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PROJECT CCB CONTROLLED DOCUMENT

EXPLORATORY SHAFT FACILITY (ESF)

SUBSYSTEM DESIGN REQUIREMENTS DOCUMENT (SDRD)

FOR TITLE II

VOLUME 2B

Received w/Ltr Dated 4/7/89

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

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NEVADA OPERATIONS OFFICE/YUCCA MOUNTAIN PROJECT OFFICE

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APPENDIX B

TEST AND IDS REQUIREMENTS
AND TEST DATA SHEETS

January 23, 1989
Benchmark #4
Review Draft
WPS-2

APPENDIX B

UNDERGROUND TEST AND INTEGRATED DATA SYSTEM (IDS) REQUIREMENTS

The Project does not presently plan to penetrate the Calico Hills unit with the ESF. However, the requirement for flexibility to sink the shafts and perform site characterization testing in the Calico Hills will be maintained.

EXPLORATORY SHAFT FACILITY

SUBSYSTEM DESIGN REQUIREMENTS DOCUMENT

EXPLORATORY SHAFT FACILITY SUBSYSTEM DESIGN REQUIREMENTS DOCUMENT
APPENDIX B
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EXPLORATORY SHAFT FACILITY TEST

EXPLORATORY SHAFT FACILITY TEST CONT'D

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Long Title	SCP Section Reference	Lead Organization	WBS Reference	Short Title for ESF SDRD Appendix B	ESF SDRD Appendix B Page #'s
Evaluation of ground support systems	8.3.1.15.1.8.2	SNL	TBD	Ground support	B-MECH-13-
Monitoring drift stability	8.3.1.15.1.8.3	SNL	TBD	Monitoring drift stability	B-MECH-14-
Air quality and ventilation	8.3.1.15.1.8.4	SNL	TBD	Air quality and ventilation	B-MECH-15-
In-situ testing of seal components	8.3.3.2.2.3	SNL	TBD	Seal Testing	B-SEAL-1-1
Overcore stress tests in the Exploratory Shaft Facility	8.3.1.15.2.1.2	USGS	TBD	Overcore stress	B-MECH-16-
Matrix hydrologic properties testing	8.3.1.2.2.3.1	USGS	TBD	Hydrologic properties samples	B-HYD-1-1
Intact-fracture test in the Exploratory Shaft Facility	8.3.1.2.2.4.1	USGS	TBD	Intact fracture	B-HYD-2-1
Percolation test in the Exploratory Shaft Facility	8.3.1.2.2.4.2	USGS	TBD	Percolation	B-HYD-3-1
Bulk-permeability test in the Exploratory Shaft Facility	8.3.1.2.2.4.3	USGS	TBD	Bulk permeability	B-HYD-4-1
Radial borehole tests in the Exploratory Shaft Facility	8.3.1.2.2.4.4	USGS	TBD	Radial boreholes	B-HYD-5-1
Excavation effects test in the Exploratory Shaft Facility	8.3.1.2.2.4.5	USGS	TBD	Excavation effects	B-HYD-6-1
Calico Hills test in the Exploratory Shaft Facility	8.3.1.2.2.4.6	USGS	TBD	Calico Hills	B-HYD-7-1
Perched water test in the Exploratory Shaft Facility	8.3.1.2.2.4.7	USGS	TBD	Perched water	B-HYD-8-1

EXPLORATORY SHAFT FACILITY TEST CONT'D

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Long Title	SCP Section Reference	Lead Organization	WBS Reference	Short Title for ESF SDRD Appendix B	ESF SDRD Appendix B Page #'s
Hydrochemistry tests in the Exploratory Shaft Facility	8.3.1.2.2.4.8	USGS	TBD	Hydrochemistry	B-HYD-9-1
Diffusion tests in the Exploratory Shaft Facility	8.3.1.2.2.5	LANL	TBD	Diffusion	B-HYD-10-1
Chloride and chlorine-36 measurements of percolation at Yucca Mountain	8.3.1.2.2.2.1	LANL	TBD	Chlorine-36	B-HYD-11-1
Engineered barrier system field tests	8.3.4.2.4.4	LLNL	TBD	Engineered barrier design	B-WP-1-1
Laboratory test (thermal and mechanical) Using samples obtained from the ESF	8.3.1.15.1.1-4	SNL	TBD	Geoengineering lab	B-MECH-17-
Multipurpose Borehole testing near the ESF	8.3.1.2.2.4.9	USGS	TBD	Multipurpose Borehole	B-MPBH-1-1

INTEGRATION SUMMARIES OF TEST REQUIREMENTS

1/23/

Long Title	Lead Organization	WBS Reference	ESF SDRD Appendix B Page #'s
Integrated Data System	LANL		B-IS-1-1
Scientific Manpower/Schedule Information	LANL		B-IS-2-1
Laboratory/Office/Storage Space Requirements	LANL		B-IS-3-1
Electrical Power Requirements	LANL		B-IS-4-1
Water System Requirements	LANL		B-IS-5-1
Compressed Air System Requirements	LANL		B-IS-6-1
Common Sampling Design Requirements in the ESF	LANL		B-IS-7-1

ACRONYM
TABLE

A/E	Architect/Engineer
AE	Acoustic Emission
BDG	Borehole Deformation Gage
BSM	Borehole Stress Meter
DAS	Data Acquisition Station
DBR	Demonstration Breakout Room
DCU	Data Collection Unit
EG&G	EG&G Energy Measurements
ES	Exploratory Shaft
ESF	Exploratory Shaft Facility (includes shafts and drifts)
F&S	Fenix & Scisson
H&N	Holmes & Narver
HPC	Hydraulic Pressure Cell
ICWG	Interface Control Working Group
IDS	Integrated Data System
kVA (also KVA)	Kilovolt-amperes
LANL	Los Alamos National Laboratory
LBL	Lawrence Berkeley Laboratory
LLNL	Lawrence Livermore National Laboratory
LRB	Long Radial Boreholes
MFT	1000 Feet
MPBH	Multipurpose Borehole
MPBX	Multiple-Point Borehole Extensometer
MTL	Main Test Level
PI	Principal Investigator, Experimentalist
RBLC	Rock Bolt Load Cell

RBT	Radial Borehole Test
REECO	Reynolds Electrical & Engineering Co., Inc.
SDRD	Subsystem Design Requirements Document
SMF	Sample Management Facility
SNL	Sandia National Laboratories
SRB	Short Radial Borehole
T&MSS	Technical and Management Support Services Contractor
TSw1	Topopah Spring Welded Unit 1
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
YMPO	Yucca Mountain Project Office

Underground Geologic Mapping Test

Description 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 Plan. ES-1, ES-2 and all drifts will be completely mapped and photographed.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Underground Geologic Mapping Test.

Performance Criteria

1a. The test organization will map each increment (up to about 18 ft) of exposed excavation. Unless safety considerations dictate to the contrary, the mapping will be done prior to installation of ground support.

1b. Survey accuracy for the ~~Underground~~ Geologic Mapping test shall be ± 1 cm with occasional accuracy to ± 2 mm (± 0.007 ft). The ability should be retained to resurvey and upgrade the initial mapping survey and reference points.

1c. Conceptual mapping equipment arrangements are shown in Figures B-GEO-1-(1) to B-GEO-1-(3) for shaft wall mapping and in Figure B-GEO-1-(4) for drift wall mapping.

1d. A securable, underground space of about 16 X 20 ft and a height at least 8 ft is required for storage of mapping equipment.

1e. A geological storage and staging trailer or building of at least 200-sq-ft area will be provided at the ESF. This building will be equipped with heating, air conditioning, electricity, running water at a sink, smoke detectors, first aid kit and shelving.

1f. The shaft sinking galloway must be provided with equipment to assure a stable platform for photography.

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

1h. A light tight photography laboratory (in a trailer or building) approximately 8 ft by 13 ft (with a minimum of 100 sq ft) will be provided at the ESF, preferably adjacent to or in the geological storage and staging trailer or building. This laboratory will be equiped 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

1. The bottom deck of the shaft sinking galloway must have at least 10 ft of clearance between the top of the bottom deck and the lowest portion of the next higher level of the galloway.

2. The view of the shaft walls from the center of the bottom deck of the galloway must be completely unobstructed below a line extending from the lower edge of the intermediate deck at 23 degrees toward the center of the galloway, except for 5 degrees in each quadrant around the circumference of the shaft that is blocked by the galloway supports.

3. The distance from the center of the galloway to the vertical supports should be as large as possible, with a minimum of 4 ft - 6 in., to permit rotation of the radial arm strike rail.

4. The working platform (bottom deck of galloway) must be equipped with extensions so that the platform can be enlarged to a maximum of 1 ft from the design excavation line.

5. The bucket well cover on the working platform will provide for mapping pedestal mounting.

6. The galloway must be stabilized during mapping.

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

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

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

3. The shaft sinking equipment must accommodate the shaft mapping equipment.

Assumptions

1. Mapping equipment will be provided by the testing organization. This includes the radial arm strike rail and the mapping pedestal.

2. The normal mapping in shafts and drifts will take 2 hours per 6-ft interval after walls are cleaned and equipment is in place.

3. Shaft and drift mapping may be sequenced with construction such that longer sections (longer than 2 m) will be mapped to reduce the frequency of the mapping operation, if that mapping will be done before ground support (except for rock bolts) is installed, except where safety considerations override.

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

5. Drift wall mapping can be performed using a scissor lift truck, for access to the crown.

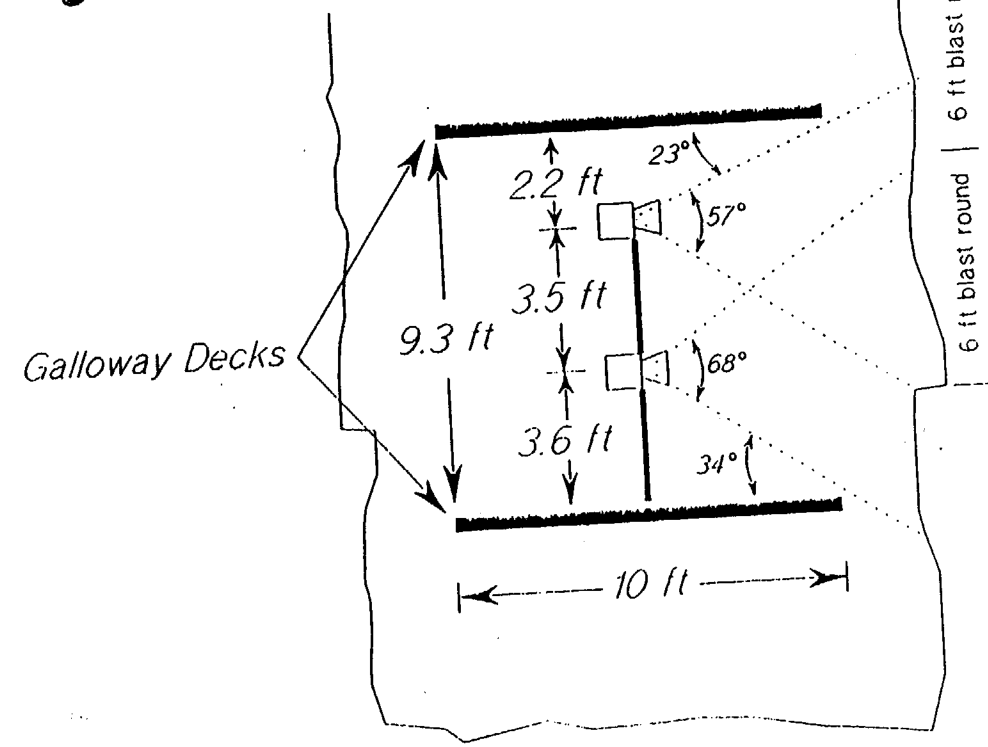
6. Voice communications from the surface will be provided to the lower deck of the galloway during shaft mapping.

7. Office and laboratory space will be provided at the Administrative and Engineering Building and the Technical Services Building in Area 25.

8. All transportable mapping equipment used by the mapping test for shaft mapping shall be of a size that can be transported in the sinking bucket.

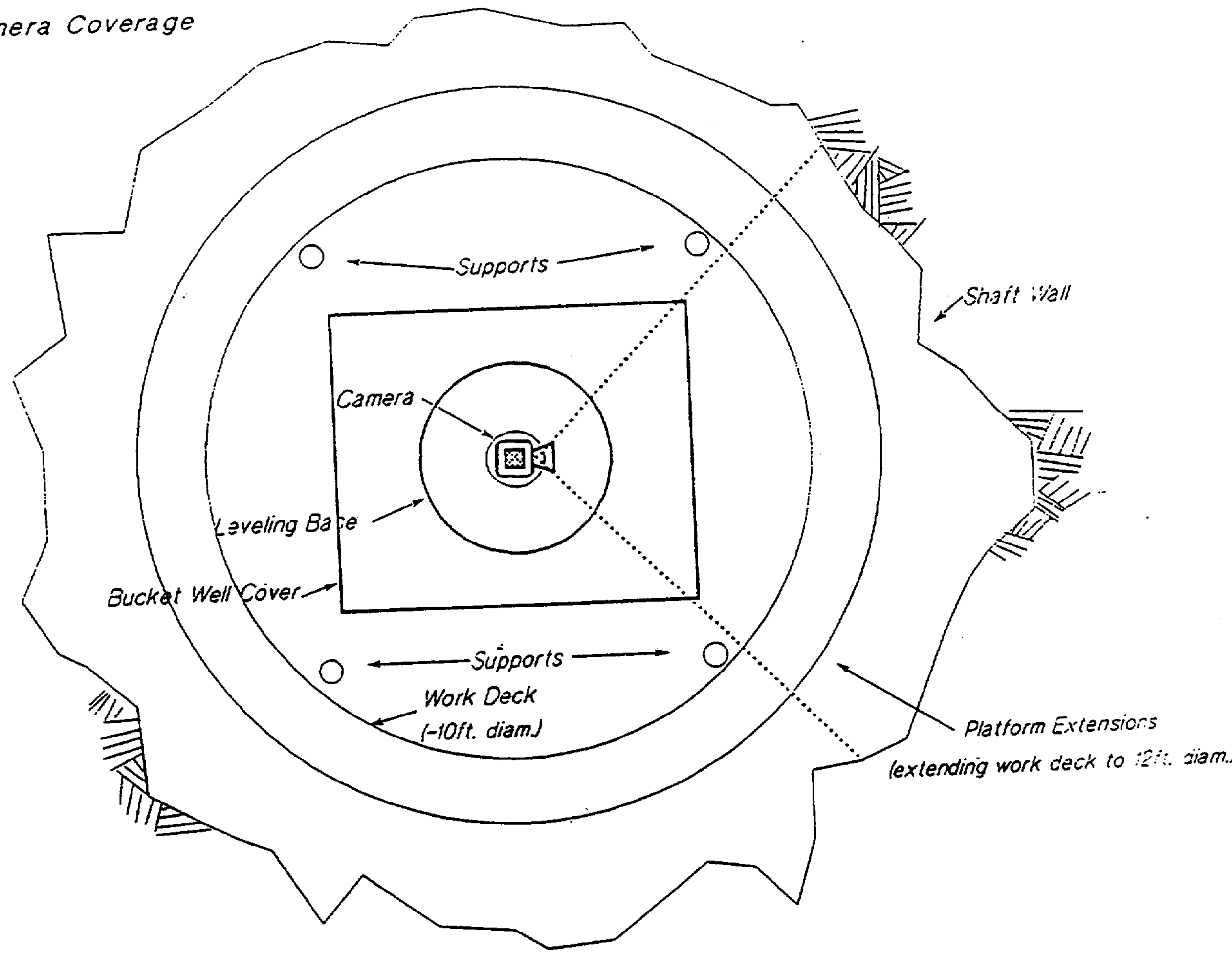
Side View of Exploratory Shaft

Camera Position and Field of View Angles for Shaft Mapping



Plan View of Exploratory Shaft

Showing Camera Coverage



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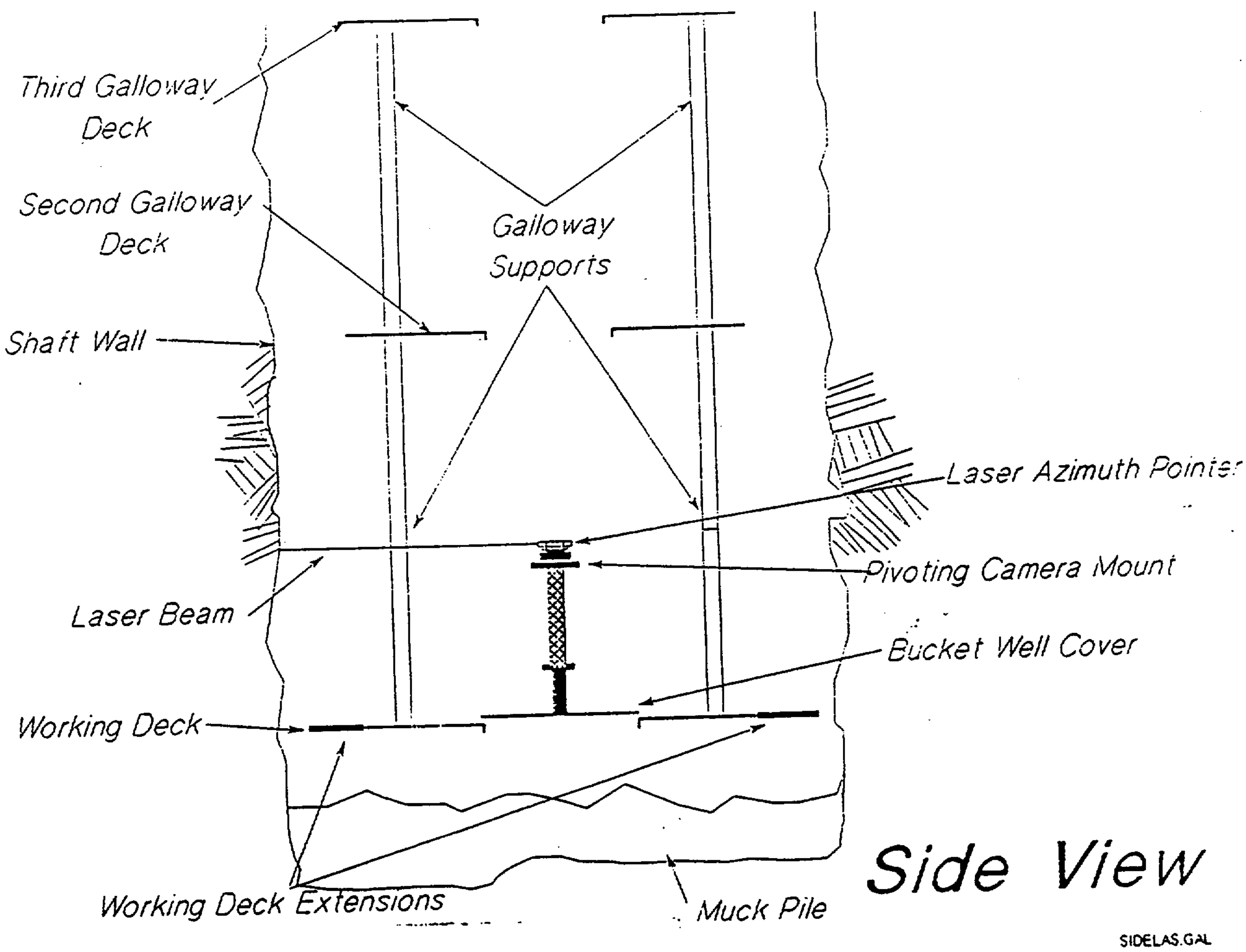
Third Galloway Deck
Second Galloway Deck
Galloway Supports
Shaft Wall
Laser Azimuth Pointer
Pivoting Camera Mount
Laser Beam
Bucket Well Cover
Working Deck
Working Deck Extensions
Muck Pile
Side View
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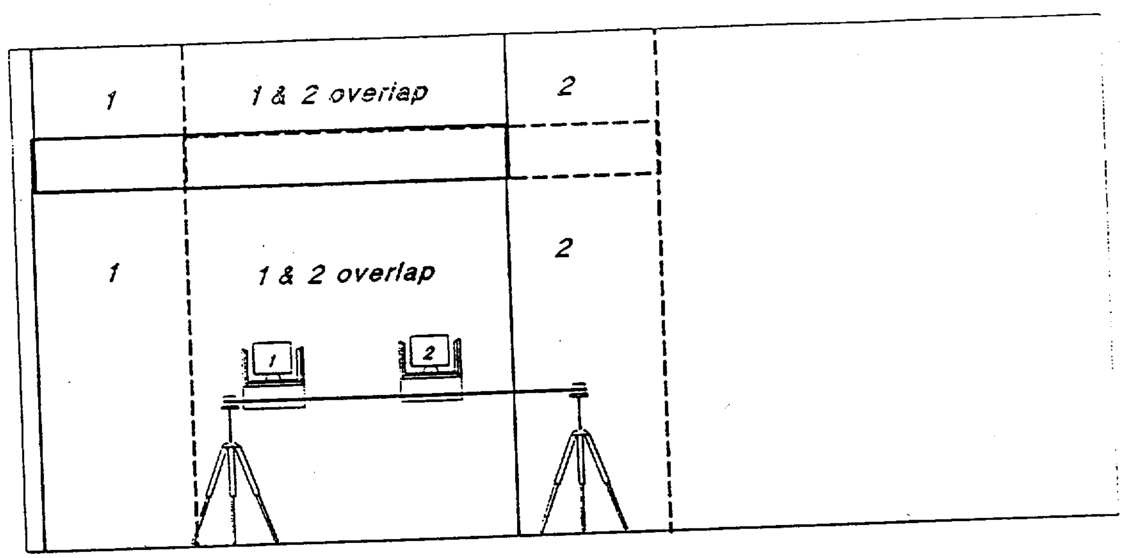
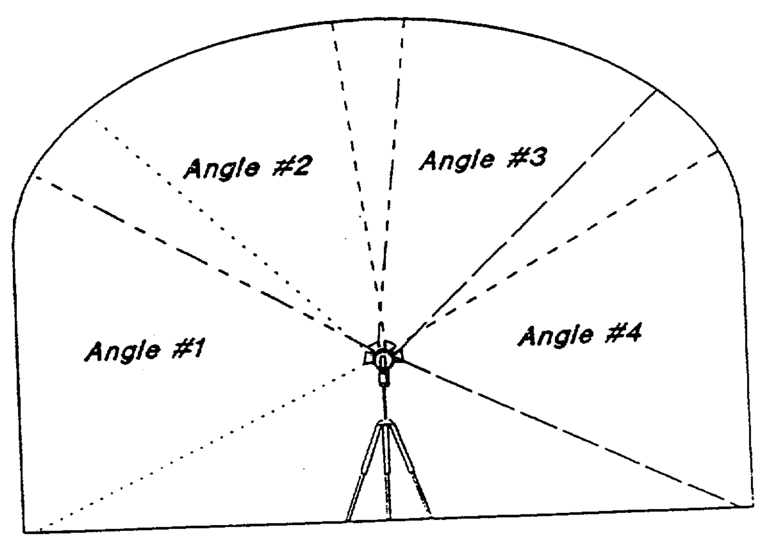
Side View



End View



B-GEO-2-1

1/23/89

Mineralogy Petrology Sampling

Definition of Test

Mineralogy-Petrology studies of the Exploratory Shaft and drifts are discussed in Section 8.3.1.3.2.1.3 of the Site Characterization Plan. Design and operational requirements for this test consist of sample collection and field observation of the rocks exposed by Exploratory Shaft Facility (ESF) excavations.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility necessary to perform the Mineralogy/Petrology Sampling Test.

Performance Criteria

1. Bulk samples will be collected from each blast round during shaft sinking and drift mining. A safe method of collecting and transporting samples to the Sample Management Facility will be provided.

2. Samples will be collected from the walls of rock exposed during excavation in all shafts and drifts.

Constraints

1. Procedures for sample collection and control will be developed by the PIs and the Sample Management Facility staff.

2. Sample collection will be from at least three levels in the rubble pile during each muck cycle.

3. For a size constraint see B-HYD-9-4.

Assumptions

1. About 6 tons of bulk rock samples will be collected from each muck round during shaft sinking. The lower Topopah Spring Member vitrophere, if penetrated, will require all rock being removed to the Sample Management Facility.

2. Bulk samples can be collected without having geologists underground, except for the lower Topopah Spring Member vitrophere and lower elevations in the Calico Hills (if penetrated).

3. Sample collection from walls will normally be accomplished by mapping geologists during the same time period as geologic mapping of the shaft is performed.

4. Drift wall sampling can be done either during mapping or at some later time if mesh can be removed.

5. A transportable bin system can be used.

6. Bulk drift sampling requirements are TBD.

7. Transportation of the samples from the ESF to the Sample Management Facility will be provided by the construction contractor.

Vertical Seismic Profiling Test

Definition of Test

The Vertical Seismic Profiling Test is discussed in Section 8.3.1.4.2.2.5 of the Site Characterization Plan. This test will be mostly done from the surface of the Yucca Mountain site away from the ESF. Some Geophones will be placed in boreholes in both ES-1 and ES-2 and in drift walls.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Vertical Seismic Profiling Test in the Exploratory Shafts and drifts of the ESF.

Performance Criteria

1. Drill holes will be located in both ES-1 and ES-2 at 30 ft increments (± 1 ft). The holes will be oriented toward the MPBH that is associated with ES-1 and ES-2 (The exact orientation will depend on the MPBH locations). The upper hole in ES-1 will be as close to the ground surface as is practical relative to collar emplacement (about 25 ft). The upper hole in ES-2 will be at the same elevation as the hole in ES-1. Note: the following information should be moved to Appendix C. Each hole will be 8 ft in depth (± 1 ft), 3.5 in. in diameter (± 0.5 in.), and drilled downward between 5 and 10 degrees from horizontal.

2. Drill holes for instrumentation are defined in Appendix C of the ESF SDRD.

3. Blockouts in the liner at each hole are required only if the holes are drilled prior to lining the shaft, or for the

convenience of the contractor if the drilling is done after shaft lining. These blockouts are to be no more than 1 ft by 1 ft and no less than 0.75 ft by 0.75 ft.

4. Electrical current (20 A, 110#V) is required for the recording vehicle. This vehicle can be located at any convenient surface location near enough to the facility to allow efficient routing of the seismic cable.

Constraints

1. Because the purpose of the test is to measure ground vibration caused by the introduction of energy from a specific source controlled by the seismic-test team, other loud noises or equipment-or machinery-induced vibration in or near the facility (especially those from hoist operation and blasting) are not allowed while the tests are in progress.

2. Because the hole locations will be known early in the excavation process, the holes can be drilled either, a) prior to blockout emplacement and lining, b) through the lining after the shafts are completed, or c) through blockout openings after the lining is in place. The only requirements are that the holes remain accessible behind a removable plug.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

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 4 tests (shafts + 3 drifts) 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 shaft 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. All VSP tests in the shafts will be conducted after both ES-1 and ES-2 are completed. Drilling of holes for emplacement of geophones can be accomplished at any convenient time. The location of the uppermost hole in ES-1 will determine the location of all other holes.

7. Geophones will be clamped into the holes during the periods of seismic measurements. The phones will be removed at the completion of each test and a cap will placed over each hole to prevent debris from accumulating in the holes. In the drifts, geophones will be attached to the walls directly by clamping to plates installed at 5 m intervals (± 0.3 m).

8. 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 surface 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 at the surface. This cable is connected to the geophone cables via "takeouts," as shown in Figure B-GEO-3(1). It is crucial that the connections be made properly and in the proper order, by personnel experienced in seismic cable layout.

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

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

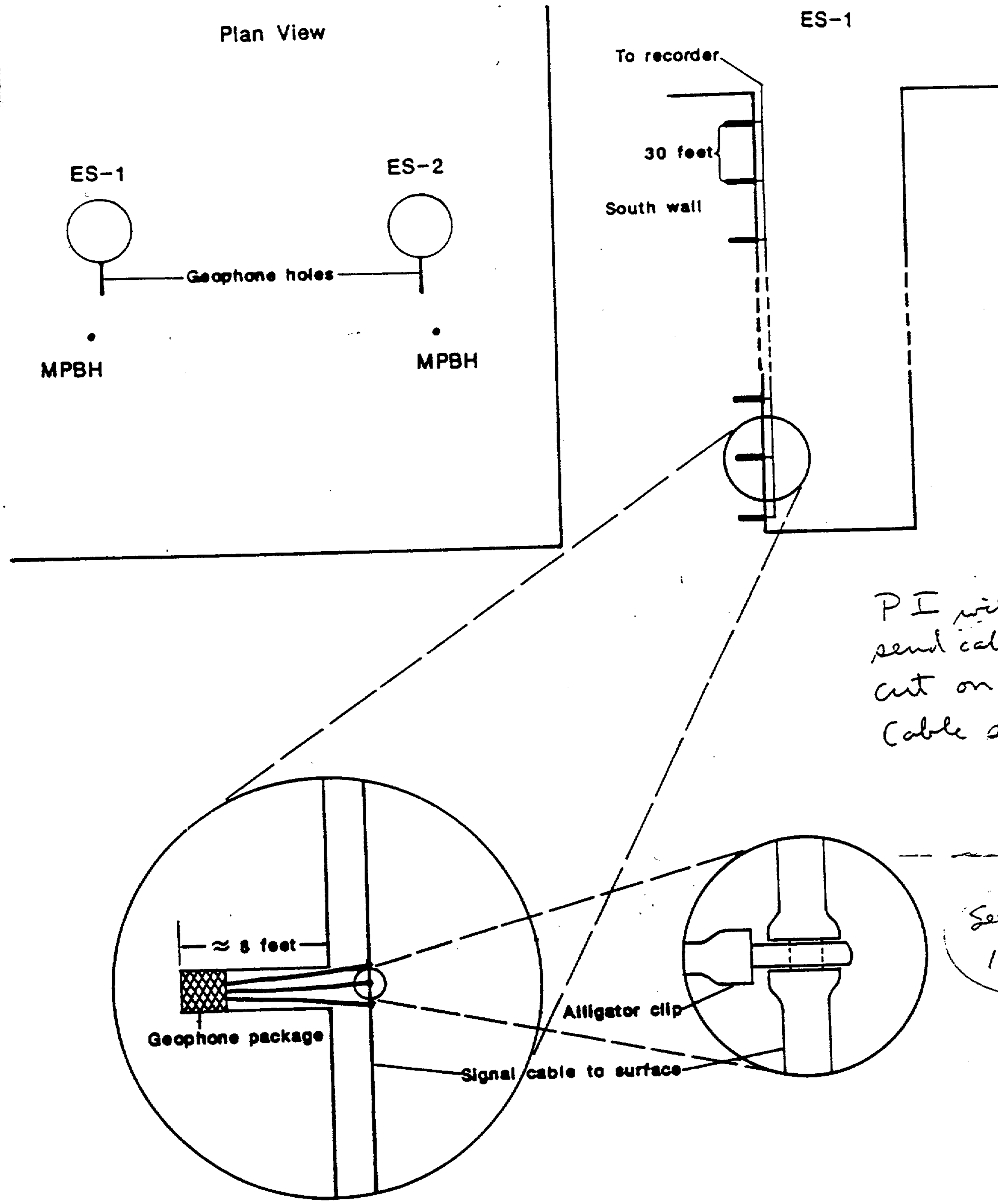
11. Water is not required for these tests, but a small amount of water used in each hole will aid in tamping material to secure the geophone.

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

13. The in-shaft 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.

14. Where geophones attach to the in-shaft 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 VSP measurement station (about every 30 feet).

15. This test is a short duration test and the PI suggests that the VSP 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 #4).



PI will send catalog cut on the Cable specs. TJm 12/2/88

See Assumptions 13 & 14 & 15

Shaft Convergence Test

Definition of Test

The Shaft Convergence Test is defined in Section 8.3.1.15.1.5.1 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Shaft Convergence Test.

Performance Criteria

1. Overcoring will be performed at each of the three planned experiment depths (roughly ± 80 m, ± 200 m, and ± 320 m). Mining will be stopped about 6 m above each experiment depth. An E-sized (37.7-mm) pilot hole will be drilled vertically down 10 m. The hole will be inspected with a borehole televiewer to select overcoring locations. The borehole deformation gage will then be set in the pilot hole and the pilot hole overcored with a 15.2-cm overcoring bit. A minimum of three such overcorings for each experiment depth will be performed (if possible). The test PI will install and orient the Borehole Deformation Gage (BDG) for the horizontal stress measurements. The test PI will remove

the overcore with the BDG and mark the exact BDG position. The borehole televiewer will take approximately 2 hours to inspect each pilot hole at each experiment depth. Placement of the BDG at each location selected will take approximately 2 hours (6 hours for 3 BDG placements at each experiment depth).

2. Six MPBXs with six convergence anchors each will be installed at each measurement location. These MPBXs and anchors will be distributed between the two parallel measurement planes, as shown in Figures B-MECH-1-(1) and B-MECH-1-(2). Each MPBX hole will be N-sized (76 mm) and diamond cored to a length of ± 15 m. The holes will be roughly horizontal and oriented as shown in each figure. There is no constraint of specific orientations; however, the angle between adjacent MPBX holes (and tape extensometer anchors, if applicable) should be about 60 degrees. Each MPBX will require a blasted recess of about 1 ft x 1 ft x 1 ft as shown in figure B-MECH-1-(3). This recess is required to protect the MPBX head from flyrock. In addition, about 1 m of the hole from the collar will need to be reamed to about a 4 in. diameter to allow insertion and grouting of the collar stabilization tube (see figure B-MECH-1-(3)). The MPBX head and collar stabilization tube must be grouted in place. The recess in the rock must be covered with a steel cover plate. Each MPBX will consist of five anchors (beginning ± 1 m from the drill hole collar) and set at 1-m intervals within the hole, and one

anchor set at 15 m from the hole collar. All MPBX anchors will be grouted in place. MPBX leads will be connected to the IDS before further mining. All leads will be protected from shaft activity (e.g., blasting, traffic, etc.) using methods to be determined and approved by the test organization. The MPBX holes will be inspected using a borehole televiewer prior to selecting exact anchor locations. This inspection will take about 2 hours per hole. The installation of each MPBX, including grouting, will take approximately 8 hours. The grout must cure for 2-3 days. Following curing of the grout for each MPBX hole, the MPBXs must be tensioned and attached to the IDS. This will take about 8 hours for each MPBX. MPBX measurements will be taken after the liner is poured and until the shaft internals are installed (unless abnormal behavior is observed).

3. Six HPCs will be installed within the concrete liner during the liner installation at each location, three in each of the two parallel measurement planes as shown in Figure B-MECH-1-(2) B and C. The HPCs will be approximately 10 cm x 20 cm in size. Details of how the HPC can be installed in the liner are shown in Figure B-MECH-1-(4). The HPCs can be attached to rebar that is attached to the plywood as shown in the figure. The HPC will be located near the center of the liner at each location. The recess shown in figure B-MECH-1-(4) will be about 25 cm x 5 cm x 5 cm and should be at the very edge of the liner to allow access to the HPC

compensating tube. The leads from the HPCs must be protected during the pouring using any technique. The leads from the HPCs must protrude through the forms in holes that are about 3/8 in. in diameter. The pressure transducers associated with each HPC will be located on the inside of the shaft and will be attached after the forms are removed. These transducers must be protected from shaft activity by placing them in a protective steel box about 12 in. x 12 in. x 6 in. The leads from to the IDS from this protective box must also be protected using prescribed methods to be approved by the test organization. The HPCs at each experiment level can be installed in 8 hours total. After pouring and curing of the concrete, each HPC must be refilled and attached to the IDS. This will take about 2 hours for each HPC. HPC measurements will be taken after the liner is poured and until the shaft internals are installed (unless abnormal behavior is observed).

4. Six tape extensometer (TE) anchors are required at each experiment depth and will be distributed between the two parallel measurement planes as shown in Figures B and C B-MECH-1-(1). The tape extensometer anchors require E-size (37.7-mm) holes percussion drilled. These holes will be roughly 8 inches deep and will also include a 6 in. x 2 in. recess that will be covered with a steel cover plate to protect the anchor from blasting (as shown in Figure B-MECH-1-(5)). The tape extensometer anchors will be epoxied in place and will be ready for

initial measurements immediately. The tape extensometer anchors must be located diametrically from the MPBXs as illustrated in Figures B and C, B-MECH-1-(1). Each diametrical measurement (from MPBX to MPBX and from TE anchor to TE anchor) will take about 10 minutes. Two measurements are required for each diameter. TE measurements will be performed every day until the liner has passed 25 ft below, then measurements will be made once a week thereafter. The TE measurements will be discontinued after the shaft internals have been installed.

5. A blockout through the liner to the rock will be installed at each MPBX collar and each tape extensometer anchor location. The blockout will be a minimum of 0.3 m x 0.3 m (1 ft x 1 ft) and will go through the liner to the rock.

6. The test will require drilling and coring of holes as defined in Appendix C of the ESF SDRD.

7. Install five MPBX anchors (beginning 1 m (3.3 ft) from the drill hole collar) at 1 m (3.3 ft) intervals within the hole and one anchor 15 m (49 ft) from the hole collar. These will be grouted in place. The MPBX head is attached to the collar and recessed into the rock. The head is protected by steel covers secured by rockbolts.

8. MPBX and HPC leads will be connected to the IDS before doing any further mining. All instrumentation leads will be protected from shaft activity (e.g., blasting, traffic, etc.) using prescribed methods (TBD).

9. MPBX and HPC measurements will be taken after the liner is poured. Shaft Convergence instrument installation and initial measurements will take approximately 12 days to accomplish at each location.

10. The test organization must be provided with "as-built" drawings of all holes, blockouts, and HPC installations.

Constraints

1. Special controlled blasting specifications may be required for about 15 ft above and below each test location.

2. MPBXs and convergence anchors will be installed at about 60 degree intervals around the shaft as shown in figure B-MECH-1-(2).

3. All holes will be drilled no greater than 1 m from the shaft bottom.

4. Reasonably competent rock is required at the test horizon to assure proper gauge installation.

5. Vertical boreholes from the UDBR cannot pass within four hole diameters of the MPBX holes.

Interface Requirements

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

   Section B-IS-1 Integrated Data System

   Section B-IS-2 Scientific Manpower/Schedule Information

   Section B-IS-3 Laboratory/Office/Storage Space Requirements

   Section B-IS-4 Electrical Power Requirements

   Section B-IS-5 Water System Requirements

   Section B-IS-6 Compressed Air System Requirements

   Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. The planned depths for the shaft convergence test are about 80 m, 200 m, 320 m. Each test consists of two levels separated by 2 m. The depths of this test can be adjusted a few feet to accommodate other activities.

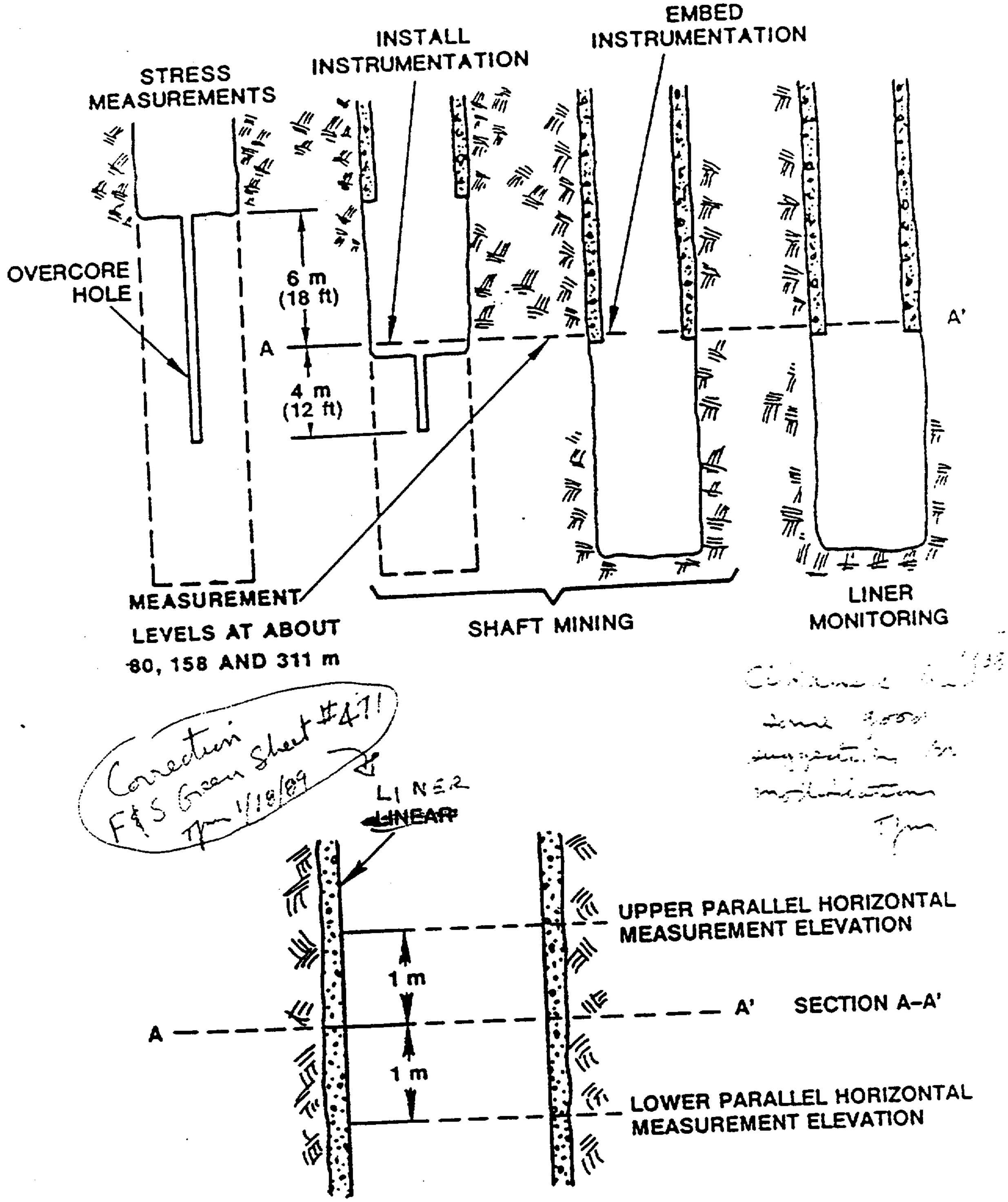


Figure A Measurement sequences for the Shaft Convergence Test showing conceptual location for the upper and lower parallel horizontal measurement elevations at eacl. major measurement location.

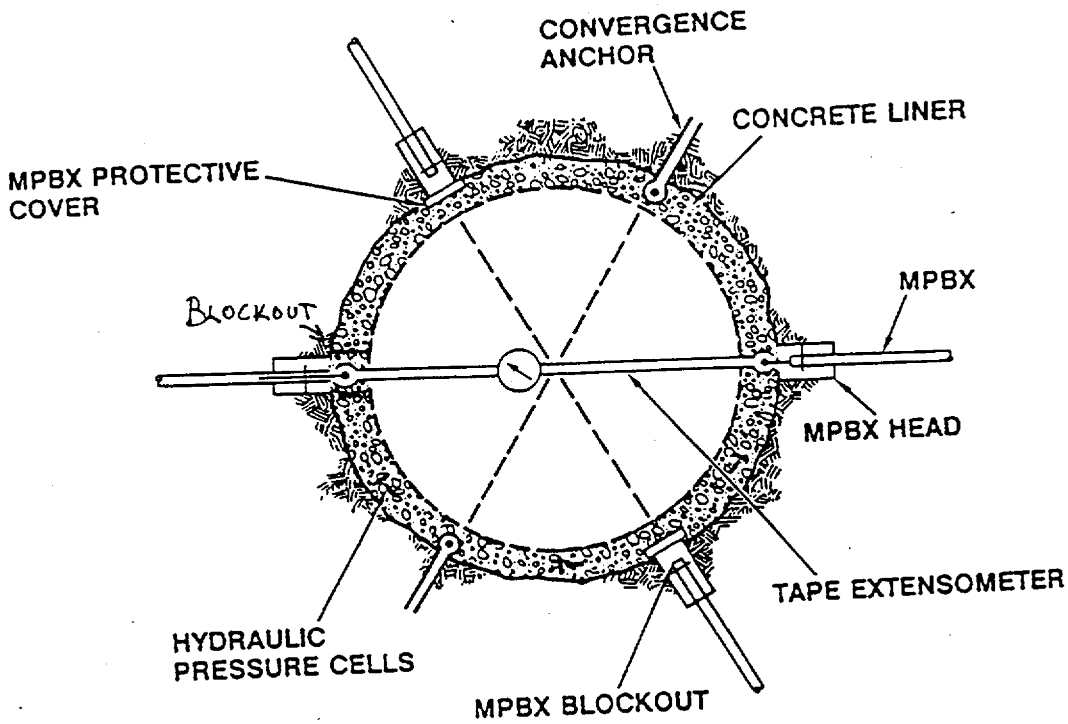
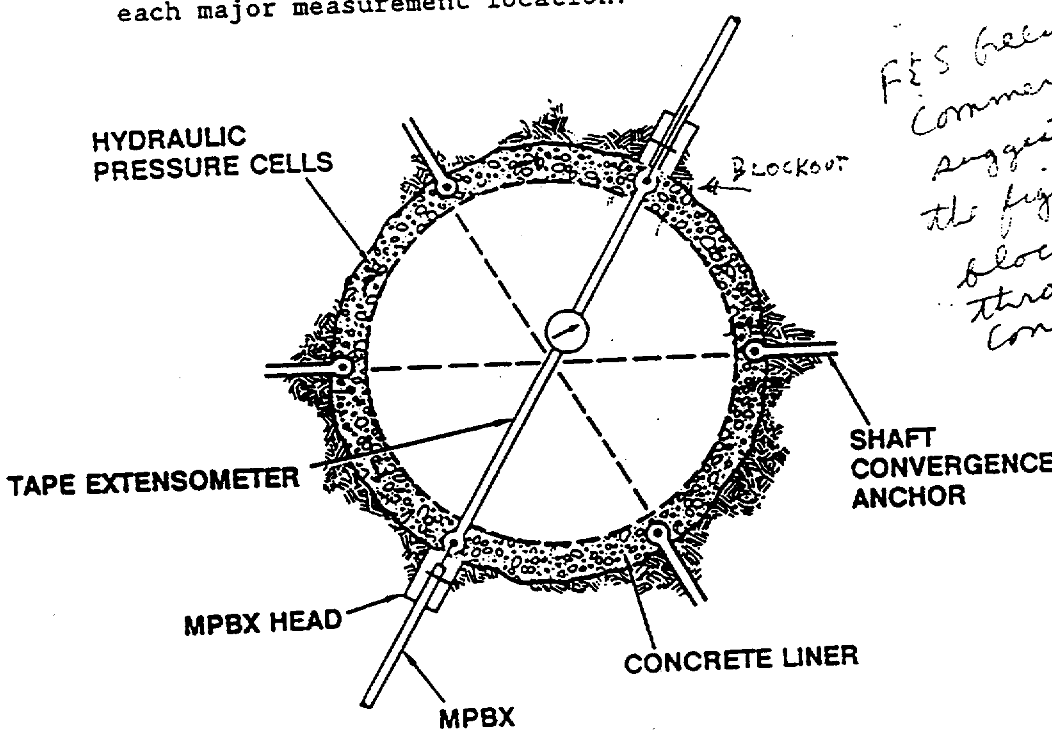
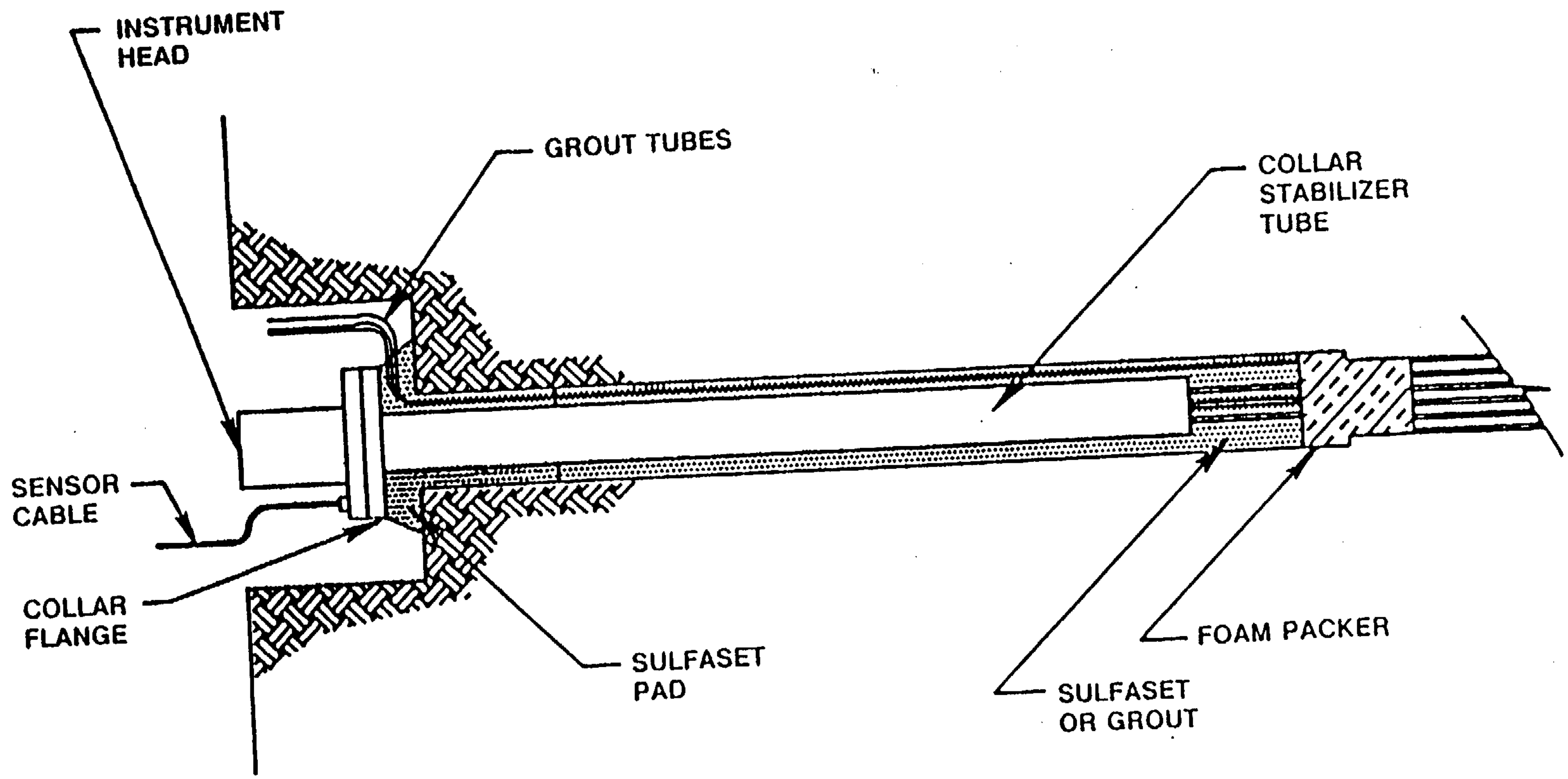


Figure B Conceptual layout for the upper parallel measurement elevation at each major measurement location.

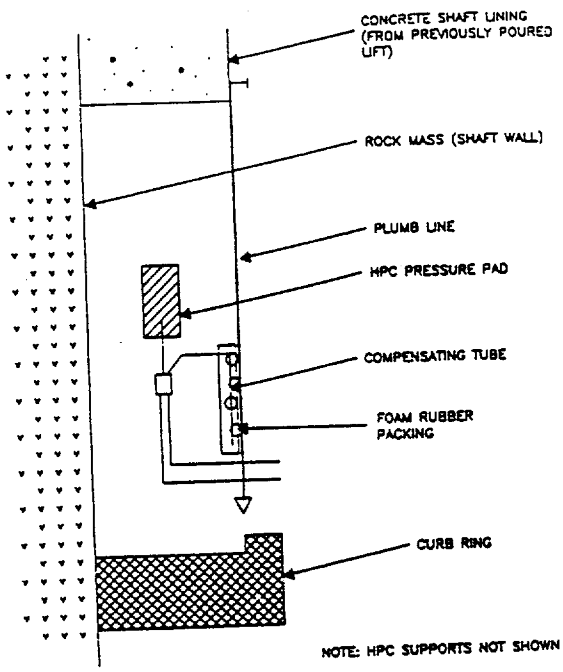


FES Green Sheet Comment # 472 suggests that the figure show the blockout through the concrete

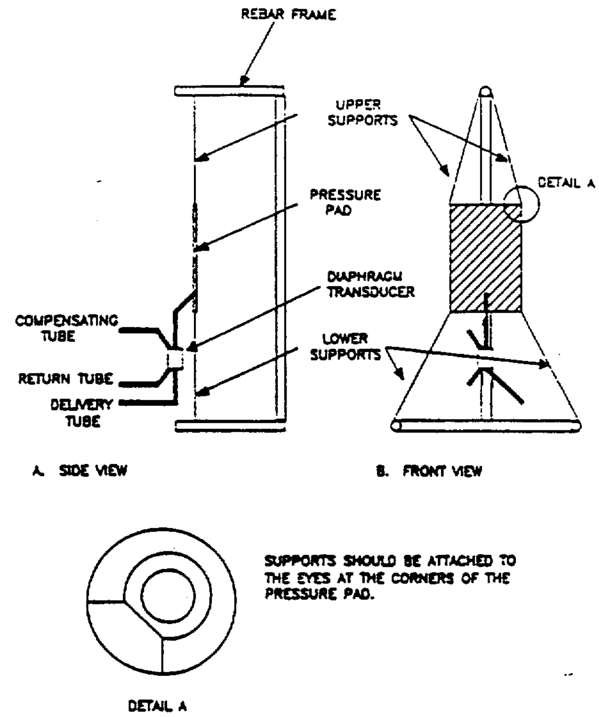
Figure C Conceptual layout for the lower parallel measurement elevation at each major measurement location.



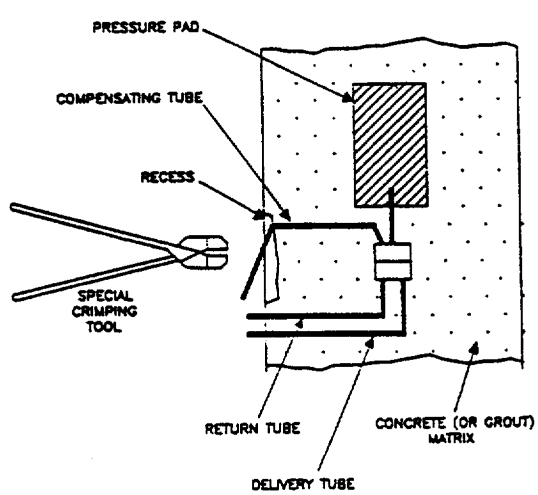
SCHEMATIC OF THE MPBX



A.

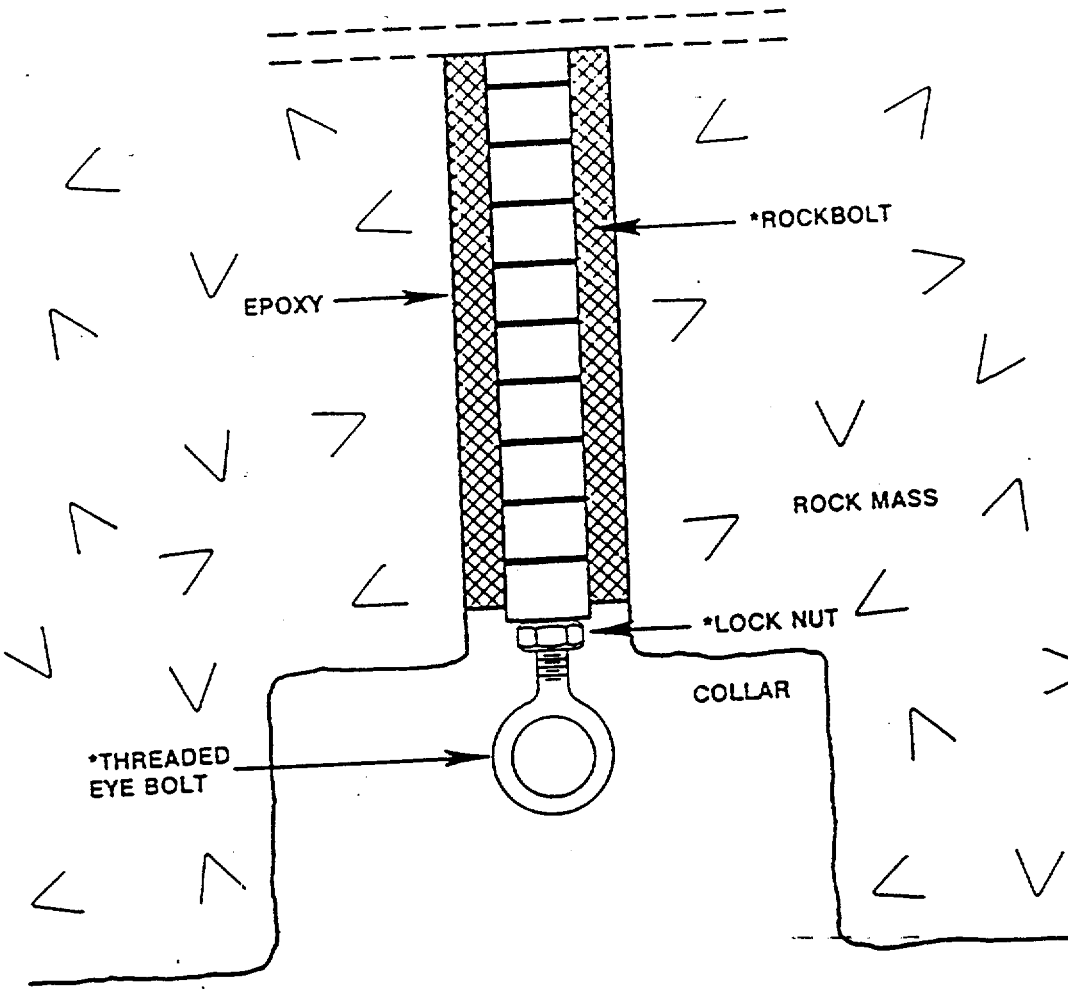


B.



C.

Figure ~~SCE2~~ - Details of HPC in Shaft Liner
3-MECH-1-(4)



*THE ROCKBOLT, EYE BOLT, AND LOCK NUT CONSTITUTE THE ANCHOR.

Schematic of Tape Extensometer Anchor

Demonstration Breakout Rooms Test

Definition of Test

The Demonstration Breakout Rooms Test is discussed in Section 8.3.1.15.1.5.2 of the Site Characterization Plan. This test is designed to study the geomechanical behavior of a typical repository sized drift.

Functional Requirement

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Demonstration Breakout Rooms testing.

Performance Criteria

1. Demonstration Breakout Rooms will be 19 ft high by 25 ft wide by 150 ft long.

2. The test will require drilling and coring of holes as defined in Appendix C of the ESF SDRD.

3. Provision for data collection by the IDS must be available prior to excavation of each room beyond 35 ft (see Assumption #2).

4. Provide access for testing work in the UDBR during shaft construction below.

Constraints

1. The orientation will coincide with the orientation planned for the underground facility with the flexibility for orientation adjustment up to 90 degrees depending on the dominant fracture orientation and the in situ stress conditions at each DBR location.

2. The construction and convergence testing of the DBRs will be done early in the construction of each level to minimize prior disturbance of the ground.

3. No mining, except to excavate each DBR, will be allowed within 50 ft of any MPBX anchor until MPBX readings are no longer being taken. Since MPBX anchors can be 50 feet from the DBR rib, this constraint effectively provides an exclusion envelope of 100 ft from the DBR ribs.

4. The convergence pins and MPBX heads should be recessed to protect from blast damage.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. The locations identified in Appendix A of the ESF SDRD are acceptable for the DBRs.

2. Drift mining will be performed using controlled blasting methods until the first measurement station at 35 ft is reached. Then a sequence of instrumentation installations with controlled blasting and ongoing data recording will take place through the next 80 ft at 8 ft intervals.

3. The general arrangement of instrumentation in the DBR is shown in Figure B-MECH-2 (1).

4. The DBRs will be used to carry out the other testing and will therefore not be available for other facility uses such as storage.

5. Phase 1 of the IDS must be operational before excavation of the UDBR starts. Phase 2 of the IDS must be operational before excavation of the DBR on the MTL starts.

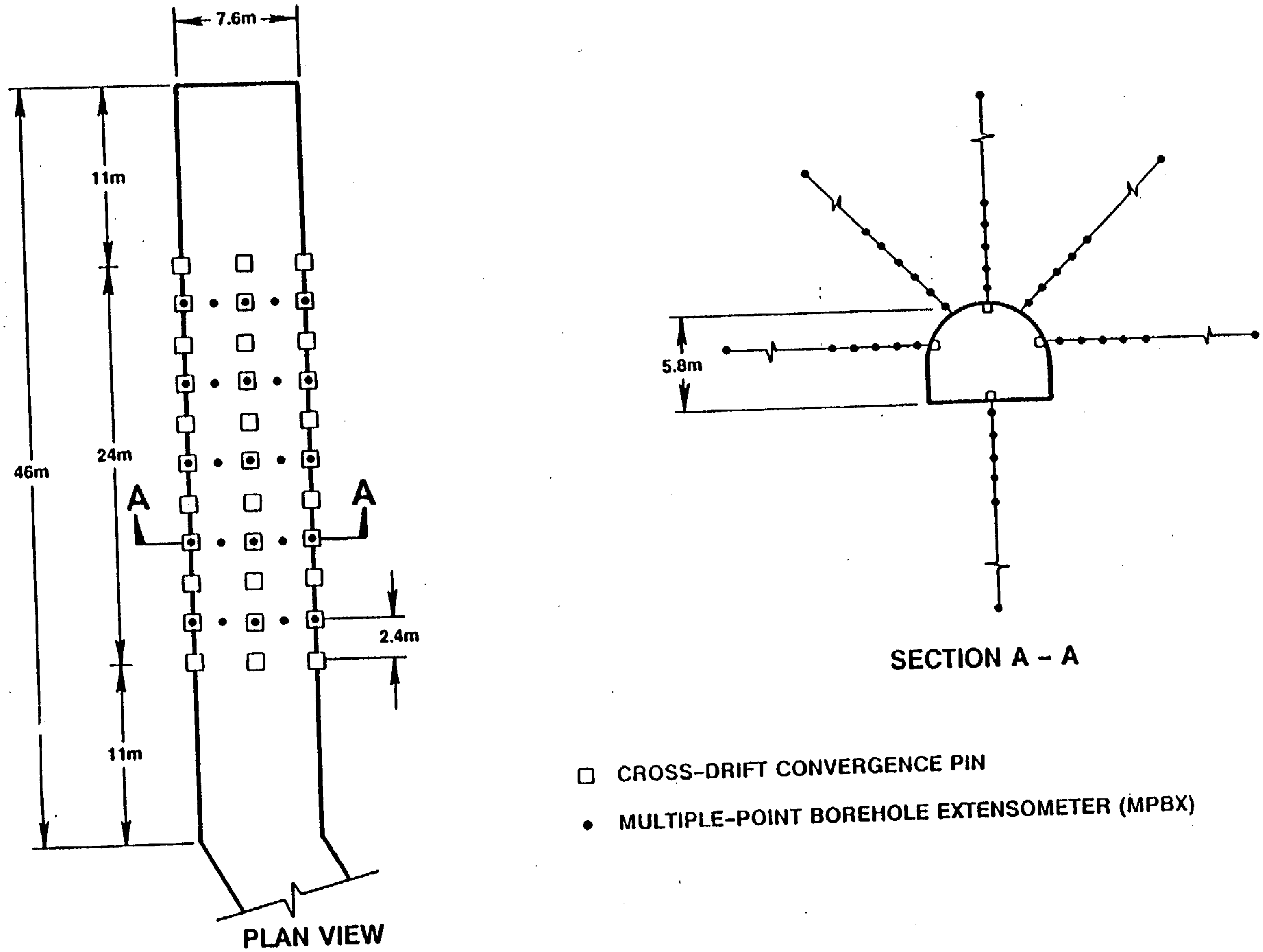


Figure B-MECH-2-(1). Demonstration Breakout Rooms Instrumentation Layout

Sequential Drift Mining Test

Definition of Test

The Sequential Drift Mining Test is discussed in Section 8.3.1.15.1.5.3 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Sequential Drift Mining Test.

