations of air resistance factors, and dust characterization will be performed on the Main Test Level and in the North and South Ramps.

1b. This test will require a radon measurement hole in the dead-end drift approximately 9m in length with a 160mm diameter.

1c. No flexibility requirements for test location or orientation have yet been identified.

1d. No figure is supplied with this test.

1e. Standard underground facilities for water, air, and electricity for drilling will be used for this test. No other special experimental needs exist.

1f. Accessibility to the dead-end drift will be required throughout the test period. Periodic access to locations throughout the ESF after construction is completed is needed for this test.

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Constraints

A. This test can be scheduled independently of the scheduling of the other tests.

B. Test preparation shall be initiated within one month after the test location is exposed. The use of underground resources (men and equipment) will be based on scheduled availability and preferably coincide with scheduled TBM shut down. Slow down of excavation progress will be avoided. Construction progress impact (far behind face) will be limited to minor interference with support forces (maintenance crews, ramp transportation vehicles, priority testing support, etc.)

C. Provision for data collection by the Integrated Data System should be available prior to conducting the measurement of radon emanation.

D. For the measurement of radon emanation part of the test, the area around the sealed test drift must not be affected by thermal or hydrological testing. Additional analyses will be performed to define acceptable amounts of thermal and hydrological change that will be allowed.

E. The measurement of radon emanation will require the sealing off the end of a drift. The remainder of the test requires only periodic air sampling, and no special constraints are required for these activities in the ESF testing, and no additional perturbation to natural conditions (stress, temperature, moisture, etc.) will result from these additional activities.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The survey of pressures and air flows will be conducted once, over a period of a few days. Heat balances will be conducted twice (once in the summer and once in the winter). These measurements will be conducted throughout the ESF after construction is completed. Data acquisition by the IDS is not required for these surveys.

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2. In the radon emanation test, continuous measurement of radon and radon daughter concentrations, temperature, humidity, barometric pressure, and air flow will be made.

3. Independent control of the ventilation air flow rate at the end of the dead-end drift will be required.

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Overcore Stress Experiments in the Exploratory Studies Facility

Definition of Test

The Overcore Stress Experiments in the Exploratory Studies Facility are discussed in Section 8.3.1.15.2.1.2 of the Site Characterization Program Baseline (SCPB).

The overcore stress experiments will be performed to determine the in situ state of stress above, within, and below the potential repository horizon, in that portion of the unsaturated zone penetrated by the ESF, to determine the extent of excavation-induced stress changes, and to relate stress parameters to rock-mass heterogeneities.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Overcore Stress Experiments Test.

Performance Criteria

1a. Adequate space is required in order to drill and core the test holes. Boreholes will be approximately 20m in length and up to 152-mm in diameter (cored). The test will be conducted in alcoves constructed from both ramps in the high lithophysal zone of the upper Topopah Spring welded unit, in alcoves on the main test level (one north end, one south end), and in the Calico Hills nonwelded unit at both ends of the facility. In addition, the test will be conducted in each alcove used for the Excavation Effects test to support the Excavation Effects test.

1b. Three sizes of boreholes will be required, all of which will be approximately 20m long. The dilatometer boreholes will have a diameter of 76mm, the pilot holes for the overcore holes will be 38mm in diameter, and the overcore boreholes will be 152mm in diameter. Dry drilling is not required.

1c. Flexibility in location of the tests is required because intact segments of core are required. Thus the location, distribution, orientation and apertures of fractures need to be examined prior to conducting tests.

1d. Standard utilities are expected to be adequate to conduct this test.

1e. Access must be maintained to the borehole locations until after overcoring is complete. No further access will be required after overcoring is complete.

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Constraints

A. This test does not require any special sequencing/timing relative to the ESF construction with the exception of the tests conducted in conjunction with the Excavation Effects test which must be conducted prior to conducting the Excavation Effects test.

B. The test must be conducted at a distance equivalent to at least two opening diameters from any opening. The test must be located at least 15m from any heater test or be conducted prior to any heater test within 15m. If water is used in drilling/coring, any hydrologic tests should be located at least several meters away. Tests conducted in the Calico Hills nonwelded unit will include hydrofracture tests conducted with low-volume amounts of water. The Calico Hills nonwelded unit test locations should be sited so as to not impact hydrologic tests or other water-sensitive tests. An analysis will be developed at a future time to determine appropriate stand-off distance for hydrologic tests.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

1. The location for the mobile laboratory will be on an auxiliary pad. The trailer will be about 12m long.

2. Testing equipment will be provided by the test organization.

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Development and Demonstration of Required Equipment

Definition of Test

The development and demonstration of required equipment activity is discussed in Section 8.3.2.5.6 of the Site Characterization Program Baseline (SCPB).

This test includes prototype testing and the development of test instrumentation for activities covered in SCPB 8.3.1.15.1.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the development and demonstration testing of required equipment.

Performance Criteria

1a. The need for special rooms/alcoves has yet to be decided.

The location of this test has not yet been decided. Locations will be chosen after the types of prototype testing and test instrumentation to be developed have been selected.

1b. No drilling requirements have yet been identified for this test.

1c. No data collection or space needs have yet been identified.

1d. No flexibility requirements have yet been identified.

1e. No general test configuration or arrangement has yet been developed for this test.

1f. Standard underground facilities for water, air, and electricity for drilling will be used for this test. No other special experimental needs are currently identified.

1g. No accessibility requirements have yet been identified.

Constraints

A. This test will be performed before the activity that it prototypes. When the type of prototype testing and test instrumentation to be demonstrated are identified, test sequencing can be determined.

B. No conflict with facility construction has currently been identified.

C. Need for the Integrated Data System is still to be determined.

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D. The interference envelope for this test is to be determined.

E. No constraints/controls have been identified.

Interface Requirements

To be determined.

Assumptions

To be determined.

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In Situ Testing of Seal Components

Definition of Test

The In Situ Testing of Seal Components activity is discussed in Section 8.3.3.2.2.3 of the Site Characterization Program Baseline (SCPB).

There are two categories of testing required in the sealing program:

Category A - Intrinsic permeability characterization of discrete, geologic features to evaluate water inflow and air outflow.

Category B - Evaluation of specific sealing concepts and sealing components including a hydrologic assessment of selected, rock-mass locations to drain water and characterization of the modified permeability zone (MPZ) in the main ramps and in the drifts parallel to the main ramp.

If a test area involves only the conductivity (hydraulic and air) characterization of a discrete geologic feature and does not involve a Category B test, the test is not considered a sealing test but is considered a necessary test to support the sealing program. It is anticipated that other organizations will be interested in this geohydrologic information and may have proposed similar tests.

Category B tests are considered the in situ sealing components tests and are the primary focus of the sealing program. There are a variety of sealing tests to be conducted in the Exploratory Studies Facility (ESF). These tests are:

- small-scale in situ seal tests
- intermediate-scale borehole seal tests
- large-scale shaft seal tests
- fracture grouting tests
- a filter/single embankment test
- engineered drainage-enhancement tests
- full-scale backfill tests in the Calico Hills unit
- bulkhead tests in the Calico Hills unit
- drift-scale backfill tests at the surface

The tests indicated above are intended to reduce the uncertainties associated with the performance of sealing components. A broad range of testing is proposed to accommodate the potential broad range of conditions that may be encountered in the underground workings. The types and numbers of sealing tests are ultimately dependent on the geology, hydrology, and design of the underground facility.

Functional Requirements

1. Provide the facility design and operational flexibility to perform intrinsic permeability characterization and the in situ testing of seal components.

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Performance Criteria

1a. Category A tests will require alcoves or adequate space for core drilling two horizontal holes with depths of approximately 20m. The first hole will be drilled perpendicular to the discrete, geologic feature and second hole will be drilled to intercept the feature at a currently unspecified angle.

Tentative locations for Category A tests include:

(i). In the North Ramp - Bow Ridge Fault, a characteristic fault or fracture zone beneath alluvium downgrade from the Bow Ridge fault, a characteristic fault or fracture zone downgrade from the alluvial area, and 2 characteristic faults or fracture zones in the Topopah Spring Member.

(ii). In the South Ramp - a characteristic fault or fracture zone from the surface through the Tiva Canyon to the ramp; a characteristic fault or fracture zone from the alluvial area, through the Tiva Canyon, the nonwelded Paintbrush tuff, and the Topopah Spring tuff, to the ramp; a characteristic fault or fracture zone near the repository boundary; and the Ghost Dance fault.

(iii). Within the Topopah Spring and Calico Hills horizons, representative Category A testing of discrete, geologic features will be the same as the testing proposed by the USGS.

1b. The Category B tests at the North Ramp TCw and nonwelded PTn locations should be developed consistent with the development of the main repository level, if possible. At each location approximately 300m of drifting will be required. The drifts will be 3.66m in height and width. Each location will include two drifts coming off of the main ramp.

(i). The drift further to the east will incline up at a 10% grade. Two drifts will come off of this drift and connect at the far end. Both of these drifts will grade up at 6%.

(ii). The second drift will be approximately 70m from the first drift. The grade of this drift will be 20% down. Two drifts will come off of this drift and both drifts will be connected at the far end. Both of these drifts will grade down at 6%.

(iii). The minimum separation of the two levels is 15m.

(iv). Two 31cm intermediate boreholes will be drilled between the two levels.

(v). Within the lower drifts the following boreholes will be developed: 2-0.9m diameter x 2.7m length holes; 2-0.9m diameter a 1.8m length holes; 3-0.46m diameter holes x 1.2m length holes; and 3-0.46m diameter x 0.6m length holes.

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(vi). Flexibility must be provided to construct two shafts, sized and lined consistent with shaft designs for the repository, between the drifts furthest from the main ramp.

(vii). A uniform compressed air supply is required at both locations.

(viii). Measurement of the air conductivity at the drift scale also be performed at both locations. This will require the pressurization of a segment of the drift and injection of a tracer. Because of the scale of this test, a larger compressed-air supply will be necessary. The requirement of the size of the air supply depends on the quality of the rock being evaluated.

(ix). Large-scale testing of the drifts will require construction of temporary bulkheads, constructed possibly of cinder blocks and sealed with gunite.

1c. The Category B Calico Hills Test south of and parallel to the southern Ghost Dance Fault drift requires a drift perpendicular to the main drift approximately 30m long. It should be the same design as the remainder of drifting in the Calico Hills unit.

(i). Associated with this drift are three alcoves: The first and second alcoves should be approximately 4m x 4m and should house the instrumentation for the experiment. They should be located off of the drift that penetrates the Ghost Dance fault furthest to the south. The third drift should be approximately 6m x 6m and should be used for storage of rockfill for the backfilling operation.

(ii). Some drilling will be required to core into the backfill as emplaced. Excavation of the backfill also may be performed to extract samples.

1d. The Category B Calico Hills Test at the north or south end of the CHn main drift (dependent on hydrologic conditions of the access ramps) requires provision of a drift having the same design as the remainder of drifts in the Calico Hills unit.

(i). The drift should be approximately 25m in length. Testing will involve the construction of a large-scale seal and subsequent testing behind the seal.

(ii). Coring of the seal may be performed to obtain strength and hydrologic properties of the seal. Flexibility to allow seal coring must be maintained.

1e. The MTL Core Test Area Category B test (coupled heated block/grout test) will utilize the Heated Block test alcove, if possible. If the existing heated-block test area is not a suitable area to conduct the heated block/grout test, then a drift of approximately 10m length x 4.9m x 4.9m will have to be developed. This drift will be constructed in the same manner as the drift containing the heated-block test.

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1f. The MTL Core Test Area Category B test (engineered drainage-enhancement tests) requires development of a drift approximately 25m long located in the MTL Core Test Area. Because testing will involve the emplacement of rockfill, a storage area will be required for the rockfill. There are no specific requirements for this area with the exception that the area have a reasonable storage capacity for the rockfill.

1g. A location must be provided at the surface (within the defined disturbance area) for simulation of rockfill placement, the testing of the rockfill, and the placement of instrumentation in the rockfill. A culvert-like facility is proposed which may be 4m in diameter and 20m long. Instrumentation ports will be placed throughout the culvert to gain remote access to the rockfill. Drilling of boreholes will be required for the instrumentation of the rockfill.

1h. Data acquisition systems and IDS connections must be provided at all test locations.

1i. At all test locations (Category A and B), standard facility support for water, power, lighting, ventilation, and communications will be required.

Constraints

To be determined, including constraints for the rock support system.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

Assumptions

None.

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Geomechanical Attributes of the Waste Package Environment

Definition of Test

The Geomechanical Attributes of the Waste Package Environment are discussed in Section 8.3.4.2.4.3 of the Site Characterization Program Baseline (SCPB).

Initial heater tests are planned in the North Ramp, with subsequent tests in the Core Test Area of the Exploratory Studies Facility (ESF) Main Test Level (MTL). The results of the North Ramp test will be used to help design the tests in the Main Test Level. Multiple tests located in the North Ramp and the Main Test Level are needed to provide information for studying the homogeneity of the potential repository horizon. The tests are designed to characterize the geomechanical response of the rock in the near-field environment to the changing environmental conditions expected to occur over the lifetime of the potential repository. Some tests will study the effect of a heating/cooling cycle on the stability of rock blocks formed by excavation of the emplacement hole. Other tests will assess the potential for spalling or other types of borehole breakout that may occur due to the heating/cooling cycle and associated changes in the rock/fracture properties. For some tests temperatures and/or stresses above those expected in the potential repository may be imposed on rock blocks to accelerate geomechanical mechanisms. Flat jacks may be used to induce elevated stress on a rock block.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the tests of the Geomechanical Attributes of the Waste Package Environment Test.

Performance Criteria

1a. Each test (North Ramp and Core Test Area of the Main Test Level) requires an alcove room of at least 1.2m long, 6.1m wide and 4.6m high. In addition, each test requires two alcoves, each with a floor area of at least 3.7m x 3.7m. One of the two alcoves will be used for an instrumentation room, therefore, it has to be air-conditioned. The other alcove will be used as storage. These two alcoves should be adjacent to the test area.

1b. The test areas in the North Ramp and the Main Test Level should be at least 9.1m from other activities and 6.1m from other openings. This separation will be evaluated as design progresses.

1c. Instrumentation borehole sizes to 7.62cm (3") in diameter and emplacement borehole sizes to 76.2cm (30") in diameter. The boreholes will be dry drilled vertically from the invert of the testing alcove.

1d. Data will be collected by the LLNL data acquisition system. The IDS will be connected to the LLNL data acquisition system.

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1e. Flexibility to adjust the test location to avoid fracture zones should be provided.

1f. Normal utility supplies (power, ventilation, water, and compressed air) in the ramps and Main Test Level, will be required. Additional requirements of power and compressed air are listed below.

1g. Power is needed for the heater (208V, 3-phase, 45 amp, voltage regulated), and for the instrumentation (120V, 30 amp UPS).

1h. Compressed air will be needed for mechanical loading of the rocks.

1i. Capability of slotting the perimeter of a 3.1m cubic block of rock, with an aperture of 1.27cm to 2.54cm is required.

1j. Access to the test area should be maintained for LLNL personnel during the duration of the tests. Ability to control access to the test area is required.

Constraints

A. The test in the North Ramp should start as early as possible so that input to the design of the test in the Main Test Level can be provided. Tests in the Main Test Level must be initiated as early as possible in order to provide adequate information to support the license application date.

B. Provision for data collection by LLNL and connection to the IDS must be available prior to the beginning of these tests.

C. Once a test has begun, no excavation that could affect the stress state near the heater may begin.

D. Site Characterization Analyses objectives require stand-off zone depends on test duration will be addressed.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1 Scientific Manpower/Schedule Information
Section 2.3.2 Laboratory/Office/Storage Space Requirements
Section 2.3.3 Electrical Power Requirements
Section 2.3.4 Water System Requirements
Section 2.3.5 Compressed Air System Requirements
Section 2.3.6 Common Sampling Design Requirements
Section 2.3.7 Communications System Requirements
Section 3.0 Integrated Data System

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Assumptions

1. Office space will be provided at the ESF, and some space will be assigned in Area 25. Office space at the test site (ESF) should provide enough space and a change house for at least 3 persons, and two computer stations.

2. LLNL will not provide any equipment to be used in the construction of the ramps, drifts, and alcoves.

3. There is no other activity in the vicinity such that the thermal load and/or mechanical load will affect the tests, and vice versa.

4. A trailer pad sufficient for a 3.7m x 18.3m machine shop trailer will be provided at the surface of the test area. LLNL will bring the trailer on site. Parking space at the trailer pad for at least one pickup truck will be provided. The trailer pad will have water, sewer, and 120/208 VAC, 3-phase power hookups.

   Note: These design requirements are for the SCP-CD emplacement configuration; review and/or revision of this test would be required if alternate configurations were proposed.

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Repository Horizon Near-Field Hydrologic Properties

Definition of Test

The Repository Horizon Near-Field Hydrologic Properties Tests are discussed in Section 8.3.4.2.4.4.1 of the Site Characterization Program Baseline (SCPB).

A series of heater tests and infiltration tests are planned in the North Ramp, as an initial test, and in the Core Test Area of the Exploratory Studies Facility (ESF) Main Test Level (MTL). The MTL tests will be conducted following the initial tests performed in the North Ramp Access. The results of the North Ramp test will be used to help designthe test on the Main Test level. The test in the North Ramp and the Main Test level will provide information for studying the homogeneity of the potential repository horizon. All tests are designed to investigate moisture movement and saturation conditions in the host rock during heating and cooling periods of waste storage and to investigate the scale effects of the heater hole on the measured parameters. Some tests will measure the parameters during the thermal cycle using ambient moisture as the initial condition. The other tests will include simulated percolation events to examine the effect of water percolating or diffusion through the rock mass.

Functional Requirements

1. Provide the facility design and operational flexibility to Repository Horizon Near-Field Hydrologic Properties Tests.

Performance Criteria

1a. Provide drift systems for the tests in the North Ramp and the MTL Core Test Area. For each test two drifts, the emplacement drift and the instrumentation drift, are required. The emplacement drift should have enough space for several heater test groups. Each heater test group consists of heater holes and instrumentation holes. The emplacement drift system should be designed so that the rock within each heater test group can be studied in 3-dimensions. The instrumentation drift should be at a lower level from the emplacement drift. An invert to invert vertical separation of about 13.7m between the emplacement drift and the instrumentation drift is required. For each heater test group, the emplacement drift includes a 76.2cm (30") diameter emplacement hole of about 12.2m deep, of which the lower 6.1m will be occupied by the heater.

The heater emplacement hole will be drilled vertically into the invert of the emplacement drift. The instrumentation drift will allow horizontal accesses to the heater and region 1.5m above and below it.

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1b. Instrumentation alcoves of at least 3.7m x 3.7m of floor space each, should be provided. Depending on layout, 2 to 3 alcoves may be needed. The instrumentation alcoves should be within 15m of the active test areas. The instrumentation alcoves should be air-conditioned.

1c. At least two (2) storage alcoves, at least 3.7m x 3.7m of floor space each, should be provided.

1d. The separation of each heater test group in a drift should be such that a minimum of 7.6m of rock in all directions around each heater will be undisturbed by other tests or activities. Enough drift should be provided for at least five (5) of such heater tests. At least one of the tests should be continued as performance confirmation testing.

1e. Width of the emplacement drift will provide an array of vertical boreholes drilled into the invert that extends 3m radially from the center of the heater.

1f. Height of the instrumentation drift will be sufficient to provide for drilling of an array of almost horizontal boreholes that extend 9.1m vertically.

1g. Horizontal and vertical clearances opposite to the collars of all instrumentation holes be sufficient to allow the use of downhole logging tools up to 4.6m in length. Horizontal and vertical clearances opposite to the heater collars be sufficient to allow 6.2m long heater assemblies to be used.

1h. Instrumentation borehole sizes to 7.62cm (3") and emplacement hole sizes to 76.2cm (30") in diameter will be drilled in each of the heater test groups. The depths of these boreholes range from about 6.2m about 18.3m. The boreholes will be either vertical or almost horizontal. Dry drilling and coring of these boreholes are required.

1i. LLNL will have its own data acquisition system (DAS). This DAS will be connected to the IDS.

1j. Flexibility to adjust the test locations to avoid fracture systems that are deemed adverse to the test, such as shear zones or faults that would perturb the overall hydrologic response of the system, is required. Sufficient drift length to allow test locations to be moved by 15.2m in either direction from the proposed location is considered adequate flexibility.

1k. Standard utility supply for the Ramps and Main Test Level (power, water, compressed air, ventilation, communication) will be needed. Other requirements are listed below.

(i). Electrical power is required for the heater and instruments. For the heater, five (5) 208V, 3-phase, 45 amp circuits connected to a standby, voltage regulated source are needed. For instrumentation power, eighteen (18) 120V, 30 amp circuits connected to uninterruptable power supply (UPS) will be needed. A minimum length of illuminated drift of 15.2m is required for

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each test location. The ability to monitor all power consumed by the lightings near the test area is required.

1l. Water will be needed for infiltration studies. (TBD)

1m. Access to the test area should be maintained during the duration of the test. Ability to control access to the test areas is required.

Constraints

A. The tests in the North Ramp should start early enough so that their results can be used as input to the design of the tests in the Main Test Level. Provision for data collection by LLNL and connection to the IDS must be available prior to the beginning of these tests.

B. The tests in the Main Test Level must be initiated as early as possible in order to provide adequate information to support the license application date.

C. Minimum vertical separation between the emplacement drift and instrumentation drifts of at least 13.7m (from invert to invert) will be required.

D. No metallic rock bolts shall be located within the test region, defined by the rock mass that is penetrated by the instrumentation boreholes, plus 1.5m.

E. Once a test has begun, no excavation that could affect the stress state near the heater may begin.

F. Site Characterization Analysis objectives requiring stand-off zones dependent on test duration are TBD and will be addressed during Title II Design.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

Section 2.3.1	Scientific Manpower/Schedule Information
Section 2.3.2	Laboratory/Office/Storage Space Requirements
Section 2.3.3	Electrical Power Requirements
Section 2.3.4	Water System Requirements
Section 2.3.5	Compressed Air System Requirements
Section 2.3.6	Common Sampling Design Requirements
Section 2.3.7	Communications System Requirements
Section 3.0	Integrated Data System

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Assumptions

1. Office space will be provided at the ESF, and some space will be assigned in Area 25. Office space at the test site (ESF) should provide enough space and a change house for at least 8 persons, and two computer workstations.

2. LLNL will not provide any equipment to be used in the construction of the ramps, drifts, and alcoves.

3. There is no other activity in the vicinity such that the thermal load and/or mechanical load will affect the tests, and vice versa.

4. A trailer pad sufficient for a 3.7m x 18.3m machine shop trailer will be provided at the surface of the test area. LLNL will bring the trailer on site. Parking space at the trailer pad for at least one pickup truck will be provided. The trailer pad will have water, sewer, and 120/208 VAC, 3-phase power hookups.

   Note: These design requirements are for the SCP-CD emplacement configuration; review and/or revision of this test would be required if alternate configurations were proposed.

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Repository Horizon Rock-Water Interaction

Definition of Test

The Repository Horizon Rock-Water Interaction Tests are discussed in Section 8.3.4.2.4.4.2 of the Site Characterization Program Baseline (SCPB).

This activity is to obtain samples for laboratory testing of rock-water interactions at high temperatures. The samples needed are 15.24cm to 20.32cm diameter cores or blocks of rock of minimum 20.32cm to 30.48cm on a side. In situ gas and water samples are also needed. These samples may be collected by LLNL or provided by other organizations (e.g. hydrochemistry, Perched Water Programs). The rock types to be studied include the lithophysal Topopah Spring tuff at the contact between the Tiva Canyon and Topopah Spring units, the welded Topopah Spring, the Basal Vitrophyre of the Topopah Spring, and the top of the zeolitic Tuff in the Calico Hills unit.

Functional Requirements

1. Provide the facility design and operational flexibility to collect samples for the Repository Horizon Rock-Water Interaction Test.

Performance Criteria

1a. There is no space requirement; no alcove is needed. The locations of the sampling include the North and South Ramps and the Main Test Level; access from the lithophysal zone of Topopah Spring Tuff at the contact of Tiva Canyon and Topopah Spring, Basal Vitrophyre of Topopah Spring, and the top of the zeolitic tuff of the Calico Hill unit.

1b. Sampling hole up to 20.32cm (8") in diameter, may be drilled a few meters deep. Dry drill is required. Block sampling may be obtained by mechanical means from drift surfaces although slotting or line drilling to obtain samples away from the immediate drift surface may be required.

1c. All data will be collected in laboratory by LLNL personnel.

1d. The timing of sample collection is flexible. They can be taken after excavation and construction phases of ramps, drifts, or alcoves.

1e. Normal power, compressed air, lighting, water, and ventilation for the Ramps and the Main Test Level will be adequate except as specifically requested for drilling.

1f. No special access is needed after initial sampling.

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Constraints

A. There is no particular sequential constraint of test.

B. The tests should be started as early as possible so that adequate information can be provided for license application date.

C. No IDS or data collection required.

D. No interference with other activities.

E. Dry drill is required to obtain samples.

F. Sample locations will be approved by the responsible PI prior to sampling activity.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.

   Section 2.3.1 Scientific Manpower/Schedule Information
   Section 2.3.2 Laboratory/Office/Storage Space Requirements
   Section 2.3.3 Electrical Power Requirements
   Section 2.3.4 Water System Requirements
   Section 2.3.5 Compressed Air System Requirements
   Section 2.3.6 Common Sampling Design Requirements
   Section 2.3.7 Communications System Requirements
   Section 3.0 Integrated Data System

Assumptions

1. Office space at the ESF and some space will be assigned in Area 25.

2. Office space at the ESF should provide enough space and change house for at least 2 persons.

3. There will be a common sampling program developed. LLNL will evaluate the sampling requirement when that program is developed.

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APPENDIX B

EXPLORATORY STUDIES FACILITY DESIGN REQUIREMENTS

SECTION 2.3

Integration Studies For ESF Testing

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ESFDR Appendix B
Section 2.3.1

Scientific Manpower Requirements for Exploratory Studies Facility Testing

Description

A testing integration study will be developed and provided in this section which defines the recommended planning and design assumptions for on-site scientific manpower requirements to support ESF testing. Initial estimates provided here were developed in 1988 (Los Alamos letter ESD-WX4-7/88-7) and will be refined as a part of the manpower integration study. This integration study will be completed during Title II design.

Functional Requirements

1. Provide the system design and operational flexibility to accommodate ESF testing manpower requirements.

Performance Criteria

1a. The ESF should be designed to accommodate a nominal scientific work force of 100 persons.

1b. Peak scientific manpower, during day shift in the first few months after MTL Core Test Area test locations first become available, is estimated to be 120 people.

Constraints

TBD

Assumptions

1. Initial analysis is based on a network of 670 resource loaded test activities. This network contained input from 19 PIs. The judgments and assumptions are discussed in a Los Alamos letter dated July 12, 1988 (ESD-WX4-7/88-7). Subsequent revision by the PIs allowed the recommended peak scientific manpower to be reduced to 120 people. Manpower estimates will be refined as test planning proceeds.

2. Manpower estimates do not include
   A. Drilling crews
   B. Cable plant installation
   C. Construction activities
   D. Official visitors

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ESFDR Appendix B
Section 2.3.2

Laboratory/Office/Storage Space Requirements

Description

The Laboratory/Office/Storage Requirements for ESF Testing are specific for facilities or areas that are dedicated to testing. They are located both above and below ground. The ESFDR, Section 1.2.6.3.2, "Test Support Facilities" presents functional requirements and performance criteria for common test support assembly, check-out, and repair facilities. That information is not duplicated in this section. Testing requirements for laboratory, office, and storage areas are dependent on test planning and design activities and will be developed and incorporated in this section as Title II design and test planning proceed.

Functional Requirements

1. Provide the design and operational flexibility for provision of adequate laboratory, office, and storage space to support the ESF testing activities.

Performance Criteria

1a. All support facilities must be located so that support can be provided to testing activities at all ESF access portals and underground test locations. If necessary, this may require some facility replication. If facilities are not replicated on each pad site, then readily accessible, unimpeded transportation between sites must be provided for.

Constraints

TBD

Assumptions

TBD

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ESFDR Appendix B
Section 2.3.3

Electrical Power Requirements for Exploratory Studies Facility Testing

Description

Appendix B, Sections 2.2 and 3.0, provide electrical power requirements for each ESF test and the IDS. If requirements are expected to exceed the designed standard power available at each underground test location (accesses and drifts), then specific power design requirements for lighting, instrumentation and heaters, data collection, or other test support are provided as performance criteria in each test subsection. No consideration of construction-related or drilling electrical power requirements is included.

If no special power requirements are anticipated for a specific test, a statement of adequacy for standard power supply is included. These statements are considered preliminary until the ESF designer provides initial ESF electrical power availability and distribution information.

As ESF Title II design test planning proceeds, this section will be used to summarize electrical power requirements for ESF testing support at all locations in the facility.

Functional Requirements

1. Provide the system design and operational flexibility to ensure adequate provision of electrical power to support all ESF test activities.

Performance Criteria

TBD

Constraints

TBD

Assumptions

1. Unless specifically defined in Sections 2.2 and 3.0, normal lighting values from design handbooks for laboratories and offices are acceptable in testing alcoves.

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ESFDR Appendix B
Section 2.3.4

Water System Design Requirements For Exploratory Studies Facility Testing

Description

A testing integration study will be conducted to define the water system requirements to support ESF testing. Results will be provided in this section as ESF Title II design and test planning proceed.

Functional Requirement

1. Provide the system design and operational flexibility to accommodate ESF testing water requirements.

Performance Criteria

1a. Each test location will have water provided. Unless specifically considered in Section 2.2, standard ESF water system capacity, to be determined by the ESF designer, is adequate. Supply lines capable of providing an intermittent flow rate of 38 lpm to each test area is minimally required.

1b. The water supply for each test shall be provided to an access coupling and an isolation valve near each test location.

1c. All water will be tagged with a suitable tracer to be determined and documented.

1d. All water used in or around the ESF for each activity will be monitored, and appropriate quantity records will be maintained by the ESF Test Coordination Office. Methods of monitoring and recording water usage will be developed by the ESF designer and are to be determined.

Constraints

A. Water system leakage must be minimized and shall be contained to the maximum extent possible.

B. A performance evaluation of all water sources used in underground construction must be performed prior to use. The analysis must assess potential impacts to characterization testing and waste isolation.

Assumptions

1. The test organizations will be responsible for the distribution system downstream from the isolation valve.

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2. Each organization will be responsible for adding test-specific tracers to its respective test (if needed) subject to tracer limitations necessitated by other tests.

3. Standards for water meter accuracy conforming to American Water Works Association standard C700-77 will be adequate.

4. Water metering will be required, as a minimum, at each tracer injection location.

5. Water usage location and quantity records will be collected and handled using procedures developed or approved by the Project Office. It is anticipated that a "best effort" criterion will be adequate.

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ESFDR APPENDIX B
Section 2.3.5

Compressed Air System Design Requirements for Exploratory Studies Facility Testing

Description

A testing integration study will be conducted to define the compressed air system requirements to support ESF testing. Results will be provided in this section as ESF Title II design and test planning proceed.

Functional Requirements

1. Provide the design and operational flexibility in the compressed air system to accommodate ESF testing requirements.

Performance Criteria

1a. Each test location will have compressed air provided. Unless specifically considered in Section 2.2, standard ESF compressed air system capacity, to be determined by the ESF designer, is considered adequate.

1b. The compressed air supply for each test shall be provided to an access coupling and an isolation valve near each test location.

1c. All compressed air will be tagged with SF6 (or other approved) tracer at a concentration TBD.

Constraints

A. Provision will be made to prevent the introduction of liquid water from the compressed air supply into tests that are sensitive to water, such as Diffusion, Bulk Permeability, Repository Horizon Near-Field Hydrologic Properties, and Radial Boreholes.

B. A performance evaluation of all gas tracers proposed for use in the ESF must be performed prior to their acceptance. The analysis must assess potential impacts to characterization testing and waste isolation.

Assumptions

1. The test organizations will be responsible for the distribution downstream from the isolation valve.

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ESFDR APPENDIX B
Section 2.3.6

Common Sampling Design Requirements for Exploratory Studies Facility Testing

Description

Sample collection requirements occur whenever cores, bulk, or other samples of rock, water, or gas are required to support ESF testing. Control and collection procedures will be developed by the PIs, with coordination and custodial documentation provided by the Sample Management Facility staff. An integration study of common sampling requirements will be conducted, and resulting requirements which provide performance criteria or constraints related to ESF design and operation will be provided in this section as test planning and design proceed.

Functional Requirements

1. Provide a system design and construction specifications with sufficient flexibility to accommodate ESF sample collection requirements.

Performance Criteria

1a. Sample collection will be required to satisfy the Performance Criteria of various ESF tests as identified in Section 2.2. The facility design must be capable of variously accommodating sample collection as specified in Section 2.2.

1b. ESF design considerations for the Underground Geologic Mapping Test (Section 2.2, subsection [B-2.2.20]) shall incorporate flexibility to accommodate sampling support for short drilling, coring, and bulk sample collection to support identified ESF test activities.

Constraints

TBD

Assumptions

None identified.

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ESFDR APPENDIX B
Section 2.3.7

Communications System Design Requirements
for Exploratory Studies Facility Testing

Description

A testing integration study will be conducted which defines the communication system requirements to support ESF Testing. Results will be provided in this section, as ESF design requirements, as test planning and Title II design proceed.

Functional Requirements

1. Provide sufficient design and operational flexibility to ensure intercom and telephone service to all ESF test locations, alcoves, and test support facilities.

Performance Criteria

1a. Permanent intercom or telephone stations must be provided in each of the major ESF test locations and IDS equipment enclosures. This includes the IDS Surface Facility and the Main Test Level IDS shop. Unless specifically considered in Section 2.2, standard ESF communication system provisions, to be determined by the ESF designer, is considered adequate.

Constraints

A. The intercom and telephone systems cabling and equipment must be designed such that no detectable electromagnetic signals are induced into the IDS data acquisition equipment or any associated sensor.

B. No data to be used for site characterization will be transmitted over the telephone or intercom systems.

C. Both telephone and intercom systems will be powered from uninterruptable power supplies.

D. The intercom system will be designed and constructed to prevent radio-frequency interference that could affect electromagnetic measurements to be made.

Assumptions

1. The type of cabling or other media used to support the intercom and telephone systems is left to the designer.

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APPENDIX B

EXPLORATORY STUDIES FACILITY DESIGN REQUIREMENTS

SECTION 3.0

Facility Design Requirements for IDS

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ESFDR Appendix B
Section 3.0

FACILITY DESIGN REQUIREMENTS FOR INTEGRATED DATA SYSTEM (IDS)

Description

This section of the ESFDR defines the ESF design requirements to support the IDS. The elements of the IDS to be supported at the ESF are grouped in five major categories:

1. An IDS Surface Facility, containing the primary IDS computers, archiving devices and communications equipment.

2. Data Acquisition Station facility support at each IDS supported test alcove or location in the ESF.

3. Cabling systems to support collection of test data, movement of data and commands between IDS components and distribution of data and status to users.

4. An underground IDS repair shop with spare parts storage capability.

5. Office space in the Area 25 Field Operations Center for IDS work stations.

Functional Requirements

1. Provide the system design and operational flexibility necessary to support the IDS.

   a. Provide the surface facilities necessary to ensure the Principal Investigators and their respective organizations adequate IDS Support to be able to perform their testing needs. The Surface Facility is to provide a controlled environment space which will contain the equipment needed to support the IDS operations and the various tests conducted by PIs throughout the ESF.

   b. Provide the facilities within the ESF necessary to ensure the Principal Investigators and their respective organizations adequate IDS support at the test locations to be able to perform their testing needs.

   c. Provide the cabling systems necessary to support the testing needs of the principal investigators and operation of the IDS.

   d. Provide an environmentally controlled underground enclosure for the repair of IDS equipment and the storage of spare parts.

   e. Provide office space in the Area 25 Field Operations Center for IDS work stations to support Principal Investigators in controlling and monitoring their tests.

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Performance Criteria

1a. A surface facility shall be provided with a minimum usable floor space of 4200 sq ft to house the IDS computers and associated equipment.

(i). The building shall have an 0.46m raised floor, to house IDS power and data cabling.

(ii). The building shall be environmentally controlled to provide a temperature of 23 degrees celsius, plus or minus two degrees, and a relative humidity of 50% non-condensing. Windows will be dust tight and an air lock type entry shall be provided.

(iii). The building's metallic segments shall be connected together in such a fashion that the entire structure can be connected to the common earth ground.

(iv). The Surface Facility requires TBD kVA, 208/120 VAC, three phase Uninterruptable Power Supply (UPS) system.

(v). The Surface Facility requires TBD kVA, 208/120 VAC, three phase normal power distribution system.

(vi). Provide the IDS surface facility with a fire suppression system designed for computer room service.

1b. A Data Acquisition Station (DAS) will be required at each IDS supported test location. The individual DAS specific facility support requirements are TBD.

(i). Each DAS must be located as near to its supported test as is possible, within the constraints of designated construction practice, and will require a minimum of 3m by 3m floor space.

(ii). DAS enclosure and environmental requirements are TBD.

1c. All IDS components and systems shall conform to the IDS Grounding and Shielding plan that will be developed as part of the IDS design.

(i). The cabling systems on all runs shall be designed to provide the maximum possible separation between the power cables, the data cables and the communications cables.

(ii). All power systems shall have their neutral and grounds returned to a single common earth ground.

(iii). A telephone is required at each DAS location.

(iv). Cabling shall be provided from each DAS to other IDS components. A data communications system shall connect to each DAS and the IDS surface facility.

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1d. The underground IDS repair and spare parts storage facility shall be located on the main test level adjacent to the core test panel.

4a. The underground repair and spare parts storage facility shall be a minimum of 100 sq m.

4b. The underground repair and spare parts storage facility shall be environmentally controlled to provide a temperature of 24 degrees celsius plus or minus 3 degrees.