Performance Criteria

1. Two instrumentation drifts will be excavated 14 ft high x 16 ft wide x 180 ft long. The centerlines of these drifts will be 110 ft apart. A third (center) repository-size drift (19 ft high x 25 ft wide x 180 ft long) will be excavated after completion of instrumentation installation from the first two drifts. Except, the first 20 ft of the center drift may be excavated at the same time as the instrumentation drifts if necessary to protect utilities.

2. The test will require drilling and coring of holes as defined in Appendix C of the ESF SDRD.

3. Provision for data collection must be available prior to excavation of the third drift.

Constraints

1. The orientation of the drifts will coincide with the orientation planned for the underground facility with flexibility for orientation adjustment depending on the

dominant fracture orientation and in situ stress condition. This flexibility shall accommodate up to a 90 degree rotation.

2. No other test alcoves or test drifts will be planned within a standoff zone of 30 ft from the walls of the instrumentation drifts around it. No other excavation can take place within the standoff zone while the test is in progress.

Interface Requirements

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

Section B-IS-1	Integrated Data System
Section B-IS-2	Scientific Manpower/Schedule Information
Section B-IS-3	Laboratory/Office/Storage Space Requirements
Section B-IS-4	Electrical Power Requirements
Section B-IS-5	Water System Requirements
Section B-IS-6	Compressed Air System Requirements
Section B-IS-7	Common Sampling Design Requirements

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

Assumptions

1. The location of the drifts as identified in Appendix A of the ESF SDRD is acceptable.

2. The general arrangement of instrumentation in the Sequential Drift Mining Test is shown in Figure B-MECH-3-(1).

3. An organizational computer room (Bally building) with dimensions of 10 ft x 15 ft (concrete pad 25 ft x 20 ft) is required to support the Sequential Drift Mining Test. This can be located in the dead end of one of the instrumentation drifts.

4. Excavation of the center drift cannot begin (except for an initial stub-out) until the associated IDS equipment is operational.

5. IDS data alcoves can be located off the instrumentation drifts provided the center pillar between the instrument access drifts is not affected.

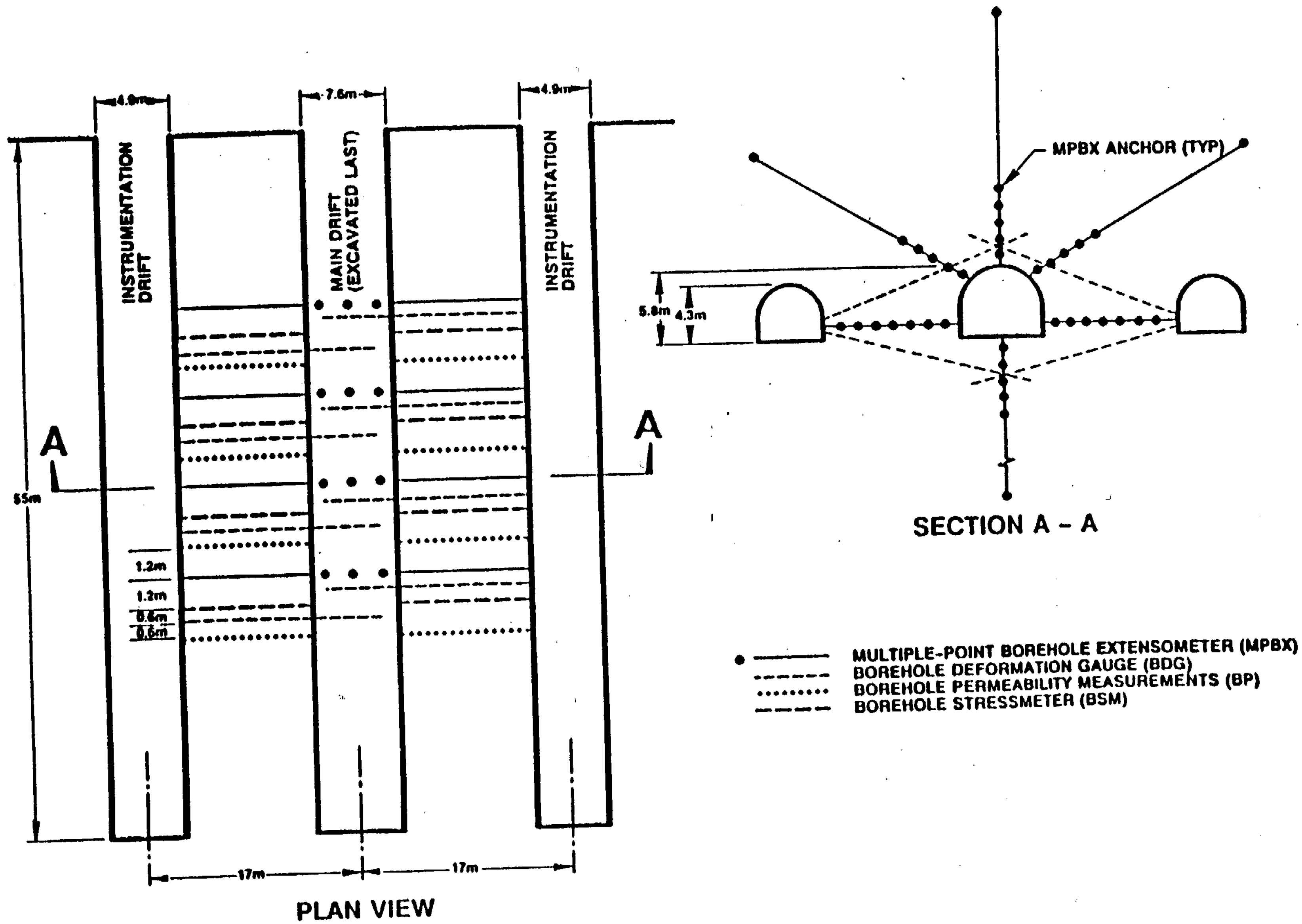


Figure B-MECH-3-(1). Sequential Drift Mining Instrumentation Layout

TSw1 Heater Test

Definition of Test

The TSw1 Heater Test is discussed in Section 8.3.1.15.1.6.1 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the TSw1 Heater Test as shown in Figure B-MECH-4-(1).

Performance Criteria

1. The TSw1 Heater Test will be performed in the Upper Demonstration Breakout Room in a location to be determined later.

2. The test will require drilling and coring of holes as defined in Appendix C of the ESF SDRD.

Constraints

1. The organizational computer and the IDS support must be operational before this test can start.

2. The radon monitoring borehole will be diamond drilled and sealed at the collar with a concrete plug. Plugs will also be installed at four separate locations in the borehole to create three sampling chambers centered at the depth of the thermocouples in the associated boreholes. Installation of the plugs will take approximately 8 hours. The borehole will be about 6 in. in diameter.

3. Each MPBX hole will be N-sized (76 mm) and diamond cored to a length as shown in the attached figures. The holes will be roughly horizontal and oriented as shown in each figure. There is no constraint on specific orientations; however, the angle should be roughly as shown in the figures. For each MPBX hole, about 1 m of the hole from the collar will need to be reamed to about 4 in. in diameter to allow insertion and grouting of the collar stabilization tube (see Figure B-MECH-4-(2)). The MPBX head and collar stabilization tube must be grouted in place. Each MPBX will consist of five anchors (beginning at the bottom of each hole) at 1-m intervals within the hole. All MPBX anchors will be grouted in place. MPBX leads will be connected to the IDS as soon as possible. All leads will be protected from shaft activity (e.g., blasting, traffic, etc.) using methods to be determined and approved by the test PI. The MPBX holes will be inspected using a borehole televiewer prior to selecting exact anchor locations. This inspection will take about 2 hours per hole. The installation of each MPBX, including grouting, will take approximately 8 hours. The grout must cure for 2-3 days. Following curing of the grout for each MPBX hole, the MPBXs must be tensioned and attached to the IDS. This will take about 8 hours for each MPBX.

4. "As built" drawings that show the location and orientations of all holes is required.

5. Dedicated thermocouple holes will be diamond drilled to E-size (37.7 mm) and will be roughly oriented as shown in Figures B-MECH-4-(3) and B-MECH-4-(4). The thermocouples will be installed by a method prescribed by the test PI and the hole will be regrouted with a TBD grout mix. The thermocouple leads must be protected from activity using a method approved by the test PI. The thermocouples will be connected to the IDS as soon as possible.

Neutron probe and moisture-sensing holes will be diamond cored and oriented as shown in the figures and as described in Appendix C of the SDRD.

The BDG holes will be E-sized (37.7 mm) diamond core holes to the depth and orientation shown in the figures. Placement of the BDGs will take about 2 hours for each. The leads from the BDGs must be protected from traffic and be hooked to the IDS as soon as possible.

Acoustic emission (AE) sensors will be installed at various locations to be determined by local geologic conditions. The AE leads will be protected from traffic and hooked to the IDS as soon as possible.

6. Heat from the test cannot be allowed to interfere with other tests.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

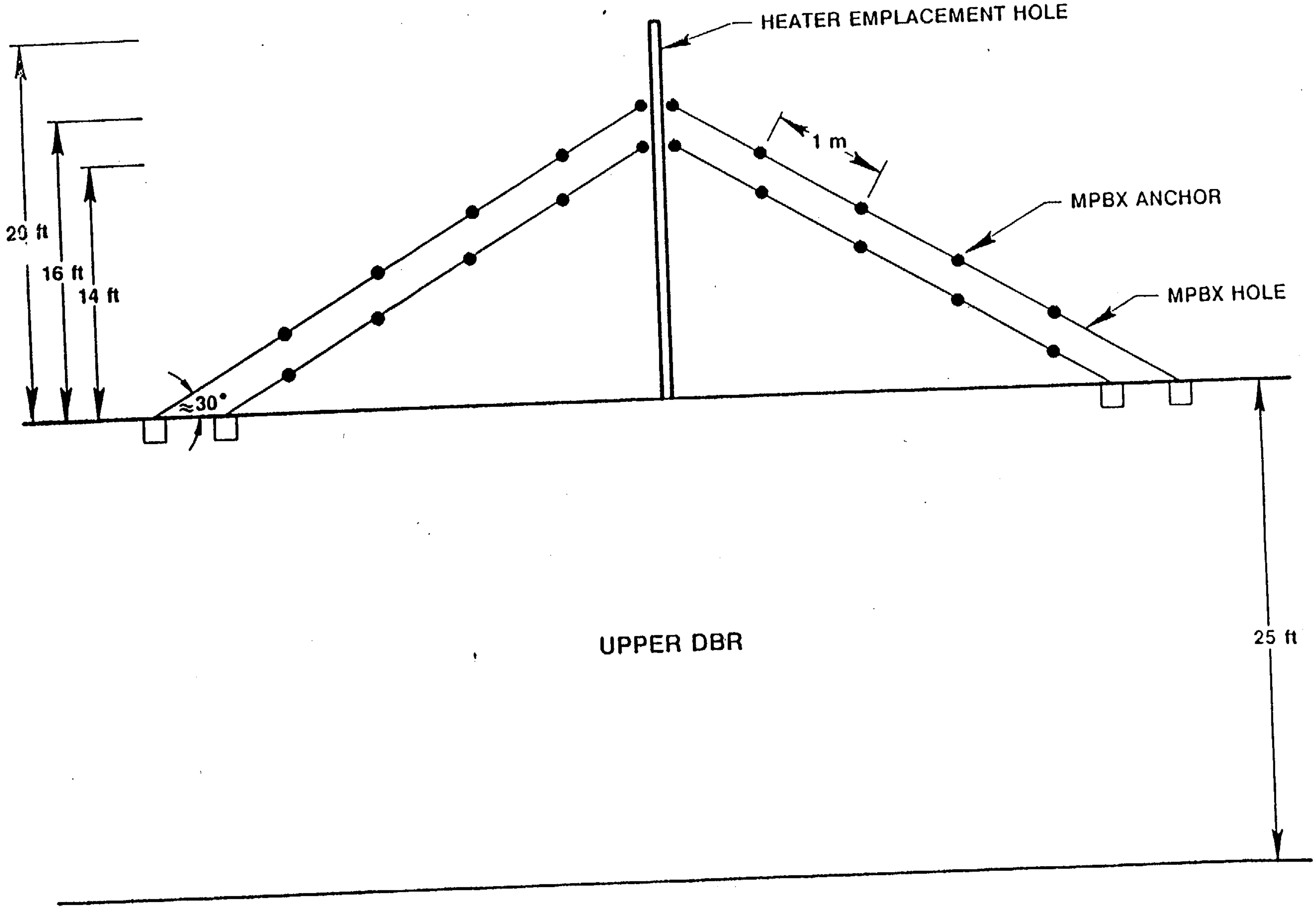
Assumptions

1. No additional excavation is required for this test.

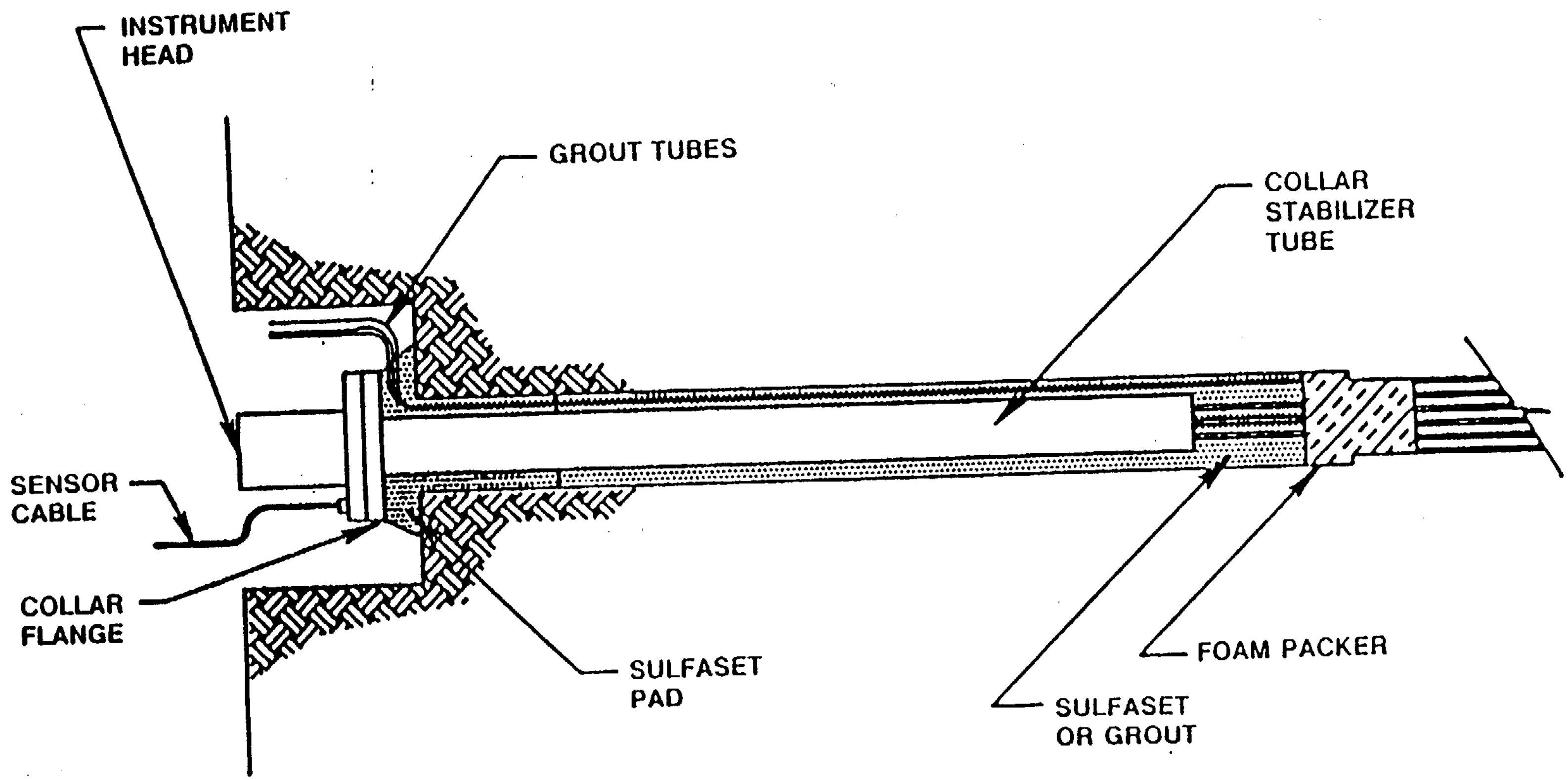
2. The exact test location will be based, in part, on the results of mapping and other observations after the UDBR has been constructed.

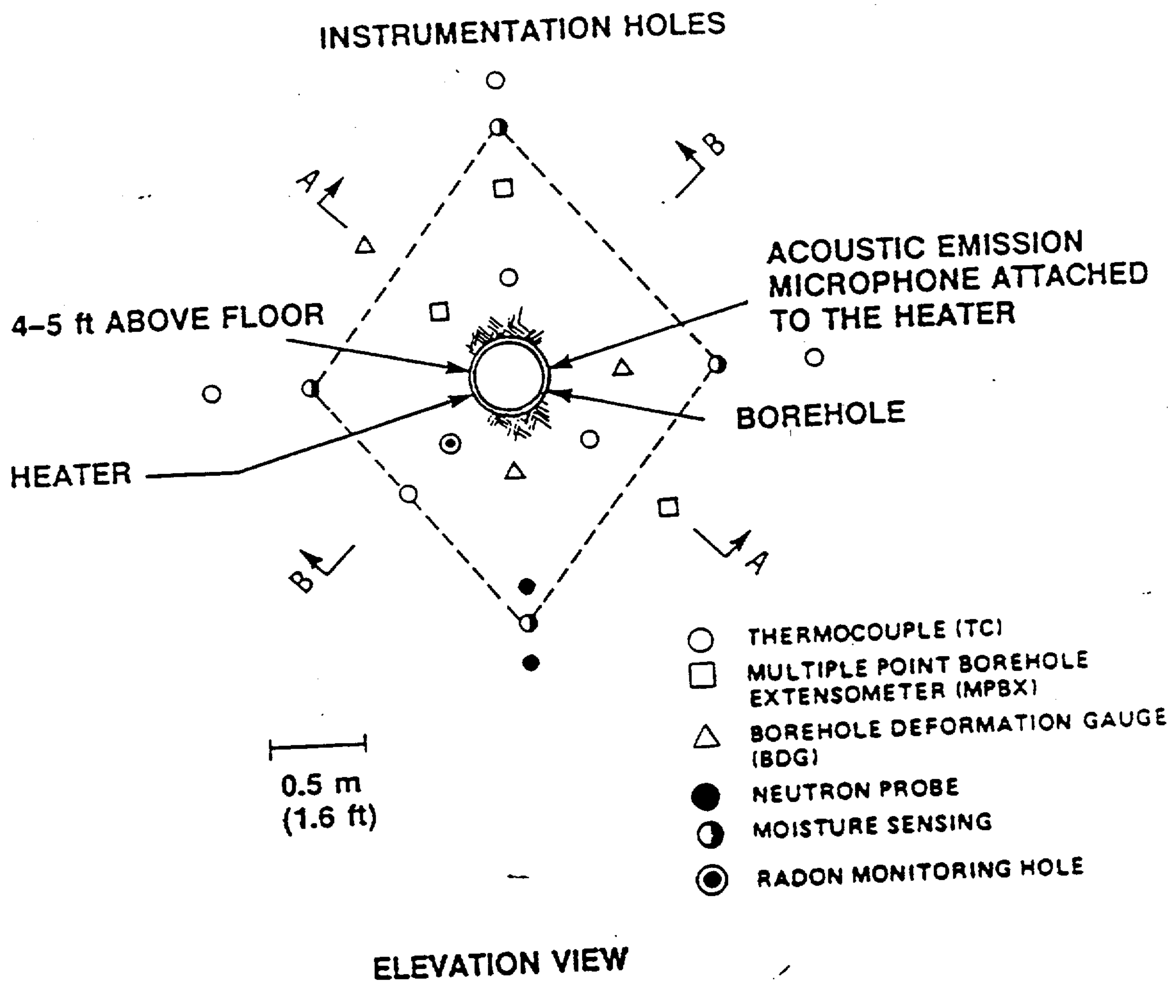
3. The test geometry is shown in Figures B-MECH-4-(2) and B-MECH-4-(3).

4. The TSw1 Heater Test can be performed after ES-1 is complete.

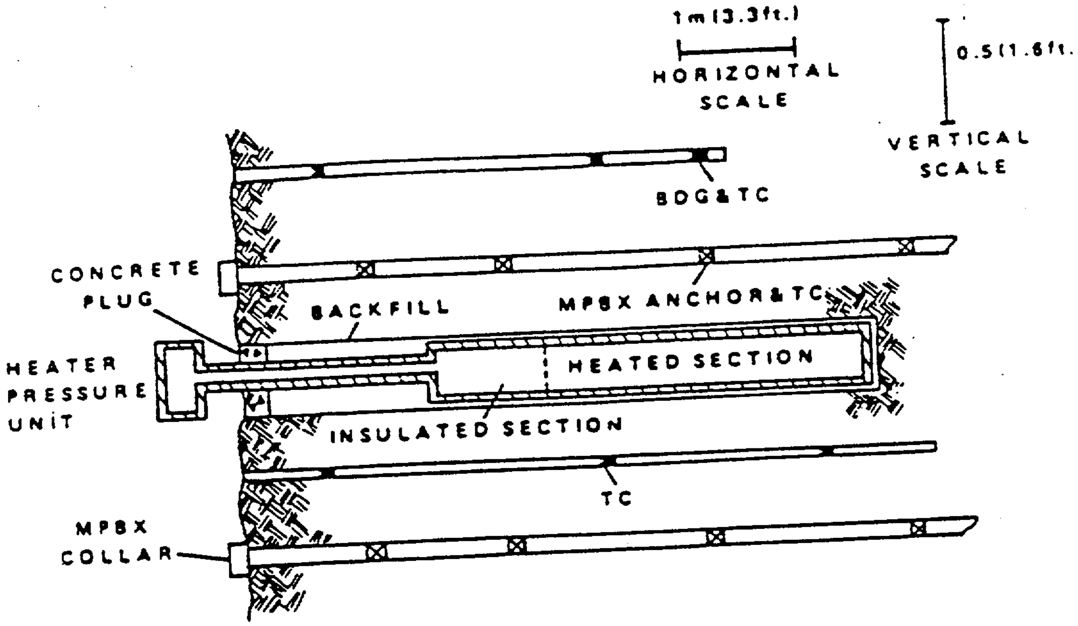


Layout for Heater Experiment in Unit TSw1 and MPBX Holes


INSTRUMENT HEAD
GROUT TUBES
COLLAR STABILIZER TUBE
SENSOR CABLE
COLLAR FLANGE
SULFASET PAD
FOAM PACKER
SULFASET OR GROUT

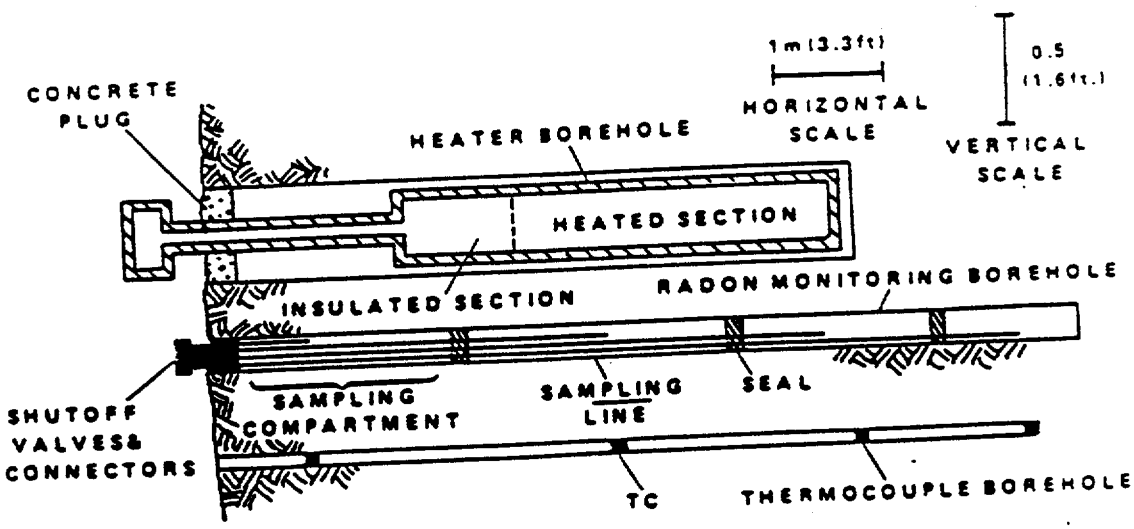


Elevation view showing heater and instrumentation holes.



SECTION A–A

Typical layout of heater and instrumentation.



SECTION B–B

Typical layout of radon-monitoring borehole.

Canister-Scale Heater Test

Definition of Test

The Canister-Scale Heater Test is discussed in Section 8.3.1.15.1.6.2 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Canister-Scale Heater Test.

Performance Criteria

1. A room at least 14 ft wide x 14 ft high x 25 ft long will be required.

2. The test will require drilling and coring of holes as defined in Appendix C of the ESF SDRD.

3. Figure B-MECH-5 (1) shows the test geometry.

Constraints

1. The radon monitoring borehole will be diamond drilled and sealed at the collar with a concrete plug. Plugs will also be installed at four separate locations in the borehole to

create four sampling chambers centered at the depth of the thermocouples in the associated boreholes. Installation of the plugs will take approximately 8 hours. The boreholes will be about 6 in. in diameter.

2. The organizational computer and the IDS support for this test must be operational before this test can start.

3. Facilities for an organizational computer are required. Each MPBX hole will be N-sized (76 mm) and diamond cored to a length as shown in the attached figures. The holes will be roughly horizontal and oriented as shown in each figure. There is no constraint on specific orientations; however, the preference angle would be roughly perpendicular to the heater emplacement hole as shown in the figure B-MECH-5-(1). For each MPBX hole, about 1 m of the hole from the collar will need to be reamed to about 4 in. in diameter to allow insertion and grouting of the collar stabilization tube (see Figure B-MECH-5-(2)). The MPBX head and collar stabilization tube must be grouted in place. Each MPBX will consist of five anchors (beginning at the bottom of each hole) at 1-m intervals within the hole. All MPBX anchors will be grouted in place. MPBX leads will be connected to the IDS as soon as possible. All leads will be protected from shaft activity (e.g., blasting, traffic, etc.) using methods to be determined and approved by the test PI. The MPBX holes will be inspected using a borehole televiewer prior to selecting exact anchor locations. This inspection will take about 2 hours per hole. The installation of each MPBX, including grouting, will take approximately 8 hours. The grout must cure for 2-3 days. Following curing of the grout for each MPBX hole, the MPBXs must be tensioned and attached to the IDS. This will take about 8 hours for each MPBX.

4. "As built" drawings that show the location and orientations of all holes is required.

5. Dedicated thermocouple holes will be diamond drilled to E-size (37.7 mm) and will be roughly oriented as shown in Figures B-MECH-5-(3) and B-MECH-(4)). The thermocouples will be installed by a method prescribed by the test PI, and the hole will be regrouted with a TBD grout mix. The thermocouple leads must be protected from activity using a method approved by the test PI. The thermocouples will be connected to the IDS as soon as possible.

   Neutron probe and moisture sensing holes will be diamond cored and oriented as shown in the figures and as described in Appendix C of the SDRD.

   The BDG holes will be E-sized (37.7 mm) diamond core holes to the depth and orientation shown in the figures. Placement of the BDGs will take about 2 hours for each. The leads from the BDGs must be protected from traffic and be hooked to the IDS as soon as possible.

   Acoustic emission (AE) sensors will be installed at various locations to be determined by local geologic conditions. The AE leads will be protected from traffic and hooked to the IDS as soon as possible.

6. Rockbolts and mesh must not be installed within 4 m of the Heater Borehole in the Rib. Rockbolts and wire mesh must not be installed within 4 m of the boreholes for MPBX's. See figure B-MECH-5-(1) for heater and MPBX locations.

7. The heater should be located at least 9 m from drifts or alcoves oriented parallel to the heater axis. This requirement insures axisymmetric thermal distribution around the heater.

8. The test needs to be located in a low traffic area because surface temperatures may reach 200°C and may pose a hazard to personnel in the area.

9. Thermomechanical and geochemical alteration of in situ conditions may extend 15 m radially from the canister and 20 m longitudinally from the placement hole. Other testing that may be affected by this zone should not take place in this zone.

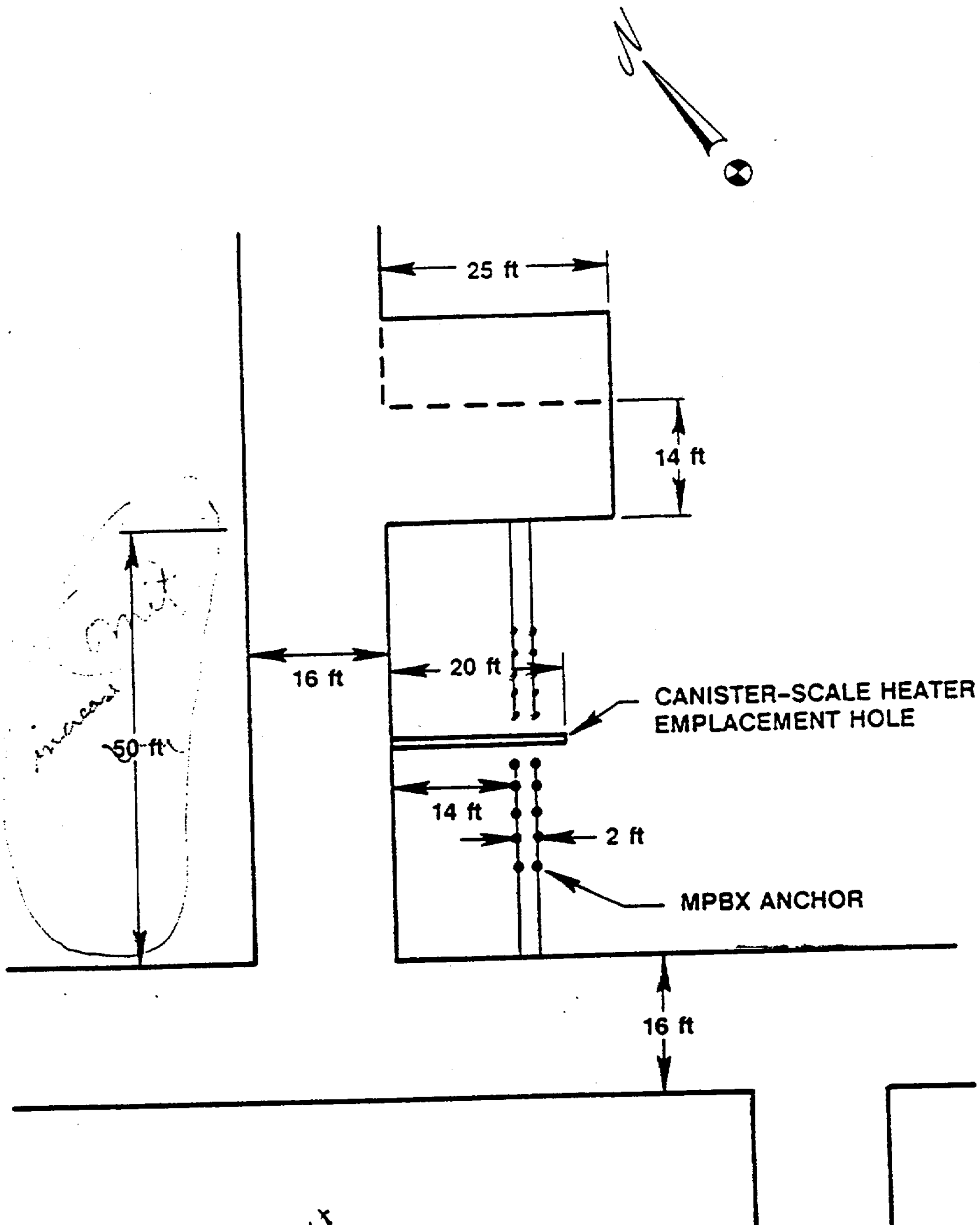
Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

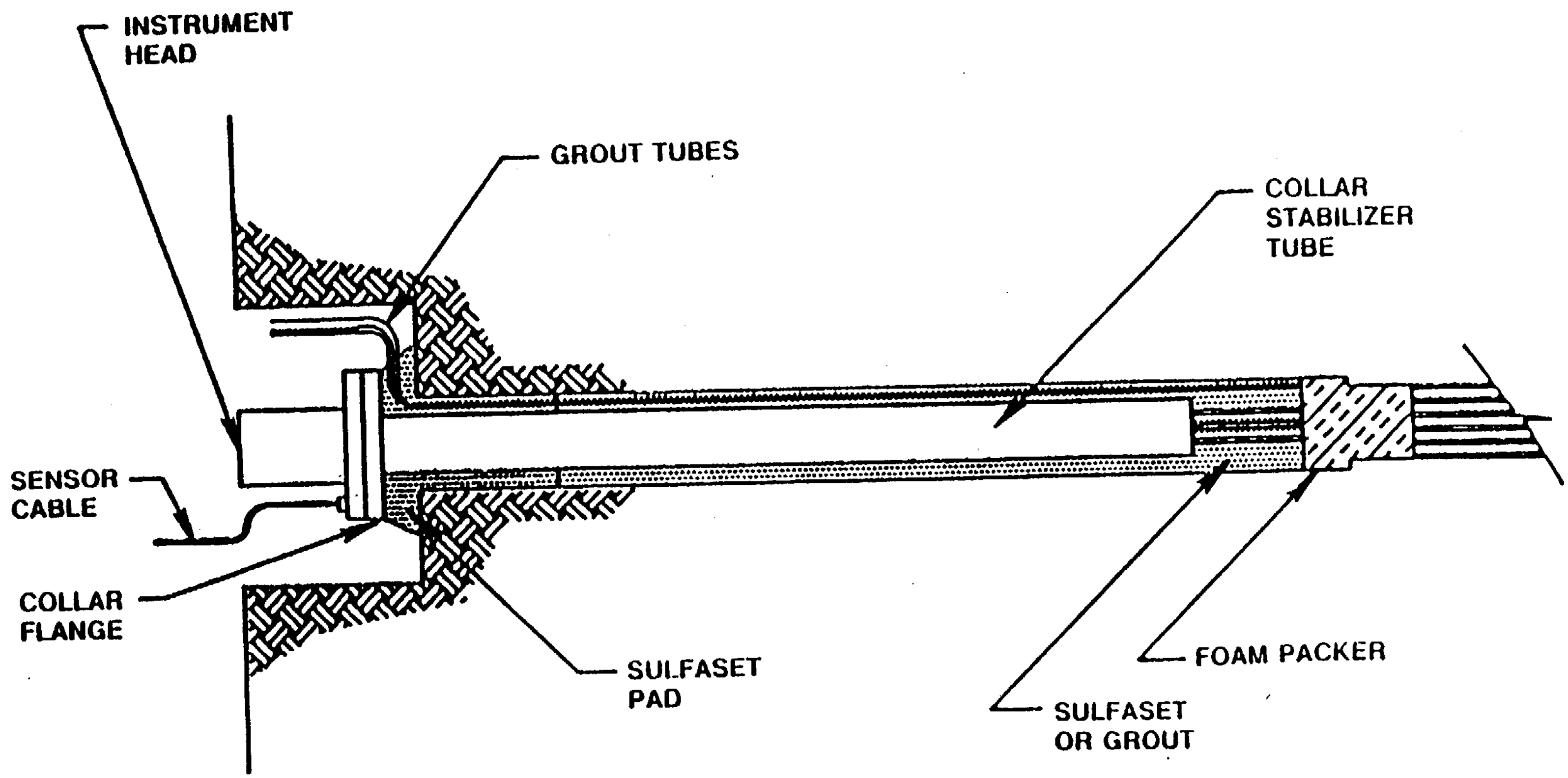
Assumptions

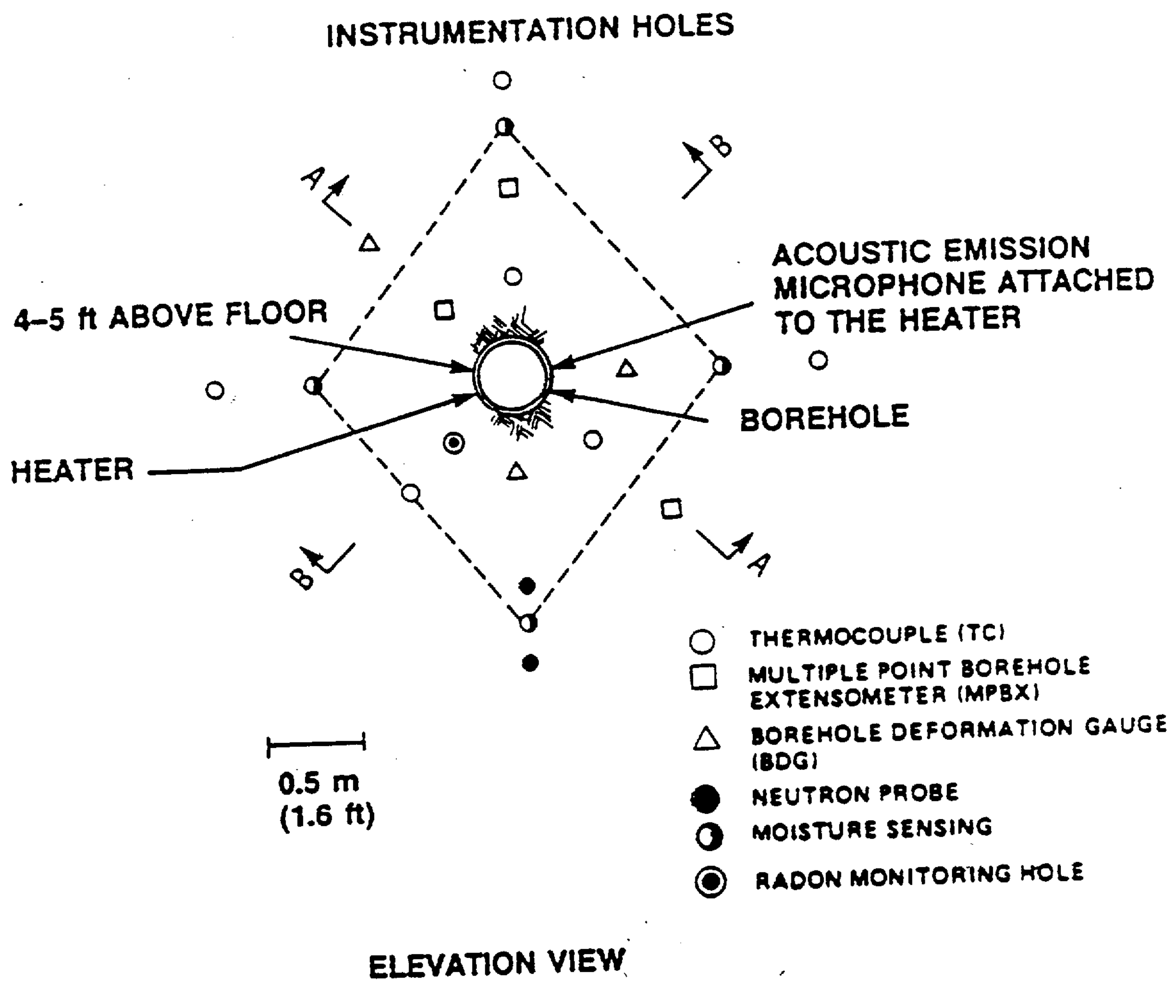
None



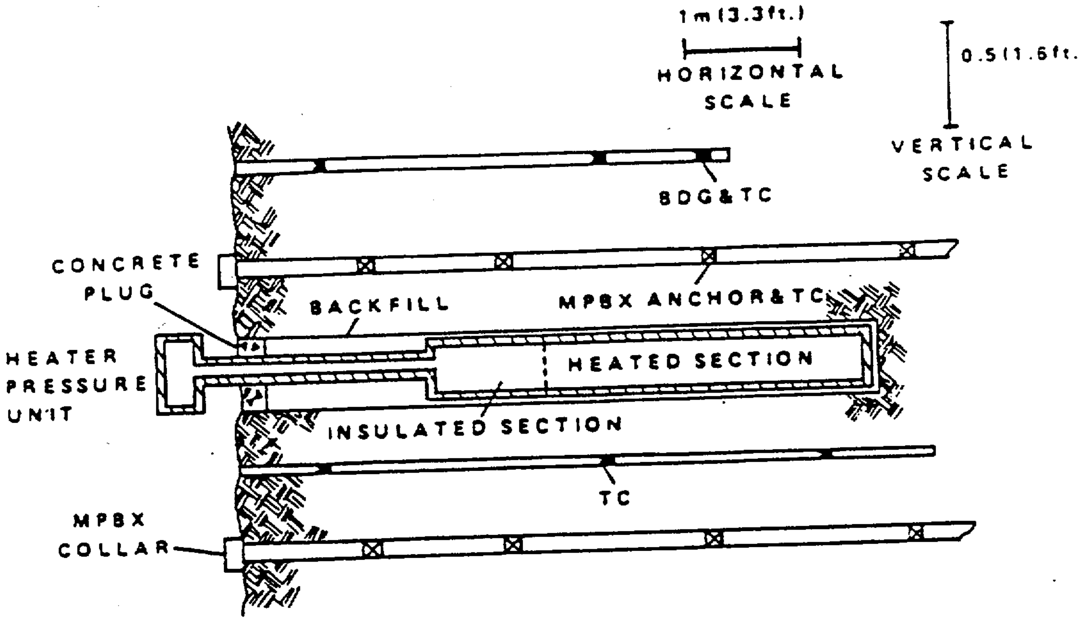
Note Green sheet #477 (F85) suggests that Constraint #7 requires at least 18 m of rib between access drifts for instr. PI should Modify Figure.

Layout for Canister-Scale Heater and MPBX Holes


INSTRUMENT HEAD
GROUT TUBES
COLLAR STABILIZER TUBE
SENSOR CABLE
COLLAR FLANGE
SULFASET PAD
FOAM PACKER
SULFASET OR GROUT

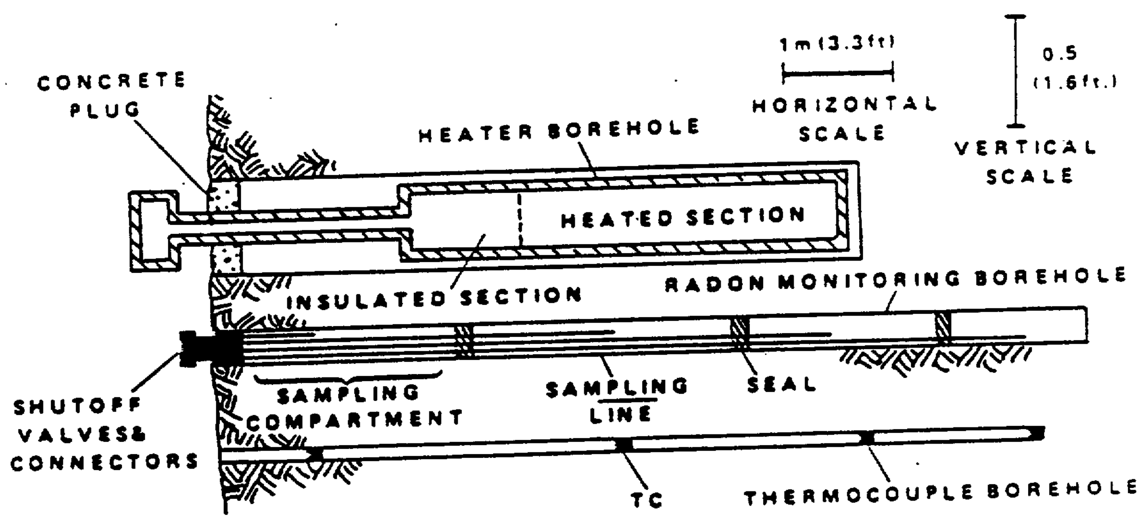


Elevation view showing heater and instrumentation holes.



SECTION A–A

Typical layout of heater and instrumentation.



SECTION B–B

Typical layout of radon-monitoring borehole.

Heated Block Test

Definition of Test

The Yucca Mountain Heated Block Test is discussed in Section 8.3.1.15.1.6.3 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Heated Block Test.

Performance Criteria

1. An experimental alcove with nominal dimensions of 27 ft x 27 ft and a height of 14 ft is required for this test. The test will be located in an alcove at the main test level in the ESF.

2. The test will require drilling and coring of holes as defined in Appendix C of the ESF SDRD.

Constraints

1. Flexibility must be provided such that the alcove could be extended (to a maximum length of 75 ft) depending on geologic conditions (such as fracture spacing and lithophysal content) or if the test is to be replicated. This decision will be made at the time of the initial alcove construction.

2. Excavation is to be accomplished using controlled blasting to provide as smooth a floor surface as can be practically constructed.

3. A Bally Building structure will be needed for equipment and test control. The floor size will be 10 ft x 15 ft on a concrete pad 15 ft x 20 ft to be located near the end of the experiment alcove.

4. Water use in and around the Heated Block test will be monitored and records made available to the Test Manager.

5. A catwalk structure with a clearance of approximately 2 ft over the experimental block will be needed to allow access to the instrumentation from above.

6. Joint spacing and orientation must be reasonably representative of the repository horizon.

7. The test should be located in a low traffic area so dust and vibrations from other construction and traffic do not interfere with sensitive displacement measurements being made.

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

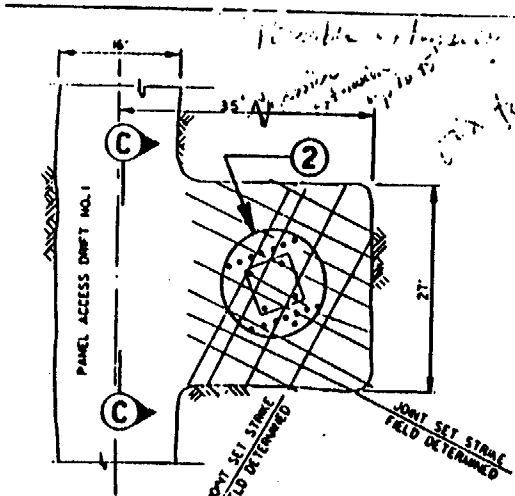
1. The cubic block will be 2 m on a side.

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

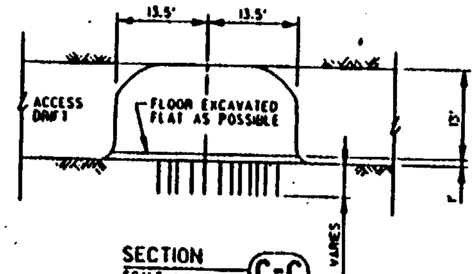
3. The test geometry shown in Figure B-MECH-6-(1) is appropriate for facility design and operational planning.

4. The decision on the final alcove length will be made concurrent with the mining activity as geologic mapping data become available.

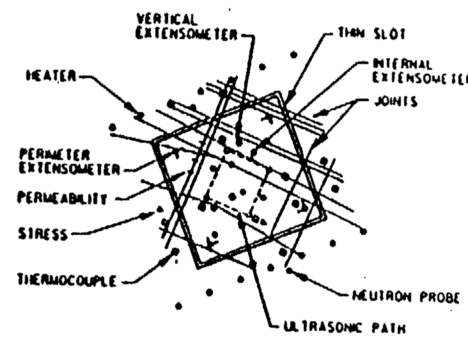
5. A hydrologically and chemical altered region may extend as much as 36 ft (11 m) from the lines of the heaters.



PLAN
SCALE: NONE



SECTION (C-C)
SCALE: NONE



DETAIL (2)
SCALE: NONE

YUCCA MTN. HEATED BLOCK TEST

QUALITY LEVELS OF THE ITEMS OR ACTIVITIES ON THIS DRAWING SHALL BE FOUND IN THE ESF QUALITY ASSURANCE LEVEL ASSIGNMENT SHEETS. (QALAS)

Thermal Stress Test

Definition of Test

The thermal stress test is described in Section 8.3.1.15.1.6.4 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Thermal Stress Test in the Lower DBR.

Performance Criteria

1. The geometry of the test is shown in Figure B-MECH-7-(1).

2. Drilling and coring requirements for instrumentation holes are defined in Appendix C of the ESF SDRD.

3. Insulation will be required as shown in Figure B-MECH-7-(1).

Constraints

1. End-anchored rock bolts will be used to support the roof during implementation of the test.

2. A work platform 8 ft high, with a working area of 30 ft x 45 ft (or a smaller moveable platform) and a capacity of 1500 pounds will be provided for the emplacement of instruments.

3. A structural steel frame may need to be constructed for the operational phase of this experiment. Design details of this equipment have not yet been developed.

4. The test location will be selected after observing rock conditions and joint orientation.

5. No mining will be allowed within a standoff distance of two drift diameters of the drift while the test is in progress.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. The test will be performed in the Lower Demonstration Breakout Room. No additional excavation is required for this test.

2. The test will be conducted in the back. A second test in the rib of the DBR is possible.

3. The test will require portions of a drift to be heated for 3-4 months. Access to the heated area will be required during testing.

4. Insulation will be Johns Manville inorganic high-temperature insulating blanket (temperature limit 700°C), 10 cm thick. The insulation will be applied over the entire region using wire mesh attached to the existing rock bolts.

5. If Prototype testing changes any information for this test, an ECR will be prepared.

6. Thermal alteration of in situ conditions will be confined to the standoff region.

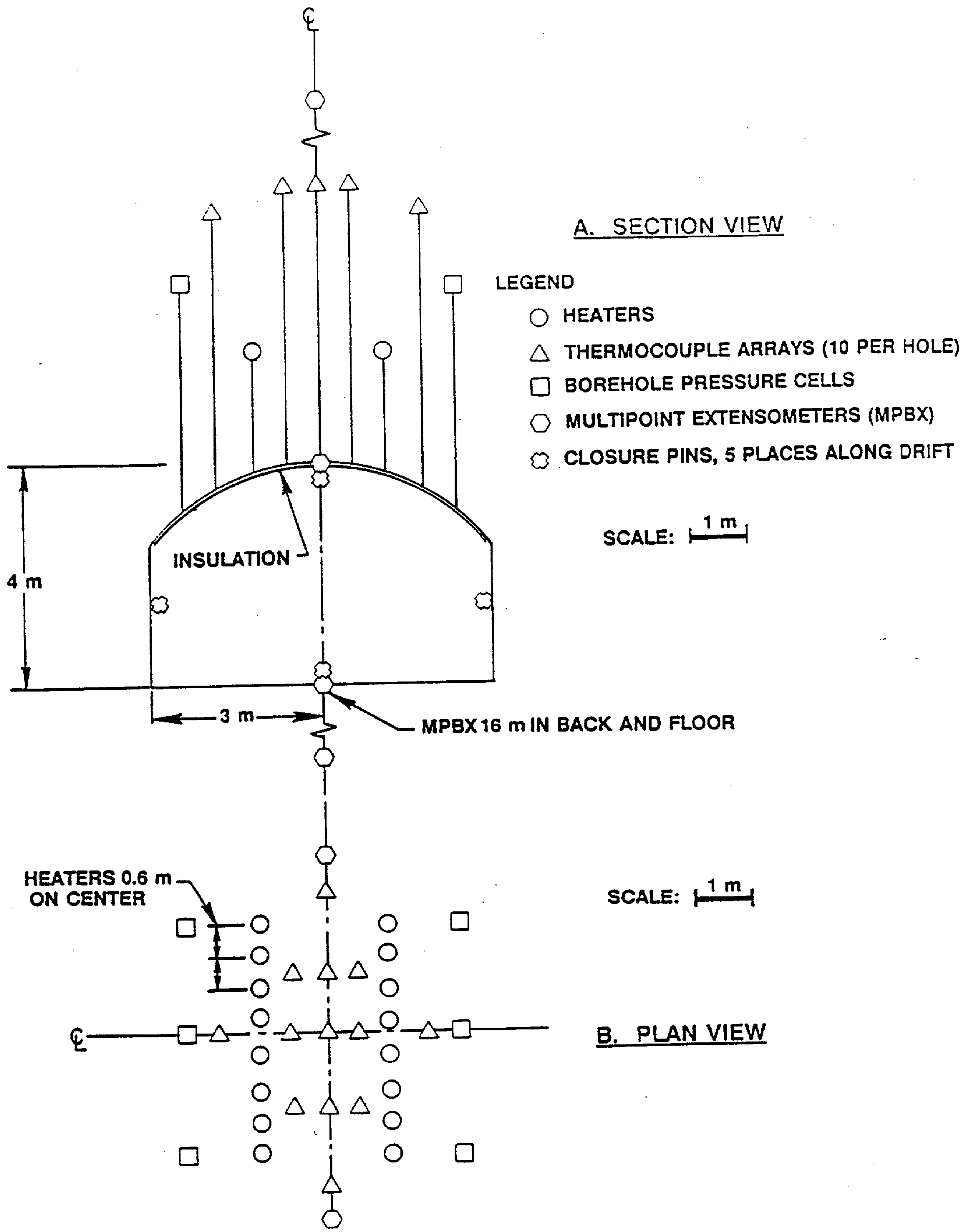


Figure B-MECH-7-(1). Conceptual Design of Prototype Thermal Stress Test

Heated Room Test

Definition of Test

The Heated Room Test is described in Section 8.3.1.15.1.6.5 of the Site Characterization Plan.

Upon completion of the Sequential Drift Mining experiment (SCP 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 repository. The drift will be instrumented to provide data on rock-mass deformation, rib stress change, thermal conductivity, heat capacity and thermal expansion coefficient, ground-support loading and deformation, and an estimate of the region in which the stress state is changed by heating. 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 leasts part of the heated phase.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Heated Room Test.

Performance Criteria

1. The conceptual arrangement of the Heated Room Test is shown in Figure B-MECH-8-(1) with additional detail shown in Figure B-MECH-8-(2). The Heated Room Test will be conducted in the space excavated during the Sequential Drift Mining Test. The exact test layout has not yet been determined. The figures can be used to estimate design and operations flexibility. Updated information will

be added through the Engineering Change Request when it becomes available.

2. The test will require drilling and coring of holes as defined in Appendix C of the ESF SDRD.

3. The heated room (drift) will be isolated by means of a thermal barrier from other ESF areas. Personnel access will require special controls.

Constraints

1. The experiment will be conducted following the Sequential Drift Mining experiment.

2. A thermal barrier will be constructed across the center drift, restricting access to the heated portion.

3. Location may be adjusted within the sequential drift mining test area so geologic conditions are representative of those expected in the repository block.

4. Because of the long test duration, the test should begin as soon as possible.

5. No other test alcoves or test drifts will be planned within a standoff zone 150 ft laterally from the centerline of the center drift and 50 ft longitudinally beyond the ends of the center drift.

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. The Organizational Computer will be in a Bally-type instrumentation building that will be shared by other geomechanics test PIs. This computer will be shared by other (SNL) heater tests.

2. All changes to the natural conditions (thermal, mechanical, chemical alteration) will be confined to the standoff zone. This is based on the assumption that a 50 kW input heater power. If the heater power is increased to accelerate the heating rate, the standoff zone may have to be reevaluated.

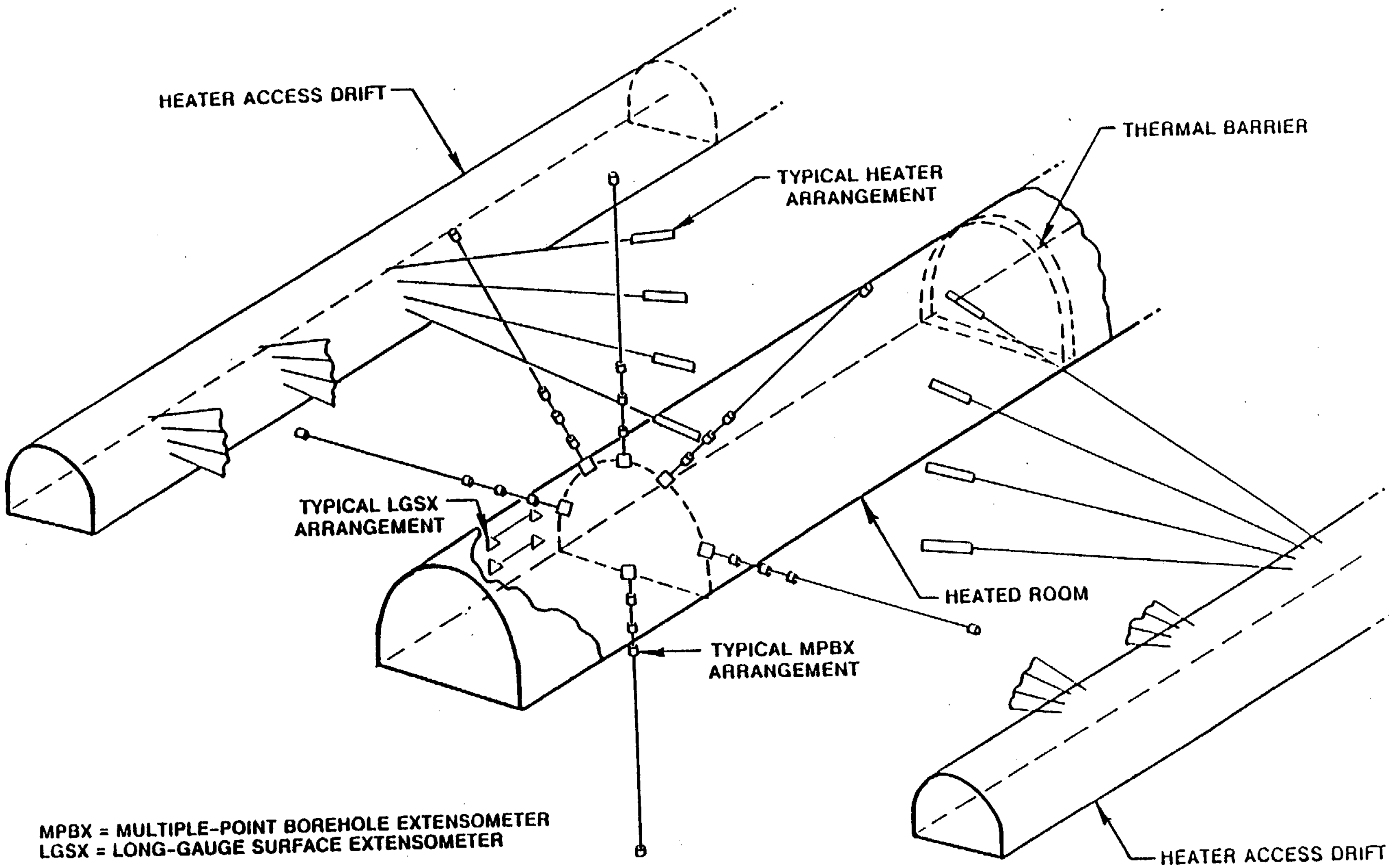
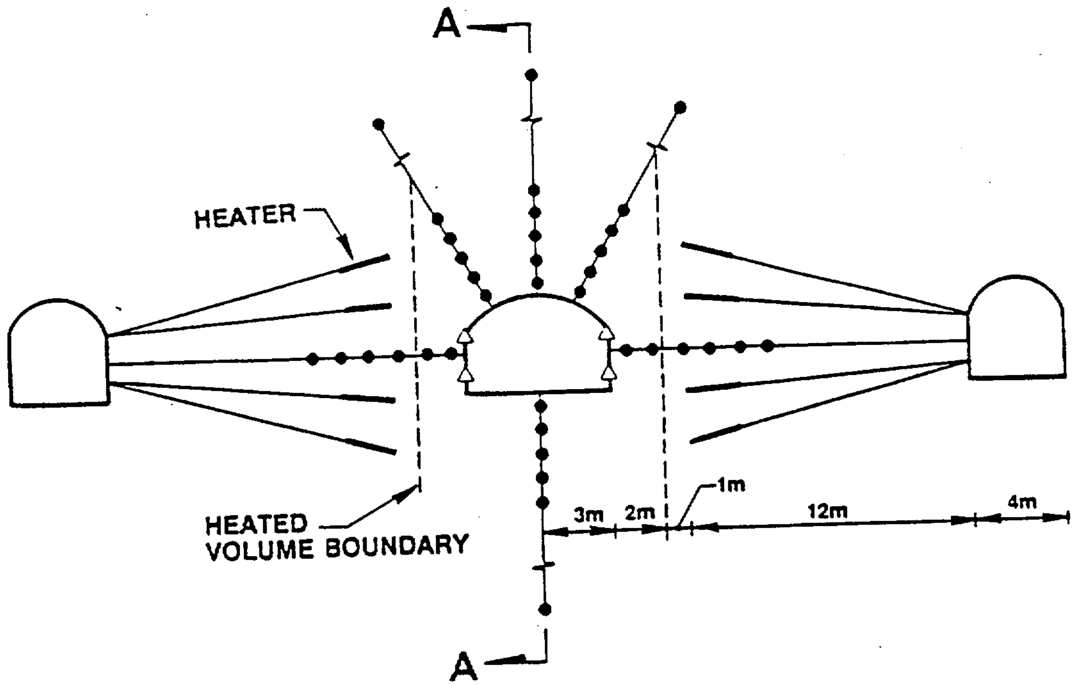
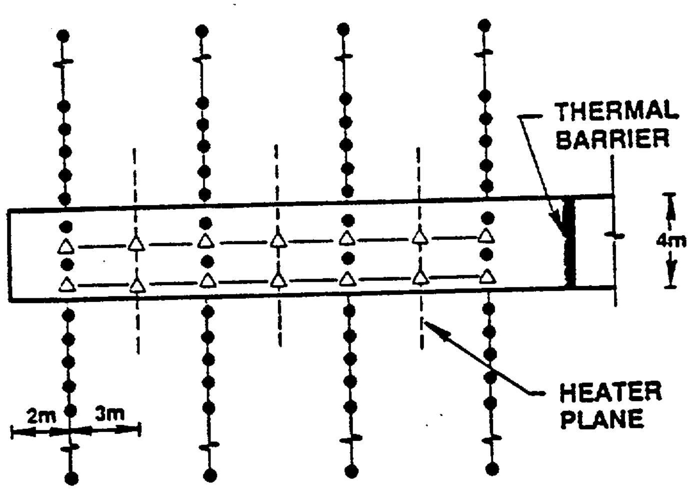


Figure B-MECH-8-(1). Conceptual Arrangement of Heated Room Test





SECTION AA

△ LONG-GAUGE SURFACE EXTENSOMETER PINS

● MULTIPLE-POINT BOREHOLE EXTENSOMETER ANCHORS

NOTE: THERMOCOUPLE AND CROSS-DRIFT CONVERGENCE MEASUREMENT PIN LOCATIONS HAVE BEEN OMITTED FOR SIMPLICITY; BOTH WILL BE USED EXTENSIVELY

Figure B-MECH-8-(2). Heated Room Test Conceptual Instrument Layout

Equipment Development Test

Definition of Test

The Development and demonstration of required equipment activity is described in Section 8.3.2.5.6 of the Site Characterization Plan. This activity is intended to provide prototype development and confirmation testing of specialized equipment needed for the repository construction or operations.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the development and demonstration testing of required equipment.

Performance Criteria

To be determined

Constraints

To be determined

Interface Requirements

To be determined

Assumptions

1. This activity can be conducted in the Demonstration Breakout Rooms or other planned alcoves. Therefore, no additional excavation is required.

2. The equipment used in this activity will be capable of disassembly into pieces small enough to be transported underground and will not create special hoisting system requirements beyond those capabilities already planned for the ESF.

3. Currently planned utility systems for the ESF are adequate to support this activity.

4. Muck generated by the horizontal boring machine can be bagged and removed using already planned equipment.

Plate Loading Test

Definition of Test

The Plate Loading Test is discussed in Section 8.3.1.15.1.7.1 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Plate Loading Test.

Performance Criteria

1. Instrumentation holes will require drilling and coring as defined in Appendix C of the ESF SDRD.

Constraints

1. Surfaces in the vicinity of the tests may require special controlled blasting specifications so they can be relatively free of blast damage.

2. There is no constraint on rock bolting in the roof for this test.
3. This test must be performed in several locations that have not been affected by other testing.

Interface Requirements

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

Section B-IS-1	Integrated Data System
Section B-IS-2	Scientific Manpower/Schedule Information
Section B-IS-3	Laboratory/Office/Storage Space Requirements
Section B-IS-4	Electrical Power Requirements
Section B-IS-5	Water System Requirements
Section B-IS-6	Compressed Air System Requirements
Section B-IS-7	Common Sampling Design Requirements

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

Assumptions

1. No additional excavation will be required as this will be performed in existing drifts.

2. The Plate Loading Test will be performed in approximately 15 locations in the ESF. This will include both demonstration breakout rooms.

3. Each test setup will take a minimum of 15 calendar days to set up and perform at each location, and, during this period, will disrupt drift accessibility. The Los Alamos Test Manager will coordinate schedules with the appropriate construction and operations managers.

4. The geometry of a typical test assembly is shown in Figure B-MECH-10(1).

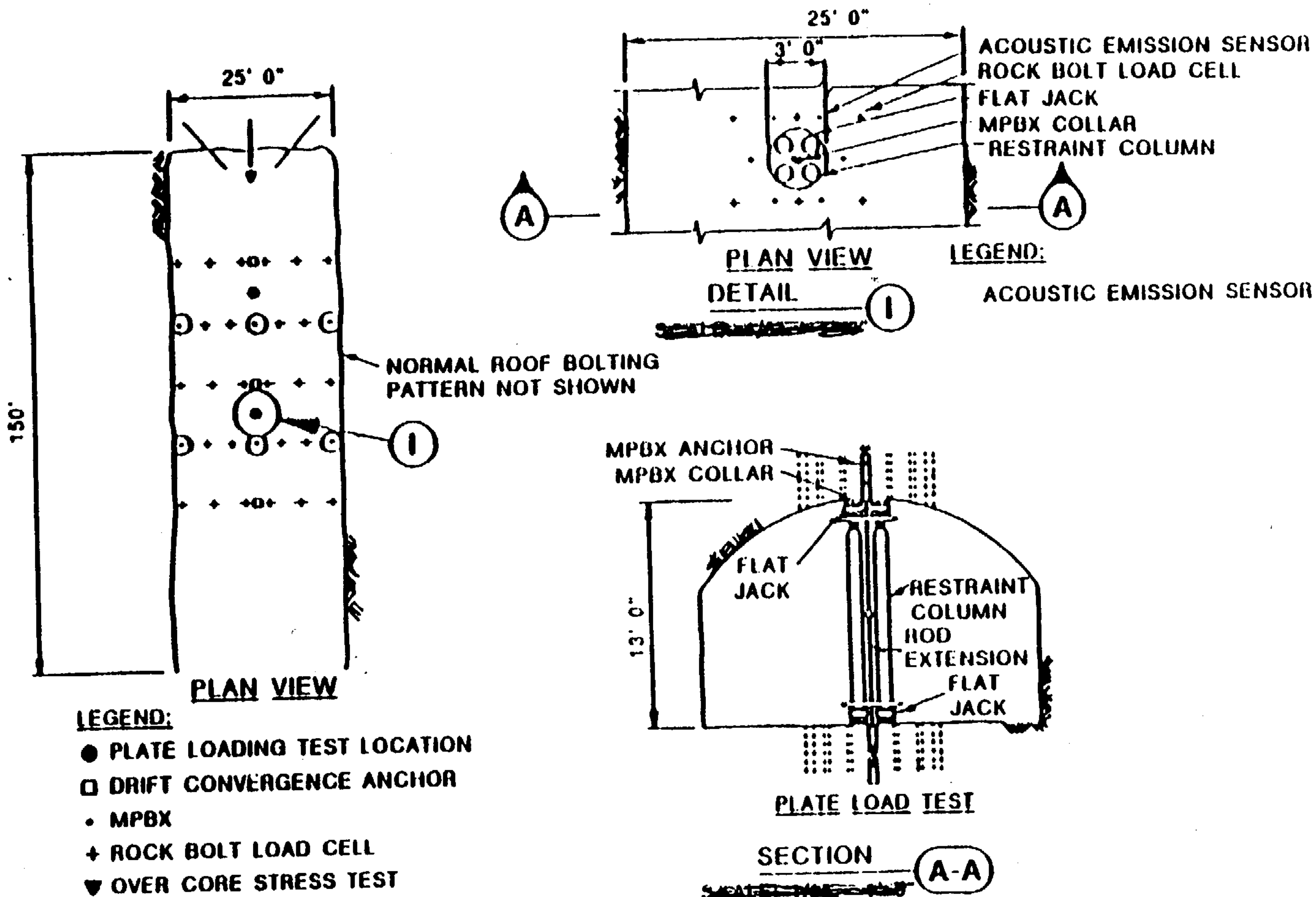


PLATE LOADING TEST LOCATIONS IN DEMONSTRATION BREAKOUT ROOM

SCALE: NONE

B-MEGil-10-(1)

Figure ~~6.4.2.15~~. Design of the plate loading test

B-MEGil-10-(1)

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 Plan.

Functional Requirements

1. The functional requirement is to provide the facility design and operational flexibility to perform the Rock Mass Response Test.

Performance Criteria

1. The test will require drilling and coring as defined in Appendix C of the ESF SDRD.

2. The in situ joint shear response portion of the experiment requires excavation of a "test pit" (about 1.5 m long x 1 m wide x 1.1 m deep) as shown in Figure B-MECH-11-(1) and B-MECH-11-(2).

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Constraint

1. Protection will be required from the high-pressure hydraulics used in this test, possibly in the form of safety barriers.

2. This test must be performed in a location that has not been affected by other testing.

Assumptions

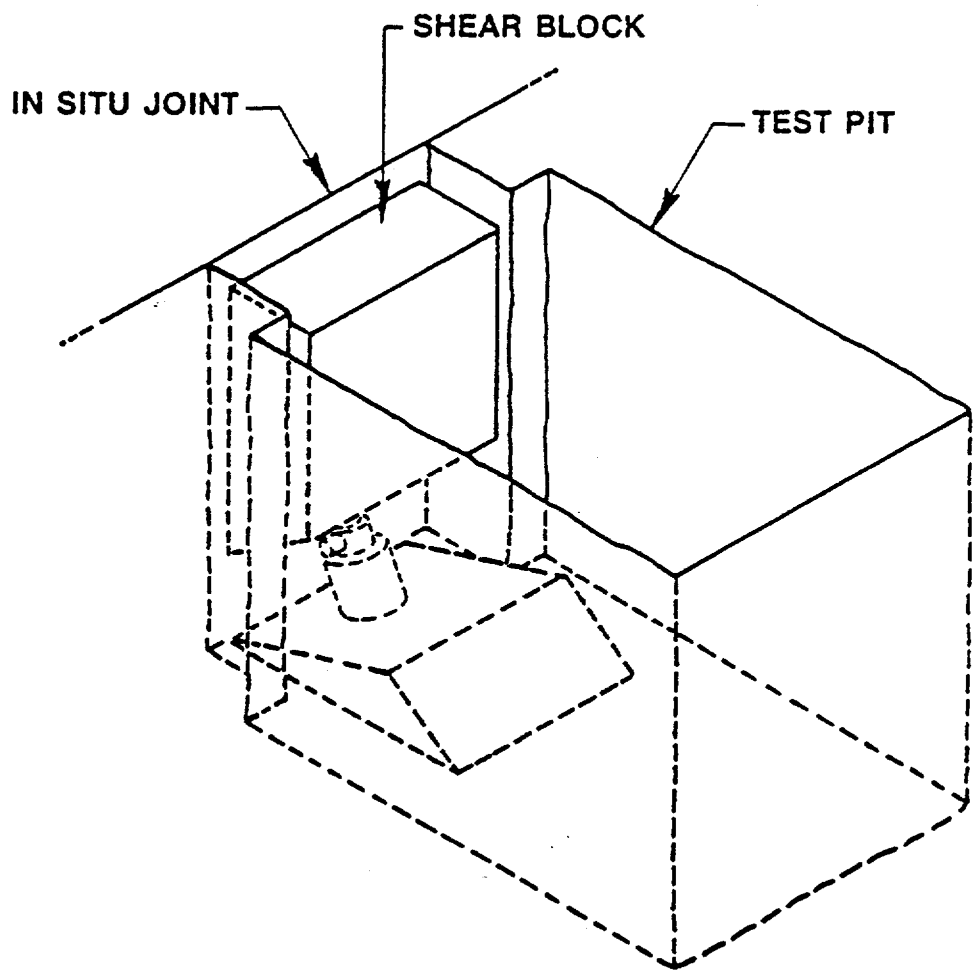
1. The location for this test will be determined after mapping data are available. Up to five locations are planned for this test; however, the assumption is that this test will be performed in the DBR at the Main Test level and in other existing drifts or alcoves.

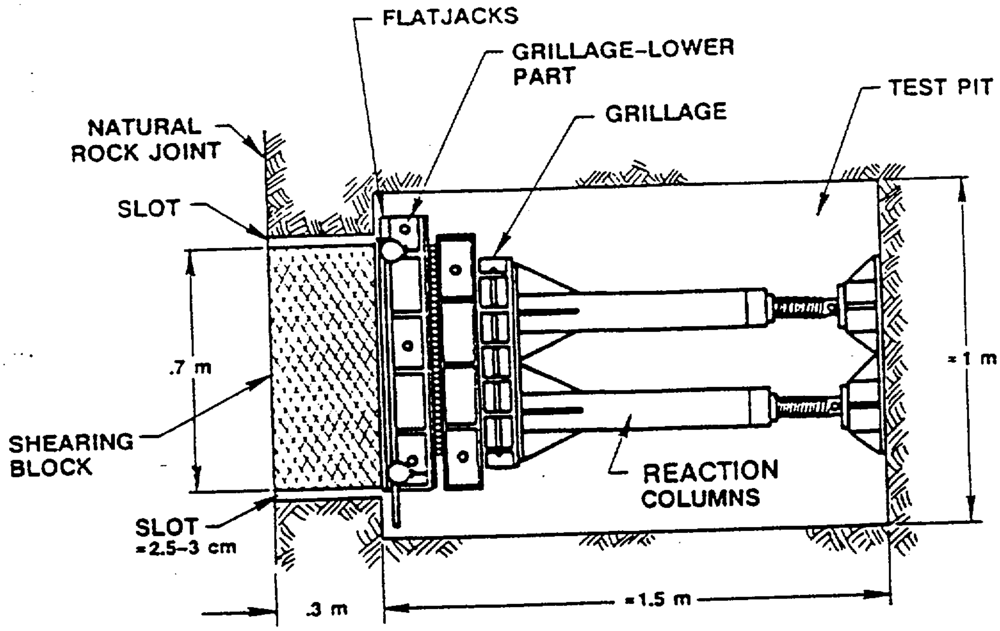
2. The "test pit" and shear block will be delineated using the hydraulic chain saws provided by the test organization. Following the cutting of the slots, the material will be excavated using mechanical means.

3. The prism of rock for the compressive strength portion will be delineated using the hydraulic chain saws provided by the test organization.

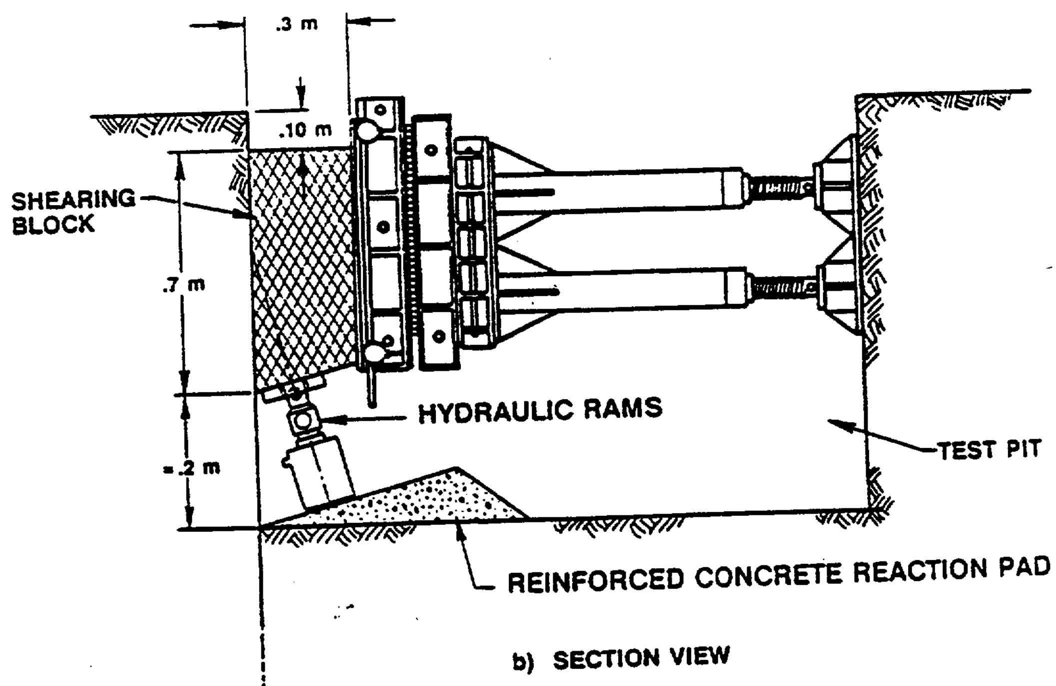
4. Concrete designs for the reaction pads are to be provided by SNL and are not a part of the facility design.

5. Test equipment and instrumentation shown in Figures B-MECH-11-(1-3) will be designed and provided by the test organization. Construction of the test reaction frames will be done by the test organization.


SHEAR BLOCK
IN SITU JOINT
TEST PIT

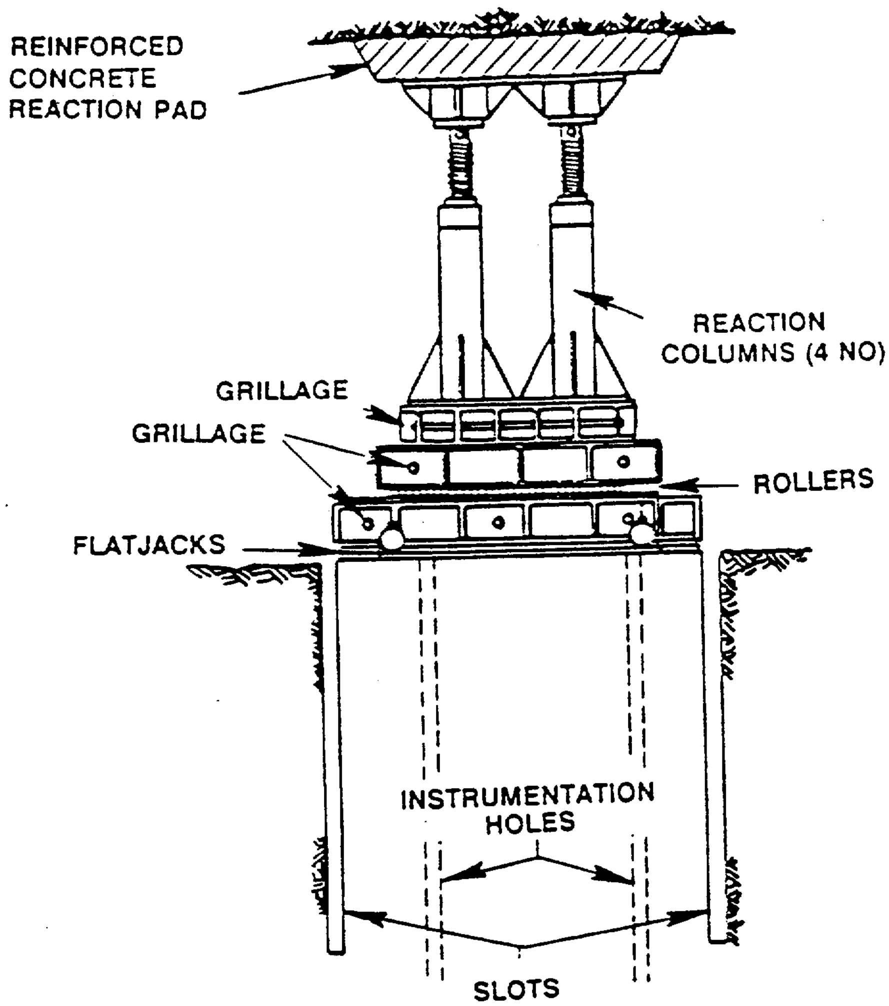


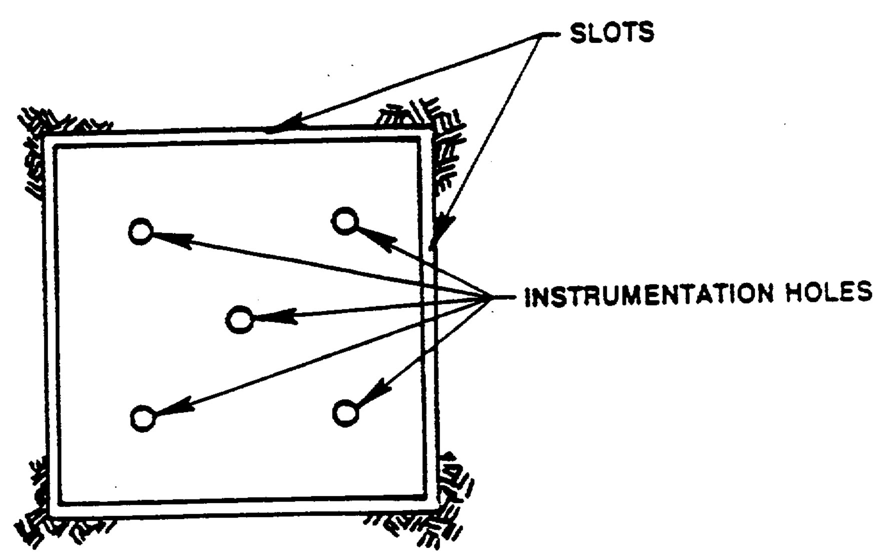
a) PLAN VIEW



b) SECTION VIEW

(a) Conceptual Layout of Equipment for the In Situ Joint Shear Response Test-Plan View, (b) Section View


REINFORCED
CONCRETE
REACTION PAD
REACTION
COLUMNS (4 NO)
GRILLAGE
GRILLAGE
ROLLERS
FLATJACKS
INSTRUMENTATION
HOLES
SLOTS


SLOTS
INSTRUMENTATION HOLES

Evaluation of Mining Methods Test

Definition of Test

The Evaluation of Mining Methods Test is described in Section 8.3.1.15.1.8.1 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Evaluation of Mining Methods.

Performance Criteria

1. This test will be conducted in conjunction with the excavation of the ESF as shown in Appendix A of the ESF SDRD.

Constraints

1. It is expected that data will be collected on the response of the rock containing different lithophysal abundances or structural characteristics.

2. Mining in the repository-scale sections of the long drifts will be directed by the PI in conjunction with the constructor and the A/E. Mining procedures (blast patterns, loadings, depths, timing, etc.) will be varied to determine the sensitivity of the rock to these parameters and to optimize results.

3. Several rounds in the repository-scale sections of the long drifts will be detonated in segments. For planning purposes, estimate six rounds.

4. Some or all of the rounds in the long drifts will be instrumented to obtain peak particle velocities. Use of this technique is contingent on its demonstrated usefulness in prior tests (Demonstration Breakout Rooms and Sequential Drift Mining).

5. Photographs will be taken of the various stages of mining in the repository-scale sections of the long drifts.

6. This test imposes no additional requirements or restrictions on mining in the shafts and the main test level beyond those given in Interface Requirement #3.

Interface Requirements

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

Section B-IS-1	Integrated Data System
Section B-IS-2	Scientific Manpower/Schedule Information
Section B-IS-3	Laboratory/Office/Storage Space Requirements
Section B-IS-4	Electrical Power Requirements
Section B-IS-5	Water System Requirements
Section B-IS-6	Compressed Air System Requirements
Section B-IS-7	Common Sampling Design Requirements

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

3. All logs and records related to mining in the shafts and the long drifts kept by the mining superintendent will be supplied to the PI on a timely basis. Records should include types and performance of equipment, blast patterns (including drill-hole locations, diameters, depths, angles, and deviations of the drilled pattern from design specifications), explosives and detonators used (including types, quantities, configurations, methods of placement, and delay sequencing and timing), cycle times (by activity), quantities of water used, and difficulties or anomalies encountered.

Assumptions

1. The normal excavation procedure and results will be studied and selected blast rounds in the long drifts may be modified to emplace instrumentation or to evaluate variation of blasting detail specifications.

2. No special utility requirements exist for this test.

3. The PI will observe and record the activities associated with excavating the long drifts.

Ground Support Test

Definition of Test

The monitoring of ground-support systems is described in Section 8.3.1.15.1.8.2 of the Site Characterization Plan. This test will monitor the selection, installation and response of ground support systems. Ground support performance and responses will be evaluated with the goal of developing ground control methodologies for the repository.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Ground Support Test.

Performance Criteria

1. The geometry of the drifts shown in Appendix A will provide adequate flexibility to implement this test.

Constraints

1. Selected rock bolts in the repository-scale sections of the long drifts will be instrumented for load measurements. Location will depend on ground conditions. It is estimated that 24 rock bolts will be instrumented.

2. Approximately 12 rock bolts in the long drifts will be pull-tested. Exact locations will depend on ground conditions. Extra bolts, in addition to those required for safety, will be installed for this purpose.

3. Where shotcrete is used, cores will be taken for laboratory testing of strength and bonding to the rock (on the order of 15 cores).

4. For each location where steel sets are used, two will be instrumented with load cells.

5. The PI will observe and record the processes of selection and installation of ground supports throughout the long drifts.

6. The PI will be informed of all work performed to maintain the openings and supports.

Assumptions

1. Formal observation and evaluations of the support selection method, support installation procedures, and support performance will be limited to the long drifts. The requirement to inform the PI of maintenance performed on openings and supports applies to the entire ESF.

Monitoring of Drift Stability Test

Definition of Test

The Monitoring Drift Stability Test is discussed in Section 8.3.1.15.1.8.3 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Monitoring of Drift Stability Test.

Performance Criteria

1. Borehole extensometers will be installed in the repository-sized sections of the long exploration drifts. A typical installation for MPBX instruments is shown in Figure B-MECH-14(1).

2. Drilling requirements for this test are defined in Appendix C of the ESF SDRD.

3. Monitoring of cross-drift convergence and borehole extensometers will continue beyond site characterization to help predict long-term stability.

4. Anchors for measuring cross-drift convergence with tape extensometers will be installed at approximately 35 locations as shown in Figure B-MECH-14-(2).

5. Seven measurement stations will contain four multiple-point borehole extensometers configured orthogonally. These stations will be in the enlarged sections of the long drifts.

6. Seven MPBXs will be installed at the intersection of the long drifts as shown in Figure B-MECH-14-(3).

Constraints

1. Tape extensometers will be used to measure convergence across the drift horizontally and vertically at each measurement station including those containing multiple-point borehole extensometers.

2. Field observations of ground conditions will be necessary before final locations of measurement stations can be specified.

3. The design of service hardware in the drifts (such as ventilation ducts, cable trays, etc.) must accommodate these measurements.

4. MPBXs and tape extensometer anchors will be installed no greater than 1 m from advancing faces.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements

Section B-IS-5 Water System Requirements
Section B-IS-6 Compressed Air System Requirements
Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

None

Intact Fracture Test

Definition of Test

The Intact Fracture Test in the Exploratory Shaft Facility is discussed in Section 8.3.1.2.2.4.1 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Intact Fracture Test.

Performance Criteria

1. Drilling requirements for this test are defined in Appendix C of the ESF SDRD.

2. Sample locations will be chosen by the PI after mapping information is available.

3. The general test sample collection geometry for fractures oriented perpendicular to the core axis (radial fractures) is shown in F&S drawing FS-GA-0163 Rev. B (Figure B-HYD-2-(1)). The sample collection geometry for fractures oriented parallel to the core axis (axial fractures) is shown in Figure B-HYD-2-(2).

Constraints

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

2. The pilot hole will be drilled about 15 cm beyond the fracture.

3. Samples will be taken from the shaft wall before the wall is covered by the shaft liner; and collected from the lower main test level.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. Twelve radial fracture samples and twelve axial fracture samples from each of four general areas will be prepared. The four units to be sampled are the Tiva Canyon, Pah Canyon, Topopah Spring members of the Paintbrush Stratigraphic unit, and in the Calico Hills stratigraphic unit.

2. Details of the sample preparation and removal are being investigated and verified as part of the prototype testing.

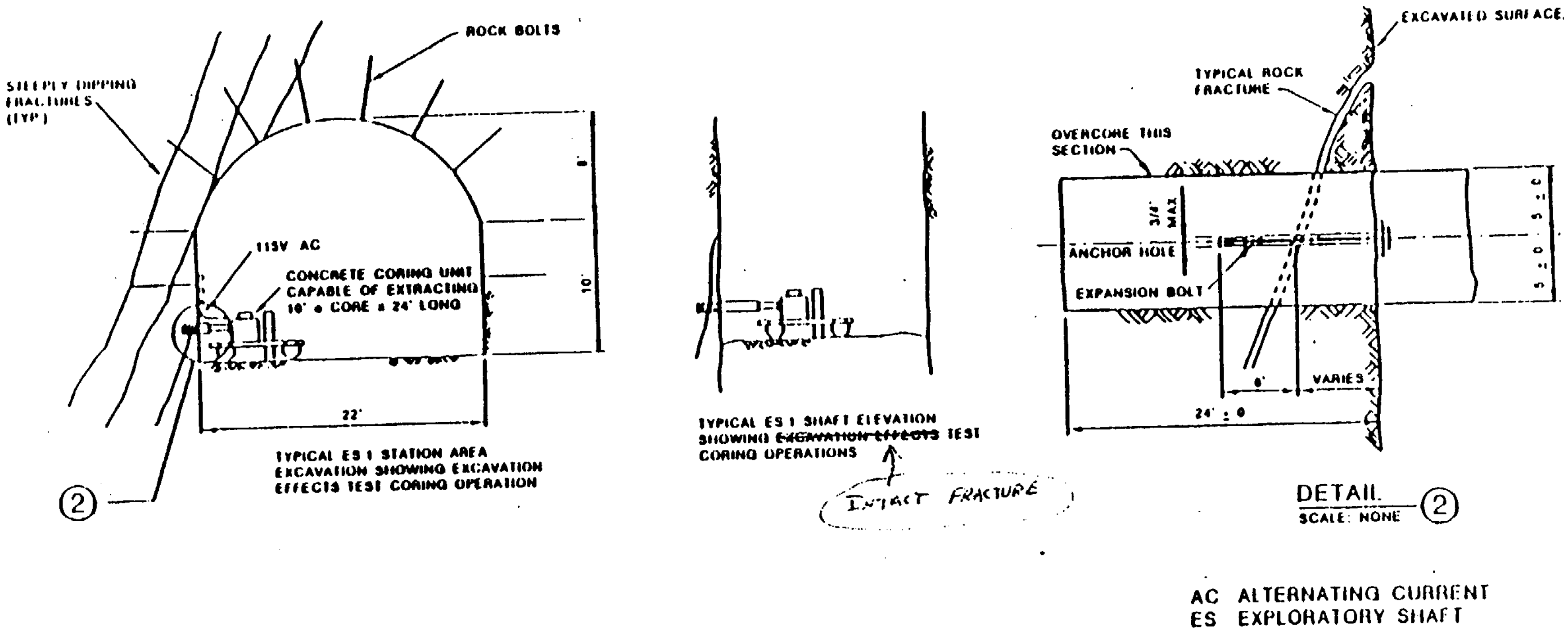
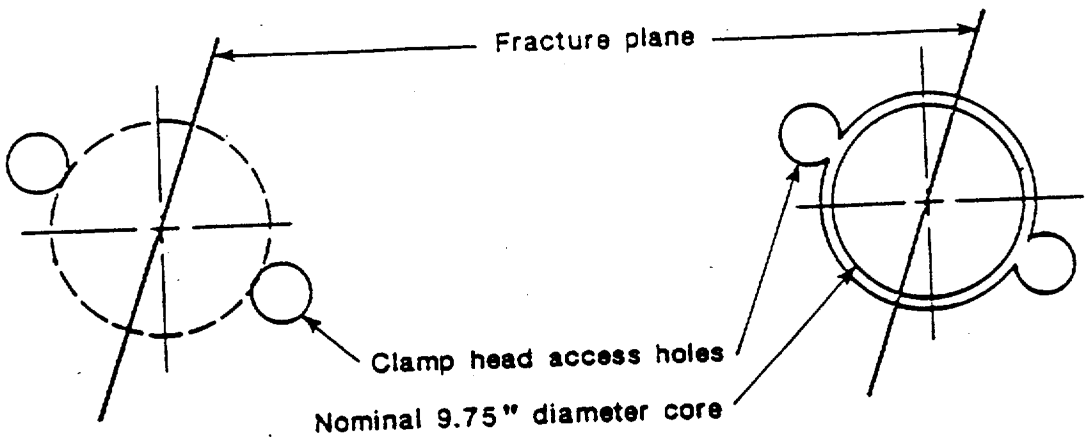
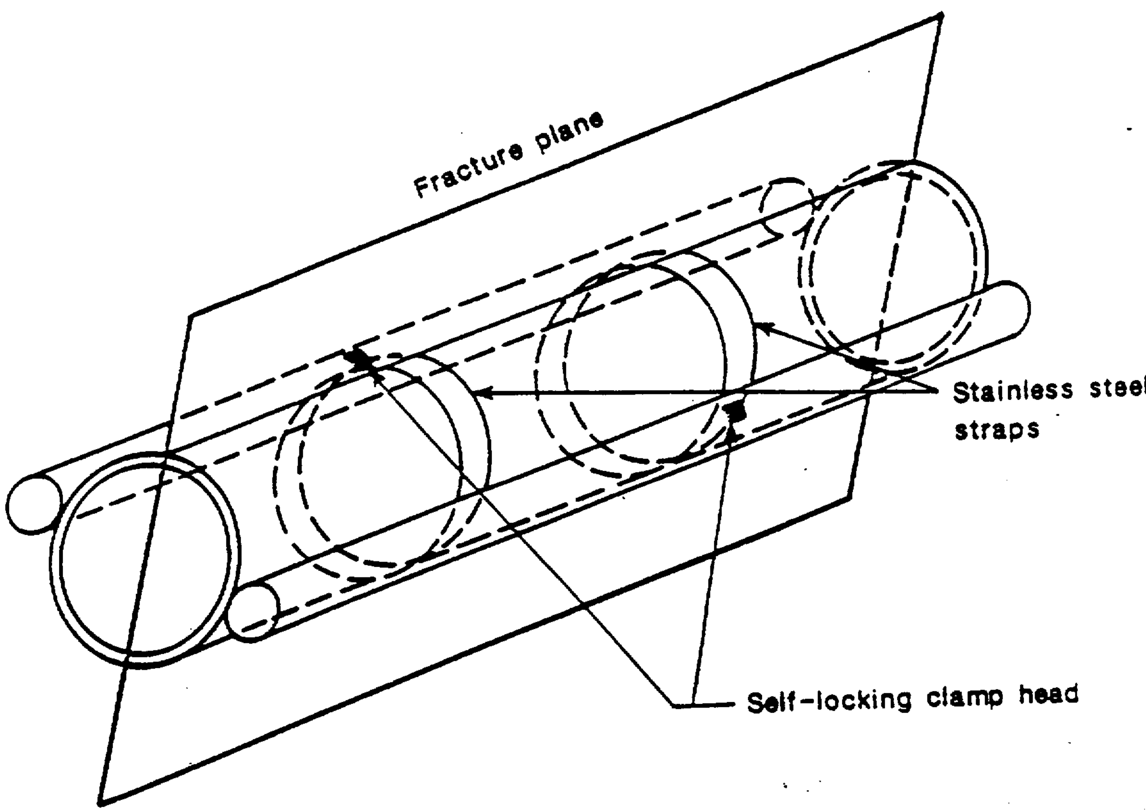


Figure 8.4.2-16. Intact fracture test arrangement - typical (from Title I 100 percent design).



Fracture plane
Clamp head access holes
Nominal 9.75" diameter core



Fracture plane
Stainless steel straps
Self-locking clamp head

Percolation Test

Definition of Test

The Infiltration Test in the Exploratory Shaft Facility is discussed in Section 8.3.1.2.2.4.2 of the Site Characterization Plan. Excavate two parallel drifts, exposing a pillar of welded tuff. Expose all six faces of the Welded Tuff sample by removing slabs of rock from the pillar between the drifts using a diamond wire saw. As each face of the sample is exposed, map fractures and attach an infiltrometer and an effluent collection system. The four veritcal faces will be sealed and supported after instruments are attached.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Infiltration Test.

Performance Criteria

1. Two parallel drifts will be excavated as part of the MTL development. Access will be from a "main test drift" (such as the Service Drift No. 4 shown in F&S Title I Drawing FS-GA-160 Rev B) The test geometry is shown in Figure B-HYD-3-(1).

2. A support system consisting of plates and long bolts will be required to clamp the test block together (Details are still TBD). Also, jacks and a steel framework will be required to support the block.

3. Drilling and coring requirements are defined in Appendix C of the ESF SDRD.

4. 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 (see Figure B-HYD-3-(2)).

Constraints

1. Flexibility in locating the block to be excavated is required because of the need for a dense fracture spacing in the block.

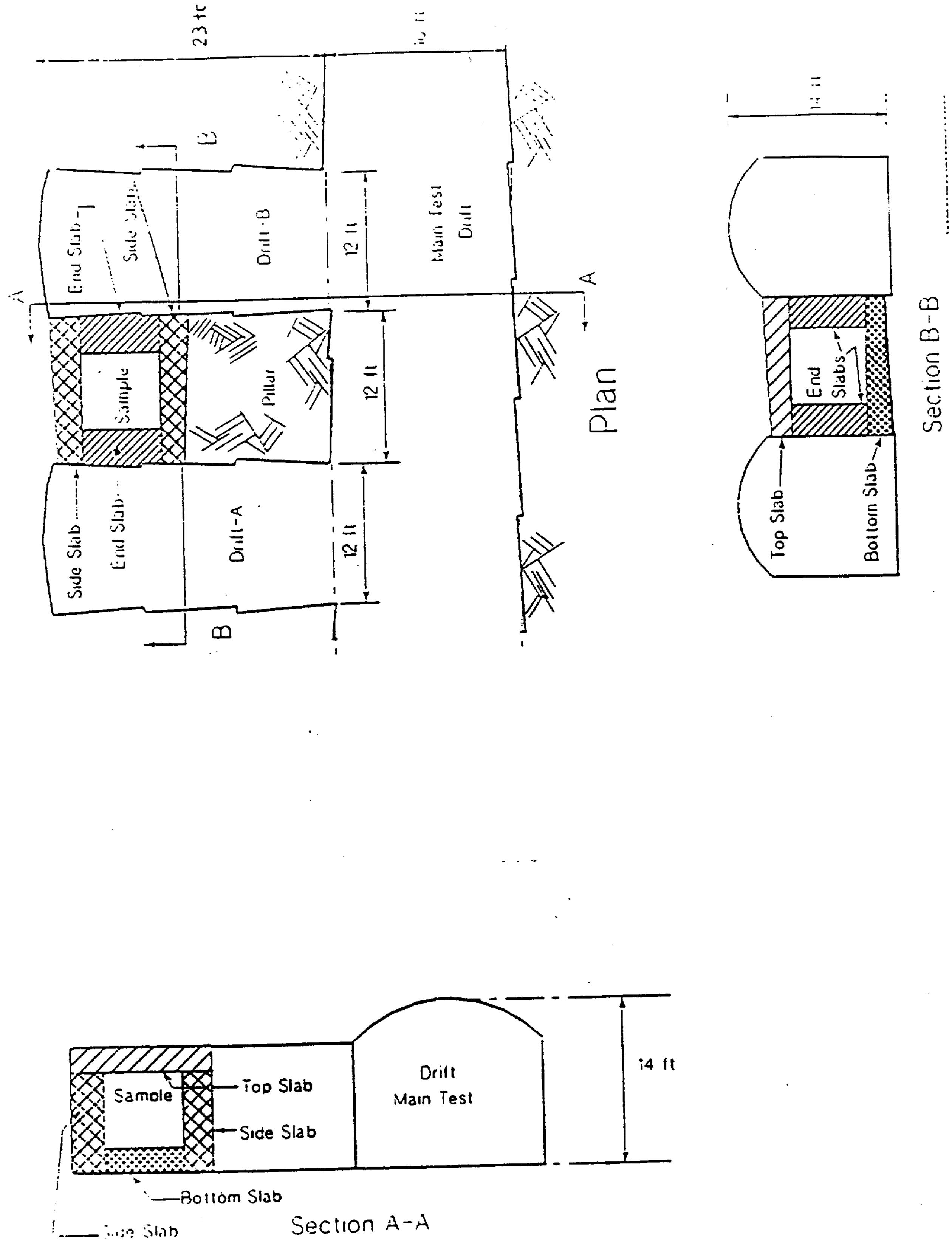
2. Special controlled blasting may be used for all infiltration test drift excavation (Drifts A & B of Figure B-HYD-3(1)).

Assumptions

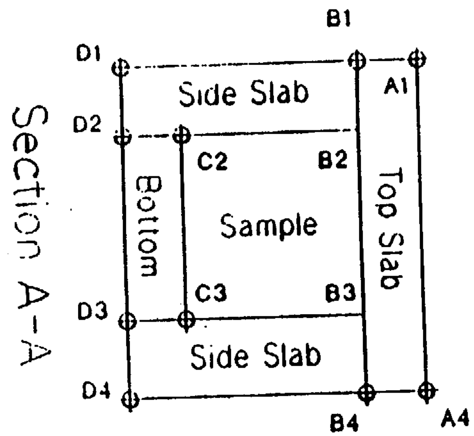
1. Wire saw cuts will use water to cool the wire and remove cuttings while controlling dust.

2. Jack hammers will be used to break the slabs for removal.

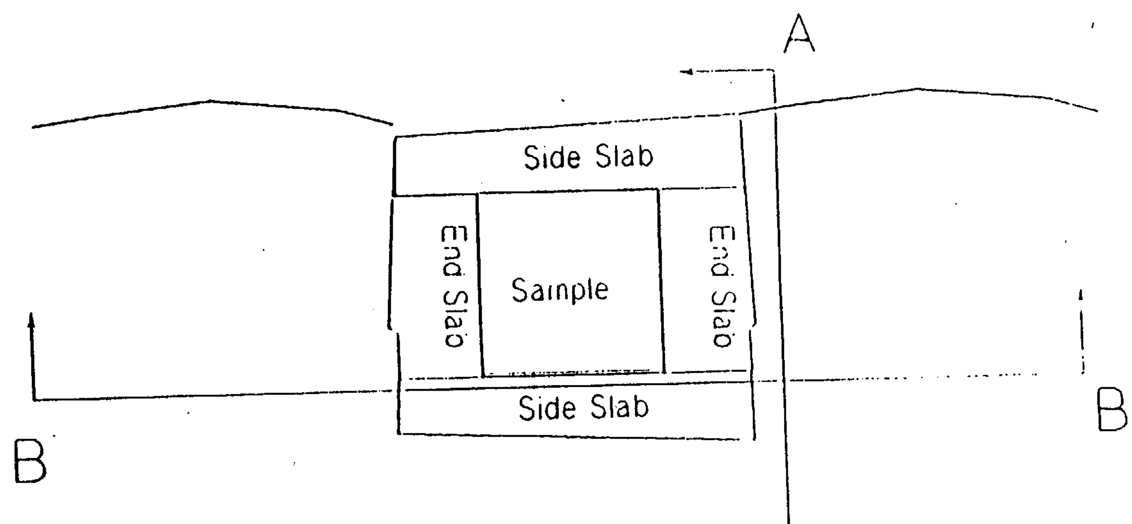
3. A schematic showing sampling/instrument holes is given in Figure B-HYD-3-(3).


23 ft
B
End Slab
Side Slab
Drift-B
12 ft
Main Test
Drift
A
Sample
Pillar
12 ft
Side Slab
End Slab
Drift-A
12 ft
B
Plan
14 ft
End
Slabs
Top Slab
Bottom Slab
Section B-B
Sample
Top Slab
Side Slab
Bottom Slab
Drift
Main Test
14 ft
Section A-A

~~Figure 28~~

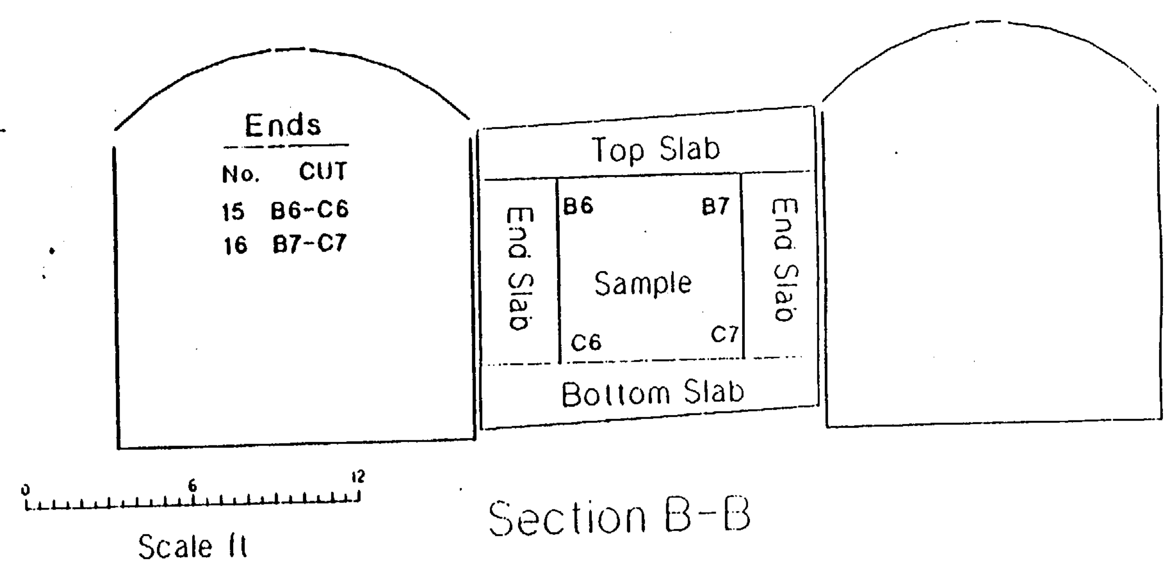


Section A-A



Plan

Bottom		Top		Sides	
No.	CUT	No.	CUT	No.	CUT
1	C2-C3	5	A1-A4	9	B3-C3
2	D2-D3	6	A1-B1	10	B2-C2
3	C2-D2	7	A4-B4	11	D1-D2
4	C3-D3	8	B1-B4	12	D3-D4
				13	B4-D4
				14	B1-D1



Section B-B

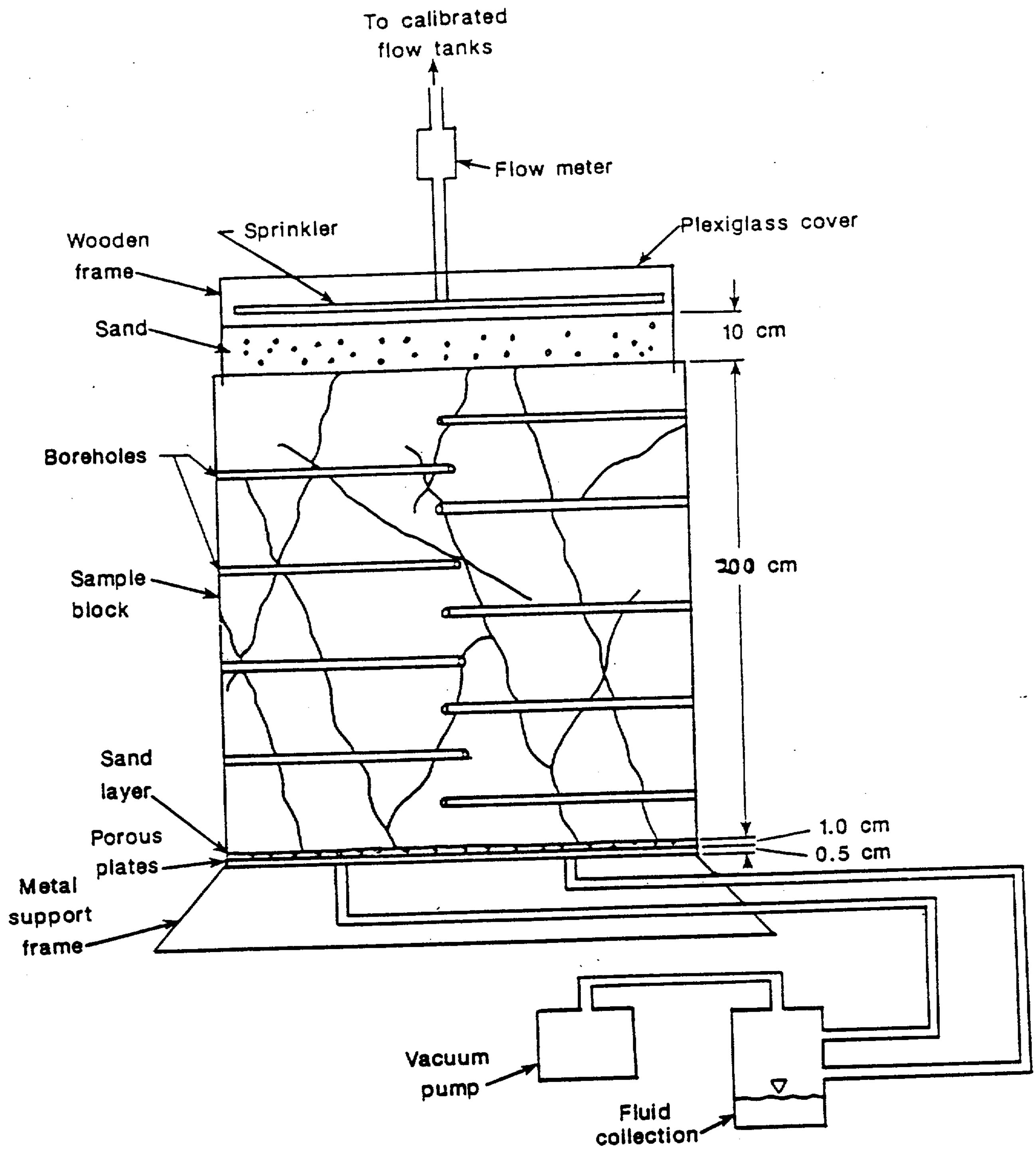


Figure 1. Schematic diagram of experimental block.

Bulk Permeability Test

Definition of Test

The Bulk Permeability Test is defined in Section 8.3.1.2.2.4.3 of the Site Characterization Plan. The test will measure the permeability of a large rock mass using cross-hole testing methods.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Bulk Permeability Test.

Performance Criteria

1. This test will require air-cored holes as defined in Appendix C of the ESF SDRD.

2. A total of four tests are planned. No drifts, alcoves or effects of other tests can be present within 50 ft of any test hole on the test side of a plane passing through the collar and normal to the center test hole. (Openings can be developed in this region after the test is complete.)

Constraints

1. Each test location will require an IDS alcove that can accommodate a Data Acquisition Station (DAS) as defined in the requirements for the IDS, (B-IS-1).

2. The DAS shall be located reasonably close to the Bulk Permeability Test holes. A distance of 50 ft or less of instrumentation lead is required.

3. The Apex holes (see Assumption 3) will be cored first followed by testing. The center hole will then be cored and tested in 2-ft increments for a total of about 150 ft. Packers will be used to isolate and pressurize zones in the holes.

4. The location of the test should be such that control panels (2 ft wide x 3 ft high x 1 ft deep) can be mounted on the rib without interfering with traffic. Test equipment for calibration, nitrogen gas bottles, etc., will be in the drift during testing. This equipment will need protection during the test from traffic.

5. Flexibility in locating and orienting the test holes is important because fracture geometry and orientation relative to the test holes are important.

6. The test holes that extend outside of the dedicated ESF test area must be coordinated with repository design and performance assessment/sealing requirements.

7. A zone of influence extends out to approximately 150 ft longitudinally and 100 ft radially from the test hole array.

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

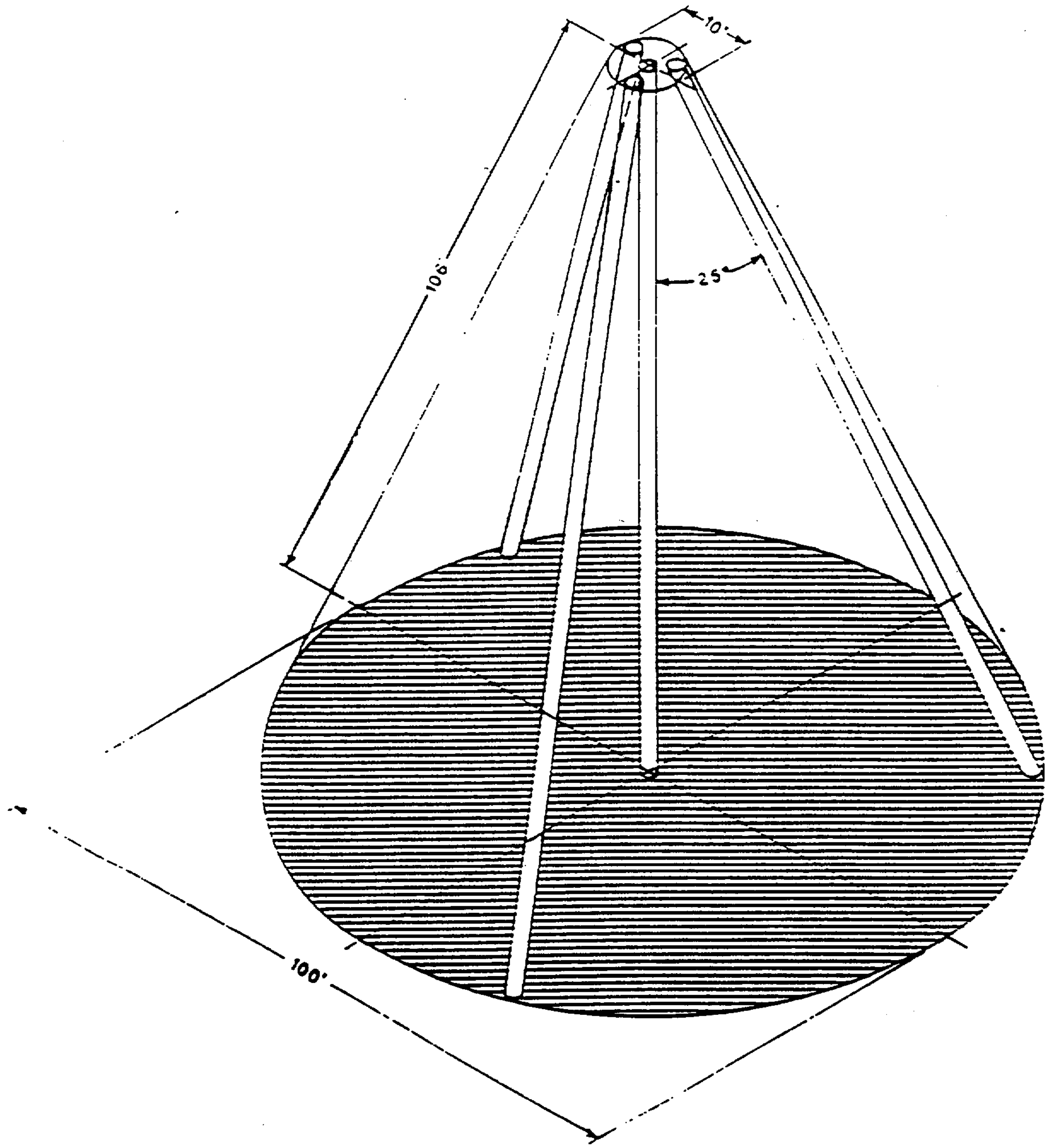
2. Detailed interface requirements will be identified and documented through the normal ICWG process.

Assumptions

1. The testing duration for each test is three months.

2. Four test holes required for each of the four tests are about 40 m long in a face-centered triangular frustum array with the apexes of the triangle 10 ft (minimum) apart at the rib or face of the drift (see Figure B-HYD-4-(1)). The three corner (apex) holes will diverge from the center hole by about 25 degrees.

3. Test locations for the first two tests will be in the ends of access drifts in the core area. The location of the other two test areas will be determined later. They will probably be somewhere in the long drifts and after all drift construction is complete.



Bulk-K Frustum Borehole Configuration

Radial Borehole Tests

Definition of Test

The Radial Borehole Tests are defined in Section 8.3.1.2.2.4.4 of the Site Characterization Plan. There will be 13 depths in ES-1 where this test will be conducted.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Radial Borehole Tests.

Performance Criteria

1. Short Radial boreholes (SRB)

1a. There will be seven depths in ES-1 where short radial borehole (SRB) tests will be conducted this test will be conducted. These depths are shown in Figure B-HYD-5-(1).

SRB #1	will be about 15 ft below the collar elevation.
SRBs #2 and #3	will straddle the contacts between the Tiva Canyon Member and the Yucca Mountain Member. The depth will be determined by the location of the contact in ES-1. Actual drill locations are planned to be within 10 ft of each side of the contact.
SRBs #4 and #5	will straddle the contact between the Pah Canyon Member and the Topopah Spring Member. These also are planned to be within 10 ft of the contact.

SRB #6 will be in the high lithophysal region of the Topopah Spring Member and above the Upper Demonstration Breakout Room.

SRB #7 will be in typical Topopah Spring Member welded rock below the Upper Demonstration Breakout Room.

SRB #8 will be below the Main Test Level breakout.

1b. The additional tests below SRB #8 that are defined in the SCP will be added if the ESF option to penetrate the Calico Hills is exercised.

1c. Two holes will be air cored at each station at right angles to each other. The azimuthal orientation of the holes will be based on fracture patterns observed during shaft mapping as explained in the SCP. The facility design should allow the flexibility for this azimuthal uncertainty.

1d. These holes will be a minimum of 30 ft long. Appendix C of the ESF SDRD defines the specifications for these holes.

1e. The facility design and operational constraints shall allow rework of these holes to replace faulty packers, and access to these holes to repair and calibrate instrumentation, handle the nitrogen gas bottles and associated hardware for trouble shooting and testing for both the SRB instrumentation and the DAS for IDS.

1f. Except for SRB #1 each SRB test location will require a space for a Data Acquisition Station (DAS) with data and power cabling as indicated in figure B-HYD-5-1-(1). For SRB #1 a surface-located DAS is required near the collar.

1g. An enclosed workspace (cutout) in the shaft wall, 3 ft H x 4 ft W X 2 ft D, should be provided between the SRB location and the DAS for equipment such as power supplies and nitrogen handling equipment used by the test organization.

1h. The ability to periodically access the SRB holes should be maintained for the entire duration of site characterization.

2. Long Radial Boreholes (LRB)

2a. Six sets of long lateral boreholes are planned for exploratory-shaft facility (Figure B-HYD-5-(2)). Each set of boreholes would contain a minimum of two and a maximum of four horizontal, long boreholes. These boreholes would be drilled with air near the center of the following geohydrologic units and subunits: (1) Tiva Canyon densely welded unit (LRB #1); (2) Paintbrush bedded and nonwelded tuffs (LRB #2); (3) upper, lithophysae-poor section of the Topopah Spring densely welded unit (LRB #3); (4) upper, litophysae-rich section of the Topopah Spring densely welded unit at the upper-demonstration breakout room (LRB #4); (5) lower, lithophysae-poor section of the Topopah Spring densely welded unit (LRB #5); and (6) lower, lithophysae-rich section of the Topopah Spring densely welded unit above the main test level (LRB #6). The long-lateral boreholes would be drilled from a small alcove off the shaft with the exception of Set 4, which could be drilled from the upper demonstration breakout room.

2b. The addition of long boreholes to the radial-boreholes test would provide access to greater volumes of rock for pneumatic testing purposes throughout the life of the site-characterization program. Testing large volumes of rock would allow for the determination of averaged gas permeability and storage properties of the medium. Also, far-field effects of shaft excavation and venting on pneumatic permeability and storage could be characterized. These holes would be dedicated to activities that do not require permanently stemmed boreholes, thus they could be utilized for no-destructive testing such as cross-hole pneumatic testing, vertical-gas permeability determinations from barometric-pressure monitoring.

2c. Six sets of long lateral boreholes will be drilled in the center of six different geohydrologic units or subunits penetrated by the shaft (as shown in Figure 2). Each set of holes will be drilled from a drilling alcove located adjacent to the shaft (as shown in Figure 5). A minimum of two and maximum of four long boreholes will make up each set. Two of the boreholes will be drilled horizontally in a southeast direction beyond USW MP-1 which will bisect the angle formed by the two long boreholes. USW MP-1 is discussed in Section B-MPBH-1 of Appendix B of the ESF SDRD. These holes will extend beyond USW MP-1 into the formation by 15 to 18 m (50 to 60 ft). It is anticipated that MP-1 will be 15 to 18 m (50 to 60 ft) from the wall of ES-1 and will be drilled from land surface (a vertical hole) prior to the start of the shaft. The remaining two boreholes of a given set will be optional and will be drilled only if the third optional multipurpose borehole is drilled midway between ES-1 and ES-2. Once again, these long boreholes will extend beyond the third multipurpose borehole, and the angle between the boreholes will be bisected by the third multipurpose borehole, similar to the plan shown in Figure 5.

2d. The borehole configuration described above will provide an opportunity to perform cross-hole pneumatic tests between USW MP-1 and the long boreholes. Divergence of the long holes from the drilling alcoves allows various scales and thus volumes of rock to be tested. Inclusion of the vertical borehole USW MP-1 in the test creates a truly three-dimensional well-test configuration. This is highly desirable for permeability anisotropy characterization.

2e. Like the short boreholes, the long boreholes also will be cored using air as the drilling medium to provide bit cooling and removal of cuttings. Drill hole diameter will be approximately 3.79 in. (HQ).

2f. The data acquisition system can be housed in the drilling alcove, therefore, no new alcove would be needed.

2g. The facility design and operational constraints shall allow rework of these holes to handle nitrogen gas bottles and associated hardware for testing and trouble-shooting for both the LBT instrumentation and the DAS for IDS.

2h. The ability to periodically access the LRB should be maintained for the entire duration of site characterization.

Constraints

None

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. There will be eight locations in ES-1 where this test will be conducted. The elevations for these have been estimated to be:

   SRB #1 elevation 4115 ± ft
   SRB #2 elevation 4007 ± ft
   SRB #3 elevation 3987 ± ft
   SRB #4 elevation 3839 ± ft
   SRB #5 elevation 3819 ± ft
   SRB #6 elevation 3704 ± ft
   SRB #7 elevation 3302 ± ft
   SRB #8 elevation 2920 ± ft

2. Testing will continue on an intermittent schedule for the duration of site characterization testing.

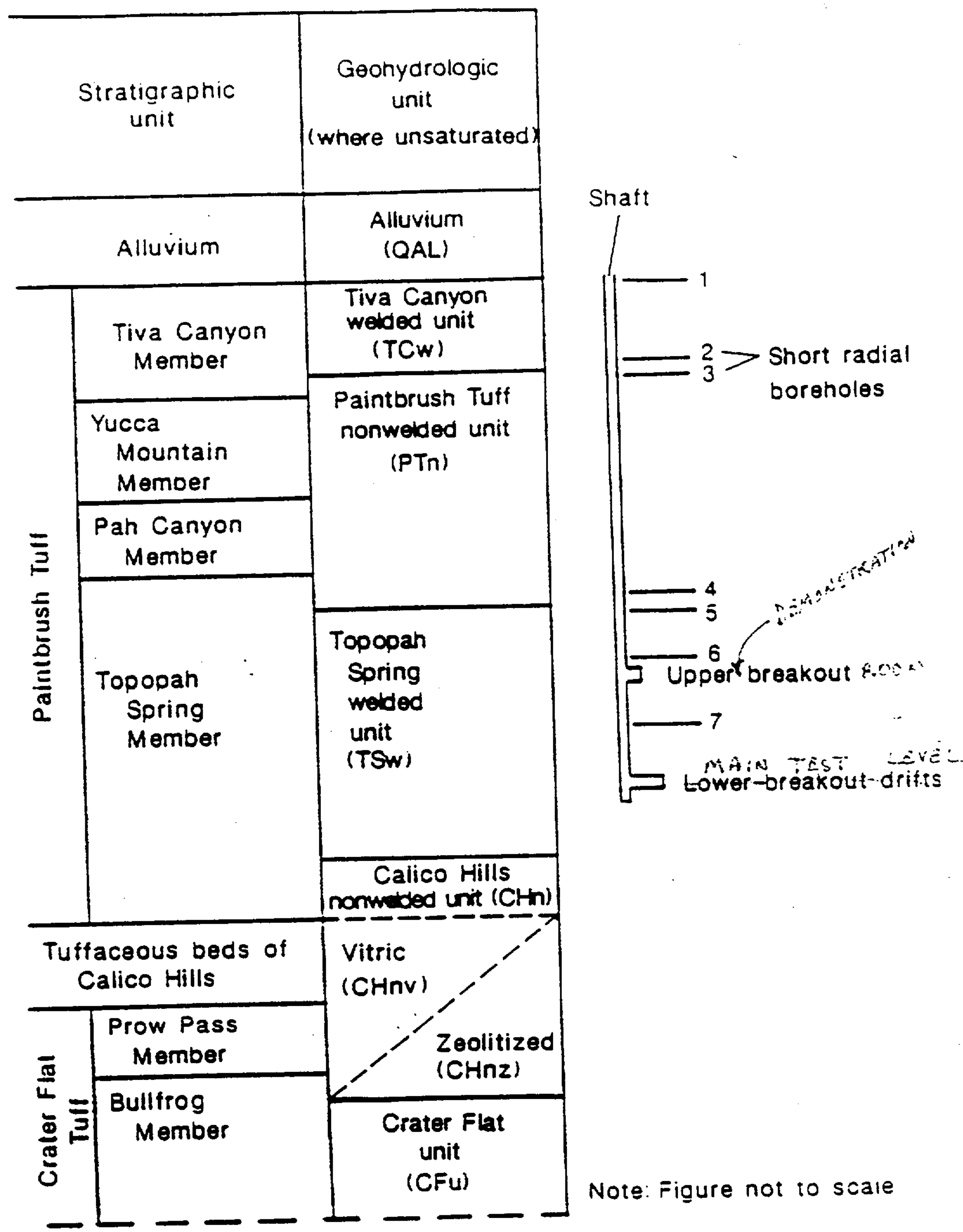


Figure ~~3.4 3.~~ 1. Vertical section of exploratory shaft showing location of the seven sets of short radial boreholes (1988).