4c. The underground repair and spare parts storage facility will require TBD UPS system power and TBD normal power distribution system.

4d. A fire suppression system shall be provided for the underground repair and spare parts storage facility.

1e. The IDS work space required in the Field Operations Center is typical office environment and a minimum of 37 sq m.

5a. The power requirements are 5 kVA, 120 VAC 1 phase and are normal power. There are no UPS power requirements.

5b. There are no "special" environmental or fire suppression requirements.

5c. Electrical cables are required between the room and the microwave equipment located elsewhere in the building for the data communications link to the IDS surface facility. Three telephones are required.

Constraints

A. The IDS Surface Facilities shall be placed as far away from any equipment likely to produce electromagnetic fields as is practical. This includes power feeders, electrical rotating machinery and other large electrical loads.

Assumptions

1. The IDS surface facility will be in place in time to support IDS installation prior to the beginning of North Ramp construction.

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APPENDIX C

(RESERVED FOR FUTURE USE)

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APPENDIX D

(RESERVED FOR FUTURE USE)

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APPENDIX E

APPLICABLE REGULATIONS, CODES, STANDARDS, AND DOE ORDERS

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APPLICABLE REGULATIONS, CODES, STANDARDS, AND DOE ORDERS

The design and construction of the ESF shall be in accordance with all applicable parts of the following:

General

CODE OF FEDERAL REGULATIONS (CFR)

- 10 CFR 20, Standards for Protection Against Radiation
- 10 CFR 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories
- 10 CFR 960, General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories
- 29 CFR 1910, Occupational Safety and Health Standards (OSHA)
- 29 CFR 1926, Safety and Health Regulations for Construction (OSHA)
- 30 CFR CHAPTER I, Mine Safety and Health Administration (MSHA)
- 40 CFR 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes

U.S. CODE (USC)

- 49 USC 1501, Federal Aviation Act

U.S. CONGRESS

- Nuclear Waste Policy Act of 1982, Public Law 97-425
- Nuclear Waste Policy Act Amendments of 1987, Public Law 100-203

U.S. DEPARTMENT OF ENERGY (DOE)

- DOE Order 5400, Environmental Quality and Impact (Also refer to ESFDR Appendix J, "Exploratory Studies Facility Environmental Requirements" which contains ESF-related environmental requirements)
  - DOE Order 5400.3, Hazardous and Radioactive Mixed Waste Program
  - DOE Order 5480.1, Chg. 12/18/80, Chapter XII, Prevention, Control, and Abatement of Environmental Pollution

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- DOE Order 5480.1B, Environmental Protection, Safety, and Health Protection Program

- DOE/NV Order 5480.1B-20, Environmental Safety and Health Program for DOE

- DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards. The Mandatory ES&H Standards (Policy Requirements) listed under 2.e.8, Mine and Tunnel Safety, do not apply.

- DOE/NV Order 5480.4-17, Environmental Protection, Safety, and Health Protection Standards, July 2, 1986

- DOE Order 5480.7, Fire Protection

- DOE Order 5480.9, Construction Safety and Health Program

- DOE Order 5480.10, Contractor Industrial Hygiene Program

- DOE/NV Order 5480.10-26, Contractor Industrial Hygiene Program

- DOE Order 5481.1B, Safety Analysis and Review System

- DOE/NV Order 5481.1B-21, Safety Analysis and Review System, January 25, 1988

- DOE Order 5482.1B, Environmental Protection, Safety, and Health Protection Appraisal Program

- DOE/NV Order 5482.1B-19, Environmental, Safety, and Health Appraisal

- DOE Order 5483.1A, 6-22-83, Occupational Safety and Health Program for Government Owned Contractor-Operated Facilities

- DOE Order 5484.1, Environmental Protection, Safety and Health Protection Information Reporting Requirements

- DOE/NV 54XA.1-2, NTS Traffic Regulations (proposed)

- DOE/NV 54XB.1-28, Laser Safety (proposed)

o DOE Order 5900, Energy Information

o DOE Order 6400, Construction and Engineering

  - DOE Order 6430.1A, General Design Criteria

o DOE/RW-0005, Mission Plan for the Civilian Radioactive Waste Management Program

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- DOE/RW-0119, OCRWM Safety Plan
- DOE/AD/06212-1, Site Development Planning Handbook
- DOE/NV/00410-77, Reynolds Electrical and Engineering Company Safety and Health Program Plan, Nevada Nuclear Waste Storage Investigations Exploratory Shaft at Yucca Mountain
- UCRL- 15910, Design Evaluation guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards, Draft (Rev. 4), May, 1989.
- DOE/EP 0108, Standard for Fire Protection of DOE Electronic Computer/Data Processing Systems
- DOE/EV 0051/1, Electrical Safety Criteria for Research and Development Activities
- DOE/EV 06194-3, DOE Explosive Safety Manual
- DOE (U.S. Department of Energy), Site Characterization Program Baseline, YMP/CM-0011, Rev. 0, Las Vegas, NV, February 21, 1991

U.S. DEPARTMENT OF INTERIOR

- Bureau of Land Management Manual (BLM Manual) Reg. 9-247

STATE OF NEVADA

- Nevada Revised Statutes (NRS) Title 40, Public Health and Safety
  - Chapter 278, Planning and Zoning
  - Chapter 439, Administration of Public Health
  - Chapter 444, Sanitation
  - Chapter 445, Water Controls, Air Pollution
  - Chapter 446, Food Establishments
  - Chapter 618, Occupational Safety and Health
- NRS Title 46, Chapter 512, State of Nevada Health and Safety Standards for Open Pit and Underground Metal and Nonmetal Mines and Sand, Gravel, and Crushed Stone Operations
- Nevada Administrative Code (NAC)
  - Chapter 444, Hazardous Waste Disposal
  - Chapter 445, Water Pollution Control, Air Pollution
  - Chapter 512, Inspection and Safety of Mines

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- o Department of Transportation
  - Standard Specifications for Road and Bridge Construction
  - Standard Plans for Road and Bridge Construction
  - Road Design Division, Design Manual, Parts 1 and 2

Industrial and Professional Society Publications

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (ASSHTO)

- o A Policy on Geometric Design of Highways and Streets

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

- o Threshold Limit Values and Biological Exposure Indices

AMERICAN CONCRETE INSTITUTE (ACI)

- o ACI 301, Specifications for Structural Concrete for Buildings
- o ACI 304, Recommended Practice for Measuring, Mixing, Transporting , and Placing Concrete
- o ACI 305, Recommended practice for Hot Weather Concreting
- o ACI 308, Standard Practice for Curing Concrete
- o ACI 316, Recommended Practice for Construction of Concrete Pavements and Concrete Bases
- o ACI 318, Building Code Requirements for Reinforced Concrete
- o ACI 318.1, Building Code Requirements for Structural Plain Concrete
- o ACI 347, Recommended Practice for Concrete Formwork

PRESTRESSED CONCRETE INSTITUTE

- o Standards

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

- o Manual of Steel Construction

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- o B31.3, Chemical Plant and and Petroleum Refinery Piping
- o C2, National Electrical Safety Code

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- ANS-2.3, Standard for Estimating Tornado and Extreme Wind Characteristics at Nuclear Power Sites

- ANS-2.5, Standard for Determining Meteorological Information at Nuclear Power Sites

- ANS-2.8, Standard for determining Design Basis Flooding at Power Reactor Sites

AMERICAN SOCIETY OF CIVIL ENGINEERS

- 7-88, Minimum Design Loads for Buildings and Other Structures

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS (ASHRAE)

- 1985 Handbooks, Fundamentals

- 1988 Handbook, Equipment

- 1987 Handbook, HVAC Systems and Applications

- 1986 Handbook, Refrigeration

- 62, Ventilation for Acceptable Indoor Air Quality

- 90.1, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

- Boiler and Pressure Vessel Code: Section VIII, Division I, Unfired Pressure Vessel Code

AMERICAN SOCIETY OF TESTING MATERIALS (ASTM)

- A184, Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement

- A185, Standard Specification for Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement

- A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

- A775, Standard Specification for Epoxy-Coated Reinforcing Steel Bars

- C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

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- D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction
- E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

AMERICAN WATER WORKS ASSOCIATION

- C700, Cold-Water Meters--Displacement Type, Bronze Main Case

AMERICAN WELDING SOCIETY

- AWS D1.1 Structural Welding Code - Steel

DIESEL ENGINE MANUFACTURER ASSOCIATION (DEMA)

- Standard Practices for Stationary Diesel and Gas Engines

INSTRUMENTATION SOCIETY OF AMERICA (ISA)

- Standards and Specifications

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- 141, Recommended Practice for Electrical Power Distribution for Industrial Plants
- 142, Recommended Practice for Grounding of Industrial and Commercial Power Systems
- 387, Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Generating Stations
- 485, Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations
- 583, Standard Modular Instrumentation and Digital Interface System
- 595, Standard Serial Highway Interface System
- 650, Qualification of Class 1E Battery Chargers and Inverters for Nuclear Power Generating Stations

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS

- Uniform Building Code (UBC)
- Uniform Mechanical Code (UMC)
- Uniform Plumbing Code (UPC)

NATIONAL ASSOCIATION OF PLUMBING-HEATING-COOLING CONTRACTORS

- National Standard Plumbing Code

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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- National Fire Codes
- 22, Water Tanks for Private Fire Protection
- 20, Centrifugal Fire Pumps
- 24, Installation of Private Fire Service Mains and Their Appurtenances
- 70, National Electrical Code

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APPENDIX F.1

CROSS REFERENCE 10 CFR 60 TO ESFDR, VOLUME 1

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10 CFR 60 Quote	ESFDR Location
10 CFR 60.15(b)	1.2.6.5 PC 1a.
10 CFR 60.15(b)	1.2.6.6 PC 1a.
10 CFR 60.15(c)(1)	1.2.6.0 C C.(1)
10 CFR 60.15(c)(1)	1.2.6.4 PC 2a.
10 CFR 60.15(c)(1)	1.2.6.5 PC 2a.
10 CFR 60.15(c)(1)	1.2.6.6 PC 2a.
10 CFR 60.15(c)(1)	1.2.6.7 C B.
10 CFR 60.15(c)(2)	1.2.6.0 C C.(2)
10 CFR 60.15(c)(2)	1.2.6.4 PC 1a.
10 CFR 60.15(c)(2)	1.2.6.5 PC 1b.
10 CFR 60.15(c)(2)	1.2.6.6 PC 1b.
10 CFR 60.15(c)(3)	1.2.6.0 C C.(3)
10 CFR 60.15(c)(3)	1.2.6.1.1 C A.
10 CFR 60.15(c)(3)	1.2.6.4 PC 2b.
10 CFR 60.15(c)(3)	1.2.6.5 PC 2b.
10 CFR 60.15(c)(3)	1.2.6.6 PC 2b.
10 CFR 60.15(c)(3)	1.2.6.8 C D.
10 CFR 60.15(c)(4)	1.2.6.0 C C.(4)
10 CFR 60.15(c)(4)	1.2.6.6 PC 2d.
10 CFR 60.21(c)(1)(ii)(D)	1.2.6.4 PC 2c.
10 CFR 60.21(c)(1)(ii)(D)	1.2.6.5 PC 2c.
10 CFR 60.21(c)(1)(ii)(D)	1.2.6.6 PC 2c.
10 CFR 60.74(a)	1.2.6.0 C D.
10 CFR 60.74(a)	1.2.6.4 C A.
10 CFR 60.74(a)	1.2.6.5 C A.
10 CFR 60.74(a)	1.2.6.6 C A.
10 CFR 60.74(a)	1.2.6.7 C C.
10 CFR 60.74(b)	1.2.6.0 C D.[2]
10 CFR 60.74(b)	1.2.6.4 C A.[2]
10 CFR 60.74(b)	1.2.6.5 C A.[2]
10 CFR 60.74(b)	1.2.6.6 C A.[2]
10 CFR 60.111(b)(1)	1.2.6.0 PC 2b.
10 CFR 60.111(b)(3)	1.2.6.0 PC 2b.[2]
10 CFR 60.130	1.2.6.0 C E.
10 CFR 60.130	1.2.6.4 PC 2d.
10 CFR 60.130	1.2.6.5 PC 2d.
10 CFR 60.130	1.2.6.6 PC 2e.
10 CFR 60.131(b)(1)	1.2.6.0 C F.
10 CFR 60.131(b)(2)	1.2.6.0 C G.
10 CFR 60.131(b)(3)(i)	1.2.6.0 C H.
10 CFR 60.131(b)(3)(ii)	1.2.6.0 C H.[2]
10 CFR 60.131(b)(3)(iii)	1.2.6.0 C H.[3]
10 CFR 60.131(b)(3)(iv)	1.2.6.0 C H.[4]
10 CFR 60.131(b)(6)	1.2.6.0 C I.
10 CFR 60.131(b)(9)	1.2.6.0 C J.
10 CFR 60.133(a)(1)	1.2.6.4 PC 2e.
10 CFR 60.133(a)(1)	1.2.6.5 PC 2e.
10 CFR 60.133(a)(1)	1.2.6.6 PC 2f.
10 CFR 60.133(a)(2)	1.2.6.4 PC 2f.

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10 CFR 60 Quote	ESFDR Location
10 CFR 60.133(a)(2)	1.2.6.5 PC 2f.
10 CFR 60.133(a)(2)	1.2.6.6 PC 2g.
10 CFR 60.133(a)(2)	1.2.6.7 C D.
10 CFR 60.133(b)	1.2.6.4 PC 2g.
10 CFR 60.133(b)	1.2.6.5 PC 2g.
10 CFR 60.133(b)	1.2.6.6 PC 2h.
10 CFR 60.133(b)	1.2.6.7 C E.
10 CFR 60.133(c)	1.2.6.5.PC 2h.
10 CFR 60.133(c)	1.2.6.6.PC 2i.
10 CFR 60.133(d)	1.2.6.0 PC 2e.
10 CFR 60.133(d)	1.2.6.4 PC 2h.
10 CFR 60.133(d)	1.2.6.5 PC 2i.
10 CFR 60.133(d)	1.2.6.6 PC 2j.
10 CFR 60.133(d)	1.2.6.7 C F.
10 CFR 60.133(d)	1.2.6.8 C E.
10 CFR 60.133(e)(1)	1.2.6.5 PC 2h.[2]
10 CFR 60.133(e)(1)	1.2.6.6 PC 2i.[2]
10 CFR 60.133(e)(2)	1.2.6.4 PC 2i.
10 CFR 60.133(e)(2)	1.2.6.5 PC 2j.
10 CFR 60.133(e)(2)	1.2.6.6 PC 2k.
10 CFR 60.133(f)	1.2.6.4 PC 2j.
10 CFR 60.133(f)	1.2.6.5 PC 2k.
10 CFR 60.133(f)	1.2.6.6 PC 2l.
10 CFR 60.133(i)	1.2.6.4 PC 2k.
10 CFR 60.133(i)	1.2.6.5 PC 2l.
10 CFR 60.133(i)	1.2.6.6 PC 2m.
10 CFR 60.134	1.2.6.0 C K.
10 CFR 60.134(a)	1.2.6.4 PC 2l.
10 CFR 60.134(a)	1.2.6.5 PC 2m.
10 CFR 60.134(a)	1.2.6.6 PC 2n.
10 CFR 60.134(b)	1.2.6.4 PC 2l.[2]
10 CFR 60.134(b)	1.2.6.5 PC 2m.[2]
10 CFR 60.134(b)	1.2.6.6 PC 2n.[2]
10 CFR 60.137	1.2.6.4 C B.
10 CFR 60.137	1.2.6.5 C B.
10 CFR 60.137	1.2.6.6 C B.
10 CFR 60.137	1.2.6.7 C G.

Sections Not Quoted verbatim

(10 CFR 60.2 "definitions apply")	1.2.6.0 Def.
(10 CFR 60.4(b) "in accord")	1.2.6.0 PC 1k.i
(10 CFR 60.15(c)(1) "in accord")	1.2.6.1 C A.
(10 CFR 60.15(c)(1) "in accord")	1.2.6.2 C A.
(10 CFR 60.21(c)(1)(ii)(E) "in accord")	1.2.6.0 PC 2d.i
(10 CFR 60.21(c)(11) "in accord")	1.2.6.0 C R.
(10 CFR 60.72 "satisfy req")	1.2.6.0 PC 1f.
(10 CFR 60.111(a) "in accord")	1.2.6.0 PC 2d.ii

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Sections Not Quoted verbatim	ESFDR Location
(10 CFR 60.112 "not affect perf obj")	1.2.6.0 C C.viii
(10 CFR 60.112 "not affect perf obj")	1.2.6.1 C C.iii
(10 CFR 60.112 "not affect perf obj")	1.2.6.2 C E.
(10 CFR 60.112 "not affect perf obj")	1.2.6.2.2 C G.
(10 CFR 60.112 "not affect perf obj")	1.2.6.2.3 C C.
(10 CFR 60.112 "not affect perf obj")	1.2.6.2.5 C C.
(10 CFR 60.112 "meet perf obj")	1.2.6.4 PC 2l.i
(10 CFR 60.112 "meet perf obj")	1.2.6.5 PC 2m.i
(10 CFR 60.112 "meet perf obj")	1.2.6.6 PC 2n.i
(10 CFR 60.112 "not affect perf obj")	1.2.6.7.5 PC 1
(10 CFR 60.112 "not affect perf obj")	1.2.6.7.6 PC 1b.
(10 CFR 60.112 "not affect perf obj")	1.2.6.7.6 PC 1e.
(10 CFR 60.112 "meet perf obj")	1.2.6.7.8 C A.
(10 CFR 60.113(a)(1)(i) "in accord")	1.2.6.0 PC 2d.iii
(10 CFR 60.113(a)(1)(ii)(A) "in accord")	1.2.6.0 PC 2d.iv
(10 CFR 60.113(a)(1)(ii)(B) "in accord")	1.2.6.0 PC 2d.iv
(10 CFR 60.122(c)(1) "in accord")	1.2.6.1.4 C A.
(10 CFR 60.130 "in accord")	1.2.6.1 C E.
(10 CFR 60.131(b)(4)(i) "in accord")	1.2.6.0 PC 2d.v
(10 CFR 60.133(a)(2) "in accord")	1.2.6.1 PC 1b.
(10 CFR 60.133(d) "in accord")	1.2.6.1 C F.
(10 CFR 60.133(d) "in accord")	1.2.6.2 C D.
(10 CFR 60.133(f) "in accord")	1.2.6.1 C C.
(10 CFR 60.133(g) "in accord")	1.2.6.0 PC 2d.vi
(10 CFR 60.133(g)(3) "in accord")	1.2.6.4 PC 1g.iii
(10 CFR 60.133(g)(3) "in accord")	1.2.6.5 PC 1h.iii
(10 CFR 60.133(g)(3) "in accord")	1.2.6.6 PC 1h.iv
(10 CFR 60.133(h) "in accord")	1.2.6.0 PC 2d.vii
(10 CFR 60.137 "in accord")	1.2.6.1 C D.
(10 CFR 60.140 "in accord")	1.2.6.0 PC 2d.viii
(10 CFR 60.141 "in accord")	1.2.6.0 PC 2d.ix
(10 CFR 60.142 "in accord")	1.2.6.0 PC 2d.x
(10 CFR 60.141 and 142 "meet req")	1.2.6.4 C B.i
(10 CFR 60.141 and 142 "meet req")	1.2.6.5 C B.i
(10 CFR 60.141 and 142 "meet req")	1.2.6.6 C B.i
(10 CFR 60.151 "in accord")	1.2.6.0 PC 2d.xi
(10 CFR 60.152 "in accord")	1.2.6.0 PC 2d.xii
(10 CFR 60 Sub F "meet req")	1.2.6.4 C B.iii
(10 CFR 60 Sub F "meet req")	1.2.6.5 C B.iii
(10 CFR 60 Sub F "meet req")	1.2.6.6 C B.iii

Appendix E of the WMSR Volume IV lists requirements from 10 CFR 60 which, according to the Nuclear Regulatory Commission (NRC) staff, must be considered in the ESF design. The NRC staff views the determination of which Part 60 requirements need to be considered in the ESF as a two-step process: 1) since the ESF will be incorporated as part of the repository, then all Part 60 requirements are applicable to the ESF; and 2) DOE must then evaluate

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which of these requirements actually have an impact on the design of the ESF. We believe that DOE's approach, discussed at the October 4, 1989, technical exchange and further explained in this transmittal is not inconsistent with NRC's approach.

All requirements have been considered in the ESFDR and nothing in this document will later preclude the potential repository complying with the requirements listed in WMSR IV. However, some of the listed 10 CFR 60 requirements do not directly influence the ESF design and are not in the ESFDR.

The use of several of the 10 CFR 60 requirements was the subject of discussion between NRC and DOE. The reasons for considering but not directly using the following 10 CFR 60 requirements in the ESFDR are given in a February 27, 1990, letter from DOE (Appel) to the NRC (Linehan) and are repeated below.

10 CFR 60.17, CONTENTS OF SITE CHARACTERIZATION PLAN

- This section does not directly impose requirements on the ESF since it only briefly identifies the required contents of the SCP, referring specifically to plans and descriptions that need to be provided in that document.

- The SCP and its supporting study plans identify the parameters that need to be considered in ESF design, construction, and operation.

10 CFR 60.24(a), UPDATING OF APPLICATION AND ENVIRONMENTAL REPORT

- This section does not directly impose requirements on the design, construction, and operation of the ESF since its focus is directed to providing for updating the license application and accompanying documents.

- It provides indirect guidance to the extent that the license application must be as complete as possible in terms of the information required for NRC to make a determination.

- The SCP provides the plans with respect to what needs to be considered in the ESF design.

10 CFR 60.113(a)(2), PRE-WASTE EMPLACEMENT GROUNDWATER TRAVEL TIME

- While the design, construction, and operation of the underground workings of the ESF could affect the location of the disturbed zone boundary, this requirements directs determination of groundwater travel time from wherever that boundary ends up being. This is effectively a siting criterion applicable to the geologic setting, but does not directly impose requirements on the ESF.

- The requirement to minimize impacts to the disturbed zone is generally covered by 60.15(c), not 60.113(a)(2).

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10 CFR 60.113(b)(2), (3), (4), FACTORS NRC WILL CONSIDER IN CASE-BY-CASE EVALUATION OF PERFORMANCE OBJECTIVES

- This section does not directly impose requirements on the ESF. This section serves to provide flexibility with respect to the numerical limits pertaining to the performance objectives for the engineered barrier system and the geologic setting, as stipulated in 60.113(a).

- The need for the ESF to allow gathering of information relevant to the factors listed in this section of Part 60 come from the scope of the site characterization program, which is defined in the SCP and related study plans.

10 CFR 60.122, SITING CRITERIA

- This sections does not directly impose requirements on the ESF since it addresses favorable and potentially adverse conditions which are to be used as siting criteria applicable to the geologic setting.

- The requirement to evaluate the existence of potentially adverse conditions, including 10 CFR 60.122(c)(1) [in the ESFDR], is addressed in program requirements documents and the SCP and its related study plans.

- Evaluation of the location of underground accesses with respect to flooding potential is being considered as part of the ESF design process in accordance with 10 CFR 60.133(d).

10 CFR 60.131(a), GENERAL DESIGN CRITERIA FOR RADIOLOGICAL PROTECTION

- This section, in particular 60.131(a)(1), needs to be considered to the extent that the ESF must be designed such that it does not preclude the repository from meeting these requirements. It should be noted that compliance with these requirements is primarily a function of equipment design and operating procedures for the purpose of radiation protection, which imposes future requirements on equipment and operations.

- It should be noted that, while the NWPA requires the NRC to concur on the need to use radioactive material during site characterization, the use of such material is not subject to NRC licensing requirements, as stipulated in 60.7. DOE radiological safety orders would be applicable.

- Currently, there is no plan to use radioactive wastes in the ESF during site characterization.

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10 CFR 60.131(b)(4)(ii), ONSITE FACILITIES FOR EMERGENCIES

- This section does not impose requirements on the ESF since it addresses requirements that are applicable only to repository operations and would not affect the design of ESF permanent components.

- The section requires that the geologic repository operations area (GROA) include onsite facilities and services for responding to radiological emergencies and that facilitate the use of available offsite services for that application.

- The ESF will include similar facilities or services in accordance with non-radiological safety requirements.

- It should be noted that, while the NWPA requires the NRC to concur on the need to use radioactive material during site characterization, the use of such material is not subject to NRC licensing requirements, as stipulated in 60.7. DOE radiological safety orders would be applicable.

- Currently, there is no plan to use radioactive wastes in the ESF during site characterization.

10 CFR 60.131(b)(8), INSTRUMENTATION AND CONTROL SYSTEMS

- This section does not directly impose requirements on the ESF since it addresses requirements that are applicable only to repository operations and would not affect the design of ESF permanent components.

- The section requires that instrumentation and control systems be provided to monitor the behavior of systems important to safety over the anticipated ranges for normal operation and for accident conditions.

- The extent to which this requirement would need to be considered in ESF design is to ensure that the ESF design does not preclude the addition of instrumentation and control systems. However, the inclusion of such a requirement is not expected to provide any additional flexibility in design beyond what already exists.

10 CFR 60.131(b)(10), SHAFT CONVEYANCES USED IN RADIOACTIVE WASTE HANDLING

- This section does not impose requirements on the ESF since it addresses requirements for hoists important to safety that are used for radioactive waste handling.

- Currently, radioactive wastes are not planned to be used in the ESF during site characterization.

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- It should be noted that, while the NWPA requires the NRC to concur on the need to use radioactive material during site characterization, the use of such material is not subject to NRC licensing requirements, as stipulated in 60.7. DOE radiological safety orders would be applicable.

10 CFR 60.143, MONITORING AND TESTING OF WASTE PACKAGES

- This section does not impose requirements on the ESF since it addresses performance confirmation monitoring and testing that is specifically applicable to the waste packages.

- Currently, no radioactive wastes are planned to be used in the ESF during site characterization.

- Likewise, in the future, the ESF portion of the geologic repository operations area will not contain waste packages.

The following additional 10 CFR 60 requirement has been considered but has not been included in the ESFDR because it is covered elsewhere.

- 10 CFR 60.16, Site characterization plan required before sinking shafts (The Site Characterization Plan has been written and NRC comments have been received and considered by DOE.)

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APPENDIX F.2

CROSS REFERENCE ESFDR, VOLUME 1, TO 10 CFR 60

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ESFDR Location	10 CFR 60 Location
1.2.6.0 Def	(10 CFR 60.2 "definitions apply")
1.2.6.0 PC 1f.	(10 CFR 60.72 "satisfy req")
1.2.6.0 PC 1k.i	(10 CFR 60.4(b) "in accord")
1.2.6.0 PC 2b.	10 CFR 60.111(b)(1)
1.2.6.0 PC 2b.[2]	10 CFR 60.111(b)(3)
1.2.6.0 PC 2d.i	(10 CFR 60.21(c)(1)(ii)(E) "in accord")
1.2.6.0 PC 2d.ii	(10 CFR 60.111(a) "in accord")
1.2.6.0 PC 2d.iii	(10 CFR 60.113(a)(1)(i) "in accord")
1.2.6.0 PC 2d.iv	(10 CFR 60.113(a)(1)(ii)(A) "in accord")
1.2.6.0 PC 2d.iv	(10 CFR 60.113(a)(1)(ii)(B) "in accord")
1.2.6.0 PC 2d.v	(10 CFR 60.131(b)(4)(i) "in accord")
1.2.6.0 PC 2d.vi	(10 CFR 60.133(g) "in accord")
1.2.6.0 PC 2d.vii	(10 CFR 60.133(h) "in accord")
1.2.6.0 PC 2d.viii	(10 CFR 60.140 "in accord")
1.2.6.0 PC 2d.ix	(10 CFR 60.141 "in accord")
1.2.6.0 PC 2d.x	(10 CFR 60.142 "in accord")
1.2.6.0 PC 2d.xi	(10 CFR 60.151 "in accord")
1.2.6.0 PC 2d.xii	(10 CFR 60.152 "in accord")
1.2.6.0 PC 2e.	10 CFR 60.133(d)
1.2.6.0 C C.(1)	10 CFR 60.15(c)(1)
1.2.6.0 C C.(2)	10 CFR 60.15(c)(2)
1.2.6.0 C C.(3)	10 CFR 60.15(c)(3)
1.2.6.0 C C.(4)	10 CFR 60.15(c)(4)
1.2.6.0 C C.viii	(10 CFR 60.112 "not affect perf obj")
1.2.6.0 C D.	10 CFR 60.74(a)
1.2.6.0 C D.[2]	10 CFR 60.74(b)
1.2.6.0 C E.	10 CFR 60.130
1.2.6.0 C F.	10 CFR 60.131(b)(1)
1.2.6.0 C G.	10 CFR 60.131(b)(2)
1.2.6.0 C H.	10 CFR 60.131(b)(3)(i)
1.2.6.0 C H.[2]	10 CFR 60.131(b)(3)(ii)
1.2.6.0 C H.[3]	10 CFR 60.131(b)(3)(iii)
1.2.6.0 C H.[4]	10 CFR 60.131(b)(3)(iv)
1.2.6.0 C I.	10 CFR 60.131(b)(6)
1.2.6.0 C J.	10 CFR 60.131(b)(9)
1.2.6.0 C K.	10 CFR 60.134
1.2.6.0 C R.	(10 CFR 60.21(c)(11) "in accord")
1.2.6.1 PC 1b.	(10 CFR 60.133(a)(2) "in accord")
1.2.6.1 C A.	(10 CFR 60.15(c)(1) "in accord")
1.2.6.1 C C.	(10 CFR 60.133(f) "in accord")
1.2.6.1 C C.iii	(10 CFR 60.112 "not affect perf obj")
1.2.6.1 C D.	(10 CFR 60.137 "in accord")
1.2.6.1 C E.	(10 CFR 60.130 "in accord")
1.2.6.1 C F.	(10 CFR 60.133(d) "in accord")
1.2.6.1.1 C A	10 CFR 60.15(c)(3)
1.2.6.1.4 C A.	(10 CFR 60.122(c)(1) "in accord")
1.2.6.2 C A.	(10 CFR 60.15(c)(1) "in accord")
1.2.6.2 C D.	(10 CFR 60.133(d) "in accord")
1.2.6.2 C E	(10 CFR 60.112 "not affect perf obj")
1.2.6.2.2 C G.	(10 CFR 60.112 "not affect perf obj")
1.2.6.2.3 C C.	(10 CFR 60.112 "not affect perf obj")
1.2.6.2.5 C C.	(10 CFR 60.112 "not affect perf obj")

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ESFDR Location	10 CFR 60 Location
1.2.6.4 PC 1a.	10 CFR 60.15(c)(2)
1.2.6.4 PC 1g.iii	(10 CFR 60.133(g)(3) "in accord")
1.2.6.4 PC 2a.	10 CFR 60.15(c)(1)
1.2.6.4 PC 2b.	10 CFR 60.15(c)(3)
1.2.6.4 PC 2c.	10 CFR 60.21(c)(1)(ii)(D)
1.2.6.4 PC 2d.	10 CFR 60.130
1.2.6.4 PC 2e.	10 CFR 60.133(a)(1)
1.2.6.4 PC 2f.	10 CFR 60.133(a)(2)
1.2.6.4 PC 2g.	10 CFR 60.133(b)
1.2.6.4 PC 2h.	10 CFR 60.133(d)
1.2.6.4 PC 2i.	10 CFR 60.133(e)(2)
1.2.6.4 PC 2j.	10 CFR 60.133(f)
1.2.6.4 PC 2k.	10 CFR 60.133(i)
1.2.6.4 PC 2l.	10 CFR 60.134(a)
1.2.6.4 PC 2l.[2]	10 CFR 60.134(b)
1.2.6.4 PC 2l.i	(10 CFR 60.112 "meet perf obj")
1.2.6.4 C A.	10 CFR 60.74(a)
1.2.6.4 C A.[2]	10 CFR 60.74(b)
1.2.6.4 C B.	10 CFR 60.137
1.2.6.4 C B.i	(10 CFR 60.141 and 142 "meet req")
1.2.6.4 C B.iii	(10 CFR 60 Sub F "meet req")
1.2.6.5 PC 1a.	10 CFR 60.15(b)
1.2.6.5 PC 1b.	10 CFR 60.15(c)(2)
1.2.6.5 PC 1h.iii	(10 CFR 60.133(g)(3) "in accord")
1.2.6.5 PC 2a.	10 CFR 60.15(c)(1)
1.2.6.5 PC 2b.	10 CFR 60.15(c)(3)
1.2.6.5 PC 2c.	10 CFR 60.21(c)(1)(ii)(D)
1.2.6.5 PC 2d.	10 CFR 60.130
1.2.6.5 PC 2e.	10 CFR 60.133(a)(1)
1.2.6.5 PC 2f.	10 CFR 60.133(a)(2)
1.2.6.5 PC 2g.	10 CFR 60.133(b)
1.2.6.5 PC 2h.	10 CFR 60.133(c)
1.2.6.5 PC 2h.[2]	10 CFR 60.133(e)(1)
1.2.6.5 PC 2i.	10 CFR 60.133(d)
1.2.6.5 PC 2j.	10 CFR 60.133(e)(2)
1.2.6.5 PC 2k.	10 CFR 60.133(f)
1.2.6.5 PC 2l.	10 CFR 60.133(i)
1.2.6.5 PC 2m.	10 CFR 60.134(a)
1.2.6.5 PC 2m.[2]	10 CFR 60.134(b)
1.2.6.5 PC 2m.i	(10 CFR 60.112 "meet perf obj")
1.2.6.5 C A.	10 CFR 60.74(a)
1.2.6.5 C A.[2]	10 CFR 60.74(b)
1.2.6.5 C B.	10 CFR 60.137
1.2.6.5 C B.i	(10 CFR 60.141 and 142 "meet req")
1.2.6.5 C B.iii	(10 CFR 60 Sub F "meet req")
1.2.6.6 PC 1a.	10 CFR 60.15(b)
1.2.6.6 PC 1b.	10 CFR 60.15(c)(2)
1.2.6.6 PC 1h.iv	(10 CFR 60.133(g)(3) "in accord")
1.2.6.6 PC 2a.	10 CFR 60.15(c)(1)
1.2.6.6 PC 2b.	10 CFR 60.15(c)(3)
1.2.6.6 PC 2c.	10 CFR 60.21(c)(1)(ii)(D)

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ESFDR Location	10 CFR 60 Location
1.2.6.6 PC 2d.	10 CFR 60.15(c)(4)
1.2.6.6 PC 2e.	10 CFR 60.130
1.2.6.6 PC 2f.	10 CFR 60.133(a)(1)
1.2.6.6 PC 2g.	10 CFR 60.133(a)(2)
1.2.6.6 PC 2h.	10 CFR 60.133(b)
1.2.6.6 PC 2i.	10 CFR 60.133(c)
1.2.6.6 PC 2i.[2]	10 CFR 60.133(e)(1)
1.2.6.6 PC 2j.	10 CFR 60.133(d)
1.2.6.6 PC 2k.	10 CFR 60.133(e)(2)
1.2.6.6 PC 2l.	10 CFR 60.133(f)
1.2.6.6 PC 2m.	10 CFR 60.133(i)
1.2.6.6 PC 2n.	10 CFR 60.134(a)
1.2.6.6 PC 2n.[2]	10 CFR 60.134(b)
1.2.6.6 PC 2n.i	(10 CFR 60.112 "meet perf obj")
1.2.6.6 C A.	10 CFR 60.74(a)
1.2.6.6 C A.[2]	10 CFR 60.74(b)
1.2.6.6 C B.	10 CFR 60.137
1.2.6.6 C B.i	(10 CFR 60.141 and 142 "meet req")
1.2.6.6 C B.iii	(10 CFR 60 Sub F "meet req")
1.2.6.7 C B.	10 CFR 60.15(c)(1)
1.2.6.7 C C.	10 CFR 60.74(a)
1.2.6.7 C D.	10 CFR 60.133(a)(2)
1.2.6.7 C E.	10 CFR 60.133(b)
1.2.6.7 C F.	10 CFR 60.133(d)
1.2.6.7 C G.	10 CFR 60.137
1.2.6.7.5 PC 1	(10 CFR 60.112 "not affect perf obj")
1.2.6.7.6 PC 1b.	(10 CFR 60.112 "not affect perf obj")
1.2.6.7.6 PC 1e.	(10 CFR 60.112 "not affect perf obj")
1.2.6.7.8 C A.	(10 CFR 60.112 "meet perf obj")
1.2.6.8 C D.	10 CFR 60.15(c)(3)
1.2.6.8 C E.	10 CFR 60.133(d)

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APPENDIX G

ESF SYSTEMS, FUNCTIONS, AND REQUIREMENTS ANALYSIS LOGIC TREE

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SYSTEMS, FUNCTIONS, AND REQUIREMENTS ANALYSIS FOR THE EXPLORATORY STUDIES FACILITY (ESF) AT YUCCA MOUNTAIN

The logic tree shown in this appendix identifies graphically the systems, functions and requirements for the ESF. It may be viewed as an activities tree for the ESF depicting how its mission will be accomplished.