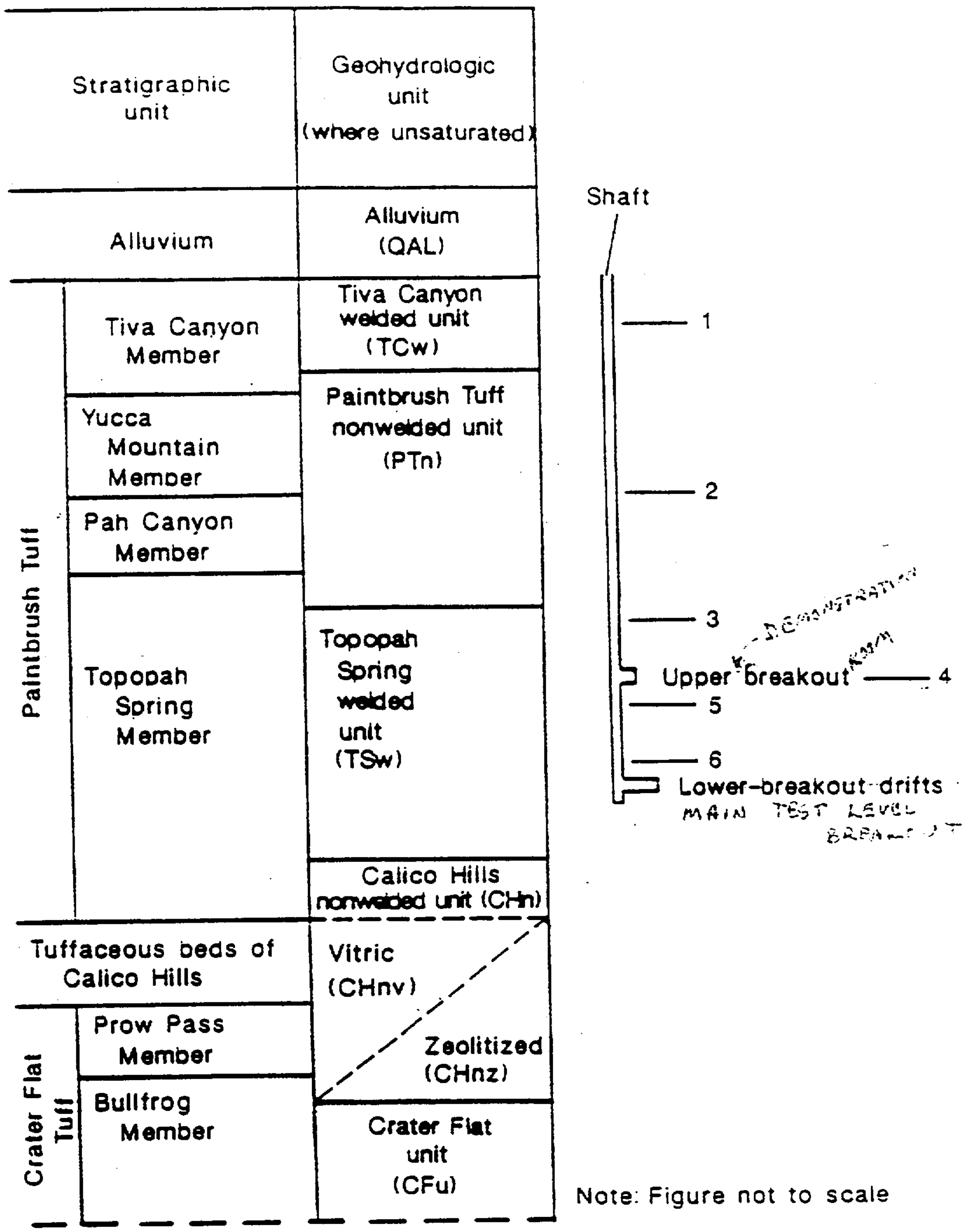


Figure ~~3.4-4~~. Vertical section of exploratory shaft showing location of the six sets of long boreholes (1988).

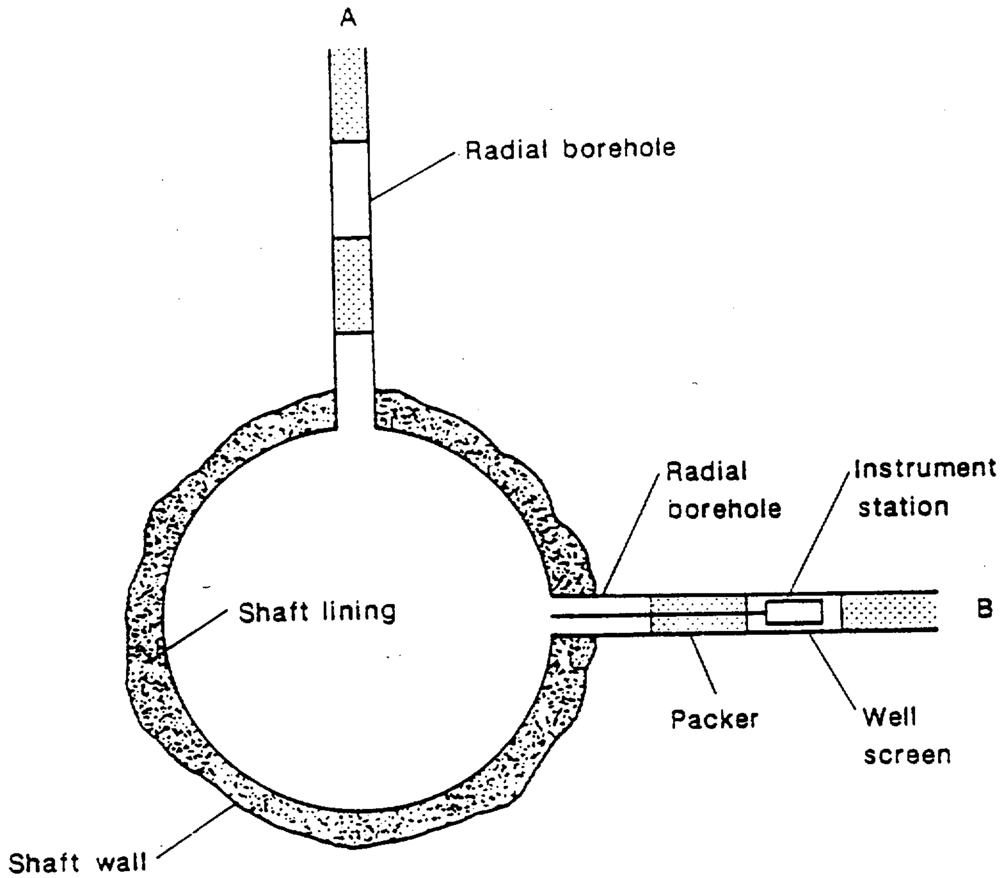


Figure ~~3.4-7.~~ 3 Horizontal section through a typical set of SHORT Radial Boreholes.

YMP

~~NNWSI~~/IDS ES-1 DATA COLLECTION UNIT

TYPICAL OF ~~[illegible]~~ EACH RBT AND EACH SHAFT CONVERGENCE TE

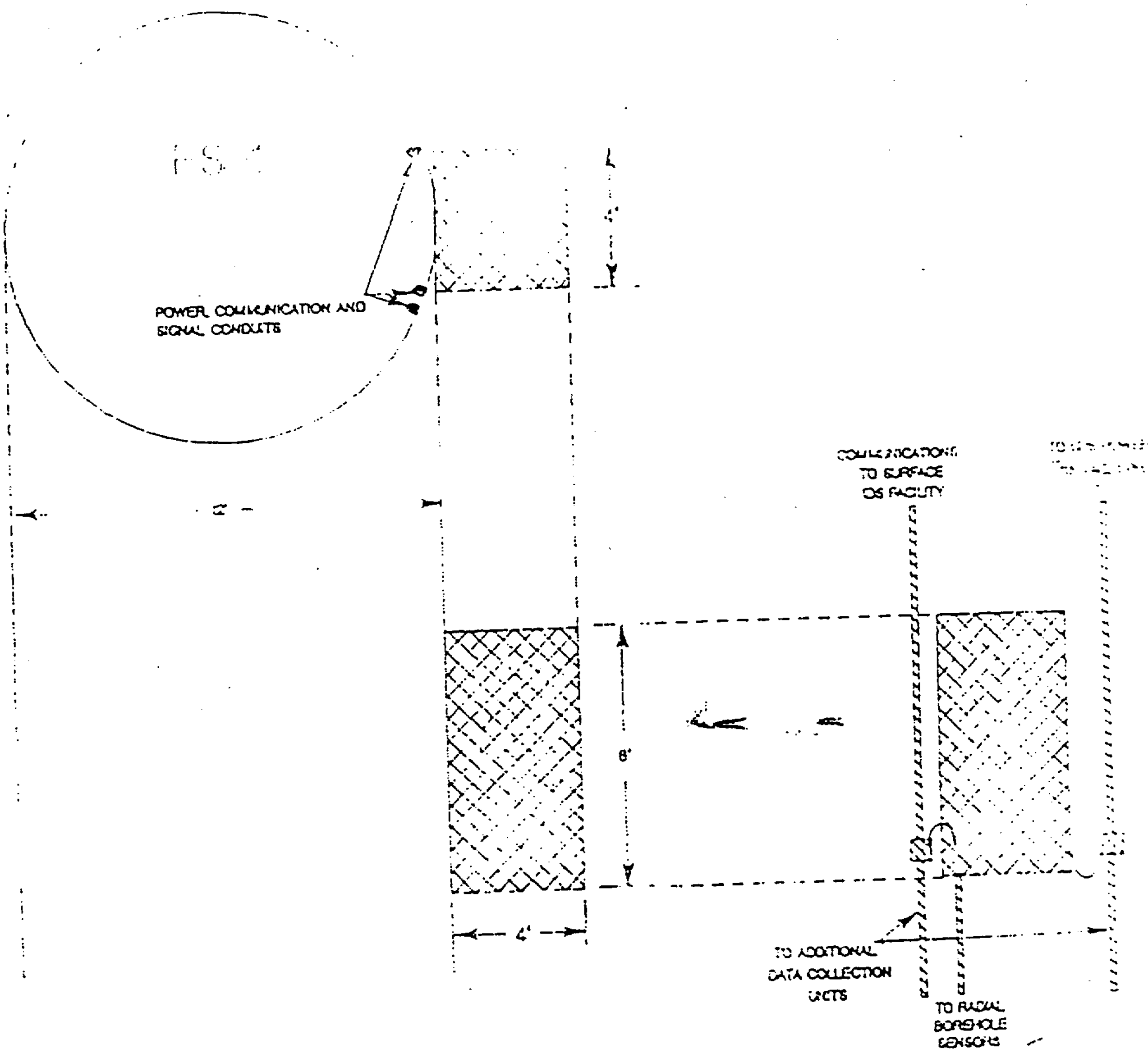


FIGURE 4

DATA COLLECTION UNIT IS TO BE LOCATED APPROXIMATELY 30' ABOVE THE BOREHOLES.
POWER IS TO BE 115 VAC, 1.5 KVA FROM AN UPS SUPPLY.
THE DCU IS TO BE HOUSED IN A HEAVY DUTY NEMA-12 CABINET MOUNTED IN SUCH A FASHION THAT THE ENTIRE UNIT CAN BE ROLLED OUT FOR MAINTENANCE AND TESTING.

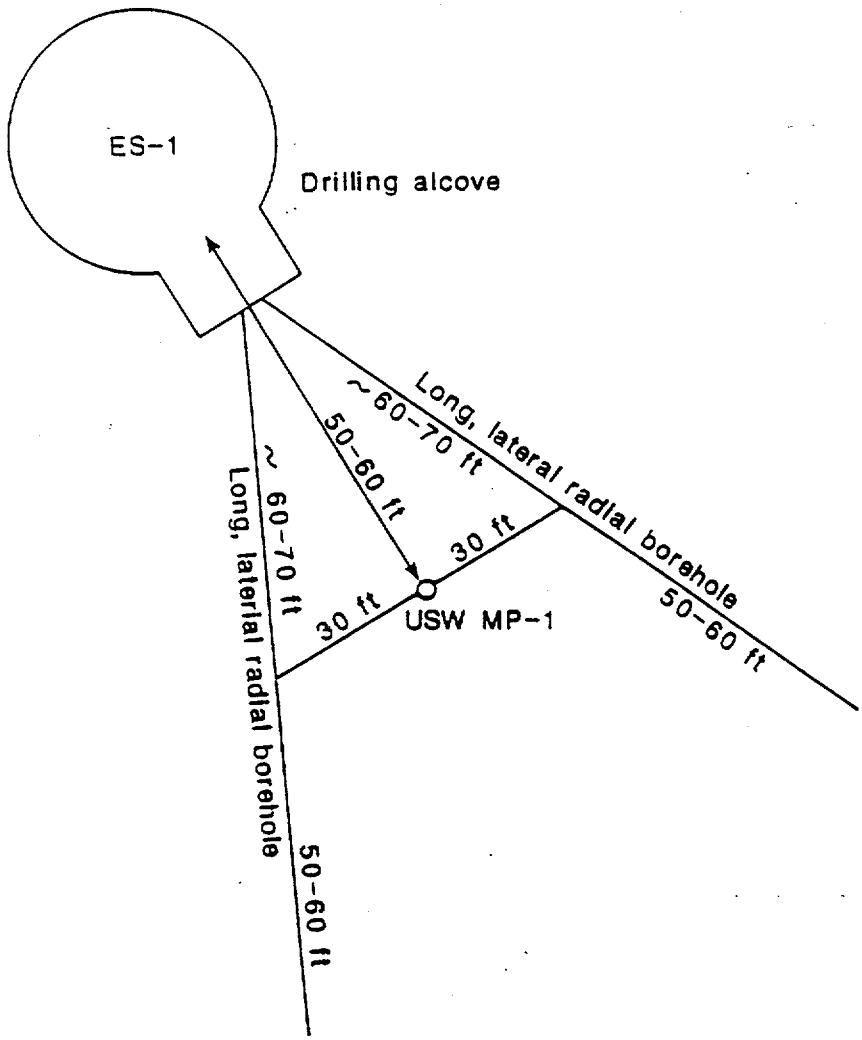


Figure ~~3.4-8.~~ 5 Long borehole configuration.

Excavation Effects Test

Definition of Test

The Excavation Effects Test is discussed in Section 8.2.3.3.4.5 of the Site Characterization Plan. This test is to be performed in ES-1 at both the Upper Demonstration Breakout Room Level and the Main Test Level.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Excavation Effects Test.

Performance Criteria

1. The geometry of the instrumentation holes is shown in Figures B-HYD-6-(1) for the MTL and B-HYD-6-(2) for the UDBR.

2. Drill and core hole specifications are defined in Appendix C of the ESF SDRD.

3. Instrument leads in the station shall be recessed and protected from traffic.

Constraints

1. The instrumentation holes will be completed before the shaft is excavated more than 4 ft beyond the breakout floors.

2. At least 100 ft of excavated shaft depth is required below the MTL to obtain sufficient data.

3. All holes will be drilled with air as defined in Appendix C of the ESF SDRD.

4. IDS support will be required upon completion of drilling and instrumentation of holes as defined in the IDS section of the ESF SDRD (reference number).

5. Allow at least 48 hours for permability testing between excavation rounds.

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

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

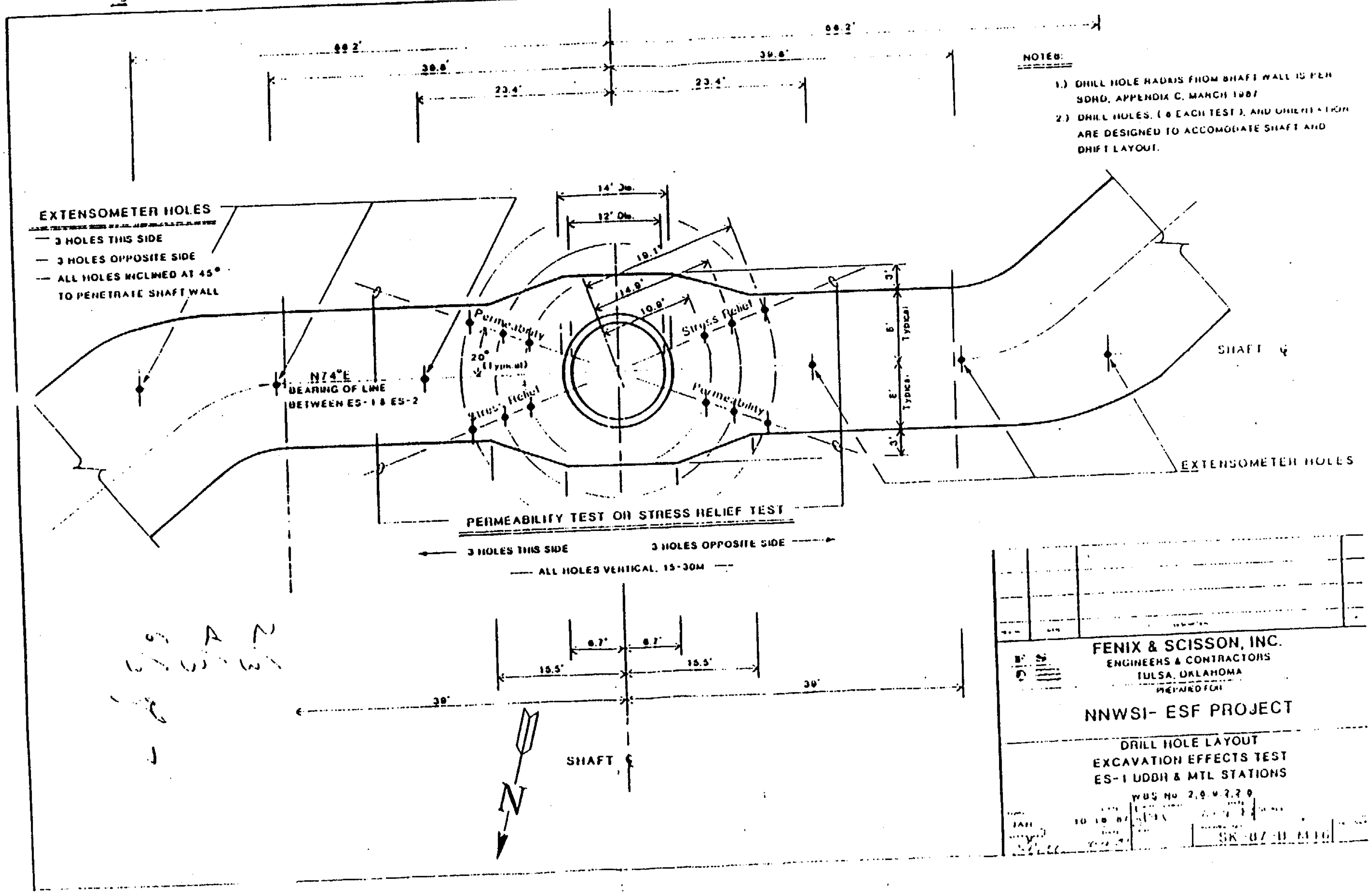
Assumptions

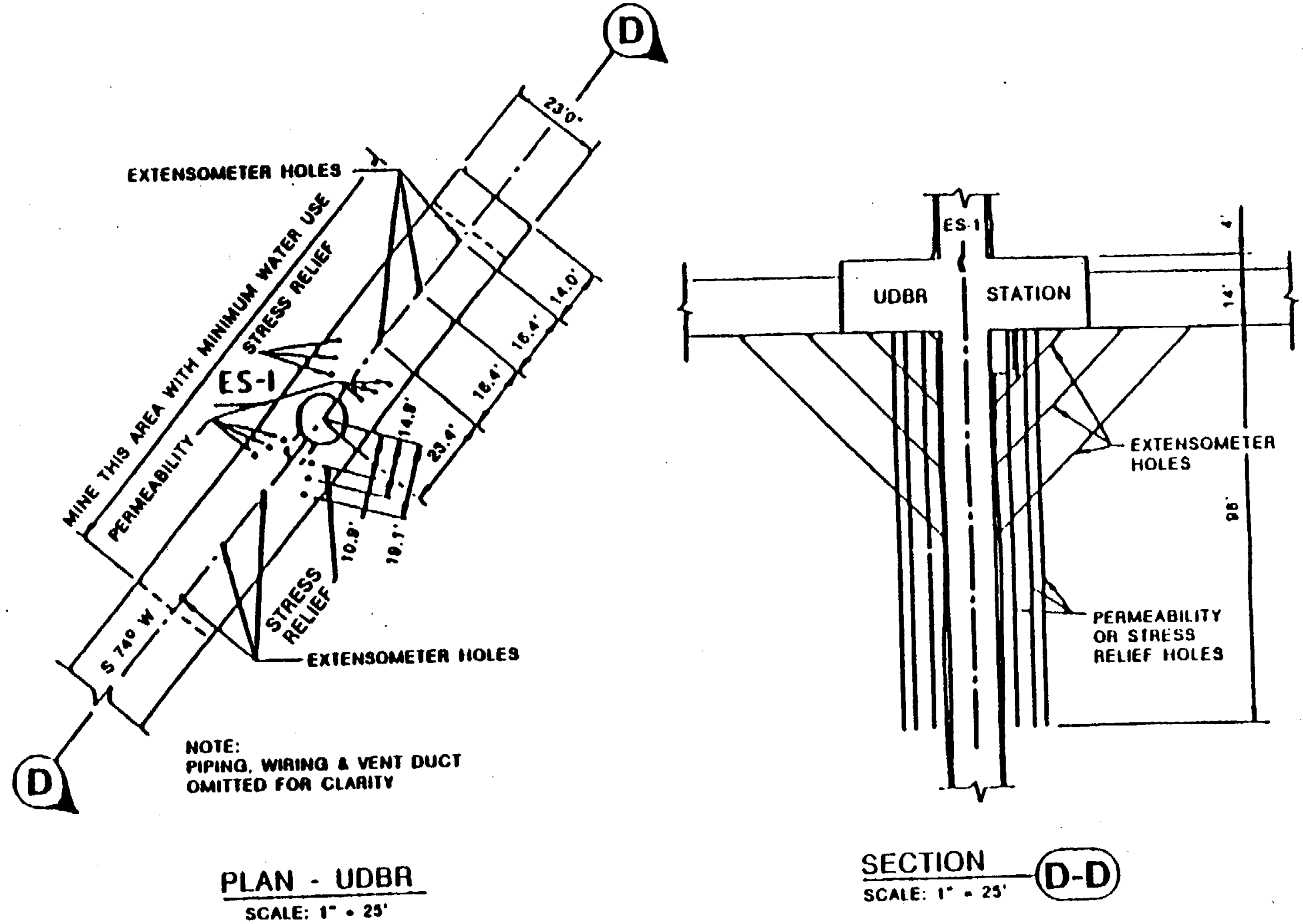
1. Logging, surveying, and packer installation in the holes can be accommodated from each breakout level.

2. Nitrogen gas bottles and associated tubing will be required for pressurizing packers and doing permeability tests.

3. There are no special requirements for utilities to support this test beyond normal requirements contained elsewhere in the design requirements.

Attachment 1





ES EXPLORATORY SHAFT
UDBR UPPER DEMONSTRATION BREAKOUT ROOM

Figure 8.4.2-17. Typical excavation effects test (from Title I 100 percent design)

Calico Hills Test

Definition of Test

The Calico Hills Test is described in Section 8.3.1.2.2.4.6 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the flexibility to perform testing in the Calico Hills. The Project does not currently plan to penetrate the Calico Hills unit with the ESF. However, the requirement for flexibility to sink the shafts and perform site characterization testing in the Calico Hills will be maintained.

Performance Criteria

1. If the ESF option to penetrate the Calico Hills is exercised, capability to drift to the Ghost Dance Fault within the unit will be required.

2. If the ESF option to penetrate the Calico Hills is exercised, capability to do the following testing will be required.

   A. Diffusion Test (B-HYD-10)
   B. Radial Borehole Tests in the shaft or drifts at geologic contacts. (B-HYD-5)
   C. Overcore Stress Test (B-Mech-16)
   D. Mapping (B-GEO-1)
   E. Sample Collection (both rubble and core)
   F. A core hole about 6 in. in diameter to the water table about 6 in. in diameter.
   G. Hydrochemistry test will collect gas samples from the Radial Boreholes (B-HYD-9).

Constraints

None

Assumptions

1. Refer to individual test reference sections for details.

Perched Water Test

Definition of Test

The Perched Water Test in the Exploratory Shaft Facility is described in Section 8.3.1.2.2.4.7 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Perched Water Test.

Performance Criteria

1. All moisture or free water that is observed in the shafts or drifts will be sampled. The technique for sampling is expected to follow the guidelines outlined in Figure B-HYD-8-(1). All such moisture observed will result in a construction hold point to allow implementation of this test.

2. Schematic details of the instrumentation for perched-water zones are shown in Figure B-HYD-8-(1).

3. Boreholes will be drilled to develop and concentrate low flow seeps for hydraulic testing, head measurement, and collection of water samples.

Constraints

1. All drilling will be done dry.

2. Procedures will be developed to provide field estimates of the total water quantities encountered.

3. Grouting will require that a chemical tracer be added to the grout.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

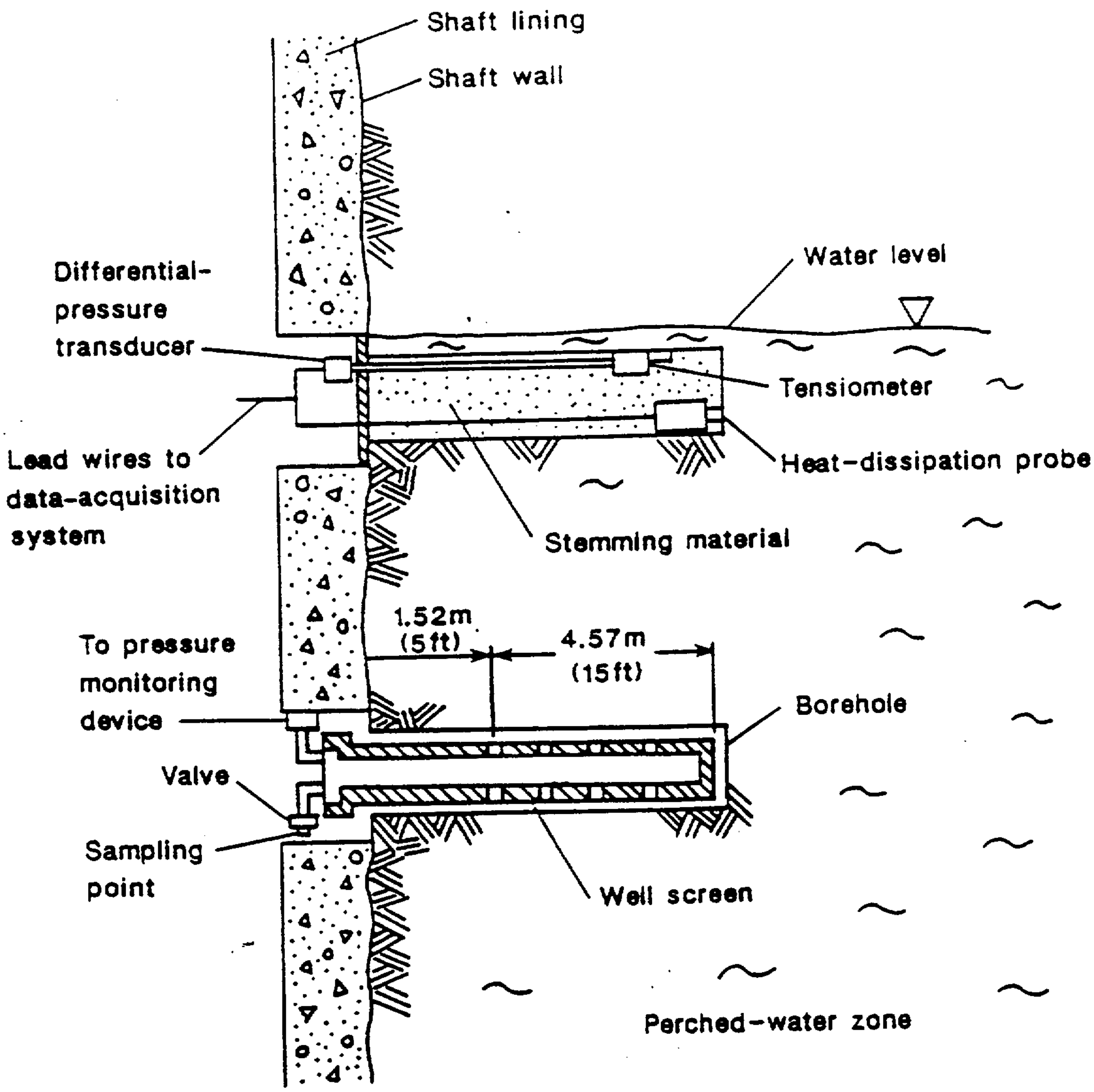
Assumptions

1. The PI will make decisions at each evidence of moisture as to what methods are needed to characterize the water.

2. The USGS will provide pumps and flow meters that will be required.

3. Criteria will be developed to define what constitutes evidence of moisture or free water.

4. The separation of the holes in figure B-HYD-8-(1) is expected to be at least TBD.



Note: Figure not to scale

Figure B-HYD-B-(1) Schematic diagram of instrumentation of perched-water zone within the exploratory shaft.

Hydrochemistry Test

Definition of Test

The Hydrochemistry Test is defined in Section 8.3.1.2.2.4.8 of the Site Characterization Plan. These test design requirements cover air and water tracer and the rock and gas sampling activities.

Functional Requirements

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

2. Chemically trace all water used at the ESF.

3. Chemically trace all compressed air used in drilling or coring.

4. Provide for gas sampling and testing from all Radial Borehole Test locations (RBT)(see Section B-HYD-5 for definition of RBT locations) and the permeability test holes of the Excavation Effects Test.

5. Provide for sample collection from all concrete, grouts, and other liquid construction materials using procedures (TBD) that are approved by the ESF Test Manager.

6. Provide for collection of large, uncontaminated rock samples from the ESF muck.

7. Provide gas sample collection holes (see Appendix C) near the radial borehole locations soon after blasting and mucking to collect *in situ* gas samples. The holes shall be located no further than TBD feet from the associated RBT locations.

Performance Criteria

1. All water in the ESF will be traced. Four separate water tracer systems are needed, each to provide a tracer concentration of about 20 parts per million. These four are
   a. All water used, whether from J-13 or elsewhere (Universal Tracer).

   b. All water going down ES-1 or ES-2, including construction water.

   c. Water used in the concrete for the collars and liner of ES-1 and ES-2 and all concrete used underground.

   d. Local tracers added at selected test alcoves, such as the Infiltration Test and The Engineered Barrier Design Test.

2. All compressed air used in coring or drilling will be tagged with SF6 to provide at least 20 parts per trillion of tracer.

3. Provide for the routing of gas sampling tubes to a suitable location for collection and processing of the gas samples. There will be one tube from each RBT location and each permeability test hole of the Excavation Effects Test. During

testing the gas inside the teflon tubes must be warmed and maintained at a minimum of 30°C. The ability to adjust the temperature of the tables to assure that no moisture condensation can occur may be required, depending on the gas composition and moisture content.

4. Provide a suitable space (location for intermittent use) for gas sampling activities and equipment. Each of the sixteen RBT locations will require space for equipment such as peristaltic pumps, silica gel towers, molecular sieve chambers, etc. Equipment for all locations can be assembled on a bench 2-1/2 ft high x 5 ft wide x 3 ft deep. A temperature controlled space 10 ft width 8 ft long 10 ft high (alcove) shall be available at the MTL. The bench will be located in this intermittant use area as illustrated in Figure B-HYD-9-(1). Prior to availability of the MTL, this intermittent use area shall be located at the UDBR.

5. Electrical power will be required as outlined in integrated Electrical Power Requirements (Section B-IS-4 of the ESF SDRD). However, a special requirement exists for about 50 watts of 12 volt Direct Current power for each peristaltic pump. Approximately 20 pumps will be used. This will not be critical power as the test can accommodate interruption if there is a power failure.

6. Water-tracer samples for chemical analysis shall be provided from various water system taps using procedures (TBD) that are approved by the ESF Test Manager.

7. Provide access to the collar of each RBT hole during gas sample pumping to allow trouble shooting and repair of potential equipment malfunction.

8. Large (about 1 ft diameter) rock samples will be collected from various geologic units and locations, and delivered to the PI prior to the use of water for wall washing or dust suppression. This will be done according to Procedure AP-6.6Q.

9. A sample sorting area (covered concrete pad about 10 ft X 10 ft) near ES-1 for selecting and sorting rubble samples may be required to preserve moisture content of the samples. This requirement may derive from AP-6.6Q. Samples once hoisted shall be packaged immediately to preserve the moisture content and shall be removed at once to the Sample Management Facility.

Constraint

1. Tracer specification must take into account requirements of other tests, specifically no chloride tracers prior to the completion of Cl^{36} sample collection.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. No added gaseous 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 NTS support organizations.

3. Tracer chemical specifications must take into account requirements from all tests but will be the responsibility of the USGS.

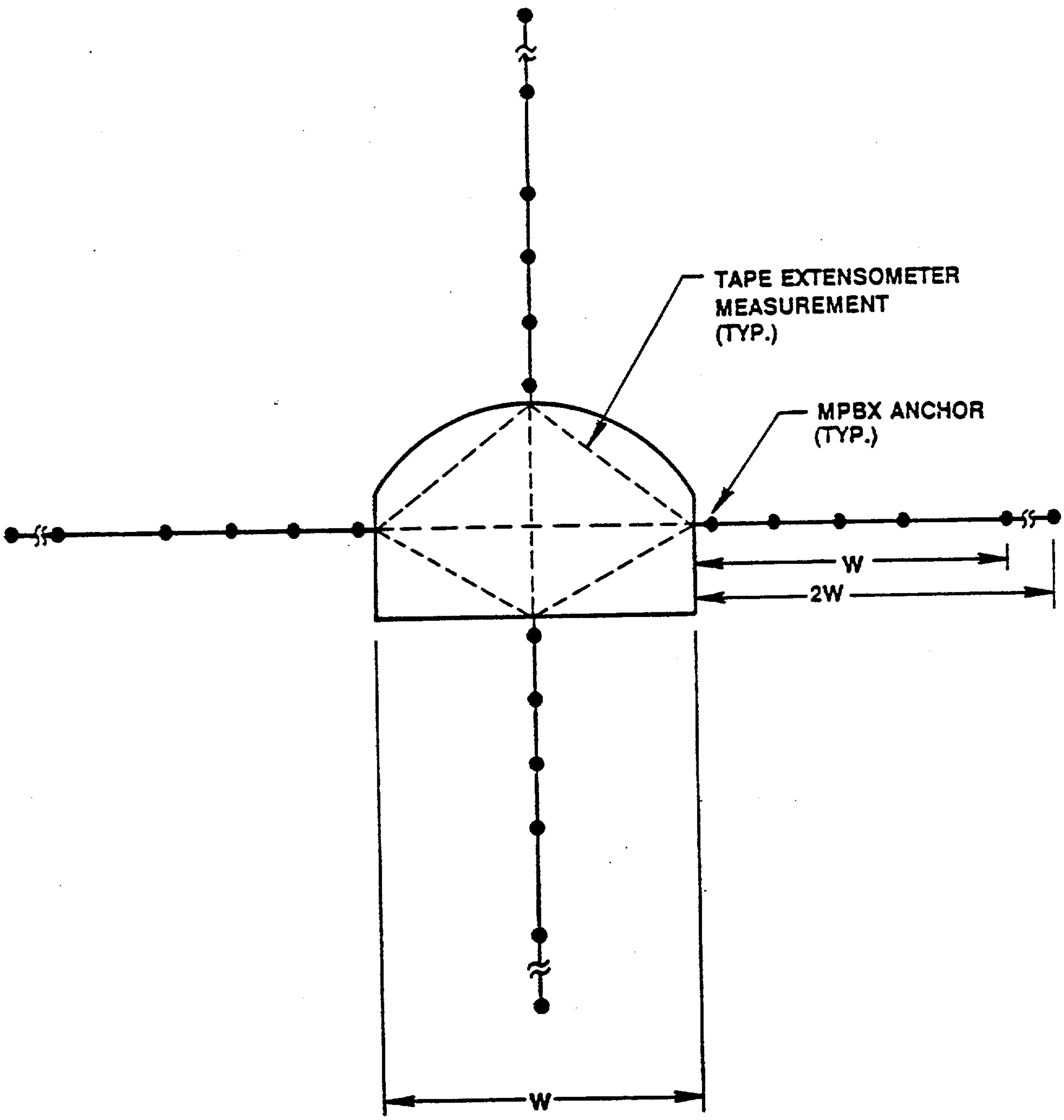
4. The universal water tracer will be Sodium Bromide.

5. The routing of the gas sample tubes may be inside a carrier pipe which can be heated (for instance with heat tape or with a stream of hot air inside the pipe) to provide a minimum sample temperature of 30°C during actual sampling operation. The ability to adjust the temperature of the tubes to assure that no moisture condensation can occur may be required.

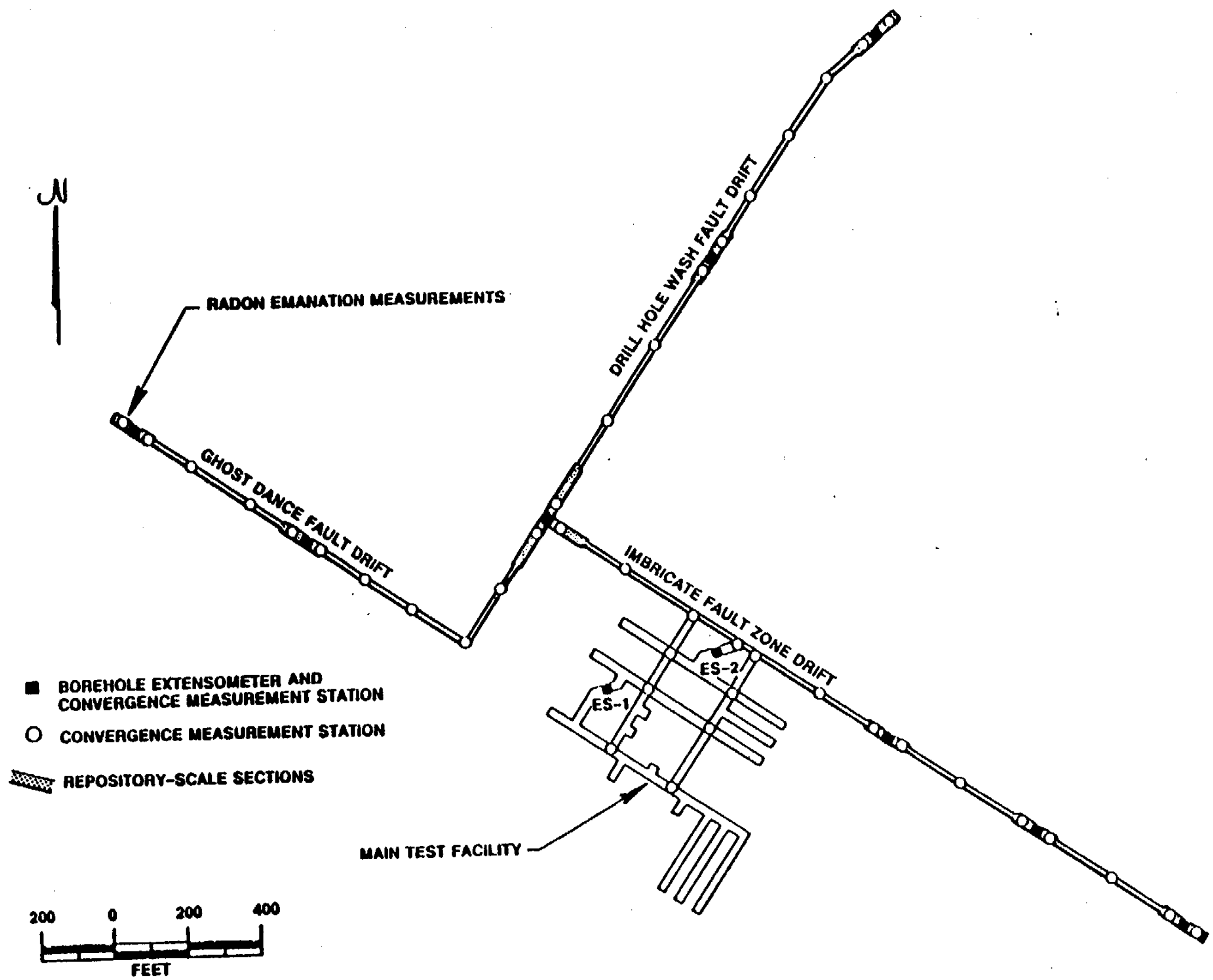
6. The gas sample tubes are thick walled Teflon tubes with an outside diameter of 0.5 in., (similar to the tubing used in the surface based sampling of the UZ holes.)

7. The gas sampling equipment (vacuum pumps, gel columns, cryostats, etc.) will be located at the UDBR until the MTL is available and will then be located at the MTL.

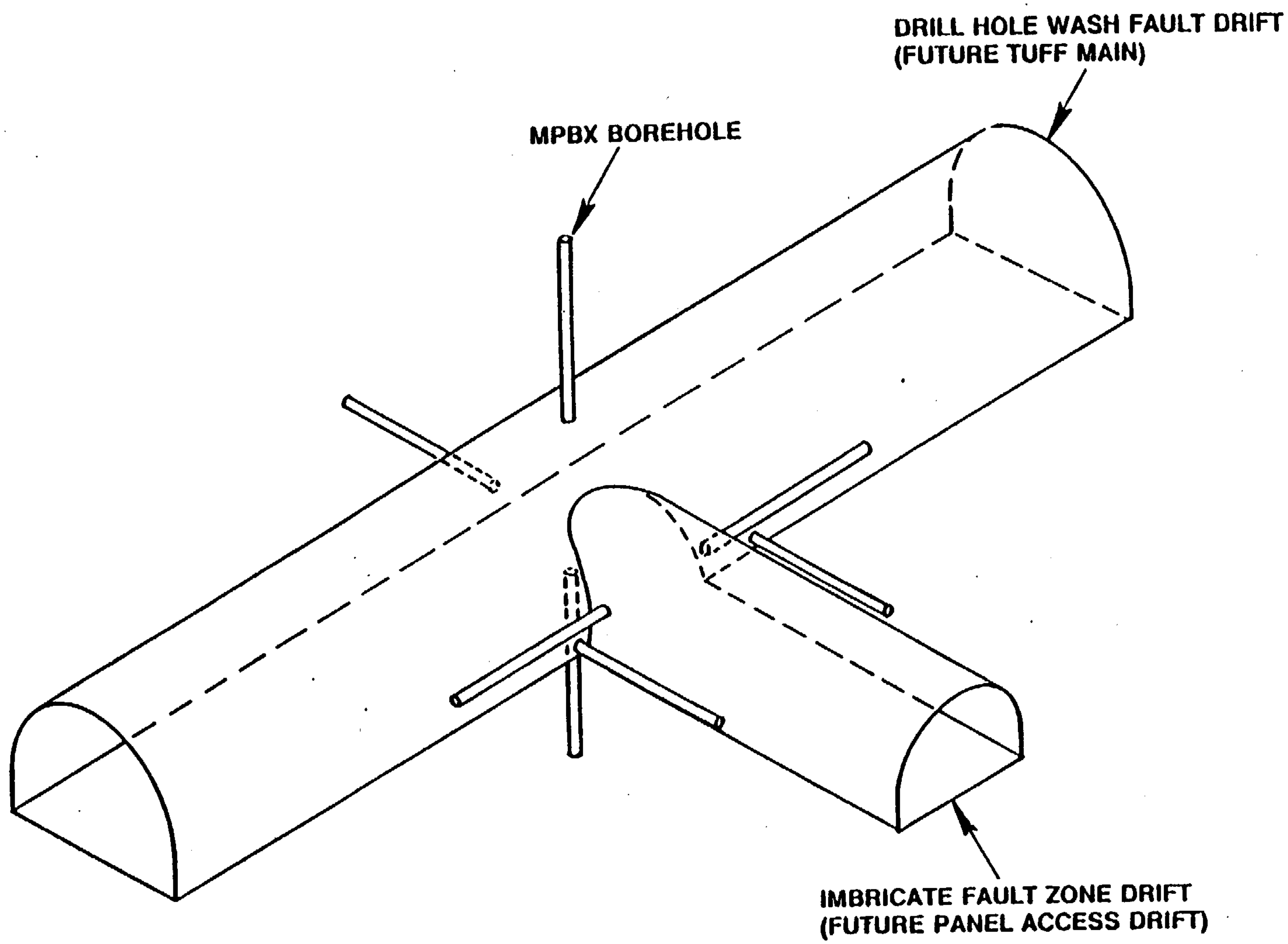
8. Gas sampling from radial boreholes will occur over a 2 to 4 week period and will be performed about every 6 months for a



Typical configuration of multiple-point borehole extensometer (MPBX) instrument station


N
RADON EMANATION MEASUREMENTS
DRILL HOLE WASH FAULT DRIFT
GHOST DANCE FAULT DRIFT
IMBRICATE FAULT ZONE DRIFT
ES-1
ES-2
BOREHOLE EXTENSOMETER AND CONVERGENCE MEASUREMENT STATION
CONVERGENCE MEASUREMENT STATION
REPOSITORY-SCALE SECTIONS
MAIN TEST FACILITY
200
0
200
400
FEET

B-MECH-14-(2)



Proposed configuration of borehole extensometers at the repository-scale intersection of the Drill Hole Wash Fault drift and the Imbricate Fault Zone drift

B-MECH-14-(3)

Air Quality and Ventilation Test

Definition of Test

The Air Quality and Ventilation test is discussed in Section 8.3.1.15.1.8.4 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Air Quality and Ventilation Test.

Performance Criteria

1. A portion of the repository scale section at the end of the drift to the Ghost Dance Fault will be sealed with a bulkhead to allow measurement of radon gas emanation.

2. Controlled air flows will be circulated behind the bulkhead.

3. This test will require a radon measurement hole in the Ghost Dance Fault drift as defined in Appendix C of the ESF SDRD.

Constraints

1. Air resistance measurements at one location in the main test area (TBD) will require the temporary removal of a ventilation duct.

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

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

3. Information collected on gas concentrations and other parameters for the ESF life-safety purposes will be examined as part of this test.

4. Independent control of the ventilation airflow rate at the end of the drift to the Ghost Dance Fault will be required.

Assumptions

1. Radon emanation measurements will be done at the end of the Ghost Dance Fault drift.

2. No additional excavation is required for this test.

3. 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 surveys will be conducted throughout the ESF after construction is completed. Data acquisition by the IDS is not required for these surveys.

4. In the radon emanation test, continuous measurement of radon and radon daughter concentrations, temperature, humidity, barometric pressure, and air flow will be made. Continuous data acquisition by the IDS is required during this testing.

Seal Testing

Definition of Test

In situ testing of seal components is discussed in Section 8.3.3.2.2.3 of the Site Characterization Plan. Details of this testing have not been determined. When the test plans have been formulated, the design requirements will be added to this section through the ECR process.

Functional Requirements

To be developed.

Performance Criteria

To be developed.

Constraints

To be developed.

Interface Requirements

To be developed.

Assumptions

To be developed.

Overcore Stress Test

Definition of Test

The Overcore Stress experiments in the Exploratory Shaft Facility are discussed in Section 8.3.1.15.2.1.2 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Overcore Stress Test.

Performance Criteria

1a. Drilling and coring holes for instrumentation are defined in Appendix C of the ESF SDRD.

1b. A mobile rock-testing facility (to be supplied by the test organization) will require an assigned space and utility hookups.

Constraints

1. The overcore test should be separated from the nearest thermal test by a minimum of 50 ft or should be completed before the heaters are energized.

2. Flexibility in location of the test holes within the DBRs is required because intact segments of overcore are required. Location, distribution, orientation and apertures of fractures need to be examined before tests are conducted.

3. In situ stresses near the bottom of the holes must not have been affected by other mining, testing or construction.

4. Test holes should not be drilled within 5 ft of other instrument holes.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. The location for the mobile laboratory will be on an auxiliary pad.

2. The Overcore Stress Test will be performed in the UDBR, the DBR in the main test level, at the bottom of ES-1 (maximum depth), and in alcove off shaft in the Calico Hills Unit.

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

Hydrologic Properties Samples

Definition of Test

The Matrix Hydrologic Properties Testing is described in Section 8.3.1.2.2.3.1 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and the operational flexibility to perform the sample collection.

Performance Criteria

1. Large sizes (estimated to be large enough not to pass a 1-ft mesh) may be required for some samples. The blasting patterns and procedures should provide the flexibility to provide some rubble of this size in selected blast rounds.

Constraints

1. Procedures and design shall be developed to minimize the water contamination of the large samples.

2. Additional criteria for sampling requirements from other tests are identified in Common Sampling Design Requirements, (B-IS-7).

3. Minimal water may be used in drilling blast holes, but samples should be collected before significant use of water for dust control.

Assumptions

1. The samples will be collected as part of the bulk sampling described in the Common Sampling Design Requirements (B-IS-7-1). The SMF will divide the bulk samples to satisfy all bulk sample requirements for this test.

2. Facilities for handling samples by the Principal Investigators will be provided as part of the SMF.

3-year period. The gas sampling in Functional Requirement #7 is a one-time activity at each location. Gas sampling from several depths may be necessary in one of the Excavation Effects Test permeability test holes after the Excavation Effects Test is complete.

9. Gaseous tracer injection system design can draw on experience gained in drilling the UZ hole with SF6 tracer.

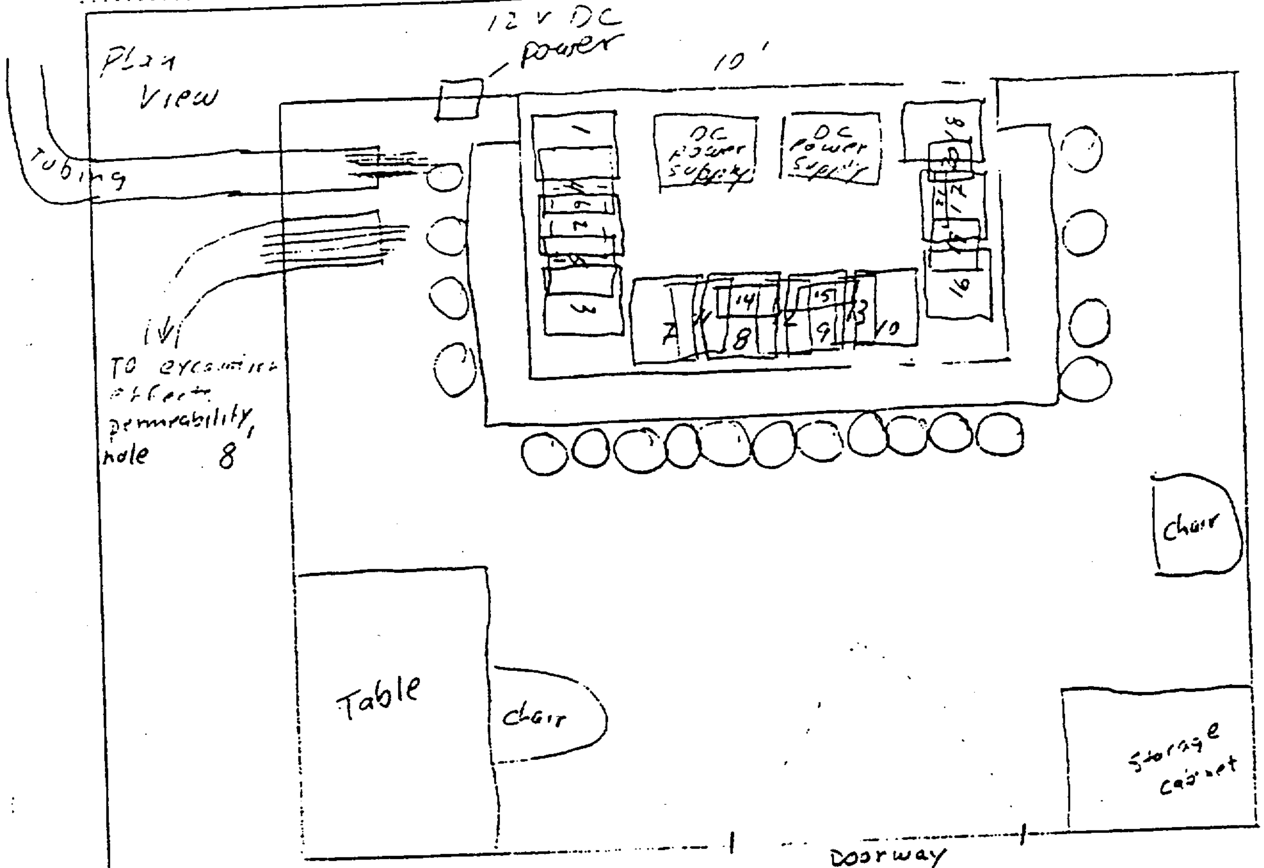
10. The procedure for collection the of the large rock samples will be combined with the collection of samples for geomechanical and other laboratory test needs. (See Section B-HYD-1 and B-IS-7).

9-2131

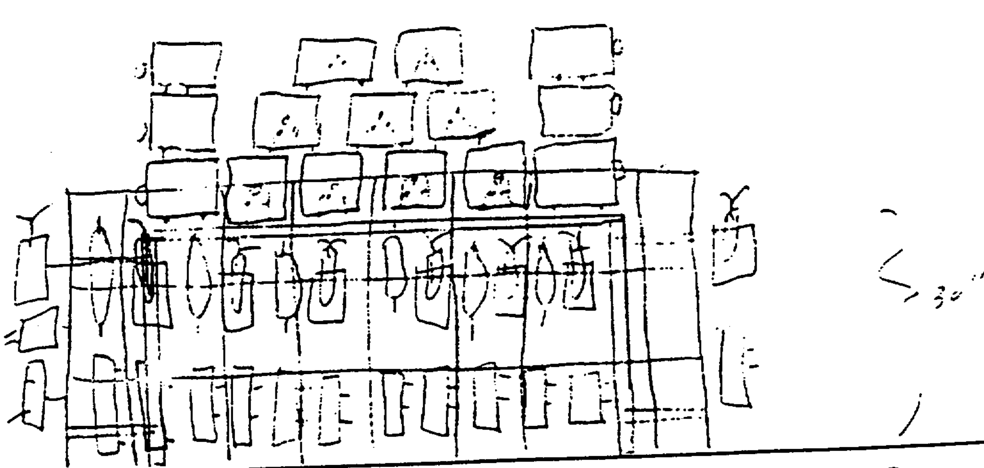
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File ATTACH 2

Radial holes



FRONT OF SAMPLING SETUP



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Diffusion Test

Definition of Test

The Diffusion Test is described in Section 8.3.1.2.2.5 of the Site Characterization Plan.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Diffusion Test at both the MTL and in the Calico Hills Drill Room.

Performance Criteria

1. Provide an alcove about 10 ft x 10 ft of sufficient size to allow drilling of the test holes. A headroom of 16 ft will be required for the drilling equipment.

2. Drilling and coring requirements for the Diffusion Test are defined in Appendix C of the ESF SDRD.

Constraints

1. The Diffusion Test should be separated by 50 ft from the nearest adjacent test.

2. The rock volume used for the actual test will be chosen to minimize the number density of fractures. Borehole logging and television will be performed.

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. The Diffusion Test may be performed either in the rib or the invert of the alcove. Present plans call for the test to be done in the invert.

2. Packers used in the Diffusion Test will be supplied by the PI.

3. Nitrogen gas bottles will be used to pressurize the packers.

Chlorine-36 Test

Definition of Test

The chloride and chlorine-36 measurement of percolation at Yucca Mountain activity is described in Section 8.3.1.2.2.2.1 of the Site Characterization Plan.

Functional Requirements

1. Provide the facility design and operational flexibility to perform the Chlorine-36 Test.

Performance Criteria

1. Samples will be collected after blasting but prior to washdown, as detailed in AP-6.6Q. Large samples >-1 ft mesh size are desireable as they are collected for the Hydrochemistry Test (B-HYD-9).

Constraints

1. The chlorine content of all explosives shall be determined and reported along with the quantity of explosives used in each blast round. The acceptable accuracy of the chlorine composition can be within ± 10% of the value for concentrations of 1% or more. Less accurate composition data are acceptable for chlorine concentration in the explosives below 1%.

2. Water used for site preparation, dust control and underground operations will be tagged with an approved tracer. Chlorine atoms will not be used for tagging until samples have been collected from the maximum depth of the ESF.

3. To the extent possible, samples for the Chlorine-36 Test shall be exposed to minimum water contamination during construction (large sample pieces collected before washdown).

Interface Requirements

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

   Section B-IS-1 Integrated Data System
   Section B-IS-2 Scientific Manpower/Schedule Information
   Section B-IS-3 Laboratory/Office/Storage Space Requirements
   Section B-IS-4 Electrical Power Requirements
   Section B-IS-5 Water System Requirements
   Section B-IS-6 Compressed Air System Requirements
   Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. Storage for 55-gal drums of samples in Area 25 will be provided as part of the SMF operational procedures.

Engineered Barrier System Field Tests (EBSFT)

Definition of Test

The Engineered Barrier System Field Tests are defined in Section 8.3.4.2.4.4 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform the Engineered Barrier System Field Tests.

2. Provide the flexibility to adjust test area location to avoid adverse rock conditions.

3. Secure surface facilities for storage of equipment and offices will be required.

4. Provide utilities to support the Engineered Barrier System Field Tests.

Performance Criteria

1. Provide underground space as defined in ESF Title I design drawing FS-GA-0166, modified as necessary to accommodate performance criteria.

2. Provide a trailer pad sufficient for a 12 x 60 machine shop trailer that the test organization will bring on site. Parking or unloading space will be required for one pickup truck at this location.

3. The trailer pad will require 120/208 VAC, 3-phase power.

4. The trailer will require water and sewer hookup.

5. Provide office space and change house for eight people and two computer workstations as part of the surface facility.

6. Underground space requirements for organizational computers and instrumentation stations are

   - 500 sq ft of space for organizational computers This space should be provided in locations within 50 feet of the active test areas. Depending on layout this may require 3 or 4 alcoves. A minimum size of 144 sq. ft. is required for any individual alcove.

   - A 110-ft. section of level drift that can be dedicated to instrumentation assembly, workbench activities is required near each of the vertical emplacment tests.

   - Storage alcoves are required near the test areas for storage of neutron and gamma logging equipment as well as other scientific equipment. The storage area requirements are approximately 100 sq. ft. of floor space, and must be located where access can be controlled for radiation safety. If this storage location is near desk/work bench or other types of personnel areas physical separation must be provided in accordance with Health and Safety guidelines for radioactive sources.

7. Coring and drilling requirements for this test are contained in Appendix C of the ESF SDRD.

8. Secure surface facilities for temporary storage of equipment will be required. This facility should be located on or near the main ESF area. Office space will be furnished in an office building.

9. 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 move by 50 ft (either direction) from the proposed location in considered adequate flexibility.

10. A minimum of 25 ft of rock in all directions around each EBSFT heater needs to be undisturbed by other activities. This equates to a minimum of 50 feet required between two EBSFT tests if they are located along the same test drift.

11. Provide tap water lines to each of the underground test drifts with a flow rate capacity of at least 5 gallons/minute.

12. Provide adequate flood lamp illumination along the testing section of each drift to permit normal reading and writing activities. A minimum length of illuminated drift of 50 ft is required for each of the test locations.

13. Provide underground power to each of the test drifts as follows: a) twelve 30 amp, 110 volt circuits, b) two 20 amp, 220 volt circuits, c) the outlets to these circuits will be installed within 50 ft of each heater borehole, and d) power provided to six of the 110 V circuits and 1 of the 220 V circuits will be uninterruptible and maintain a constant voltage (+/- 5 volts).

14. The azimuth for all the test drifts should be the same as that intended for the repository emplacement drifts (+/-5 degrees).

15. Removable platform with elevated flooring will be installed above instrumentation boreholes drilled in to the invert to allow personnel and equipment to move over the instrumented area. The platform needs to be at least 3 feet above the invert to allow for cabling, etc. from the boreholes. The platform must be removable in sections sufficiently large to allow access to the borehole for normal work activities requiring two people.

16. Working platforms or scaffolding (minimum width of 3 ft) will be required in the drift(s) where horizontal holes are drilled into a rib more than 6 ft above the invert. The platform should allow access to the borehole(s) and be permanently available to allow for measurements that will be conducted through-out the entire test duration. The platform must allow access to all of the holes and must, therefore, either be movable and provide for elevation flexibility of the working level or must be designed to allow independent access for all holes.

17. Drifts are required to provide for 3 vertical EBSFT tests. Flexibility must be maintained to perform 2 additional horizontal EBSFT tests if required by programmatic or technical needs.

18. Location of at least one of the EBSFT tests should be such that the test can be continued as performance confirmation testing. This requires a block of rock at least 100 ft x 100 ft in horizontal area. Access drifts will be required along

the perimeter of this block at an elevation 30 feet lower than the test drifts to allow horizontal instrument holes to be drilled towards the heater. Access will be required along two perpendicular drifts at the test drift elevation which extend through the heater test area to the perimeter of the block to provide for vertical instrumentation boreholes.

19. Compressed air will be required at each of the test locations to perform permeability tests. The air supply will require a maximum of 150 scfm and a minimum pressure of 30 psig.

20. Drift ventilation relative humidity, air temperature and air flow rate monitoring will be required in the test drift areas.

21. Ability to control access to test areas is required.

22. Dust control within the test portions of the drift will be required.

23. Location of the tests must prevent fly rock or vibration damage to instrumentation from mining activities.

24. Three headset intercom (or equivalent) will be required at each of the test areas and organizational computer rooms to allow communication between test area and computer areas.

25. Telephone service is required at each of the computer rooms. Two voice communication lines and one data link line will be required at each location. In addition, one voice line will be required at each heater test location within 15 feet of each heater borehole.

26. Ability to construct a water delivery and containment system to provide for water infiltration into the rock mass over one of the three test areas is required. This system may be as wide as the test drift, and three times as long as it is wide. It will be determined later whether this system will consist of sprinklers or a sand bed.

Constraints

1. Minimum vertical separation between heater/test drifts and instrumentation drift(s) of 30 feet will be required.

2. Width of heater/test drifts will provide for an array of vertical boreholes drilled into the invert that extend 10 feet radially from the center of the heater.

3. Height of instrumentation drift will be sufficient to provide for drilling of an array of boreholes that extend 15 feet vertically.

4. The location of alcoves for the IDS and the instrumentation stations must be a design compromise between the competing goals of minimizing instrumentation lead lengths while at the same time not unduly disturbing the stress and temperature fields in the vicinity of the test packages.

5. Instrumentation stations shall be removed from main haulage drifts to minimize dust and vibration.

6. No rockbolts should be located within the test region that is defined by the rock mass that is enclosed by the instrumentation boreholes plus 5 ft of rock surrounding these holes.

7. Horizontal and vertical clearances of at least 16 ft will be provided opposite the collars of all instrumentation holes to allow the use of downhole logging tools up to 15 ft in length. Horizontal and vertical clearances of at least 22 ft will be provided opposite heater collars to allow 20 ft-long heater assemblies to be used.

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

9. Other tests must be located so they will cause no significant drying or temperature changes in the rock in the vicinity of the heaters.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. The machine shop trailer will be located on the auxilary pad.

2. Office space will be provided at the ESF and some space will be assigned in Area 25. Office space on the surface can be shared with other test organizations.

3. Figures B-WP-1-(1) through B-WP-1-(4) is a possible geometry to provide for 3 vertical tests meeting the requirements listed above.

4. The stress altered region extends two drift diameters from the outer drifts.

5. The thermal, chemical and hydrologic zones of influence are expected to be contained well within the zone of stress alteration.

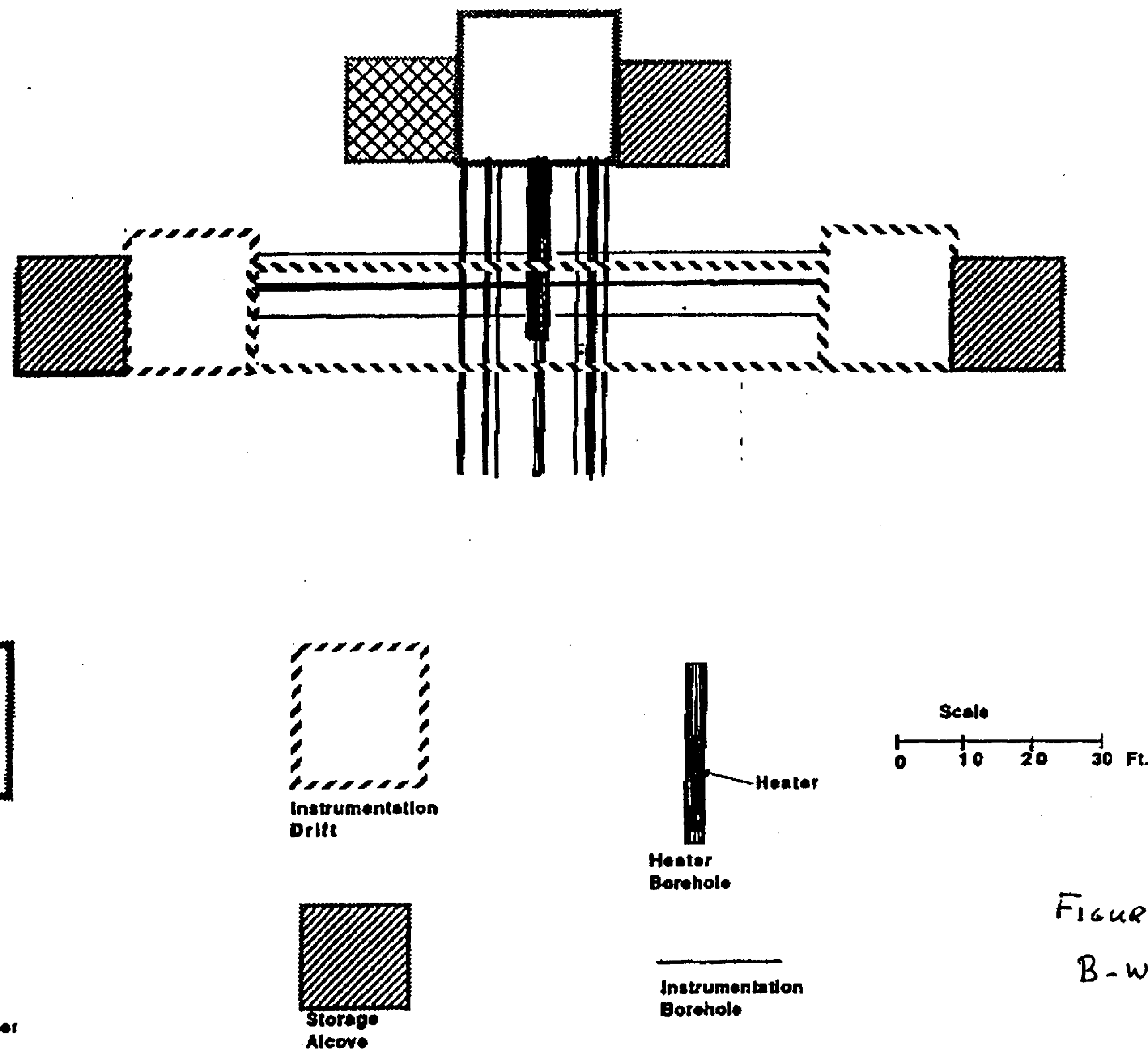


FIGURE 1. FRONT VIEW

B-WP-1-(1)

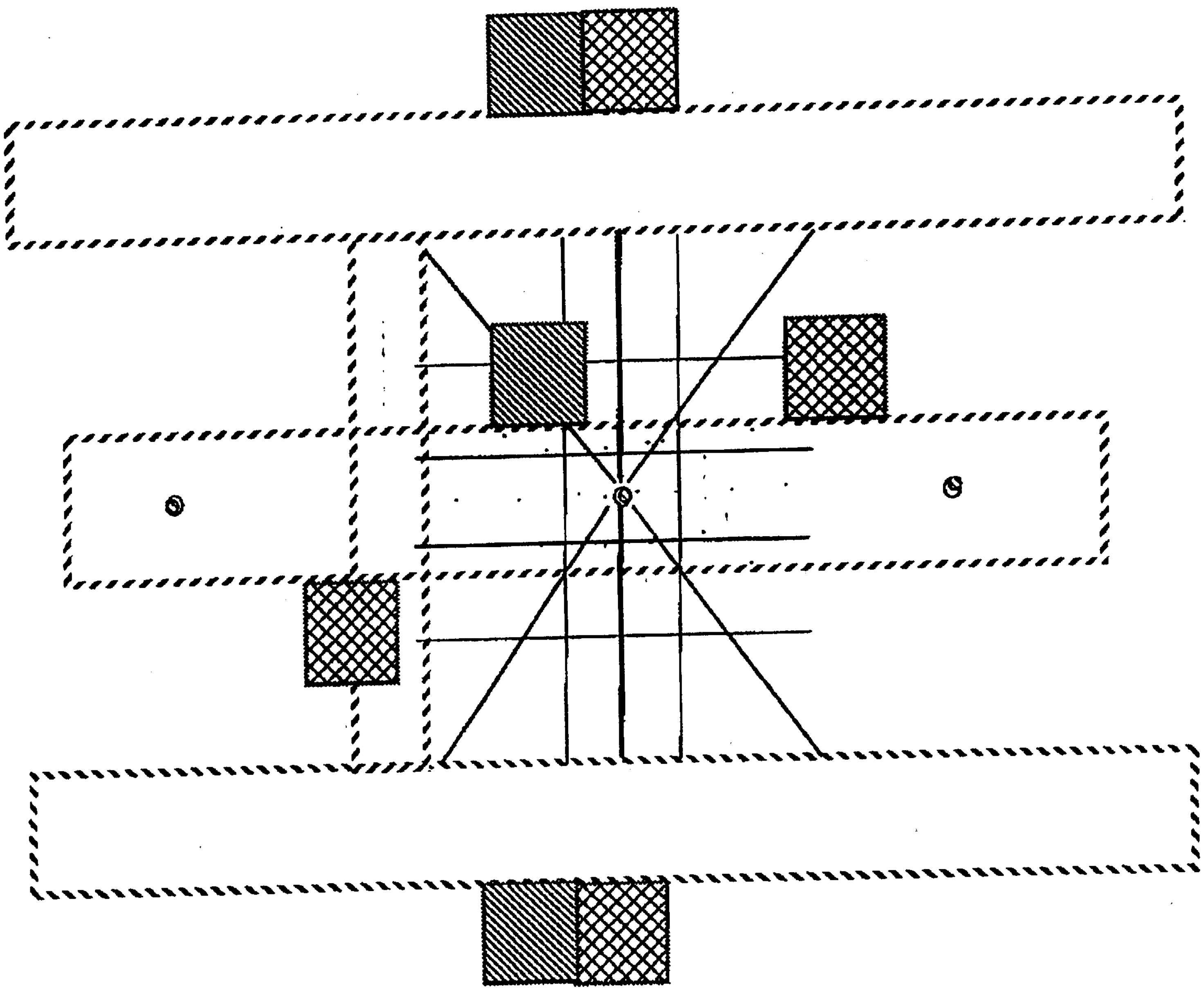


FIGURE 2 - PLAN VIEW B-WP-1-(2)

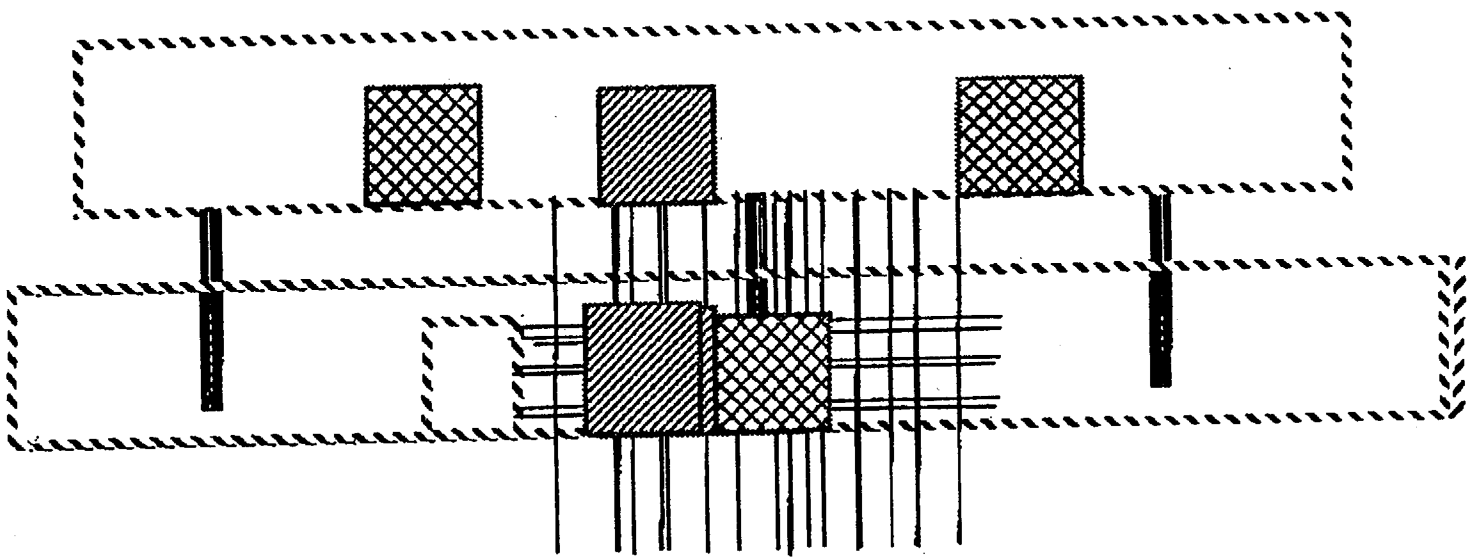
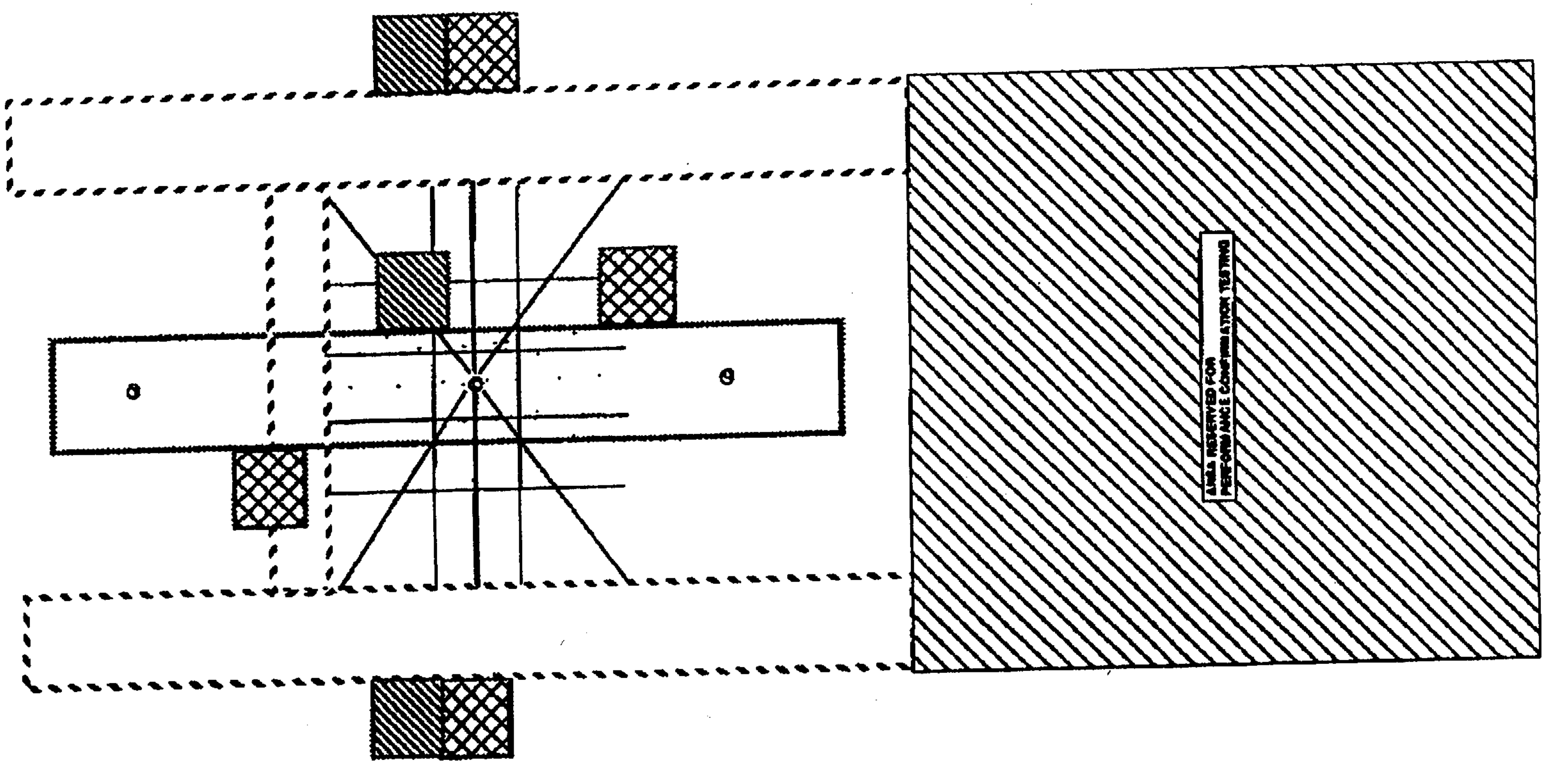


FIGURE 3. SIDE VIEW B-WP-1-(3)



B-WP-1-(4)
Figure 4. Plan View showing area for Performance Confirmation Testing

Geoengineering Laboratory Samples

Definition of Test

The laboratory test (thermal and mechanical) using samples obtained from the ESF is discussed in Section 8.3.1.15.1 of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and the operational flexibility to perform the sample collection.

Performance Criteria

None

Constraints

None

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. Samples collected as described in the Mineralogy Petrology Sampling Test (B-GEO-2) will be divided at the SMF to supply samples for this testing.

2. Facilities for handling samples by the Principal Investigators will be provided as part of the SMF.

Multipurpose-Borehole

Definition of Test

The multipurpose-borehole (MPBH) testing near the exploratory shafts is discussed in Section 8.3.1.2.2.4.9 of the Statutory Draft of the Site Characterization Plan.

Functional Requirements

1. The functional design requirement is to provide the facility design and operational flexibility to perform testing in the multipurpose-boreholes.

Performance Criteria

1. MPBH-1 will be located near ES-1 and MPBH-2 will be near ES-2.

2. Periodic geophysical logging and pneumatic testing will be conducted in the MPBHs to monitor conditions during and after shaft construction.

Constraints

1. Each hole will be approximately 15 to 18 m from the corresponding shaft wall.

2. MPBH-1 will be drilled first.

3. Both of the MPBH boreholes will be drilled and completed before the start of construction for either of the exploratory shafts.

4. Hydraulic and hydrochemical sampling will be completed prior to construction of either of the two exploratory shafts.

5. Gas tracer will be used.

6. About 25 kg of cuttings will be collected for ^{36}Cl analysis each 25 m or more often.

7. Other tests should not be planned within a 28 ft radius of a vertical line passing through the surface location of each hole. (Check Radial Borehole Test for conflict?)

8. Drilling accuracy will be within 1.5°, which translates to a maximum of 28 ft deviation of the hole at 1050 ft (323 m) depths.

9. Both boreholes will be located such that they do not penetrate within a distance of either two shaft or drift diameters, as appropriate, of any underground opening.

Interface Requirements

1. Interface requirements to other systems, if applicable, are discussed in the appropriate integration studies.
   - Section B-IS-1 Integrated Data System
   - Section B-IS-2 Scientific Manpower/Schedule Information
   - Section B-IS-3 Laboratory/Office/Storage Space Requirements
   - Section B-IS-4 Electrical Power Requirements
   - Section B-IS-5 Water System Requirements
   - Section B-IS-6 Compressed Air System Requirements
   - Section B-IS-7 Common Sampling Design Requirements

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

Assumptions

1. There will be two multipurpose boreholes. Figure B-MPBH-1-(1) shows the conceptual geometry with respect to the MTL.

2. The multipurpose-boreholes will be emplaced using dry-drilling and spot-coring techniques.

3. Both boreholes will be about 15 cm in diameter and will be drilled to depths approximately equal to the corresponding shafts unless such depth would require penetration within either two shaft or drift diameters. In this case, a depth just short of two drift or shaft diameters is acceptable.

4. Cross hole testing between Radial Borehole Test and MPBH-1 is planned.

5. A third MPBH may be drilled somewhere between ES-1 and ES-2 if further study indicates the need for such a borehole.

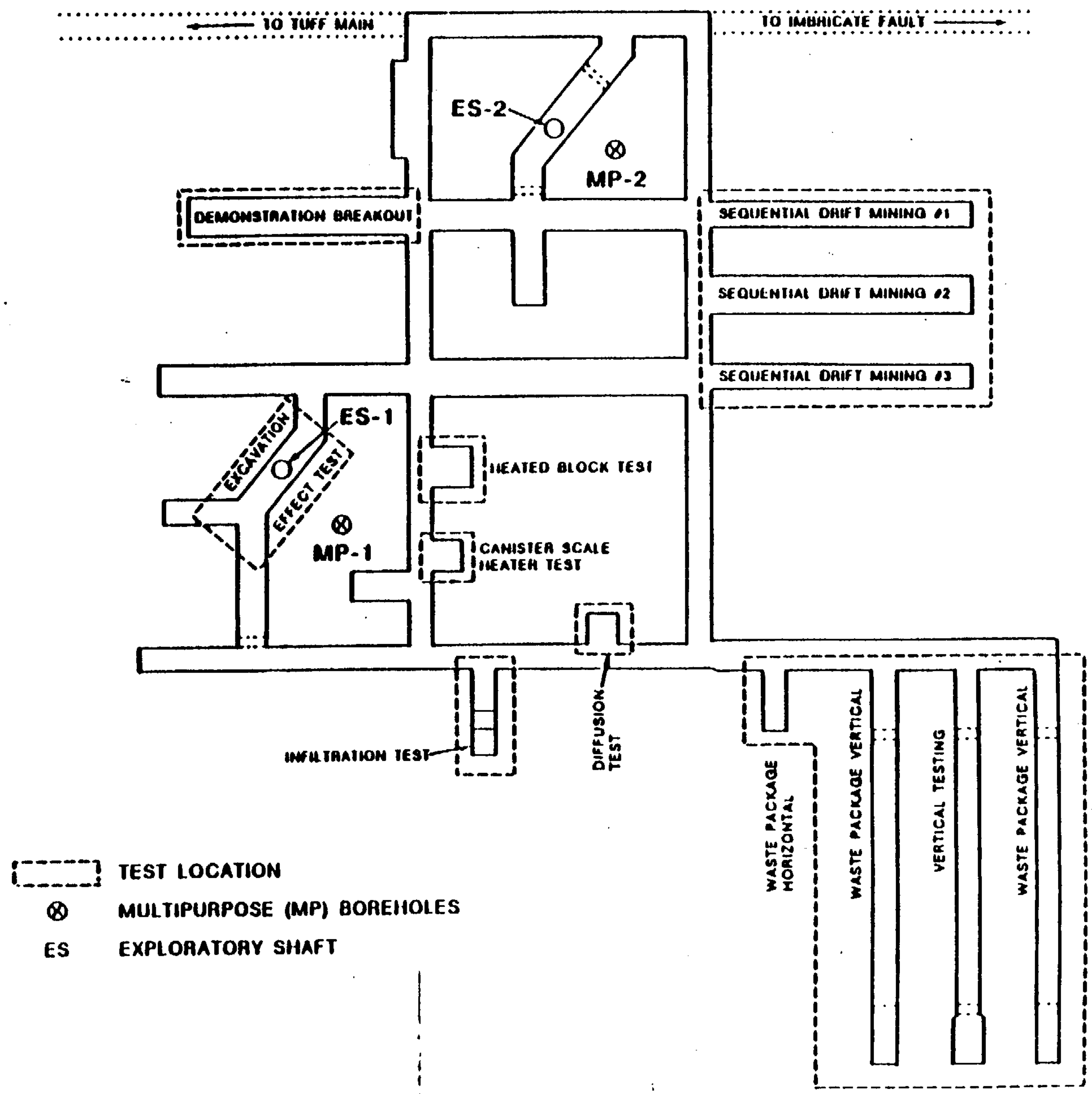


Figure 8.4.2-19. Location of multipurpose boreholes at the main test level (from Title I 100 percent design)

B-IS-1-1
1/23/89

IDS REQUIREMENTS

Definition of Component

1a. The IDS Surface Facility will be the principal location for housing of the primary IDS computers, dat. archiving devices and communications equipment. These systems will be used to collect, store and display ESF Site Characterization Data as the information is generated by geological tests conducted by PIs at the surface, in the vertical shafts and on the main test level.

1b. A surface facility to the instrumentation to be installed for Radial Borehole Test #1 is planned. This set of boreholes will be located 15 feet below the top of the shaft collar on ES-1.

2a. The IDS facility requirements to support the instrumentation to be installed for Radial Borehole and shaft convergence tests in ES-1.

2b. Data Acquisitions Station to be positioned in various locations on the main test level to provide support for site characterization tests.

Functional Requirements

1a. Provide the surface facilities necessary to provide the Principle Investigators and their respective organizations adequate IDS Support to be able to perform their testing needs.

1b. 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 location.

1c. To provide an enclosure (temporary building) on the surface, near ES-1, to contain the computer and data acquisition equipment needed to support RBT #1. Also, a concrete pad for a DCU (a permanent structure) must be provided immediately adjacent to ES-1 to support a data collection unit. In addition, a junction box, capable of interfacing 220 sensors, must be installed in ES-1 at the radial borehole location.

2. Provide the in-shaft facility necessary to provide the principal investigators and their respective organizations adequate IDS support to be able to perform their testing needs.

3. Provide the UDBR facilities necessary to provide the Principal Investigators and their respective organizations adequate IDS support to be able to perform their testing needs.

4. Provide the MTL facilities necessary to provide the Principal Investigators and their organizations adequate IDS design support to be able to perform their testing needs. The sizes of the equipment enclosures and their respective mounting pads are given in the attached IDS EQUIPMENT DATA SHEETS and B-IS-3 (Laboratory/Office/Storage Space Requirements). A typical Data Acquisition Station is shown on Figure B-IS-(4).

Performance Criteria

1a. A 50 feet x 50 feet metal (Butler type) building is required to house the IDS computers and associated equipment. Figure B-IS-(1) is a conceptual floorplan showing function allocation of space.

1b. The Butler building will have an 18 inch raised floor, or overhead raceways to house IDS power and data cabling. The cabling systems will be designed to provide the maximum possible separations between the power cables, the data cables and the communication cables.

1c. The Butler building will be environmentally controlled to provide a temperature of 74 degrees fahrenheit, plus or minus three degrees, and a relative humidity of 50% non-condensing. In addition windows will be dust tight and an air lock type entry will be provided.

1d. All power systems must have their neutral and grounds returned to a single common earth ground. In addition the metal building metallic segments must be connected together in such a fashion that the entire structure can be connected to the common earth ground.

1e. Non-power cabling is divided into three categories: Inter-IDS functions, which include information and control links between various IDS components; Intra-IDS functions, which include communications paths from the surface IDS computer system to off-site locations; and sensor functions which is the cabling plant necessary to support devices installed by PIs to acquire Site Characterization data. The cable routing for all of these cable types is shown in EG&G Drawing YF-91050001. The individual cable specifications will be furnished as the information becomes available.

1f. The Surface Facility requires 50 kVA, 208/120 VAC, three phase Uninterruptable Power derived as shown on Attachments #2 and #3.

1g. The Surface Facility requires 50 kVA, 208/120 VAC, three phase non-UPS power derived as shown on Figures B-IS-(2) and B-IS-(3).

1h. A halon system with water sprinkler back-up will be provided as the fire suppression system to the IDS buildings.

1i. A metal enclosure of at least 180 square feet is required to house the IDS computers and associated equipment for the RBT #1. The enclosure can be either an instrumentation trailer or a metal building. The enclosure will be used to house the RBT #1 support equipment until the IDS Surface FAcility becomes available. At that point the support equipment will be moved to the IDS Surface Facility. The enclosure will be located as near as possible to ES-1.

1j. The metal enclosure will be environmentally controlled to provide a temperature of 74 degrees fahrenheit, plus or minus three degrees, and a relative humidity of 50%, non-condensing.

The enclosure must be quipped with a filtered, positive pressure ventilation system to reduce the introduction of dust and other harmful materials.

1k. The cabling systems on all runs will be designed to provide the maximum possible separation between the power cables, the data cables and the communications cables.

1l. All power systems must have their neutral and grounds returned to a single common earth ground. In addition the metal building metallic segments must be connected together in such a fashion that the entire structure can be connected to the common earth ground.

1m. Cabling must be provided to connect the equipment in the surface enclosure to a sensor junction box located adjacent to the radial boreholes. This cabling must be able to support data/control links for IEEE-488 (General Purpose Interface Bus) and EIA Standard RS-232-C. In addition, cables must be available to provide Experimenters Intercom and Common Data service. The individual cable specifications will be furnished as the information becomes available.

1n. The RBT surface enclosure requires 1.5 kVA, 208/120 VAC, three phase Uninterruptable Power derived as shown on Figures B-IS-(2) and B-IS-(3).

1o. The RBT surface enclosure requires 1.5 kVA, 208/120 VAC, three phase non-UPS power derived as shown on Figures B-IS-(2) and B-IS-(3).

1p. A halon fire suppression system will be provided.

1q. Communications provided to this building will be ethernet A and B.

1r. There will be 220 channels provided to his building.

2a. Thirteen in-shaft data collection units will be provided see B-IS-3 (Laboratory/Office/Storage Space Requirements) for location and dimensions of these units. The units will be recessed in the shaft liner. The recessed location should be approximately 30 feet above the test that they are intended to support.

2b. The units will be controlled environmentally. A filtered air system and air conditioning will be provided. The air conditioner will keep the temperature at 74 degrees fahrenheit, plus or minus three degrees.

2c. These units will be constructed to provide maximum protection from construction accidents, but yet easy access to the instrumentation will be needed.

2d. 0.5 kVA, 120 VAC, single phase non-UPS power is required for all recessed units.

2e. 1.5 kVA, 120 VAC, single phase UPS power is required for all recessed units.

2f. 1.5 kVA, 120 VAC, and single phase emergency power is required for all recessed units.

2g. The in-shaft data collection unit # 1 will have communications channels to the me[illegible] building adjacent to the shaft. The remaining in-shaft collection units will have their communications channels link to the data alcoves at the UDBR or MTL, whichever is easier to use.

2h. In-shaft data collection units 2, 3, 5, 6, and 8 require 220 channels.

2i. In-shaft data collection units 4 and 7 require 342 channels.

2j. In-shaft data collection unit 9 requires 200 channels.

2k. A cabling zone box must be provided in the near vicinity of each radial borehole or shaft convergence borehole. These zone boxes will provide connections for 220 data channels for radial borehole tests and 342 data channels in those locations where radial borehole tests and shaft convergence test coincide.

2l. Cabling must be provided between each zone box and its associated Data Collection Unit. Specific cable types and numbers will be furnished as the information is developed.

3a. Two 9 feet by 20 feet metal (Bally) buildings, with air lock entries are required to house the UDBR IDS equipment. There buildings will be occupied by the USGS and SNL, respectively.

3b. These buildings will have an 18 inch raised floor to house data cabling.

3c. These buildings will be environmentally controlled. An optimum temperature of 74 degrees fahrenheit plus or minus three degrees, and a relative humidity of 50% is required.

3d. 15 kVA, 120/208 VAC, three phase non-UPS power is required.

3e. 20 kVA, 120/208 VAC, three phase UPS power is required.

3f. 20 kVA, 120/208 VAC, three phase emergency power is required.

3g. A halon fire suppression system is needed for both DAS.

3h. Communications for each of these DAS will be ether net A and B, and 2 telephones in each DAS.

3i. The SNL DAS will require 787 data channels.

3j. The USGS DAS will require 1000 data channels.

4a. Fifteen Data Acquisition Stations will be provided. The specific tests to be supported are given in the attached IDS Equipment data sheets.

4b. Each Data Acquisition Station must be located as near to its supported test as is possible, within the constraints of good mining practice.

4c. Each Data Acquisition station will be environmentally controlled to provide a temperature of 74 degrees fahrenheit, plus or minus three degrees, and a relative humidity of 50% non-condensing. An air lock entry will be provided for each DAS.

4d. Zone boxes must be distributed in each test area to allow the connection of sensors. The Zone boxes must support up to 200 sensors of various types and must be installed such that the cable runs to the sensor groups is as short as possible.

4e. Cabling must be provided between each zone box and its associated Data Acquisition Station. Specific cable types and numbers will be furnished as the information is developed.

4f. Cabling must be provided from each DAS to other IDS components as indicated on EG&G Drawing YF-91050001.

4g. The cabling systems will be designed to provide the maximum possible separation between the power cables, the data cables and the communications cables.

4h. All power systems must have their neutral and grounds returned to a single common earth ground.

4i. UPS and non-UPS power must be supplied to the Data Acquisition Stations as indicated on the attached IDS Equipment sheets. The IDS power will be derived as shown on Figures B-IS-(5) and B-IS-(6), (IDS Underground Power Distribution).

4j. The Data Acquisition Stations will be connected to the Experimenters Intercom system and will include one telephone per station.

4k. Five metal (BAlly) buildings are required to house the SNL IDS equipment at the MTL.

4l. 4 - 9 feet x 20 feet buildings with air-lock entries will be provided.

4m. These buildings will be environmentally controlled, and will have an 18 inch raised floor to house data cabling, an optimum temperature of 74 degrees fahrenheit plus or minus three degrees, and a relative humidity of 50% will be provided.

4n. UPS and emergency power required is 20 kVA, 120/208 VAC, three phase. Non-UPS required is 15 kVA, 120/208 VAC, three phase.

4o. A halon fire suppression system will be needed for each building.

4p. Communications required for each building are ethernet A and B, and 2 telephones.

4q. One building will be located adjacent to the LDBR and will require 787 data channels.

4r. One building will be located adjacent to the Yucca Mountain Heated Room test and will require 278 data channels.

4s. Two buildings will be located adjacent to the Sequential Drift Mining test and will require 402 data channels each.

4t. The fifth building's dimensions are 15 feet x 55 feet, and air lock entries will be provided.

4u. This building will be environmentally controlled. An 18 inch raised floor will be provided to house data cabling, an optimum temperature of 74 degrees fahrenheit will be required, plus or minus three degrees, and a relative humidity of 50 % will be needed.

4v. 35 kVA, 120/208 VAC, three phase UPS power is required.

4w. 30 kVA, 120/208 VAC, three phase non-UPS and emergency power is required.

4x. A halon fire suppression system with sprinkler backup will be provided.

4y. Communications needed for this building will be ethernet A and B, 6 telephones, and an intercom system.

4z. This building will require 205 data channels.

4aa. Five metal (Bally) buildings are required to house the USGS/LANL IDS equipment at the MTL.

4bb. Five 9 feet x 40 feet buildings with air lock entries will be provided.

4cc. These buildings will support, respectively, the diffusion (LANL) Test, Infiltration (USGS) Test and Bulk Permeability (USGS) Test 1 through 4.

4dd. These buildings will be environmentally controlled. They will have an 18 inch raised floor to house data cabling, an optimum temperature of 74 degrees fahrenheit, plus or minus three degrees, and a relative humidity of 50%.

4ee. UPS and emergency power required is 20 kVA, 120/208 VAC, three phase. Non-UPS power required is 15kVA, 120/208 VAC, three phase.

4ff. A halon fire suppression system is needed for each building.

4gg. Communications required for each building are ethernet A and B, and 3 telephones.

4hh. The location of the Diffusion/Infiltration Tests DAS building will be adjacent to the Infiltration Test, while the location of the Bulk Permeability Tests DAS building will be adjacent to each Bulk Permeability Test.

4ii. The Diffusion/Infiltration Tests building will require 2000 data channels. The Bulk Permeability Tests buildings will each require 1775 data channels.

4jj. One metal (Bally) building is required to house the USGS IDS equipment at the CHDR.

4kk. One 9 feet x 40 feet building with an air lock entry will be provided.

4ll. This building will support the Calico Hills (USGS) Tests.

4mm. This building will be environmentally controlled. It will have an 18 inch raised floor to house data cabling, an optimum temperature of 74 degrees fahrenheit, plus or minus three degrees, and a relative humidity of 50%

4nn. UPS and emergency power required is 20 kVA, 120/208 VAC, three phase. Non-UPS power is 15 kVA, 120/208 VAC, three phase.

4oo. A halon fire suppression system is needed for this building.

4pp. Communications required for this building are ethernet A and B, and 3 telephones.

4qq. The location of this DAS building will be at the CHDR, and will be situated in such a way that all Calico Hills tests can be served in an optimum fashion.

4rr. This building will require 1000 data channels.

4ss. Two metal (Bally) buildings are required to house the LLNL IDS equipment at the MTL.

4tt. Two 9 feet x 20 feet buildings with an air lock entry is required.

4uu. These buildings will support the LLNL Waste Package Horizontal and Waste Package Vertical Tests.

4vv. These buildings will be environmentally controlled. They will have an 18 inch raised floor, an optimum temperature of 74 degrees fahrenheit, plus or minus three degrees, and a relative humidity of 50%.

4ww. UPS and emergency power required is 20 kVA, 120/208 VAC, three phase. Non-UPS power is 15 kVA, 120/208 VAC, three phase.

4xx. A halon fire suppression system is needed for these buildings.

4yy. Communications required for these buildings are ethernets A and B.

4zz. One DAS building will be located adjacent to the Waste Package Horizontal Test, and the other will be located adjacent to the Waste Package Vertical Test.

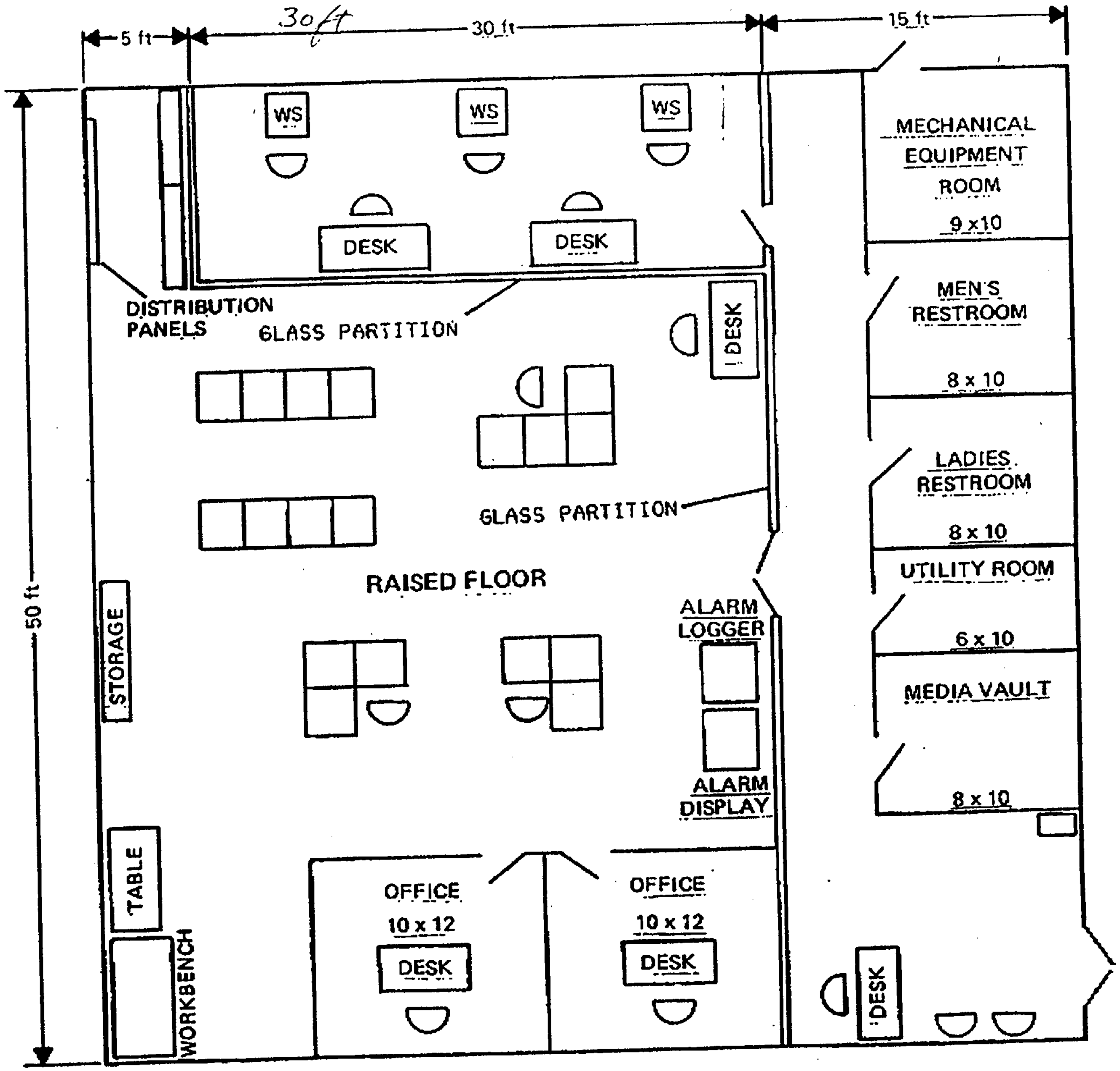
4aaa. The Waste Package Horizontal Test will require 869 channels. The Waste Package Vertical Test will require 1000 data channels.

Constraints

1. The IDS Surface Facilities must 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.

<u>Assumptions</u>

1. The IDS surface facility will be in place in time to support IDS installation and startup of the equipment required to acquire data from Radial Borehole Test #2.
2. The Temporary enclosure and DCU (FR #1c) will be in place in time to support RBT #1. RBT #1 is expected to be located 15 feet below the top of ES-1 collar.



IDS Surface facility layout (approx. 2500 sq. ft.)

SDRD APP. B
SECTION B-IS-1
~~ATTACHMENT~~ FIGURE ~~#~~ B-IS-(1)

S. DEPARTMENT OF ENERGY

OCRWM

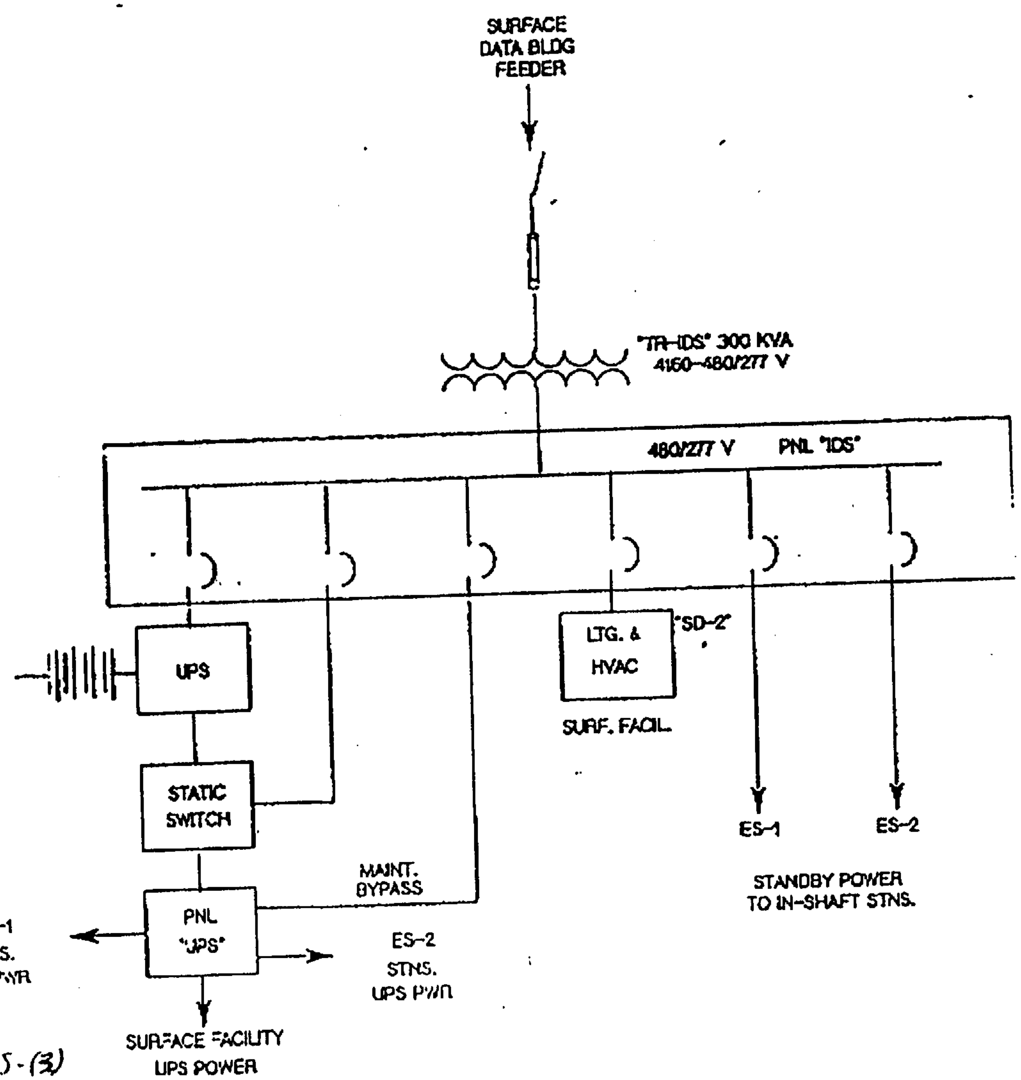
Nevada Nuclear Waste Storage Investigations PROJECT

YUCCA MOUNTAIN

OGR

IDS SURFACE DATA BLDG. SIMPLIFIED POWER DISTRIBUTION

Los Alamos



SDRD App. B
Section B-IS-1
~~Attachment~~ 3 Figure B-IS-(3)

DEPARTMENT OF ENERGY

OCRWM

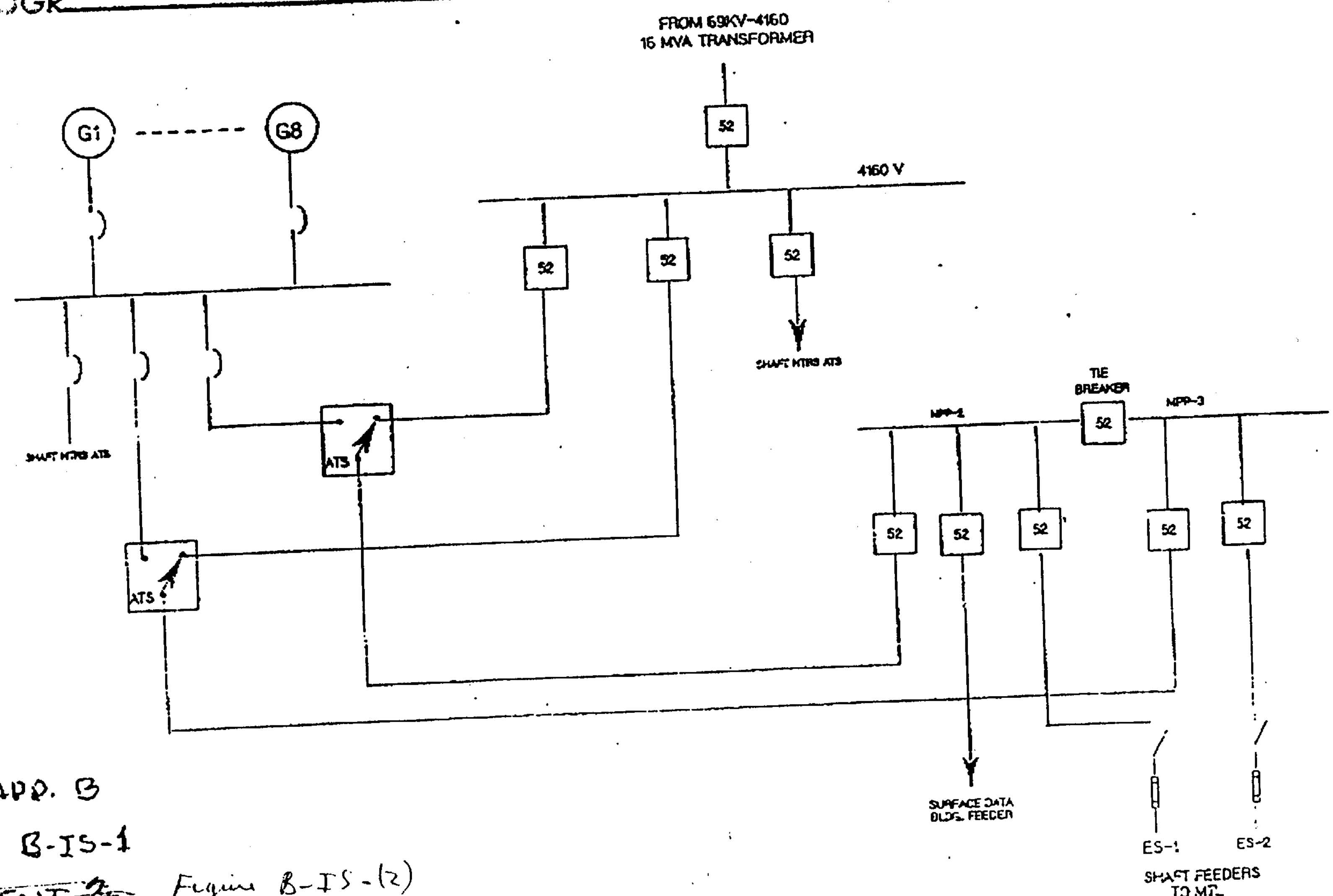
OGR

Nevada Nuclear Waste Storage Investigations PROJECT

YUCCA MOUNTAIN

IDS SURFACE FACILITIES SIMPLIFIED 1-LINE DIAG.

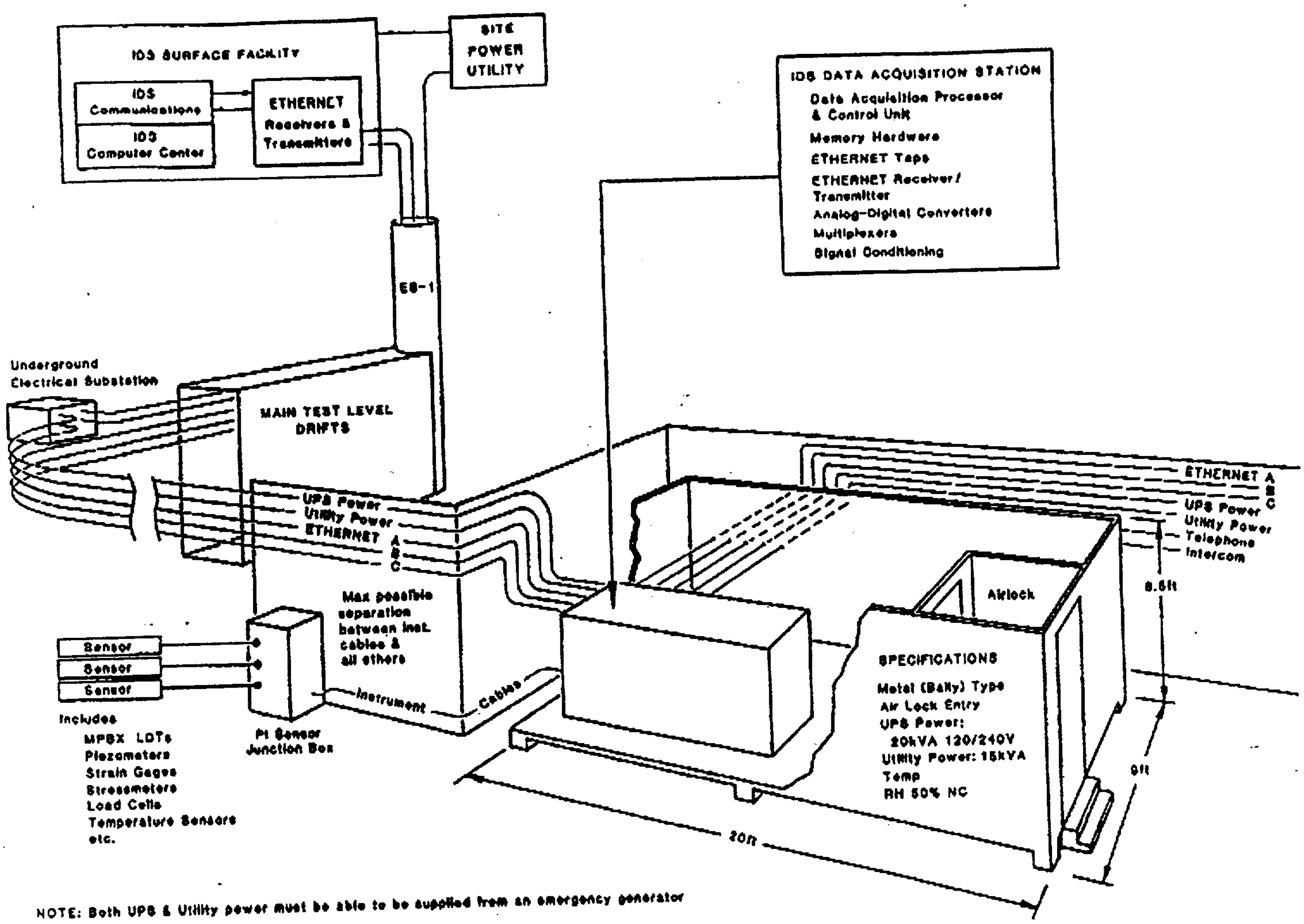
Los Alamos



SDRD APP. B

SECTION B-IS-1

~~ATTACHMENT 2~~ Figure B-IS-(2)



NOTE: Both UPS & Utility power must be able to be supplied from an emergency generator

IDS Data Acquisition Station

B-IDS (4)

U.S. DEPARTMENT OF ENERGY

OCRWM

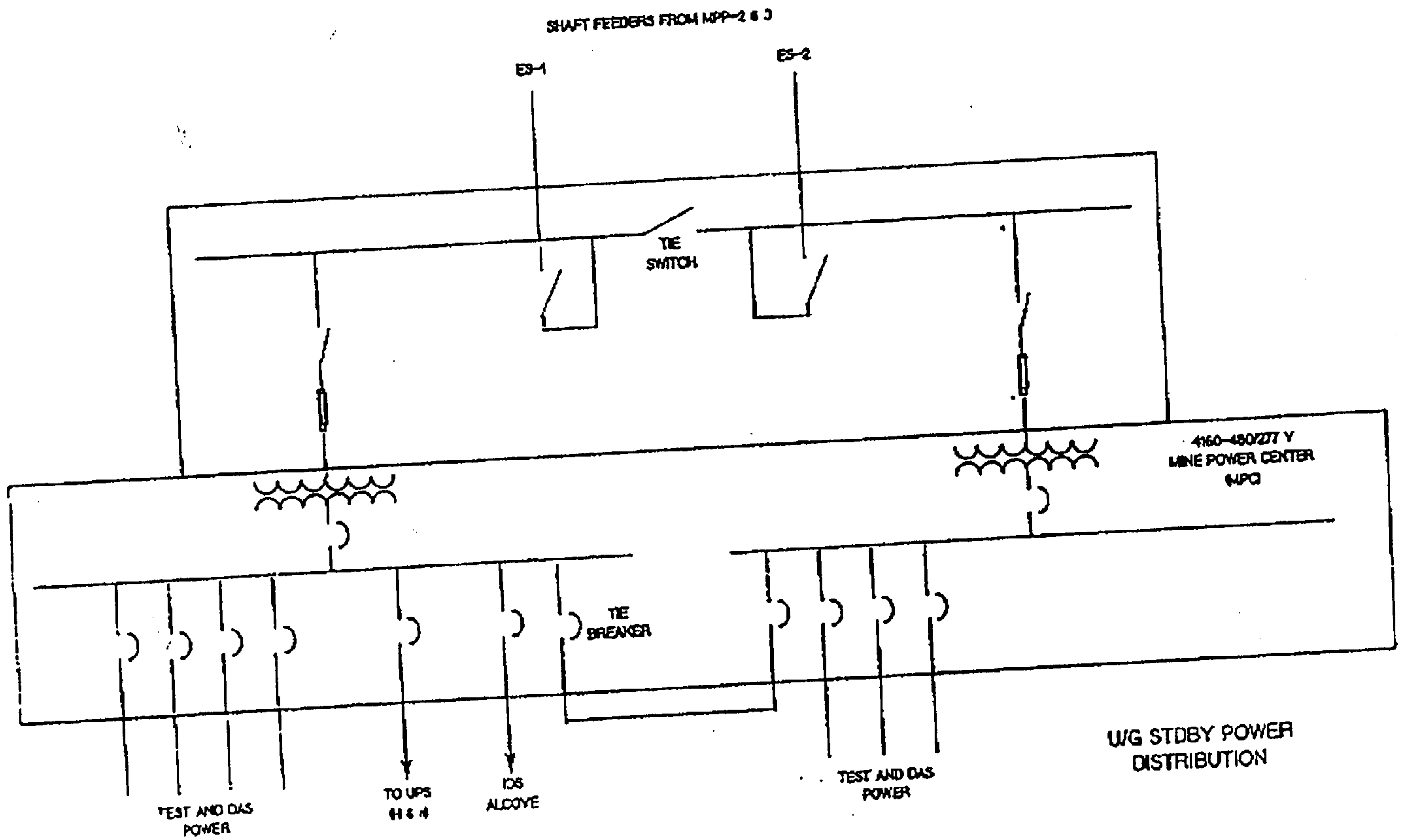
Nevada Nuclear Waste Storage Investigations PROJECT

YUCCA MOUNTAIN

OGR

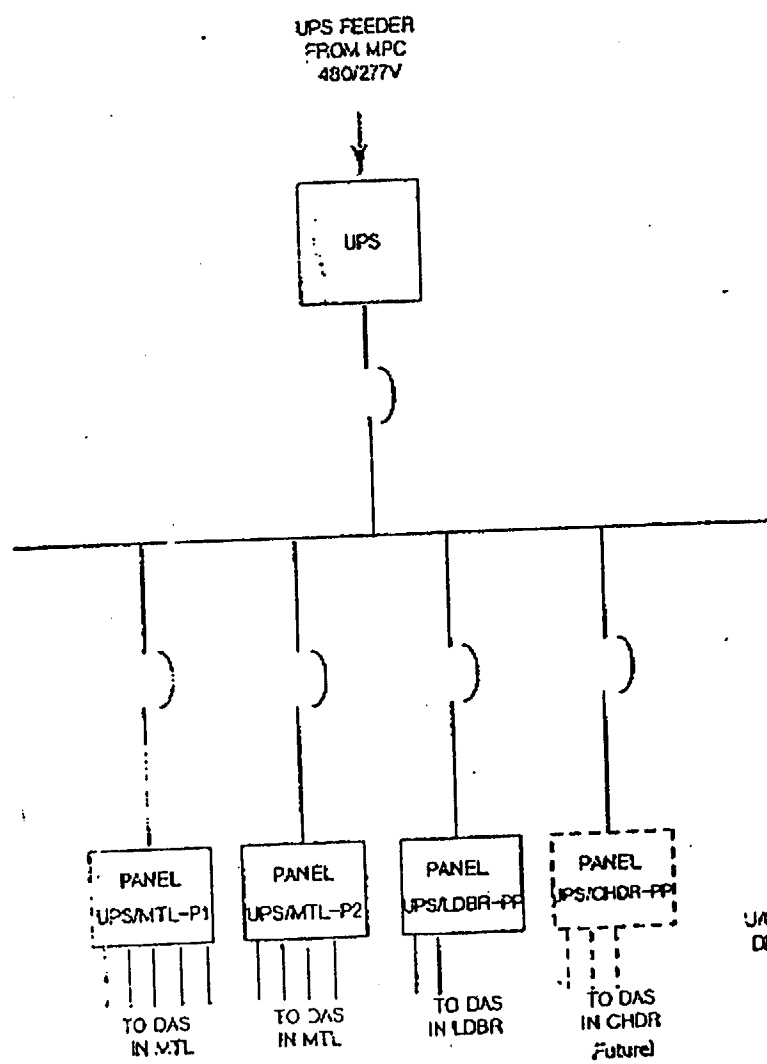
Los Alamos

IDS UNDERGROUND SIMPLIFIED POWER DISTRIBUTION DIAGRAM



B-IDS (5)

IDS UNDERGROUND UPS DISTRIBUTION



U/G UPS POWER DISTRIBUTION

B-IDS(b)

1/23/89

*** IDS EQUIPMENT DATA SHEET #1 ***

THE COMPONENT NAME IS IDS SURFACE COMPUTER SYSTEM

THE TEST SUPPORTED ARE ALL

THIS COMPONENT IS LOCATED IN IDS MAIN SURFACE FACILITY

THE SIZE OF THE COMPONENT ENCLOSURE IS 50" X 50' (2500 FT. SQ.)

THE TYPE OF CONSTRUCTION IS METAL (BUTLER) TYPE

THE ENCLOSURE IS MOUNTED CONCRETE PAD

THE UPS POWER REQUIRED IS 50 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 50 KVA, 208/120 3 PHASE

THE ENVIRONMENTAL REQUIREMENTS ARE RAISED FLOOR, 74 +/-03 DEG, RH 50%NC

FIRE REQUIREMENTS ARE HALON, SPRINKLER BACKUP

COMMUNICATIONS TO THIS COMPONENT 3 ETHERNET, TELEPHONE, INTERCOM

CABLING 3 ETHERNETS ITEM #1

NOTES MET. AND OTHER COMMON DATA CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #2 ***

THE COMPONENT NAME IS A & E BUILDING IDS FACILITY

THE TEST SUPPORTED ARE WORKSTATIONS, CALIBRATION AND STORAGE

THIS COMPONENT IS LOCATED IN A & E BUILDING, AREA 25

THE SIZE OF THE COMPONENT ENCLOSURE IS 2575 SQ. FT.

THE TYPE OF CONSTRUCTION IS TYPICAL FOR OFFICE AND STORAGE SPACES

THE ENCLOSURE IS MOUNTED NA

THE UPS POWER REQUIRED IS NONE

THE NON-UPS POWER REQUIRED IS 5 KVA, 120 VAC, 1 PHASE

THE ENVIRONMENTAL REQUIREMENTS ARE TYPICAL FOR OFFICE SPACES

FIRE REQUIREMENTS ARE

COMMUNICATIONS TO THIS COMPONENT RS-232 CONNECTIONS TO MICROWAVE LINK

CABLING ITEM #2

NOTES CALIBRATION AND TESTING

1/23/89

*** IDS EQUIPMENT DATA SHEET #3 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #1

THE TEST SUPPORTED ARE RADIAL BOREHOLE #1

THIS COMPONENT IS LOCATED IN ON SURFACE ADJACENT TO ES-1

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED ON CONCRETE PAD, 17' X 26'

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE TEMPERATURE 74 +/-3 DEG., RH 50%NC

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #3

NOTES 220 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #4 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #2

THE TEST SUPPORTED ARE RADIAL BOREHOLE #2

THIS COMPONENT IS LOCATED IN ES-1, 30 FEET ABOVE BOREHOLE #2

THE SIZE OF THE COMPONENT ENCLOSURE IS 4' X 4' X 8

THE TYPE OF CONSTRUCTION IS HEAVY DUTY NEMA-12 (SEE ATTACHED SKETCH)

THE ENCLOSURE IS MOUNTED RECESSED IN SHAFT WALL IN SPACE 4' X 4' X 8

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE FILTERED AIR, TEMPERATURE CONTROL

FIRE REQUIREMENTS ARE NONE

COMMUNICATIONS TO THIS COMPONENT DATA TO SURFACE AND/OR DATA ALCOVE, IN

CABLING ITEM #4

NOTES 220 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #5 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #3

THE TEST SUPPORTED ARE RADIAL BOREHOLE #3

THIS COMPONENT IS LOCATED IN ES-1, 30 FEET ABOVE BOREHOLE #3

THE SIZE OF THE COMPONENT ENCLOSURE IS 4' X 4' X 8'

THE TYPE OF CONSTRUCTION IS HEAVY DUTY NEMA-12 (SEE ATTACHED SKETCH

THE ENCLOSURE IS MOUNTED RECESSED IN SHAFT WALL IN SPACE 4' X 4' X 8

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE FILTERED AIR, TEMPERATURE CONTROL

FIRE REQUIREMENTS ARE NONE

COMMUNICATIONS TO THIS COMPONENT DATA TO SURFACE AND/OR DATA ALCOVE, IN

CABLING ITEM #5

NOTES 220 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #6 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #4

THE TEST SUPPORTED ARE RADIAL BOREHOLE #4, SHAFT CONV. #1

THIS COMPONENT IS LOCATED IN ES-1, 30 FEET ABOVE BOREHOLE #4

THE SIZE OF THE COMPONENT ENCLOSURE IS 4' X 4' X 8'

THE TYPE OF CONSTRUCTION IS HEAVY DUTY NEMA-12 (SEE ATTACHED SKETCH)

THE ENCLOSURE IS MOUNTED RECESSED IN SHAFT WALL IN SPACE 4' X 4' X 8

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE FILTERED AIR, TEMPERATURE CONTROL

FIRE REQUIREMENTS ARE NONE

COMMUNICATIONS TO THIS COMPONENT DATA TO SURFACE AND/OR DATA ALCOVE, IN

CABLING ITEM #6

NOTES 342 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #7 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #5

THE TEST SUPPORTED ARE RADIAL BOREHOLE #5

THIS COMPONENT IS LOCATED IN ES-1, 30 FEET ABOVE BOREHOLE #5

THE SIZE OF THE COMPONENT ENCLOSURE IS 4' X 4' X 8'

THE TYPE OF CONSTRUCTION IS HEAVY DUTY NEMA-12 (SEE ATTACHED SKETCH)

THE ENCLOSURE IS MOUNTED RECESSED IN SHAFT WALL IN SPACE 4' X 4' X 8

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE FILTERED AIR, TEMPERATURE CONTROL

FIRE REQUIREMENTS ARE NONE

COMMUNICATIONS TO THIS COMPONENT DATA TO SURFACE AND/OR DATA ALCOVE, IN

CABLING ITEM #7

NOTES 220 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #8 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #6

THE TEST SUPPORTED ARE RADIAL BOREHOLE #6

THIS COMPONENT IS LOCATED IN ES-1, 30 FEET ABOVE BOREHOLE #6

THE SIZE OF THE COMPONENT ENCLOSURE IS 4' X 4' X 8'

THE TYPE OF CONSTRUCTION IS HEAVY DUTY NEMA-12 (SEE ATTACHED SKETCH)

THE ENCLOSURE IS MOUNTED RECESSED IN SHAFT WALL IN SPACE 4' X 4' X 8

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE FILTERED AIR, TEMPERATURE CONTROL

FIRE REQUIREMENTS ARE NONE

COMMUNICATIONS TO THIS COMPONENT DATA TO SURFACE AND/OR DATA ALCOVE, IN

CABLING ITEM #8

NOTES 220 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #9 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #7

THE TEST SUPPORTED ARE RADIAL BOREHOLE #7, SHAFT CONV. #2

THIS COMPONENT IS LOCATED IN ES-01, 30 FEET ABOVE BOREHOLE #7

THE SIZE OF THE COMPONENT ENCLOSURE IS 4' X 4' X 8'

THE TYPE OF CONSTRUCTION IS HEAVY DUTY NEMA-12 (SEE ATTACHED SKETCH)

THE ENCLOSURE IS MOUNTED RECESSED IN SHAFT WALL IN SPACE 4' X 4' X 8

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE FILTERED AIR, TEMPERATURE CONTROL

FIRE REQUIREMENTS ARE NONE

COMMUNICATIONS TO THIS COMPONENT DATA TO SURFACE AND/OR DATA ALCOVE, IN CABLING ITEM #9

NOTES 342 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #10 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #8

THE TEST SUPPORTED ARE RADIAL BOREHOLE #8

THIS COMPONENT IS LOCATED IN ES-1, 30 FEET ABOVE BOREHOLE #8

THE SIZE OF THE COMPONENT ENCLOSURE IS 4' X 4' X 8'

THE TYPE OF CONSTRUCTION IS HEAVY DUTY NEMA-12 (SEE ATTACHED SKETCH)

THE ENCLOSURE IS MOUNTED RECESSED IN SHAFT WALL SPACE 4' X 4' X 8

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE FILTERED AIR, POSSIBLE TEMPERATURE C

FIRE REQUIREMENTS ARE NONE

COMMUNICATIONS TO THIS COMPONENT DATA TO SURFACE AND/OR DATA ALCOVE, IN

CABLING ITEM #10

NOTES 220 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #11 ***

THE COMPONENT NAME IS IN-SHAFT DATA COLLECTION UNIT #9

THE TEST SUPPORTED ARE SHAFT CONVERGENCE TEST #3

THIS COMPONENT IS LOCATED IN ES-1 30 FEET ABOVE SHAFT CONV. TEST

THE SIZE OF THE COMPONENT ENCLOSURE IS 4' X 4' X 8'

THE TYPE OF CONSTRUCTION IS HEAVY DUTY NEMA-12

THE ENCLOSURE IS MOUNTED RECESSED IN SHAFT WALL IN SPACE 4' X 4' X 8

THE UPS POWER REQUIRED IS 1.5 KVA, 120 VAC, 1 PHASE

THE NON-UPS POWER REQUIRED IS 0.5 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE FILTERED AIR, TEMPERATURE CONTROL

FIRE REQUIREMENTS ARE NONE

COMMUNICATIONS TO THIS COMPONENT

CABLING ITEM #11

NOTES 200 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #12 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #1

THE TEST SUPPORTED ARE UDBR USGS TESTS

THIS COMPONENT IS LOCATED IN UDBR

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 26'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #12

NOTES 1000 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #13 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #2

THE TEST SUPPORTED ARE UDBR SNL TESTS

THIS COMPONENT IS LOCATED IN UDBR

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 26'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT

CABLING ITEM #13

NOTES 787 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #14 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #3

THE TEST SUPPORTED ARE LDBR SNL TESTS

THIS COMPONENT IS LOCATED IN MAIN TEST LEVEL, ADJACENT TO LDBR

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD 17' X 26'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 WI.