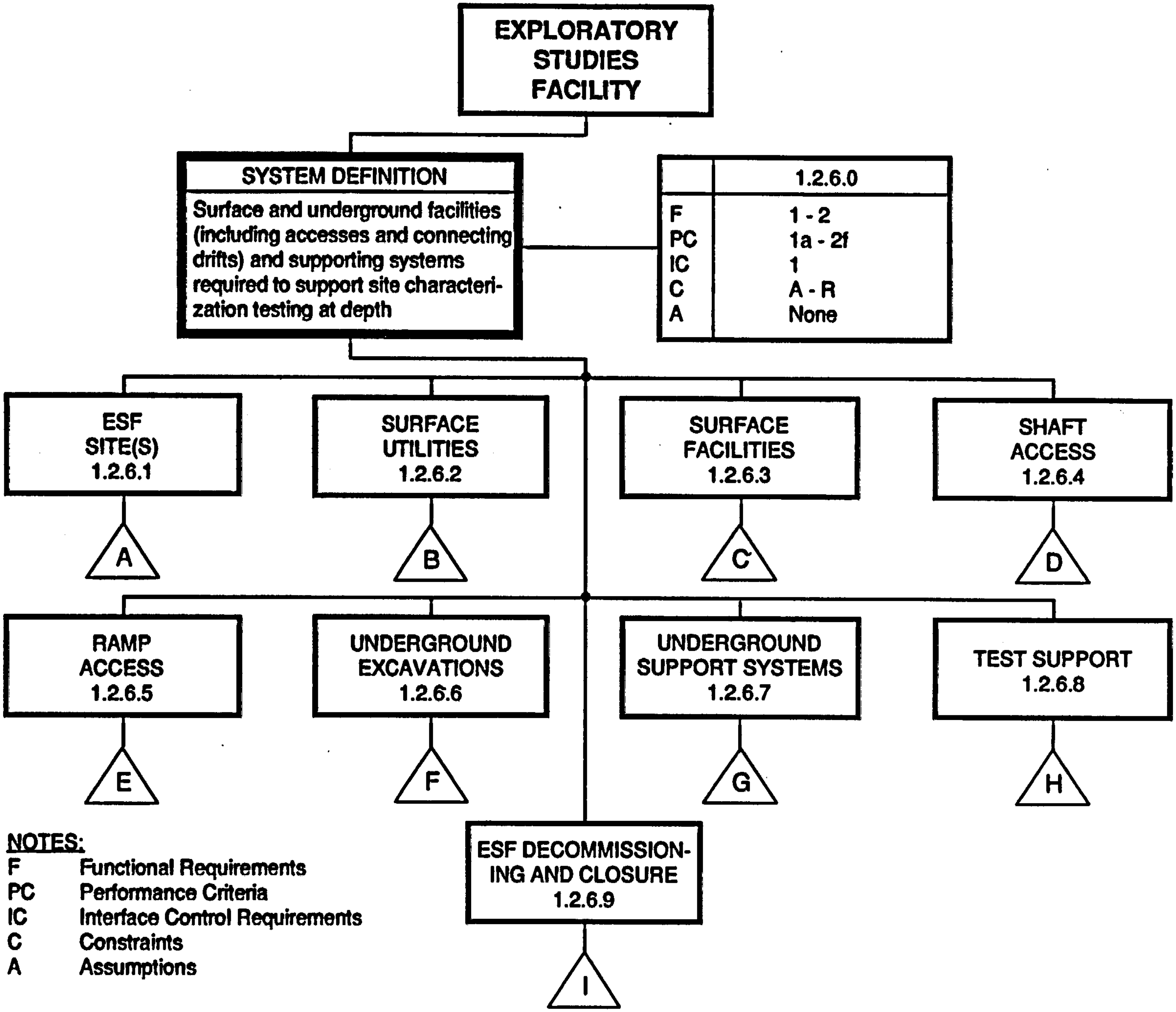
A description of the logic tree is as follows: Each major system is stated in a bold-lined rectangle. Lower-tier subsystems are identified in the rectangles immediately below the superior system. The systems are those identified in the ESFDR document text; i.e., 1.2.6.0 Exploratory Shaft Facility (ESF) identifies the main all-encompassing system, and 1.2.6.1 ESF site(s) identifies a lower-tier or subelement system to 1.2.6.0. Main site(s) (1.2.6.1.1) is yet a lower-tier to 1.2.6.1 and so forth.

Functions and Requirements are shown for each system in the thin-lined rectangle connected to the immediate right of each system rectangle. The functions and requirements are listed in the rectangle and are identified as follows:

F = Functional Requirements
PC = Performance Criteria
IC = Interface Control Requirements
C = Constraints
A = Assumptions

Definitions of these elements are stated in the ESFDR Introduction.

Numerous triangles containing at least one letter and possibly a number occur throughout the tree. These are "off-page connectors." As one proceeds downward from the top of the tree, an off page connector symbol means that the tree is continued on another page at the corresponding set of alphabet letters.



NOTES:

F	Functional Requirements
PC	Performance Criteria
IC	Interface Control Requirements
C	Constraints
A	Assumptions

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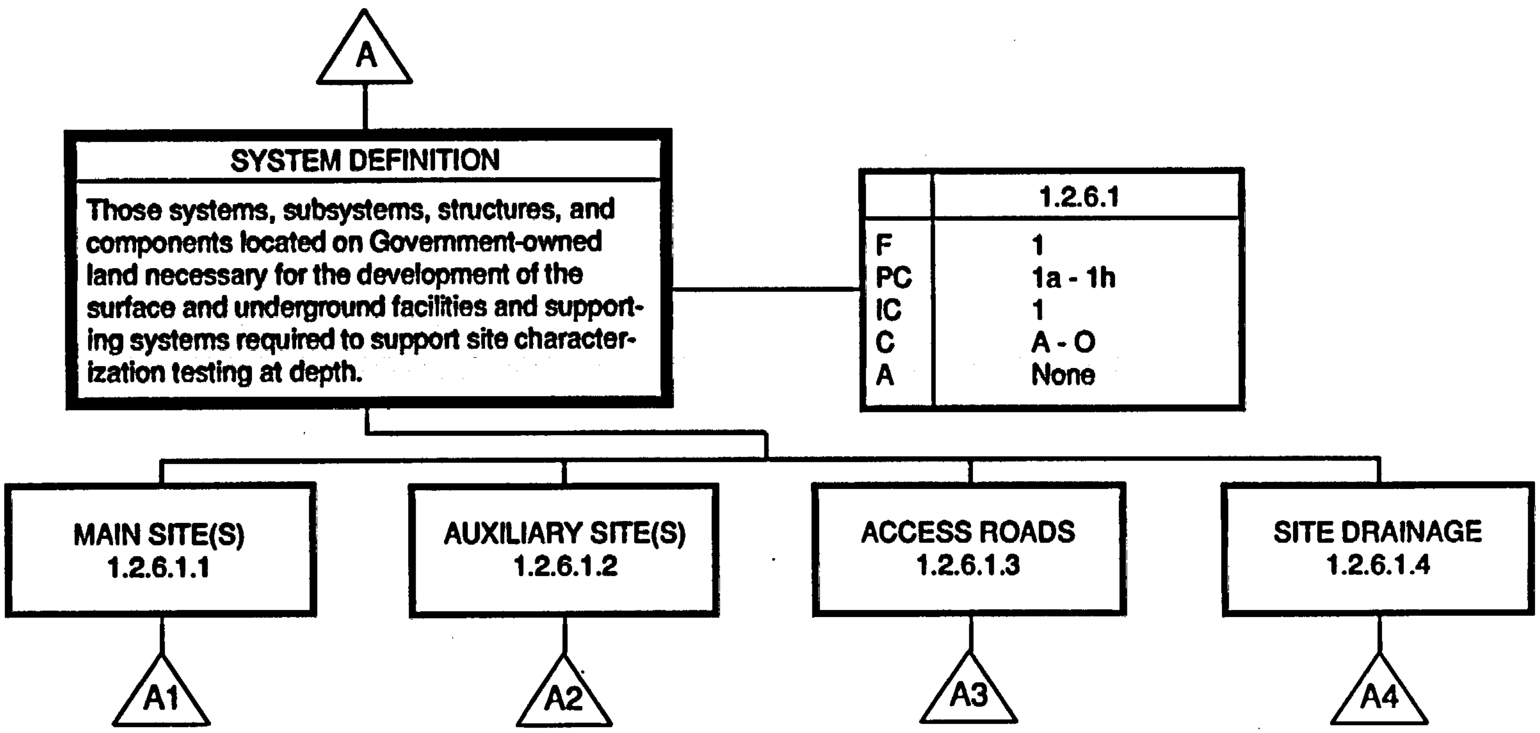
ESF SITE(S)



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MAIN SITE(S)

A1

SYSTEM DEFINITION

Located on the surface, accommodates structures, systems, and components for direct construction of shaft(s) and/or ramps to provide access to the underground site characterization areas but does not include initial construction and test support facilities.

	1.2.6.1.1
F	1
PC	1a - 1b
IC	None
C	A - B
A	1

AUXILIARY SITE(S)

A2

SYSTEM DEFINITION

The Auxiliary Site(s) consist of the areas prepared to support the ESF construction and operation not fulfilled by Main Site(s).

	1.2.6.1.2
F	1
PC	1a - 1b
IC	None
C	A - F
A	None

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ACCESS ROADS

A3

SYSTEM DEFINITION

All features needed to provide vehicular access to all surface areas designated as required to support the ESF.

	1.2.6.1.3
F	1
PC	1a - 1c
IC	None
C	A - G
A	None

SITE DRAINAGE

A4

SYSTEM DEFINITION

Those items and measures utilized to control drainage and runoff water to preclude damage by erosion or flooding.

	1.2.6.1.4
F	1
PC	1
IC	None
C	A
A	None

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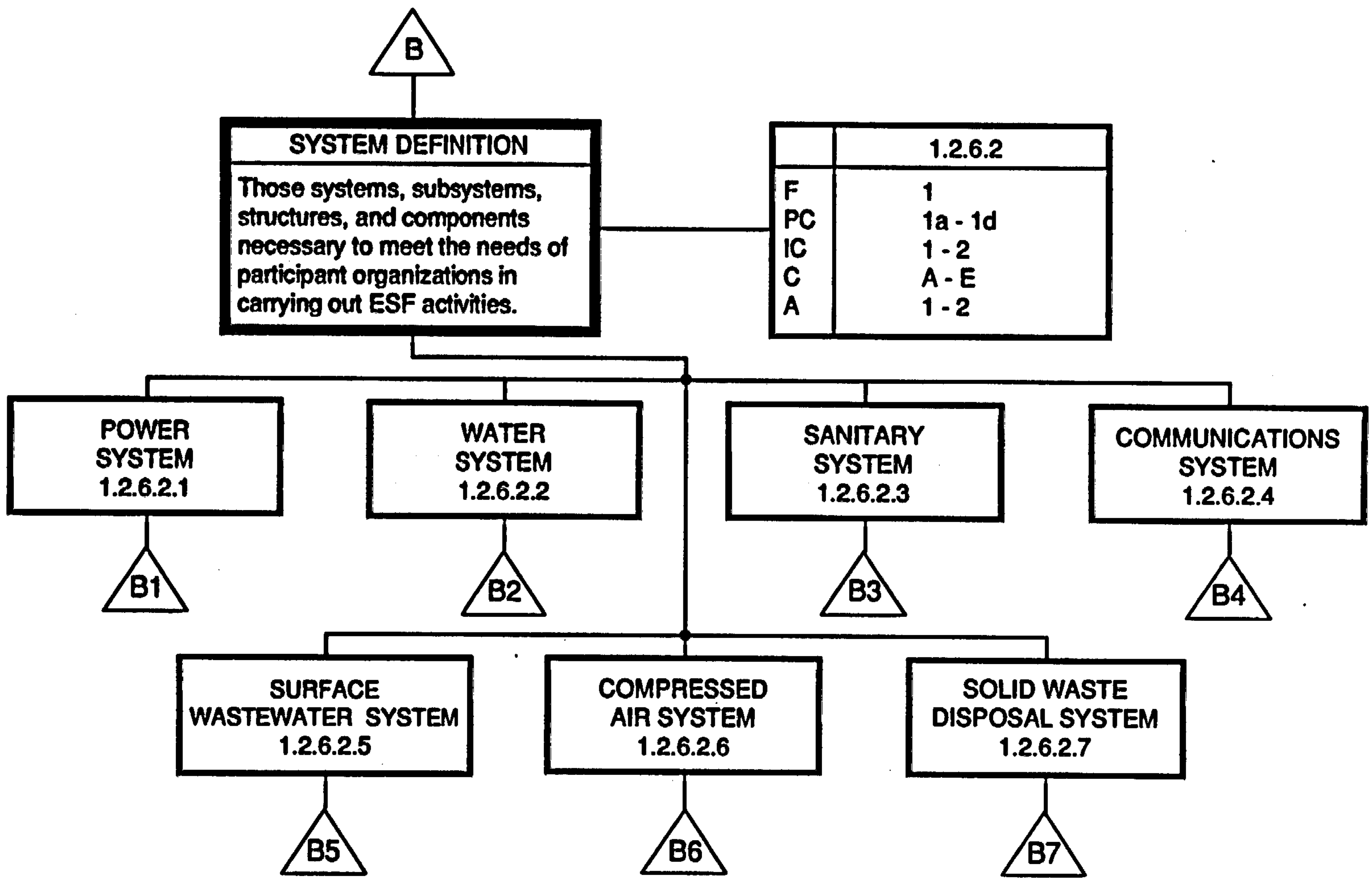
SURFACE UTILITIES



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POWER SYSTEM

B1

SYSTEM DEFINITION

Those systems, subsystems, components, and structures that supply electrical power to the ESF Site.

	1.2.6.2.1
F	1
PC	1a - 1i
IC	None
C	A - E
A	None

WATER SYSTEM

B2

SYSTEM DEFINITION

Those systems, subsystems, and components that supply and distribute the potable and non-potable water for the ESF.

	1.2.6.2.2
F	1
PC	1a - 1i
IC	None
C	A - G
A	None

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SANITARY SYSTEM

B3

SYSTEM DEFINITION

Those systems, subsystems, and components that provide for the surface collection and disposal of sanitary sewage for the support of ESF operations.

	1.2.6.2.3
F	1
PC	1a - 1b
IC	None
C	A - C
A	None

COMMUNICATIONS SYSTEM

B4

SYSTEM DEFINITION

Those systems, subsystems, and components that provide equipment and services for linking the surface areas, the underground areas, and the facilities with each other and with all outside commercial communications systems.

	1.2.6.2.4
F	1
PC	1a - 1g
IC	None
C	A - J
A	1

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SURFACE WASTEWATER SYSTEM

B5

SYSTEM DEFINITION

Those systems, subsystems, and components that provide equipment for collection, transfer, treatment, and disposal of liquid non-sanitary wastes generated underground in the ESF during construction and operations.

	1.2.6.2.5
F	1
PC	1
IC	None
C	A - C
A	None

COMPRESSED AIR SYSTEM

B6

SYSTEM DEFINITION

Those systems, subsystems, and components that provide the production and distribution of compressed air throughout the ESF.

	1.2.6.2.6
F	1
PC	1a - 1d
IC	None
C	A
A	None

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SOLID WASTE DISPOSAL SYSTEM

B7

SYSTEM DEFINITION

Those systems and subsystems required for collection, transport and disposal of solid waste during the ESF construction, operation, testing, and closure activities.

	1.2.6.2.7
F	1
PC	1
IC	None
C	None
A	None

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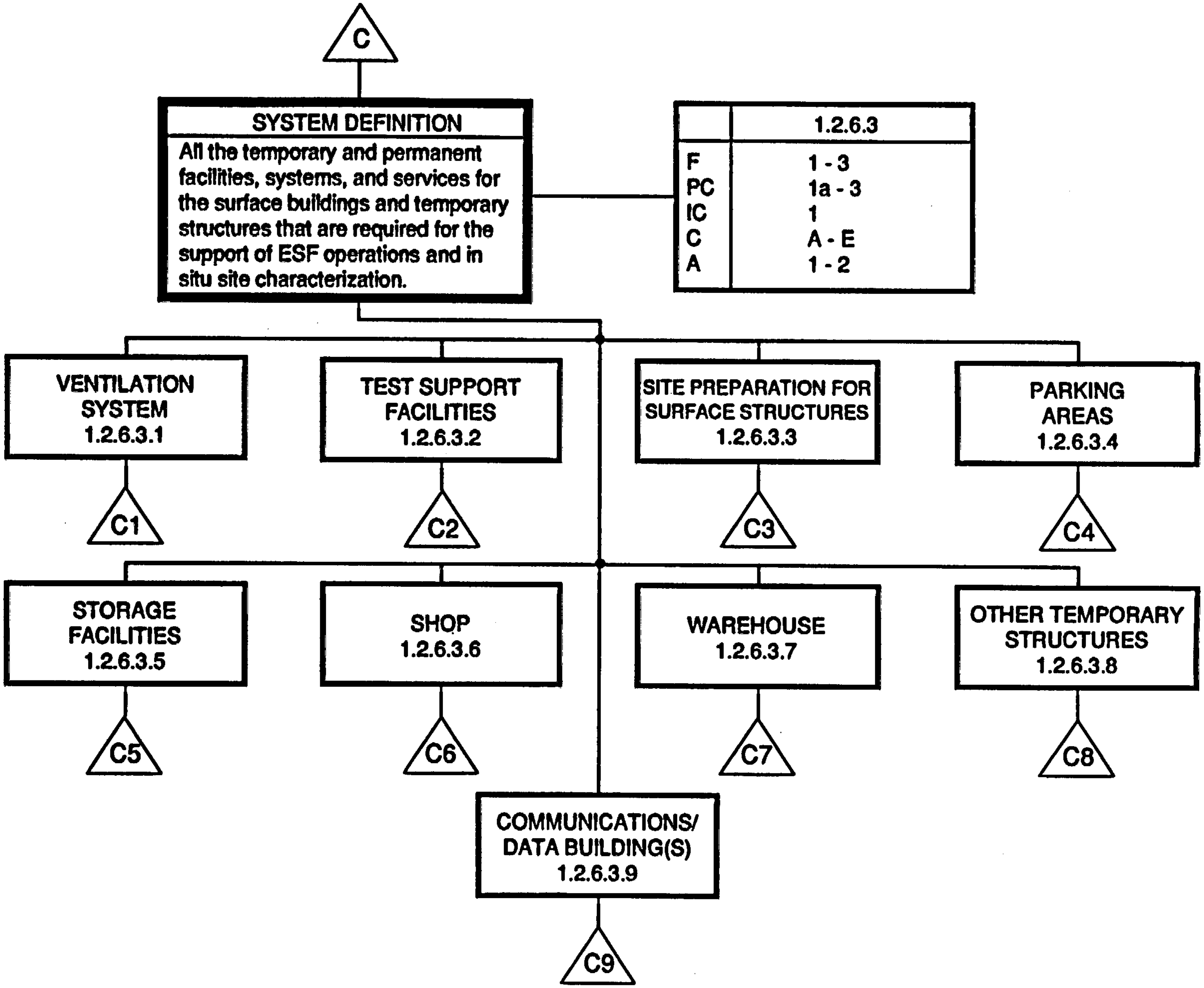
SURFACE FACILITIES



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VENTILATION SYSTEM

C1

SYSTEM DEFINITION

Those surface systems, subsystems, and components that supply fresh air, conditioned if required, to the ventilation distribution system.

	1.2.6.3.1
F	1
PC	1a - 1e
IC	None
C	A - D
A	1

TEST SUPPORT FACILITIES

C2

SYSTEM DEFINITION

Those surface facilities that accommodate the Principal Investigators' testing apparatus for equipment assembly, check out, and repair.

	1.2.6.3.2
F	1
PC	1
IC	None
C	None
A	None

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SITE PREPARATION FOR SURFACE STRUCTURES

C3

SYSTEM DEFINITION

All of the facilities, systems, and services required by the structures during construction and operation of the ESF.

	1.2.6.3.3
F	1
PC	1a - 1b
IC	None
C	None
A	None

PARKING AREAS

C4

SYSTEM DEFINITION

All space and allowances for vehicle parking required to support construction, operation, and testing in the ESF.

	1.2.6.3.4
F	1
PC	1a - 1e
IC	None
C	A - B
A	None

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STORAGE FACILITIES

C5

SYSTEM DEFINITION
All areas, structures, and supporting services to store equipment, supplies, and vehicles in a yard type environment.

	1.2.6.3.5
F	1
PC	1a -1c
IC	None
C	A - B
A	None

SHOP

C6

SYSTEM DEFINITION
All of the facilities, systems, and services for the routine maintenance and repair of the construction and testing equipment designated for the ESF, and of the equipment for maintenance of the grounds.

	1.2.6.3.6
F	1
PC	1a - 1e
IC	None
C	A - E
A	1

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WAREHOUSE

C7

SYSTEM DEFINITION

All the facilities, systems, and services for the safe storage and dispensing of ESF materials that require indoor storage and are not stored in the open areas provided under 1.2.6.3.5, Storage Facilities.

	1.2.6.3.7
F	1
PC	1a - 1b
IC	None
C	A - E
A	None

OTHER TEMPORARY STRUCTURES

C8

SYSTEM DEFINITION

The systems and services that will be utilized for the offices, change rooms, first aid and underground rescue apparatus center, security offices, and space required to support ESF construction, scientific, operations, and maintenance personnel for the Site Characterization Program, including site preparation.

	1.2.6.3.8
F	1
PC	1a - 1e
IC	None
C	A - B
A	1 - 2

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COMMUNICATIONS/DATA BUILDING(S)

C9

SYSTEM DEFINITION

Provides for all the facilities, systems, and services for the communications, data collection, and transmissions that are required to support construction and testing.

	1.2.6.3.9
F	1
PC	1a - 1d
IC	None
C	A
A	None

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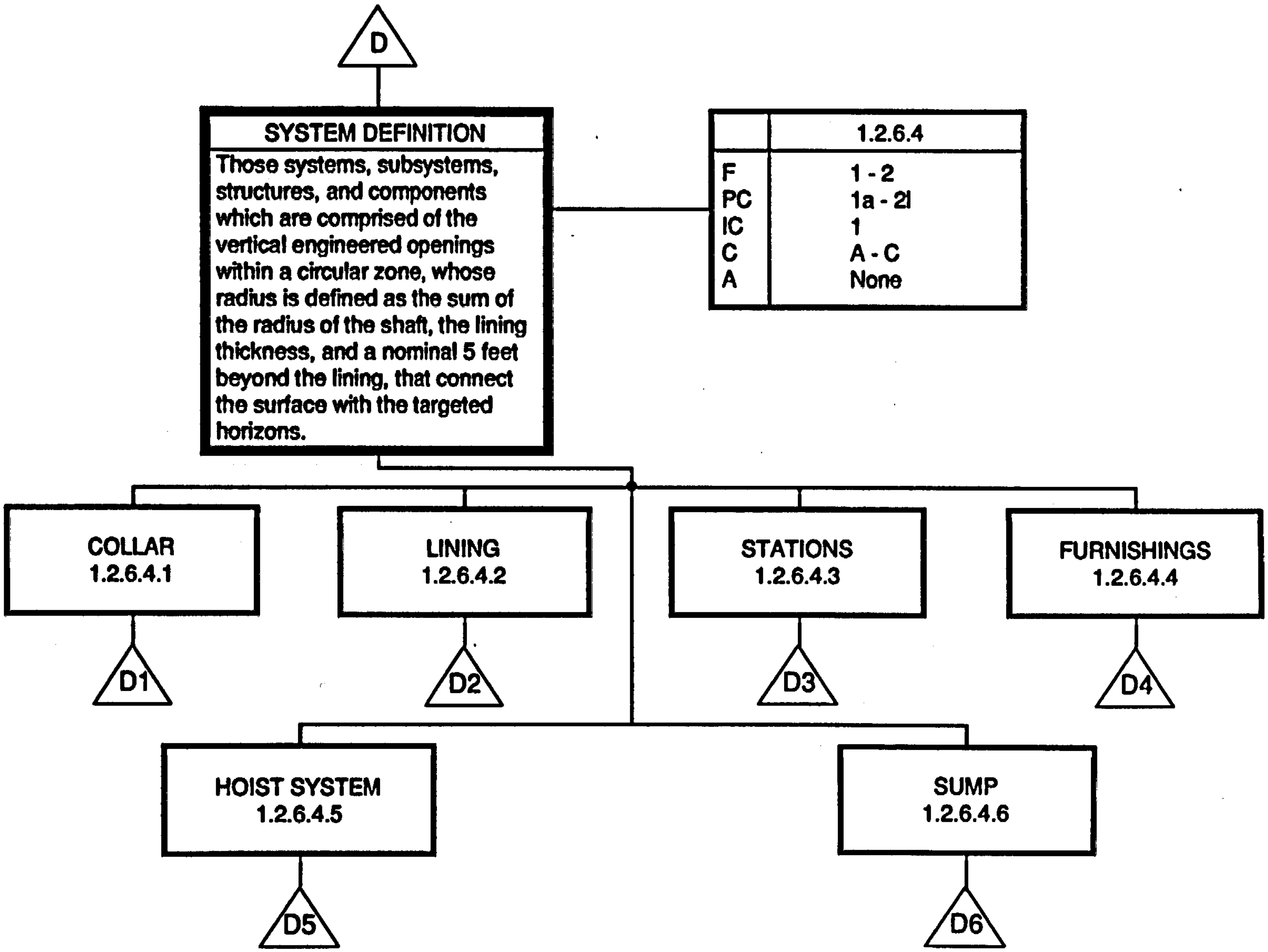
SHAFT ACCESS



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COLLAR

D1

SYSTEM DEFINITION

The foundation at the uppermost portion of the shaft used to support the headframe and shaft construction activities.

	1.2.6.4.1
F	1
PC	1a - 1b
IC	None
C	A - B
A	None

LINING

D2

SYSTEM DEFINITION

Those components (e.g., concrete) which are provided to maintain the integrity of the intended opening.

	1.2.6.4.2
F	1
PC	1a - 1d
IC	None
C	A - C
A	None

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STATIONS

D3

SYSTEM DEFINITION

The initial underground opening at predetermined horizons adjacent to the shaft.

	1.2.6.4.3
F	1
PC	1a - 1h
IC	None
C	A
A	None

FURNISHINGS

D4

SYSTEM DEFINITION

Those structural steel sets consisting of buntons attached to fabricated brackets, which are fixed to the shaft wall or to other structural members.

	1.2.6.4.4
F	1
PC	1a - 1f
IC	None
C	A - D
A	None

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HOIST SYSTEM

D5

SYSTEM DEFINITION

Those systems and components for the transportation of personnel and equipment between the surface and subsurface to meet the needs of shaft construction and underground site characterization testing.

	1.2.6.4.5
F	1
PC	1a - 1j
IC	None
C	A - H
A	None

SUMP

D6

SYSTEM DEFINITION

The area at the bottom of the shaft, below the adjacent horizontal excavation, that contains collection and transfer equipment for the underground wastewater collection system.

	1.2.6.4.6
F	1
PC	1a - 1d
IC	None
C	A
A	None

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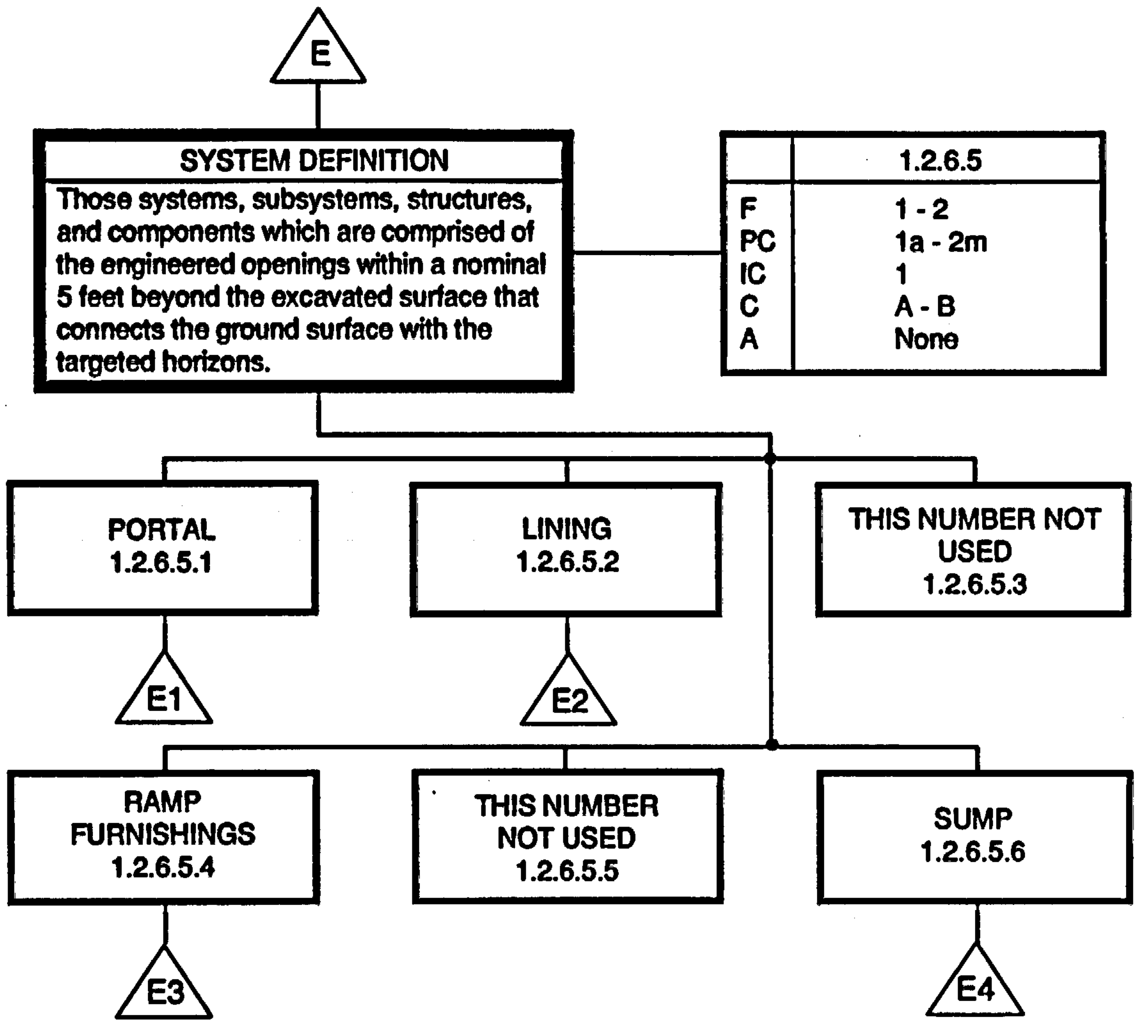
RAMP ACCESS



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PORTAL

E1

SYSTEM DEFINITION

The rock face and retaining structure at the surface entrance of the ramp.

	1.2.6.5.1
F	1
PC	1
IC	None
C	A - B
A	None

LINING

E2

SYSTEM DEFINITION

Those components which are provided to maintain integrity of the intended opening (e.g., concrete).

	1.2.6.5.2
F	1
PC	1a - 1d
IC	None
C	A - C
A	None

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RAMP FURNISHINGS

E3

SYSTEM DEFINITION

Furnishings include fabricated brackets which are fixed to the ramp wall or other support members.

	1.2.6.5.4
F	1
PC	1a - 1c
IC	None
C	A - D
A	None

SUMP

E4

SYSTEM DEFINITION

The area(s) within the ramp that collects underground wastewater for transfer to the underground wastewater collection system.

	1.2.6.5.6
F	1
PC	1a - 1c
IC	None
C	None
A	None

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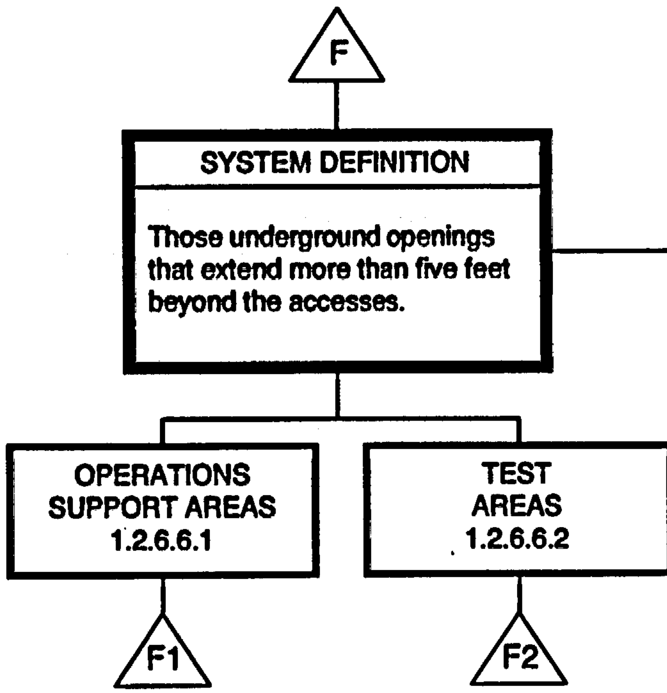
UNDERGROUND EXCAVATIONS



	1.2.6.6
F	1 - 2
PC	1a - 2n
IC	1
C	A - B
A	None

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OPERATIONS SUPPORT AREAS

F1

SYSTEM DEFINITION

Underground openings: drift(s), refuge room(s), operations admin. area, underground shop(s), lunchroom(s), storage facility(ies), maintenance shop(s), power dist. areas, fuel storage, and equipment storage.

	1.2.6.6.1
F	1
PC	1a - 1c
IC	None
C	A - B
A	None

TEST AREAS*

F2

SYSTEM DEFINITION

Openings excavated off the ESF access stations at the upper demonstration breakout room, the main test level, Calico Hills, and other areas.

	1.2.6.6.2
F	1
PC	1
IC	None
C	A - B
A	None

* The tests that will be performed in these areas are defined in Appendix B of the ESFDR.

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UNDERGROUND SUPPORT SYSTEMS

G

SYSTEM DEFINITION

Utilities and provisions for power, communications, lighting, ventilation, water, wastewater removal, compressed air, fire protection, materials and muck handling, sanitation, and safety monitoring and warning.

	1.2.6.7
F	1 - 3
PC	1a - 3b
IC	1
C	A - L
A	None

- POWER DISTRIBUTION SYSTEM 1.2.6.7.1 — G1
- (THIS NUMBER NOT USED) 1.2.6.7.2
- LIGHTING SYSTEM 1.2.6.7.3 — G2
- VENTILATION DISTRIBUTION SYSTEM 1.2.6.7.4 — G3
- WATER DISTRIBUTION SYSTEM 1.2.6.7.5 — G4
- UNDERGROUND WASTE-WATER COLLECTION SYSTEM 1.2.6.7.6 — G5
- COMPRESSED AIR DISTRIBUTION SYSTEM 1.2.6.7.7 — G6
- FIRE PROTECTION SYSTEM 1.2.6.7.8 — G7
- MUCK AND MATERIAL HANDLING SYSTEMS 1.2.6.7.9 — G8
- SANITARY FACILITIES 1.2.6.7.10 — G9
- MONITORING AND WARNING SYSTEMS 1.2.6.7.11 — G10

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POWER DISTRIBUTION SYSTEM

G1

SYSTEM DEFINITION

Systems, subsystems, and components that distribute electrical power to the underground systems.

	1.2.6.7.1
F	1
PC	1a - 1d
IC	None
C	A - F
A	None

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LIGHTING SYSTEM

G2

SYSTEM DEFINITION

Systems, subsystems, and components that provide for the illumination of the ESF underground areas.

	1.2.6.7.3
F	1
PC	1a - 1d
IC	None
C	A - C
A	None

VENTILATION DISTRIBUTION SYSTEM

G3

SYSTEM DEFINITION

Systems, subsystems, and components that allow fresh air to be supplied and exhaust air to be removed from the underground working areas.

	1.2.6.7.4
F	1
PC	1a - 1g
IC	None
C	A - I
A	1

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WATER DISTRIBUTION SYSTEM

G4

SYSTEM DEFINITION
Systems, subsystems, and components that distribute water within the underground facility.

	1.2.6.7.5
F	1
PC	1
IC	None
C	A
A	1

UNDERGROUND WASTEWATER COLLECTION SYSTEM

G5

SYSTEM DEFINITION
Systems, subsystems, and components that collect, control, and transfer underground wastewater to the surface wastewater system (1.2.6.2.5).

	1.2.6.7.6
F	1
PC	1a - 1f
IC	None
C	None
A	None

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COMPRESSED AIR DISTRIBUTION SYSTEM

G6

SYSTEM DEFINITION

Systems, subsystems, and components that distribute compressed air throughout the underground ESF facility.

	1.2.6.7.7
F	1
PC	1
IC	None
C	None
A	None

FIRE PROTECTION SYSTEM

G7

SYSTEM DEFINITION

Systems, subsystems, and components that provide detection and corrective response to extinguish fires within the underground facilities.

	1.2.6.7.8
F	1
PC	1a - 1c
IC	None
C	A - C
A	None

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MUCK AND MATERIAL HANDLING SYSTEMS

G8

SYSTEM DEFINITION

Systems, subsystems, structures, equipment, and components that transport excavated rock (muck), materials, and equipment between surface and subsurface.

	1.2.6.7.9
F	1
PC	1a - 1c
IC	None
C	A - F
A	None

SANITARY FACILITIES

G9

SYSTEM DEFINITION

System that provides for human waste collection underground.

	1.2.6.7.10
F	1
PC	1a - 1c
IC	None
C	None
A	None

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MONITORING AND WARNING SYSTEMS

G10

SYSTEM DEFINITION

System required to monitor underground conditions and to alert onsite personnel of possible dangerous situations.

	1.2.6.7.11
F	1
PC	1a - 1e
IC	None
C	A - C
A	None

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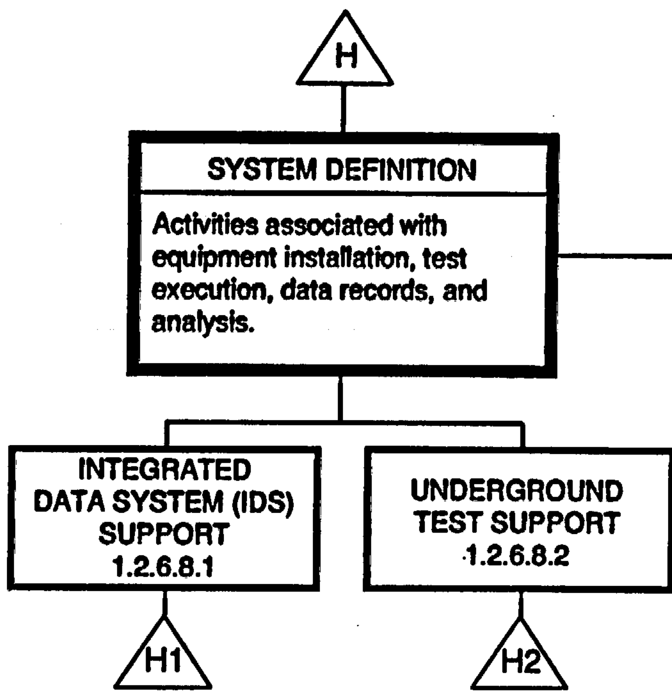
TEST SUPPORT*



	1.2.6.8
F	1
PC	1a - 1d
IC	1
C	A - E
A	1

* Tests are defined in Appendix B of the ESFDR.