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #14

NOTES 787 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #15 ***

THE COMPONENT NAME IS IDS ALCOVE COMPUTER SYSTEM, STA #4

THE TEST SUPPORTED ARE HEATED BLOCK, CANISTER SCALE HEATER

THIS COMPONENT IS LOCATED IN IDS ALCOVE, MAIN TEST LEVEL

THE SIZE OF THE COMPONENT ENCLOSURE IS 15' X 55' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL, AIR LOCK ENTRY, RAISED FLOOR

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 25' X 71'

THE UPS POWER REQUIRED IS 35 KVA, 120/208 VAC, 3 PHASE

THE NON-UPS POWER REQUIRED IS 30 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON, SPRINKLER BACKUP

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B, TELEPHONE, INTERCOM

CABLING VARIOUS ETHERNET ITEM #15

NOTES 705 CHANNELS, USER WORK STATIONS

1/23/89

*** IDS EQUIPMENT DATA SHEET #16 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #5

THE TEST SUPPORTED ARE WEST BULK PERMEABILITY #1

THIS COMPONENT IS LOCATED IN MAIN TEST LEVEL, ADJACENT TO #1 BULK PER

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 40' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 46'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #16

NOTES 1775 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #17 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #6

THE TEST SUPPORTED ARE DIFFUSION, INFILTRATION

THIS COMPONENT IS LOCATED IN MTL ADJACENT TO DIFFUSION TEST

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 40' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 46'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #17

NOTES 2000 CHANNEL CAPACITY, NON-REDUNDANT, USER WORK STATIONS

1/23/89

*** IDS EQUIPMENT DATA SHEET #18 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #7

THE TEST SUPPORTED ARE YUCCA MTN. HEATED ROOM TEST

THIS COMPONENT IS LOCATED IN MTL ADJACENT TO YM TEST

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 26'

THE UPS POWER REQUIRED IS 20 KVA, 208/120 VAC, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT

CABLING ITEM #18

NOTES 278 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #19 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #8

THE TEST SUPPORTED ARE WASTE PACKAGE HORIZONTAL TEST

THIS COMPONENT IS LOCATED IN MTL ACROSS DRIFT FROM WP HORIZONTAL TEST

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 26'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #19

NOTES 869 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #20 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #9

THE TEST SUPPORTED ARE WASTE PACKAGE VERTICAL TEST

THIS COMPONENT IS LOCATED IN MTL ACROSS DRIFT FROM WP VERTICAL TEST

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 36'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #20

NOTES 1000 CHANNEL CAPACITY, NON-REDUNDANT

1/23/89

*** IDS EQUIPMENT DATA SHEET #21 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #10

THE TEST SUPPORTED ARE SOUTH BULK PERMEABILITY #2

THIS COMPONENT IS LOCATED IN MTL ADJACENT TO #2 BULK PERMEABILITY TES

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 40' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD 17' X 46'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #21

NOTES 1775 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #22 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #11

THE TEST SUPPORTED ARE SEQUENTIAL DRIFT MINING #1

THIS COMPONENT IS LOCATED IN MTL ADJACENT TO SEQUENTIAL DRIFT MINING

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 26'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA, 120 VAC

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #22

NOTES 482 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #23 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #12

THE TEST SUPPORTED ARE SEQUENTIAL DRIFT MINING #1

THIS COMPONENT IS LOCATED IN MTL ADJACENT TO SEQUENTIAL DRIFT MINING

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 20' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 26'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA, 120 VAC, 1 PHASE

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #23

NOTES 482 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #24 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #13

THE TEST SUPPORTED ARE EAST BULK PERMEABILITY #3

THIS COMPONENT IS LOCATED IN MTL ADJACENT TO #3 BULK PERMEABILITY TES

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 40' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 46'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #24

NOTES 1775 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #25 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #14

THE TEST SUPPORTED ARE NORTH BULK PERMEABILITY #4

THIS COMPONENT IS LOCATED IN MTL ADJACENT TO #4 BULK PERMEABILITY TES

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 40' X 8.5

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 46'

THE UPS POWER REQUIRED IS 20 KVA, 208/120 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #25

NOTES 1775 CHANNELS

1/23/89

*** IDS EQUIPMENT DATA SHEET #26 ***

THE COMPONENT NAME IS DATA ACQUISITION STATION #15

THE TEST SUPPORTED ARE CALICO HILLS TESTS

THIS COMPONENT IS LOCATED IN CALICO HILLS

THE SIZE OF THE COMPONENT ENCLOSURE IS 9' X 40' X 8.5'

THE TYPE OF CONSTRUCTION IS METAL (BALLY) TYPE, AIR LOCK ENTRY

THE ENCLOSURE IS MOUNTED CONCRETE PAD, 17' X 46'

THE UPS POWER REQUIRED IS 20 KVA, 208/120, 3 PHASE

THE NON-UPS POWER REQUIRED IS 15 KVA

THE ENVIRONMENTAL REQUIREMENTS ARE COMPUTER GRADE

FIRE REQUIREMENTS ARE HALON

COMMUNICATIONS TO THIS COMPONENT ETHERNET A & B

CABLING ITEM #26

NOTES 1000 CHANNELS

Scientific Manpower Requirements for Testing

Definition of Test

This testing integration study defines the recommended planning and design assumptions for on-site scientific manpower requirements to support ESF testing.

Functional Requirements

1. Provide the system design sufficient flexibility to accommodate ESF testing requirements.

Performance Criteria

1. The ESF should be designed to accommodate a nominal scientific workforce of 100 persons.

2. Peak scientific manpower, during day shift in the first few months as the MTL test areas first become available, is estimated to be 120 people.

Assumptions

1. The analysis was based on a network of 670 test activities with resource loading. 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.

2. This manpower estimate does not include

   A. Drilling crews

   B. Cable plant installation

   C. Construction activities

   D. Official visitors

Laboratory/Office/Storage Space Requirements

Functional Requirements

1. Provide adequate space at the ESF, surface and underground, for each testing organization to be able to satisfactorily perform the following tests.
   a. Min/Pet Sampling Test (LANL)
   b. Hydrologic Properties Sampling Test (USGS-Hyd)
   c. Chlorine-36 Test (LANL)
   d. Geoengineering Laboratory Samples Test (SNL)
   e. Diffusion Test (LANL)
   f. Overcore Stress Test (USGS-Mech)

2. Provide adequate space at the ESF, surface and underground, for each testing organization to be able to satisfactorily perform the following tests.
   a. Demonstration Breakout Room Test (UDBR and MTL)(SNL)
   b. Plate Loading Test (SNL)
   c. TSw1 Heater Test (SNL)
   d. Sequential Drift Mining Test (SNL)
   e. Horizontal Boring Machine Test (SNL)
   f. Excavation Effects Test (UDBR and MTL)(USGS-Hyd)
   g. Intact Fracture Test (USGS-Hyd)

3. Provide adequate space at the ESF, surface and underground, for each testing organization to be able to satisfactorily perform the following tests.
   a. Underground Geologic Mapping Test (USGS-Geo)
   b. Vertical Seismic Profiling Test (LBL)
   c. Shaft Convergence Test (SNL)
   d. Radial Borehole Test (USGS-Hyd)
   e. Perched Water Test (USGS-Hyd)
   f. Hydrochemistry Test (USGS-Hyd)

4. Provide adequate space at the ESF, surface and underground, for each testing organization to be able to satisfactorily perform the following tests.
    a. Evaluation of Mining Methods Test (SNL)
    b. Monitoring of Ground Support Systems Test (SNL)
    c. Monitoring Drift Stability Test (SNL)
    d. Air Quality and Ventilation Test (SNL)

5. Provide adequate space at the ESF, surface and underground for each testing organization to be able to satisfactorily perform the following tests.
    a. Canister Scale Heater Test (SNL)
    b. Yucca Mountain Heated Block Test (SNL)
    c. Thermal Stress Measurements Test (SNL)
    d. Rock Mass Strength Test (SNL)

6. Provide adequate space at the ESF, surface and underground for each testing organization to be able to satisfactorily perform the following tests.
    a. Infiltration Test (USGS-Hyd)
    b. Bulk Permeability Test (USGS-Hyd)
    c. Calico Hills Test (USGS-Hyd)

7. Provide adequate space at the ESF, surface and underground for each testing organization to be able to satisfactorily perform the following tests.
    a. Heated Room Test (SNL)
    b. Engineered Barrier Design Test (LLNL)

Performance Criteria

1a. 150 sq ft of office space and limited storage space at the ESF (surface) will be provided.

1b. 150 sq ft of storage space for three rock collection bins. This space will be located near the ES-1 shaft, and will be common to the sample collection point at the ES-1 collar.

1c. An alcove 10 ft x 10 ft x 16 ft will be provided at the MTL and the CHDR to perform the drilling for the Diffusion Test (see performance Criteria 6c.)

1d. Storage space for four nitrogen bottles will be provided in the Diffusion Test alcove.

1e. Adequate space will be provided in the drifts at the MTL and CHDR to perform overcoring for the Overcore Stress Test.

1f. 1000 sq ft of space will be provided at the auxiliary pad for two semi-trailer units. (purpose?)

2a. 200 sq ft of office space and limited storage space at the ESF (surface) will be provided.

2b. The Demonstration Breakout Room will require an area 25 ft wide x 19 ft high x 150 ft long at both the UDBR and MTL. The 150 ft length begins at the corner of any opening perpendicular to the DBR drift and extends without any alcoves or openings within the drift for 150 ft.

2c. A DAS will be provided for the SNL tests at the UDBR and the DBR at the MTL. It will require an area 17 ft wide x 14 ft high x 26 ft long.

2d. Space for the TSw1 Heater Test will be provided at the UDBR. At this time, no additional excavation is needed.

2e. Space for the Plate Loading Tests will be provided at the UDBR and MTL. Approximately 15 plate loading tests will be performed in the ESF, and no additional excavation is planned at this time.

2f. Space for the Excavation Effect Test will be provided at the UDBR and MTL. No additional excavation is planned at this time.

2g. A DAS will be provided for the Excavation Effects Test at the UDBR. Dimensions for the DAS are 17 ft wide x 14 ft high x 26 ft long.

2h. Space for the Equipment Development Test will be provided at the MTL. No additional excavation is required at this time.

2i. Three drifts will be excavated for the Sequential Drift Mining Test. Two instrumentation drifts will be 16 ft wide x 14 ft high x 180 ft long. The third (center) drift will be 25 ft wide x 10 ft high x 180 ft long.

2j. Two DAS alcoves are required for the Sequential Drift Mining Test. Each DAS alcove will be 17 ft wide x 12 ft high x 26 ft long.

2k. An organization computer alcove is also required for the Sequential Drift Mining Test. This alcove is 20 ft width x 12 ft high x 25 ft long.

21. Space for the Intact Fracture Test will be needed in the shaft for drilling purposes.

3a. 100 sq ft of office space, storage space and lab lay down area at the ESF (surface) will be provided.

3b. An alcove will be excavated at the MTL for storing equipment and supplies. This alcove will be constructed to afford no access to unauthorized personnel. The minimum dimensions will be 16 ft wide x 10 ft high x 20 ft long.

3c. Alcoves will be excavated in the shaft rib at depths of 70.86 m (232.48 ft), 190.86 m (626.20 ft) and 310.86 m (1019.92 ft) for the shaft convergence data collection units. The units are 4 ft wide x 8 ft high x 4 ft deep. (Shaft convergence test 1 and 2 can share the data collection units with Radial Borehole Test 7.)

3d. Alcoves will be excavated in the shaft rib at depths of 28.35 m (93 ft), 34.44 m (113 ft), 79.55 m (261 ft), 85.64 m (281 ft), 120.69 m (396 ft), 243.22 m (798 ft), and 359.65 m (1180 ft) for the Radial Borehole Test data collection units. The units are 4 ft wide x 8 ft high x 4 ft deep (see performance criteria 3c). The alcove should be constructed to accommodate a shelf 4 ft wide x 3 ft high x 4 ft deep. Total alcove dimensions will be 4 ft wide x 8 ft high x 4 ft deep.

3e. The Hydrochemistry Test will require an alcove at the UDBR and MTL. The dimensions of this alcove are 10 ft wide x 10 ft high x 8 ft long.

4a. 100 sq ft of office space and limited storage space at the ESF (surface) will be provided.

4b. No additional excavation will be required for the Evaluation of Mining Methods Test, Monitoring of Ground Support Systems Test, and Air Quality and Ventilation Test.

4c. Space will be provided at the end of the Ghost Dance Fault drift to perform the Air Quality and Ventilation Drift. This portion of the drift will be sealed by a bulk head.

5a. 100 sq ft of office space and limited storage space at the ESF (surface) will be provided.

5b. An alcove at the MTL will be required for the Canister Scale Heater Test. The dimensions of this alcove are 14 ft wide x 14 ft high x 25 feet deep.

5c. An alcove at the MTL will be required for the Heated Block Test. The dimensions of this alcove are 27 ft wide x 14 ft high x 27 ft deep.

5d. A DAS alcove will be needed for the Canister Scale Heater Test and the Heated Block Test. The dimensions for this alcove are 25 ft wide x 12 ft high x 21 ft long.

5e. An organizational computer alcove will be required. The dimensions for this alcove are 20 ft wide x 12 ft high x 25 ft long.

5f. Space for the Thermal Stress Measurements Test will be provided. No additional excavation is required for this test.

5g. Space for the Rock Mass Response Test will be required at five locations throughout the MTL. No additional excavation is required for this test.

6a. 100 sq ft of office space and limited storage space at the ESF (surface) will be provided.

6b. Space for the Infiltration Test will be provided. Dimensions for this test will TBD.

6c. A DAS alcove is needed for this test. Dimensions for this alcove are 17 ft wide x 12 ft high x 46 ft long. This DAS will be shared with the Diffusion Test.

6d. Space for the Bulk Permeability Test will be provided. The Bulk Permeability Test is composed of four separate drill rooms, two at each end of service drift four, and two whose locations and dimensions will be determined at a later date.

6e. A DAS alcove will be required for each separate Bulk Permeability Test. Dimensions for each of these alcoves are 17 ft wide x 12 ft high x 46 ft long.

7a. 500 sq ft of office space and limited storage space at the ESF (surface) will be provided.

7b. Space for the Heated Room Test will be required. No additional excavation for this test is needed.

7c. The Heated Room Test will require an organizational computer alcove. Dimensions for this alcove are 20 ft wide x 12 ft high x 25 ft long.

7d. The Heated Room Test will require a DAS alcove. The dimensions for this alcove are 17 ft wide x 12 ft high x 26 ft deep.

7e. 200 sq ft of space will be provided on the surface at the auxiliary pad for a machine shop trailer.

7f. An organizational computer drift will be needed by the Engineered Barrier Test. The dimensions for this alcove are 25 ft wide x 12 ft high x 40 ft long.

7g. The Engineered Barrier Test requires two DAS alcoves. The dimensions for these alcoves are 17 ft wide x 12 ft high x 26 ft long.

7h. The Engineered Barrier Test is composed of four drifts. Three of these drifts are 16 ft wide x 14 ft high x 120 ft long, and the fourth drift is 16 ft wide x 14 ft high x 40 ft long.

Constraints

None

'2/5/86

ELECTRICAL POWER REQUIREMENTS FOR ESF TESTING B-IS-4-1

LOCATION : SHAFT

TEST NAME	VOLTS	PHASE	WATTS	USE
SHAFT WALL MAPPING	120	SINGLE	600	LIGHTS
MIN/PET SAMPLING				
VERTICAL SEISMIC PROFILING (1)	120	SINGLE	300	INSTRUMENTATION
SHAFT CONVERGENCE (1)(2)	120	SINGLE	300	INSTRUMENTATION
HYDROLOGIC PROPERTIES SAMPLES (1)				
RADIAL BOREHOLES (1)(3)	120	SINGLE	300	INSTRUMENTATION
	120	SINGLE	150	LOGGING
PERCHED WATER (1)	120	SINGLE	300	INSTRUMENTATION
HYDROCHEMISTRY				
CHLORINE-36 (1)				

ELECTRICAL POWER REQUIREMENTS FOR ESF TESTING

LOCATION: UPPER DEMONSTRATION BREAKOUT ROOM

TEST NAME	VOLTS	PHASE	WATTS	USE
DRIFT WALL MAPPING	120	SINGLE	600	LIGHTS
MIN/PET SAMPLING				
VERTICAL SEISMIC PROFILING (4)	120	SINGLE	300	INSTRUMENTATION
UPPER DEMONSTRATION BREAKOUT ROOM	120	SINGLE	1200	LIGHTS
TSW1 HEATER TEST	120 120 208	SINGLE SINGLE TRIPLE	300 600 1200	INSTRUMENTATION LIGHTS HEATER
OVERCORE STRESS	120	SINGLE	600	TV BORE HOLE CAMERA
HYDROLOGIC PROPERTIES SAMPLES (4)				
EXCAVATION EFFECTS	120	SINGLE	600	INSTRUMENTATION
PLATE LOADING	120 120	SINGLE SINGLE	600 300	LIGHTS INSTRUMENTATION

ELECTRICAL POWER REQUIREMENTS FOR ESF TESTING

LOCATION: MAIN TEST LEVEL

TEST NAME	VOLTS	PHASE	WATTS	USE
DRIFT WALL MAPPING	120	SINGLE	600	LIGHTS
MIN/PET SAMPLING				
VERTICAL SEISMIC PROFILING (4)	120	SINGLE	300	INSTRUMENTATION
DEMONSTRATION BREAKOUT ROOM	120	SINGLE	1200	LIGHTS
	120	SINGLE	300	INSTRUMENTATION
SEQUENTIAL DRIFT MINING	120	SINGLE	2400	LIGHTS
	120	SINGLE	600	INSTRUMENTATION
CANISTER SCALE HEATER	120	SINGLE	600	LIGHTS
	120	SINGLE	300	INSTRUMENTATION
	208	TRIPLE	5000	HEATER
HEATED BLOCK	120	SINGLE	600	LIGHTS
	120	SINGLE	300	INSTRUMENTATION
	480	TRIPLE	14000	HEATERS
THERMAL STRESS	120	SINGLE	600	LIGHTS
	220	SINGLE	300	INSTRUMENTATION
	480	TRIPLE	24000	HEATERS
HEATED ROOM	120	SINGLE	600	LIGHTS
	120	SINGLE	300	INSTRUMENTATION
	480	TRIPLE	96000	HEATERS

ELECTRICAL POWER REQUIREMENTS FOR ESF TESTING

LOCATION: MAIN TEST LEVEL

TEST NAME	VOLTS	PHASE	WATTS	USE
HORIZONTAL BORING	480	TRIPLE	10000	POWER TO MACHINE
PLATE LOADING (5)	120 120	SINGLE SINGLE	2400 600	LIGHTS INSTRUMENTATION
ROCK MASS RESPONSE	120 120	SINGLE SINGLE	600 300	LIGHTS INSTRUMENTATION
EVALUATION OF MINING METHODS				
GROUND SUPPORT				
MONITORING DRIFT STABILITY (6)	120	SINGLE	900	INSTRUMENTATION
AIR QUALITY & VENTILATION (7)	120	SINGLE	300	INSTRUMENTATION
OVERCORE STRESS	120	SINGLE	150	TV BOREHOLE CAMERA
HYDROLOGIC PROPERTIES SAMPLES (4)	120 120	SINGLE SINGLE	1200 300	LIGHTS INSTRUMENTATION
INFILTRATION TEST	120 120	SINGLE SINGLE	1200 300	LIGHTS INSTRUMENTATION
EXCAVATION EFFECTS	120	SINGLE	600	INSTRUMENTATION
HYDROCHEMISTRY TEST	12	DIRECT CURRENT	1000	20 PERISTALTIC PUMPS @ 50 WATTS EACH

ELECTRICAL POWER REQUIREMENTS FOR ESF TESTING

LOCATION: MAIN TEST LEVEL

TEST NAME	VOLTS	PHASE	WATTS	USE
DIFFUSION TEST (8)	120	SINGLE	600	LIGHTS
	120	SINGLE	300	INSTRUMENTATION
ENGINEERED BARRIER DESIGN	120	SINGLE	2400	LIGHTS
	120	SINGLE	300	INSTRUMENTATION
	480	TRIPLE	25000	HEATERS

FOOT NOTES AND CLARIFICATION NOTES

(1) THE LIGHTS FOR SHAFT WALL MAPPING CAN BE USED.

(2) SHAFT CONVERGENCE TEST HAS THREE LOCATIONS IN ES-1

(3) RADIAL BOREHOLES TEST HAS EIGHT LOCATIONS IN ES-1

(4) THE LIGHTS FOR DRIFT WALL MAPPING CAN BE USED.

(5) PLATE LOADING IS IN DBR AND DRIFTS A, B, C OF THE SEQUENTIAL DRIFT MINING TEST.

(6) LOCATION IS IN ALL THREE LONG DRIFTS.

(7) LOCATION IS AT THE END OF ONE OF THE LONG DRIFTS.

(8) MANY TESTS THAT WILL BE REPEATED IN THE CALICO HILLS UNIT (IF TESTING IS DONE IN THAT HORIZON) WILL HAVE POWER REQUIREMENTS THAT CAN BE ASSUMED TO BE THE SAME AS THE CORRESPONDING TEST AT OTHER LOCATIONS IN THE ESF.

(9) UNLESS OTHERWISE DEFINED, NORMAL LIGHTING VALUES FROM DESIGN HANDBOOKS FOR LABORATORIES AND OFFICES ARE ACCEPTABLE IN THE TESTING ALCOVES.

Water System Design Requirements For ESF Testing

Definition of Study

This testing integration study defines the water system requirements to support ESF testing.

Functional Requirement

1. Provide the system design with sufficient flexibility to accommodate ESF testing requirements.

Performance Criteria

1. Each test location will have water provided.

2. All water will be tagged with a suitable tracer as defined in the Hydrochemistry Test requirements (B-HYD-9).

3. All water use in or around the ESF for each activity will be monitored and appropriate quantity records will be provided to the Test Manager's Office.

Constraints

1. Unless otherwise defined, a supply line capable of providing an intermittent flow rate of 10 gpm to each test area is required.

2. The water supply for each test shall be provided to an access coupling and an isolation valve near each test location.

3. A monitoring system will be installed to monitor water in/water out of the ESF.

4. Water leakage will be kept to a minimum and will be contained to the maximum extent possible.

Assumptions

1. Standard mine plant water is acceptable.

2. The test organization will be responsible for the distribution system downstream from the isolation valve.

3. Each organization will be responsible for adding a tracer to its respective test (if needed) subject to tracer limitations necessitated by other tests.

4. Standards for water meter accuracy conforming to American Water Works Association standard C700-77 will be adequate.

5. Water metering will be required, as a minimum, at each tracer injection location (Reference B-HYD-9).

6. Water usage quantity records will be collected and handled using procedures developed by the project and approved by the Test Manager. It is anticipated that a "best effort" criterion will apply.

Compressed Air System Design Requirements for ESF Testing

Definition of Test

This testing integration study defines the compressed air system requirements to support ESF testing.

Functional Requirements

1. The functional design requirement is to provide the flexibility in the compressed air system to accommodate ESF testing requirements.

Performance Criteria

1. Each test location will have compressed air provided.

2. All compressed air will be tagged with SF_6 tracer to a nominal concentration of 20 parts per trillion.

Constraints

1. 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 the Diffusion Test, the Bulk Permeability Test, and the Radial Borehole Test.

Interfaces

1. The compressed air supply for each test shall be provided to an access coupling and an isolation valve near each test location.

Assumptions

1. Standard mine plant compressed air is suitable for all test areas.

2. The test organization will be responsible for the distribution downstream from the isolation valve.

Common Sampling Design Requirements in the ESF

Definition of Study

Sample collection requirements occur whenever coring is required and as a part of four specific tests: 1) Mineralogy Petrology Sampling (B-GEO-2), 2) Hydrologic Properties Samples (B-HYD-1), 3) Chlorine 36 Test (B-HYD-11), and 4) Geoengineering Laboratory Samples (B-MECH-17). Control and collection procedures will be developed by the PIs and the Sample Management Facility staff.

Functional Requirements

1. The functional design requirement is to provide a system design and construction specifications with sufficient flexibility to accommodate ESF sample collection requirements.

Performance Criteria

1. Sample collection will be required to satisfy the Performance Criteria, Constraints and Assumptions contained in following specific test requirements:

   - Mineralogy Petrology Sampling (B-GEO-2)
   - Hydrologic Properties Samples (B-HYD-1)
   - Chlorine 36 Test (B-HYD-11)
   - Geoengineering Laboratory Samples (B-MECH-17)

2. Core samples from coring operations (reference Appendix C of the ESF SDRD) in the ESF will be handled and controlled using procedures developed by the PIs and the Sample Management Facility staff.

Constraints

Assumptions

SDRD APPENDIX C

ESF DRILLING REQUIREMENTS

APPENDIX C of the SDRD: ESF DRILLING REQUIREMENTS
LANL: RAY/NEWSOM File Name: APXC189.WKT Revision Date: 1/13/89

UNDERGROUND GEOLOGIC MAPPING-USBR
SDRD/B-GEO-1 SCP/8.3.1.4.2.2.4

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
MTL	Geothermal	10	3.79	HQ	150	1500	tbd	h	c	a	6

MIN/PET SAMPLING-LANL
SDRD/B-GEO-2 SCP/8.3.1.3.2.1.3

No drilling required for this test.

VERTICAL SEISMIC PROFILING-LBL
SDRD/B-GEO-3 SCP/8.3.1.4.2.2.5

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
ES-1	Seismic	37	3.79	HQ	12	444	tbd	i-dn	c	w	13
ES-2	Seismic	38	3.79	HQ	12	456	tbd	i-dn	c	w	13

SHAFT CONVERGENCE-SNL
SDRD/B-MECH-1 SCP/8.3.1.15.1.5.1

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
S-240	Pilot	1	1.485	EQ	30	30	na	v-dn	c	w	
S-240	Overcore	1	~6.25		30	30	na	v-dn	c	w	7
S-259	MPBX	4	2.98	NQ	50	200	tbd	h	c	w	1
S-261	MPBX	2	2.98	NQ	50	100	tbd	h	c	w	1
S-259	Tape Extens.	2	1.125	FF	0.75	1.5	tbd	h	p	w	2
S-261	Tape Extens.	4	1.125	FF	0.75	3	tbd	h	p	w	2
S-500	Pilot	1	1.485	EQ	30	30	na	v-dn	c	w	
S-500	Overcore	1	~6.25		30	30	na	v-dn	c	w	7
S-519	MPBX	4	2.98	NQ	50	200	tbd	h	c	w	1
S-521	MPBX	2	2.98	NQ	50	100	tbd	h	c	w	1
S-519	Tape Extens.	2	1.125	FF	0.75	1.5	tbd	h	p	w	2
S-521	Tape Extens.	4	1.125	FF	0.75	3	tbd	h	p	w	2
S-1000	Pilot	1	1.485	EQ	30	30	na	v-dn	c	w	
S-1000	Overcore	1	~6.25		30	30	na	v-dn	c	w	7
S-1019	MPBX	4	2.98	NQ	50	200	tbd	h	c	w	1
S-1021	MPBX	2	2.98	NQ	50	100	tbd	h	c	w	1
S-1019	Tape Extens.	2	1.125	FF	0.75	1.5	tbd	h	p	w	2
S-1021	Tape Extens.	4	1.125	FF	0.75	3	tbd	h	p	w	2

DEMONSTRATION BREAKOUT ROOMS-SNL
SDRD/B-MECH-2 SCP/8.3.1.15.1.5.2

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
UDBR	MPBX	5	2.98	NQ	50	250	na	v-up	c	w	1
UDBR	MPBX	5	2.98	NQ	50	250	na	v-dn	c	w	1
UDBR	MPBX	10	2.98	NQ	50	500	tbd	h	c	w	1
UDBR	MPBX	10	2.98	NQ	50	500	tbd	i-up	c	w	1

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
UDBR	Tape Extens.	12	1.125	FF	0.75	9	tbd	h	p	w	2
UDBR	Tape Extens.	6	1.125	FF	0.75	4.5	na	v-up	p	w	2
UDBR	Tape Extens.	6	1.125	FF	0.75	4.5	na	v-dn	p	w	2
MTL	MPBX	5	2.98	NQ	50	250	na	v-up	c	w	1
MTL	MPBX	5	2.98	NQ	50	250	na	v-dn	c	w	1
MTL	MPBX	10	2.98	NQ	50	500	tbd	h	c	w	1
MTL	MPBX	10	2.98	NQ	50	500	tbd	i-up	c	w	1
MTL	Tape Extens.	12	1.125	FF	0.75	9	tbd	h	p	w	2
MTL	Tape Extens.	6	1.125	FF	0.75	4.5	na	v-up	p	w	2
MTL	Tape Extens.	6	1.125	FF	0.75	4.5	na	v-dn	p	w	2

SEQUENTIAL DRIFT MINING-SNL
SDRD/B-MECH-3 SCP/8.3.1.15.1.5.3

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
MTL	MPBX	4	2.98	NQ	50	200	na	v-up	c	a	1
MTL	MPBX	4	2.98	NQ	50	200	na	v-dn	c	a	1
MTL	MPBX	8	2.98	NQ	35	280	tbd	h	c	a	1
MTL	MPXB	8	2.98	NQ	50	400	tbd	i-up	c	a	1
MTL	Tape Extens.	10	1.125	FF	0.75	7.5	tbd	h	p	a	2
MTL	Tape Extens.	5	1.125	FF	0.75	3.75	na	v-up	p	a	2
MTL	Tape Extens.	5	1.125	FF	0.75	3.75	na	v-dn	p	a	2
MTL	Deflectometer	8	2.98	NQ	85	680	tbd	i-up	c	a	
MTL	Deflectometer	8	2.98	NQ	85	680	tbd	i-dn	c	a	
MTL	Stressmeter	8	2.36	BQ	35	280	tbd	h	c	a	
MTL	Permeability	8	2.98	NQ	35	280	tbd	h	c	a	

TSw1 HEATER-SNL
SDRD/B-MECH-4 SCP/8.3.1.15.1.6.1

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
UDBR	MPBX	3	2.98	NQ	30	90	tbd	h	c	w	1, 8
UDBR	MPBX	4	2.98	NQ	30	120	tbd	h	c	w	1, 9
UDBR	Thermocouple	6	1.485	EQ	30	180	tbd	h	c	w	
UDBR	Deform. Gage	3	1.485	EQ	30	90	tbd	h	c	w	
UDBR	Neutron Probe	2	2.98	NQ	30	60	tbd	h	c	w	
UDBR	Moisture Sens.	4	2.98	NQ	30	120	tbd	h	c	w	
UDBR	Radon	1	~6.25		30	30	tbd	h	c	w	
UDBR	Heater	1	26		20	20	tbd	h	c	w	

Canister-Scale Heater-SNL
SDRD/B-MECH-5 SCP/8.3.1.15.1.6.2

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
MTL	MPBX	3	2.98	NQ	30	90	tbd	h	c	w	1, 8
MTL	MPBX	4	2.98	NQ	30	120	tbd	h	c	w	1, 9
MTL	Thermocouple	6	1.485	EQ	30	180	tbd	h	c	w	
MTL	Deform. Gage	3	1.485	EQ	30	90	tbd	h	c	w	
MTL	Neutron Probe	2	2.98	NQ	30	60	tbd	h	c	w	

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
MTL	Moisture Sens.	4	2.98	NQ	30	120	tbd	h	c	w	
MTL	Radon	1	~6.25		30	30	tbd	h	c	w	
MTL	Heater	1	26		20	20	tbd	h	c	w	

HEATED BLOCK-SNL
SDRD/B-MECH-6 SCP/8.3.1.15.1.6.3

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
MTL	MPBX	2	2.98	NQ	8	16	na	v	c	w	1
MTL	MPBX	2	2.98	NQ	8	16	tbd	h	c	w	1
MTL	Surface Extens	12	1.485	EQ	9.6	115.2	na	v	c	w	
MTL	Stressmeter	10	2.36	BQ	6.6	66	na	v	c	w	
MTL	Permeability	3	2.98	NQ	5	15	na	v	c	w	
MTL	Thermocouple	16	1.485	EQ	10.5	168	na	v	c	w	
MTL	Neutron Probe	1	2.98	NQ	13	13	na	v	c	w	
MTL	Ultrasonic	4	2.98	NQ	13	52	na	v	c	w	
MTL	Heater	14	1.485	EQ	10.5	147	na	v	c	w	

THERMAL STRESS-SNL
SDRD/B-MECH-7 SCP/8.3.1.15.1.6.4

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
LDBR	Heater	16	1.485	EQ	7	112	na	v-up	c	w	
LDBR	Thermocouple	13	1.485	EQ	15	195	na	v-up	c	w	
LDBR	MPBX	2	2.98	NQ	50	100	na	v-up	c	w	1
LDBR	MPBX	1	2.98	NQ	50	50	na	v-dn	c	w	1
LDBR	Stressmeter	6	2.36	BQ	15	90	na	v-up	c	w	
LDBR	Tape Extens.	5	1.125	FF	0.75	3.75	na	v-up	p	w	2
LDBR	Tape Extens.	5	1.125	FF	0.75	3.75	na	v-dn	p	w	2
LDBR	Tape Extens.	10	1.125	FF	0.75	7.5	tbd	h	p	w	2

HEATED ROOM-SNL
SDRD/B-MECH-8 SCP/8.3.1.15.1.6.5

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
MTL	Heater	12	~6.25		35	420	tbd	h	c	w	1
MTL	Heater	6	~6.25		37	222	tbd	i-up	c	w	1
MTL	Heater	6	~6.25		37	222	tbd	i-dn	c	w	1
MTL	Surface Extens	14	1.125	FF	0.75	10.5	tbd	h	p	w	
MTL	Surface Extens	14	1.125	FF	0.75	10.5	na	v	p	w	

PLATE LOADING-SNL
SDRD/B-MECH-10 SCP/8.3.1.15.1.7.1

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
UDBR	MPBX	2	2.98	NQ	50	100	na	v-up	c	w	1
UDBR	MPBX	2	2.98	NQ	50	100	na	v-dn	c	w	1
UDBR	Tape Extens.	8	1.125	FF	0.75	6	na	v	p	w	2
UDBR	Acoust. Emiss.	2	2.98	NQ	15	30	na	v-up	c	w	

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
LDBR	MPBX	2	2.98	NQ	50	100	na	v-up	c	w	1
LDBR	MPBX	2	2.98	NQ	50	100	na	v-dn	c	w	1
LDBR	Tape Extens.	8	1.125	FF	0.75	6	na	v	p	w	2
LDBR	Acoust. Emiss.	2	2.98	NQ	15	30	na	v-up	c	w	
MTL	MPBX	11	2.98	NQ	50	550	na	v-up	c	w	1
MTL	MPBX	11	2.98	NQ	50	550	na	v-dn	c	w	1
MTL	Tape Extens.	44	1.125	FF	0.75	33	na	v	p	w	2
MTL	Acoust. Emiss.	11	2.98	NQ	15	165	na	v-up	c	w	

ROCK MASS RESPONSE-SNL
SDRD/B-MECH-11 SCP/8.3.1.15.1.7.2

MTL	MPBX	25	1.485	EQ	8	200	tbd	tbd	c	a	1, 10
MTL	FracDefGage	5	2.98	NQ	3	15	na	v-dn	c	a	

MINING METHODS-SNL
SDRD/B-MECH-12 SCP/8.3.1.15.1.8.1

No holes identified.

GROUND SUPPORT-SNL
SDRD/B-MECH-13 SCP/8.3.1.15.1.8.2

No holes identified.

MONITORING DRIFT STABILITY-SNL
SDRD/B-MECH-14 SCP/8.3.1.15.1.8.3

MTL-LD	MPBX	11	2.98	NQ	50	550	na	v-up	c	w	1, 5
MTL-LD	MPBX	11	2.98	NQ	50	550	na	v-dn	c	w	1, 5
MTL-LD	MPBX	25	2.98	NQ	50	1250	tbd	h	c	w	1, 5
MTL-LD	Tape Extens.	40	1.125	FF	0.75	30	na	v-up	p	w	2, 4
MTL-LD	Tape Extens.	40	1.125	FF	0.75	30	na	v-dn	p	w	2, 4
MTL-LD	Tape Extens.	80	1.125	FF	0.75	60	tbd	h	p	w	2, 4

AIR QUALITY AND VENTILATION-SNL
SDRD/B-MECH-15 SCP/8.3.1.15.1.8.4

MTL-LD	Radon	1	~6.25		30	30	tbd	h	c	w	3

LOCATION	HOLE DESIGNATION	#	DIAM. "In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS

SEAL TESTING-SNL
SDRD/B-SEAL-1 SCP/8.3.3.2

Hole requirements to be determined.

OVERCORE STRESS-USGS
SDRD/B-MECH-16 SCP/8.3.1.15.2.1.2

LOCATION	HOLE DESIGNATION	#	DIAM. "In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
UDBR Set 1	Dilatomtr	1	2.98	NQ	65	65	tbd	h	c	w	NQ Core
UDBR	Pilot	1	1.485	EX	65	65	tbd	h	c	w	EX Core/6' Stage
UDBR	OCH	1	6	NK	65	65	tbd	h	c	w	6" Mason/6' Stage
UDBR Set 2	Dilatomtr	1	2.98	NQ	65	65	tbd	h	c	w	NQ Core
UDBR	Pilot	1	1.485	EX	65	65	tbd	h	c	w	EX Core/6' Stage
UDBR	OCH	1	6	NK	65	65	tbd	h	c	w	6" Mason/6' Stage
UDBR Set 3	Dilatomtr	1	2.98	NQ	65	65	na	v	c	w	NQ Core
UDBR	Pilot	1	1.485	EX	65	65	na	v	c	w	EX Core/6' Stage
UDBR	OCH	1	6	NK	65	65	na	v	c	w	6" Mason/6' Stage
MTL Set 4	Dilatomtr	1	2.98	NQ	65	65	tbd	h	c	w	NQ Core
MTL	Pilot	1	1.485	EX	65	65	tbd	h	c	w	EX Core/6' Stage
MTL	OCH	1	6	NK	65	65	tbd	h	c	w	6" Mason/6' Stage
MTL Set 5	Dilatomtr	1	2.98	NQ	65	65	tbd	h	c	w	NQ Core
MTL	Pilot	1	1.485	EX	65	65	tbd	h	c	w	EX Core/6' Stage
MTL	OCH	1	6	NK	65	65	tbd	h	c	w	6" Mason/6' Stage
MTL Set 6	Dilatomtr	1	2.98	NQ	65	65	na	v	c	w	NQ Core
MTL	Pilot	1	1.485	EX	65	65	na	v	c	w	EX Core, 6' Stage
MTL	OCH	1	6	NK	65	65	na	v	c	w	6" Mason/6' Stage
CHDR Set 7	Dilatomtr	1	2.98	NQ	65	65	tbd	h	c	w	NQ Core
CHDR	Pilot	1	1.485	EX	65	65	tbd	h	c	w	EX Core/6' Stage
CHDR	OCH	1	6	NK	65	65	tbd	h	c	w	6" Mason/6' Stage
CHDR Set 8	Dilatomtr	1	2.98	NQ	65	65	tbd	h	c	w	NQ Core
CHDR	Pilot	1	1.485	EX	65	65	tbd	h	c	w	EX Core/6' Stage
CHDR	OCH	1	6	NK	65	65	tbd	h	c	w	6" Mason/6' Stage
CHDR Set 9	Dilatomtr	1	2.98	NQ	65	65	na	v	c	w	NQ Core
CHDR	Pilot	1	1.485	EX	65	65	na	v	c	w	EX Core/6' Stage
CHDR	OCH	1	6	NK	65	65	na	v	c	w	6" Mason/6' Stage

HYDROLOGIC PROPERTIES SAMPLES-USGS
SDRD/B-HYD-1 SCP/8.3.1.2.2.3.1

No holes required for this test.

INTACT FRACTURE-USGS
SDRD/B-HYD-2 SCP/8.3.1.2.2.4.1

LOCATION	HOLE DESIGNATION	#	DIAM. "In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
UDBR	Radial Anchor	12	0.75	FF	10	120	tbd	i	b	a	Milw .75" FF Bit
UDBR	Radial O-core	12	11	NK	10	120	tbd	i	c	a	24"L x 10" dia

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
UDBR	Axial Clamps	24	3.79	HQ	10	240	tbd	i	c	a	HQ Core
UDBR	Axial Core	12	11	NK	10	120	tbd	i	c	a	24"L x 10" dia
MTL	Radial Anchor	12	0.75	FF	10	120	tbd	i	b	a	Milw .75" FF Bit
MTL	Radial O-core	12	11	NK	10	120	tbd	i	c	a	24"L x 10" dia
MTL	Axial Clamps	24	3.79	HQ	10	240	tbd	i	c	a	HQ Core
MTL	Axial Core	12	11	NK	10	120	tbd	i	c	a	24"L x 10" dia
CHDR	Radial Anchor	12	0.75	FF	10	120	tbd	i	b	a	Milw .75" FF Bit
CHDR	Radial O-core	12	11	NK	10	120	tbd	i	c	a	24"L x 10" dia
CHDR	Axial Clamps	24	3.79	HQ	10	240	tbd	i	c	a	HQ Core
CHDR	Axial Core	12	11	NK	10	120	tbd	i	c	a	24"L x 10" dia
TBD	Radial Anchor	12	0.75	FF	10	120	tbd	i	b	a	Milw .75" FF Bit
TBD	Radial O-core	12	11	NK	10	120	tbd	i	c	a	24"L x 10" dia
TBD	Axial Clamps	24	3.79	HQ	10	240	tbd	i	c	a	HQ Core
TBD	Axial Core	12	11	NK	10	120	tbd	i	c	a	24"L x 10" dia

PERCOLATION-USGS
SDRD/B-HYD-3 SCP/8.3.1.2.2.4.2

MTL	Upper rows	tbd	3.79	HQ	tbd	0	tbd	h	c	tbd	
MTL	Saw Access	10	3.79	HQ	tbd	0	tbd	h	c	tbd	

BULK PERMEABILITY-USGS
SDRD/B-HYD-4 SCP/8.3.1.2.2.4.3

MTL Set 1	Observation	3	2.98	NQ	115	345	tbd	i	c	a	Diverge at 25 deg
MTL	Injection	1	2.98	NQ	115	115	tbd	h	c	a	Core/test each 2'
MTL Set 2	Observation	3	2.98	NQ	115	345	tbd	i	c	a	Diverge at 25 deg
MTL	Injection	1	2.98	NQ	115	115	tbd	h	c	a	Core/test each 2'
MTL Set 3	Observation	3	2.98	NQ	115	345	tbd	i	c	a	Diverge at 25 deg
MTL	Injection	1	2.98	NQ	115	115	tbd	h	c	a	Core/test each 2'
MTL Set 4	Observation	3	2.98	NQ	115	345	tbd	i	c	a	Diverge at 25 deg
MTL	Injection	1	2.98	NQ	115	115	tbd	h	c	a	Core/test each 2'

RADIAL BOREHOLES-USGS
SDRD/B-HYD-5 SCP/8.3.1.2.2.4.4

SHAFT, TBD	SRB	14	3.79	HQ	30	420	tbd	h	c	a	7 sets of 2
	LRB	12	3.79	HQ	100	1200	tbd	h	c	a	6 sets of 2

EXCAVATION EFFECTS-USBR
SDRD/B-HYD-6 SCP/8.3.1.2.2.4.5

UDBR Set 1	Permeability	6	3.79	HQ	100	600	na	v	c	a	HQ Core, packers
UDBR	Stress Relief	6	2.98	NQ	100	600	na	v	c	a	NQ Core/size imp
UDBR	Extensometer	2	2.98	NQ	23	46	tbd	i	c	a	NQ Core, i-dn 45

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
UDBR	Extensometer	2	2.98	NQ	46	92	tbd	i	c	a	NQ Core, i-dn 45
UDBR	Extensometer	2	2.98	NQ	70	140	tbd	i	c	a	NQ Core, i-dn 45
MTL Set 2	Permeability	6	3.79	HQ	100	600	na	v	c	a	NQ Core, angled
MTL	Stress Relief	6	2.98	NQ	100	600	na	v	c	a	NQ Core/size imp
MTL	Extensometer	2	2.98	NQ	23	46	tbd	i	c	a	NQ Core, i-dn 45
MTL	Extensometer	2	2.98	NQ	46	92	tbd	i	c	a	NQ Core, i-dn 45
MTL	Extensometer	2	2.98	NQ	70	140	tbd	i	c	a	NQ Core, i-dn 45

CALICO HILLS-USGS
SDRD/B-HYD-7 SCP/8.3.1.2.2.4.6

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
CHDR	Phase 1	1	6		355	355	na	v	c	a	5.75" Core
CHDR	Phase 2	5	3.79	HQ	30	150	tbd	i	c	a	One for injection
CHDR	Phase 3	8	3.79	HQ	30	240	tbd	h	c	a	Four sets/2 holes

PERCHED WATER-USGS
SDRD/B-HYD-8 SCP/8.3.1.2.2.4.7

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
SHAFT, TBD	Small flow	8	1.125	FF	20	160	tbd	h	p	a	Use rock bolter
SHAFT, TBD	Frac flow	2	1.125	FF	20	40	tbd	tbd	p	a	Use rock bolter
SHAFT, TBD	Wet zone	1	1.125	FF	40	40	tbd	tbd	p	a	Use rock bolter
SHAFT, TBD	Moist zone	4	3.79	HQ	216	864	tbd	h	c	a	HQ Core

HYDROCHEMISTRY-USGS
SDRD/B-HYD-9 SCP/8.3.1.2.2.4.8

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
SHAFT, TBD	Gas Sampling	7	1.125	FF	5	35	tbd	h	p	a	No oil/gas/H2O!

DIFFUSION-LANL
SDRD/B-HYD-10 SCP/8.3.1.2.2.5

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
MTL Set 1	Pilot	2	3.5	DTH	33	66	na	v	p	a	3.5" DTH
MTL	Center pilot	2	1.175	RWT	1.5	3	na	v	c	a	14" to 18" L
MTL	Pilot ream	2	13	DTH	32.5	65	na	v	p	a	DTH 13" HO
MTL	OCH	2	12	NK	3	6	na	v	c	a	11" Core, 36" L
CHDR Set 2	Pilot	2	3.5	DTH	33	66	na	v	p	a	3.5" DTH
CHDR	Center pilot	2	1.175	RWT	1.5	3	na	v	c	a	14" to 18" L
CHDR	Pilot ream	2	13	DTH	32.5	65	na	v	p	a	DTH 13" HO
CHDR	OCH	2	12	NK	3	6	na	v	c	a	11" Core, 36" L

CHLORINE-36-LANL
SDRD/B-HYD-11 SCP/8.3.1.2.2.2.1

No drill holes required for this test.

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT	LGTH. (Ft.)	TOTAL (Ft.)	DIR.	HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS
ENGINEERED BARRIER DESIGN-LLNL											
SDRD/B-WP-1 SCP/8.3.4.2.4.4											
MTL Set 1	Heater pilot	3	3.79	HQ	40	120	na	v	c	a	HQ Core
MTL	Heater	3	30	NK	40	120	na	v	tbd	a	
MTL	Instrument	32	3.79	HQ	60	1920	na	v	c	a	May change, NQ
MTL	Instrument	24	3.79	HQ	40	960	tbd	i	c	a	Ang -5 deg
MTL Set 2	Heater pilot	2	3.79	HQ	40	80	tbd	h	c	a	HQ Core
MTL	Heater	2	30	NK	40	80	tbd	h	tbd	a	
MTL	Instrument	32	3.79	HQ	60	1920	tbd	i	c	a	May change, NQ
MTL	Instrument	32	3.79	HQ	80	2560	tbd	i	c	a	May change, NQ
GEOENGINEERING LAB-SNL											
SDRD/B-MECH-17 SCP/8.3.1.15.1.1											
UDBR	Sample Collect	5	12	NK	3	15	tbd	h	c	w	
UDBR	Sample Collect	15	15	NK	4	60	tbd	h	c	w	
MTL	Sample Collect	40	15	NK	3	120	tbd	h	c	w	
MTL	Sample Collect	5	15	NK	3	15	na	v-up	c	w	
MTL	Sample Collect	5	15	NK	3	15	tbd	i-up	c	w	
MULTIPURPOSE BOREHOLE-USGS											
SDRD/B-MPBH-1 SCP/8.3.1.2.2.4.9											
Surface	USW MP-1	1	~7		1100	1100	na	v	c/p	a	11
Surface	USW MP-2	1	~7		1100	1100	na	v	c/p	a	12
		1433 HOLES				37920. FEET					

NOTE: All hole dimensions are nominal.

COMMENTS:
1. Ream holes 3 ft. from end to 4-in. diameter.
2. Ream holes 3 in. from end to 3-in. diameter.
3. Hole will be located at the end of the Ghost Dance Fault drift.
4. Holes will be distributed throughout the long drifts and the Main Test Level.
5. Holes will be located in the repository-scale portions of the long drifts.
6. Holes will be angled 45 degrees to drift axis.
7. Overcore bit.
8. MPBXs are parallel to heater.
9. MPBXs are perpendicular to heater.
10. This experiment is intended to be reiterated in both vertical and horizontal orientations at up to five locations.
11. Continuously core Yucca Mt. and Pah Canyon members of Paintbrush Tuff, perched water

LOCATION	HOLE DESIGNATION	#	DIAM. ~In.	BIT LGTH. (Ft.)	TOTAL (Ft.)	DIR. HOLE ORIE	HOLE TYPE	DRL FLU	COMMENTS

zones bracketing UDBR and MTL. One to two feet of core at 10ft. intervals in remainder of borehole.

12.Cored as deemed necessary based on MP-1.

13.These holes can be drilled before shaft lining (using blockouts) or after lining.

GENERAL COMMENTS:

In most cases, holes are in a vertical plane normal to the major axis of the opening.
TBD-To be determined.

NOTATION:

Location		Drilling Fluid:	
S	Shaft	w	Water
MTL	Main Test Level	a	air
MTL-LD	Long Drifts on MTL		
DBR	Demonstration Breakout Room		
UDBR	Upper DBR		
LDBR	Lower DBR		

Orientation:		Hole Type:	
v	Vertical	c	Diamond Cored
h	Horizontal	p	Percussion Drilled
i	Inclined	b	Bored

SDRD APPENDIX D

ESF RELATED REFERENCABLE PROJECT DOCUMENTATION

ACGIH (American Conference of Governmental Industrial Hygienists), 1986. TLVs Threshhold Limit Values and Biological Exposure Indices for 1986-1987, Cincinnati, Ohio.

AEC (Atomic Energy Commission), 1974. Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants, Regulatory Guide 1.21, Directorate of Regulatory Standards, Washington, D.C.

ANSI/ANS (American National Standard Institute/American Nuclear Society), 1981. "American National Standard for Determining Design Basis Flooding at Power Reactor Sites," ANSI/ANS-2.8-1981, American Nuclear Society, La Grange Park, Ill.

ANSI/ASME (American National Standard Institute/American Society of Mechanical Engineers), 1979. Addenda to ANSI/ASME NQA-1-1979, Quality Assurance Program Requirements for Nuclear Power Plants, New York.

ANSI/ASME (American National Standards Institute/American Society of Mechanical Engineers), 1983. Quality Assurance Program Requirements for Nuclear Facilities, NQA-1-1983, New York.

APHA, AWWA, WPCF (American Public Health Association, American Water Well Association, Water Pollution Control Federation), 1985. Standard Methods for Examination of Water and Wastewater, American Public Health Association, Washington, D.C.

ASME (American Society of Mechanical Engineers), 1986. Article 10, "Leak Testing," Section V, "Nondestructive Examination," Boiler and Pressure Vessel Code, New York, pp. 113-122.

ASTM (American Society for Testing and Materials), 1984a. "Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil", Annual Book of ASTM Standards, D 3441-79, Vol. 04.08, Philadelphia, Penn., pp. 533-540.

ASTM (American Society for Testing and Materials), 1984b. "Standard Method for Penetration Test and Split-Barrel Sampling of Soils," ASTM D 1586-67 (reapproved 1974), American Society for Testing and Materials, Philadelphia, Penn., pp. 295-297.

Abrams, A. 1977. "Mud Design to Minimize Rock Impairment Due to Particle Invasion," Journal of Petroleum Technology, pp. 586-592.

Albers, J. P., 1967. "Belt of Sigmoidal Bending and Right-Lateral Faulting in the Western Great Basin," Geological Society of America Bulletin, Vol. 78, pp. 143-156.

Algermissen, S. T., and D. M. Perkins, 1976. A Probabilistic Estimate of the Maximum Acceleration in Rock in the Contiguous United States, USGS-OFR-76-416, Open-File Report, U.S. Geological Survey.

Altman, W. D., J. P. Donnelly, and J. E. Kennedy, 1988. Peer Review for High-Level Nuclear Waste Repositories, NUREG-1297, U.S. Nuclear Regulatory Commission.

Amyx, J. W., D. M. Bass, Jr., and R. L. Whiting, 1960. Petroleum Reservoir Engineering, Physical Properties, McGraw-Hill Book Co., New York. pp. 91-96.

Anderson, L. A., 1982. "Rock Property Analysis for Core Samples from Yucca Mountain Boreholes, Nevada Test Site, Nevada [abs.]," EOS, Transactions, American Geophysical Union, Vol. 63, No. 45, p. 1111.

Arkley, R. J., 1963. "Calculation of Carbonate and Water Movement in Soil From Climatic Data," Soil Science, Vol. 96, pp. 239-248.

Asfari, A., and P. A. Witherspoon, 1973. "Numerical Simulation of Naturally Fractured Reservoirs," Third Numerical Simulation of Reservoir Performance Symposium of SPE of AIME, Houston, Texas, January 10-12, 1973, SPE-4290, Dallas Society of Petroleum Engineers.

Auld, 1983.

Ayer, J. E., A. T. Clark, P. Loysen, M. Y. Ballinger, J. Mishima, P. C. Owczarski, W. S. Gregory, and B. D. Nichols, 1988. Nuclear Fuel Cycle Facility Accident Analysis Handbook, NUREG-1320, U.S. Nuclear Regulatory Commission, Washington, D.C.

BLM (Bureau of Land Management), 1985. Right-of-Way Plans of Development & Grants, BLM Manual Handbook H-2801-1.

Ballard, R. F., and F. G. McClean, 1975. "Seismic Field Methods for In Situ Moduli," in Proceedings of the Conference on In Situ Measurement of Soil Properties, June 1-4, 1975, North Carolina State University, Raleigh, North Carolina Specialty Conference of the Geotechnical Engineering Division (ASCE), Vol. 1, American Society of Civil Engineers, New York, pp. 121-150.

Ballivy, G., 1986. "Presentation on Planning," October 7, 1986, AECL-Fuel Waste Technology Branch, Grouting Experiment Team Meeting No. 3 (ms),

Barbier, M. G., 1983. The Mini-Sosie Method, International Human Resources Development Corporation, Boston, Mass.

Barenblatt, G. I., I. P. Zhelton, and I. N. Kochina, 1960. "Basic Concepts in the Theory of Seepage of Homogeneous Liquids in Fissured Rocks [Strata]," PMM, Vol. 24, No. 5, pp. 1286-1303.

Barnes, 1979.

Barr, G. E., and W. B. Miller, 1987. Simple Models of the Saturated Zone at Yucca Mountain, SAND87-0112, Sandia National Laboratories, Albuquerque, N. Mex.

Barton, C. C., and E. Larsen, 1985. "Fractal Geometry of Two-Dimensional Fracture Networks at Yucca Mountain, Southwestern Nevada," in Proceedings of the International Symposium on Fundamentals of Rock Joints, Bjorkliden, Sweden, September 15-20, 1985, O. Stephansson (ed.), pp. 77-84.

Barton, C. C., E. Larsen, and P. E. Baechle, 1985. "Fractal Geometry of Two-Dimensional Planar Sections Through Fracture Networks at Yucca Mountain, Southwestern Nevada" (Abstract), EOS (Tansactions of the American Geophysical Union), Vol. 66, No. 46, p 1089.

Barton, C. C., C. B. Gott, and J. R. Montgomery, 1986. "Fractal Scaling of Fracture and Fault Maps at Yucca Mountain, Southern Nevada (abstract)," EOS (Transactions of the American Geophysical Union), Vol. 67, No. 44, pp. 870-871.

Barton, N., and V. Choubey, 1977. "The Shear Strength of Rock Joints in Theory and Practice," Rock Mechanics, Vol. 10, pp. 1-54.

Barton, N., R. Lien, and J. Lunde, 1974a. Analysis of Rock Mass Quality and Support Practice in Tunneling and a Guide for Estimating Support Requirements, Internal Report 54206, Norwegian Geotechnical Institute, Oslo, Norway.

Barton, N., R. Lien, and J. Lunde, 1974b. "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, Vol. 6, No. 4, pp. 189-236.

Bath, G. D., and C. E. Jahren, 1984. Interpretations of Magnetic Anomalies at a Potential Repository Site Located in the Yucca Mountain Area, Nevada Test Site, USGS-OFR-84-120, Open-File Report, U.S. Geological Survey.

Bath, G. D., and C. E. Jahren, 1985. Investigation of an Aeromagnetic Anomaly on West Side of Yucca Mountain, Nye County, Nevada, USGS-OFR-85-459, Open-File Report, U.S. Geological Survey.

Bath, G. D., G. L. Dixon, and J. G. Rosenbaum, 1982. "Relation of Aeromagnetic Anomalies to Faulted Volcanic Terrains at the Nevada Test Site [abs.]," Geological Society of America, Abstracts with Programs, Vol. 14, No. 6, p. 302.

Bathe, K-J., 1975. ADINA: A Finite Element Program for Automatic Dynamic Incremental Nonlinear Analysis, Report 82448-1, Massachusetts Institute of Technology, Acoustics and Vibration Laboratory, Mechanical Engineering Department, Cambridge.

Bathe, K-J., 1977. ADINAT: Finite Element Program for Automatic Dynamic Incremental Nonlinear Analysis of Temperature, Report 82448-5, Massachusetts Institute of Technology, Cambridge.

Bauer, S. J., J. F. Holland, and D. K. Parrish, 1985. "Implications About In Situ Stress at Yucca Mountain," in Proceedings of the 26th U.S. Symposium on Rock Mechanics, Vol II, Rapid City, South Dakota, pp. 1113-1120.

Bauer, S. J., L. S. Costin, and J. F. Holland, 1988. Preliminary Scoping Analyses in Support of In Situ Thermomechanical Investigations, SAND88-2785, in prep. Sandia National Laboratories, Albuquerque, N. Mex.

Bear, J., 1972. Dynamics of Fluids in Porous Media, Part 1, University Microfilms International, Ann Arbor, Mich., p. 7.

Bedinger, M. S., K. A. Sargent, and W. H. Langer (eds.), 1984. Studies of Geology and Hydrology in the Basin and Range Province, Southwestern United States, for Isolation of High-Level Radioactive Waste, Characterization of the Death Valley Region, Nevada and California, USGS-OFR-84-743, Open-File Report, U.S. Geological Survey.

Bell, 1988.

Benson, L. V., J. H. Robison, R. K. Blankennagel, and A. E. Ogard, 1983. Chemical Composition of Ground Water and the Locations of Permeable Zones in the Yucca Mountain Area, Nevada, USGS-OFR-83-854, Open-File Report, U.S. Geological Survey.

Bentley, C. B., 1984. Geohydrologic Data for Test Well USW G-4, Yucca Mountain Area, Nye County, Nevada, USGS-OFR-84-063, Open-File Report, U.S. Geological Survey.

Berger, P., and A. M. Johnson, 1980. "First-Order Analysis of Deformation of a Thrust Sheet Moving Over a Ramp," Tectonophysics, Vol. 70, pp. T9-T24.

Berger, P., and A. M. Johnson, 1982. "Folding of Passive Layers and Forms of Minor Structures Near Terminations of Blind Thrust Faults--Application to the Central Appalachian Blind Thrust," Journal of Structural Geology, Vol. 4, No. 3, pp. 343-353.

Bernreuter, D. L., J. B. Savy, and R. W. Mensing, 1986. "Probabilistic Earthquake-Hazards Assessments," in Proceedings of Conference XXXIV, November 25-27, 1985, San Francisco, California, Walter W. Hays (ed.), USGS-OFR-86-185, Open-File Report, U.S. Geological Survey, pp. 314-352.

Berry, N., P. Ekman, D. Givens, M. Kaplan, G. Kula, T. Sebeok, and P. Tannenbaum, 1984. Reducing the Likelihood of Future Human Activities That Could Affect Geologic High-Level Waste Repositories, BMI/ONWI-537, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus Institute, Columbus, Ohio,

Bertram, S. G., 1984. NNWSI Exploratory Shaft Site and Construction Method Recommendation Report, SAND84-1003, Sandia National Laboratories, Albuquerque, N. Mex.

Beven, K., and P. Germann, 1982. "Macropores and Water Flow in Soils," Water Resources Research, Vol. 18, No. 5, pp. 1311-1325.

Bieniawski, Z. T., 1968. "The Effect of Specimen Size on Compressive Strength of Coal," International Journal of Rock Mechanics & Mineral Science, Vol. 5, pp. 325-335.

Bieniawski, Z. T., 1974. "Geomechanics Classification of Rock Masses and Its Application in Tunneling," Advances in Rock Mechanics, Vol. II, Part A, Proceedings of the Third Congress of the International Society of Rock Mechanics, National Academy of Sciences, Washington, D.C., pp. 27-38.

Bieniawski, Z. T., 1976. "Rock Mass Classifications in Rock Engineering," in Proceedings of the Symposium on Exploration for Rock Engineering, Johannesburg, 1-5 November 1976, Z. T. Bieniawski (ed.), Vol. 1, A. A. Balkema, Cape Town, South Africa, pp. 97-106.

Bieniawski, Z. T., 1978. "Determining Rock Mass Deformability: Experience from Case Histories," International Journal of Rock Mechanics, Mining Science, and Geomechanical Abstracts, Vol. 15, Pergamon Press, Great Britain, pp. 237-247.

Birgersson, L., and I. Neretnieks, 1982. "Diffusion in the Matrix of Granitic Rock: Field Test in the Stripa Mine," in Proceedings of the Materials Research Society Fifth International Symposium on the Scientific Basis for Nuclear Waste Management, June 7-10, 1982, Berlin, Germany, W. Lutze (ed.).

Bixler, N. E., 1985. NORIA--A Finite Element Computer Program for Analyzing Water, Vapor, Air, and Energy Transport in Porous Media, SAND84-2057, Sandia National Laboratories, Albuquerque, N. Mex.

Blacic, J. D., D. T. Vaniman, D. L. Bish, C. J. Duffy, and R. C. Gooley, 1986. Effects of Long-Term Exposure of Tuffs to High-Level Nuclear Waste Repository Conditions: Final Report, LA-9330-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Blanchard, M. B., and D. R. Elle, 1988. Letter from M. B. Blanchard (WMPO) and D. R. Elle (HPED); regarding distribution of abstracts from the technical presentations given at the information exchange meeting between the Department of Energy (DOE) Hydrology/Radionuclide Migration Program (HRMP and the Nevada Nuclear Waste Storage Investigations (NNWSI) Project.

Blanford, M. L., and J. D. Osnes, 1987. Numerical Analyses of the G-Tunnel Small-Diameter Heater Experiments, SAND85-7115, prepared by RE/SPEC, Inc., for Sandia National Laboratories, Albuquerque, N. Mex.

Blankennagel, R. K., 1967. Hydraulic Testing Techniques of Deep Drill Holes at Pahute Mesa, Nevada Test Site, USGS-OFR-67-18, Open-File Report, U.S. Geological Survey.

Blankennagel, R. K., and J. E. Weir, Jr., 1973. Geohydrology of the Eastern Part of Pahute Mesa, Nevada Test Site, Nye County, Nevada, U.S. Geological Survey Professional Paper 712-B, U.S. Goverment Printing Office, Washington, D.C.

Bodvarsson, G. S., A. Niemi, A. Spencer, and M. P. Attanyake, 1988. Preliminary Calculations of the Effects of air and Liquid Water-Drilling on Moisture Conditions in Unsaturated Rocks, LBL-25073, Lawrence Berkeley Laboratory, Berkeley, Calif.

Bonham Jr., H. F., 1988. "Models for Volcanic-Hosted Epithermal Precious Metal Deposits," in Bulk-Mineable Precious-Metal Deposits of the Western United States, Symposium Proceedings, R. R. Schaefer, J. J. Cooper, and P. G. Vikre (eds.), The Geological Society of Nevada, Reno, pp. 259-271.

Bonilla, M. G., 1982. Evaluation of Potential Surface Faulting and Other Tectonic Deformation, NUREG/CR-2991, U.S. Department of the Interior Geological Survey, Reston, Va.

Bonilla, M. G., R. K. Mark, and J. J. Lienkaemper, 1984. "Statistical Relations Among Earthquake Magnitude, Surface Rupture Length, and Surface Fault Displacement," Bulletin of the Seismological Society of America, Vol. 74, No. 6, pp. 2379-2411.

Boulton, N. S., 1963. "Analysis of Data from Non-equilibrium Pumping Tests Allowing for Delayed Yield from Storage," in Proceedings of the Institution of Civil Engineers, Vol. 26, pp. 469-482.

Bowker, A. H., and G. J. Lieberman, 1972. Engineering Statistics, 2nd Edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, pp. 308-317.

Bradley, R. S., 1985. Quaternary Paleoclimatology, Methods of Paleoclimatic Reconstruction, Allen & Unwin, Boston, Mass., pp. 72-78.

Brady, B. H. G., and E. T. Brown, 1985. Rock Mechanics for Underground Mining, George Allen & Unwin, p. 187.

Bredehoeft, J. D., 1962. "Response of Well-Aquifer Systems to Earth Tides," Journal of Geophysical Research, Vol. 72, No. 12, pp. 3075-3087.

Brennecke, L., and E. Lohmeyer, 1938. Der Grundbau (Foundation Engineering), Vol. I, Pt. I, Ernst John, Berlin.

Brinberg, D., and J. E. McGrath, 1985. Validity and the Research Process, SAGE Publications, Beverly Hills, Calif.

Broch, E. and J. A. Franklin, 1972. "The Point-Load Strength Test," International Journal of Rock Mechanics and Mining Sciences, Vol. 9, No. 6, pp. 669-697.

Brown, et al, 1987.

Brown, L. D., P. A. Krumhansl, C. E. Chapin, A. R. Sanford, F. A. Cook, S. Kaufman, J. E. Oliver, and F. S. Schilt, 1979. "COCORP Seismic Reflection Studies of the Rio Grande Rift," Rio Grange Rift: Tectonics and Magmatism, R. E. Riecker (ed.), American Geophysical Union, Washington, D.C., pp. 169-183.

Bruton, C. J., and H. F. Shaw, 1987. Geochemical Simulation of Reaction Between Spent Fuel Waste Form and J-13 Water at 25 deg. C and 90 deg. C, UCRL-96702, preprint, Lawrence Livermore National Laboratory, Livermore, Calif.,

Buckau, G., R. Stumpe, and J. I. Kim, 1986. "Americium Colloid Generation in Groundwaters and Its Speciation by Laser-Induced Photoacoustic Spectroscopy," Journal of the Less-Common Metals, Vol. 122, pp. 555-562.

Buckley, J. T., Y. C. Kim, M. S. Nataraja, and D. H. Tiktinsky, 1986. "Evaluating Host Rock Representativeness Through Geostatistics," 27th U.S. Symposium on Rock Mechanics, H. L. Hartman (ed.), Society of Mining Engineers, pp. 821-816.

Bull, W. B., 1984. "Tectonic Geomorphology," Journal of Geological Education, Vol. 32, pp. 310-324.

Bull, W. B., and L. D. McFadden, 1977. "Tectonic Geomorphology North and South of the Garlock Fault, California," in Geomorphology in Arid Regions, Proceedings of the 8th Annual Geomorphology Symposium Held at the State University of New York at Binghamton, September 23-24, 1977, D. O. Doehring (ed.), pp. 115-138.

Bullard, K. L., 1986. PMF (Probable Maximum Flood) Study for Nevada Nuclear Waste Storage Investigations Project, GR-87-8, U.S. Department of the Interior, Bureau of Reclamation, Washington, D.C.

Burchfiel, B. C., 1965. "Structural Geology of the Specter Range Quadrangle, Nevada, and Its Regional Significance," Geological Society of America Bulletin, Vol. 76, pp. 175-192.

Burns, P. J., 1982. TAC02D - A Finite Element Heat Transfer Code, UCID-17980, Rev. 2, Lawrence Livermore National Laboratory, Livermore, Calif.

Buscheck, T. A., and J. J. Nitao, in prep. Preliminary Scoping Calculations of Hydrothermal Flow in Variably Saturated, Fractured, Welded Tuff During the Engineering Design Test at the Yucca Mountain Test Site, UCIDxxxxxx.

Butkovich, T. R., and J. L. Yow, Jr., 1986. Theromechanical Scoping Calculations for the Waste Package Environment Tests, UCID-20758, Lawrence Livermore National Laboratory, Livermore, Calif.

Byers, F. M., Jr., 1985. Petrochemical Variation of Topopah Spring Tuff Matrix with Depth (Stratigraphic Level), Drill Hole USW G-4 Yucca Mountain, Nevada, LA-10561-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Byers, F. M., Jr., and L. M. Moore, 1987. Petrographic Variation of the Topopah Spring Tuff Matrix Within and Between Cored Drill Holes, Yucca Mountain, Nevada, LA-10901-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

CLIMAP Project Members, 1981. Seasonal Reconstructions of the Earth's Surface at the Last Glacial Maximum, Map and Chart Series, MC-36, Geological Society of America, Boulder, Colo.

Cale, Jr., W. G., and H. H. Shugart, 1980. Ecological Reality and Model Validation, International Congress on Applied Systems Research and Cybernetics, 12 Dec., 1980, Acapulco, Mexico, CONF-801231-1,

California Administrative Code, 1091a. Title 8. "Industrial Relations," Chapter 4. "Division of Industrial Safety," Subchapter 20. "Tunnel Safety Orders," Article 11. "Change Houses and Sanitation," Office of Administrative Hearings, Department of General Services, State of California, North Highlands.

California Administrative Code, 1981b. Title 8, "Industrial Relations," Subchapter 17, "Mine Safety Orders," Article 18, "Conveyors and Tramways," pp. 650.3-650.7.

Campbell, K., 1987. Lateral Continuity of Sorptive Mineral Zones Underlying Yucca Mountain, Nevada, LA-11070-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Campbell, J. E., R. T. Dillon, M. S. Tierney, H. T. Davis, P. E. McGrath, F. J. Pearson, Jr., H. R. Shaw, J. C. Helton, and F. A. Donath, 1978. Risk Methodology for Geologic Disposal of Radioactive Waste: Interim Report, NUREG/CR-0458, SAND78-0029, Sandia National Laboratories, Albuquerque, N. Mex.

Campbell, J. E., P. C. Kaestner, B. S. Langkopf, and R. B. Lentz, 1980. Risk Methodology for Geologic Disposal Radioactive Waste: The Network Flow and Transport (NWFT) Model, SAND79-1920: NUREG/CR-1190, Sandia National Laboratories, Albuquerque, N. Mex.

Carr, M. D., S. J. Waddell, G. S. Vick, J. M. Stock, S. A. Monsen, A. G. Harris, B. W. Cork, and F. M. Byers, Jr., 1986. Geology of Drill Hole UE25p#1: A Test Hole into Pre-Tertiary Rocks near Yucca Mountain, Southern Nevada, USGS-OFR-86-175, Open-File Report, U.S. Geological Survey.

Carr, W. J., 1974. Summary of Tectonic and Structural Evidence for Stress Orientation at the Nevada Test Site, USGS-OFR-74-176, Open-File Report, U.S. Geological Survey.

Carr, W. J., 1984. Regional Structural Setting of Yucca Mountain, Southwestern Nevada, and Late Cenozoic Rates of Tectonic Activity in Part of the Southwestern Basin, Nevada and California, USGS-OFR-84-854, Open-File Report, U.S. Geological Survey.

Carr, W. J., and L. D. Parrish, 1985. Geology of Drill Hole USW VH-2, and Structure of Crater Flat, Southwestern Nevada, USGS-OFR-85-475, Open-File Report, U.S. Geological Survey, 41 p.

Case, J. B., and P. C. Kelsall, 1987. Modification of Rock Mass Permeability in the Zone Surrounding a Shaft in Fractured, Welded Tuff, SAND86-7001, Sandia National Laboratories, Albuquerque, N. Mex.

Cattermole, J. M., and W. R. Hansen, 1962. Geologic Effects of the High-Explosive Tests in the USGS Tunnel Area Nevada Test Site, Geological Survey Professional Paper 382-B, U.S. Geological Survey.

Cederberg, G. A., R. L. Street, and J. O. Leckie, 1985. "A Groundwater Mass Transport and Equilibrium Chemistry Model for Multicomponent Systems," Water Resources Research, Vol. 21, No. 8, pp. 1095-1104.

Chen, E. P., 1987. A Computational Model for Jointed Media with Orthogonal Sets of Joints, SAND86-1122, Sandia National Laboratories, Albuquerque, N. Mex.

Childs, E. C., 1957. "The Physics of Land Drainage," Drainage of Agricultural Lands, J. N. Luthin (ed.), Chapter 1, American Society of Agronomy, Madison, Wis., pp. 1-78.

Cinco, H., F. Samaniego, and N. Dominguez, 1978. "Transient Pressure Behavior for a Well with a Finite-Conductivity Vertical Fracture," Society of Petroleum Engineers Journal, Vol. 18, No. 1, pp. 253-264.

Claassen, H. C., 1985. Sources and Mechanisms of Recharge for Ground Water in the West-Central Amargosa Desert, Nevada--A Geochemical Interpretation, U.S. Geological Survey Professional Paper 712-F, U.S. Government Printing Office, Washington, D.C.

Claassen, H. C., 1986. "Late-Wisconsin Paleohydrology of the West-Central Amargosa Desert, Nevada, U.S.A.," Chemical Geology (Isotope Geoscience Section), Vol. 58, pp. 311-323.

Codell, R., 1986. Draft Generic Position on Groundwater Travel Time, U.S. Nuclear Regulatory Commission, Washington, D.C.

Cole, C. R., 1986. Evaluation and Status Report on HYDROCOIN at Midway, PNL-6087, Pacific Northwest Laboratory, Richland, Wash.

Connard, G., R. Couch, and M. Gemperle, 1983. "Analysis of Aeromagnetic Measurements from the Cascade Range in Central Oregon," Geophysics, Vol. 48, No. 3, pp. 376-390.

Constantz, J., 1982. "Temperature Dependence of Unsaturated Hydraulic Conductivity of Two Soils," Soil Science Society of America Journal, Vol. 46, No. 1, pp. 466-470.

Constantz, J., and W. N. Herkelrath, 1984. "Submersible Pressure Outflow Cell for Measurement of Soil Water Retention and Diffusivity from 5 to 95 deg. C," Soil Science Society of America Journal, Vol. 48, No. 1, pp. 7-10.

Coons, W. E., A. Bergstrom, P. Gnirk, M. Gray, B. Knecht, R. Pusch, J. Steadman, M. Tokonami, and M. Vaajasaari, 1987. "State-of-the-Art Report on Potentially Useful Materials for Sealing Nuclear Waste Repositories," Stripa Project 87-12, Swedish Nuclear Fuel and Waste Management Co., Stockholm.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. "Response of a Finite-Diameter Well to an Instantaneous Charge of Water," Water Resources Research, Vol. 3, No. 1, pp. 263-369.

Cording, E. S., 1974. "Measurement of Displacements in Tunnels," in Proceedings of the Second International Congress of the International Association of Engineering Geology, Sao Paulo, 18-24 August, 1974-Brazil,

Corley, J. P., and C. D. Corbit, 1983. Guide for Effluent Radiological Measurements at DOE Installations, DOE/EP-0096, U.S. Department of Energy, Washington, D.C.

Corley, J. P., and D. H. Denham, 1981. Guide for: Environmental Radiological Surveillance at U.S. Department of Energy Installations, DOE/EP-0023, U.S. Department of Energy, Washington, D.C.

Costa, J. E., 1983. "Paleohydraulic Reconstruction of Flash-Flood Peaks from Boulder Deposits in the Colorado Front Range," Geological Society of America Bulletin, Vol. 94, pp. 986-1004.

Costin, L. S., and S. J. Bauer, in prep. Preliminary Analyses of the Excavation Investigation Experiments Proposed for the Exploration Shaft at Yucca Mountain, Nevada Test Site, SAND87-1575, Sandia National Laboratories, Albuquerque, N. Mex.

Costin, L. S., and E. P. Chen, in prep. An Analysis of the G-Tunnel Heated Block Thermal-Mechanical Response using a Compliant-Joint Rock Mass Model, SAND87-2699, in prep., Sandia National Laboratories, Albuquerque, N. Mex.

Couch, R., G. Connard, M. Gemperle, W. McLain, J. Huppinen, R. Foote, and P. Douguin, 1985. "Curie-Point Depths in the Cascade Range: Mt. Hood to Mt. Lassen," EOS, Vol. 66, No. 46, p. 870.

Craig, R. W., and J. H. Robison, 1984. Geohydrology of Rocks Penetrated by Test Well UE-25p#1, Yucca Mountain Area, Nye County, Nevada, USGS-WRI-84-4248, Water-Resources Investigations Report, U.S. Geological Survey.

Crampin, S., R. McGonigle, and D. Bamford, 1980. "Estimating Crack Parameters from Observations of P-Wave Velocity Anistropy," Geophysics, Vol. 45, No. 3, pp. 345-360.

Cranwell, et al, 1982.

Crippen, J. R. and C. D. Bue, 1977. Maximum Flood Flows in the Conterminous United States, USGS-WSP-1887, Water-Supply Paper, U.S. Geological Survey.

Crone et al, 1985.

Crowe, B., and B. Turrin, 1988. Preliminary Geologic Map of the Lathrop Wells Volcanic Center; TWS-Inc-3/88-7,

Crowe, B. M., M. E. Johnson, and R. J. Beckman, 1982. "Calculation of the Probability of Volcanic Disruption of a High-Level Radioactive Waste Repository within Southern Nevada, USA," Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 3, No. 2, pp. 167-190.

Crowe, B. M., S. Self, D. Vaniman, R. Amos, and F. Perry, 1983a. "Aspects of Potential Magmatic Disruption of a High-Level Radioactive Waste Repository in Southern Nevada," Journal of Geology, Vol. 91, pp. 259-276.

Crowe, B. M., D. T. Vaniman, and W. J. Carr, 1983b. Status of Volcanic Hazard Studies for the Nevada Nuclear Waste Storage Investigations, LA-9325-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Crowe, B. M., K. H. Wohletz, D. T. Vaniman, E. Gladney, and N. Bower, 1986. Status of Volcanic Hazard Studies for the Nevada Nuclear Waste Storage Investigations, LA-9325-MS, Vol. II, Los Alamos National Laboratory, Los Alamos, N. Mex.

Crowe, B. M., F. V. Perry, B. D. Turrin, S. G. Wells, and L. D. MacFadden, 1988. "Volcanic Hazard Assessment for Storage of High-Level Radioactive Waste at Yucca Mountain, Nevada," Geological Society of America, Cordilleran Section, Vol. 20, No. 3, p. 153.

Czarnecki, J. B., 1985. Simulated Effects of Increased Recharge on the Ground-Water Flow System of Yucca Mountain and Vicinity, Nevada-California, USGS-WRI-84-4344, Water-Resources Investigations Report, U.S. Geological Survey.

Czarnecki, J. B., 1987. "Should the Furnace Creek Ranch - Franklin Lake Playa Ground-Water Subbasin Simply Be the Franklin Lake Playa Ground-Water Subbasin?," American Geophysical Union, (abs.), EOS, Vol. 68, No. 44, P. 1292.

Czarnecki, and Oatfield, 1986.

Czarnecki, J. B., and R. K. Waddell, 1984. Finite-Element Simulation of Ground-Water Flow in the Vicinity of Yucca Mountain, Nevada-California, USGS-WRI-84-4349, Water-Resources Investigations Report, U.S. Geological Survey.

DOE (U.S. Department of Energy), 1979. Technology for Commercial Radioactive Waste Management, DOE/ET-0028, five volumes, Washington, D.C.

DOE (U.S. Department of Energy), 1980. "Environmental Protection, Safety, and Health Protection Program for DOE Operations," DOE Order 5480.1, Washington, D.C.

DOE (U.S. Department of Energy), 1981a. "Environmental Protection, Safety, and Health Protection Program for DOE Operations," DOE Order 5480.1A, Washington, D.C.

DOE (U.S. Department of Energy), 1981b. "Reactor and Nonreactor Facility Emergency Planning, Preparedness and Response Program for Department of Energy Operations," DOE Order 5500.3, Washington, D.C.

DOE (U.S. Department of Energy), 1983a. "General Design Criteria Manual," DOE Order 6430.1, Washington, D.C.

DOE (U.S. Department of Energy), 1983b. "Management of Construction Projects," DOE Order 6410.1, Washington, D.C.

DOE (U.S. Department of Energy), 1983c. "Quality Assurance," DOE Order 5700.6A-4, Nevada Operations Office, Las Vegas, Nev.

DOE (U.S. Department of Energy), 1983d. "Site Development and Facility Utilization Planning," DOE Order 4320.1A, Washington, D.C.

DOE (U.S. Department of Energy), 1984a. "Environmental Protection, Safety, and Health Protection Standards," DOE Order 5480.4, Washington, D.C.

DOE (U.S. Department of Energy), 1984b. "Nuclear Waste Policy Act of 1982; General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories," Federal Register, Vol. 49, pp. 47714-47770.

DOE (U.S. Department of Energy), 1985a. Mission Plan for the Civilian Radioactive Waste Management Program, Overview and Current Program Plans, DOE/RW-0005, three volumes, Washington, D.C.

DOE (U.S. Department of Energy), 1985a. Analysis of Total System Life Cycle Cost for OCRWM Program, DOE/RW-0024, Washington, D.C.

DOE (U.S. Department of Energy), 1985c. "Radiation Protection," DOE Order 5480.11, Washington, D.C.

DOE (Department of Energy), 1985d. OCRWM Quality Assurance Management Policies and Requirements, DOE/RW-0032.

DOE (U.S. Department of Energy), 1986a. A Multiattribute Utility Analysis of Sites Nominated for Characterization for the First Radioactive-Waste Repository--A Decision-Aiding Methodology, DOE/RW-0074, Washington, D.C.

DOE (U.S. Department of Energy), 1986b. Final Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0073, Washington, D.C.

DOE (U.S. Department of Energy), 1986c. Generic Requirements for a Mined Geologic Disposal System, DOE/NE/44301-1, Washington, D.C.

DOE (U.S. Department of Energy), 1986d. Issues Hierarchy for a Mined Geologic Disposal System, OGR/B-10, OCRWM, Washington, D.C.

DOE (U.S. Department of Energy), 1986e. "Environment, Safety, and Health Program for Department of Energy Operations," DOE Order 5480.1B, Washington, D.C.

DOE (U.S. Department of Energy), 1986f. Waste Management Systems Requirements and Descriptions (SRD), DOE/RW-0063, Washington, D.C.

DOE (U.S. Department of Energy), 1987a. Analysis of the Total System Life Cycle Cost for the Civilian Radioactive Waste Management Program, DOE/RW-0047, 2 volumes, Washington, D.C.

DOE (Department of Energy), 1987b. Environmental Regulation Compliance Plan,

DOE (U.S. Department of Energy), 1987c. Exploratory Shaft Facility Subsystem Design Requirements Document, Yucca Mountain Site, NVO-309, 2 volumes, Nevada Operations Office, Las Vegas, Nev.

DOE (U.S. Department of Energy), 1987d. NNWSI Project Radiological Monitoring Plan, DOE/NV-10576-6, Las Vegas, Nev.

DOE (Department of Energy), 1987e. OCRWM Mission Plan Amendment With Comments on the Draft Amendment and Responses to the Comments, DOE/RW-0128.

DOE (Department of Energy), 1988a. Draft 1988 Mission Plan Amendment, DOE/RW-0187.

DOE, (U.S. Department of Energy), 1988b. NNWSI Project Site Atlas, Draft, YMP-8821.

DOE (Department of Energy), 1988c. NNWSI Quality Assurance Plan, NNWSI/88-9, Rev. 1.

DOE (Department of Energy), 1988d. NNWSI Surface-Based Investigation Plan, VOL. 3.

DOE/NV (Department of Energy), 1988. Waste Management Project Office Quality Assurance Plan, WMPO/88-1, Rev. 0.

DOE/NVO (U.S. Department of Energy, Nevada Operations Office), 1983. Public Hearings Panel Report, A Summary of Public Concerns Regarding the Characterization of a Repository Site in Nevada, NVO-263, Las Vegas, Nev.

DOE/NVO (U.S. Department of Energy, Nevada Operations), 1984. Nevada Nuclear Waste Storage Investigations Quality Assurance Plan, NVO-196-17 (Rev. 3), Nevada Operations Office, Las Vegas, Nev.

DOI (U.S. Department of the Interior), 1985. A Proposed Program to Study the Water Resources of the Carbonate-Rock System of Eastern and Southern Nevada, Washington, D.C.

Daemen, et al, 1983.

Daniels, J. J., and J. H. Scott, 1981. Interpretation of Hole-to-Surface Resistivity Measurements at Yucca Mountain, Nevada Test Site, USGS-OFR-81-1336, Open-File Report, U.S. Geological Survey.

Daniels, J. J., J. H. Scott, and J. T. Hagstrum, 1981. Interpretation of Geophysical Well-Log Measurements in Drill Holes UE25a-4, -5, -6, and -7, Yucca Mountain, Nevada Test Site, USGS-OFR-81-389, Open-File Report, U.S. Geological Survey.

Daniels, W. R., K. Wolfsberg, R. S. Rundberg, with others, 1982. Summary Report on the Geochemistry of Yucca Mountain and Environs, J. Heiken (ed.), LA-9328-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Davis, S. N., and R. J. M. DeWiest, 1966. Hydrogeology, John Wiley & Sons, New York, pp. 319, 333, 336-33

Delany, J. M., 1985. Reaction of Topopah Spring Tuff with J-13 Water: A Geochemical Modeling Approach Using the EQ3/6 Reaction Path Code, UCRL-53631, Lawrence Livermore National Laboratory, Livermore, Calif.

De Marsily, G., 1986. Quantitative Hydrogeology, Groundwater Hydrology for Engineers, Academic Press, Inc., New York, pp. 24-25.

Dennis, A. W., J. C. Frostenson, and K. J. Hong, 1984a. NNWSI Repository Worker Radiation Exposure, Vol. I, Spent Fuel and High-Level Waste Operations in a Geologic Repository in Tuff, SAND83-7436/1, Sandia National Laboratories, Albuquerque, N. Mex.

Dennis, A. W., R. Mulkin, and J. C. Frostenson, 1984b. Operational Procedures for Receiving, Packaging, Emplacing, SAND83-1982C, Sandia National Laboratories, Albuquerque, N. Mex.

Dettinger, M. D., and J. L. Wilson, 1981. "First Order Analysis of Uncertainty in Numerical Models of Groundwater Flow, Part 1, Mathematical Development," Water Resources Research, Vol. 17, No. 1, pp. 149-161.

de Voogd, B., L. Serpa, L. Brown, E. Hauser, S. Kaufman, J. Oliver, B. W. Troxel, J. Willemin and L. A. Wright, 1986. "Death Valley Bright Spot: A Midcrustal Magma Body in the Southern Great Basin, California?," Geology, Vol. 14, pp. 64-67.

Dial, B. W., D. E. Maxwell, E. G. McNulty, and M. Reeves, 1988. "Near-Field Shaft Response Analysis Using the CAVS Jointed Rock Model," in Key Questions in Rock Mechanics: Proceedings of the 29th U.S. Symposium, University of Minnesota/Minneapolis/13-15 June 1988, P. A. Cundall, R. L. Sterling, A. M. Starfield (eds.). pp. 421-428.

Dixon, D. A., and M. N. Gray, 1985a. "The Engineering Properties of Buffer Material," in Proceedings of the 19th Information Meeting of the Nuclear Fuel Waste Management Program, Toronto, Ontario, Canada, TR-350.

Dockery Ander, H., 1984. Rotation of Late Cenozoic Extensional Stresses, Yucca Flat Region, Nevada Test Site, Nevada, unpublished Ph.D. thesis, Rice University, Houston, Tex., 77 p.

Dohrenwend, J. C., 1984. "Nivation Landforms in the Western Great Basin and Their Paleoclimatic Significance," Quaternary Research, Vol. 22, pp. 275-288.

Dohrenwend, J. C., 1987. "Basin and Range," Geomorphic Systems of North America W. L. Graf (ed.), The Geological Society of America, Boulder, Colo. p. 331.

Donath and Cranwell, 1981.

Dorn, R. I., 1983. "Cation-Ratio Dating: A New Rock Varnish Age-Determination Technique," Quaternary Research, Vol. 20, pp. 49-73.

Dudley, W. W., Jr., and J. D. Larson, 1976. Effect of Irrigation Pumping on Desert Pupfish Habitats in Ash Meadows, Nye County, Nevada, U.S. Geological Survey Professional Paper 927, U.S. Goverment Printing Office, Washington, D.C.

Dudley, A. L., R. R. Peters, J. H. Gauthier, M. L. Wilson, M. S. Tierney, and E. A. Klavetter, 1988. Total System Performance Assessment Code (TOSPAC) Volume 1: Physical and Mathematical Bases SAND85-0002(draft), Sandia National Laboratories, Albuquerque, N. Mex.

EPA (U.S. Environmental Protection Agency), 1975. Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, AD/A119 287, Washington, D.C.

EPA (U.S. Environmental Protection Agency), 1984. Ground-Water Protection Strategy, Office of Ground-Water Protection, Washington, D.C.

EPA (Environmental Protection Agency), 1985.

EPA (U.S. Environmental Protection Agency), 1986. Guideline on Air Quality Models (Revised), EPA-450/2-78-027R, Office of Air Quality Planning and Standards, Research Triangle Park, N.C.

EPA (U.S. Environmental Protection Agency), 1987. Protocol for Applying and Validating the CMB Model, EPA-450/4-87-010, EPRI (Electric Power Research Institute), 1986. Seismic Hazard Methodology for the Central and Eastern United States, EPRI NP-4726, No. 1, Risk Engineering, Inc., Woodward-Clyde Consultants, Geomatrix Consultants, Inc., and CYGNA Corporation.

Eaton, R. R., D. K. Gartling, and D. E. Larson, 1983. SAGUARO - A Finite Element Computer Program for Partially Saturated Porous Flow Problems, SAND82-2772, Sandia National Laboratories, Albuquerque, N. Mex.

Eberl, D., and J. Hower, 1976. "Kinetics of Illite Formation," Geological Society of America Bulletin, 60914, Vol. 87, pp. 1326-1330.

Eby, 1981.

Ehgartner, B. L., 1987. Sensitivity Analyses of Underground Drift Temperature, Stresses, and Safety Factors to Variation in the Rock Mass Properties of Tuff for a Nuclear Waste Repository Located at Yucca Mountain, Nevada, SAND86-1250, Sandia National Laboratories, Albuquerque, N. Mex.

Ehgartner, B. L., and R. C. Kalinski, 1988. A Synopsis of Analyses (1981-87) Peformed to Assess the Stability of Underground Excavations at Yucca Mountain, SAND88-2294, Sandia National Laboratories, Albuquerque, N. Mex.

Einziger, R. E., 1985. Technical Test Description of Activities to Determine the Potential for Spent Fuel Oxidation in a Tuff Repository, HEDL-7540, Hanford Engineering Development Laboratory, Richland, Wash.

Eisenberg, N. A., and A. E. Van Luik, 1987. "Validation Actitivies Addressing Performance Issues Pertinent to the U.S. DOE Geologic Repository Projects," in Proceedings of the Geoval-87 Symposium, April 7-9, Stockholm, Sweden, pp. 423-455.

Eisenberg, N. A., A. E. Van Luik, L. E. Plansky, and R. J. Van Vleet, 1987. "A Proposed Validation Strategy for the U.S. DOE Office of Civilian Radioactive Waste Management Geologic Repository Program," in Proceedings of Geoval-87, Stockholm, Sweden, April 7-9, 1987, pp. 1-33.

Eiswirth, M., J. I. Kim, and Ch. Lierse, 1985. "Optical Absorption Spectra of Pu(IV) in Carbonate/Bicarbonate Media," Radiochimica Acta Vol. 38, pp. 197-201.

Ekren, E. B., 1968. "Geologic Setting of Nevada Test Site and Nellis Air Force Range," Nevada Test Site, E. B. Eckel (ed.), Geological Society of America Memoir 110, pp. 11-19.

Ekren, E. B., and F. M. Byers, Jr., 1985. Geologic Map of the Gabbs Mountain, Mount Ferguson, Luning, and Sunrise Flat Quadrangles, Mineral and Nye Counties, Nevada, U.S. Geological Survey Miscellaneous Investigations Series Map I-1577, Scale 1:48,000. U.S. Geological Survey.

Ekren, E. B., E. N. Hinrichs, W. D. Quinlivan, and D. L. Hoover, 1973. Geologic Map of the Moores Station Quadrangle, Nye County, Nevada, U.S. Geological Survey Miscellaneous Investigations Series Map I-756, U.S. Geological Survey.

Ekren, E. B., C. L. Rogers, G. L. Dixon, 1973. Geologic and Bouguer Gravity Map of the Reveille Quadrange, Nye County, Nevada, U.S. Geological Survey Miscellaneous Investigation Series Map I-806, U.S. Geological Survey.

Elder, J. C., J. M. Graf, J. M. Dewart, T. E. Buhl, W. J. Wenzel, L. J. Walker, and A. K. Stoker, 1986. A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities, LA-10294-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Ellis, W. L., and H. S. Swolfs, 1983. Preliminary Assessment of In Situ Geomechanical Characteristics in Drill Hole USW G-1, Yucca Mountain, Nevada, USGS-OFR-83-401, Open-File Report, U.S. Geological Survey.

Endo, H. K., and P. A. Witherspoon, 1985. "Mechanical Transport and Porous Media Equivalence in Anisotropic Fracture Networks," Hydrogeology of Rocks of Low Permeability, Memoires of the International Association of Hydrogeologists, 17th International Congress, 1985, Tucson, Ariz., pp. 527-537.

Erickson, J. R., and R. K. Waddell, 1985. Identification and Characterization of Hydrologic Properties of Fractured Tuff using Hydraulic and Tracer Tests--Test Well USW H-4, Yucca Mountain, Nye County, Nevada, USGS-WRI-85-4066, Water-Resources Investigations Report, U.S. Geological Survey.

Erickson, J. R., D. L. Galloway, and K. Karasaki, 1985. "Interpretations of Falling-Head Injection Test Data for Fractured Volcanic Tuffs, Yucca Mountain, Nevada Test Site," Geological Society of America Abstracts with Programs, Vol. 17, No. 7, pp. 574-575.

Evans, D. A., and T. J. Nicholson, 1987. "Flow and Transport Through Unsaturated Fractured Rock, Geophysical Monograph 42, American Geophysical Union, D. D. Evans and T. J. Nicholson (eds.), Vol. IV Series, pp. 1-10.

F & S (Fenix & Scisson, Inc.), 1986. NNWSI Hole Histories, DOE/NV/10322-9 thru 21 & 24. Mercury, Nev.

F & S (Fenix & Scisson), 1988. Impact Analysis for Calico Hills Penetration and Exploratory Drift and Tuff Main Extension to Limits of the Repository Block, WMPO Action Item 88-1995, 111 p.

FLPMA (Federal Land Policy and Management Act), 1976. Public Law 94-579, 90 Stat. 2743,

Federal Mine Safety and Health Act of 1977, 1977. "Federal Mine Safety and Health Amendements Act of 1977," Public Law 95-164, 91 STAT. 1290-1322.

Feller, 1960.

Feller, 1966.

Fernandez, J. A., 1985. Repository Sealing Plan for the Nevada Nuclear Waste Storage Investigations Project Fiscal Year 1984 Through 1990, SAND84-0910, Sandia National Laboratories, Albuquerque, N. Mex.

Fernandez, J. A., and M. D. Freshley, 1984. Repository Sealing Concepts for the Nevada Nuclear Waste Storage Investigations Project, SAND83-1778, Sandia National Laboratories, Albuquerque, N. Mex.

Fernandez, J. A, P. C. Kelsall, J. B. Case, and D. Meyer, 1987. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program, SAND84-1895, Sandia National Laboratories, Albuquerque, N. Mex.

Fernandez, J. A., T. E. Hinkebein, and J. B. Case, 1988. Analyses to Evaluate the Effect of the Exploratory Shaft on Repository Performance of Yucca Mountain, SAND85-0598, Sandia National Laboratories, Albuquerque, N. Mex.

Fisher, R. V., and H.-U. Schmincke, 1984. Pyroclastic Rocks, Springer-Verlag, Germany, pp. 139-141, 144, 20

Fitterman, D. V., 1982. Magnetometric Resistivity Survey Near Fortymile Wash, Nevada Test Site, Nevada, USGS-OFR-82-401, Open-File Report, U.S. Geological Survey.

Flanigan, V. J., 1981. A Slingram Survey at Yucca Mountain on the Nevada Test Site, USGS-OFR-81-980, Open-File Report, U.S. Geological Survey.

Flores, R. J., 1986. Retrievability: Strategy for Compliance Demonstration, SAND84-2242, Sandia National Laboratories, Albuquerque, N. Mex.

Forester, R. M., 1987. "Late-Quaternary Paleoclimate Records from Lacustrine Ostracodes," North America and Adjacent Oceans during the Last Deglaciation, W. F. Ruddiman and H. E. Wright, Jr. (eds.), Geological Society of America.

Fournier, R. O., M. L. Sorey, R. H. Mariner and A. H. Truesdell, 1979. "Chemical and Isotopic Prediction of Aquifer Temperatures in the Geothermal System at Long Valley, California," Journal of Volcanology and Geothermal Research, Vol. 5, Elsevier Scientific Publishing Co., Amsterdam, pp. 17-34.

Fouty, S. C., 1984. Index to Published Geologic Maps in the Region Around the Potential Yucca Mountain Nuclear Waste Repository Site, Southern Nye County, Nevada, USGS-OFR-84-524, Open-File Report, U.S. Geological Survey.

Freeze, R. A., and J. A. Cherry, 1979. Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, pp. 389-390, 551-552

Frischknecht, F. C., and P. V. Raab, 1984. "Time-Domain Electromagnetic Soundings at the Nevada Test Site, Nevada," Geophysics, Vol. 49, No. 7, pp. 981-992.

Frizzell, V. A. Jr., and M. L. Zoback, 1987. "Stress Orientation Determined from Fault Slip Data in Hampel Wash Area, Nevada, and Its Relations to Contemporary Regional Stress Field," Tectonics, Vol. 6, No. 2, pp. 89-98.

Furgerson, R. B., 1982. Remote-Reference Magnetotelluric Survey Nevada Test Site and Vicinity, Nevada and California, USGS-OFR-82-465, Open-File Report, U.S. Geological Survey.

SDRD APPENDIX D

ESF RELATED REFERENCABLE PROJECT DOCUMENTATION

Galloway, D., and M. Sullivan, 1986. "Estimates of Confined and Unconfined Aquifer Characteristics from Ground-Water Level Fluctuations, Yucca Mountain, Nevada," EOS, Vol. 67, No. 44, p. 942.

Galloway, D. L., and J. R. Erickson, 1985. "Tracer Test for Evaluating Nonpumping Intraborehole Flow in Fractured Media," Transactions, American Nuclear Society, Nuclear Techniques for Hydrogeological Studies, Vol. 50, pp. 192-193.

Gartling, D. K., 1982. COYOTE - A Finite Element Computer Program for Nonlinear Heat Conduction Problems, SAND77-1332, Sandia National Laboratories, Albuquerque, N. Mex.

Gartling, D. K., and C. E. Hickox, 1982. MARIAH - A Finite Element Computer Program for Incompressible Porous Flow Problems: Theoretical Background, SAND79-1622, Sandia National Laboratories, Albuquerque, N. Mex.

Gass, S. I., 1983. "Decision-Aiding Models: Validation, Assessment, and Related Issues for Policy Analysis," Operations Research, Vol. 31, No. 4, pp. 603-631.

Gerhardt, P. (ed.), 1981. Manual of Methods for General Bacteriology, American Society for Microbiology, Washington, D.C., pp. 127-130.

Gianella, V. P., and E. Callaghan, 1934a. "The Cedar Mountain, Nevada, Earthquake of December 20, 1932," Bulletin of the Seismological Society of America, Vol. 24, No. 4, pp. 345-377.

Gianella, V. P., and E. Callaghan, 1934b. "The Earthquake of December 20, 1932, at Cedar Mountain, Nevada and Its Bearing on the Genesis of Basin Range Structure," Journal of Geology, Vol. 42, No. 1, pp. 1-22.

Gile, L. H., F. F. Peterson, and R. B. Grossman, 1965. "Morphological and Genetic Sequences of Carbonate Accumulates in Desert Soil, Soil Science Vol. 101, No. 5, pp. 347-360.

Glover, K. C., 1986. A Dual-Porosity Model for Simulating Solute Transport in Oil Shale, USGS-WRI-85-4281, Water Resources Investigations Report, U.S. Geological Survey.

Gnirk et al, 1988.

Goodman, R. E., 1980. Introduction to Rock Mechanics, John Wiley & Sons, Inc., New York.

Gordon, M. N. Tanious, J. Bradbury, L. Kovach, and R. Codell, 1986. Draft Generic Technical Position: Interpretation and Identification of the Extent of the Disturbed Zone in the High-Level Waste Rule (10 CFR 60), U.S. Nuclear Regulatory Commission, Washington, D.C.

Grambow, B., 1984. "A Physical-Chemical Model for the Mechanism of Glass Corrosion - with Particular Consideration of Simulated Radioactive Waste Glasses," Dissertation, Freien Universitaet, Berlin, Germany, DP-tr-78, Available in translation from NTIS.

Grambow, B., H. P. Hermansson, I. K. Bjorner, and L. Werme, 1985. "Glass/Waste Reaction With and Without Bentonite Present - Experiment and Model," in Scientific Basis for Nuclear Waste Management IX, Materials Research Society Symposia Proceedings, Stockholm, Sweden, September 9-11, 1985, L. O. Werme (ed.), Vol. 50, Materials Research Society, Pittsburgh, Penn., pp. 187-194.

Grambow, B., H. U. Zwicky, G. Bart, I. K. Bjorner, and L. O. Werme, 1987. "Modeling of the Effect of Iron Corrosion Products on Nuclear Waste Glass Performance," in Scientific Basis for Nuclear Waste Management X, Materials Research Society Symposia Proceedings, December 1-4, 1986, Boston, Massachusetts, J. K. Bates and W. B. Seefeldt (eds.), Vol. 84, Materials Research Society, Pittsburgh, Penn., pp. 471-481.

Gray, M. N. (comp.), 1986. Stripa Phase III, Report on Sealing Materials and Methods (ms), Atomic Energy of Canada Limited, Pinawa, Manitoba, 25 p.

Gray, 1987.

Greenhaus, M. R., and C. J. Zablocki, 1982. A Schlumberger Resistivity Survey of the Amargosa Desert, Southern Nevada, USGS-OFR-82-897, Open-File Report, U.S. Geological Survey,

Griffiths, D. H., and R. F. King, 1965. Applied Geophysics for Engineers and Geologists, Pergamon Press, New York, pp. 121-132.

Gringarten, A. C., 1982. "Flow-Test Evaluation of Fractured Reservoirs," Recent Trends in Hydrogeology, Geological Society of America Special Paper 189, pp. 237-263.

Gringarten, A. C., and H. J. Ramey, Jr., 1974. "Unsteady-State Pressure Distributions Created by a Well with a Single Horizontal Fracture, Partial Penetration, or Restricted Entry," Society of Petroleum Engineers Journal, Vol. 14, No. 4, pp. 413-426.

Gringarten, A. C., and P. A. Witherspoon, 1972. "A Method of Analyzing Pumping Test Data from Fractured Aquifers," in Proceedings, Symposium on Percolation in Fissured Rock, Vol. 3, International Society of Rock Mechanics, Stuttgart, pp. B1-B9.

Gringarten, A. C., H. J. Ramey, Jr., and R. Raghaven, 1974. "Unsteady-State Pressure Distributions Created by a Well with a Single Infinite-Conductivity Vertical Fracture," Society of Petroleum Engineers Journal, Vol. 14, No. 4, pp. 347-360.

Gringarten, A. C., D. P. Bourdet, P. A. Landel, and V. J. Kniazeff, 1979. "A Comparison Between Different Skin and Wellbore Storage Type-Curves for Early-Time Transient Analysis," SPE-AIME 54th Annual Technical Conference and Exhibition, Las Vegas, Nevada, September 23-26, 1979, SPE-8205, Dallas Society of Petroleum Engineers, Dallas, Tex.

Gromme, C. S., E. H. McKee, M. C. Blake, Jr., 1972. "Paleomagnetic Correlations and Potassium-Argon Dating of Middle Tertiary Ash-Flow Sheets in the Eastern Great Basin, Nevada and Utah," Geological Society of America Bulletin, Vol. 83, pp. 1619-1638.

Grove, D. B., and W. A. Beetem, 1971. "Porosity and Dispersion Constant Calculations for a Fractured Carbonate Aquifer Using the Two Well Tracer Method," Water Resources Research, Vol. 7, No. 1, U.S. Geological Survey, Water Resources Division, pp. 128-134.

Grutzeck, M. W., B. E. Scheetz, E. L. White, and D. M. Roy, 1980. "Modified Cement-Based Borehole Plugging Materials: Properties and Potential Longevity," in Proceedings of a Workshop on Borehold and Shaft Plugging,

Gulick, Jr., C. W., 1978. Borehole Plugging - Materials Development Program, SAND78-0715, Sandia National Laboratories, Albuquerque, N. Mex.

Hagan, R. M., H. R. Haise, and T. W. Edminster (eds.), 1967. Irrigation of Agricultural Lands, No. 11, American Society of Agronomy, Inc., Madison, Wisc.

Hagstrum, J. T., J. J. Daniels, and J. H. Scott, 1980. Interpretation of Geophysical Well Log Measurements in Drill Hole UE25a-1, Nevada Test Site, USGS-OFR-80-941, Open-File Report, Radioactive Waste Program, U.S. Geological Survey.

Hallquist, J. O., 1983. NIKE2D - A Vectorized, Implicit, Finite Deformation, Finite Element Code for Analyzing the Static and Dynamic Response of 2-D Solids, UCID-19677, Lawrence Livermore National Laboratory, Livermore, Calif.

Hammermeister, D. P., D. O. Blout, and J. C. McDaniel, 1985. "Drilling and Coring Methods That Minimize the Disturbance of Cutting, Core, and Rock Formation in the Unsaturated Zone, Yucca Mountain, Nevada," in Proceedings of the NWWA Conference on Characterization and Monitoring of the Vadose (Unsaturated) Zone, November 19-21, 1985, Denver, Colo., National Water Well Association, Worthington, Ohio, pp. 507-541.

Hammersley, J. M., and D. C. Handscomb, 1964. "General Principles of the Monte Carlo Method," Monte Carlo Methods, Chapter 5, John Wiley & Sons, Inc., New York, pp. 50-75.

Hanson, J. M., 1984. Evaluation of Subsurface Fracture Geometry Using Fluid Pressure Response to Solid Earth Tidal Strain, UCID-20156, Lawrence Livermore National Laboratory, Livermore, Calif., 135 p.

Hantush, M. S., 1960. "Modification of the Theory of Leaky Aquifer," Journal of Geophysical Research, Vol. 65, No. 11, pp. 3713-3725.

Hantush, M. S., and C. E. Jacob, 1955. "Non-Steady Radial Flow in an Infinite Leaky Aquifer," Transactions, American Geophysical Union, Vol. 36, No. 1, pp. 95-100.

Harder, Jr., L. S., and H. B. Seed, 1986. Determination of Penetration Resistance for Coarse Grained Soils Using the Becker Hammer Drill, UCB-EERC-86-06, University of California, Berkeley.

Hardyman, R. F. E. B. Ekren, and F. M. Byers, Jr., 1975. "Cenozoic Strike-Slip, Normal, and Detachment Faults in Northern Part of the Walker Lane, West-Central Nevada," Geological Society of America Abstracts with Programs, Vol. 7 p. 1100.

Harmsen, S., and S. Harding, 1981. "Surface Motion Over a Sedimentary Valley for Incident Plane P and SV Waves," Bulletin of the Seismological Society of America, Vol. 71, No. 3, pp. 655-670.

Harrington, C. D., and J. W. Whitney, 1987. "Scanning Electron Microscope Method for Rock-Varnish Dating," Geology, Vol. 15, pp. 967-970.

Harris, A. G., B. R. Warlow, C. C. Rust and G. K. Merrill, 1980. Maps for Assessing Thermal Maturity (Conodont Color Alteration Index Maps) in Ordovician Through Triassic Rocks in Nevada and Utah and Adjacent Parts of Idaho and California, Miscellaneous Investigations Series Map I-1249, U.S. Geological Survey.

Hartzell, S., 1985. "The Use of Small Earthquakes as Green's Functions," Strong Ground Motion Simulation and Earthquake Engineering Applications: A Technological Assessment, R. E. Scholl and J. L. King (eds.), Publication No. 85-02, Section 22, Earthquake Engineering Research Institute, pp. 22-1 to 22-8.

Hasselmann, K., 1976. "Stochastic Climate Models, Part I, Theory," Tellus, Vol. 28, pp. 473-484.

Hassler, G. L., 1944. "Method and Apparatus for Permeability Measurements," U.S. Patent No. 2,345,935, April, 4.

Hassler, G. L., and E. Brunner, 1945. "Measurement of Capillary Pressures in Small Core Samples," Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology 1945, Vol. 160, pp. 114-123.

Hayden, N. K., 1985. Benchmarking NNWSI Flow and Transport Codes: Cove 1 Results, SAND84-0996, Sandia National Laboratories, Albuquerque, N. Mex.

Hayes, et al, 1987.

Hays, J. D., J. Imbrie, and N. J. Shackleton, 1976. Variations in the Earth's Orbit: Pacemaker of the Ice Ages, Science, Vol. 194, No. 4270, pp. 1121-1132.

Healey, D. L., F. G. Clutsom, and D. A. Glover, 1986. Borehole Gravity Meter Survey in Drill Hole USW G-4, Yucca Mountain Area, Nye County, Nevada, USGS-OFR-86-205, Open-File Report, U.S. Geological Survey.

Healy, J. H., S. H. Hickman, M. D. Zoback, and W. L. Ellis, 1984. Report on Televiewer Log and Stress Measurements in Core Hole USW-G1, Nevada Test Site, December 13-22, 1981, USGS-OFR-84-15, Open-File Report, U.S. Geological Survey.

Herzig, J. P., D. M. LeClerc, and P. LeGoff, 1970. "Flow of Suspensions Through Porous Media, Application to Deep Filtration," Industrial & Engineering Chemistry, Vol. 62, No. 5, pp. 8-35.

Hill, D. P., R. E. Wallance, and R. S. Cockerham, 1985. "Review of Evidence on the Potential for Major Earthquakes and Volcanism in the Long Valley-Mono Craters-White Mountains Regions of Eastern California," Earthquake Prediction, Earthquake Prediction Research Vol. 3, No. 3-4, Terra Scientific Publishing Co., Tokyo, Japan, pp. 571-594.

Hill, J., 1985. Structural Analysis of the NNWSI Exploratory Shaft, SAND84-2354, Sandia National Laboratories, Albuquerque, N. Mex.

Hillel, D., 1971. Soil and Water: Physical Principles and Processes, Academic Press, Inc., Orlando, Florida, pp. 140-143.

Hillel, D. I., 1982. Introduction to Soil Physics, Academic Press, Inc., New York.

Hils, 1975.

Ho, D. M., R. L. Sayre and C. L. Wu, 1986. Suitability of Natural Soils for Foundations for Surface Facilities at the Prospective Yucca Mountain Nuclear Waste Repository, SAND85-7107, Sandia National Laboratories, Albuquerque, N. Mex.

Hoek, E., and E. T. Brown, 1980. Underground Excavations in Rock, Institution of Mining & Metallurgy, London, pp. 137-139, 285-298

Hoffman, D. C., R. Stone, and W. W. Dudley, Jr., 1977. Radioactivity in the Underground Environment of the Cambric Nuclear Explosion at the Nevada Test Site, LA-6877-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Hoffman, F. O., C. W. Miller, D. L. Shaeffer, and C. T. Garten, Jr. 1977. "Computer Codes for the Assessment of Radionuclides Released to the Environment, Nuclear Safety, Vol. 18, No. 3, pp. 343-354.

Hoffman, L. R., and W. D. Mooney, 1983. A Seismic Study of Yucca Mountain and Vicinity, Southern Nevada; Data Report of Preliminary Results, USGS-OFR-83-588, Open-File Report, U.S. Geological Survey.

Holt, J. G. (ed.), 1984. Bergey's Manual of Systematic Bacteriology, two volumes, Williams & Wilkins, Baltimore, Maryland.

Hooten, R. D., 1986a. "Cement-Based Construction Grouts for Possible Use at the URL," Ontario Hydro Research, Report No. 83-393-K.

Hooten, R. D. 1986b. "Development of Concrete Mixtures for Radioactive Waste Disposal," 2nd International Conference on Radioactive Waste Management, Canadian Nuclear Society, Winnipeg, Canada.

Hoover, D. B., M. P. Chornack, K. H. Nervick, and M. M. Broker, 1982. Electrical Studies at the Proposed Wahmonie and Calico Hills Nuclear Waste Sites, Nevada Test Site, Nye County, Nevada, USGS-OFR-82-466, Open-File Report, U.S. Geological Survey.

Hopkins, P. L., R. R. Eaton, and S. Sinnock, 1987. Effect of Drift Ventilation on Repository Hydrology and Resulting Solute Transport Implications, SAND86-1571, Sandia National Laboratory, Albuquerque, N. Mex.

Hose, R. K., 1983. Geologic Map of the Cockalorum Wash Quadrangle, Eureka and Nye Counties, Nevada, U.S. Geological Survey Miscellaneous Investigation Series Map I-1410, U.S. Geological Survey.

Houston, J. R., D. L. Strenge, and E. C. Watson, 1974. DACRIN - A Computer Program for Calculating Organ Dose from Acute or Chronic Radionuclide Inhalation, BNWL-B-389, Pacific Northwest Laboratory, Richland, Wash.

Hsieh, P. A., S. P. Neuman, G. K. Stiles, and E. S. Simpson, 1985. "Field Determination of the Three-Dimensional Hydraulic Conductivity Tensor of Anisotropic Media, 2. Methodology and Application to Fractured Rocks," Water Resources Research, Vol. 21, No. 11, pp. 1667-1676.

Huben, and Nelson, 1988.

Hunt, C. B., T. W. Robinson, W. A. Bowles, and A. L. Washburn, 1966. Hydrologic Basin, Death Valley, California, U.S. Geological Survey Professional Paper 494-B, U.S. Goverment Printing Office, Washington, D.C.

Hunter, and Mann, 1988.

Hunter et al, 1986.

Hustrulid, W., 1984a. Lining Considerations for a Circular Vertical Shaft in Generic Tuff, SAND83-7068, Sandia National Laboratories, Albuquerque, N. Mex.

Hustrulid, W., 1984b. Preliminary Stability Analysis for the Exploratory Shaft, SAND83-7069, Sandia National Laboratories, Albuquerque, N. Mex.

Huyakorn, P. S., B. H. Lester and J. W. Mercer, 1983. "An Efficient Finite-Element Technique for Modeling Transport in Fractured Porous Media, 1. Single Species Transport," Water Resources Research, Vol. 19, No. 3, pp. 841-854.

Hvorslev, M. J., 1949. Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes, (reprinted as Hvorslev, 1965, by Engineering Foundation), U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Miss., pp. 15-17.

IAEA (International Atomic Energy Agency), 1982. Radioactive Waste Management Glossary, IAEA-TECDOC-264, International Atomic Energy Agency, Vienna

IAEA (International Atomic Energy Agency), 1983a. Concepts and Examples of Safety Analyses for Radioactive Waste Repositories in Continental Geological Formations, Safety Series No. 58, Vienna, Austria.

IAEA (International Atomic Energy Agency), 1983b. Criteria for Underground Disposal of Solid Radioactive Wastes, Recommendations, Safety Series No. 60, Vienna, Austria.

IAEA (International Atomic Energy Agency), 1985. Performance Assessment for Underground Radioactive Waste Disposal Systems, Safety Series No. 68, Vienna, Austria.

ICRP (International Commission of Radiological Protection), 1977. Recommendations of the International Commission on Radiological Protection, ICRP Publication 26, Pergamon Press, Oxford, England.

ICRP (International Commission of Radiological Protection), 1978. Limits for Intake of Radionuclides by Workers, Annals of the ICRP, ICRP Publication 30, Pergamon Press, Oxford, England.

INTERA Environmental Consultants, Inc., 1983. WAPPA: A Waste Package Performance Assessment Code, ONWI-452, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio.

INTRACOIN (International Nuclide Transport Code Intercomparison Study), 1986. Final Report Level 1, Code Verification, SKI 84:3, Stockholm, Sweden.

ISRM (International Society for Rock Mechanics), 1981. Rock Characterization Testing & Monitoring, E. T. Brown (ed.), Pergamon Press, New York, pp. 33,62-67.

ISRM (International Society of Rock Mechanics), 1981. "Part 1. Suggested Method for In-Situ Determination of Direct Shear Strength," Rock Characterization Testing and Monitoring: ISRM Suggested Methods, E. T. Brown (ed.), pp. 131-135.

Iman, R. L., and W. J. Conover, 1982. Sensitivity Analysis Techniques - Self-Teaching Curriculum, SAND81-1978, Sandia National Laboratories, Albuquerque, N. Mex.

Iman, R. L., and J. C. Helton, 1985. A Comparison of Uncertainty and Sensitivity Analysis Techniques for Computer Models, NUREG/CR-3904, SAND84-1461, Sandia National Laboratories, Albuquerque, N. Mex.

Imbrie, J., and J. Z. Imbrie, 1980. "Modeling the Climatic Response to Orbital Variations," Science, Vol. 207, pp. 943-953.

Iwai, 1976.

Izett, G. A., 1982. The Bishop Ash Bed and Some Older Compositionally Similar Ash Beds in California, Nevada, and Utah, USGS-OFR-82-582, Open-File Report, U.S. Geological Survey, 44 p.

Jahns, H., 1966. "Measuring the Strength of Rock In-Situ at Increasing Scale," in Proceedings 1st Congress International Society of Rock Mechanics (London), Vol. 1, pp. 477-482.

Jansma, P. E., D. B. Snyder, and D. A. Ponce, 1982. Principal Facts of Gravity Stations with Gravity and Magnetic Profiles from the Southwest Nevada Test Site, Nye County, Nevada, as of January, 1982, USGS-OFR-82-1041, Open-File Report, U.S. Geological Survey.

Jiracek, G. R., M. E. Ander, and H. T. Holcombe, 1979. "Magnetotelluric Soundings of Crustal Conductive Zones in Major Continental Rifts," Rio Grande Rift: Tectonic and Magmatism, R. E. Riecker (ed.), American Geophysical Union, Washington, D.C., pp. 209-221.

Johnson, R. L., and R. K. Thomas, 1983. "Constitutive Model for Ubiquitously Jointed Rock Masses," Submitted to the International Conference on Constitutive Laws for Engineering Materials, Jan. 10, 1983, Tucson, AZ., SAND81-2443C, Sandia National Laboratories, Albuquerque, N. Mex., 8 p.

Johnson, R. L., 1981. Thermo-Mechanical Scoping Calculations for a High Level Nuclear Waste Repository in Tuff, SAND81-0629, Sandia National Laboratories, Albuquerque, N. Mex.

Johnson, R. L., and S. J. Bauer, 1987. Unit Evaluation at Yucca Mountain, Nevada Test Site: Near-Field Thermal and Mechanical Calculations Using the SANDIA-ADINA Code, SAND83-0030, Sandia National Laboratories, Albuquerque, N. Mex.

Johnstone, J. K., R. R. Peters, and P. F. Gnirk, 1984. Unit Evaluation at Yucca Mountain, Nevada Test Site: Summary Report and Recommendation, SAND83-0372, Sandia National Laboratories, Albuquerque, N. Mex.

Kale, Stephen H., 1986. Letter to Stephen H. Kale, from Robert Browning - NRC Staff Comments on the DOE Final Environmental Assessments, 104 p.

Kane, M. F., and R. E. Bracken, 1983. Aeromagnetic Map of Yucca Mountain and Surrounding Regions, Southwest Nevada, USGS-OFR-83-616, Open-File Report, U.S. Geological Survey.

Kane, M. F., M. W. Webring, and B. K. Bhattacharyya, 1981. A Preliminary Analysis of Gravity and Aeromagnetic Surveys of the Timber Mountain Area, Southern Nevada, USGS-OFR-81-189, Open-File Report, U.S. Geological Survey.

Kane, M. F., G. D. Bath, D. B. Snyder, J. G. Rosenbaum, H. W. Oliver, D. A. Ponce, and D. L. Healey, 1982. "Gravity and Magnetic Studies in the Region of the Nevada Test Site [abs.], EOS, Transactions, American Geophysical Union, Vol. 63, No. 45, p. 1099.

Kanehiro, B. Y., and T. N. Narasimhan, 1980. "Aquifer Response to Earth Tides," Well Testing in Low Permeability Environments, Third Invitational Well-Testing Symposium, Berkeley, Calif., March 26-28, 1980, pp. 120-129.

Kaplan, M. F., 1982. Archaeological Data as a Basis for Repository Marker Design, ONWI-354, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio.

Karasaki, K., 1987. Well Test Analysis in Fractured Media, LBL-21442, Lawrence Berkeley Laboratory, Berkeley, Calif.

Kathren, R. L., J. M. Selby, and E. J. Vallario, 1980. A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable (ALARA), DOE/EV/1830-T5, Battelle Pacific Northwest Laboratories, Richland, Wash.

Kauahikaua, J., 1981. Interpretation of Time-Domain Electromagnetic Soundings in the Calico Hills Area, Nevada Test Site, Nye County, Nevada, USGS-OFR-81-988, Open-File Report, U.S. Geological Survey.

Keller, G. V., and F. C. Frischnecht, 1966. Electrical Methods in Geophysical Prospecting, Pergamon Press, New York.

Kelsall, P. C., J. B. Case, and C. R. Chabannes, 1982. A Preliminary Evaluation of the Rock Mass Disturbance Resulting from Shaft, Tunnel, or Borehole Excavation, ONWI-411, Office of Nuclear Waste Isolation, Columbus, Ohio.

Kelsall, P. C., J. B. Case, and C. R. Chabannes, 1984. "Evaluation of Excavation-Induced Changes in Rock Permeability," International Journal of Rock Mechanics, Mining Science, and Geomechanical Abstracts, Vol. 21, No. 3, pp. 123-135.

Kerrisk, J. F., 1987. Groundwater Chemistry at Yucca Mountain, Nevada, and Vicinity, LA-10929-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Khilar, D. C., H. S. Fogler, and D. H. Gray, 1985. "Model for Piping-Plugging in Earthen Structures," Journal of Geotechnical Engineering, Vol. III, No. 7, American Society of Civil Engineers, pp. 833-846.

Kim, J. I., 1986. "Chemical Behaviour of Transuranic Elements in Natural Aquatic Systems," Handbook on the Physics and Chemistry of the Actnides, A. J. Freeman, and C. Keller (eds.), pp. 413-455.

King, J. L., and B. E. Tucker, 1984. "Observed Variation of Earthquake Motion across a Sediment-Filled Valley," Bulletin of the Seismological Society of America, Vol. 74, No. 1, pp. 137-151.

Kipp, K. L., Jr., 1986. HST3D: A Computer Code for Simulation of Heat and Solute Transport in Three-Dimensional Ground-Water Flow Systems, USGS-WRI-86-4095, Water-Resources Investigations Report, U.S. Geological Survey.

Kipp, Jr., K. L., 1987. "Effect of Topography on Gas flow in Unsaturated Fractured Rock: Numerical Simulation," American Geophysical Union, D. D. Evans, and T. J. Nicholson (eds.), pp 171-176.

Kistler, R. W., 1968. "Potassium-Argon Ages of Volcanic Rocks in Nye and Esmeralda Counties," Nevada Test Site, E. B. Eckel (ed.), Geological Society of America Memoir 110, Boulder, Colo., pp. 251-262.

Klavetter, E. A., and R. R. Peters, 1986. Fluid Flow in a Fractured Rock Mass, SAND85-0855, Sandia National Laboratories, Albuquerque, N. Mex.

Klavetter, E. A., and R. R. Peters, 1986. Estimation of Hydrologic Properties of an Unsaturated, Fractured Rock Mass, SAND84-2642, Sandia National Laboratories, Albuquerque, N. Mex.

Klavetter, E. A., and R. R. Peters, 1987. An Evaluation of the Use of Mercury Porosimetry in Calculating Hydrologic Properties of Tuffs From Yucca Mountain, Nevada, SAND86-0286, Sandia National Laboratories, Albuquerque, N. Mex.

Klett, R. D., E. S. Hertel, Jr., and M. A. Ellis, 1980. Systems Engineering Programs for Geologic Nuclear Waste Disposal, SAND80-0440, Sandia National Laboratories, Albuquerque, N. Mex.