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INTEGRATED DATA SYSTEM (IDS) SUPPORT

H1

SYSTEM DEFINITION

Providing facilities as described in ESFDR Appendix B

	1.2.6.8.1
F	1
PC	1
IC	1 - 2
C	None
A	None

UNDERGROUND TEST SUPPORT

H2

SYSTEM DEFINITION

Four types of tests:
- Geologic
- Geomechanic
- Near-field and thermally perturbed
- Hydrologic and transport phenomena

	1.2.6.8.2
F	1
PC	1
IC	None
C	A
A	None

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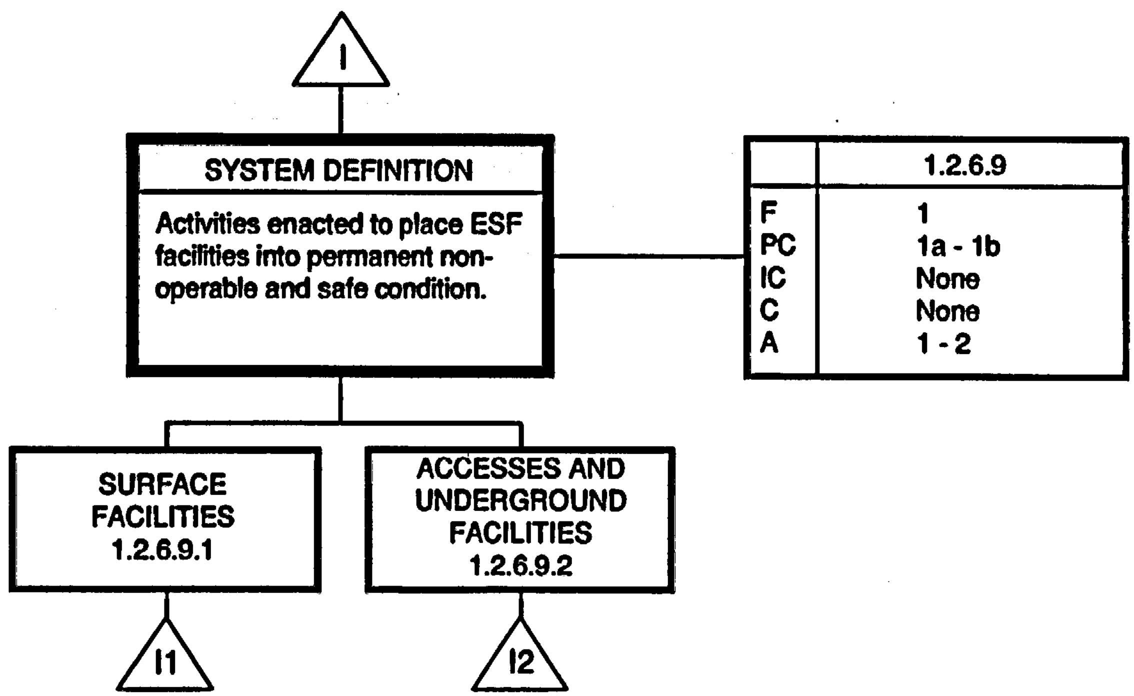
ESF DECOMMISSIONING AND CLOSURE



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APPENDIX H

REQUIREMENTS TRACEABILITY MATRIX

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APPENDIX H

The terms and format of the Requirements Traceability Matrix are explained as follows:

Column (1), ESFDR Requirement, lists the requirements by ESFDR section number. Refer to the ESFDR for the actual requirements.

Column (2), Location in ESFDR, Rev. 0, identifies whether the ESF requirements have been traced to a source of authority. The source of authority for most of the requirements in the ESFDR is the formal review performed for Revision 0 of the ESFDR. That review was performed in accordance with Sandia National Laboratories Procedure DOP 3-13, "Independent Technical and Management Reviews of Documents." "Same" in this column indicates that the present numbered location of the statement is the same as it was in ESFDR Rev. 0.

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.0 EXPLORATORY STUDIES FACILITY	
1.2.6.0 PC 1a.	SAME
1.2.6.0 PC 1b.	SAME
1.2.6.0 PC 1c.	SAME
1.2.6.0 PC 1d.	SAME
1.2.6.0 PC 1d.i	SAME + 1.2.6.0 PC 1d.iii
1.2.6.0 PC 1e.	SAME
1.2.6.0 PC 1f.	SAME
1.2.6.0 PC 1g.	SAME
1.2.6.0 PC 1h.	SAME
1.2.6.0 PC 1i.	SAME
1.2.6.0 PC 1j.	SAME
1.2.6.0 PC 1j.i	SAME
1.2.6.0 PC 1j.ii	SAME
1.2.6.0 PC 1k.	SAME
1.2.6.0 PC 1k.i	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 1l	New text added to document project surveying practice
1.2.6.0 PC 1l.i	New text added to document project surveying practice
1.2.6.0 PC 1l.ii	New text added to document project surveying practice
1.2.6.0 PC 1l.iii	New text added to document project surveying practice
1.2.6.0 PC 2a.	SAME
1.2.6.0 PC 2b	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2b [2]	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2b.i.	1.2.6.0 PC 2b.
1.2.6.0 PC 2b.i.a	1.2.6.0 PC 2b.i
1.2.6.0 PC 2b.i.b	1.2.6.0 PC 2b.ii
1.2.6.0 PC 2b.i.c	1.2.6.0 PC 2b.iii
1.2.6.0 PC 2b.i.d	1.2.6.0 PC 2b.iv
1.2.6.0 PC 2b. (end)	SAME
1.2.6.0 PC 2c.	SAME
1.2.6.0 PC 2c.i	SAME
1.2.6.0 PC 2c.ii	SAME
1.2.6.0 PC 2c.iii	SAME
1.2.6.0 PC 2c.iv	SAME
1.2.6.0 PC 2c.v	SAME
1.2.6.0 PC 2c.vi	SAME
1.2.6.0 PC 2d.	SAME
1.2.6.0 PC 2d.i	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.ii	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.iii	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.iv	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.v	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.vi	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.vii	New text added to comply with WMSR IV, Appendix E

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.0 PC 2d.viii	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.ix	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.x	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.xi	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2d.xii	New text added to comply with WMSR IV, Appendix E
1.2.6.0 PC 2e.	SAME
1.2.6.0 PC 2f.	SAME
1.2.6.0 PC 2f.i	SAME
1.2.6.0 PC 2f.i.a	SAME
1.2.6.0 C A.	
1.2.6.0 C B.	SAME
1.2.6.0 C C.	SAME
1.2.6.0 C C.(1)	SAME
1.2.6.0 C C.(2)	SAME
1.2.6.0 C C.(3)	SAME
1.2.6.0 C C.(4)	SAME
1.2.6.0 C C.i	SAME
1.2.6.0 C C.ii	SAME
1.2.6.0 C C.iii	SAME
1.2.6.0 C C.iv	SAME
1.2.6.0 C C.v	SAME
1.2.6.0 C C.v[2]	SAME
1.2.6.0 C C.v[3]	SAME
1.2.6.0 C C.vi	SAME
1.2.6.0 C C.vii	SAME
1.2.6.0 C C.viii	SAME
1.2.6.0 C D.	SAME
1.2.6.0 C D.[2]	SAME
1.2.6.0 C E.	SAME
1.2.6.0 C E.i	SAME
1.2.6.0 C E.ii	SAME
1.2.6.0 C F	New text added to comply with WMSR IV, Appendix E
1.2.6.0 C G	New text added to comply with WMSR IV, Appendix E
1.2.6.0 C H	New text added to comply with WMSR IV, Appendix E
1.2.6.0 C H [2]	New text added to comply with WMSR IV, Appendix E
1.2.6.0 C H [3]	New text added to comply with WMSR IV, Appendix E
1.2.6.0 C H [4]	New text added to comply with WMSR IV, Appendix E
1.2.6.0 C I	New text added to comply with WMSR IV, Appendix E
1.2.6.0 C J.	1.2.6.0 C G.
1.2.6.0 C J.i	1.2.6.0 C G.i
1.2.6.0 C K.	1.2.6.0 C H.
1.2.6.0 C L.	1.2.6.0 C F.
1.2.6.0 C M.	1.2.6.0 C I.
1.2.6.0 C N.	1.2.6.0 C J.
1.2.6.0 C O.	1.2.6.0 C K.
1.2.6.0 C P	1.2.6.0 C L.
1.2.6.0 C Q.	New text added as 1.2.6.0 C M with Revision of 5/31/91
1.2.6.0 C R.	New text added as 1.2.6.0 C N with Revision of 7/01/91

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.1. ESF SITE(S)	
1.2.6.1 PC 1a.	SAME
1.2.6.1 PC 1b.	SAME
1.2.6.1 PC 1c.	SAME
1.2.6.1 PC 1d.	SAME
1.2.6.1 PC 1e.	SAME
1.2.6.1 PC 1f.	SAME
1.2.6.1 PC 1g.	SAME
1.2.6.1 PC 1h.	SAME
1.2.6.1 C A.	SAME
1.2.6.1 C B.	SAME
1.2.6.1 C C.	SAME
1.2.6.1 C C.i	SAME
1.2.6.1 C C.ii	SAME
1.2.6.1 C C.iii	SAME
1.2.6.1 C D.	SAME
1.2.6.1 C E.	SAME
1.2.6.1 C F.	SAME
1.2.6.1 C F.i	SAME
1.2.6.1 C F.ii	SAME
1.2.6.1 C F.iii	SAME
1.2.6.1 C F.iv	SAME
1.2.6.1 C F.v	SAME
1.2.6.1 C F.vi	1.2.6.1 C O
1.2.6.1 C G.	SAME
1.2.6.1 C H.	SAME
1.2.6.1 C I.	SAME
1.2.6.1 C J.	SAME
1.2.6.1 C K.	SAME
1.2.6.1 C L.	SAME
1.2.6.1 C M.	SAME
1.2.6.1 C N.	SAME
1.2.6.1 C O	C 2 in ESFDR Appendix A.1
1.2.6.1.1 PC 1a.	SAME
1.2.6.1.1 PC 1a.i	SAME
1.2.6.1.1 PC 1a.ii	SAME
1.2.6.1.1 PC 1a.iii	SAME
1.2.6.1.1 PC 1a.iv	SAME
1.2.6.1.1 PC 1a.v	SAME
1.2.6.1.1 PC 1a.vi	SAME
1.2.6.1.1 PC 1a.vii	SAME
1.2.6.1.1 PC 1a.viii	SAME
1.2.6.1.1 PC 1a.ix	SAME
1.2.6.1.1 PC 1a.x	SAME
1.2.6.1.1 PC 1a.xi	SAME
1.2.6.1.1 PC 1a.xii	SAME
1.2.6.1.1 PC 1a.xiii	New text per YMPO request for a helicopter pad

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.1.1 PC 1b.	SAME
1.2.6.1.1 C A.	SAME
1.2.6.1.1 C B.	SAME
1.2.6.1.2 PC 1a.	SAME
1.2.6.1.2 PC 1a.i	SAME
1.2.6.1.2 PC 1a.i.a	SAME
1.2.6.1.2 PC 1a.i.b	SAME
1.2.6.1.2 PC 1a.i.c	SAME
1.2.6.1.2 PC 1a.i.d	SAME
1.2.6.1.2 PC 1a.i.e	SAME
1.2.6.1.2 PC 1a.i.f	SAME
1.2.6.1.2 PC 1a.ii	SAME
1.2.6.1.2 PC 1a.ii.a	SAME
1.2.6.1.2 PC 1a.ii.b	SAME
1.2.6.1.2 PC 1a.ii.c	SAME
1.2.6.1.2 PC 1a.ii.d	SAME
1.2.6.1.2 PC 1a.ii.e	SAME
1.2.6.1.2 PC 1a.ii.f	SAME
1.2.6.1.2 PC 1a.ii.g	SAME
1.2.6.1.2 PC 1a.ii.h	SAME
1.2.6.1.2 PC 1a.ii.i	SAME
1.2.6.1.2 PC 1a.ii.j	SAME
1.2.6.1.2 PC 1a.iii	SAME
1.2.6.1.2 PC 1a.iii.a	SAME
1.2.6.1.2 PC 1a.iii.b	SAME
1.2.6.1.2 PC 1a.iii.c	SAME
1.2.6.1.2 PC 1a.iii.d	SAME
1.2.6.1.2 PC 1a.iii.e	SAME
1.2.6.1.2 PC 1a.iii.f	SAME
1.2.6.1.2 PC 1a.iv.	SAME
1.2.6.1.2 PC 1a.iv.a	SAME
1.2.6.1.2 PC 1a.v.	SAME
1.2.6.1.2 PC 1a.v.a	SAME
1.2.6.1.2 PC 1a.v.b	SAME
1.2.6.1.2 PC 1a.v.c	SAME
1.2.6.1.2 PC 1a.v.d	SAME
1.2.6.1.2 PC 1a.v.e	SAME
1.2.6.1.2 PC 1a.v.f	SAME
1.2.6.1.2 PC 1a.v.g	SAME
1.2.6.1.2 PC 1a.vi	SAME
1.2.6.1.2 PC 1a.vi.a	SAME
1.2.6.1.2 PC 1a.vi.b	SAME
1.2.6.1.2 PC 1a.vi.c	SAME
1.2.6.1.2 PC 1a.vi.d	SAME
1.2.6.1.2 PC 1a.vi.e	SAME
1.2.6.1.2 PC 1b.	SAME
1.2.6.1.2 PC 1b.i	SAME
1.2.6.1.2 PC 1b.ii	1.2.6.1.2 PC 1b.iv
1.2.6.1.2 PC 1b.iii	1.2.6.1.2 PC 1b.v

(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.1.2 C A.	SAME
1.2.6.1.2 C B.	SAME
1.2.6.1.2 C C.	SAME
1.2.6.1.2 C D.	Part of 1.2.6.1.2 C C
1.2.6.1.2 C E.	1.2.6.1.2 C D
1.2.6.1.2 C F.	1.2.6.1.2 A 2
1.2.6.1.3 PC 1a.	1.2.6.1.3 PC 1b.
1.2.6.1.3 PC 1b.	1.2.6.1.3 PC 1c.
1.2.6.1.3 PC 1c.	1.2.6.1.3 PC 1d.
1.2.6.1.3 C A.	SAME
1.2.6.1.3 C B.	SAME
1.2.6.1.3 C C.	SAME
1.2.6.1.3 C D.	SAME
1.2.6.1.3 C E.	SAME
1.2.6.1.3 C F.	SAME
1.2.6.1.3 C G.	SAME
1.2.6.1.4 PC 1.	SAME
1.2.6.1.4 C A.	SAME
1.2.6.2 SURFACE UTILITIES	
1.2.6.2 PC 1a.	SAME
1.2.6.2 PC 1b.	SAME
1.2.6.2 PC 1c.	SAME
1.2.6.2 PC 1d.	1.2.6.2 PC 1e.
1.2.6.2 C A.	SAME
1.2.6.2 C B.	1.2.6.2 C C.
1.2.6.2 C C.	1.2.6.2 C D.
1.2.6.2 C D.	1.2.6.2 C E.
1.2.6.2 C E.	1.2.6.2 C F.
1.2.6.2.1 PC 1a.	SAME
1.2.6.2.1 PC 1b.	SAME
1.2.6.2.1 PC 1c.	SAME
1.2.6.2.1 PC 1d.	SAME
1.2.6.2.1 PC 1e.	1.2.6.2.1 PC 1f.
1.2.6.2.1 PC 1f.	1.2.6.2.1 PC 1g.
1.2.6.2.1 PC 1f.i	1.2.6.2.1 PC 1g.i
1.2.6.2.1 PC 1f.ii	1.2.6.2.1 PC 1g.ii
1.2.6.2.1 PC 1f.iii	1.2.6.2.1 PC 1g.iii
1.2.6.2.1 PC 1f.iv	1.2.6.2.1 PC 1g.iv
1.2.6.2.1 PC 1f.v	1.2.6.2.1 PC 1g.v
1.2.6.2.1 PC 1f.vi	1.2.6.2.1 PC 1g.vi
1.2.6.2.1 PC 1f.vii	1.2.6.2.1 PC 1g.vii
1.2.6.2.1 PC 1f.viii	1.2.6.2.1 PC 1g.ix
1.2.6.2.1 PC 1f.ix	1.2.6.2.1 PC 1g.x

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.2.1 PC 1f.x	1.2.6.2.1 PC 1g.xi
1.2.6.2.1 PC 1g.	1.2.6.2.1 PC 1h.
1.2.6.2.1 PC 1h.	1.2.6.2.1 PC 1i.
1.2.6.2.1 PC 1h.i	1.2.6.2.1 PC 1i.i
1.2.6.2.1 PC 1h.ii	1.2.6.2.1 PC 1i.ii
1.2.6.2.1 PC 1h.iii	1.2.6.2.1 C B
1.2.6.2.1 PC 1i.	1.2.6.2.1 PC 1j.
1.2.6.2.1 PC 1i.i	1.2.6.2.1 PC 1j.i
1.2.6.2.1 C A.	SAME
1.2.6.2.1 C B.	1.2.6.2.1 C C
1.2.6.2.1 C C.	1.2.6.2.1 C D
1.2.6.2.1 C D.	1.2.6.2.1 C F
1.2.6.2.1 C E.	1.2.6.2.1 C G
1.2.6.2.2 PC 1a.	SAME
1.2.6.2.2 PC 1b.	SAME
1.2.6.2.2 PC 1c.	SAME
1.2.6.2.2 PC 1d.	SAME
1.2.6.2.2 PC 1e.	SAME
1.2.6.2.2 PC 1f.	SAME
1.2.6.2.2 PC 1g.	SAME
1.2.6.2.2 PC 1h.	SAME
1.2.6.2.2 PC 1i.	SAME
1.2.6.2.2 C A.	SAME
1.2.6.2.2 C B.	SAME
1.2.6.2.2 C C.	SAME
1.2.6.2.2 C D.	SAME
1.2.6.2.2 C E.	SAME
1.2.6.2.2 C F.	SAME
1.2.6.2.2 C F.i	SAME
1.2.6.2.2 C G.	SAME
1.2.6.2.3 PC 1a.	SAME
1.2.6.2.3 PC 1b.	1.2.6.2.3 PC 1c
1.2.6.2.3 C A.	SAME
1.2.6.2.3 C B.	SAME
1.2.6.2.3 C C.	SAME
1.2.6.2.4 PC 1a.	SAME
1.2.6.2.4 PC 1b.	SAME
1.2.6.2.4 PC 1c.	SAME
1.2.6.2.4 PC 1d.	SAME
1.2.6.2.4 PC 1e.	SAME
1.2.6.2.4 PC 1f.	SAME
1.2.6.2.4 PC 1g.	SAME
1.2.6.2.4 C A.	SAME
1.2.6.2.4 C B.	SAME
1.2.6.2.4 C C.	SAME
1.2.6.2.4 C D.	SAME
1.2.6.2.4 C E.	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.2.4 C F.	SAME
1.2.6.2.4 C G.	SAME
1.2.6.2.4 C H.	SAME
1.2.6.2.4 C I.	SAME
1.2.6.2.4 C J.	SAME
1.2.6.2.5 PC 1.	SAME
1.2.6.2.5 C A.	SAME
1.2.6.2.5 C B.	SAME
1.2.6.2.5 C C.	SAME
1.2.6.2.6 PC 1a.	SAME
1.2.6.2.6 PC 1b.	SAME
1.2.6.2.6 PC 1c.	SAME
1.2.6.2.6 PC 1d.	SAME
1.2.6.2.6 C A.	SAME
1.2.6.2.7 PC 1	New text to replace a TBD
1.2.6.3 SURFACE FACILITIES	
1.2.6.3 PC 1a.	SAME
1.2.6.3 PC 1a.i	SAME
1.2.6.3 PC 1a.ii	SAME
1.2.6.3 PC 1a.iii	SAME
1.2.6.3 PC 1a.iv	SAME
1.2.6.3 PC 1a.v	SAME
1.2.6.3 PC 1a.vi	SAME
1.2.6.3 PC 1a.vii	SAME
1.2.6.3 PC 1a.viii	SAME
1.2.6.3 PC 1a.ix	SAME
1.2.6.3 PC 1a.x	SAME
1.2.6.3 PC 1a.xi	SAME
1.2.6.3 PC 1a.xii	SAME
1.2.6.3 PC 1a.xiii	SAME
1.2.6.3 PC 1a.xiv	SAME
1.2.6.3 PC 1a.xv	SAME
1.2.6.3 PC 1a.xvi	SAME
1.2.6.3 PC 1a.xvii	SAME
1.2.6.3 PC 1a.xviii	SAME
1.2.6.3 PC 1a.xix	SAME
1.2.6.3 PC 1a.xx	SAME
1.2.6.3 PC 1a.xxi	SAME
1.2.6.3 PC 1b.	SAME
1.2.6.3 PC 1c.	SAME
1.2.6.3 PC 1d.	SAME
1.2.6.3 PC 1e.	SAME
1.2.6.3 PC 1f.	SAME
1.2.6.3 PC 1g.	SAME
1.2.6.3 PC 1h	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.3 PC 1i.	SAME
1.2.6.3 PC 1j.	New text requested by J. Gardiner (YMPO)
1.2.6.3 PC 2a.	SAME
1.2.6.3 PC 2b.	SAME
1.2.6.3 PC 3.	SAME
1.2.6.3 C A.	SAME
1.2.6.3 C B.	SAME
1.2.6.3 C C.	SAME
1.2.6.3 C D.	SAME
1.2.6.3 C E.	SAME
1.2.6.3.1 PC 1a.	SAME
1.2.6.3.1 PC 1b.	SAME
1.2.6.3.1 PC 1c.	SAME
1.2.6.3.1 PC 1d.	SAME
1.2.6.3.1 PC 1e.	SAME
1.2.6.3.1 C A.	SAME
1.2.6.3.1 C B.	SAME
1.2.6.3.1 C C.	SAME
1.2.6.3.1 C D.	SAME
1.2.6.3.2 PC 1.	SAME
1.2.6.3.3 PC 1a.	SAME
1.2.6.3.3 PC 1b.	SAME
1.2.6.3.4 PC 1a.	SAME
1.2.6.3.4 PC 1a.i	SAME
1.2.6.3.4 PC 1a.ii	SAME
1.2.6.3.4 PC 1a.iii	SAME
1.2.6.3.4 PC 1a.iv	SAME
1.2.6.3.4 PC 1a.v	SAME
1.2.6.3.4 PC 1a.vi	SAME
1.2.6.3.4 PC 1b.	Part of 1.2.6.3.4 PC 1b
1.2.6.3.4 PC 1c.	SAME
1.2.6.3.4 PC 1d.	SAME
1.2.6.3.4 PC 1e.	SAME
1.2.6.3.4 C A.	SAME
1.2.6.3.4 C B.	SAME
1.2.6.3.5 PC 1a.	SAME
1.2.6.3.5 PC 1a.i	SAME
1.2.6.3.5 PC 1a.ii	SAME
1.2.6.3.5 PC 1a.iii	SAME
1.2.6.3.5 PC 1a.iv	SAME
1.2.6.3.5 PC 1a.v	SAME
1.2.6.3.5 PC 1a.vi	SAME
1.2.6.3.5 PC 1a.vii	SAME
1.2.6.3.5 PC 1a.viii	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.3.5 PC 1a.ix	SAME
1.2.6.3.5 PC 1a.x	SAME
1.2.6.3.5 PC 1a.xi	SAME
1.2.6.3.5 PC 1b.	SAME
1.2.6.3.5 PC 1c.	SAME
1.2.6.3.5 C A.	SAME
1.2.6.3.5 C B.	SAME
1.2.6.3.6 PC 1a.	SAME
1.2.6.3.6 PC 1b.	SAME
1.2.6.3.6 PC 1c.	SAME
1.2.6.3.6 PC 1d.	SAME
1.2.6.3.6 PC 1e.	SAME
1.2.6.3.6 C A.	SAME
1.2.6.3.6 C B.	SAME
1.2.6.3.6 C C.	SAME
1.2.6.3.6 C D.	SAME
1.2.6.3.6 C E.	SAME
1.2.6.3.7 PC 1a.	SAME
1.2.6.3.7 PC 1b.	SAME
1.2.6.3.7 C A.	SAME
1.2.6.3.7 C B.	SAME
1.2.6.3.7 C C.	SAME
1.2.6.3.7 C D.	SAME
1.2.6.3.7 C E.	SAME
1.2.6.3.8 PC 1a.	SAME
1.2.6.3.8 PC 1a.i	SAME
1.2.6.3.8 PC 1a.ii	SAME
1.2.6.3.8 PC 1a.iii	SAME
1.2.6.3.8 PC 1a.iv	SAME
1.2.6.3.8 PC 1a.v	SAME
1.2.6.3.8 PC 1a.vi	SAME
1.2.6.3.8 PC 1b.	SAME
1.2.6.3.8 PC 1c.	SAME
1.2.6.3.8 PC 1d.	SAME
1.2.6.3.8 PC 1e.	SAME
1.2.6.3.8 C A.	SAME
1.2.6.3.8 C B.	SAME
1.2.6.3.9 PC 1a.	SAME
1.2.6.3.9 PC 1b.	SAME
1.2.6.3.9 PC 1c.	SAME
1.2.6.3.9 PC 1c.i	SAME
1.2.6.3.9 PC 1c.ii	SAME
1.2.6.3.9 PC 1c.iii	SAME
1.2.6.3.9 PC 1c.iv	SAME
1.2.6.3.9 PC 1c.v	SAME
1.2.6.3.9 PC 1c.vi	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.3.9 PC 1c.vii	SAME
1.2.6.3.9 PC 1d.	SAME
1.2.6.3.9 C A.	SAME
1.2.6.4 SHAFT ACCESS	
1.2.6.4 PC 1a.	1.2.6.4 PC 1b.
1.2.6.4 PC 1b.	1.2.6.4 PC 1c.
1.2.6.4 PC 1b.i	1.2.6.4 PC 1c.
1.2.6.4 PC 1b.ii	1.2.6.4 PC 1c.ii
1.2.6.4 PC 1b.iii	1.2.6.4 PC 1c.iii
1.2.6.4 PC 1b.iv	1.2.6.4 PC 1c.iv
1.2.6.4 PC 1c.	1.2.6.4 PC 1d.
1.2.6.4 PC 1c.i	New text same as 1.2.6.6 PC 1d.i, added for consistency
1.2.6.4 PC 1c.ii	New text same as 1.2.6.6 PC 1d.iii, added for consistency
1.2.6.4 PC 1c.iii	1.2.6.4 PC 1d.ii
1.2.6.4 PC 1c.iv	1.2.6.4 PC 1d.iii
1.2.6.4 PC 1c.v	1.2.6.4 PC 1d.iv
1.2.6.4 PC 1c.vi	1.2.6.4 PC 1d.v
1.2.6.4 PC 1c.vii	1.2.6.4 PC 1d.vi
1.2.6.4 PC 1c.viii	1.2.6.4 PC 1d.vii
1.2.6.4 PC 1c.ix	New text same as 1.2.6.6 PC 1d.xi, added for consistency
1.2.6.4 PC 1c.x	1.2.6.4 PC 1d.viii
1.2.6.4 PC 1c.xi	1.2.6.4 PC 1d.ix
1.2.6.4 PC 1c.xii	1.2.6.4 PC 1d.x
1.2.6.4 PC 1c.xiii	1.2.6.4 PC 1d.xi
1.2.6.4 PC 1c.xiv	1.2.6.4 PC 1d.xii
1.2.6.4 PC 1d.	1.2.6.4 PC 1e.
1.2.6.4 PC 1e.	1.2.6.4 PC 1f.
1.2.6.4 PC 1e.i	1.2.6.4 PC 1f.i
1.2.6.4 PC 1e.ii	1.2.6.4 PC 1f.ii
1.2.6.4 PC 1f.	1.2.6.4 PC 1g.
1.2.6.4 PC 1g.	1.2.6.4 PC 1h.
1.2.6.4 PC 1g.i	1.2.6.4 PC 1h.i
1.2.6.4 PC 1g.ii	1.2.6.4 PC 1h.ii
1.2.6.4 PC 1g.iii	New text same as 1.2.6.6 PC 1h.iv, added for consistency
1.2.6.4 PC 1h.	1.2.6.4 PC 1i.
1.2.6.4 PC 1h.i	1.2.6.4 PC 1i.i
1.2.6.4 PC 1h.ii	1.2.6.4 PC 1i.ii + 1.2.6.5.2 PC 1a, added for consistency with 1.2.6.5 PC 1i.iii
1.2.6.4 PC 1i.	1.2.6.4 PC 1j.
1.2.6.4 PC 1i.i	1.2.6.4 PC 1j.i
1.2.6.4 PC 1i.ii	1.2.6.4 PC 1j.ii
1.2.6.4 PC 2a.	SAME
1.2.6.4 PC 2a.i	SAME
1.2.6.4 PC 2a.ii	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.4 PC 2a.ii.a	SAME
1.2.6.4 PC 2a.ii.b	SAME
1.2.6.4 PC 2a.ii.c	SAME
1.2.6.4 PC 2a.ii.d	SAME
1.2.6.4 PC 2a.ii.e	SAME
1.2.6.4 PC 2a.ii.f	SAME
1.2.6.4 PC 2a.iii	SAME
1.2.6.4 PC 2a.iv	SAME
1.2.6.4 PC 2a.v	SAME
1.2.6.4 PC 2b.	SAME
1.2.6.4 PC 2b.i	SAME
1.2.6.4 PC 2b.ii	SAME
1.2.6.4 PC 2b.iii	SAME
1.2.6.4 PC 2b.iv	SAME
1.2.6.4 PC 2c.	New text added to comply with WMSR IV, Appendix E
1.2.6.4 PC 2c.i	New text added from DAA
1.2.6.4 PC 2c.ii	New text added from DAA
1.2.6.4 PC 2c.iii	New text added from DAA
1.2.6.4 PC 2c.iv	New text added from DAA
1.2.6.4 PC 2d.	1.2.6.4 PC 2c.
1.2.6.4 PC 2e.	1.2.6.4 PC 2d.
1.2.6.4 PC 2e.i	1.2.6.4 PC 2d.i
1.2.6.4 PC 2e.ii	1.2.6.4 PC 2d.ii
1.2.6.4 PC 2e.iii	1.2.6.4 PC 2d.iii
1.2.6.4 PC 2f.	1.2.6.4 PC 2e.
1.2.6.4 PC 2f.i	1.2.6.4 PC 2e.i
1.2.6.4 PC 2f.ii	New text same as 1.2.6.6 PC 2f.ii, added for consistency
1.2.6.4 PC 2f.iii	1.2.6.4 PC 2e.ii
1.2.6.4 PC 2g.	1.2.6.4 PC 2f.
1.2.6.4 PC 2h.	1.2.6.4 PC 2g.
1.2.6.4 PC 2h.i	1.2.6.4 PC 2g.i
1.2.6.4 PC 2h.ii	1.2.6.4 PC 2g.ii
1.2.6.4 PC 2h.iii	1.2.6.4 PC 2g.iii
1.2.6.4 PC 2h.iv	1.2.6.4 PC 2g.iv
1.2.6.4 PC 2h.v	1.2.6.4 PC 2i.v.d
1.2.6.4 PC 2i.	1.2.6.4 PC 2h.
1.2.6.4 PC 2i.i	1.2.6.4 PC 2h.i
1.2.6.4 PC 2i.ii	1.2.6.4 PC 2h.ii
1.2.6.4 PC 2j.	1.2.6.4 PC 2i.
1.2.6.4 PC 2j.i	1.2.6.4 PC 2i.i + 1.2.6.4 PC.2i.v
1.2.6.4 PC 2j.i [2]	1.2.6.4 PC.2i.v [2]
1.2.6.4 PC 2j.i.a	1.2.6.4 PC.2i.v.a
1.2.6.4 PC 2j.i.b	1.2.6.4 PC.2i.v.b
1.2.6.4 PC 2j.ii	1.2.6.4 PC 2i.ii
1.2.6.4 PC 2j.iii	1.2.6.4 PC.2i.iv
1.2.6.4 PC 2j.iii.a	1.2.6.4 PC.2i.iv.a
1.2.6.4 PC 2j.iii.b	1.2.6.4 PC.2i.iv.b
1.2.6.4 PC 2j.iii.c	1.2.6.4 PC.2i.iv.c
1.2.6.4 PC 2j.iv	1.2.6.4 PC.2i.vii

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.4 PC.2j.v	1.2.6.4 PC 2i.iii
1.2.6.4 PC.2j.v.a	1.2.6.4 PC 2i.iii.a
1.2.6.4 PC.2j.v.b	1.2.6.4 PC 2i.iii.b
1.2.6.4 PC.2j.v.c	1.2.6.4 PC 2i.iii.c
1.2.6.4 PC.2j.v.d	1.2.6.4 PC 2i.iii.d
1.2.6.4 PC 2k.	1.2.6.4 PC 2j.
1.2.6.4 PC 2k.i	1.2.6.4 PC 2j.i
1.2.6.4 PC 2k.ii	1.2.6.4 PC 2j.ii
1.2.6.4 PC 2k.iii	1.2.6.4 PC 2j.iii
1.2.6.4 PC 2l.	1.2.6.4 PC 2k.
1.2.6.4 PC 2l. [2]	1.2.6.4 PC 2k. [2]
1.2.6.4 PC 2l.i	1.2.6.4 PC 2k.i
1.2.6.4 PC 2l.ii	1.2.6.4 PC 2k.ii
1.2.6.4 PC 2l.iii	1.2.6.4 PC 2k.iii
1.2.6.4 PC 2l.iii.a	1.2.6.4 PC 2k.iii.a
1.2.6.4 PC 2l.iii.b	1.2.6.4 PC 2k.iii.b
1.2.6.4 PC 2l.iii.c	1.2.6.4 PC 2k.iii.c
1.2.6.4 PC 2l.iii NOTE	1.2.6.4 PC 2k.iii NOTE
1.2.6.4 PC 2l.iv	1.2.6.4 PC 2k.iv
1.2.6.4 PC 2l.v	1.2.6.4 PC 2k.v
1.2.6.4 C A.	SAME
1.2.6.4 C A. [2]	SAME
1.2.6.4 C A.i	SAME
1.2.6.4 C B.	SAME
1.2.6.4 C B.i	SAME
1.2.6.4 C B.ii	SAME
1.2.6.4 C B.iii	SAME
1.2.6.4 C C	New text requested by YMPO
1.2.6.4.1 PC 1a.	SAME
1.2.6.4.1 PC 1b.	SAME
1.2.6.4.1 C A.	SAME
1.2.6.4.1 C B.	SAME
1.2.6.4.2 PC 1a.	SAME
1.2.6.4.2 PC 1b.	SAME
1.2.6.4.2 PC 1c.	SAME
1.2.6.4.2 PC 1d.	SAME
1.2.6.4.2 C A.	SAME
1.2.6.4.2 C B.	SAME
1.2.6.4.2 C C.	1.2.6.4.2 C D (because 1.2.6.4.2. C C during Revision of 5/31/91)
1.2.6.4.3 PC 1a.	SAME
1.2.6.4.3 PC 1b.	SAME
1.2.6.4.3 PC 1c.	SAME
1.2.6.4.3 PC 1d.	SAME
1.2.6.4.3 PC 1e.	SAME
1.2.6.4.3 PC 1f.	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.4.3 PC 1g.	SAME
1.2.6.4.3 PC 1h.	SAME
1.2.6.4.3 C A	New text requested by YMPO
1.2.6.4.4 PC 1a.	SAME
1.2.6.4.4 PC 1b.	SAME
1.2.6.4.4 PC 1c.	SAME
1.2.6.4.4 PC 1d	SAME
1.2.6.4.4 PC 1e.	SAME
1.2.6.4.4 PC 1f.	SAME
1.2.6.4.4 PC 1f.i	SAME
1.2.6.4.4 PC 1f.ii	SAME
1.2.6.4.4 PC 1f.iii	SAME
1.2.6.4.4 PC 1f.iv	SAME
1.2.6.4.4 PC 1f.v	SAME
1.2.6.4.4 PC 1f.vi	SAME
1.2.6.4.4 PC 1f.vii	SAME
1.2.6.4.4 PC 1f.viii	SAME
1.2.6.4.4 C A.	SAME
1.2.6.4.4 C B.	SAME
1.2.6.4.4 C C.	Part of 1.2.6.4.4 C C
1.2.6.4.4 C D.	Part of 1.2.6.4.4 C C
1.2.6.4.5 PC 1a.	SAME
1.2.6.4.5 PC 1b.	SAME
1.2.6.4.5 PC 1c.	SAME
1.2.6.4.5 PC 1d.	SAME
1.2.6.4.5 PC 1e.	SAME
1.2.6.4.5 PC 1f.	SAME
1.2.6.4.5 PC 1g.	SAME
1.2.6.4.5 PC 1h.	SAME
1.2.6.4.5 PC 1i.	SAME
1.2.6.4.5 PC 1j.	SAME
1.2.6.4.5 C A.	SAME
1.2.6.4.5 C B.	SAME
1.2.6.4.5 C C.	SAME
1.2.6.4.5 C D.	SAME
1.2.6.4.5 C E.	SAME
1.2.6.4.5 C F.	SAME
1.2.6.4.5 C G.	SAME
1.2.6.4.5 C H.	SAME
1.2.6.4.6 PC 1a.	SAME
1.2.6.4.6 PC 1b.	SAME
1.2.6.4.6 PC 1c.	SAME
1.2.6.4.6 PC 1d	New text added to correct an omission
1.2.6.4.6 C A.	1.2.6.4.6 C B

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.5 RAMP ACCESS	
1.2.6.5 PC 1a.	SAME
1.2.6.5 PC 1a.i	SAME
1.2.6.5 PC 1a.ii	SAME
1.2.6.5 PC 1a.iii	SAME+ 1.2.6.4 PC 1a.iv
1.2.6.5 PC 1b.	SAME
1.2.6.5 PC 1c.	SAME
1.2.6.5 PC 1c.i	SAME
1.2.6.5 PC 1c.ii	SAME
1.2.6.5 PC 1c.iii	SAME
1.2.6.5 PC 1c.iv	SAME
1.2.6.5 PC 1c.v	SAME
1.2.6.5 PC 1d.	SAME
1.2.6.5 PC 1d.i	New text same as 1.2.6.6 PC 1d.i, added for consistency
1.2.6.5 PC 1d.ii	New text same as 1.2.6.6 PC 1d.iii, added for consistency
1.2.6.5 PC 1d.iii	1.2.6.5 PC 1d.ii
1.2.6.5 PC 1d.iv	1.2.6.5 PC 1d.iii
1.2.6.5 PC 1d.v	1.2.6.5 PC 1d.iv
1.2.6.5 PC 1d.vi	1.2.6.5 PC 1d.v
1.2.6.5 PC 1d.vii	1.2.6.5 PC 1d.vi
1.2.6.5 PC 1d.viii	1.2.6.5 PC 1d.vii
1.2.6.5 PC 1d.ix	New text same as 1.2.6.6 PC 1d.xi, added for consistency
1.2.6.5 PC 1d.x	1.2.6.5 PC 1d.viii
1.2.6.5 PC 1d.xi	1.2.6.5 PC 1d.ix
1.2.6.5 PC 1d.xii	1.2.6.5 PC 1d.x
1.2.6.5 PC 1d.xiii	1.2.6.5 PC 1d.xi
1.2.6.5 PC 1d.xiv	1.2.6.5 PC 1d.xii
1.2.6.5 PC 1e.	SAME
1.2.6.5 PC 1f.	SAME
1.2.6.5 PC 1f.i	SAME
1.2.6.5 PC 1f.ii	SAME
1.2.6.5 PC 1f.iii	SAME
1.2.6.5 PC 1f.iv	SAME
1.2.6.5 PC 1f.v	SAME
1.2.6.5 PC 1g.	SAME
1.2.6.5 PC 1h.	SAME
1.2.6.5 PC 1h.i	SAME
1.2.6.5 PC 1h.ii	SAME
1.2.6.5 PC 1h.iii	New text same as 1.2.6.6 PC 1h.iv, added for consistency
1.2.6.5 PC 1i.	SAME
1.2.6.5 PC 1i.i	SAME
1.2.6.5 PC 1i.ii	SAME
1.2.6.5 PC 1i.iii	1.2.6.5 PC 1i.iv + 1.2.6.5.2 PC 1a.
1.2.6.5 PC 1i.iv	1.2.6.5 PC 1i.v
1.2.6.5 PC 1j.	SAME

(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.5 PC 1j.i	SAME
1.2.6.5 PC 1j.ii	SAME
1.2.6.5 PC 2a.	SAME
1.2.6.5 PC 2a.i	SAME
1.2.6.5 PC 2a.ii	SAME
1.2.6.5 PC 2a.ii.a	SAME
1.2.6.5 PC 2a.ii.b	SAME
1.2.6.5 PC 2a.ii.c	SAME
1.2.6.5 PC 2a.ii.d	SAME
1.2.6.5 PC 2a.ii.e	SAME
1.2.6.5 PC 2a.ii.f	SAME
1.2.6.5 PC 2a.iii	SAME
1.2.6.5 PC 2a.iv	SAME
1.2.6.5 PC 2a.v	SAME
1.2.6.5 PC 2b.	SAME
1.2.6.5 PC 2b.i	SAME
1.2.6.5 PC 2b.ii	SAME
1.2.6.5 PC 2b.iii	SAME
1.2.6.5 PC 2b.iv	SAME
1.2.6.5 PC 2c.	New text added to comply with WMSR IV, Appendix E
1.2.6.5 PC 2c.i	New text added from DAA
1.2.6.5 PC 2c.ii	New text added from DAA
1.2.6.5 PC 2c.iii	New text added from DAA
1.2.6.5 PC 2c.iv	New text added from DAA
1.2.6.5 PC 2d.	1.2.6.5 PC 2c.
1.2.6.5 PC 2e.	1.2.6.5 PC 2d.
1.2.6.5 PC 2e.i	1.2.6.5 PC 2d.i
1.2.6.5 PC 2e.ii	1.2.6.5 PC 2d.ii
1.2.6.5 PC 2e.iii	1.2.6.5 PC 2d.iii
1.2.6.5 PC 2e.iv	1.2.6.5 PC 2d.iv
1.2.6.5 PC 2f.	1.2.6.5 PC 2e.
1.2.6.5 PC 2f.i	1.2.6.5 PC 2e.i
1.2.6.5 PC 2f.ii	New text same as 1.2.6.6 PC 2f.ii, added for consistency
1.2.6.5 PC 2f.iii	1.2.6.5 PC 2e.ii
1.2.6.5 PC 2g.	1.2.6.5 PC 2f.
1.2.6.5 PC 2g.i	New text, same as 1.2.6.6 PC 2g.i, added for consistency
1.2.6.5 PC 2h.	New text added to comply with WMSR IV, Appendix E
1.2.6.5 PC 2h. [2]	New text added to comply with WMSR IV, Appendix E
1.2.6.5 PC 2h.i	New text added to supplement 1.2.6.5 PC 2h
1.2.6.5 PC 2i.	1.2.6.5 PC 2g.
1.2.6.5 PC 2i.i	1.2.6.5 PC 2g.i
1.2.6.5 PC 2i.ii	1.2.6.5 PC 2g.ii
1.2.6.5 PC 2i.iii	1.2.6.5 PC 2g.iii
1.2.6.5 PC 2i.iv	1.2.6.5 PC 2g.iv
1.2.6.5 PC 2i.v	1.2.6.5 PC 2g.v
1.2.6.5 PC 2i.vi	1.2.6.5 PC 2i.iv.d
1.2.6.5 PC 2j.	1.2.6.5 PC 2h.
1.2.6.5 PC 2j.i	1.2.6.5 PC 2h.i

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.5 PC 2j.ii	1.2.6.5 PC 2h.ii
1.2.6.5 PC 2j.iii	1.2.6.5 PC 2h.iii
1.2.6.5 PC 2k.	1.2.6.5 PC 2i.
1.2.6.5 PC 2k.i	1.2.6.5 PC 2i.i + 1.2.6.5 PC 2i.v
1.2.6.5 PC 2k.i [2]	1.2.6.5 PC 2i.v [2]
1.2.6.5 PC 2k.i.a	1.2.6.5 PC 2i.v.a
1.2.6.5 PC 2k.i.b	1.2.6.5 PC 2i.v.b
1.2.6.5 PC 2k.ii	1.2.6.5 PC 2i.ii
1.2.6.5 PC 2k.iii	Parts of 1.2.6.5 PC 2i.iv & 1.2.6.6 PC 2j.iv [2]
1.2.6.5 PC 2k.iv	Parts of 1.2.6.5 PC 2i.iv & 1.2.6.6 PC 2j.iv
1.2.6.5 PC 2k.iv.a	1.2.6.5 PC 2i.iv.a
1.2.6.5 PC 2k.iv.b	1.2.6.5 PC 2i.iv.b
1.2.6.5 PC 2k.iv.c	1.2.6.5 PC 2i.iv.c
1.2.6.5 PC 2k.v	1.2.6.5 PC 2i.vii
1.2.6.5 PC 2k.vi	1.2.6.5 PC 2i.iii
1.2.6.5 PC 2k.vi.a	1.2.6.5 PC 2i.iii.a
1.2.6.5 PC 2k.vi.b	1.2.6.5 PC 2i.iii.b
1.2.6.5 PC 2k.vi.c	1.2.6.5 PC 2i.iii.c
1.2.6.5 PC 2k.vi.d	1.2.6.5 PC 2i.iii.d
1.2.6.5 PC 2l.	1.2.6.5 PC 2j.
1.2.6.5 PC 2l.i	1.2.6.5 PC 2j.i
1.2.6.5 PC 2l.ii	1.2.6.5 PC 2j.ii
1.2.6.5 PC 2l.iii	1.2.6.5 PC 2j.iii
1.2.6.5 PC 2m.	1.2.6.5 PC 2k.
1.2.6.5 PC 2m. [2]	1.2.6.5 PC 2k. [2]
1.2.6.5 PC 2m.i	1.2.6.5 PC 2k.i
1.2.6.5 PC 2m.ii	1.2.6.5 PC 2k.ii
1.2.6.5 PC 2m.iii	1.2.6.5 PC 2k.iii
1.2.6.5 PC 2m.iii.a	1.2.6.5 PC 2k.iii.a
1.2.6.5 PC 2m.iii.b	1.2.6.5 PC 2k.iii.b
1.2.6.5 PC 2m.iii.c	1.2.6.5 PC 2k.iii.c
1.2.6.5 PC 2m.iv	1.2.6.5 PC 2k.iv
1.2.6.5 PC 2m.v	1.2.6.5 PC 2k.v
1.2.6.5 C A.	SAME
1.2.6.5 C A. [2]	SAME
1.2.6.5 C A.i	SAME
1.2.6.5 C B.	SAME
1.2.6.5 C B.i	SAME
1.2.6.5 C B.ii	SAME
1.2.6.5 C B.iii	SAME
1.2.6.5.1 PC 1.	SAME
1.2.6.5.1 C A.	SAME
1.2.6.5.1 C B.	SAME
1.2.6.5.2 PC 1a.	1.2.6.5.2 PC 1b.
1.2.6.5.2 PC 1b.	1.2.6.5.2 PC 1c.
1.2.6.5.2 PC 1c.	1.2.6.5.2 PC 1d.
1.2.6.5.2 PC 1d.	1.2.6.5.2 PC 1e.

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.5.2 C A.	SAME
1.2.6.5.2 C B.	SAME
1.2.6.5.2 C C.	SAME
1.2.6.5.4 PC 1a.	SAME
1.2.6.5.4 PC 1b.	SAME
1.2.6.5.4 PC 1c.	SAME
1.2.6.5.4 PC 1c.i	SAME
1.2.6.5.4 PC 1c.ii	SAME
1.2.6.5.4 PC 1c.iii	SAME
1.2.6.5.4 PC 1c.iv	SAME
1.2.6.5.4 PC 1c.v	SAME
1.2.6.5.4 PC 1c.vi	SAME
1.2.6.5.4 PC 1c.vii	SAME
1.2.6.5.4 PC 1c.viii	SAME
1.2.6.5.4 C A.	SAME
1.2.6.5.4 C B.	SAME
1.2.6.5.4 C C.	Part of 1.2.6.5.4 C C.
1.2.6.5.4 C D.	Part of 1.2.6.5.4 C C.
1.2.6.5.5 This number not used	
1.2.6.5.6 PC 1a.	SAME
1.2.6.5.6 PC 1b.	SAME
1.2.6.5.6 PC 1c	New text added to correct an omission
1.2.6.6 UNDERGROUND EXCAVATIONS	
1.2.6.6 PC 1a.	SAME
1.2.6.6 PC 1a.i	SAME
1.2.6.6 PC 1a.ii	SAME
1.2.6.6 PC 1a.iii	1.2.6.6 PC 1a.iv
1.2.6.6 PC 1b.	SAME
1.2.6.6 PC 1b.i	SAME
1.2.6.6 PC 1b.ii	SAME
1.2.6.6 PC 1c.	SAME
1.2.6.6 PC 1c.i	SAME
1.2.6.6 PC 1c.ii	SAME
1.2.6.6 PC 1c.iii	SAME+ 1.2.6.6 PC 1c.iii(1)
1.2.6.6 PC 1c.iv	SAME
1.2.6.6 PC 1c.v	SAME
1.2.6.6 PC 1c.vi	SAME
1.2.6.6 PC 1d.	SAME
1.2.6.6 PC 1d.i	SAME
1.2.6.6 PC 1d.ii	SAME
1.2.6.6 PC 1d.iii	SAME
1.2.6.6 PC 1d.iv	1.2.6.6 PC 1d.v
1.2.6.6 PC 1d.v	1.2.6.6 PC 1d.vi
1.2.6.6 PC 1d.vi	1.2.6.6 PC 1d.vii

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.6 PC 1d.vii	1.2.6.6 PC 1d.viii
1.2.6.6 PC 1d.viii	1.2.6.6 PC 1d.ix
1.2.6.6 PC 1d.ix	1.2.6.6 PC id.x
1.2.6.6 PC 1d.x	1.2.6.6 PC 1d.xi
1.2.6.6 PC 1d.xi	1.2.6.6 PC 1d.xii
1.2.6.6 PC 1d.xii	1.2.6.6 PC 1d.xiii
1.2.6.6 PC 1d.xiii	1.2.6.6 PC 1d.xiv
1.2.6.6 PC 1d.xiv	1.2.6.6 PC 1d.xv
1.2.6.6 PC 1d.xv	1.2.6.6 PC 1d.xvi
1.2.6.6 PC 1e.	SAME
1.2.6.6 PC 1e.i	Part of 1.2.6.6 PC 1e.i
1.2.6.6 PC 1e.ii	Part of 1.2.6.6 PC 1e.i
1.2.6.6 PC 1f.	SAME
1.2.6.6 PC 1f.i	SAME
1.2.6.6 PC 1f.ii	SAME
1.2.6.6 PC 1f.iii	SAME
1.2.6.6 PC 1g.	SAME
1.2.6.6 PC 1h.	SAME
1.2.6.6 PC 1h.i	SAME
1.2.6.6 PC 1h.ii	SAME
1.2.6.6 PC 1h.iii	SAME
1.2.6.6 PC 1h.iv	SAME
1.2.6.6 PC 1i.	SAME
1.2.6.6 PC 1i.i	SAME
1.2.6.6 PC 1i.ii	SAME
1.2.6.6 PC 1i.iii	SAME
1.2.6.6 PC 2a.	SAME
1.2.6.6 PC 2a.i	SAME
1.2.6.6 PC 2a.ii	SAME
1.2.6.6 PC 2a.ii.a	SAME
1.2.6.6 PC 2a.ii.b	SAME
1.2.6.6 PC 2a.ii.c	SAME
1.2.6.6 PC 2a.ii.d	SAME
1.2.6.6 PC 2a.ii.e	SAME
1.2.6.6 PC 2a.ii.f	SAME
1.2.6.6 PC 2a.iii	New text same as 1.2.6.4 PC 2a.iii and 1.2.6.5 PC 2a.iii, added for consistency
1.2.6.6 PC 2a.iv	1.2.6.6 PC 2a.iii
1.2.6.6 PC 2a.v	1.2.6.6 PC 2a.iv
1.2.6.6 PC 2b.	SAME
1.2.6.6 PC 2b.i	Part of 1.2.6.6 PC 2b.i
1.2.6.6 PC 2b.i.a	Part of 1.2.6.6 PC 2b.i
1.2.6.6 PC 2b.i.b	Part of 1.2.6.6 PC 2b.i
1.2.6.6 PC 2b.ii	SAME
1.2.6.6 PC 2b.iii	SAME
1.2.6.6 PC 2b.iii.a	SAME
1.2.6.6 PC 2b.iii.b	SAME
1.2.6.6 PC 2b.iii.c	SAME
1.2.6.6 PC 2c.	New text added to comply with WMSR IV, Appendix E
1.2.6.6 PC 2c.i	New text added from DAA

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.6 PC 2c.ii	New text added from DAA
1.2.6.6 PC 2c.iii	New text added from DAA
1.2.6.6 PC 2d.	1.2.6.6 PC 2c.
1.2.6.6 PC 2d.i	1.2.6.6 PC 2c.i
1.2.6.6 PC 2d.ii	1.2.6.6 PC 2c.ii
1.2.6.6 PC 2d.iii	1.2.6.6 PC 2c.vi
1.2.6.6 PC 2d.iv	1.2.6.6 PC 2c.viii
1.2.6.6 PC 2d.v	1.2.6.6 PC 2c.ix
1.2.6.6 PC 2e.	1.2.6.6 PC 2d.
1.2.6.6 PC 2f.	1.2.6.6 PC 2e.
1.2.6.6 PC 2f.i	1.2.6.6 PC 2e.i
1.2.6.6 PC 2f.ii	1.2.6.6 PC 2e.ii
1.2.6.6 PC 2f.iii	1.2.6.6 PC 2e.iii
1.2.6.6 PC 2f.iv	1.2.6.6 PC 2e.iv
1.2.6.6 PC 2f.v	1.2.6.6 PC 2e.v
1.2.6.6 PC 2g.	1.2.6.6 PC 2f.
1.2.6.6 PC 2g.i	1.2.6.6 PC 2f.i
1.2.6.6 PC 2g.ii	1.2.6.6 PC 2f.ii
1.2.6.6 PC 2g.iii	1.2.6.6 PC 2f.iii
1.2.6.6 PC 2g.iv	1.2.6.6 PC 2f.iv
1.2.6.6 PC 2h.	1.2.6.6 PC 2g.
1.2.6.6 PC 2h.i	1.2.6.6 PC 2g.i
1.2.6.6 PC 2h.ii	1.2.6.6 PC 2g.ii
1.2.6.6 PC 2h.iii	1.2.6.6 PC 2g.iii
1.2.6.6 PC 2i.	New text added to comply with WMSR IV, Appendix E
1.2.6.6 PC 2i. [2]	New text added to comply with WMSR IV, Appendix E
1.2.6.6 PC 2i.i	New text added to supplement 1.2.6.6 PC 2i.
1.2.6.6 PC 2j.	1.2.6.6 PC 2h.
1.2.6.6 PC 2j.i	1.2.6.6 PC 2h.i
1.2.6.6 PC 2j.ii	1.2.6.6 PC 2h.ii
1.2.6.6 PC 2j.iii	1.2.6.6 PC 2h.iii
1.2.6.6 PC 2j.iv	1.2.6.6 PC 2h.iv
1.2.6.6 PC 2j.v	1.2.6.6 PC 2h.v
1.2.6.6 PC 2j.vi	1.2.6.6 PC 2h.vi
1.2.6.6 PC 2j.vii	1.2.6.6 PC 2h.vii
1.2.6.6 PC 2j.viii	1.2.6.6 PC 2j.v.d
1.2.6.6 PC 2k.	1.2.6.6 PC 2i.
1.2.6.6 PC 2k.i	1.2.6.6 PC 2i.i
1.2.6.6 PC 2k.ii	1.2.6.6 PC 2i.ii
1.2.6.6 PC 2k.iii	1.2.6.6 PC 2i.iii
1.2.6.6 PC 2k.iv	1.2.6.6 PC 2i.iv
1.2.6.6 PC 2k.v	1.2.6.6 PC 2i.v
1.2.6.6 PC 2l.	1.2.6.6 PC 2j.
1.2.6.6 PC 2l.i	1.2.6.6 PC 2j.i + 1.2.6.6 PC 2j.vi
1.2.6.6 PC 2l.i [2]	1.2.6.6 PC 2j.vi [2]
1.2.6.6 PC 2l.i.a	1.2.6.6 PC 2j.vi.a
1.2.6.6 PC 2l.i.b	1.2.6.6 PC 2j.vi.b
1.2.6.6 PC 2l.ii	1.2.6.6 PC 2j.ii
1.2.6.6 PC 2l.iii	1.2.6.6 PC 2j.v
1.2.6.6 PC 2l.iv	Parts of 1.2.6.6 PC 2j.iv & 1.2.6.6 PC 2j.iv [2]

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.6 PC 2l.iv.a	1.2.6.6 PC 2j.iv.a
1.2.6.6 PC 2l.iv.b	1.2.6.6 PC 2j.iv.b
1.2.6.6 PC 2l.iv.c	1.2.6.6 PC 2j.iv.c
1.2.6.6 PC 2l.v	1.2.6.6 PC 2j.x
1.2.6.6 PC 2l.vi	1.2.6.6 PC 2j.iii
1.2.6.6 PC 2l.vi.a	1.2.6.6 PC 2j.iii.a
1.2.6.6 PC 2l.vi.b	1.2.6.6 PC 2j.iii.b
1.2.6.6 PC 2l.vi.c	1.2.6.6 PC 2j.iii.c
1.2.6.6 PC 2l.vi.d	1.2.6.6 PC 2j.iii.d
1.2.6.6 PC 2m.	1.2.6.6 PC 2k.
1.2.6.6 PC 2m.i	1.2.6.6 PC 2k.i
1.2.6.6 PC 2m.ii	1.2.6.6 PC 2k.ii
1.2.6.6 PC 2m.iii	1.2.6.6 PC 2k.iii
1.2.6.6 PC 2m.iv	1.2.6.6 PC 2k.iv
1.2.6.6 PC 2m.v	1.2.6.6 PC 2k.v
1.2.6.6 PC 2n.	1.2.6.6 PC 2l.
1.2.6.6 PC 2n. [2]	1.2.6.6 PC 2l. [2]
1.2.6.6 PC 2n.i	1.2.6.6 PC 2l.i
1.2.6.6 PC 2n.ii	1.2.6.6 PC 2l.ii
1.2.6.6 PC 2n.iii	1.2.6.6 PC 2l.iv
1.2.6.6 PC 2n.iv	1.2.6.6 PC 2l.v
1.2.6.6 PC 2n.v	1.2.6.6 PC 2l.vi
1.2.6.6 PC 2n.v.a	1.2.6.6 PC 2l.vi.a
1.2.6.6 PC 2n.v.b	1.2.6.6 PC 2l.vi.c
1.2.6.6 C A.	SAME
1.2.6.6 C A. [2]	SAME
1.2.6.6 C A.i	SAME
1.2.6.6 C A.ii	SAME
1.2.6.6 C B.	SAME
1.2.6.6 C B.i	SAME
1.2.6.6 C B.ii	SAME
1.2.6.6 C B.iii	SAME
1.2.6.6.1 PC 1a.	SAME
1.2.6.6.1 PC 1b.	SAME
1.2.6.6.1 PC 1c.	SAME
1.2.6.6.1 C A.	SAME
1.2.6.6.1 C B.	SAME
1.2.6.6.2 PC 1.	SAME
1.2.6.6.2 C A.	SAME
1.2.6.6.2 C B.	SAME
1.2.6.7 UNDERGROUND SUPPORT SYSTEMS	
1.2.6.7 PC 1a.	SAME
1.2.6.7 PC 1b.	SAME
1.2.6.7 PC 1c.	SAME
1.2.6.7 PC 1d.	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.7 PC 1e.	SAME
1.2.6.7 PC 1f.	SAME
1.2.6.7 PC 2.	1.2.6.7 PC 2a.
1.2.6.7 PC 3a.	SAME
1.2.6.7 PC 3b.	SAME
1.2.6.7 C A.	SAME
1.2.6.7 C B.	SAME
1.2.6.7 C B.i	SAME
1.2.6.7 C C.	SAME
1.2.6.7 C C.i	SAME
1.2.6.7 C D.	SAME
1.2.6.7 C D.i	SAME
1.2.6.7 C D.ii	SAME
1.2.6.7 C E.	SAME
1.2.6.7 C E.i	1.2.6.7 C E.ii
1.2.6.7 C E.ii	1.2.6.7 C E.iii
1.2.6.7 C F.	SAME
1.2.6.7 C F.i	SAME
1.2.6.7 C F.ii	SAME
1.2.6.7 C F.iii	SAME
1.2.6.7 C G.	SAME
1.2.6.7 C G.i	SAME
1.2.6.7 C H.	SAME
1.2.6.7 C I.	SAME
1.2.6.7 C J.	SAME
1.2.6.7 C K.	SAME
1.2.6.7 C L.	1.2.6.7.6 C A
1.2.6.7.1 PC 1a.	SAME
1.2.6.7.1 PC 1b.	SAME
1.2.6.7.1 PC 1c.	SAME
1.2.6.7.1 PC 1d.	SAME
1.2.6.7.1 C A.	SAME
1.2.6.7.1 C B.	SAME
1.2.6.7.1 C C.	SAME
1.2.6.7.1 C D.	SAME
1.2.6.7.1 C E.	SAME
1.2.6.7.1 C F.	SAME
1.2.6.7.2 This number not used	
1.2.6.7.3 PC 1a.	SAME
1.2.6.7.3 PC 1b.	SAME
1.2.6.7.3 PC 1c.	SAME
1.2.6.7.3 PC 1d.	SAME
1.2.6.7.3 C A.	SAME
1.2.6.7.3 C B.	SAME
1.2.6.7.3 C C.	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.7.4 PC 1a.	SAME
1.2.6.7.4 PC 1b.	SAME
1.2.6.7.4 PC 1c.	SAME
1.2.6.7.4 PC 1d.	SAME
1.2.6.7.4 PC 1e.	SAME
1.2.6.7.4 PC 1f.	SAME
1.2.6.7.4 PC 1g.	SAME
1.2.6.7.4 C A.	SAME
1.2.6.7.4 C B.	SAME
1.2.6.7.4 C C.	SAME
1.2.6.7.4 C D.	SAME
1.2.6.7.4 C E.	SAME
1.2.6.7.4 C F.	SAME
1.2.6.7.4 C G.	SAME
1.2.6.7.4 C H.	SAME
1.2.6.7.4 C I.	SAME
1.2.6.7.5 PC 1	SAME
1.2.6.7.5 C A.	SAME
1.2.6.7.6 PC 1a.	SAME
1.2.6.7.6 PC 1b.	SAME
1.2.6.7.6 PC 1b.i	SAME
1.2.6.7.6 PC 1b.ii	1.2.6.7.6 PC 1b.iii
1.2.6.7.6 PC 1b.iii	1.2.6.7.6 PC 1b.iv
1.2.6.7.6 PC 1b.iv	1.2.6.7.6 PC 1b.v
1.2.6.7.6 PC 1c.	SAME
1.2.6.7.6 PC 1c.i	SAME
1.2.6.7.6 PC 1d.	SAME
1.2.6.7.6 PC 1e.	SAME
1.2.6.7.6 PC 1f.	SAME
1.2.6.7.7 PC 1.	SAME
1.2.6.7.8 PC 1a.	SAME
1.2.6.7.8 PC 1b.	SAME
1.2.6.7.8 PC 1c.	SAME
1.2.6.7.8 C A.	SAME
1.2.6.7.8 C A.i	New text added to require serious consideration be given before committing to using water to fight fires underground
1.2.6.7.8 C B.	SAME
1.2.6.7.8 C C.	SAME
1.2.6.7.9 PC 1a.	SAME
1.2.6.7.9 PC 1b.	SAME
1.2.6.7.9 PC 1c.	SAME
1.2.6.7.9 C A.	SAME
1.2.6.7.9 C B.	SAME
1.2.6.7.9 C C.	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.7.9 C D.	SAME
1.2.6.7.9 C E.	SAME
1.2.6.7.9 C F.	New text added to correct omission in overall monitoring system
1.2.6.7.10 PC 1a.	SAME
1.2.6.7.10 PC 1b.	1.2.6.7.10 PC 1c.
1.2.6.7.10 PC 1c.	New text added to correct omission
1.2.6.7.11 PC 1a.	SAME
1.2.6.7.11 PC 1b.	SAME
1.2.6.7.11 PC 1c.	SAME
1.2.6.7.11 PC 1d.	SAME
1.2.6.7.11 PC 1e.	SAME
1.2.6.7.11 PC 1e.i	SAME
1.2.6.7.11 C A.	SAME
1.2.6.7.11 C B.	SAME
1.2.6.7.11 C C.	New text added to correct omission which otherwise might result in unnecessary additional facilities
1.2.6.8 TEST SUPPORT	
1.2.6.8 PC 1a.	SAME
1.2.6.8 PC 1b.	1.2.6.8 PC 1c.
1.2.6.8 PC 1c.	1.2.6.8 PC 1d.
1.2.6.8 PC 1d.	1.2.6.8 PC 1e.
1.2.6.8 C A.	SAME
1.2.6.8 C B.	SAME
1.2.6.8 C B.i	SAME
1.2.6.8 C C.	SAME
1.2.6.8 C C.i	SAME
1.2.6.8 C D.	SAME
1.2.6.8 C D.i	SAME
1.2.6.8 C D.ii	1.2.6.8 C D.iii
1.2.6.8 C E.	SAME
1.2.6.8 C E.i	SAME
1.2.6.8 C E.ii	SAME
1.2.6.8 C E.iii	SAME
1.2.6.8 C E.iv	SAME
1.2.6.8 C E.v	SAME
1.2.6.8 C E.vi	SAME
1.2.6.8 C E.vii	SAME
1.2.6.8 C E.viii	SAME
1.2.6.8 C E.ix	SAME
1.2.6.8.1 PC 1.	SAME
1.2.6.8.2 PC 1.	SAME
1.2.6.8.2 C A.	SAME

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(1) ESFDR Requirement	(2) Location in ESFDR Rev. 0
1.2.6.9 ESF DECOMMISSIONING AND CLOSURE	
1.2.6.9 PC 1a.	SAME
1.2.6.9 PC 1b.	SAME
1.2.6.9.1 PC 1a.	SAME
1.2.6.9.1 PC 1.b	SAME
1.2.6.9.1 C A.	SAME
1.2.6.9.1 C A.i	SAME
1.2.6.9.1 C A.ii	SAME
1.2.6.9.1 C A.iii	SAME
1.2.6.9.1 C B.	SAME
1.2.6.9.2 PC 1.	SAME
1.2.6.9.2 C A.	SAME
1.2.6.9.2 C A.i	SAME
1.2.6.9.2 C A.ii	SAME
1.2.6.9.2 C A.iii	SAME
1.2.6.9.2 C A.iv	SAME

The following statements which were in ESFDR Rev. 0 have been deleted for the reasons given.

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Location in ESFDR Rev. 0	Reason for Deletion
1.2.6.0 PC 1d.ii	Statement says the obvious. There is no other way to incorporate an uncertainty allowance.
1.2.6.0 C E.iii	Deleted from Revision of 5/31/91. Requirement satisfied by selecting Yucca Mountain and the particular rock horizon to be characterized.
1.2.6.1.2 PC 1b.ii	Not applicable to new configuration.
1.2.6.1.2 PC 1b.iii	Not applicable to new configuration.
1.2.6.1.3 PC 1a.	Redundant to new 1.2.6.1.3 PC 1a.
1.2.6.2 PC 1d.	Redundant to new 1.2.6.2 PC 1a.
1.2.6.2 C B.	Statement says the obvious. In addition, it could force all utilities to be connected to a comparable offsite one.
1.2.6.2.1 PC 1e.	Redundant to new 1.2.6.2.1 PC 1b.
1.2.6.2.1 C E.	This is properly the constructor's responsibility. It does not belong in a design requirements document.
1.2.6.2.3 PC 1b.	Redundant to new 1.2.6.2.3 PC 1b.
1.2.6.4 PC 1a.	Not applicable to new configuration.
1.2.6.4 PC 1a.i	Not applicable to new configuration.
1.2.6.4 PC 1a.ii	Not applicable to new configuration.
1.2.6.4 PC 1a.iii	Not applicable to new configuration.
1.2.6.4 PC 1d.i	Redundant to new 1.2.6.4 PC 1c.i.
1.2.6.4 PC 1i.iii	Not applicable to new configuration.
1.2.6.4 PC 2d.iv	Not applicable to new configuration.
1.2.6.4 PC 2d.v	Covered in Boundaries and Interfaces.
1.2.6.4 PC 2h.iii	Not applicable to new configuration.
1.2.6.4 PC 2i.vi	Unnecessary - it is a definition of controlled blasting which is covered in new 1.2.6.4 PC 2i.iv.
1.2.6.4 PC 2i.viii	Redundant to new 1.2.6.4 PC 2a.i.
1.2.6.4.2 C C	Deleted during Revision of 5/31/91. Deals with shaft design methodology and does not belong in a design requirements document.
1.2.6.4.5 C I.	Not applicable to new configuration.
1.2.6.4.6 C A.	Not applicable to new configuration.
1.2.6.5 PC 1d.i	Redundant to new 1.2.6.5 PC 1d.i.
1.2.6.5 PC 1i.iii	Redundant to new 1.2.6.5 PC 1i.i and 1i.ii.
1.2.6.5 PC 2d.v	Covered in Boundaries and Interfaces.
1.2.6.5 PC 2i.vi	Unnecessary - it is a definition of controlled blasting which is covered in new 1.2.6.5 PC 2j.v.
1.2.6.5 PC 2i.viii	Redundant to new 1.2.6.5 PC 2a.i.
1.2.6.5.3	Entire section not applicable to new configuration.

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Location in ESFDR Rev. 0	Reason for Deletion
1.2.6.6 PC 1a.iii	Redundant to 1.2.6.6 PC 1a.ii.
1.2.6.6 PC 1c.iii(2)	Not applicable to new configuration.
1.2.6.6 PC 1c.vii	Not applicable to new configuration.
1.2.6.6 PC 1c.viii	Not applicable to new configuration.
1.2.6.6 PC 1c.ix	Not applicable to new configuration.
1.2.6.6 PC 1c.x	Not applicable to new configuration.
1.2.6.6 PC 1d.iv	Redundant to new 1.2.6.6 PC 1d.iv.
1.2.6.6 PC 1d.xvii	Covered in ESFDR Appendix B.
1.2.6.6 PC 2c.iii	Partly covered in Boundaries and Interfaces and partly not applicable to new configuration.
1.2.6.6 PC 2c.iv	Partly covered in Boundaries and Interfaces and partly not not applicable to new configuration.
1.2.6.6 PC 2c.v	Partly covered in Boundaries and Interfaces and partly not not applicable to new configuration.
1.2.6.6 PC 2c.vii	Not applicable to new configuration.
1.2.6.6 PC 2c.x	Covered in Boundaries and Interfaces.
1.2.6.6 PC 2j.vii	Redundant to new 1.2.6.6 PC 2k.iii.
1.2.6.6 PC 2j.viii	Redundant to new 1.2.6.6 PC 2a.i.
1.2.6.6 PC 2j.ix	Unnecessary - it is a definition of controlled blasting which is covered in new 1.2.6.6 PC 2k.v.
1.2.6.6 PC 2l.iii	Not applicable to new configuration.
1.2.6.6 PC 2l.vi.b	Not applicable to new configuration.
1.2.6.6 PC 2l.vi.d	Not applicable to new configuration.
1.2.6.7 PC 2b.	Covered in new 1.2.6.7 PC 2.
1.2.6.7 C E.i	Partly redundant to new 1.2.6.7 C E.ii and partly not applicable to new configuration (new configuration covers intent).
1.2.6.7.6 PC 1b.ii	Numbers not applicable to new configuration; Design Organization needs to recalculate the rates for the new configuration. No need to state the rates in the ESFDR.
1.2.6.7.10 PC 1b.	Operational requirement - no need to state this as a design requirement.
1.2.6.7.11 PC 1f.	Covered in ESFDR Appendix B.
1.2.6.8 PC 1b.	Redundant to new 1.2.6.8 PC 1c.
1.2.6.8 PC 1f.	Redundant to new 1.2.6.8 PC 1b.
1.2.6.8 C D.ii	Should be covered in ESFDR Appendix B.
1.2.6.8 C E.ii	Covered in ESFDR Appendix B.
1.2.6.9 PC 1c.	Covered in Boundaries and Interfaces.

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APPENDIX I

PERFORMANCE ASSESSMENT ANALYSES

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APPENDIX I: PERFORMANCE ASSESSMENT ANALYSES

I.1 Introduction

This appendix presents the relationships among the Nuclear Regulatory Commission (NRC) regulations governing the design, construction, and operation of the Exploratory Studies Facility (ESF); the ESF design requirements (ESFDR); and performance assessment (PA) analyses. Summaries of analyses performed to date and recommendations derived from the results of these analyses are also included.

The strategy for complying with the 10 CFR 60 requirements related to PA is discussed in Section I.1. Also discussed in Section I.1 are the relationships among ESFDR requirements specified in the NRC 10 CFR 60, the ESFDR, and PA analyses. Summaries of the results of analyses completed to date and the associated recommendations are presented in Section I.2. A glossary of abbreviations and acronyms are provided in Section I.3.

The 10 CFR 60 requirements that apply to the design, construction, and operation of the ESF are the basis for compliance. These 10 CFR 60 requirements are taken to be the 57 sections or requirements identified and agreed upon by the DOE and NRC. All 57 of these 10 CFR 60 requirements are considered and the ESFDR requirements associated with these 10 CFR 60 requirements are linked (see Table I.2 and its discussion at the end of this section). Compliance with the 10 CFR 60 requirements is then demonstrated by addressing the concerns in the ESFDR requirements. The DAA strategy for showing compliance is employed wherein the hierarchy of requirements was established. Compliance with the higher-level requirements is demonstrated by showing compliance collectively with the lower-level requirements. To this end, the ESFDR requirements are divided into the following groups:

- Those for which no PA analysis have been identified, however other means for demonstrating compliance may be required,
- Those which can be satisfied by roll-ups of lower-level requirements, and
- Those requiring PA analysis.

Table I.1 contains a list of the analyses defined to date. These analyses were defined to quantify criteria in Chapters 0 through 5 of the ESF SDRD Benchmark 5 (ESF Title II Design Summary Report (Rev. 0)) and were grouped by disciplines: hydraulics, rock mechanics, thermal, chemical, and safety. Since their definition, the SDRD has evolved into the ESFDR, for which these analyses are applicable but not exhaustive.

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TABLE I.1 Analysis Supporting ESF Design

Analysis Number	Title
1	Surface Construction Water Movement
2	Construction Water Movement
3	Sewage and Settling Pond Water Movement
4	Water Entry into Shafts Through Rock Mass Surrounding Shaft Collar & Liner
5	Shaft and Main Pad Blasting Effects
6	Shaft and Collar Creep
7	Shaft, Ramp, and Collar Thermal Stress
8	Far Field Thermal Effects
9	Systems and Components Important to Safety
10	Hydrologic and Geochemical Effects of Tracers
11	Hydrologic and Geochemical Effects of Chemicals and Materials in the ESF

Analyses 1--9 have been completed while analyses 10 and 11 are integral parts of the design and construction process and are ongoing. These analyses are based on available data and on the present conceptual understanding of the processes and mechanisms perceived active at Yucca Mountain and may be refined as better understanding evolves through site characterization and through additional analyses. These analyses have been reviewed for applicability to the Revised ESF Title I Configuration. The recommendations put forth in this Appendix are based on the results of this review and are to be used in the Revised ESF Title II design.

Follow-up studies that address uncertainties and the sensitivity of the results to alternate conceptual models should be conducted. The sensitivity of the results of these analyses to design changes should also be ascertained. Recommendations based on the results of these analyses are intended to provide guidance for applying engineering judgment during the design, construction, and operation of the ESF.

Additional analyses will be defined as appropriate, through interactions among analysts, architects/ engineers, and investigators responsible for site characterization activities. It is also anticipated that the results of analyses will impact the design and result in changes in ESFDR performance criteria. Further, analysis results may suggest additional analyses are necessary or that scheduled analyses are not needed. To accommodate this flexibility, this appendix will be dynamic and will be periodically updated to report the results of analyses and recommendations.

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Table I.2 presents the relationship among the 10 CFR 60 requirements applicable to the design, construction, and operation of the ESF; the ESFDR requirements; and the results of PA analyses. Columns 1-6 of Table I.2 are the reference baseline for analysis support for the ESFDR. A unique label, which is displayed in the first column of Table I.2, has been assigned each requirement to facilitate requirement reference.

The second column, the 10 CFR 60 Requirement column, cites the 10 CFR 60 requirements applicable to the design, construction, or operation of the ESF and the third column, the ESFDR Requirement column, contains the associated ESFDR requirement. A blank in the 10 CFR 60 column, indicates that the ESFDR requirement cited in the ESFDR Requirement column has been identified as needing analysis but the ESFDR requirement is not a direct descendant of an applicable 10 CFR 60 requirement. A blank in the ESFDR Requirement column indicates that the current version of the ESFDR does not contain a requirement that corresponds to the 10 CFR 60 listed in the 10 CFR 60 Requirement column.

The fourth column, the ESFDR or 10 CFR 60 Description column, contains a condensed description of the ESFDR requirement contained in the 10 CFR 60 Requirement column. The fourth column contains a condensed description of the 10 CFR 60 requirement when the ESFDR Requirement column is blank.

The fifth column, the ESF Subsystem column, refers to the ESF subsystem to which requirements apply. The sixth column, the ESFDR status column, provides the ESFDR status of concerns expressed in requirements. The seventh column, the Analysis Group column, provides the analysis grouping. The last column, the Analysis Number column, provides the relationship between PA analyses listed in Table I.1 and requirements. Numbers in this column refer to the analysis numbers in Table I.1 and indicate that the results of the corresponding analysis can be applied to address concerns expressed in the requirement. Numbers annotated with "f" indicate that further analysis is required to adequately address all of the concerns expressed in the requirement. Numbers without that annotation indicate that the results from the corresponding analysis adequately address concerns expressed in the requirement. Note that the results from more than one analysis may be required to address all of the concerns addressed in a requirement.

Descriptions at the end of Table I.2 provide additional information for interpreting data in Table I.2. Definitions of other acronyms and abbreviations used in Table I.2 are provided in Section I.3.

Table I.2 PA Analysis Support for the ESF

	Lbl	10 CFR Requirement	ESFDR Requirement	ESFDR or 10 CFR 60 Description	Sub-Syst.	St.	ANALYSIS Group	ANALYSIS No.
•	2	60.15(b)	1.2.6.0 PC 1a.	Base location & design of shafts & ramps on drillcore & results of investigations.	Gen.		Y	
	6	60.15(c)(1)	1.2.6.0 C (1)	Limit potential for adverse impacts on repository performance.	Gen.		R	•
	7	60.15(c)(1)	1.2.6.1 C A.	Limit potential for adverse impacts on repository performance.	Site		R	•
	8	60.15(c)(1)	1.2.6.2 C A.	Limit potential for adverse impacts on repository performance.	SU		R	•
	12	60.15(c)(1)	1.2.6.7 C B.	Limit potential for adverse impacts on repository performance.	UGSS		R	•
	44	60.15(c)(1)	1.2.6.0 C C.iii	Control all substances & tracers added to water & compressed air.	Gen.		Y	101,111
	45	60.15(c)(1)	1.2.6.0 C C.iv	Use of hydrocarbons and solvents comply with criteria determined by PA.	Gen.		Y	111
	13	60.15(c)(1)	1.2.6.4 PC 2a.ii	Review materials for substance effects on EBS & waste isolation.	Shaft		Y	111
	14	60.15(c)(1)	1.2.6.5 PC 2a.ii	Review materials for substance effects on EBS & waste isolation.	Ramp		Y	111
	15	60.15(c)(1)	1.2.6.6 PC 2a.ii	Review materials for substance effects on EBS & waste isolation.	UGE		Y	111
	16	60.15(c)(1)	1.2.6.4 PC 2a.iii	Assess impacts of materials & support components on waste isolation.	Shaft		Y	111
	17	60.15(c)(1)	1.2.6.5 PC 2a.iii	Assess impacts of materials & support components on waste isolation.	Ramp		Y	111
	18	60.15(c)(1)	1.2.6.6 PC 2a.iii	Assess impacts of materials & support components on waste isolation.	UGE		Y	111
	21	60.15(c)(1)	1.2.6.4 PC 2a.v	Shaft shall not compromise ability to isolate waste.	Shaft		Y	•
	22	60.15(c)(1)	1.2.6.5 PC 2a.v	Ramp shall not compromise ability to isolate waste.	Ramp		Y	•
	23	60.15(c)(1)	1.2.6.6 PC 2a.v	Underground excavation shall not compromise ability to isolate waste.	UGE		Y	•
	31	60.15(c)(2)	1.2.6.4 PC 1a.	Limit number of boreholes & shafts to accommodate site characterization.	Shaft		Y	
	32	60.15(c)(2)	1.2.6.5 PC 1b.	Limit number of boreholes & shafts to accommodate site characterization.	Ramp		Y	
	33	60.15(c)(2)	1.2.6.6 PC 1b.	Limit number of boreholes & shafts to accommodate site characterization.	UGE		Y	
	40	60.15(c)(3)	1.2.6.6 PC 2b.ii	No boreholes within 15 m. of UG openings outside ESF dedicated test area.	UGE		Y	
	41	60.15(c)(3)	1.2.6.6 PC 2b.iii	PA prior to horizontal boreholes from main test level.	UGE		Y	
	42	60.15(c)(3)	1.2.6.8 C D.ii	Boreholes shall not penetrate TSW2 base without evaluation.	UGT		Y	
	43	60.15(c)(4)	1.2.6.0 C C.i	UG construction shall not adversely affect site characterization.	Gen.		Y	
	47	60.15(c)(4)	1.2.6.6 PC 2d.i	Consider impacts on waste isolation of locating UGF outside perimeter drift.	UGE		Y	
	48	60.15(c)(4)	1.2.6.6 PC 2d.ii	75 ft. stand off from ESF test area.	UGE		Y	
	49	60.15(c)(4)	1.2.6.6 PC 2d.v	Verify < 30% extraction ratio in ESF.	UGE		Y	
	52	60.21(c)(1)(ii)(D)	1.2.6.4 PC 2a.i	Shaft ground support system shall limit adverse effects on waste isolation.	Shaft		Y	
	343	60.21(c)(1)(ii)(D)	1.2.6.4 PC 2a.ii	Diameter shall limit adverse effects on waste isolation.	Shaft		Y	
	53	60.21(c)(1)(ii)(D)	1.2.6.5 PC 2a.i	Ramp ground support system shall limit adverse effects on waste isolation.	Ramp		Y	
	344	60.21(c)(1)(ii)(D)	1.2.6.5 PC 2a.ii	Diameter shall limit adverse effects on waste isolation.	Ramp		Y	
	345	60.21(c)(1)(ii)(D)	1.2.6.6 PC 2a.i	Layout and drift size shall limit adverse effects on waste isolation.	UGE		Y	
	54	60.21(c)(1)(ii)(D)	1.2.6.6 PC 2a.ii	Underground facility ground support shall limit adverse effects on waste isolation.	UGE		Y	
	346	60.21(c)(1)(ii)(D)	1.2.6.4 PC 2a.iii	Liner shall limit adverse effects on waste isolation.	Shaft		Y	
	347	60.21(c)(1)(ii)(D)	1.2.6.5 PC 2a.iii	Liner shall limit adverse effects on waste isolation.	Ramp		Y	
	348	60.21(c)(1)(ii)(D)	1.2.6.4 PC 2a.iv	Operational seals shall limit adverse effects on waste isolation.	Shaft		Y	
	349	60.21(c)(1)(ii)(D)	1.2.6.5 PC 2a.iv	Operational seals shall limit adverse effects on waste isolation.	Ramp		Y	

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Table I.2 PA Analysis Support for the ESF (cont.)

	Lbl	10 CFR Requirement	ESFDR Requirement	ESFDR or 10 CFR 60 Description	Sub-Syst.	St.	ANALYSIS Group	ANALYSIS No.
	350	60.21(c)(1)(ii)(D)	1.2.6.6 PC 2o.iii	Operational seals shall limit adverse effects on waste isolation.	UGE	TBD	Y	
	57	60.21(c)(11)	1.2.6.0 C R.	Design considerations intended to facilitate permanent closure.	Gen		Y	
	71	60.111(b)(1)	1.2.6.0 PC 2b.	GROA designed to perserve retrievability.	UGE		Y	
	74	60.112	1.2.6.1 C C.iii	Shall not affect the capability to meet performance objectives.	Site	TBD	R	•
	76	60.112	1.2.6.2 C. E.	Shall not affect the capability to meet performance objectives.	SU		R	•
	77	60.112	1.2.6.4 PC 2l.i	Shall not affect the capability to meet performance objectives.	Shaft	TBD	R	•
	78	60.112	1.2.6.5 PC 2m.i	Shall not affect the capability to meet performance objectives.	Ramp	TBD	R	•
	79	60.112	1.2.6.6 PC 2n.i	Shall not affect the capability to meet performance objectives.	UGE	TBD	R	•
	80	60.112	1.2.6.7.5 PC 1.	Shall not affect the capability to meet performance objectives.	UGT		R	•
	351	60.112	1.2.6.7.6 PC 1b.	Shall not affect the capability to meet performance objectives.	UGT		R	•
	352	60.112	1.2.6.7.6 PC 1e.	Shall not affect the capability to meet performance objectives.	UGT		R	•
	353	60.112	1.2.6.7.6 C A.i	Shall not affect the capability to meet performance objectives.	UGT	TBD	R	•
	46	60.112	1.2.6.0 C C.viii	Shall not affect overall system performance objectives.	Gen.		R	•
	82	60.113(a)(1)(ii)(A) & (B)	1.2.6.0 PC 2d.iii	Containment of HLW shall be substantially comlete during decay period & release of HLW shall be gradual pro	Gen.		R	•
	84	60.113(a)(1)(ii)(A) & (B)	1.2.6.0 PC 2d.iv	Minimum period of substantially complete containment and maximum release rate.	Gen.		R	•
•	124	60.122(c)(1)	1.2.6.2 C B.	Preclude water inflow to ESF following water tank failures.	SU		Y	
•	125	60.122(c)(1)	1.2.6.2 C C.	Preclude water inflow to ESF following water pipe ruptures.	SU		Y	
	92	60.122(c)(1)	1.2.6.1.4 C A.	Control drainage to reduce potential for flooding.	Site		Y	
•	123	60.133(a)(2)	1.2.6.1.4 C A.	Control drainage to reduce potential for flooding.	Site		Y	
•	100	60.130	1.2.6.4 PC 1e.viii	Tag fluids, gases, and other materials used in construction.	Shaft	TBD	Y	10f,11f
•	101	60.130	1.2.6.5 PC 1d.viii	Tag fluids, gases, and other materials used in construction.	Ramp	TBD	Y	10f,11f
•	102	60.130	1.2.6.6 PC 1d.ix	Tag fluids, gases, and other materials used in construction.	UGE	TBD	Y	10f,11f
	24	60.133(a)(1)	1.2.6.4 PC 2e.i	Rock support & structural materials shall be compatible with waste isolation.	Shaft	TBD	Y	11f
	27	60.133(a)(1)	1.2.6.4 PC 2e.ii	Rock support & structural materials shall not lessen radionuclide containment.	Shaft	TBD	Y	11f
	25	60.133(a)(1)	1.2.6.5 PC 2e.i	Rock support & structural materials shall be compatible with waste isolation.	Ramp	TBD	Y	11f
	28	60.133(a)(1)	1.2.6.5 PC 2e.ii	Rock support & structural materials shall not lessen radionuclide containment.	Ramp	TBD	Y	11f
	114	60.133(a)(1)	1.2.6.4 PC 2e.iii	Configuration shall contribute to or not detract from performance.	Shaft	TBD	Y	
	115	60.133(a)(1)	1.2.6.5 PC 2e.iii	Configuration shall contribute to or not detract from performance.	Ramp	TBD	Y	
	120	60.133(a)(1)	1.2.6.6 PC 2l.ii	Drift spacing shall be a minimum of two drift diameters.	UGE		Y	2
	26	60.133(a)(1)	1.2.6.6 PC 2l.iv	Rock support & structural materials shall be compatible with waste isolation.	UGE	TBD	Y	11f
	121	60.133(a)(1)	1.2.6.6 PC 2l.v	The UGF shall contribute to or not detract from performance.	UGE	TBD	Y	
	122	60.133(a)(2)	1.2.6.1 PC 1b.	Locate shaft collar & ramp portal to protect from probable maximum flood.	Site		Y	
	130	60.133(a)(2)	1.2.6.4 PC 2l.iii	Design collar to prevent significant water inflow during characterization.	Shaft		Y	4
	131	60.133(a)(2)	1.2.6.5 PC 2l.iii	Design portal to prevent significant water inflow during floods.	Ramp		Y	
	354	60.133(a)(2)	1.2.6.4 PC 2l.ii	Materials & UG design to limit geochemical effects in event of fire.	Shaft	TBD	Y	

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Table I.2 PA Analysis Support for the ESF (cont.)

							ANALYSIS	
	Lbl	10 CFR Requirement	ESFDR Requirement	ESFDR or 10 CFR 60 Description	Sub-Syst.	St.	Group	No.
	355	60.133(a)(2)	1.2.6.5 PC 2f.ii	Materials & UG design to limit geochemical effects in event of fire.	Ramp	TBD	Y	
	132	60.133(a)(2)	1.2.6.6 PC 2g.ii	Materials & UG design to limit geochemical effects in event of fire.	UGE	TBD	Y	
	133	60.133(a)(2)	1.2.6.6 PC 2g.iii	Materials & UG design to limit geochemical effects in event of fire.	UGE		Y	
•	192	60.133(b)	1.2.6.4 PC 1c.iv	Water use in const./oper. shall not cause interference of tests.	Shaft		Y	2
•	193	60.133(b)	1.2.6.5 PC 1d.iv	Water use in const./oper. shall not cause interference of tests.	Ramp		Y	2
•	194	60.133(b)	1.2.6.6 PC 1d.v	Water use in const./oper. shall not cause interference of tests.	UGE		Y	2
•	195	60.133(b)	1.2.6.4 PC 1c.v	Dust control & cleaning walls to limit adverse effects on SC.	Shaft		Y	11f
•	196	60.133(b)	1.2.6.5 PC 1d.v	Dust control & cleaning walls to limit adverse effects on SC.	Ramp		Y	11f
•	197	60.133(b)	1.2.6.6 PC 1d.vi	Dust control & cleaning walls to limit adverse effects on SC.	UGE		Y	11f
•	138	60.133(b)	1.2.6.4 PC 1b.i	Accomodate site specific conditions so that testing is not adversely affected.	Shaft		Y	
•	139	60.133(b)	1.2.6.5 PC 1c.i	Accomodate site specific conditions so that testing is not adversely affected.	Ramp		Y	
•	140	60.133(b)	1.2.6.6 PC 1c.ii	Accomodate site specific conditions so that testing is not adversely affected.	UGE		Y	
•	148	60.133(b)	1.2.6.4 PC 1c.xiv	Locate relative to other accesses to limit interference of tests in either.	Shaft		Y	2
•	149	60.133(b)	1.2.6.5 PC 1d.xiv	Locate relative to other accesses to limit interference of tests in either.	Ramp		Y	2
•	235	60.133(b)	1.2.6.6 PC 2f.ii	Drift spacing shall be a minimum of two drift diameters.	UGE		Y	2
	154	60.133(b)	1.2.6.4 PC 2g.	Design facility with flexibility to adjust for site specific conditions.	Shaft		Y	
	155	60.133(b)	1.2.6.5 PC 2g.	Design facility with flexibility to adjust for site specific conditions.	Ramp		Y	
	156	60.133(b)	1.2.6.6 PC 2h.	Design facility with flexibility to adjust for site specific conditions.	UGE		Y	
	157	60.133(b)	1.2.6.7 C E.	Design facility with flexibility to adjust for site specific conditions.	UGSS		Y	
•	158	60.133(b)	1.2.6.6 PC 1c.iv	Limit interference between tests & between construction & tests.	UGE		Y	
•	159	60.133(b)	1.2.6.6 PC 2b.ii	No boreholes within 15 m. of UG openings outside ESF dedicated test area.	UGE	TBV	Y	
	160	60.133(b)	1.2.6.8 C A.	Location of tests shall not interfere with or endanger structured stability.	UGT		Y	
•	376	60.133(c)	1.2.6.4 PC 1i.i	Design to maintain stability through retrieval period.	Shaft		Y	
•	377	60.133(c)	1.2.6.5 PC 1j.i	Design to maintain stability through retrieval period.	Ramp		Y	
•	162	60.133(c)	1.2.6.0 PC 2e.ii	Design & construct shaft collars & ramp portals for a 100 year life.	Gen.	TBV	Y	
	167	60.133(c)	1.2.6.5 PC 2h.	UGF shall be designed to permit retrieval of waste.	Ramp		Y	
	168	60.133(c)	1.2.6.6 PC 2i.	UGF shall be designed to permit retrieval of waste.	UGE		Y	
	169	60.133(d)	1.2.6.0 PC 2e.	ESF design shall provide for control of water or gas intrusion.	Gen.		Y	
	171	60.133(d)	1.2.6.1 C F.i.	Limit use of water.	Site		Y	1f
	172	60.133(d)	1.2.6.1 C F.ii	Avoid blockage of water that could impact post-closure performance.	Site		Y	
	175	60.133(d)	1.2.6.2 C D.	Fluids recovered shall be disposed to avoid performance impacts.	SU		Y	3f,11f
	239	60.133(d)	1.2.6.8 C E.v	Fluids recovered shall be disposed to avoid performance impacts.	UGT		Y	11f
•	179	60.133(d)	1.2.6.2.3 PC 1a.	Sewage effluent shall not affect site characterization.	SU		Y	
•	180	60.133(d)	1.2.6.2.5 C B.	Prevent interference with characterization activities by the SWWCS.	SU		Y	3
	188	60.133(d)	1.2.6.8 C E.vi	Excess water shall be removed.	UGT	TBD	Y	

Table I.2 PA Analysis Support for the ESF (cont.)

	Lbl	10 CFR Requirement	ESFDR Requirement	ESFDR or 10 CFR 60 Description	Sub-Syst.	St.	ANALYSIS Group	ANALYSIS No.
	198	60.133(d)	1.2.6.8 C E.vii	Cleaning of ESF walls shall limit water saturation.	UGT		Y	
•	199	60.133(d)	1.2.6.4 PC 1o.vi	Tag fluids, gases, and other materials used in construction.	Shaft		Y	10f,11f
•	200	60.133(d)	1.2.6.5 PC 1d.vi	Tag fluids, gases, and other materials used in construction.	Ramp		Y	10f,11f
•	201	60.133(d)	1.2.6.6 PC 1d.vii	Tag fluids, gases, and other materials used in construction.	UGE	TBD	Y	10f,11f
•	202	60.133(d)	1.2.6.4 PC 1o.vii	Fluids & materials shall be evaluated before use.	Shaft	TBD	Y	11f
•	203	60.133(d)	1.2.6.5 PC 1d.vii	Fluids & materials shall be evaluated before use.	Ramp	TBD	Y	11f
•	204	60.133(d)	1.2.6.6 PC 1d.viii	Fluids & materials shall be evaluated before use.	UGE	TBD	Y	11f
	205	60.133(d)	1.2.6.8 C E.i	Fluids & materials shall be evaluated before use.	UGT	TBD	Y	11f
•	206	60.133(d)	1.2.6.4 PC 1o.x	Control blasting agents and explosives so SC is not adversely affected.	Shaft		Y	
•	207	60.133(d)	1.2.6.5 PC 1d.x	Control blasting agents and explosives so SC is not adversely affected.	Ramp		Y	
•	208	60.133(d)	1.2.6.6 PC 1d.xi	Control blasting agents and explosives so SC is not adversely affected.	UGE		Y	
•	209	60.133(d)	1.2.6.4 PC 1o.xi	Evaluate chemical content of blasting agents and explosives.	Shaft	TBD	Y	
•	210	60.133(d)	1.2.6.5 PC 1d.xi	Evaluate chemical content of blasting agents and explosives.	Ramp	TBD	Y	
	211	60.133(d)	1.2.6.6 PC 1d.xii	Evaluate chemical content of blasting agents and explosives.	UGE	TBD	Y	
•	212	60.133(d)	1.2.6.4 PC 1o.xiv	Locate relative to other accesses to limit interference of tests in either.	Shaft		Y	2
•	213	60.133(d)	1.2.6.5 PC 1d.xi	Locate relative to other accesses to limit interference of tests in either.	Ramp		Y	2
	214	60.133(d)	1.2.6.4 PC 2h.i	Limit water use to limit effects on waste isolation.	Shaft		Y	2
	215	60.133(d)	1.2.6.5 PC 2i.ii	Limit water use to limit effects on waste isolation.	Ramp		Y	2
	216	60.133(d)	1.2.6.6 PC 2j.iv	Limit water use to limit effects on waste isolation.	UGE		Y	2
	217	60.133(d)	1.2.6.8 C E.ii	Limit water use to limit effects on waste containment & isolation.	UGT	TBD	Y	
	220	60.133(d)	1.2.6.5 PC 2i.i	Drainage plan shall be consistent with repository oper. & postclosure sealing.	Ramp	TBD	Y	
	221	60.133(d)	1.2.6.6 PC 2j.ii	Drainage plan shall be consistent with repository oper. & postclosure sealing.	UGE		Y	
•	233	60..133(b)	1.2.6.6 PC 1d.x	Control combustible materials to limit adverse effects on testing.	UGE		Y	
	242	60.133(d)	1.2.6.8 C E.ix	Gaseous products shall not produce adverse geochemical affects.	UGT	TBD	Y	11f
•	243	60.133(e)(1)	1.2.6.4 PC 1i.i	Design to maintain stability through retrieval period.	Shaft		Y	
•	364	60.133(e)(1)	1.2.6.5 PC 1j.i	Design to maintain stability through retrieval period.	Shaft		Y	
	245	60.133(e)(1)	1.2.6.5 PC 2h.(2)	Maintain retrievability.	Shaft		Y	
	246	60.133(e)(2)	1.2.6.4 PC 2i.	Design openings to reduce potential for rock movement or fracturing.	Shaft		Y	
	247	60.133(e)(2)	1.2.6.5 PC 2j.	Design openings to reduce potential for rock movement or fracturing.	Ramp		Y	
	248	60.133(e)(2)	1.2.6.6 PC 2k.ii	Design openings to reduce potential for rock movement or fracturing.	UGE		Y	
	249	60.133(e)(2)	1.2.6.4 PC 2i.i	Shall withstand effects of seismic events.	Shaft		Y	
	250	60.133(e)(2)	1.2.6.5 PC 2j.i	Shall withstand effects of seismic events.	Ramp		Y	
	251	60.133(e)(2)	1.2.6.6 PC 2k.iii	Shall withstand effects of seismic events.	UGE		Y	
	252	60.133(e)(2)	1.2.6.4 PC 2i.ii	Locate accesses to limit potential mech. & hydrological interference.	Shaft		Y	2
	253	60.133(e)(2)	1.2.6.5 PC 2j.ii	Locate accesses to limit potential mech. & hydrological interference.	Ramp		Y	2

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Table I.2 PA Analysis Support for the ESF (cont.)

							ANALYSIS	
	Lbl	10 CFR Requirement	ESFDR Requirement	ESFDR or 10 CFR 60 Description	Sub-Syst.	St.	Group	No.
	256	60.133(e)(2)	1.2.6.6 PC 2k.i	Design of UG openings to provide for safe, maintainable ground control.	UGE		Y	
	257	60.133(e)(2)	1.2.6.6 PC 2k.iv	Design MTL to limit overall response to excavation.	UGE		Y	
	258	60.133(e)(2)	1.2.6.6 PC 2k.v	Design UG openings to limit changes in rock properties.	UGE		Y	
	260	60.133(f)	1.2.6.1 C C.ii	Construction methods shall limit damage to underlying rock mass.	Site		Y	5f
	261	60.133(f)	1.2.6.1 C C.iii	Shall not affect the capability to meet performance objectives.	Site	TBD	Y	
	262	60.133(f)	1.2.6.1 C C.i	Shall not significantly increase pathways/reduce performance.	Site		Y	5f
	263	60.133(f)	1.2.6.4 PC 2j.ii	Shall provide stability and minimize creation of preferential pathways.	Shaft		Y	
	264	60.133(f)	1.2.6.5 PC 2k.ii	Shall provide stability and minimize creation of preferential pathways.	Ramp		Y	
	265	60.133(f)	1.2.6.6 PC 2l.ii	Shall provide stability and minimize creation of preferential pathways.	UGE		Y	
	266	60.133(f)	1.2.6.4 PC 2j.v.a.	Area w/o thermal load, diametrical closure rate decreasing after const.	Shaft	TBD	Y	
	267	60.133(f)	1.2.6.5 PC 2k.vi.a.	Area w/o thermal load, diametrical closure rate decreasing after const.	Ramp	TBD	Y	
	268	60.133(f)	1.2.6.6 PC 2l.vi.a.	Area w/o thermal load, diametrical closure rate decreasing after const.	UGE	TBD	Y	
	341	60.133(f)	1.2.6.4 PC 2j. iv	Controlled blasting shall limit disturbance of surrounding rock mass.	Shaft		Y	5f
	272	60.133(f)	1.2.6.4 PC 2j.iii.a	Controlled blasting shall limit disturbance of surrounding rock mass.	Shaft		Y	
	342	60.133(f)	1.2.6.5. PC 2k.v	Controlled blasting shall limit disturbance of surrounding rock mass.	Ramp		Y	5f
	273	60.133(f)	1.2.6.4 PC 2j.i.a	Blast induced change in permeability > .5 opening dimension < 1 O.M.	Shaft		Y	5f
	274	60.133(f)	1.2.6.5 PC 2k.ia	Blast induced change in permeability > .5 opening dimension < 1 O.M.	Ramp		Y	5f
	275	60.133(f)	1.2.6.6 PC 2l.i.a	Blast induced change in permeability > .5 opening dimension < 1 O.M.	UGE		Y	5f
	281	60.133(f)	1.2.6.6 PC 2l.v	Use controlled drilling & blasting methods to limit excavation induced damage.	UGE		Y	5f
	291	60.133(h)	1.2.6.0 PC 2d.vii	EBS shall assist geologic setting in meeting performance objectives.	Gen.		Y	
	294	60.133(i)	1.2.6.4 PC 2k. i	Consider thermal , mechanical & hydrologic response of host rock.	Shaft	TBD	Y	6f
	295	60.133(i)	1.2.6.5 PC 2l.i	Consider therimal , mechanical & hydrologic response of host rock.	Ramp	TBD	Y	6f
	296	60.133(i)	1.2.6.6 PC 2m.i	Consider thermal , mechanical & hydrologic response of host rock.	UGE	TBD	Y	6f
	338	60.133(i)	1.2.6.4 PC 2k. ii	Thermal loads shall be considered in predicting the long-term response.	Shaft		Y	
	339	60.133(i)	1.2.6.5 PC 2l. ii	Thermal loads shall be considered in predicting the long-term response.	Ramp		Y	
	297	60.133(i)	1.2.6.6 PC 2m. ii	Thermal loads shall be considered in predicting the long-term response.	UGE		Y	
	340	60.133(i)	1.2.6.4 PC 2k. iii	Shall withstand pressures exerted due to thermal loads.	Shaft	TBD	Y	7f
	366	60.133(i)	1.2.6.5 PC 2l. iii	Shall withstand pressures exerted due to thermal loads.	Ramp	TBD	Y	7f
	299	60.133(i)	1.2.6.6 PC 2m. iv	Shall withstand pressures exerted due to thermal loads.	UGE	TBD	Y	7f
	298	60.133(i)	1.2.6.6 PC 2m.iii	Thermal & thermomechanical effects shall not increase saturation.	UGE	TBD	Y	
	300	60.133(i)	1.2.6.6 PC 2m.v	Thermal effects shall not increase temperature in TSw3 or CHn > 115 C.	UGE		Y	8f
	301	60.134(a) & (b)	1.2.6.0 C K.	Seals shall prevent surface penetrations from creating preferential pathways.	Gen.		Y	
	302	60.134(a) & (b)	1.2.6.4 PC 2l.	Seals shall prevent surface penetrations from creating preferential pathways.	Shaft	TBD	Y	
	303	60.134(a) & (b)	1.2.6.5 PC 2m.	Seals shall prevent surface penetrations from creating preferential pathways.	Ramp	TBD	Y	
	304	60.134(a) & (b)	1.2.6.6 PC 2n.	Seals shall prevent surface penetrations from creating preferential pathways.	UGE	TBD	Y	

Table I.2 PA Analysis Support for the ESF (concl.)

Lbl	10 CFR Requirement	ESFDR Requirement	ESFDR or 10 CFR 60 Description	Sub-Syst.	St.	ANALYSIS Group	ANALYSIS No.
367	60.134(a), (b), & (c)	1.2.6.4 PC 2l.iii	Construction materials shall not interfere with postclosure sealing.	Shaft	TBD	Y	
368	60.134(a) , (b), & (c)	1.2.6.5 PC 2m.iii	Construction materials shall not interfere with postclosure sealing.	Ramp	TBD	Y	
305	60.137	1.2.6.1 C D.	Site shall facilitate performance confirmation testing.	Site	TBD	Y	•
306	60.137	1.2.6.4 C B.I	Performance confirmation testing shall consider adverse impacts on site.	Shaft		Y	•
307	60.137	1.2.6.5 C B.I	Performance confirmation testing shall consider adverse impacts on site.	Ramp		Y	•
308	60.137	1.2.6.6 C B.I	Performance confirmation testing shall consider adverse impacts on site.	UGE		Y	•
369	60.141 & 60.142	1.2.6.4 C B.I	Performance confirmation testing shall consider adverse impacts on site.	Shaft		Y	•
370	60.141 & 60.142	1.2.6.5 C B.I	Performance confirmation testing shall consider adverse impacts on site.	Ramp		Y	•
371	60.141 & 60.142	1.2.6.6 C B.I	Performance confirmation testing shall consider adverse impacts on site.	UGE		Y	•
323	60.151	1.2.6.0 PC 2d.xi	QA program applicability.	Gen.		Y	•
325		1.2.6.1.1 PC 1a.i.	Analysis shall determine if muck and access roads should be included on MS.	Site		Y	
326		1.2.6.1.1 PC 1a.ii.	Analysis shall determine if shaft accesses should be included on MS.	Site		Y	
327		1.2.6.1.1 PC 1a.iii.	Analysis shall determine if ramp accesses should be included on MS.	Site		Y	
329		1.2.6.1.1 PC 1a.v.	Analysis shall determine if construction facilities should be included on MS.	Site		Y	
330		1.2.6.1.1 PC 1a.vi.	Analysis shall determine if muck handling facilities should be included on MS.	Site		Y	
332		1.2.6.1.1 PC 1a.viii.	Analysis shall determine if utilities should be included on MS.	Site		Y	
331		1.2.6.1.1 PC 1a.xii.	Analysis shall determine if multi purpose boreholes should be included on MS.	Site		Y	
333		1.2.6.1.2 PC 1a.i.	Analysis shall determine if items of construction utilities shall be incl'd.	AS		Y	
334		1.2.6.1.2 PC 1a.ii.	Analysis shall determine if construction surface storage shall be incl'd.	AS		Y	
335		1.2.6.1.2 PC 1a.v	Analysis shall determine if SC surface storage shall be included.	AS		Y	

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Legend for Table I.2

Heading	Definition
Sub-system	
AS	Auxiliary site
CHn	Calico Hills nonwelded vitric unit
DECOM	Decommissioned
EBS	Engineered barrier system
FPS	Fire Protection System
Gen	General
GROA	General repository operations area
MEM	Mechanical excavation methods
MS	Main site
MTL	Main test level
Ramp	Ramps
SC	Site characterization
SF	Surface facilities
Shaft	Shaft
Site	Site
SU	Surface utilities
SWS	Surface water systems
TBM	Tunnel boring machine
TSw3	Topopah Springs Welded Level 3
UGE	Underground excavation
UGSS	Underground service systems
UGT	Underground testing
UGWWCS	Underground waste water collection system
WDS	Water distribution system
ESFDR Requirement	
1.2.6.X	Refers to a specific ESFDR requirement.

Heading	Definition
Analysis group	
N	No PA analyses are required
R	Compliance is demonstrated by satisfying lower level requirements.
Y	PA analysis are required to demonstrate compliance.
Analysis No.	
xx	Analysis number from Table I.2: the result from corresponding analysis adequately address concerns expressed in the requirement.
xxf	Analysis number from Table I.2: results from the corresponding analysis may be applied to address the concerns expressed in the requirement. Further analysis is required.
*	Results from all of the analyses listed in Table I.2 may be applied in addressing the concerns in the requirements.
St.	
TBD	To be determined
TBV	To be verified
Left Margin Annotation	
*	Indicates an ESFDR/10 CFR 60 linkage, due to NRC interpretations of 10 CFR 60, that is not shown in Volume 1.

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I.2 Analyses Summary

The analyses summarized in this appendix are based on widely used conceptual and mathematical models that incorporate our present understanding of processes and mechanisms ongoing at Yucca Mountain. It should be emphasized that the results of these analyses may not agree with results of future analyses based on alternate conceptual models. As our knowledge of the site increases these uncertainties may be reduced or removed by future analyses. Recommendations based on these analyses are provided only as guidance and will be evaluated and revised through continual interactions among the architectural engineers, analysts, and investigators responsible for site characterization. Thus, refinement of the results is an ongoing and iterative process, which must complement site characterization. These analyses were based on the ESF Title II Design (ESF Title II Summary Report (Rev. 0)), but the analyses have been reviewed for applicability to the Revised ESF Title I Configuration. The recommendations which follow are based on this review and are to be used in the Revised ESF Title II design.

I.2.1 Analysis 1. Surface Construction Water Movement Above the Repository

Purpose:
To provide numerical criteria for limiting the amount of water that can be placed on the surface above the repository and for determining the lateral extent of water as it flows within the mountain due to the application of water at the surface.

Summary:
The calculations were performed in accordance with Sandia National Laboratories (SNL) internal documents Problem Definition Memos PDM 72-28 (one-dimensional) and PDM 72-29 (two- dimensional).

A series of one-dimensional calculations were made using TOSPAC to estimate changes in saturation at depth and to provide input to the two-dimensional calculations. The two-dimensional calculations were performed using NORIA-SP to substantiate the one-dimensional results and to determine the lateral movement of the water within the mountain due to application of water at the surface.

The physics associated with water transport at the surface are complicated and include unpredictable variables such as the weather and topography. Thus, the amount of water that will enter the mountain can only be inferred from measurements of rainfall, surface evaporation, run-off, the amount of water applied on the surface and through a surface water balance. Because only the water that enters the mountain can affect repository performance and underground tests, these calculations were posed in terms of the amount of water

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penetrating the surface rather than the amount of water applied to the surface. This minimizes complications and uncertainties associated with surface water balances and scenarios for water application in the calculations.

The result of this analysis shows that 16 cubic meters of water per square meter of surface area can enter the mountain without increasing the saturation at the repository horizon within 10,000 years. Additionally, the lateral extent of the water is confined to within four times the wetted surface area. Sixteen cubic meters of water per square meter of surface area is the amount of water that would infiltrate the mountain after five years of infiltration at a constant rate of 8.76 mm/day (2.0 gallons/yd^2/day).

These results address concerns expressed in ESFDR requirement 1.2.6.1 C F.i.

Recommendation:
The results of Analysis 1 indicate that limiting the cumulative total amount of water (including precipitation) placed onto the surface above the potential repository to 3,540 gallons per square yard (16 cubic meters per square meter) of watered area will not impact the performance of the repository in 10,000 years (1.2.6.1 C F.i). Monitor precipitation and surface water applications from all operations such as dust suppression, surface base testing, compaction and repository construction; and budget water applications onto the surface such that the total water budget does not exceed 3,540 gallons per square yard of watered area above the "potential" repository. Limit water use to as low as reasonably achievable.

Citations for the data used, lists of assumptions, results, and the rationale for applying the results to address concerns expressed in requirements can be found in SNL's YMP record center under file codes 70/12147/PDM 72-28/1.0/QA and 70/12147/PDM 72-29/1.0/QA.

I.2.2 Analysis 2. Analyses of Construction Water Movement

Purpose:
To estimate the potential for water used in the construction of shafts and ramps to interfere with experiments conducted in the surrounding host rock.

Summary:
The calculations were performed in accordance with the SNL internal document Problem Definition Memo PDM 72-30. One-dimensional calculations using NORIA-SP were performed to determine construction water movement from shafts and drifts. The results and conclusions for drifts may also be applied to ramps. These calculations are extensions of the analyses performed by Eaton and Peterson [1988] but at higher

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construction water requirements and higher retention factors (i.e., for more water entering the surrounding host rock). The calculations were performed as summarized below:

<u>Shafts</u>
Geometry
  One-dimensional axisymmetric
  Shaft radius: 2.21 m
Modified Permeability Zone (MPZ): one diameter
Parameters
  Stratigraphic Units:
    Tiva Canyon, Paintbrush, Topopah Springs, Calico Hills
  Construction water used:
    2.856 cubic meters per meter of shaft
  Retention factor
    Without ventilation: 15 percent
    With ventilation: 10, 15, 20 percent

<u>Drifts</u>
Geometry
  One-dimensional cartesian
  Drift dimensions:
    height 14 feet, width 21 feet per the ESF Title II Design Summary Report (Rev. 0)design
Modified Permeability Zone (MPZ): 2.76 m
Parameters
  Stratigraphic Units:
    Topopah Springs, Calico Hills
  Construction water used:
    2.918 cubic meters per meter of drift
  Retention factor
    Without ventilation: 15 percent
    With ventilation: 10, 15, 20 percent

The results of these calculations show that ventilation removes the retained construction water and dries out the surrounding rock.

The penetration of water into the rock at constant values of saturation change is illustrated as a function of time. These curves provide bounds for evaluating the interference of construction water with experiments conducted in the surrounding host rock.

These results address concerns expressed in ESFDR requirements 1.2.6.4 PC 1c.iv, 1.2.6.4 PC 1c.x , 1.2.6.4 PC 1c.xiv, 1.2.6.4 PC 2i.ii, 1.2.6.5 PC 1d.iv, 1.2.6.5 PC 1d.xi, 1.2.6.5 PC 1d.xiv, 1.2.6.5 PC 2i.ii, 1.2.6.5 PC 2j.ii, 1.2.6.6 PC 1d.v, 1.2.6.6 PC 2f.ii and 1.2.6.6 PC 2j.ii.

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Recommendation:
Separate shafts, ramps, and drifts from other accesses 34 meters in the Calico Hills and 20 meters elsewhere to limit interference of tests in either (1.2.6.4 PC 1c.xiv, 1.2.6.4 PC 2i.ii, 1.2.6.5 PC 1d.xiv, 1.2.6.5 PC 2i.ii, 1.2.6.5 PC 2j.ii, 1.2.6.6 PC 2f.ii, and 1.2.6.6 PC 2j.ii). For cases where these criteria are restrictive, use the loci of saturation change as a function of distance from shafts to limit hydrological interference to acceptable levels.

Recommendation:
Separate tests 17 meters from shafts, ramps, and drifts in the Calico Hills and 10 meters from shafts elsewhere to prevent interference of construction with tests (1.2.6.4 PC 1c.iv, 1.2.6.5 PC 1d.iv, and 1.2.6.6 PC 1d.v). For cases where these criteria are restrictive, use the loci of saturation change as a function of distance from shafts to design experiments such that the hydrological interference is within acceptable limits.

Citations for the data used, lists of assumptions, results, and the rationale for applying the results to address concerns expressed in requirements can be found in SNL's YMP record center under file code 70/12147/PDM 72-30/1.0/QA.

I.2.3 Analysis 3. Analyses of Sewage and Settling Pond Water Movement

Purpose:
To estimate the potential for water leakage from settling ponds in the muck storage area and discharged from the sewage pond system to interfere with experiments conducted in the ESF.

Summary:
The calculations were performed in accordance with Problem Definition Memo PDM 72-31.

Calculations were performed to evaluate both sewage ponds and settling ponds using the conditions summarized below.

Sewage ponds
The potential effects of the sewage pond locations were investigated by performing calculations at two locations; one near the edge of the repository block and the other approximately two miles east of the repository boundary. These calculations predicted water movement from the sewage ponds at the two locations. These locations were selected to correspond to the Title II design for the locations for muck settling ponds and sewage ponds.

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The sewage pond size was obtained from the ESF Title II Design Summary Report (Rev. 0) and the pond was assumed to be unlined and to contain sewage at a constant 1.83 meters depth for five years.

Settling ponds
Water movement from settling ponds and the effects of leaks in pond liners were predicted by calculations for leakages which correspond to 100, 10, and 1 percent of the Title II design settling pond surface area. Leaks were assumed to be discrete with negligible impedance to flow and the depth of the pond was assumed to be a constant 3.05 m.

Summary:
These calculations show that water leakage from settling ponds in the muck storage area and in the location of the sewage ponds have no effect on the saturation at the repository horizon and will not interfere with experiments conducted in the ESF.

These results adequately address concerns expressed in ESFDR requirements 1.2.6.2 C A, 1.2.6.2.3 C B, and 1.2.6.2.5 C B and address concerns expressed for fluids with transport properties similar to water in requirement 1.2.6.2 C D.

Recommendation:
Storage of wastewater in ponds located outside the repository block will not affect repository performance (1.2.6.2 C A).

Recommendation:
Sewage ponds located outside the repository block will not affect repository performance (1.2.6.2.3 C B).

Recommendation:
Locate waste water ponds at least 700 feet from site characterization activities to assure that the wastewater will not interfere with site characterization anywhere in the repository block. Use the two-dimensional saturation profiles produced from the results of this analysis to determine the interference from ponds located closer to the repository block (1.2.6.2.5 C B).

Recommendation:
Fluids with transport properties similar to water stored in ponds located outside the repository block will not affect repository performance (1.2.6.2 C D).

Citations for the data used, lists of assumptions, results, and the rationale for applying the results to address concerns expressed in requirements can be found in SNL's YMP record center under file code 70/12147/PDM 72-31/1.0/QA.

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I.2.4 Analysis 4. Water Entry Into Shafts Through Rock Mass Surrounding Shaft Collar and Liner

Purpose:
To determine the amount of water entering the shaft through the near-surface fracture network.

These calculations were performed in accordance with the SNL internal document Problem Definition Memo PDM 76-08.

Three scenarios considered in this study are as described below (Fernandez et al., 1989):

(1) The rainfall rate scenario in which the flow of water into the fractures is controlled by the rate of rainfall. Rain falling in excess of the fracture network's ability to absorb water is assumed to drain off the pad. This is not the case if the pad site is restored after closure of the ESF so that the postclosure hydrology of the pad site is like that prior to construction or if the engineered drainage features around the ESF pad do not maintain drainage.

(2) The sheet flow scenario in which sheet flow is assumed to occur over the pad. This scenario assumes that no restoration of the ES pad occurs and that the amount of water entering the fracture network is limited only by the network's ability to absorb water.

(3) The zones of influence of the Probable Maximum Flood Channel and the shaft (worst case) are 43 and 42 meters, respectively. Thus, locating shafts more than 85 meters from the Probable Maximum Flood Channel will prevent water inflow into shafts during flooding.

These analyses were performed under the assumption that no remedial measures were performed in the vicinity of the shaft to limit water inflow into the rock matrix. The retarding effect of an alluvial cover was neglected.

The primary conclusion of this analysis is that the water entry into the exploratory shaft by way of the rock mass behind the shaft collar is less than the storage and drainage capacity of the shaft sump under the host rock conditions. Performance implications associated with this water flow are not expected. For this reason no design constraints are imposed on the shaft collar to limit the permeability of rock behind the collar. This conclusion adequately addresses a concern expressed in ESFDR requirement 1.2.6.4 PC 2f.iii.

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It is necessary to emphasize that should significant water entry occur behind the shaft collar as a result of shaft excavation, remedial measures may be applied. These remedial measures include grouting the fractures near the collar and restoring the pad area at closure using the strategies to control infiltration given in Section 8.3.2 of Fernandez et al. (1989).

Recommendation:
Locate shafts 85 meters from the Maximum Probable Flood Channel to prevent inflow during floods (1.2.6.4 PC 2f.iii).

Citations for the data used, lists of assumptions, results, and the rationale for applying the results to address concerns expressed in requirements can be found in SNL's YMP record center under file code 70/12471/PDM 76-08/1.0/QA.

I.2.5 Analysis 5. Shaft and Main Pad Blasting Effects

Purpose:
To provide quantitative estimates of the extent of fracturing which may result from blasting used to excavate the shaft and bring the pad area to grade. The blast design will be assessed to determine the length of fractures predicted to extend from blast holes.

Summary:
This evaluation was performed in accordance with the SNL internal document Design Investigation Memo DIM 257.

An assessment of the extent of fracturing in preparation of the pad, collar, and shaft for the Exploratory Shaft Facility has been completed. The investigation provides background and guidance for determining if controlled blasting can be used to limit excavation-induced damage to the rock. This assessment is based on the Site Characterization Plan Conceptual Design Report (SCP-CDR), MacDougall [1987]. The results, for the most part, are specific to that design, however, the results may be applied to the Revised ESF Title I Configuration as described herein. For this analysis a preliminary conceptual design for the pad was used because no reference design for the pad existed. For the collar and shaft the extent of fracturing was based on McKenzie [1987].

For the pad, the assessment indicates that if the Tiva Canyon unit is locally high in lithophysal content, then surface preparations (which must include a cut and fill operation) could be completed by ripping. If the Tiva Canyon unit is low in lithophysal content, a bench blast design is conceived to minimize damage. This information applies to ESFDR requirements 1.2.6.1 C C.i and 1.2.6.1 C C.ii.

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For the shaft, a review of the blast design prepared by Fenix and Scisson indicates that damage caused by blasting could extend 3 to 4 feet (0.9 to 1.2 m) beyond the excavation wall. The comments on this design provide a means to understand and possibly decrease the expected blast-induced damage.

This analysis addresses the extent of fracturing due to blasting, and therefore may be applied in a generic fashion to the following requirements: 1.2.6.1 C C.i, 1.2.6.1 C C.ii, 1.2.6.4 PC 2j.i.a ,1.2.6.4 PC 2j.iv, , 1.2.6.5 PC 2k.i.a, 1.2.6.5 PC 2k.v, 1.2.6.6 PC 21.i.a, and 1.2.6.6 PC 21.v.

The empirical methods used in this analysis specifically were not developed for tuff and may not be directly applicable. Computer analysis methods employing a more quantitative approach will be conducted as the required data (e.g., dynamic rock properties) become available.

Recommendation:
The results of Analysis 5 indicate that excavation methods incorporating ripping in high lithophysae material and a bench blast design for low lithophysae material should be considered to limit damage to the underlying rock mass (1.2.6.1 C C.i and 1.2.6.1 C C.ii).

Recommendation:
The results of Analysis 5 indicate that a goal for the extension of blast-induced fracturing into intact rock should be limited to less than 1 m using controlled blasting. (1.2.6.4 PC 2j.i.a, 1.2.6.4 PC 2j.iv, 1.2.6.5 PC 2k.i.a, 1.2.6.5 PC 2k.v, 1.2.6.6 PC 21.i.a, and 1.2.6.6 PC 21.v)

Citations for the data used, lists of assumptions, results, and the rationale for applying the results to address concerns expressed in requirements can be found in SNL's YMP record center under file code 60/12147/DIM 257/1.0/QA.

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I.2.6 Analysis 6. Shaft and Collar Creep

Purpose:
The purpose of this analysis is to estimate the potential for rock creep and its effect on the shaft and collar.

This analysis was performed in accordance with the SNL internal document Design Investigation Memo DIM 256.

This assessment is based on the Site Characterization Plan Conceptual Design Report (SCP-CDR), MacDougall [1987]. The results, for the most part, are specific to that design, however, the results may be applied to the Revised ESF Title I Configuration as described herein. This investigation provides background and guidance to assess if total closure of the rock around the shaft is expected to be less than 76 mm (3 inches) in 100 years and if the diametrical closure will average less than 1 mm per year.

The thermal and mechanical environment in the vicinity of the shafts (unlined) for the 100-year operational period is reviewed in light of potential time-dependent deformation mechanisms. Magnitudes of creep strains will be on the same order as the magnitudes of the instantaneous elastic and plastic strains resulting from excavation of the shaft ($\sim 10^{-3}$). Data from existing tunnels in rocks having mineralogies, structures (joints, fractures, and deformation), and overburden similar to those at the Yucca Mountain site suggest that creep deformation is not likely to lead to deformations that produce instability. Calculations of the creep strain in granitic rocks at temperatures and stresses more severe than those expected at the ESF result in creep strain magnitudes that are on the same order as the elastic and plastic strain magnitudes expected in tuff. The most significant unknown in this study is the potential magnitude of creep along fractures. It is concluded that creep strains on favorably oriented fractures may exceed the estimated matrix strains. The strain magnitudes postulated based on the review of available information can be accommodated in an appropriate liner design for the ESF.

Data available for predicting the creep strains at the ESF are sparse. The potential creep phenomena should be further studied through an integrated laboratory and field experimentation program and monitoring program coupled with analyses.

This analysis addresses the potential for collar creep and its potential effects, and therefore may be applied in a generic fashion to the following requirements: 1.2.6.4 PC 2k.i, 1.2.6.5 PC 2l.i, 1.2.6.6 PC 2m.i.

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Recommendation:
The results of Analysis 6 indicate that the thermomechanical response of the host rock matrix and surrounding strata to time-dependent deformation mechanisms will be comparable to the instantaneous elastic and plastic strains ($\sim 10^{-3}$) for rock units at and above the TSw2 resulting from excavation of the shaft (1.2.6.4 PC 2k.i, 1.2.6.5 PC 2l.i, and 1.2.6.6 PC 2m.i). This recommendation may not be appropriate for the Calico Hills unit.

Citations for the data used, lists of assumptions, results, and the rationale for applying the results to address concerns expressed in requirements can be found in SNL's YMP record center under file code 60/12147/DIM 256/1.0/QA.

I.2.7 Analysis 7. Shaft, Ramp, and Collar Thermal Stress

Purpose:
The purpose of this analysis is to provide quantitative estimates of the thermal stresses expected on the shaft liner and collar, through the shaft breakout zones, the main test level, and along the main access drifts in the potential repository.

Summary:
The analysis was performed in accordance with the SNL internal document Problem Definition Memo PDM 75-13 Rev C.

This analysis is based on the Site Characterization Plan Conceptual Design Report (SCP-CDR), MacDougall [1987]. The results, for the most part, are specific to that design, however, the results may be applied to the Revised ESF Title I Configuration as described herein. The computer code STRES3D was used to predict the temperature, stress and strain resulting from the emplacement of heat generating high-level waste. This model simplifies the geometry of the potential repository as a semi-infinite elastic half space. The panels containing waste are modeled as four exponentially decaying source terms for the first 1,000 years after waste emplacement and six source terms for times of 1,000 to 10,000 years. Waste is assumed to be emplaced within 25 years. A total of 130 plate elements were used to model the waste panels.

The thermally-induced axial stress (vertical) change at the location of ES1 and ES2 indicate a stress decrease at all times. The thermally-induced horizontal normal stresses are compressive at elevations below 3450 feet elevation (in and below the TSw2) at both shaft locations with negative stress changes generated near the surface.

At the ES1 location, changes in the north-south and east-west horizontal stresses peak at approximately the same value at 2000 years. The maximum north-south horizontal stress change is approximately 1.8 MPa and the maximum east-west horizontal

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stress change is approximately 1.7 MPa. The maximum vertical stress change at the ES1 location occurs 300 years after the start of waste emplacement and is approximately 2.2 MPa (negative).

At the location of ES2, the maximum temperature is slightly less than that for ES1. The maximum vertical stress change is 1.6 MPa (negative) and occurs at 300 years. The maximum north-south horizontal stress change occurs at 2000 years at a value of approximately 1.7 MPa (compressive). The maximum east-west horizontal stress change of approximately 2.1 MPa (compressive) occurs at 500 years.

The temperature changes at the upper and lower breakout rooms are significantly lower than at the MTL. The temperatures and stress changes at the MTL are strongly dependent on the location relative to the closest waste emplacement panels.

Stress and temperature changes along the centerline of the mains and the exploratory drifts are presented. The temperature at the centerline of the main drifts will reach approximately 57° C (a change of 32° C). For the exploratory drifts, which later function as panel access drifts, temperature changes of approximately 70° C are predicted and the horizontal compressive stress at the drift location is predicted to increase by 11 MPa.

The numerical values presented are based on thermal and thermomechanical properties which are cited in PDM 75-13 Rev. C., and are sensitive to the repository layout, waste emplacement loading density, and the in situ site conditions.

The results of this analysis provide general information which might be used to address concerns expressed in ESFDR requirements 1.2.6.4 PC 2k.iii, 1.2.6.5 PC 2l.iii, and 1.2.6.6 PC 2m.iv. Further analysis are required.

Recommendation:
The results of Analysis 7 indicate that during the 100 years following waste emplacement the thermal and thermomechanical response of the host rock at the location of ES1 and ES2will be such that the vertical stress will have decreased by less than 2 MPa at the proposed elevation of the potential repository (1.2.6.4 PC 2k.iii, 1.2.6.5 PC 2l.iii, and 1.2.6.6 PC 2m.iv).

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Recommendation:
The results of Analysis 7 indicate that horizontal stresses increase at the ES locations on the order of 0.3 MPa (maximum north-south horizontal stress change for first 100 years) and on the order of 1.3 MPa (maximum east-west horizontal stress change due to thermal loading of the repository) at the potential repository horizon. The maximum vertical stress is expected to decrease on the order of 1.7 MPa for the same time frame (1.2.6.4 PC 2k.iii, 1.2.6.5 PC 2l.iii, and 1.2.6.6 PC 2m.iv) at these same locations.

Citations for the data used, lists of assumptions, results, and the rationale for applying the results to address concerns expressed in requirements can be found in SNL's YMP record center under file code 70/124232/PDM 75-13 Rev. C/1.0/QA.

I.2.8 Analysis 8. Far Field Thermal Effects

Purpose:
To provide three-dimensional far-field predictions for the temperatures surrounding a potential repository.

Summary:
The analysis was performed in accordance with the SNL internal document Problem Definition Memo PDM 75-13.

This analysis is based on the Site Characterization Plan Conceptual Design Report (SCP-CDR), MacDougall [1987]. The results, for the most part, are specific to that design, however, the results may be applied to the Revised ESF Title I Configuration as described herein. The thermal calculations were conducted as part of the thermal-mechanical calculations using STRES3D and are discussed in Analysis 7. The results of Analysis 8 indicate that the maximum temperature from waste emplacement at the TSw3-CHn boundary under the main test level will be less than 45 C°. Further analysis will be required.

These results address concerns expressed in ESFDR requirement 1.2.6.6 PC 2m.v.

Recommendation:
Unless the output of the heaters exceed the thermal loading of the repository, the temperature at the TsW3-CHn boundary will not exceed 115°C (1.2.6.6 PC 2m.v).

Citations for the data used, lists of assumptions, results, and the rationale for applying the results to address concerns expressed in requirements can be found in SNL's YMP record center under file code 70/124232/PDM 75-13 Rev. C/1.0/QA.

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I.2.9 Analysis 9. Systems and Components Important to Safety

Purpose:
To perform a technical review of the documentation identifying Items Important to Safety, Items Important to Waste Isolation and the Quality Activities List.

The documents describing the Q-List, the Quality Activities List and the Project Requirements List have been reviewed and published by the Quality Review Board as YMP/90-55, YMP/90-56, and YMP/90-57 respectively. (1.2.6.0 PC 2d.xi)

Recommendation:
Items and activities to be included as Items Important to Safety, Items Important to Waste Isolation and the Quality Activities List are identified in the results of Analysis 9.

I.2.10 Analysis 10. Analyses of the Hydrologic and Geochemical Effects of Tracers

Purpose:
To identify, characterize and control tracer tagging compounds and to evaluate their potential effects on experiments and waste isolation.

Summary:
Analysis 10 and 11 have been combined into a Memo of Understanding (MOU 330011) among YMP participants that will create a project control list for tracers and materials including water which will be used at Yucca Mountain. This document formalizes the relationships required to perform the work described in Analyses 10 and 11.

This analysis will address concerns expressed in ESFDR requirement 1.2.6.0 C C.iii, 1.2.6.4 PC 1c.viii, 1.2.6.5 PC 1d.viii, and 1.2.6.6 PC 1d.ix.

Recommendation:
Analysis 10 is ongoing as part of Memorandum of Understanding 330011. The region of influence related to hydrological and geochemical effects of tracers is assumed to be similar to the area influenced by water (1.2.6.0 C C.iii, 1.2.6.4 PC 1c.viii, 1.2.6.5 PC 1d.viii, and 1.2.6.6 PC 1d.ix). After the tracers have been identified and their transport properties characterized, analyses may show that the transport of certain tracers may significantly differ from the transport of water.

I.2.11 Analysis 11. Analyses of the Hydrologic and Geochemical Effects of Chemicals

Purpose:
To identify, characterize, and control materials and chemicals and to evaluate their potential effects on experiments and waste isolation.

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Analysis 10 and 11 have been combined into a Memo of Understanding (MOU 330011) among YMP participants that create a project control list for tracers and materials including water which will be used at Yucca mountain. This document formalizes the relationships required to perform the work described in Analyses 10 and 11.

This analysis will address concerns expressed in ESFDR requirements 1.2.6.0 C C.iii, 1.2.6.0 C C.iv, 1.2.6.2 C D., 1.2.6.4 PC 1c.v, 1.2.6.4 PC 1c.vi, 1.2.6.4 PC 1c.vii, 1.2.6.4 PC 1c.viii, 1.2.6.4 PC 2a.ii, 1.2.6.4 PC 2a.iii, 1.2.6.4 PC 2e.i, 1.2.6.4 PC 2e.ii, 1.2.6.5 PC 1d.v, 1.2.6.5 PC 1d.vi, 1.2.6.5 PC 1d.vii,1.2.6.5 PC 1d.viii, 1.2.6.5 PC 2a.ii, 1.2.6.5 PC 2a.iii, 1.2.6.5 PC 2e.i, 1.2.6.5 PC 2e.ii, 1.2.6.6 PC 1d.ix, 1.2.6.6 PC 1d.vi, 1.2.6.6 PC 1d.vii, 1.2.6.6 PC 1d.viii, 1.2.6.6 PC 2a.ii, 1.2.6.6 PC 2a.iii, 1.2.6.6 PC 2f.iv, 1.2.6.8 C E.i, 1.2.6.8 C E.ix, and 1.2.6.8 C E.v.

Recommendation:
Analysis 11 is ongoing as part of Memorandum of Understanding 330011. The region of influence related to hydrological and geochemical effects of hydrocarbons and solvents is assumed to be similar to the area influenced by water (1.2.6.0 C C.iv). After the materials and chemicals have been identified and their transport properties characterized, analyses may show that the transport of certain materials and chemicals may significantly differ from the transport of water.

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References

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2. Fernandez, J. A., T. E. Hinkebein and J. B. Case, 1989. Selected Analyses to Evaluate the Effect of the Exploratory Shafts on Repository Performance at Yucca Mountain, SAND 85-0598, Sandia National Laboratories.

3. MacDougall, H. R., L. W. Scully, and J. R. Tillerson, 1987 NNWSI Project Site Characterization Plan Conceptual Design Report, SAND 84-2641, Sandia National Laboratories, Albuquerque, NM.

4. McKenzie, J. B., 1987, NNWSI Exploratory Shaft Facility - ESF Controlled Blasting Report (Study No. 4 of 11) Revision 1, ESF-FFTL-004, Fenix & Scisson, Inc. (1987).

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I.3 Acronyms and Abbreviations:

CHn	Calico Hills non vitric
DAA	Design Acceptability Analysis
DECOM	Decommissioning
DIM	Design Investigation Memo
DOE	Department of Energy
EBS	Engineered Barrier System
EIS	Environmental Impact Statement
ESF	Exploratory Studies Facility
ESFDR	Exploratory Studies Facility Design Requirements
GROA	Geologic repository operations area
HLW	High level waste
MEM	Mechanical excavation Methods
MS	Main site
MTL	Main test level
MPZ	Modified Permeability Zone
NORIA-SP	Groundwater flow computer code
NRC	Nuclear Regulatory Commission
PA	Performance Assessment
PDM	Problem Definition Memo
Rad	Radiological
SAND	Indicates a Sandia National Laboratories report
SC	Site characterization
SCA	Comparative Analysis of Alternative Sites
SCM	Shaft Construction Method
SCP	Site Characterization Plan
SCP-CDR	Site Characterization Plan Conceptual Design Report
SDRD	Subsystems Design Requirements Document
SF	Surface facilities
SP	Site preparation
SCM	Shaft construction method
SCP	Site Characterization Plan
SNL	Sandia National Laboratories
SP	Site preparation
SU	Surface utilities
SWS	Surface water system
SWWCS	Surface waste water control system
TBD	To be determined
TBM	Tunnel boring machine
TBV	To be verified
TIG	Technical Integration Group
TOSPAC	Total Systems Performance Assessment Code (computer code)
TSw2	Topopah Springs Welded Unit 2
TSw3	Topopah Springs Welded Unit 3
UGE	Underground excavations
UGF	Underground facility
UGSS	Underground support systems
UGT	Underground testing
UGTS	Underground test support
UGU	Underground utilities
UGWWCS	Underground waste water collection system
YMP	Yucca Mountain Project

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APPENDIX J

EXPLORATORY STUDIES FACILITY ENVIRONMENTAL REQUIREMENTS

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EXPLORATORY STUDIES FACILITY ENVIRONMENTAL REQUIREMENTS

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APPENDIX J
EXPLORATORY STUDIES FACILITY ENVIRONMENTAL REQUIREMENTS

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this appendix is to provide a brief, but comprehensive, presentation of the environmental requirements (Federal, State, and local) that apply to all ESF activities. These requirements affect all phases of the ESF process, from permitting before work is allowed to commence, through construction, operation, and closure. Inclusion of these requirements in the design of site characterization activities is essential to ensuring that the activities are conducted in a manner that will protect, maintain, and restore environmental quality; minimize potential threats to the environment, and comply with environmental regulations and policies.

1.2 OVERVIEW OF THE ENVIRONMENTAL PROGRAM

The U.S. Department of Energy (DOE) is committed to performing its activities in an environmentally safe and sound manner, and will comply with all applicable environmental statutes and regulations. To fulfill this commitment at the Yucca Mountain site, the DOE has established an environmental program that assures that site characterization studies will be conducted in such a way that applicable environmental regulatory and programmatic requirements are met. The Yucca Mountain Site Characterization Project (YMP) environmental program is structured to satisfy the statutory requirements of the Nuclear Waste Policy Act (NWPA), as amended; the National Environmental Policy Act (NEPA); the Atomic Energy Act (AEA); and other applicable statutes, regulations and DOE Orders.

The YMP environmental program has been delineated in documents previously issued by the DOE. The Environmental Management Plan (DOE, 1990a) describes how the program is managed and integrated with other parts of the YMP. Federal and State statutes, regulations, requirements, and DOE Orders that apply to the YMP, and a brief description of each, are presented in the Environmental Regulatory and Compliance Plan (ERCP; DOE, 1988a). The ERCP describes how the YMP would satisfy the environmental regulatory requirements for site characterization, and identifies the information necessary to prepare a specific permit application. Environmental monitoring and mitigation program requirements being implemented by the YMP, as required by by the NWPA as amended, are set forth in the Environmental Monitoring and Mitigation Plan (EMMP; DOE, 1988b). Reclamation requirements applicable to the YMP are described in the Reclamation Implementation Plan (RIP; DOE, 1991), and the requirements to be satisfied for the Environmental Impact Statement (EIS) will be defined in the EIS Implementation Plan, to be prepared after EIS scoping meetings have been held. Data collection required by these plans is planned and performed as described in the Environmental Field Activity Plans (EFAPs; DOE, 1988c-g and 1990b,c).

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1.3 SCOPE OF APPENDIX J

The documents mentioned in the previous section represent various elements of the YMP environmental program. Together, they (and certain others not essential to this document) provide a network of plans designed to ensure that the Yucca Mountain environment is protected throughout the period of site characterization study. Not all portions of the plans are relevant to ESF activities, however. The remainder of this document uses information provided in appropriate sections of these various plans to define the requirements that must be satisfied to comply with Federal, State, and local environmental regulations during the performance of ESF activities. Requirements are given for each of the major environmental areas of concern (e.g., air, water, biological resources, hazardous waste management, etc.) likely to be affected by ESF activities.

1.4 ENVIRONMENTAL REQUIREMENTS FLOWDOWN

The ERCP was the upper-tier reference document used for determining the environmental regulatory requirements identified in this Appendix. The environmental requirements presented in the ERCP were derived from applicable Federal, State, and local environmental laws, regulations and orders. The ERCP has been approved by the Office of Environment, Safety and Health and the Office of General Council. Table 1 presents the flowdown interfaces between the ERCP and Appendix J.

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TABLE 1. FLOWDOWN INTERFACES BETWEEN THE ERCP AND APPENDIX J

ENVIRONMENTAL REGULATIONS	ERCP SECTION	APPENDIX J SECTION	APPENDIX J SECTION TITLES
NUCLEAR WASTE POLICY ACT	1.1	9.0	RECLAMATION
ANTIQUITIES ACT	3.2.1	8.0	ARCH. RESOURCE PROTECTION
AMERICAN INDIAN RELIGIOUS FREEDOM ACT	3.2.2	8.0	ARCH. RESOURCE PROTECTION
ARCHAEOLOGICAL RESOURCES PROTECTION ACT	3.2.3	8.0	ARCH. RESOURCE PROTECTION
COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, & LIABILITY ACT	3.2.4	6.0	SOLID & HAZARDOUS WASTE MGMT.
ENDANGERED SPECIES ACT	3.2.5	7.0	BIOLOGICAL RESOURCE PROTECTION
FARMLAND PROTECTION POLICY ACT	3.2.6	9.0	RECLAMATION
FEDERAL LAND POLICY & MANAGEMENT ACT	3.2.7	11.0	LAND ACCESS
HAZARDOUS MATERIAL TRANSPORTATION ACT	3.2.8	6.0	SOLID & HAZARDOUS WASTE MGMT.
MATERIALS ACT	3.2.9	11.0	LAND ACCESS
NATIONAL ENVIRONMENTAL POLICY ACT	3.2.10	11.0	LAND ACCESS
NATIONAL HISTORIC PRESERVATION ACT	3.2.11	8.0	ARCH. RESOURCE PROTECTION
NOISE CONTROL ACT	3.2.12	13.0	NOISE
EO 11988, FLOODPLAIN MANAGEMENT	3.2.13	12.0	FLOODPLAIN/WETLANDS PROTECTION
EO 11990, PROTECTION OF WETLANDS	3.2.14	12.0	FLOODPLAIN/WETLANDS PROTECTION

TABLE 1. FLOWDOWN INTERFACES BETWEEN THE ERCP AND APPENDIX J (continued)

ENVIRONMENTAL REGULATIONS	ERCP SECTION	APPENDIX J SECTION	APPENDIX J SECTION TITLES
CLEAN AIR ACT	3.3.1	2.0	AIR POLLUTION CONTROL
FEDERAL WATER POLLUTION CONTROL ACT	3.3.2	5.0	WATER POLLUTION CONTROL
RESOURCE CONSERVATION & RECOVERY ACT	3.3.3	6.0	SOLID/HAZARDOUS WASTE MGMT.
SAFE DRINKING WATER ACT	3.3.4	4.0	DRINKING WATER PROTECTION
UNDERGROUND INJECTION CONTROL PROGRAM	3.3.4a	4.0	DRINKING WATER PROTECTION
APPROVAL OF PLANS TO CONSTRUCT SANITARY AND SEWAGE COLLECTION SYSTEM AND PERMIT TO OPERATE SYSTEM	3.4.1	5.0	WATER POLLUTION CONTROL
PERMIT TO APPROPRIATE PUBLIC WATERS OF NEVADA	3.4.2	3.0	WATER APPROPRIATION
NEVADA WATER POLLUTION CONTROL LAW	3.4.3	5.2	WATER POLLUTION CONTROL
NEVADA STATE WILDLIFE STATUTES	3.4.4	7.0	BIOLOGICAL RESOURCE PROTECTION
NEVADA STATE VEGETATION STATUTES	3.4.5	7.0	BIOLOGICAL RESOURCE PROTECTION
DOE ORDERS	3.5	10.0	RADIOLOGICAL HEALTH AND SAFETY

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2.0 AIR POLLUTION CONTROL

CLEAN AIR ACT, as amended (P.L.* 95-95; 42 USC* 7401-7642; 40 CFR* 50-53, 58, 60-61, 81.300-.400, 124; EO* 12088; NRS* 445.401 et seq; NAC* 445.430-.944)

Background

The Clean Air Act (CAA, 1977) establishes Federal policy for preserving and enhancing the quality of the Nation's air resources to protect the public health and welfare. The Act ensures, through a State-issued permit program, that adequate steps are taken to control the release of air contaminants from industrial processes and land-disturbing activities. Section 118 of the CAA requires Federal agencies to comply with all Federal, State, interstate, and local requirements regarding the control and abatement of air pollution in the same manner, and to the same extent, as any non-governmental entity.

In 1980, the EPA approved Nevada's plan to implement and enforce the CAA, and in 1988, the agency granted Nevada the authority to implement the "Prevention of Significant Deterioration" (PSD) Program of the CAA. Authority to regulate radioactive air emissions has been retained by the EPA, however. Responsibility for implementing and enforcing the CAA in Nevada resides with the Nevada Division of Environmental Protection (NDEP).

Applicability to the ESF

Site characterization activities such as construction and operation of the exploratory shaft, operation of concrete-batch plants, and land disturbances from field testing and site preparation will generate particulate and gaseous emissions of air pollutants. The origin of most particulates will be non-point sources, e.g., drilling, blasting, rock removal and storage, surface grading and leveling, wind erosion, vehicle travel, and diesel and gasoline engines. Permits will be required for the performance of many of these activities.

Requirements for the ESF

- An Air Quality Surface Disturbance Permit is required before any land-disturbing activities are initiated. A strategy for dust minimization, in particular, must be included in any plan for surface-disturbing activities.

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*Key:
- P.L. = Public Law
- USC = U.S. Code
- CFR = Code of Federal Regulations
- EO = Executive Order
- NRS = Nevada Revised Statutes
- NAC = Nevada Administrative Code

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- All stationary sources (point sources) of air emissions shall comply with the applicable provisions of the CAA, as amended (42 USC 7401), which may include PSD permitting, or offset Policy Review, or both. Federal regulations pertaining to compliance with the CAA include:

  40 CFR 50 (National Primary and Secondary Ambient Air Quality Standards) and 40 CFR 60 (Standards of Performance for New Stationary Sources). The YMP shall comply with the State or local standards included under the stipulations of NRS Chapter 445.401-601 for Air Quality - (1) Permit to Construct, (2) Prevention of Significant Deterioration, and (3) Permit to Operate.

- Registration Certificates

  Registration Certificates are required for all new sources (property and/or equipment) that may emit air contaminants, including concrete batch plant, shaker plant, and ESF Exhaust Shaft (if constructed).

  A separate Registration Certificate is required for each new single source of contaminants prior to the commencement of the activity generating the contaminants.

  The Registration Certificate for a point source will be denied if the point source (1) will prevent the maintenance of State and National ambient air-quality standards; (2) is contrary to the State's air-pollution control strategy; (3) will cause a violation of 40 CFR 60-61 (New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants); or (4) if the best available technology is not defined and adopted as an emission limitation for the source.

  Exemptions to these requirements that are pertinent to site characterization at Yucca Mountain include air-conditioning equipment or fuel-burning equipment that has a heat-input rating of less than 4,000,000 Btu per hour; motor vehicles and internal combustion engines; incinerators with rated burning capacity of less then 25 pounds per hour; storage containers for gasoline, petroleum distillates, or other volatile organic compounds having a capacity of less then 40,000 gallons; equipment used solely for the processing of food for human consumption; disturbing less than 20 acres per year of topsoil; and process weight rates of less than 50 pounds per hour.

- Operating Permits

  A valid Registration Certificate for the source must be in-hand before an Operating Permit is issued.

  An Operating Permit is required within 180 days after start-up for each new source that emits or may emit air contaminants. It is a document issued and signed by the Air Quality Officer (AQO) that approves the operation of a new or existing single source of air contaminants. The Operating Permit may or may not include stipulations.

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After obtaining an Operating Permit, the operator (in this case, the DOE) is responsible for maintaining emissions of air pollutants within the limits specified in the permit. Planned activities (e.g., scheduled maintenance, testing or repairs) that may result in excess emissions of air contaminants prohibited by NAC 445.430 to 445.846 must be reported to the AQO at least 24 hours in advance of the scheduled activity. In the event that an equipment malfunction (or startup or shutdown) or human error results in excess emissions, the AQO must be notified within 24 hours of the incident and a written report submitted within 15 days of the event (NAC 445.667).

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3.0 WATER APPROPRIATIONS

NEVADA WATER LAW, (NRS 533.325-.540; 534.010-.190)

Background

The State of Nevada requires a permit for the appropriation of State waters. The purpose of a Water Appropriation Permit is to prevent possible interference with prior water rights and/or improper use of waters not legally available for use. The Nevada State Engineer's Office administers Nevada water law.

Applicability to the ESF

Site characterization activities will require water. These requirements are currently based on the use of water from Well J-13, but apply to water from any well at the site.

Requirements for the ESF

- Water withdrawal cannot start until a permit is obtained.
- Construction of new facilities, including pumps and the water pipeline to the ESF, cannot begin until a permit is obtained.
- Water use must not exceed quantities allowed by the permit.
- Pump tests are generally excluded from a permit but the exclusion must be requested for each pump test.
- Any dam that will be 10 feet or more in height or, if less than 10 feet in height, will impound more than 10 acre feet of water, must be approved by the State Engineer at least 30 days before construction is to begin.

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4.0 DRINKING WATER PROTECTION

4.1 SAFE DRINKING WATER ACT OF 1974, as amended (P.L. 93-523; 42 USC 300f-300j-10; 40 CFR 124, 141, 143; EO 12088; NRS 445.361 et seq; NAC 445.244-.420)

Background

The Safe Drinking Water Act (SDWA, 1974) grants the EPA authority to regulate public drinking water supplies by establishing drinking water regulations, delegating authority for enforcement of drinking water standards to the States, and protecting aquifers from such things as injection of wastes and other materials into wells.

In 1978, the EPA approved Nevada's program for enforcing the drinking water standards established by the EPA. The Nevada Division of Health within the Nevada Department of Human Resources is the agency responsible for this enforcement.

Construction characteristics of water-supply wells are addressed in NAC 445.358 through 445.400. Storage and distribution specifications required for a public drinking water supply are discussed in NAC 445.410-.418.

Applicability to the ESF

A drinking water system is planned to supply surface facilities for the ESF. By definition, the water supply is considered a "public water supply" since it will probably service 15 or more connections or 25 people for more than 60 days per year. Bottled water will be purchased for drinking water purposes underground.

Requirements for the ESF

- A permit is needed to construct a drinking water system (NAC 445.370-.420).

- Drinking water must meet the standards set forth in 40 CFR 141 and NAC 445.244-.262.

- The water quality monitoring system shall have the capability to sample, measure, and analyze physical, chemical, and biological conditions consistent with the requirements of the Clean Water Act (CWA, 1972) and the SDWA (1974). Such capability must also be compatible with the type and range of concentrations/occurrences of conditions specified in the governing regulations (e.g., 40 CFR 122, 125, 141, 142, 143, and State and local regulations).

- Periodic testing of the system's water quality (at the discretion of the State Health Officer, but probably monthly for bacteriological content) will be required.

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4.2 UNDERGROUND INJECTION CONTROL PROGRAM (91 Stat. 1397; P.L. 93-523; 42 USC 300h (Part C); 40 CFR 124, 144-147; NAC 445.422-.4278; NRS 445.131-.354)

Background

Federal agencies engaged in any activity resulting in an underground injection that may jeopardize a drinking water supply must comply with all Federal, State, and local requirements concerning underground injections. Federal requirements are promulgated under Part C of the Safe Drinking Water Act. The EPA granted the State of Nevada's Division of Environmental Protection the authority to implement and enforce an underground injection control (UIC) program. Nevada's UIC program seeks to prohibit the pollution of existing and potential sources of underground drinking water in Nevada. Exemptions to obtaining a permit would be granted only if the affected groundwater is not now, and will not be, a source of drinking water, or if the total dissolved solids of the affected groundwater exceeds 10,000 milligrams per liter and the water is not reasonably expected to become a supply of drinking water (NAC 445.424).

Applicability to the ESF

Studies proposed for the ESF to characterize the hydrologic environment of Yucca Mountain may require the use of tracers. The State of Nevada has determined that the use of tracers must be regulated under the UIC program.

Requirements for the ESF

- A permit must be obtained for any activity that includes underground injection (NRS 445.131-.354).

- Tracers added to the water system must be of a composition and concentration compatible with the sanitary waste disposal system.

- Infiltration studies using tracers may require a permit.

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5.0 WATER POLLUTION CONTROL

5.1 FEDERAL WATER POLLUTION CONTROL ACT, as amended by the Clean Water Act of 1972, and the WATER QUALITY ACT OF 1987, as amended (33 USC 1251-1376; 33 CFR 209, 320, 323-330; 40 CFR 110, 112, 116, 117, 121, 122-125, 129, 133, 136, 230, 401, and 403; EO 12088; NAC 445.070-.241)

The Federal Acts cited in this section are referred to collectively throughout the remainder of this discussion as "the Clean Water Act." The Clean Water Act (CWA, 1972) establishes Federal policy for restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters. Among other things, the Act provides for the EPA or Federally-authorized States to implement permit programs for regulating the discharge of pollutants to navigable waters from any point source, as follows:

- o Title IV of the Act (i.e., Permits and Licenses, Section 402, the National Pollutant Discharge Elimination System [NPDES]) is administered by the State of Nevada;
- o Federal effluent limitations for direct discharges, and pre-treatment standards for discharges into publicly-owned treatment works (Title III of the Act) are enforced by the EPA;
- o A program to regulate the discharge of oil and hazardous substances (Section 311 of the Act) is enforced by the EPA; and
- o A permit system for the use of dredge and fill material (Section 404 of the Act) is administered by the U.S. Army Corps of Engineers.

5.1.1 NPDES Permit Program

Background

Section 313 of the CWA directs Federal agencies to comply with all Federal, State, interstate, and local requirements regarding the control and abatement of water pollution in the same manner, and to the same extent, as any non-government entity.

On September 9, 1975, the EPA approved Nevada's NPDES permit program and authorized Nevada to implement and enforce the program. The Nevada Department of Environmental Protection (NDEP) is the agency responsible for issuing or denying NPDES permits.

Applicability to the ESF

Water-related activities which may require an NPDES permit include all point source discharges. Examples of these are stormwater discharge, sewage treatment facilities, mine waste-water ponds, rock storage piles, pump tests, drinking-water supplies, monitoring and injection wells, and infiltration studies.

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Requirements for the ESF

- An NPDES permit must be obtained for stormwater and effluent discharges.

- All waste waters shall be treated and disposed of in accordance with NPDES permit conditions.

- NPDES permits may contain written effluent limitations based on a variety of criteria, including the effects of the discharge on the receiving waters and the use of these receiving waters (NAC 445.155).

- The permit may also require, at the discretion of the Water Quality Officer (WQO), the installation, use, and maintenance of equipment to monitor specified pollutants, and that monitoring records be retained, generally for three years.

- If monitoring is required, the results of the monitoring will be reported to the WQO on a schedule specified in the permit, but not less frequently than once a year.

- The WQO has the authority to enter any premises where a permitted discharge is located for purposes of accessing and copying records, inspecting monitoring equipment, and sampling discharges. The costs of any test associated with these visits are the responsibility of the DOE.

- Any modifications of the facility or increases in the rate or type of permitted discharge must be reported to the WQO. If the modifications exceed permit conditions, a new NPDES permit must be obtained. An NPDES permit can be modified, suspended, or revoked by the WQO if, among other things, the terms of the permit are violated.

- A permit is valid for no more than 5 years. Renewal must be made to the WQO within 180 days of expiration.

5.1.2 Corps of Engineers Section 404 Permit

Background

Any Federal agency, State or individual that plans to dredge, fill, modify, or discharge into navigable waters or waters of the United States, as defined in the CWA, must first receive a Section 404 permit from the U.S. Army Corps of Engineers (Corps) (Section 404 of the CWA [33 CFR 320.2(g)]). Section 404 establishes Federal policy for restoring and maintaining the chemical, physical, and biological characteristics of the Nation's waterways. (Floodplain compliance is discussed in Section 12.0.)

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Applicability to the ESF

On April 28, 1988, the DOE submitted an informal opinion to the Corps concerning the applicability of Section 404 of the CWA to site characterization at Yucca Mountain, and requested a formal determination by the Corps regarding Section 404 permitting applicability. Site characterization will require re-routing small segments of several dry washes along the east side of Yucca Mountain. The Corps conducted an on-site inspection at Yucca Mountain on October 18, 1989. On November 15, 1989, the Corps made a formal determination that re-routing of washes for site characterization would require Section 404 permitting, to be authorized under a Nationwide General Permit. This type of Section 404 permit allows the discharge of dredged or fill material into isolated, nontidal waters of the United States, including wetlands that are not part of a surface tributary system to interstate waters of the United States. The Corps included the YMP in a nationwide permit on August 17, 1990. Any significant changes in ESF design may require a review of our current Section 404 permit.

Requirements for the ESF

- A Section 404 permit must be obtained (or modified) before Yucca Mountain washes can be altered.

5.2 NEVADA WATER POLLUTION CONTROL LAW, (NRS 445.131-.399)

Background

The Nevada Water Pollution Control Law was enacted to maintain the quality of the waters of the State of Nevada for public health and enjoyment, protection of animal life, operation of existing industries, the pursuit of agriculture, and the economic development of the State. This law is administered by the NDEP which requires that discharges of pollutants into the subsurface be controlled if the potential for contamination of groundwater supplies exists. If the NDEP determines that there is a potential for contamination, the agency will generally require, through issuance of zero-discharge permits, that impoundments be lined sufficiently to prevent seepage of pollutants into the ground.

Applicability to the ESF

Site characterization activities such as the construction and use of sewage lagoons and mud and cutting pits, must be evaluated to determine their potential to contaminate groundwater supplies.

Requirements for the ESF

- A discharge permit will be obtained or zero-discharge demonstrated for all ponds and water impoundments.

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- Runoff from disturbed areas will be controlled to minimize erosion (see Reclamation Section).

- Runoff from potentially contaminated areas (e.g., parking lots) will be controlled.

5.3 SANITARY AND SEWAGE-COLLECTION SYSTEM REQUIREMENTS (NAC 444.750-.840; 445.179-.182)

Background

The purpose of this permit authority is to regulate the design, construction, and operation of sanitary and sewage collection systems and to grant operating permits for such facilities in an effort to prevent or limit discharges of pollutants into waters of the State. NDEP administers this regulation.

Applicability to the ESF

The ESF will require a sanitary and sewage collection system.

Requirements for the ESF

- A permit will be required for sanitary and sewage collection or treatment systems.

- The design of the system must comply with NAC 445.140-.241.

- Construction plans must be prepared by a licensed engineer.

- The facility must be located outside of the floodplain.

- The ultimate disposal of sludge from the wastewater treatment facilities shall be performed in accordance with the requirements of Section 405 of the CWA, in addition to any applicable permit conditions.

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6.0 SOLID AND HAZARDOUS WASTE MANAGEMENT

6.1 RESOURCE CONSERVATION AND RECOVERY ACT OF 1976, as amended (P.L. 94-580; 42 USC 6901-6987; 40 CFR 124, 240, 241, 243-247, 260-264, 266, 270, 271, and 280; NRS 459.400 et seq; NAC 444.570-.748, and 444.842-.8746)

Background

Management and disposal of solid and hazardous wastes (excluding radioactive wastes) shall be conducted in accordance with the requirements of the Resource Conservation and Recovery Act (RCRA), as amended, which includes RCRA permitting for hazardous wastes. The EPA has authorized the State of Nevada to administer Subtitle C of RCRA, regulating the management and disposal of hazardous wastes.

Applicability to the ESF

ESF activities may require the use of hazardous materials and the generation of both solid and hazardous wastes. The proper handling and disposal of solid and hazardous materials will require compliance with various federal and state regulations. Reporting requirements in the event of spills are included. Activities covered in this section include hazardous materials, landfills, use of insecticides and pesticides, toxic substances, and transportation of hazardous materials.

Requirements for the ESF

- Use of hazardous materials onsite must receive prior approval from the Yucca Mountain Site Characterization Project Office (YMPO), as per Administrative Procedure (AP)-6.13 (Authorization for Use of Regulated Hazardous Substances and Materials).

- The use of hazardous materials onsite must conform to the guidelines provided in the Hazardous Materials Management and Handling Program (HMMHP; draft in review).

- The requirements for management and disposal of hazardous wastes must be satisfied in accordance with Subtitle C of RCRA.

- Use of underground storage tanks must be in accordance with Subtitle I, RCRA.

- Use of recycled and recovered materials shall be given high priority, as required by Subtitle F.

- Non-hazardous solid waste will be recollected and hauled to an approved landfill, as required by NAC 444.570-.748.

- Soil contaminated with spilled oil or fuel must be disposed of in an approved landfill or by another approved method.

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6.2 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) (42 USC 9601 et seq; 40 CFR 300, 302, 355, 370, and 372; EO 12580)

Background

CERCLA (as amended by SARA), also known as "Superfund," was created in 1980. The act provides for the clean-up of, and emergency response to, hazardous substances released into the environment, and for the clean-up of hazardous waste sites that present a substantial danger to public health and welfare. The emergency response and clean-up of hazardous substances released into the environment shall be conducted according to CERCLA.

Applicability to the ESF

The use of hazardous materials at the ESF will require that materials be transported, handled, stored, and disposed of properly, and may result in spills requiring corrective action.

Requirements for the ESF

- Any spills of hazardous substances must be reported to appropriate agencies and officials, and be cleaned up in compliance with the Superfund Act.

- A "Spill Contingency Plan" is required for ESF activities.

- All field personnel must be trained in the proper handling of hazardous substances and in response actions to be taken in the event of a spill.

- Use of hazardous materials must comply with Community-Right-To-Know regulations under Title III of SARA.

- Transportation of all hazardous materials to the Yucca Mountain site must meet the requirements of the Hazardous Material Transportation Act (49 USC 1801; 49 CFR 171-178).

- The handling, use, and disposal of any toxic substances shall comply with the requirements of the Toxic Substances Control Act (TSCA), as amended (15 USC 2601).

- The use of pesticides shall comply with the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA, P.L.2-140 and P.L.95-396).

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7.0 BIOLOGICAL RESOURCE PROTECTION

ENDANGERED SPECIES ACT of 1973 (P.L. 93-205, as amended; 16 USC 1531-1543; 50 CFR 13, 17, 222, 226, 227, 402, 424, and 450-453)

Nevada State Wildlife Statutes (NRS 501.105-.110; NAC 503.010-.080)

Nevada State Vegetation Statutes (NRS 501.105, 527.050 et seq; NAC 527.010-.020

Background

Any Federal activity or Federally-supported activity must be performed in compliance with the Endangered Species Act (ESA, 1973). Accordingly, any Federal activity that could directly affect protected fish, wildlife, or vegetation, or destroy or alter the specific habitat of protected species, must be designed to avoid or mitigate all potentially adverse impacts. In addition, Nevada statutes provide for the protection of various wildlife and vegetation indigenous to the state.

Applicability to the ESF

The desert tortoise, existing at the Yucca Mountain site, has been listed as a Federally-protected, threatened species. ESF activities will require the performance of surface-disturbing work having the potential to affect the desert tortoise. Actions taken during site characterization must not jeopardize the continued existence of this species.

Requirements for the ESF

The following constraints are derived from requirements set forth in the Biological Opinion (BO) rendered by the U.S. Fish and Wildlife Service (McNatt, 1990) and are consistent with accepted revisions to the BO.

- Threatened or endangered species must be protected, in compliance with the ESA, as stipulated in the BO.

- Prior to any land disturbance, a preactivity survey must be conducted by qualified Project Office-designated participants to determine if the proposed activity will impact any important biological resources.

- All personnel working at the site must complete the Environmental Requirements Training Program (ERTP).

- Any harassment of the desert tortoise is to be avoided. Neither the animal itself nor its burrow is to be touched or disturbed by other than a qualified biologist. Stay at least ten feet away from any burrow six inches or larger in height or width.

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- If a desert tortoise is seen in the construction area, work shall cease and the Yucca Mountain Project Office (YMPO) and the Project Site Manager shall be notified. It may be necessary for a qualified biologist to relocate the tortoise before work may resume.

- Avoid hitting any animals which may be crossing roads or trails.

- Field participants are required to notify the YMPO immediately upon finding an injured or dead tortoise.

- Covered trash containers will be provided so that food and other garbage is discarded in a manner that will not attract ravens.

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8.0 ARCHAEOLOGICAL RESOURCE PROTECTION

NATIONAL HISTORIC PRESERVATION ACT OF 1966, as amended (16 USC 470 et seq; 36 CFR 60, 61, 63, 65, 67, 68, and 800; EO 11593), HISTORIC SITES, BUILDINGS, AND ANTIQUITIES ACT, as amended (16 USC 361-467), ARCHAEOLOGICAL AND HISTORIC PRESERVATION ACT (16 USC 469-469c)

AMERICAN INDIAN RELIGIOUS FREEDOM ACT OF 1978, (P.L. 95-341; 42 USC 1996; 36 CFR 296; 43 CFR 7)

ANTIQUITIES ACT (16 USC 431, 432, and 433; 25 CFR 261; 36 CFR 296; 43 CFR 3 and 7)

ARCHAEOLOGICAL RESOURCES PROTECTION ACT of 1979, (16 USC 470aa-47011; 36 CFR 296; 43 CFR 7)

Background

The goal of all of the laws listed above, in terms of Federal activities, is to ensure consideration of the values of historic properties in carrying out Federal activities, and to make every effort to identify and mitigate impacts to significant historic properties. The National Historic Preservation Act (NHPA) is the principal authority to which the DOE will respond with regard to the protection of historic properties. The NHPA requires all Federal agencies to take into account the effects of their undertakings (e.g., site characterization) on historic properties, and to allow the Advisory Council on Historic Preservation (ACHP) to comment on the adequacy of the agency's plans. Historic properties are defined as any properties included in, or eligible for inclusion in, the National Register of Historic Places.

Applicability to the ESF

The YMP area contains many historic sites and artifacts which require protection under the NHPA, Antiquities Act (AA), the American Indian Religious Freedom Act (AIRFA), and the Archaeological Resources Protection Act (ARPA). The implementation of the Programmatic Agreement (PA, 1988) between the DOE and the ACHP will satisfy the YMP's commitments and responsibilities under these various Acts.

Requirements for the ESF

The following constraints established to protect archaeological resources are consistent with applicable Federal, State, and local environmental regulations.

- A preactivity survey must be conducted by qualified YMPO contractors to determine if the proposed activity will affect archaeological resources.

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- If archaeological resources are identified within the area proposed for the activity, it may be necessary to relocate the activity, to recover data from the site prior to trenching, or to designate an "Inclusion Area" for the activity. An Inclusion Area should clearly delineate an area within which surface-disturbing activities are restricted. Any area beyond the Inclusion Area boundary is off-limits to equipment and personnel to prevent inadvertent disturbance of an archaeological resource.

- A site-specific Data Recovery Plan shall be prepared by a designated archaeologist and approved by the ACHP prior to recovering data from the site.

- If archaeological resources are discovered within the area approved for activity, work shall cease and the YMPO Operations Control Branch and Project Site Manager will be notified.

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9.0 RECLAMATION

Nuclear Waste Policy Act of 1982, as amended (P.L. 97-425, 42 USC 10101)

Farmland Protection Policy Act of 1981 (7 USC 4201)

Background

In compliance with the Nuclear Waste Policy Act (NWPA), as amended, the DOE has developed a program for the reclamation of areas disturbed by site characterization. This program requires that disturbed land be returned to a stable ecological state with a form and productivity similar to its predisturbed state.

Applicability to the ESF

BLM Right-of-Way-Reservations and the NWPA Section 113(b)(1)(A) require that areas altered by site characterization activities be reclaimed. Any surface-disturbing activities to be undertaken at Yucca Mountain under the purview of the YMP must be planned in accordance with the Reclamation Implementation Plan (RIP; DOE, 1991a). In addition, the Farmland Protection Policy Act (FPPA, 1981) requires consultation with the Soil Conservation Service regarding protection of prime or unique farmlands.

Requirements for the ESF

- Reclamation activities will be carried out as described in the RIP.
- A preactivity survey must be conducted to determine biotic, soil type, and reclamation capabilities of each site.
- Surface-disturbing activity reclamation specifications shall include considerations to minimize dust and other environmental impacts.
- Guidelines in the RIP should be followed, including requirements for:
  - o Site inventory
  - o Site clearing
  - o Topsoil storage and management
  - o Erosion control
  - o Drainage control
  - o Site abandonment and facility decommissioning
  - o Recontouring
  - o Revegetation
  - o Irrigation
  - o Post-reclamation monitoring

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10.0 RADIOLOGICAL HEALTH AND SAFETY

DOE Order 5400.5, Radiation Protection of the Public and the Environment

DOE Order 5480.11, Radiation Protection for Occupational Workers

Background

The NWPA, as amended, and the NEPA require the DOE to conduct radiological studies and radiological monitoring at the Yucca Mountain site. The DOE, the EPA, and the NRC each have established rules, regulations, and orders pertaining to radiological health and safety. In the event of conflicts or duplications among the radiological requirements listed in the Regulatory Compliance Plan (DOE, 1990d), the requirement holding the highest authority will prevail. In general, Public Laws are the most authoritative, followed by the Code of Federal Regulations, Project Positions and NRC guidance. Department Orders are the least authoritative. In the absence of more authoritative requirements, however, site characterization activities will be carried out in compliance with DOE Orders relating to radiological health, safety and environmental protection, as described in the Radiological Monitoring Plan (DOE, 1990e).

Applicability to the ESF

It is anticipated that four potential sources of radioactive materials will exist at the Yucca Mountain site during site characterization.

1. Release of naturally-occurring radionuclides from mining activities;
2. Discharge of groundwater, expected to contain only natural background radioactivity, to the surface;
3. Resuspension of radioactive materials previously deposited during nuclear testing at the NTS; and
4. Release of short-lived radioactive tracers as part of geohydrological modeling, and the small potential for release of radioactive material during well-logging activities.

Because only a small volume of rock will be mined and a small amount of groundwater released to the surface during site characterization, it is estimated that radioactive releases will amount to only a small fraction of the natural background radiation always present, and will not constitute a significant radiological impact.

The resuspension of previously-deposited radioactive materials during site characterization is also expected to be insignificant compared to natural background because of the low concentration of radioactive materials present in the existing environment. However, estimates presented in the Environmental Assessment (DOE, 1986) may include inherent uncertainties

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because past radiological monitoring at and around the Yucca Mountain site has been limited. To verify that there will be no significant impact, as mandated by the Environmental Monitoring and Mitigation Plan (EMMP; DOE, 1988b), radiological monitoring will be conducted in the areas of (1) radioactive material concentrations in air, soils, biota, and groundwater; and (2) external radiation background field.

Requirements for the ESF

- The ESF shall comply with the requirements of the Yucca Mountain Project Radiological Monitoring Plan (RMP; DOE, 1990e).
- Consistent with the requirements of DOE Order 5480.11, equipment is considered to be potentially contaminated if it has been used or stored in a controlled area that has contained unconfined radioactive material. Prior to its use, such equipment must be surveyed to determine whether both removable and total surface contamination is greater than the levels specified in DOE Order 5400.5.
- Limited radon monitoring in a mine or in mine exhaust is required when the mine is initially opened, and may be necessary throughout the duration of many site characterization activities.
- If radioactive tracers are used, the DOE will comply with 40 CFR Part 144 and NAC Chapter 445.
- If radioactive material or radiation-producing equipment is used on State or private land (not controlled by the U.S. Government), compliance with the State of Nevada Regulations for Radiation Control is required.

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11.0 LAND ACCESS

FEDERAL LAND POLICY AND MANAGEMENT ACT of 1976 (P.L. 94-579; 43 USC 1701-1784; 43 CFR 2800)

Background

The Federal Land Policy and Management Plan (FLPMA) establishes U.S. Government policy with regard to government-owned lands administered by the Bureau of Land Management (BLM). FLPMA mandates that such lands be managed in a manner that will (1) protect the quality of scientific, scenic, historical, ecological, environmental, and archaeological values; (2) preserve and protect certain public lands in their natural condition; (3) provide food and habitat for fish and domestic animals; and (4) provide for outdoor recreation and human occupancy and use.

Applicability to the ESF

Federal activities requiring access to, and activity on, public lands require compliance with the FLPMA. Because the Yucca Mountain site is partially on BLM-administered public land and BLM-administered Air Force land, and because activities will occur on BLM lands, as well, DOE compliance with BLM requirements for access and use of this land is mandatory.

The DOE obtained access to the BLM and Air Force lands for site characterization through Rights-of-Way granted in January 1988 and October 1989.

Requirements for the ESF

In issuing these Rights-of-Way, the BLM has stipulated specific environmental requirements which include:

- Access approval for the activity must be confirmed by the Project Office.

- A copy of the BLM Right-of-Way Reservation (ROWR) Agreement (BLM, 1988; BLM, 1989) must be available at the job-site when work is being conducted in the field.

- Stipulations listed in the ROWR Agreement (BLM, 1988; BLM, 1989) must be followed.

- Off-road driving or parking is prohibited unless specifically permitted in writing by the YMPO. Any access route or area of disturbance will be specifically approved through the environmental review process. Existing trails may be used if prior environmental approval is obtained.

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- Sand and gravel must be obtained from a source authorized by a BLM free-use permit (Materials Act, 1947) or from a duly permitted commercial source.

- Core holes and wells containing potentially usable water should be left in a manner which facilitates their development as water sources. Prior to termination of the agreement or abandonment of the holes/wells, the DOE will consult BLM to determine if the holes will be sealed and capped, plugged, or turned over to the BLM as is.

- The DOE is required to fulfill all requirements applicable to the NEPA (1969), as required by NWPA (1982, as amended), as well as all requirements for mitigation, stabilization, and rehabilitation, as described in the Plan of Development and listed in Sections 4.1.1.4 and 4.1.2.6 of the Yucca Mountain Environmental Assessment (DOE, 1986). This responsibility will continue until the requirements are met, regardless of expiration of the Right-of-Way reservation.

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12.0 FLOODPLAIN PROTECTION

Executive Order 11988, Floodplain Management (10 CFR 1022)

Executive Order 11990, Protection of Wetlands (10 CFR 1022)

Background

Executive Order (EO) 11988 requires each Federal agency to take action to reduce the risk of flood damage, minimize the impact of floods on human safety, health, and welfare, and restore and preserve the natural and beneficial values served by floodplains. In conjunction, EO 11990 stipulates that long- and short-term adverse impacts from the destruction or modification of wetlands, or direct or indirect support of new construction in wetlands, is to be avoided if a practicable alternative is available.

Applicability to the ESF

Activities planned within the 100-year floodplain at the Yucca Mountain site require certain compliance actions (EO 11988, as implemented by 10 CFR 1022). Although compliance with EO 11990 is required for all Federal and Federally-supported activities and projects, the U.S. Fish and Wildlife Service has determined that site characterization activities should not affect any wetlands at or near the Yucca Mountain site. (Also see Section 5.1.2 of this document.) Floodplain Assessment of Surface-Based Investigations at the Yucca Mountain Site, Nye County, Nevada (YMP-91-11) (DOE, 1991b), shall be consulted to determine if activities are within the 100 year floodplain.

Requirements for the ESF

- Any activity conducted in a floodplain must be preceded by a floodplain/wetlands assessment, in compliance with 10 CFR Part 1022.

- Alternatives to building in the defined 100-year floodplain must be identified and considered.

- Structures/facilities built in the floodplain should be designed to both minimize effects on the floodplain and protect the structure/facilities in the floodplain.

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13.0 NOISE

NOISE CONTROL ACT OF 1972, as amended by the Quiet Communities Act of 1978, (42 USC 4901-4918; EO 12088)

Background

Federal agencies must carry out their programs in a manner that promotes an environment free of noise that could jeopardize public health or welfare.

Applicability to the ESF

Construction and operational activities for the ESF will cause noise pollution that must be monitored to ensure that the noise does not jeopardize worker health or cause significant impacts to wildlife.

Requirements for the ESF

- Noise levels must be controlled and monitored, in accordance with regulations implementing the Noise Control Act (40 CFR 1, Subchapter G).

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APPENDIX K

CORRELATION OF DAA CRITERIA WITH CORRESPONDING ESFDR CRITERIA

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APPENDIX K

The ESF Title I Design Acceptability Analysis and Comparative Evaluation of Alternative ESF Locations (DAA) (YMP/89-3) was, in part, a review of the adequacy of ESF Title I design for three concerns expressed by the NRC. The three concerns are listed on page INTRO-2 of this document. This appendix contains a cross reference between the DAA criteria and the corresponding ESFDR statements. The full text of the DAA criteria has been removed from this appendix and replaced with a table which provides a cross reference between the DAA criteria and the ESFDR statements. This table provides an explanation for those criteria that are not applicable to design organization activities. It is important to note that some of the sub-section numbers on the ESFDR statements have been changed by this revision. Therefore, this table should only be correlated with this version of the ESFDR. Appendix I-3 of the DAA contains a detailed discussion of the development process for the DAA criteria as applied to the baseline Title I design.

The DAA also made recommendations (see DAA Volume 1, Page 2-54 through 2-58) regarding each of the NRC concerns. This appendix relates these recommendations to the DAA criteria and ESFDR requirements. Typical references used to identify recommendations are C2-5 and C2-5,7. The C2 identifies this as a recommendation related to NRC Concern #2. The 5 and 7 identify specific Recommendations Numbers 5 and 7 related to NRC Concern #2.

This appendix of the ESFDR is not intended to demonstrate how all the DAA criteria are applied to the Yucca Mountain Site Characterization Project. It is only meant to capture those criteria which are to be implemented by the Design Organization in total, or in conjunction with testing and performance assessment activities. Some criteria cannot be fully addressed by the Design Organization until more detailed guidance or results have been provided as a result of performance assessment analyses and test planning activities.

At the time the DAA criteria were developed, a baseline ESF/repository configuration existed which consisted of a two shaft access to the underground facilities. This is shown in the ESF Title I Design Summary Report, Revision 0. Since then, a comparative evaluation of alternative configurations (ESF Alternatives Study, SAND91-0025) utilizing variations in major design features was performed to satisfy 10 CFR 60.21(c)(1)(ii)(D). This alternative study resulted in the identification of an ESF/repository configuration (Option 30, modified) which appeared to provide enhanced long-term performance capabilities. A major difference in the configuration was that the new configuration contained two ramps instead of two shafts for access to the underground facilities. A design study was initiated and the baseline Title I configuration was revised to reflect the two ramp access configuration. This is shown in the ESF Title I Design Summary Report, Revision 1. As a result, some of the DAA criteria which were developed for the two shaft access configuration no longer apply to the new configuration. The DAA criteria which are not applicable to the current Title I design configuration are noted in this appendix.

Additionally, there are some DAA criteria which pertain to underground test planning and testing activities which do not impact the designers activities.

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These criteria have been identified in the table. DAA criteria which pertain to test planning and the testing program are intended to be captured in a separate requirements document.

The structure of the DAA criteria numbers has been maintained consistent with numbering scheme presented in the last revision of this appendix, however, because some of the ESFDR statements have been moved or modified, the ESFDR numbers may have changed. This scheme assists with correlation of the DAA criteria with the NRC concerns, the 10CFR60 requirements, the ESF physical subsystem and individual criterion.

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DAA	ESFDR	COMMENTS/ASSOCIATED RECOMMENDATIONS
1.1.1.1	1.2.6.1 CA	C1-1,2,4,6,7,8,9,10,11,12,14,15,17,18,19,20
1.1.2.1	1.2.6.2 CA	
	1.2.6.2 CB	
	1.2.6.2 CC	
	1.2.6.2.3 CB	
	1.2.6.2.5 CB	
1.1.4.1	1.2.6.4 PC2a.i	
1.1.5.1	1.2.6.5 PC2a.i	
1.1.6.1	1.2.6.6 PC2a.i	
1.1.7.1	1.2.6.7 CB.i	
1.1.8.1		SEE NOTE 1
1.1.8.2		SEE NOTE 1
1.1.9.1	1.2.6.4 PC2l.i	
	1.2.6.5 PC2m.i	
	1.2.6.6 PC2n.i	
1.2.4.1	1.2.6.0 PC2b.i	C1-12,20
1.2.4.2	1.2.6.4 PC2b.i	
1.2.5.1	1.2.6.0 PC2b.i	C1-12
1.2.5.2	1.2.6.5 PC2b.i	
1.2.6.1	1.2.6.6 PC2b.i	C1-14
1.2.6.2	1.2.6.6 PC2b.ii	C1-15
1.2.6.3	1.2.6.6 PC2b.iii.c	C1-13
1.2.8.1	1.2.6.8 CD.i	C1-11
1.2.8.2	1.2.6.8 CD.ii	C1-14
1.3.4.1		Properly applies to repository, not ESF
1.3.4.2	1.2.6.4 PC2c.i	C1-10
1.3.4.3	1.2.6.4 PC2c.ii	
1.3.4.4	1.2.6.4 PC2c.iii	
1.3.4.5	1.2.6.4 PC2c.iv	
1.3.5.1		Properly applies to repository, not ESF
1.3.5.2	1.2.6.5 PC2c.i	
1.3.5.3	1.2.6.5 PC2c.ii	
1.3.5.4	1.2.6.5 PC2c.iii	
1.3.5.5	1.2.6.5 PC2c.iv	
1.3.6.1	1.2.6.6 PC2c.i	
1.3.6.2	1.2.6.6 PC2c.ii	
1.3.6.3	1.2.6.6 PC2c.iii	
1.4.1.1	1.2.6.1 CB	
1.4.4.1	1.2.6.4.2 CC	
1.4.4.2	1.2.6.4 PC2l.ii	C1-17
1.4.4.3	1.2.6.4.4 CC	
1.4.5.1	1.2.6.5.2 CC	
1.4.5.2	1.2.6.5 PC2m.ii	C1-17
1.4.5.3	1.2.6.5.4 CC	
1.4.6.1	1.2.6.6 PC2j.ii	
1.4.6.2	1.2.6.7 CH	
1.4.9.1	1.2.6.4 PC2l.i	
	1.2.6.5 PC2m.i	
	1.2.6.6 PC2n.i	

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DAA	ESFDR	COMMENTS/ASSOCIATED RECOMMENDSTIONS
1.5.8.1	1.2.6.4 CA.i	
	1.2.6.5 CA.i	
	1.2.6.6 CA.i	
1.5.8.2	1.2.6.4 CA[2]	
	1.2.6.5 CA[2]	
	1.2.6.6 CA[2]	
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1.6.4.1	1.2.6.4 PC1.i	
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1.6.8.2		SEE NOTE 1
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1.10.5.4	1.2.6.5 PC2a.ii	C1-6
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1.10.6.5	1.2.6.6 PC2a.ii	C1-6
1.10.6.6	1.2.6.6 PC2a.iv	C1-6
1.10.6.7	1.2.6.6 PC2a.v	
1.10.6.8	1.2.6.6 PC2a.ii	
1.10.7.1	1.2.6.7 CD.i	
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1.10.8.3		SEE NOTE 1
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1.11.5.1	1.2.6.5 PC2e.iii	
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1.11.6.3	1.2.6.6 PC1a.ii	
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1.11.6.8	1.2.6.6 PC2j.ii	
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1.12.2.1	1.2.6.2 CB	
1.12.2.2	1.2.6.2 CC	
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1.12.5.1	1.2.6.5 PC2f.i	
1.12.6.1	1.2.6.6 PC2g.i	
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1.14.4.6	1.2.6.4 PC2h.iii	
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1.14.4.8	1.2.6.4 PC1c.iii	
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1.14.5.1	1.2.6.5 PC2i.ii	
1.14.5.2	1.2.6.5 PC2i.iii	
1.14.5.3	1.2.6.5 PC2i.i	
1.14.5.4	1.2.6.5 PC1d.iii	
1.14.5.5	1.2.6.5 PC2i.iv	
1.14.5.6	1.2.6.5 PC2i.ii	
1.14.5.7	1.2.6.5 PC1d.iii	
1.14.5.8	1.2.6.5 PC2i.v	
1.14.6.1	1.2.6.6 PC2j.iv	
1.14.6.2	1.2.6.6 PC2j.v	
1.14.6.3	1.2.6.6 PC2j.ii	
1.14.6.4	1.2.6.6 PC2j.iv	
1.14.6.5	1.2.6.6 PC1d.iv	
1.14.6.6	1.2.6.6 PC1d.iv	
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1.16.1.1	1.2.6.1 CC.ii	C1-1
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1.16.4.2	1.2.6.4 PC2j.i	
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1.16.4.4	1.2.6.4 PC2j.i.a	
1.16.5.1	1.2.6.5 PC2a.i	
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1.16.6.1	1.2.6.6 PC2l.i	
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1.17.5.1		SEE NOTE 2
1.17.6.1		SEE NOTE 2
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1.20.8.1		SEE NOTE 1
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2.1.6.1	1.2.6.6 CA.i	
2.1.6.2	1.2.6.6 CA.i	
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2.1.8.1		SEE NOTE 1
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2.4.6.5	1.2.6.6 PC1c.iii	
2.4.7.1	1.2.6.7 CE.ii	
2.4.7.2	1.2.6.7 CE.i	
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2.5.4.3		N/A TO CURRENT ESF CONFIGURATION
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2.5.5.2	1.2.6.5 PC1d.iii	
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2.5.6.2	1.2.6.6 PC1d.iv	
2.5.6.3	1.2.6.6 PC2j.ii	
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2.6.4.2	1.2.6.4 PC2i.ii	
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2.6.5.2	1.2.6.5 PC2j.ii	
2.6.6.1	1.2.6.6 PC2k.iv	
2.6.6.2	1.2.6.6 PC2k.v	
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2.8.6.1	1.2.6.6 CB.iii	
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2.8.6.3	1.2.6.6 CB.ii	
2.8.6.4	1.2.6.6 PC1c.iv	
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2.8.8.1		SEE NOTE 1
3.1.4.1		N/A TO CURRENT ESF CONFIGURATION
3.1.4.2		N/A TO CURRENT ESF CONFIGURATION
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3.2.8.1		SEE NOTE 1
3.3.8.1		SEE NOTE 1
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3.5.5.1	1.2.6.5 PC1c.i	C3-3
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NOTES:

1. This DAA criterion was developed from specific 10CFR60 requirements and is considered to be applicable to the test planning aspect of the ESF/repository and is applied through the test requirements in Appendix B. As such, this criterion is not addressed in the ESFDR.

2. This DAA criterion was developed from specific 10CFR60 requirements and is considered to be applicable to the performance assessment aspect of the ESF/repository. Some of these criteria are applicable to analyses performed to support ESF/repository design and others of these criteria will be used to support design confirmation and the determination of overall site acceptability. This criterion is considered in 1.2.6.0 PC2d to the extent that the ESF does not preclude the repository's ability to meet 10 CFR 60 requirements.