Knauss, K. G., 1981. Dating Fault Associated Quaternary Material from the Nevada Test Site Using Uranium-Series Methods, UCRL-53231, Lawrence Livermore National Laboratory, Livermore, Calif.

Knuepfer, P. L. K., P. J. Lemiszki, T. A. Hauge, L. D. Brown, S. Kaufman, and J. E. Oliver, 1987. "Crustal Structure of the Basin and Range-Sierra Nevada Transition from COCORP Deep Seismic-Reflection Profiling," Geological Society of America Bulletin, Vol. 98, pp. 488-496.

Kohler, M. A., T. J. Nordenson, and D. R. Baker, 1959. Evaporation Maps for the United States, U.S. Weather Service, U.S. Department of Commerce, Technical Paper No. 37, U.S. Government Printing Office, Washington, D.C.

Kopf, R. W., 1982. Hydrotectonics: Principles and Relevance, USGS-OFR-82-307, Open-File Report, U.S. Geological Survey.

Koster van Groos, A. F., 1981. Determination of Dehydration Temperatures of a Secondary Vug-Filling Mineral (Smectite Clay) Using a Differential Thermal Analysis at Various Pressures, RHO-BWI-C-102, Rockwell Hanford Operations, Richland, Wash.

Kreamer, D. K., 1982. In Situ Measurement of Gas Diffusion Characteristics in Unsaturated Porous Media by Means of Tracer Experiments, unpublished Ph.D. dissertation, University of Arizona, Ariz.

Kukla, G., A. Berger, R. Lotti, and J. Brown, 1981. "Orbital Signature of Interglacials," Nature, Vol. 290, pp. 295-300.

Kume, J., and D. P. Hammermeister, 1987. "Geologic Factors that Affect Physical and Hydrologic Properties of Volcanic Tuffs in the Unsaturated Zone, Yucca Mountain, Nevada," Geological Society of America Abstracts with Program, Vol. 19, No. 7, p. 735.

Kunz, K. S., and M. P. Tixier, 1955. "Temperature Surveys in Gas Producing Wells," Transactions, American Institute of Mining Engineers, Vol. 204, pp. 111-119.

Kurz, M. D., and W. J. Jenkins, 1981. "The Distributuion of Helium in Oceanic Basalt Glasses," Earth and Planetary Science Letters, Vol. 53, pp. 41-54.

Kurz, M. D., W. J. Jenkins, S. R. Hart, and D. Clague, 1983. "Helium Isotopic Variations in Volcanic Rocks from Loihi Seamount and the Island of Hawaii," Earth and Planetary Science Letters, Vol. 66, pp. 388-406,

Kutzbach, J. E., and B. L. Otto-Bliesner, 1982. "The Sensitivity of the African-Asian Monsoonal Climate to Orbital Parameter Changes for 9000 Years B.P. in a Low-Resolution General Circulation Model," Journal of the Atmospheric Sciences, Vol. 39, No. 6, pp. 1177-1188.

Kwicklis, E. N., and D. T. Hoxie, 1988. "Numerical Simulation of Liquid-Water Infiltration Into a Fractured Welded Tuff," Workshop IV on Flow and Transport through Unsaturated Fractured Rock as Related to a High-Level Radioactive Waste Repository, (abstract), University of Arizona, Tucson, Ariz.

Lachenbruch, A. H., J. H. Sass, R. J. Munroe, and T. H. Moses, Jr. 1976. "Geothermal Setting and Simple Heat Conduction Models of the Long Valley Caldera," Journal of Geophysical Research, Vol. 81, No. 5, pp. 769-784.

Langkopf, B. S., 1987. Proposed Preliminary Definition of the Disturbed-Zone Boundary Appropriate for a Repository at Yucca Mountain, SAND86-1955, Sandia National Laboratories, Albuquerque, N. Mex.

Langton, and Roy, 1983.

Laub, T. W., and L. J. Jardine, 1987. Initial Q-List for the Prospective Yucca Mountain Repository Based on Items Important to Safety and Waste Isolation, SAND86-1965C, Sandia National Laboratories, Albuquerque, N. Mex.

LeRoy, L. W., D. O. LeRoy, and J. W. Raese (eds.), 1977. Subsurface Geology - Petroleum Mining Construction, Colorado School of Mines, Golden.

Libardi, P. L., K. Reichardt, D. R. Nielsen, and J. W. Biggar, 1980. "Simple Field Methods for Estimating Soil Hydraulic Conductivity," Soil Science Society of America Journal, Vol. 44, No. 1, pp. 3-7.

Liepins, L. Z., 1987. Survey of 14-C Literature Relevant to a Geologic Nuclear Waste Repository, LA-10991-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Lin, Y. T., and M. S. Tierney, 1986. Preliminary Estimates of Groundwater Travel Time and Radionuclide Transport at the Yucca Mountain Repository Site, SAND85-2701, Sandia National Laboratories, Albuquerque, N. Mex.

Lin, Y. T., 1985. SPARTAN--A Simple Performance Assessment Code for the Nevada Nuclear Waste Storage Investigations Project, SAND85-0602, Sandia National Laboratories, Albuquerque, N. Mex.

Lineham, J. L., 1987. Letter from J. L. Lineham (NRC) to Carl Gertz (WMPO); regarding proposed changes to the Nevada Nuclear Waste Storage Investigations Project Exploratory Shaft Facility, March, 1987.

Lingle, and Bush, 1982.

Link, R. L., S. E. Logan, H. S. Ng, F. A. Rockenbach, and K. J. Hong, 1982. Parametric Studies of Radiological Consequences of Basaltic Volcanism, SAND81-2375, Sandia National Laboratories, Albuquerque, N. Mex., pp. 4-347.

Locke, A., P. Billingsley, and E. B. Mayo, 1940. "Sierra Nevada Tectonic Patterns," Bulletin of the Geological Society of America, Vol. 51, pp. 513-540.

Loeve, 1960

Long, J. C. S., J. S. Remer, C. P. Wilson, and P. A. Witherspoon, 1982. "Porous Media Equivalents for Networks of Discontinuous Fractures," Water Resources Research, Vol. 18, No. 3, pp. 645-658.

Loos, W., 1937. Praktische Anwendungder Baugrunduntersuchungen (Practical Applications of Soil Investigations), Springer, Berlin.

Loudon, T. V., 1979. Computer Methods in Geology, Academic Press, San Francisco, Calif., pp. 221-226.

ME (Mining Engineering), 1988. Industrial Minerals 1987, Industry Newswatch Vol. 40, No. 6, p. 414.

MLWA (Military Lands Withdrawal Acts), 1986. "Military Lands Withdrawal Acts of 1986," Public Law 99-606, 100 Stat. 3457.

Maldonado, F. (comp.), 1985a. Geologic Map of the Jackass Flats Area, Nye County, Nevada, Miscellaneous Investigations Series Map I-1519, U.S. Geological Survey.

Maldonado, F., 1985b. "Late Tertiary Detachment Faults in the Bullfrog Hills, Southwestern Nevada [abs.]," Geological Society of America, Abstracts with Programs, Vol. 17, No. 7, p. 651.

Maldonado, F., D. C. Muller, and J. N. Morrison, 1979. Preliminary Geologic and Geophysical Data of the UE25a-3 Exploratory Drill Hole, Nevada Test Site, Nevada, USGS-1543-6, U.S. Geological Survey.

Mankin, J. B., R. V. O'Neill, H. H. Shugart, and B. W. Rust, 1977. "The Importance of Validation in Ecosystem Analysis," New Directions in the Analysis of Ecological Systems, Part 1, G. S. Innis (ed.), Vol. 5, No. 1, pp. 63-71.

Mansure, A. J., 1985. Underground Facility Area Requirements for a Radioactive Waste Repository at Yucca Mountain, SAND84-1153, Sandia National Laboratories, Albuquerque, N. Mex.

Mansure, A. J., and T. S. Ortiz, 1984. Preliminary Evaluation of the Subsurface Area Available for a Potential Nuclear Waste Repository at Yucca Mountain, SAND84-0175, Sandia National Laboratories, Albuquerque, N. Mex.

Mantoglou, A., and L. W. Gelhar, 1985. Large-Scale Models of Transient Unsaturated Flow and Contaminant Transport Using Stochastic Methods, Report No. 299, Ralph M. Parsons Laboratory Hydrology and Water Resource Systems, Massachusetts Institute of Technology, Cambridge, Mass.

Mantoglou, A., and L. W. Gelhar, 1987. "Stochastic Modeling of Large-Scale Transient Unsaturated Flow Systems," Water Resources Research, Vol. 23, No. 1, pp. 37-46.

Marion, G. M., W. H. Schlesinger, and P. J. Fonteyn, 1985. "CALDEP: A Regional Model for Soil CaCO3 (Caliche) Deposition in Southwestern Deserts, Soil Science, Vol. 139, No. 5, pp. 468-481.

Martinez, M. J., 1985. FEMTRAN - A Finite Element Computer Program for Simulating Radionuclide Transport Through Porous Media, SAND84-0747, Sandia National Laboratories, Albuquerque, N. Mex.

Martinez, M. J., 1988. Capillary-Driven Flow in a Fracture Located in a Porous Medium, SAND84-1697, Sandia National Laboratories, Albuquerque, N. Mex.

Marvin, R. F., H. H. Mehnert, and E. H. McKee, 1973. "A Summary of Radiometric Ages of Tertiary Volcanic Rocks in Nevada and Eastern California, Part III - Southeastern Nevada," Isochron/West, Vol. No. 6, pp. 1-30.

Mather, B., 1967.

Matheron, G., 1971. The Theory of Regionalized Variables and Its Applications, No. 5, Ecole Nationale Superieure des Mines de Paris.

Matthusen, A. C., 1986. Effects of Differing Lithologies on Headcuts and Knickpoints in Ephemeral Streams, unpublished M.S. thesis, University of Illinois, Chicago, Ill.

Mattson, S. R., 1988. "Mineral Resource Evaluation: Implications of Human Intrusion and Interference on a High Level Nuclear Waste Repository," Waste Management Eighty Eight, Vol. 2, pp. 915-924.

Mauro, J. J., D. Michlewicz, and A. Letizia, 1977. Evaluation of Environmental Dosimetry Models for Applicability to Possible Radioactive Waste Repository Discharges, Y/OWI/SUB-77/45705, Envirosphere Co., New York.

Maxwell, A. A., and Z. B. Fry, 1967. "A Procedure for Determining Elastic Moduli of In Situ Soils by Dynamic Techniques," in Proceedings International Symposium on Wave Propagation and Dynamic Properties of Earth Materials,

Mayer, L., L. D. McFadden, and J. W. Harden, 1988. "Distribution of Calcium Carbonate in Desert Soils: A Model," Geology, Vol. 16, pp. 303-306.

McArthur, R. D., and N. R. Burkhard, 1986. Geological and Geophysical Investigations of Mid Valley, UCID-20740, Lawrence Livermore National Laboratory, Livermore, Calif.

McCombie, C., and B. Knecht, 1986. "Stripa Project - Grouting of Small Fractures in Crystalline Rock in the Framework of Nuclear Waste Disposal: A Summary of the Situation in Switzerland (ms)," Nationale Genossenschaft fur die Lagerung Redioaktiver Abfalle (NALGRA), Baden, 6 p.

McDonald, M. G., and A. W. Harbaugh, 1984. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, USGS-OFR-83-875, Open-File Report, U.S. Geological Survey.

McFadden, L. D., and J. C. Tinsley, 1985. "Rate and Depth of Pedogenic-Carbonate Accumulation in Soils: Formulation and Testing of a Compartment Model," Soils and Quaternary Geology of the Southwestern United States, D. L. Weide (ed.), Geological Society of America Special Paper 203, pp. 23-41.

McFadden, L. D., S. G. Wells, and J. C. Dohrenwend, 1986. "Influences of Quaternary Climatic Changes on Processes of Soil Development on Desert Loess Deposits of the Cima Volcanic Field, California," Catena, Vol. 13, No. 4, pp. 361-389.

McGarr, A., 1984. "Scaling of Ground Motion Parameters, State of Stress, and Focal Depth," Journal of Geophysical Research, Vol. 89, No. B8, pp. 6969-6879.

McGarr, A., S. M. Spottiswoode, and N. C. Gay, 1975. "Relationship of Mine Tremors to Induced Stresses and to Rock Properties in the Focal Region," Bulletin of the Seismological Society of America, Vol. 65, No. 4, pp. 981-993.

McGovern, T. F., 1983. An Evaluation of Seismic Reflection Studies in the Yucca Mountain Area, Nevada Test Site, with an introduction by L. W. Pankratz and H. D. Ackermann, USGS-OFR-83-912, Open-File Report, U.S. Geological Survey.

Meremonte, M. E., and A. M. Rogers, 1987. Historical Catalog of Southern Great Basin Earthquakes 1868-1978, USGS-OFR-87-80, Open-File Report, U.S. Geological Survey.

Meyer, D., and J. J. Howard, (eds.), 1983. Evaluation of Clays and Clay Minerals for Application to Repository Sealing, ONWI-486, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio,

Miller, G. A., 1977. Appraisal of the Water Resources of Death Valley, California-Nevada, USGS-OFR-77-728, Open-File Report, U.S. Geological Survey.

Mills, M., and D. Vogt, 1983. A Summary of Computer Codes for Radiological Assessment, NUREG/CR-3209, Nuclear Regulatory Commission, Washington, D.C.

Moench, A. F., 1984. "Double-Porosity Models for a Fissured Groundwater Reservoir with Fracture Skin," Water Resources Research, Vol. 20, No. 7, pp. 831-846.

Moench, A. F., and P. A. Hsieh, 1985. "Analysis of Slug Test Data in a Well with Finite Thickness Skin," Hydrogeology of Rocks of Low Permeability, Memoires of the International Association of Hydrologists, 17th International Congress, January 7-12, 1985, Tucson, Az., pp. 17-29.

Molinari, M. P., 1984. Late Cenozoic Geology and Tectonics of Stewart and Monte Cristo Valleys, West-Central Nevada, M.S. thesis, University of Nevada, Reno, 124 p.

Monfort, M. E., and J. R. Evans, 1982. Three-Dimensional Modeling of the Nevada Test Site and Vicinity from Teleseismic P-Wave Residuals, USGS-OFR-82-409, Open-File Report, U.S. Geological Survey.

Montazer, P., 1982. Permeability of Unsaturated, Fractured Metamorphic Rocks Near an Underground Opening, Ph.D. thesis T-2540, Colorado School of Mines, Golden, Colo.

Montazer, P., 1985. Letter from P. Montazer (USGS) to P. L. Aamodt (LANL), December 4, 1985; regarding dry mining of infiltration and bulk permeability test rooms.

Montazer, P., 1986. Letter from P. Montazer (USGS) to M. B. Blanchard (WMPO), November 21, 1986; regarding justification of dry core drilling program.

Montazer, P., and W. E. Wilson, 1984. Conceptual Hydrologic Model of Flow in the Unsaturated Zone, Yucca Mountain, Nevada, USGS-WRI-84-4345, Water-Resources Investigations Report, U.S. Geological Survey.

Montazer, P., E. P. Weeks, F. Thamir, S. N. Yard, and P. B. Hofrichter, 1985. "Monitoring the Vadose Zone in Fractured Tuff, Yucca Mountain, Nevada," Characterization and Monitoring of the Vadose Zone, National Water Well Association Symposium, Denver, Colorado, November 19-21, 1985.

Mooney, W. D., D. B. Snyder, and L. R. Hoffman, 1982. "Seismic Refraction and Gravity Modeling of Yucca Mountain, Nevada Test Site, Southern Nevada [abs.]," EOS, Transactions, American Geophysical Union, Vol. 63, No. 45, p. 1100.

Moore, R. E., C. F. Baes, III, L. M. McDowell-Boyer, A. P. Watson, F. O. Hoffman, J. C. Pleasant, and C. W. Miller, 1979. AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides, ORNL-5532, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Morgan, P., and C. A. Swanberg, 1978. "Heat Flow, Topography, Lithospheric Thickness and Gravity Anomalies in the United States," EOS, Transactions, American Geophysical Union, Vol. 59, No. 13, p. 1204.

Mualem, Y., 1976. "A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Materials," Water Resources Research, Vol. 12, No. 3, American Geophysical Union, Washington, D.C., pp. 513-522.

Muller, D. C., 1982. "Commercial Borehole Geophysical Logs at Yucca Mountain, Nevada [abs.]" EOS, Transactions, American Geophysical Union, Vol. 63, No. 45, p. 1111.

Muller, D. C., 1985. "Computer Method to Detect and Correct Cycle Skipping on Sonic Logs," Transactions of the SPWLA Twenty-Sixth Annual Logging Symposium, Vol. I, Paper R, Society of Professional Well Log Analysts, Houston, Tex., pp. 1-18.

Muller, D. C., and J. E. Kibler, 1983. Commercial Geophysical Well Logs from the USW G-1 Drill Hole, Nevada Test Site, Nevada, USGS-OFR-83-321, Open-File Report, U.S. Geological Survey, 7 p.

Muller, D. C., and J. E. Kibler, 1984. Preliminary Analysis of Geophysical Logs from Drill Hole UE-25p#1, Yucca Mountain, Nye County, Nevada, USGS-OFR-84-649, Open-File Report, U.S. Geological Survey, 14 p.

Muller, D. C., and J. E. Kibler, 1985. Preliminary Analysis of Geophysical Logs from the WT Series of Drill Holes, Yucca Mountain, Nye County, Nevada, USGS-OFR-86-46, Open-File Report, U.S. Geological Survey.

Munson, L. H., 1983. Licensee Programs for Maintaining Occupational Exposure to Radiation As Low As Is Reasonably Achievable, NUREG/CR-3254, Pacific Northwest Laboratory, Richland, Wash.

Murphy, H. D., 1982. "Enhanced Interpretation on Temperature Surveys Taken during Injection or Production," Journal of Petroleum Technology, pp. 1313-1326.

NCRP (National Council on Radiation Protection and Measurements), 1984. Radiological Assessment: Predicting the Transport, Bioaccumulation and Uptake by Man of Radionuclides Released to the Environment, Report No. 76, Bethesda, Maryland.

NEPA (National Environmental Policy Act), 1969. 42 U.S.C. 4341; Amended by PL 94-52, July 3, 1975; PL 94-83, August 9, 1975.

NEPA (National Environmental Policy Act), 1970. 42 USC 4321, Public Law 91-190, 83 Stat. 852-856,et seq, Washington, D.C.

NRC, (Nuclear Regulatory Commission), 1968.

NRC (U.S. Nuclear Regulatory Commission), 1973. Concrete Radiation Shields for Nuclear Power Plants, Regulatory Guide 1.69, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1974. Termination of Operating Licenses for Nuclear Reactors, Regulatory Guide 1.86, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1975. Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable, Regulatory Guide 8.10, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1976a. Acceptable Programs for Respiratory Protection, Regulatory Guide 8.15, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1976b. Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors, Regulatory Guide 1.112, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1976c. Preparation of Environmental Reports for Nuclear Power Stations, Revision 2, Regulatory Guide 4.2, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1977a. Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, Regulatory Guide 1.109, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1977b. Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I, Regulatory Guide 1.113, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1977c. Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, Regulatory Guide 1.111, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1978. Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, Revision 3, Regulatory Guide 1.70, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1979a. Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants Design Stage Man-Rem Estimates, Regulatory Guide 8.19, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1979b. Site Investigation for Foundations of Nuclear Power Plants, Regulatory Guide 1.132, Office of Standards Development, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1980. Meteorological Programs in Support of Nuclear Power Plants, Regulatory Guide 1.23, Washington, D.C.

NRC (U.S. Nuclear Regulatory Comission), 1981a. Criticality Accident Alarm Systems, Regulatory Guide 8.12, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1981b. Criticality and Other Interior Evacuation Signals, Regulatory Guide 8.5, Revision 1, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1981c. "Disposal of High-Level Radioactive Wastes in Geologic Repositories: Licensing Procedures," Federal Register, Vol. 46, pp. 13971-13987.

NRC (U.S. Nuclear Regulatory Commission), 1982a. Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, Regulatory Guide 1.145, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1982b. Preparation of Environmental Reports for Uranium Mills, Regulatory Guide 3.8, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1983a. PRA Procedures Guide: A Guide to the Performance of Probabalistic Risk Assessments for Nuclear Power Plants, NUREG/CR-2300, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1983b. Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste, Regulatory Guide 4.18, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1983c. Staff Analysis of Public Comments on Proposed rule 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories, NUREG-0804, pp. 518-520.

NRC (U.S. Nuclear Regulatory Commission), 1984a. Determination of Radionuclide Solubility in Groundwater for Assessment of High-Level Waste Isolation, U.S. Nuclear Regulatory Commission Technical Position, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1984b. Draft Generic Technical Position on Licensing Assessment Methodology for High-Level Waste Geologic Repositories, Division of Waste Management, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1984c. Draft Issue-Oriented Site Technical Position (ISTP) For Nevada Nuclear Waste Storage Investigations (NNWSI), Division of Waste Management, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1984d. NRC Review Plan: Quality Assurance Programs for Site Chartacterization of High Level Nuclear Waste Repositories, Division of Waste Management, Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1985. Draft Technical Position: Interpretation and Identification of the Extent of the Disturbed Zone in the High Level Waste Rule (10 CFR 60),

NRC (U.S. Nuclear Regulatory Commission), 1986a. "Disposal of High-Level Radioactive Wastes in Geologic Repositories; Conforming Amendments," Federal Register, Vol. 51, Washington, D.C., pp. 22288-22300.

NRC (U.S. Nuclear Regulatory Commission), 1986b. Draft Generic Technical Position: Interpretation and Identification of the Extent of the Disturbed Zone in the High-Level Waste Rule (10 CFR 60), M. Gordon, N. Tanious, J. Bradbury, L. Kovack and R. Codell (eds.), Washington, D.C.

NRC (U.S. Nuclear Regulatory Commission), 1987. Standard Format and Content of Site Characterization Plans for High-Level-Waste Geological Repositories, Regulatory Guide 4.17, Washington, D.C.

NRC (Nuclear Regulatory Commission), 1988a. Qualification of Existing Data for High-Level Nuclear Waste Repositories, NUREG-1298, Prepared by W.D. Altman, J.P. Donnelly, and J.E. Kennedy.

NRC (Nuclear Regulatory Commission), 1988b. Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements, NUREG-1318, Prepared by A. B. Duncan, S. G. Bilhorn, and J. E. Kennedy.

NRC/DOE (U.S. Nuclear Regulatory Commission/U.S. Department of Energy), 1983. "Agreement Concerning the NRC On-Site Representative (OR) for the Repository Projects during Site Investigation and Characterization, 48 FR 38701, 8/25/83," Appendix 7, pp. 1-4.

NRDC (Natural Resources Defense Council, Inc.) v. EPA (Environmental Protection Agency), 1987. No. 85-1915, 86-1096, 86-1097, 86-1098 U.S. Court of Appeals For the First Circuit.

NWPA (Nuclear Waste Policy Act), 1983. "Nuclear Waste Policy Act of 1982," Public Law 97-425, 42 USC 10101-10226, Washington, D.C.

NWPAA (Nuclear Waste Policy Act Amendments), 1987. Amendments to the Nuclear Waste Policy Act of 1982 - Public Law 100-203 - December 22, 1987, 100th Congress, Title V, pp 236-266.

Naff, R. L., 1973. Hydrogeology of the Southern Part of Amargosa Desert in Nevada, Master's thesis, University of Nevada, Reno.

Napier, B. A., W. E. Kennedy, Jr., and J. K. Soldat, 1980. PABLM - A Computer Program to Calculate Accumulated Radiation Doses from Radionuclides in the Environment, PNL-3209, Pacific Northwest Laboratory, Richland, Wash., 205 p.

National Research Council, 1983. A Study of the Isolation System for Geologic Disposal of Radioactive Wastes, National Academy Press, Washington, D.C.

Neal, J. T., 1986. Preliminary Validation of Geology at Site for Repository Surface Facilities, Yucca Mountain, Nevada, SAND85-0815, Sandia National Laboratories, Albuquerque, N. Mex.

Nelson, C. E., and D. L. Giles, 1985. "Hydrothermal Eruption Mechanisms and Hot Spring Gold Deposits," Economic Geology, Vol. 80, pp. 1633-1639.

Neuman, S. P., and P. A. Witherspoon, 1969a. "Applicability of Current Theories of Flow in Leaky Aquifers," Water Resources Research, Vol. 5, No. 4, pp. 817-829.

Neuman, S. P., and P. A. Witherspoon, 1969b. "Theory of Flow in a Confined Two Aquifer System," Water Resources Research, Vol. 5, No. 4, pp. 803-816.

Nevada Revised Statutes 46, xxxx.

Nimick, F. B., and A. R. Lappin, 1985. Thermal Conductivity of Silicic Tuffs from Yucca Mountain and Rainier Mesa, Nye County, Nevada, SAND83-1711/1J, Sandia National Laboratories, Albuquerque, N. Mex.

Nimick, F. B., and B. M. Schwartz, 1987. Bulk, Thermal, and Mechanical Properties of the Topopah Spring Member of the Paintbrush Tuff, Yucca Mountain, Nevada, SAND85-0762, Sandia National Laboratories, Albuquerque, N. Mex.

Nimick, F. B., L. E. Shepard, and T. E. Blejwas, 1988. Preliminary Evaluation of the Exploratory Shaft Representatativeness for the NNWSI Project, Draft, SAND88-1685, Sandia National Laboratories, Albuquerque, N. Mex.

Nimmo, J. R., J. Rubin, and D. Hammermeister, 1987. "Unsaturated Flow in a Centrifugal Field: Measurements of Hydraulic Conductivity and Testing of Darcy's Law," Water Resources Research, Vol. 23, No. 1, pp. 124-134.

Nitao, J. J., 1988. Numerical Modeling of the Thermal and Hydrological Environment Around a Nuclear Waste Package Using the Equivalent Continuum Appromixation: Horizontal Employment, UCID-21444, Lawrence Livermore Laboratory, Livermore, Calif.

Nuttall, H. E., 1986. Population Balance Model for Colloid Transport, NNWSI Milestone R318, LA-UR-86-1914, Los Alamos National Laboratory, Los Alamos, N. Mex.

OGR (Office of Geological Repositories), 1987. Plan for Advanced Conceptual Design of the Repository and Waste Package.

O'Brien, P. D., 1985. Reference Nuclear Waste Descriptions for a Geologic Repository at Yucca Mountain, Nevada, SAND84-1848, Sandia National Laboratories, Albuquerque, N. Mex.

O'Connell, W. J., and R. S. Drach, 1986. Waste Package Performance Assessment: Deterministic System Model -- Program Scope and Specification, UCRL-53761, Lawrence Livermore National Laboratory, Livermore, Calif.

Ohtsuki, A., and K. Harumi, 1983. "Effect of Topography and Subsurface Inhomogeneities of Seismic SV Waves," Earthquake Engineering and Structural Dynamics, Vol. 11, pp. 441-462.

Olofsson, U., and B. Allard, 1986. Formation and Transport of Americium Pseudocolloids in Aqueous Systems, SKB Technical Report 86-02, Department of Nuclear Chemistry, Chalmers University of Technology, Goteborg, Sweden.

Olson, J. J., R. J. Willard, D. E. Fogelson, and K. E. Hjelmstad, 1973. "Rock Damage from Small Charge Blasting in Granite," BuMines Report of Investigations 7751, 44 p.

Olsson, W. A., 1987. Rock Joint Compliance Studies, SAND86-0177, Sandia National Laboratories, Albuquerque, N. Mex.

Olsson, W., 1988. Compliance and Strength of Artifical Joints in Topopah Spring Tuff, SAND88-0660, Sandia National Laboratories, Albuquerque, N. Mex.

Orkild, xxxx. Personal communications cited in SCP reference 3336, McArthur and Burkhard,

Ortiz, T. S., R. L. Williams, F. B. Nimick, B. C. Whittet, and D. L. South, 1985. A Three-Dimensional Model of Reference Thermal/Mechanical and Hydrological Stratigraphy at Yucca Mountain, Southern Nevada, SAND84-1076, Sandia National Laboratories, Albuquerque, N. Mex.

Oversby, V. M., 1986. Spent Fuel As A Waste Form - Data Needs to Allow Long Term Performance Assessment Under Repository Disposal Conditions, UCRL-94659, preprint, Lawrence Livermore National Laboratory, Livermore, Calif.

Oversby, V. M., and R. D. McCright, 1984. Laboratory Experiments Designed to Provide Limits on the Radionuclide Source Term for the NNWSI Project, UCRL-91257, Lawrence Livermore National Laboratory, Livermore, Calif.

Oversby, V. M., and R. D. McCright, 1985. "Laboratory Experiments Designed to Provide Limits on the Radionuclide Source Term for the NNWSI Project," in Proceedings of the Workshop on the Source Term for Radionuclide Migration from High-Level Waste or Spent Nuclear Fuel Under Realistic Repository Conditions, T. O. Hunter and A. B. Muller (eds.), SAND85-0380, Sandia National Laboratories, Albuquerque, N. Mex. pp. 175-187.

Owens, W. W., D. R. Parrish, and W. E. Lamoreaux, 1956. "An Evaluation of a Gas Drive Method for Determining Relative Permeability Relationships," Transactions of the American Institute of Mining, Metallurgical, and Petroleum Engineers,, Vol. 207, pp. 275-280.

Pankratz, L. W., 1982. Reconnaissance Seismic Refraction Studies at Calico Hills, Wahmonie, and Yucca Mountain, Southwest Nevada Test Site, Nye County, Nevada, USGS-OFR-82-478, Open-File Report, U.S. Geological Survey.

Papadopulos, I. S., 1965. "Nonsteady Flow to a Well in an Infinite Anisotropic Aquifer," in Proceedings, Dubrovnik Symposium of Hydrology of Fractured Rocks, Vol. 1, pp. 21-31.

Parkhurst, D. L., D. C. Thorstenson, and L. N. Plummer, 1980. PHREEQE: A Computer Program for Geochemical Calculations, USGS-OFR-80-96, Open-File Report, U.S. Geological Survey.

Parks, C. V., et al, 1987. Assessment of Shielding Analysis Methods, Codes, and Data for Spent Fuel Transport/Storage Applications, ORNL/CSD/TM-246(Draft), Oak Ridge National Laboratory, Tenn.

Passioura, J. B., 1976. "Determining Soil Water Diffusivities from One-Step Outflow Experiments," Australian Journal of Soil Research, Vol. 15, pp. 1-8.

Peters, R. R., 1988. YMP Hydrologic Technical Correspondence in Support of Site Characterization Plan, SAND88-2784, in prep. Sandia National Laboratories, Albuquerque, N. Mex.

Peters, R. R., and J. H. Gauthier, 1986. Memo dated January 17, 1986 to F. W. Bingham, The effect of seismic and tectonic activity on radionuclide containment at Yucca Mountain, Nevada. SAND88-2784, Sandia National Laboratories, Albuquerque, N. Mex.

Peters, R. R., and E. A. Klavetter, 1988. "A Continuum Model for Water Movement in an Unsaturated Fractured Rock Mass," Water Resources Research, Vol. 24, No. 3, pp. 416-430.

Peters, R. R., E. A. Klavetter, I. J. Hall, S. C. Blair, P. R. Heller and G. W. Gee, 1984. Fracture and Matrix Hydrologic Characteristics of Tuffaceous Materials from Yucca Mountain, Nye County, Nevada, SAND84-1471, Sandia National Laboratories, Albuquerque, N. Mex.

Peters, R. R., J. H. Gauthier, and A. L. Dudley, 1986. The Effect of Percolation Rate on Water-Travel Time in Deep, Partially Saturated Zones, SAND85-0854, Sandia National Laboratories, Albuquerque, N. Mex.

Peterson, D. W., 1979. "Significance of the Flattening of Pumice Fragments in Ash-Flow Tuffs," Ash-Flow Tuffs, C. E. Chapin, and W. E. Elston (eds.), Geological Society of America Special Paper 180, pp. 195-204.

Peterson, A. C., R. R. Eaton, A. J. Russo, and J. A. Lewin 1988. Technical Correspondence in Support of an Evaluation of the Hydrologic Effects of Exploratory Shaft Construction at Yucca Mountain, SAND88-2936, Sandia National Laboratories, Albuquerque, N. Mex.

Phene, C. J., G. J. Hoffman, and S. L. Rawlins, 1971. "Measuring Soil Matric Potential In-Situ by Sensing Heat Dissipation within a Porous Body: I. Theory and Sensor Construction," in Soil Science Society of America Proceedings, Vol. 35, pp. 27-33.

Phinney, D. L., F. J. Ryerson, V. M. Oversby, W. A. Lanford, R. D. Aines, and J. K. Bates, 1986. Integrated Testing of the SRL-165 Glass Waste Form, UCRL-94658, preprint, Lawrence Livermore National Laboratory, Livermore, Calif.

Pickett, G. R., 1977. "Resistivity, Radioactivity and Acoustic Logs," Subsurface Geology, L. W. LeRoy, D. O. Leroy, and J. W. Raese, (eds.), pp. 304-336.

Pinder, G. F., 1976. Galerkin-Finite Element Models for Aquifer Simulation, 76-WR-5, Water Resources Program, Department of Civil Engineering, Department of Geological and Geophysical Sciences, Princeton University.

Plummer, L. N., B. F. Jones, and A. H. Truesdell, 1976. WATEQF - A Fortran IV Version of WATEQ, A Computer Program for Calculating Chemical Equilibrium of Natural Waters, USGS-WRI-76-13, Water-Resources Investigations Report, U.S. Geological Survey.

Pollard, D., 1983. "Ice-Age Simulations with a Calving Ice-Sheet Model," Quaternary Research, Vol. 20, pp. 30-48.

Ponce, D. A., 1981. Preliminary Gravity Investigations of the Wahmonie Site, Nevada Test Site, Nye County, Nevada, USGS-OFR-81-522, Open-File Report, U.S. Geological Survey, 64 p.

Ponce, D. A., 1984. "Gravity and Magnetic Evidence for a Granitic Intrusion Near Wahomie Site, Nevada Test Site, Nevada," Journal of Geophysical Research, Vol. 89, No. B11, pp. 9401-9413.

Ponce, D. A., and W. F. Hanna, 1982. Preliminary Appraisal of Gravity and Magnetic Data at Syncline Ridge, Western Yucca Flat, Nevada Test Site, Nye County, Nevada, USGS-OFR-82-931, Open-File Report, U.S. Geological Survey.

Ponce, D. A., and H. W. Oliver, 1981. Charleston Peak Gravity Calibration Loop, Nevada, USGS-OFR-81-985, Open-File Report, U.S. Geological Survey.

Ponce, D. A., S. S. C. Wu, and J. B. Spielman, 1985. Comparison of Survey and Photogrammetry Methods to Position Gravity Data, Yucca Mountain, Nevada, USGS-OFR-85-36, Open-File Report, U.S. Geological Survey.

Prats, M., 1972. "The Influence of Oriented Arrays of Thin Impermeable Shale Lenses or of Highly Conductive Natural Fractures on Apparent Permeability Anisotropy," Journal of Petroleum Technology, Vol. 24, No. 10, pp. 1219-1221.

Pratt, A. W., 1969. "Heat Transmission in Low Conductivity Materials," Thermal Conductivity, R. P. Tye, (ed.), Academic Press, New York, pp. 301-405.

Pratt, H. R., A. D. Black, W. S. Brown, and W. F. Brace, 1972. "The Effect of Specimen Size on the Mechanical Properties of Unjointed Diorite," International Journal of Rock Mechanics and Mining Science, Vol. 9, No. 4, pp. 513-529.

Price, R. H., F. B. Nimick, J. R. Connolly, K. Keil, B. M. Schwartz, and S. J. Spence, 1985. Preliminary Characterization of the Petrologic, Bulk, and Mechanical Properties of a Lithophysal Zone within the Topopah Spring Member of the Paintbrush Tuff, SAND84-0860, Sandia National Laboratories, Albuquerque, N. Mex.

Pruess, K., and J. S. Y. Wang, 1984. "TOUGH--A Numerical Model for Nonisothermal Unsaturated Flow to Study Waste Canister Heating Effects," in Scientific Basis for Nuclear Waste Management VII, Materials Research Society Symposia Proceedings, Boston, Massachusetts, November 1983, G. L. McVay (ed.), Vol. 26, North-Holland, Elsevier Science Publishing Co., Inc., New York, pp. 1031-1038.

Pusch, R., 1986. "Rock Sealing Materials and Techniques Used in Sweden (MS)," Swedish Geological Col, Lund, 26 p.

Pusch, R., M. Erlstrom, and L. Borgesson, 1985. Sealing of Rock Fractures - A Survey of Potentially Useful Methods and Substances, SKB Technical Report 85-17, Swedish Nuclear Fuel & Waste Management Co., Stockholm, 136 p.

Quiring, R. F., 1968. Climatological Data, Nevada Test Site and Nuclear Rocket Development Station, ESSA Technical Memorandum ARL-7, Environmental Sciences Service Administration, U.S. Department of Commerce, Las Vegas, Nev.

REECO (Reynolds Electrical & Engineering Co.) 1984a. NNWSI Mixing Lithium Chloride, FOD/Drilling Department Operational Procedure No. 212, 1 p.

REECO (Reynolds Electrical & Engineering Co.), 1984b. NNWSI Mixing Lithium Bromide, FOD/Drilling Department Operational Procedure, 1 p.

Ramirez, A. L., and W. D. Daily, 1985. "Preliminary Evaluation of Alterant Geophysical Tomography in Welded Tuff," 26th US Symposium on Rock Mechanics, Rapid City, SD, 26 - 28 June, 1985, pp. 807-815.

Rasmuson, A., and I. Neretnieks, 1981. "Migration of Radionuclides in Fissured Rock: The Influence of Micropore Diffusion and Longitudinal Dispersion," Journal of Geophysical Research, Vol. 86, No. B5, pp. 3749-3758.

Rautman, C. A., B. C. Whittet, and D. L. South, 1987. Definitions of Reference Boundaries for the Proposed Geologic Repository at the Yucca Mountain, Nevada, SAND86-2157, Sandia National Laboratories, Albuquerque, N. Mex.

Rautman, et al, 1988. Estimates of Spatial Variability of Volcanic Tuffs, Yucca Mountain, SANDXX-XXXX, in prep.

Reasenberg, P., W. Ellsworth, and A. Walter, 1980. "Teleseismic Evidence for a Low-Velocity Body Under the Coso Geothermal Area," Journal of Geophysical Research, Vol. 85, No. B5, pp. 2471-2483.

Reda, D. C., 1986. "Influence of Transverse Microfractures on the Imbitition of Water Into Initially Dry Tuffaceous Rock," in Proceedings Symposium on Flow and Transport Through Unsaturated Fractured Rock, American Geophysical Union Fall Meeting San Francisco, CA., December 1986, SAND86-0420C, Sandia National Laboratories, Albuquerque, N. Mex.

Redpath, B. A., and T. E. Ricketts, 1987. "An Improved Scaling Procedure for Close-in Blast Motions," in Proceedings of the Third Mini-Symposium on Explosives and Blasting Research, 13th Annual Conference on Explosives and Blasting Techniques, R. D. Boddorff (ed.), Society of Explosive Engineers, Miami, Fla. pp. 118-131.

Reheis, M., 1986. Preliminary Study of Quaternary Faulting on the East Side of Bare Mountain, Nye County, Nevada, USGS-OFR-86-576, Open-File Report, U.S. Geological Survey, 14 p.

Reilly, T. E., 1984. A Galerkin Finite-Element Flow Model to Predict the Transient Response of a Radially Symmetric Aquifer, USGS-WSP-84-2198, Water-Supply Paper, U.S. Government Printing Office, Washington, D.C., 33 p.

Reisenauer, A. E., K. T. Key, T. N. Narasimhan, and R. W. Nelson, 1982. TRUST: A Computer Program for Variably Saturated Flow in Multidimensional, Deformable Media, NUREG/CR-2360, U.S. Nuclear Regulatory Commission, Washington, D.C.

Reiter, L., and R. E. Jackson, 1983. Seismic Hazard Review for the Systematic Evaluation Program--A Use of Probability in Decision Making, NUREG-0967, U.S. Nuclear Regulatory Commission, Washington, D.C.

Rhoads, G. H. Jr., and E. S. Robinson, 1979. "Determination of Aquifer Parameters from Well Tides," Journal of Geophysical Research, Vol. 84, No. B11, pp. 6071-6082.

Rice, J. R., and M. P. Cleary, 1976. "Some Basic Stress-Diffusion Solutions for Fluid-Saturated Elastic Porous Media with Compressible Constituents, Reviews of Geophysics and Space Physics, Vol. 14, No. 2, pp. 227-241.

Richards, L. A., and G. Ogata, 1958. "Thermocouple for Vapor Pressure Measurement in Biological and Soil Systems at High Humidity," Science, Vol. 128, American Association for the Advancement of Science, Washington, D.C., pp. 1089-1090.

Rinehart, J. S., 1975. Stress Transients in Solids, HyperDynamics, Santa Fe, New Mex., pp. 30-31.

Rinehart, E. J., A. R. Sanford, and R. M. Ward, 1979. "Geographic Extent and Shape of an Extensive Magma Body at Mid-Crustal Depths in the Rio Grande Rift Near Socorro, New Mexico," Rio Grande Rift: Tectonics and Magmatism, R. E. Riecker (ed.), American Geophysical Union, Washington, D.C., pp. 237-251.

Robbins, S. L., J. W. Schmoker, and T. C. Hester, 1982. Principal Facts and Density Estimates for Borehole Gravity Stations in Exploratory Wells Ue4ah, Ue7j, Uelh, Uelq, Ue2co, and USW-H1 at the Nevada Test Site, Nye County, Nevada, USGS-OFR-82-277, Open-File Report, U.S. Geological Survey.

Robinson, and Beetem, 1965.

Robinson, G. D., 1985. Structure of Pre-Cenozoic Rocks in the Vicinity of Yucca Mountian, Nye County, Nevada--A Potential Nuclear-Waste Disposal Site, U.S. Geological Survey Bulletin 1647, U.S. Geological Survey.

Robison, J. H., 1984. Ground-Water Level Data and Preliminary Potentiometric-Surface Maps, Yucca Mountain and Vicinity, Nye County, Nevada, USGS-WRI-84-4197, Water-Resources Investigations Report, U.S. Geological Survey.

Robison, J. H., 1986. Letter from J. H. Robison (USGS) to D. L. Vieth (DOE/NVO), September 17, 1986; regarding revisions of Yucca Mountain water levels.

Rogers, A. M., S. C. Harmsen, and W. J. Carr, 1981. Southern Great Basin Seismological Data Report for 1980 and Preliminary Data Analysis, USGS-OFR-81-1086, Open-File Report, U.S. Geological Survey.

Rogers, A. M., S. C. Harmsen, W. J. Carr, and W. Spence, 1983. Southern Great Basin Seismological Data Report for 1981 and Preliminary Data Analysis, USGS-OFR-83-669, Open-File Report, U.S. Geological Survey.

Rose, W., and W. A. Bruce, 1949. "Evaluation of Capillary Character in Petroleum Reservoir Rock," Transactions of the American Institute of Mining and Metallurgical Engineers, Technical Paper 2594, Vol. 186, pp. 127-142.

Roseboom, E. H., Jr., 1983. Disposal of High-Level Nuclear Waste Above the Water Table in Arid Regions, U.S. Geological Survey Circular 903, Alexandria, Va., 21 p.

Rosenbaum, J. G., 1983. "Evidence for a Hematitic TCRM in a Welded Tuff, Yucca Mountain, Nevada [abs.]," EOS, Transactions, American Geophysical Union, Vol. 64, No. 45, p. 683.

Rosenbaum, J. G., 1985. "Inclination Error Produced by Welding in a Miocene Ash-Flow Tuff, Nevada [abs.]," EOS, Transactions, American Geophysical Union, Vol. 66, No. 18, p. 256.

Rosenbaum, J. G., and W. C. Rivers, 1984. Paleomagnetic Orientation of Core from Drill Hole USW GU-3, Yucca Mountain, Nevada: Tiva Canyon Member of the Paintbrush Tuff, USGS-OFR-85-48, Open-File Report, U.S. Geological Survey.

Rosenbaum, J. G., and D. B. Snyder, 1985. Preliminary Interpretation of Paleomagnetic and Magnetic Property Data from Drill Holes USW G-1, G-2, GU-3, G-3, and VH-1 and Surface Localities in the Vicinity of Yucca Mountain, Nye County, Nevada, USGS-OFR-85-49, Open-File Report, U.S. Geological Survey.

Rosholt, J. N., 1985. Uranium-Trend Systematics for Dating Quaternary Sediments, USGS-OFR-85-298, Open-File Report, U.S. Geological Survey.

Rosholt, J. N., C. A. Bush, W. J. Carr, D. L. Hoover, W C Swadley, and J. R. Dooley, Jr., 1985. Uranium-Trend Dating of Quaternary Deposits in the Nevada Test Site Area, Nevada and California, USGS-OFR-85-540, Open-File Report, U.S. Geological Survey.

Ross, 1985.

Ross, B., 1986. "Scenarios in Performance Assessment of High-Level Waste Repositories," Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 7(1), pp. 47-61.

Ross, B., 1987. A First Survey of Disruption Scenarios for a High-Level-Waste Repository at Yucca Mountain, Nevada, SAND85-7117, Sandia National Laboratories, Albuquerque, N. Mex.

Roy, D. M., and C. A. Langton, 1982. Longevity of Borehole and Shaft Sealing Materials: Characterization of Cement Based Ancient Building Materials, ONWI-202. Battelle Project Management Divn., Office of Nuclear Waste Isolation,

Roy et al, 1982.

Rulon, J. J., G. S. Bodvarsson, and P. Montazer, 1985. "Numerical Simulations of Flow in the Unsaturated Zone, Yucca Mountain, Nevada," EOS, Vol. 66, No. 46, p. 883.

Rulon, J., G. S. Bodvarsson, and P. Montazer, 1986. Preliminary Numerical Simulations of Groundwater Flow in the Unsaturated Zone, Yucca Mountain, Nevada, LBL-20553, Lawrence Berkeley Laboratory, Berkeley, Calif.

Russell, E. W., and T. A. Nelson, 1988. Plan for Waste Package Design, Fabrication and Prototype Testing for NNWSI, UCID-21347, Lawrence Livermore National Laboratory, Livermore, Calif.

Russo, A. J., and D. C. Reda, 1988. Drying of an Initially Saturated Fractured Volcanic Tuff, SAND87-0293C, Sandia National Laboratories, Albuquerque, N. Mex.

Russo, R. E., F. R. McLarnon, J. D. Spear, and E. J. Cairns, 1987. "Probe Beam Deflection for In Situ Measurements of Concentration and Spectroscopic Behavior During Copper Oxidation and Reduction," Journal of the Electrochemical Society, Vol. 134, No. 11, pp. 2783-2787.

SAIC (Science Applications International Corporation), 1985. Meteorological Monitoring Plan for the Nevada Nuclear Waste Storage Investigations Project, Yucca Mountain Site, DOE/NV/10270-5, Las Vegas, Nev.

SAIC (Science Applications International Corporation), 1986a. NNWSI Project Quality Assurance Program Plan.

SAIC (Science Applications International Corporation), 1986b. Site Characterization Radiological Monitoring Plan for the Nevada Nuclear Waste Storage Investigations Project Yucca Mountain Site, DOE/NV/10270-14, Las Vegas, Nev.

SNL (Sandia National Laboratories), 1987. Site Characterization Plan Conceptual Design Report, SAND84-2641, 6 Vol., Sandia National Laboratories, Albuquerque, N. Mex.

Saad, K. F., 1967. "Determination of the Vertical and Horizontal Permeabilities of Fractured Water-Bearing Formations," Bulletin of the International Association of Scientific Hydrology, Vol. 1, pp. 22-26.

Saltzman, B., and A. Sutera, 1984. "A Model of the Internal Feedback System Involved in Late Quaternary Climatic Variations," Journal of the Atmospheric Science, Vol. 41, No. 5, pp. 736-745.

Sargent, R. G., 1987. "An Overview of Verification and Validation of Simulation Models," in IEEE Proceedings of the 1987 Winter Simulation Conference, pp. 33-39.

Sargent, K. A., and K. Roggensack, 1984. Map Showing Outcrops of Pre-Quaternary Ash-Flow Tuffs and Volcaniclastic Rocks, Basin and Range Province, Nevada, USGS-WRI-83-4119-E, Water Investigations Report, U. S. Geological Survey.

Sass, J. H., and P. Morgan, 1988. "Conductive Heat Flux in VC-1 and the Thermal Regime of Valles Caldera, Jemez Mountains, New Mexico," Journal of Geophysical Research, Vol. 93, No. B6, pp. 6027-6039.

Sass, J. H., A. H. Lachenbruch, and C. W. Mase, 1980. Analysis of Thermal Data from Drill Holes UE24a-3 and UE25a-1, Calico Hills and Yucca Mountain, Nevada Test Site, USGS-OFR-80-826, Open-File Report, U.S. Geological Survey.

Sass, J., A. Lachenbruch, F. Grubb, and T. Moses, 1983. Status of Thermal Observations at Yucca Mountain, Nevada, USGS Letter Report, 10 p.

Savage, W. Z., and W. K. Smith, 1986. A Model for the Plastic Flow of Landslides, U.S. Geological Survey Professional Paper 1385, U.S. Government Printing Office, Washington, D.C.

Scheetz, B. E., and D. M. Roy, in prep. 1986. Preliminary Survey of the Stability of Silica-Rich Cementitious Mortars (82-22 and 84-12) with Tuff, Los Alamos National Laboratories, Los Alamos, N. Mex. 69 p.

Schmertmann, J. H., 1970. "Static Cone to Compute Static Settlement Over Sand," in Journal of the Soil Mechanics and Foundations Division, Proceedings of the American Society of Civil Engineerings, ASCE 96, No. SM3, pp. 1011-1042.

Schnabel, P., H. B. Seed, and J. Lysmer, 1971. Modification of Seismograph Records for Effects of Local Soil Conditions, Report No. EERC 71-8, University of California, Berkeley.

Schoff, S. L., and J. E. Moore (comps.), 1964. Chemistry and Movement of Ground Water, Nevada Test Site, USGS-TEI-838, Trace-Elements Investigations Report, U.S. Geological Survey.

Schonblom, J. E., 1961. "Quantitative Interpretation of Temperature Logs in Flowing Gas Wells," Second Annual Meeting of Society of Professional Well Log Analysts, Dallas, Texas, May 18-19, 1961.

Schrepp, W., R. Stumpe, J. I. Kim, and H. Walther, 1983. "Oxidation-State-Specific Detection of Uranium in Aqueous Solution by Photoacoustic Spectroscopy," Applied Physics, Vol. B 32, PP. 207-209.

Schwartz, and Crone, 1985.

Schwartz, F. W., and L. Smith, 1985. "A New Continuum Approach for Modeling Dispersion in Fractured Media," Hydrogeology of Rocks of Low Permeability, Memoirs of the International Association of Hydrogeologists, 17th International Congress, 1985, Tucson, Ariz., pp. 538-546.

Scott, C., and A. K. Chamberlain, 1987. "Blackburn Field, Nevada: A Case History," Oil and Gas Journal, August 17, 1987, 4 p.

Scott, R. B., 1986. "Extensional Tectonics at Yucca Mountian, Southern Nevada," Geological Society of America, Abstracts with Programs, 1986, Rocky Mountain Section, Flagstaff, Ariz., April 30-May 2, 1986, Vol. 18, No. 5, p. 411.

Scott, R. B., and J. Bonk, 1984. Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, with Geologic Sections, USGS-OFR-84-494, Open-File Report, U.S. Geological Survey.

Scott, R. B. and M. Castellanos, 1984. Stratigraphic and Structural Relations of Volcanic Rocks in Drill Holes USW GU-3 and USW G-3, Yucca Mountain, Nye County, Nevada, USGS-OFR-84-491, Open-File Report, U.S. Geological Survey.

Scott, R. B., and J. G. Rosenbaum, 1986. "Evidence of Rotation About a Vertical Axis during Extension at Yucca Mountain, Southern Nevada," Transactions, American Geophysical Union, EOS, Vol. 67, No. 16, p. 358.

Scott, R. B., and J. W. Whitney, 1987. "The Upper Crustal Detachment System at Yucca Mountain, SW Nevada," Geological Society of America Abstracts with Programs, pp. 332-333.

Scott, R. B., R. W. Spengler, S. Diehl, A. R. Lappin, and M. P. Chornak, 1983. "Geologic Character of Tuffs in the Unsaturated Zone at Yucca Mountain, Southern Nevada," Role of the Unsaturated Zone in Radioactive and Hazardous Waste Disposal, J. W. Mercer, P. S. C. Rao, and I. W. Marine (eds.), Ann Arbor Science Publishers, Ann Arbor, Mich., pp. 289-335.

Scott, R. B., G. D. Bath, V. J. Flanigan, D. B. Hoover, J. G. Rosenbaum, and R. W. Spengler, 1984. Geological and Geophysical Evidence of Structures in Northwest-Trending Washes, Yucca Mountain, Southern Nevada, and Their Possible Significance to a Nuclear Waste Repository in the Unsaturated Zone, USGS-OFR-84-567, Open-File Report, U.S. Geological Survey.

Seed, H. B., R. T. Wong, I. M. Idriss, and K. Tokimatsu, 1984. Moduli and Damping Factors for Dynamic Analyses of Cohesionless Soils, UCB/EERC-84/14, University of California, Berkeley.

Senterfit, R. M., D. B. Hoover, and M. Chornack, 1982. Resistivity Soundings Investigation by the Schlumberger Method in the Yucca Mountain and Jackass Flats Area, Nevada Test Site, Nevada, USGS-OFR-82-1043, Open-File Report, U.S. Geological Survey.

Sheridan, M. F., and D. M. Ragan, 1976. Compaction of Ash-Flow Tuffs, Compaction of Coarse-Grained Sediments, II, G. V. Chilingarian, and K. H. Wolf (eds.), Elsevier Science Publishing Company, Netherlands, pp. 677-717.

Shreir, L. L. (ed.), 1976. "The Atmosphere," Corrosion, Metal/Environment Reactions, Vol. 1, Newnes-Butterworths, London, pp. 2:26-2:37.

Silling, S. A., 1982. Final Technical Position on Documentation of Computer Codes for High-Level Waste Management, NUREG-0856, U.S. Nuclear Regulatory Commission, Washington, D.C.

Sinnock, S., and J. A. Fernandez, 1982. Summary and Conclusions of the NNWSI Area-to-Location Screening Activity, NVO-247, Nevada Operations Office, U.S. Department of Energy, Las Vegas, Nev.

Sinnock, S., J. A. Fernandez, and W. S. Twenhofel (eds.), 1984a. Attributes and Associated Favorability Graphs for the NNWSI Area-to-Location Screening Activity, SAND82-0838, Sandia National Laboratories, Albuquerque, N. Mex.

Sinnock, S., Y. T. Lin, and J. P. Brannen, 1984b. Preliminary Bounds on the Expected Postclosure Performance of the Yucca Mountain Repository Site, Southern Nevada, SAND84-1492, Sandia National Laboratories, Albuquerque, N. Mex.

Sinnock, S. (ed.), Y. T. Lin, and M. S. Tierney, 1986. Preliminary Estimates of Groundwater Travel Time and Radionuclide Transport at the Yucca Mountain Repository Site, SAND85-2701, Sandia National Laboratories, Albuquerque, N. Mex.

Sinton, P. O., and J. S. Downey, 1986. "Three-Dimensional, Steady-State, Finite-Difference Model of the Ground-Water Flow System in the Death Valley Ground-Water Basin Nevada--California, EOS, Vol. 67, No. 44, p. 942.

Siskind, D. E., and R. R. Fumanti, 1974. "Blast-Produced Fractures in Lithonia Granite," BuMines Report of Investigations 7901, 38 p.

Siskind, D. E., R. C. Steckley, and J. J. Olson, 1973. "Fracturing in the Zone Around a Blasthole, White Pine, Michigan," BuMines Report of Investigations 7753, 20 p.

Slemmons, 1982.

Slemmons, D. B., and C. M. Depolo, 1986. "Evaluation of Active Faulting and Associated Hazards," Active Tectonics, National Academy Press, Washington, D.C., pp. 45-62.

Smith, C., and H. P. Ross, 1982. Interpretation of Resistivity and Induced Polarization Profiles with Severe Topographic Effects, Yucca Mountain Area, Nevada Test Site, Nevada, USGS-OFR-82-182, Open-File Report, U.S. Geological Survey.

Smith, C., H. P. Ross, and R. Edquist, 1981. Interpreted Resistivity and IP Section Line W1, Wahmonie Area, Nevada Test Site, Nevada, USGS-OFR-81-1350, Open-File Report, U.S. Geological Survey.

Smith, G. I., 1983. "Paleohydrologic Regimes in the Southwestern Great Basin, 0-3.2 my Ago, Compared with Other Long Records of Global Climate," Quaternary Research, Vol. 22, pp. 1-17.

Smith, H. D., 1985. Zircaloy Cladding Corrosion Degradation in a Tuff Repository: Initial Experimental Plan, HEDL-7455, Rev. 1, Hanford Engineering Development Laboratory, Richland, Wash.

Smith, L., and F. W. Schwartz, 1980. "Mass Transport 1. A Stochastic Analysis of Macroscopic Dispersion," Water Resources Research, Vol. 16, No. 2, pp. 303-313.

Smith, R. L., 1979. "Ash-Flow Magmatism," The Geological Society of America, Geological Society of America Special Paper 180, pp. 5-27.

Smyth, J. R., 1982. "Zeolite Stability Constraints on Radioactive Waste Isolation in Zeolite-Bearing Volcanic Rocks," Journal of Geology, Vol. 90, pp. 195-201.

Smyth, J. R., and F. A. Caporuscio, 1981. Review of the Thermal Stability and Cation Exchange Properties of the Zeolite Minerals Clinoptilolite, Mordenite, and Analcime: Applications to Radioactive Waste Isolation in Silicic Tuff, LA-8841-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Snow, D. T., 1969. "Anisotropic Permeability of Fractured Media," Water Resources Research, Vol. 5, No. 6, pp. 1273-1289.

Snyder, D. B., 1981. "Gravity Interpretation of Yucca Mountain, Nye County, Nevada and Its Implications for Southern Nevada Structure," EOS, Vol. 62, No. 45, p. 1039.

Snyder, D. B., and W. J. Carr, 1982. Preliminary Results of Gravity Investigations at Yucca Mountain and Vicinity, Southern Nye County, Nevada, USGS-OFR-82-701, Open-File Report, U.S. Geological Survey.

Snyder, D. B., and W. J. Carr, 1984. "Interpretation of Gravity Data in a Complex Volcano-Tectonic Setting, Southwestern Nevada," Journal of Geophysical Research, Vol. 89, No. B12, pp. 10,193-10,206.

Snyder, D. B., and H. W. Oliver, 1981. Preliminary Results of Gravity Investigations of the Calico Hills, Nevada Test Site, Nye County, Nevada, USGS-OFR-81-101, Open-File Report, U.S. Geological Survey.

Spaeth, M. E., 1987. Letter from M. E. Spaeth (SAIC) to D. L. Vieth (WMPO), L87-ENV-MIF-10, March 17, 1987; regarding preliminary environmental analysis of proposed changes to ESF design and schedule.

Spaeth, M. E., 1988. Letter from M. E. Spaeth (SAIC) to C. E. Gertz (WMPO) dated August 8, 1988; regarding Contract DE-AC08-87NV10576, Summary of Results from Dry Drilling and Coring Technology Workshop.

Sparks, R. S. J., S. Self, and G. P. L. Walker, 1973. "Products of Ignimbrite Eruptions," Geology, Vol. 1, No. 3, pp. 115-118.

Spaulding, W. G., and L. J. Graumlich, 1986. "The Last Pluvial Climatic Episodes in the Deserts of Southwestern North America," Nature, Vol. 320, pp. 441-444.

Spengler, R. W., and M. P. Chornack, 1984. Stratigraphic and Structural Characteristics of Volcanic Rocks in Core Hole USW G-4, Yucca Mountain, Nye County, Nevada, with a section on geophysical logs by D. C. Muller and J. E. Kibler, USGS-OFR-84-789, Open-File Report, U.S. Geological Survey.

Spengler, R. W., and J. G. Rosenbaum, 1980. Preliminary Interpretations of Geologic Results Obtained from Boreholes UE25a-4, -5, -6, and -7, Yucca Mountain, Nevada Test Site, USGS-OFR-80-929, Open-File Report, U.S. Geological Survey.

Spengler, R. W., D. C. Muller, and R. B. Livermore, 1979. Preliminary Report on the Geology and Geophysics of Drill Hole UE25a-1, Yucca Mountain, Nevada Test Site, USGS-OFR-79-1244, Open-File Report, U.S. Geological Survey.

Spengler, R. W., F. M. Byers, Jr., and J. B. Warner, 1981. Stratigraphy and Structure of Volcanic Rocks in Drill Hole USW G-1, Yucca Mountain, Nye County, Nevada, USGS-OFR-81-1349, Open-File Report, U.S. Geological Survey.

Spudich, P., 1985. "Calculation of Ground Motion Time Histories Using Green's Function Summation," Strong Ground Motion Simulations and Earthquake Engineering Applications, R. E. Scholl, and J. L. King (eds.), Publication No. 85-02, Earthquake Engineering Research Institute, pp. 19-1 to 19-7.

Squires, R. R., and R. L. Young, 1984. Flood Potential of Fortymile Wash and Its Principal Southwestern Tributaries, Nevada Test Site, Southern Nevada, USGS-WRI-83-4001, Water-Resources Investigations Report, U.S. Geological Survey.

St. John, C. M., 1987a. Interaction of Nuclear Waste Panels with Shafts and Access Ramps for a Potential Repository at Yucca Mountain, SAND84-7213, Sandia National Laboratories, Albuquerque, N. Mex.

St. John, C. M., 1987b. Investigative Study of the Underground Excavations for a Nuclear Waste Repository in Tuff, SAND83-7451, Sandia National Laboratories, Albuquerque, N. Mex.

St. John, C. M., 1987c. Reference Thermal and Thermal/Mechanical Analyses of Drifts for Vertical and Horizontal Emplacement of Nuclear Waste in a Repository in Tuff, SAND86-7005, Sandia National Laboratories, Albuquerque, N. Mex.

St. John, C. M., 1987d. Thermomechanical Analysis of Underground Excavations in the Vicinity of a Nuclear Waste Isolation Panel, SAND84-7208, Sandia National Laboratories, Albuquerque, N. Mex.

St. John, C. M., and S. J. Mitchell, 1987. Investigation of Excavation Stability in a Finite Repository, SAND86-7011, Sandia National Laboratories, Albuquerque, N. Mex.

Staehle, R. W., 1971. "Stress Corrosion Cracking of the Fe-Cr-Ni Alloy System," The Theory of Stress Corrosion Cracking in Alloys, J. C. Scully (ed.), National Atlantic Treaty Organization Scientific Affairs Division, Brussels, Belgium.

Stannard, D. I., 1985. "Design and Performance of a Machine Used in the Calculation of Bowen Ratios," in Proceedings of the NWWA Conference on Characterization and Monitoring of the Vadose (Unsaturated) Zone, November 19-21, 1985, Denver, Colo., pp. 143-156.

Stanton, R. L., 1972. Ore Petrology, McGraw-Hill Book Co., New York, pp. 305-351, 522.

Stein, R., 1988. Letter from Ralph Stein (DOE) to John Linehan (NRC); regarding waste acceptance preliminary specifications for the defense waste processing facility high-level waste form.

Stewart, J. H., 1980. Geology of Nevada, A Discussion to Accompany the Geologic Map of Nevada, Nevada Bureau of Mines & Geology Special Publication No. 4, University of Nevada, Reno.

Stinebaugh, R. E., and J. C. Frostenson, 1986. Disposal of Radioactive Waste Packages in Vertical Boreholes--A Description of the Operations and Equipment for Emplacement and Retrieval, SAND84-1010, Sandia National Laboratories, Albuquerque, N. Mex.

Stinebaugh, R. E., and J. C. Frostenson, 1987. Worker Radiation Doses during Vertical Emplacement and Retrieval of Spent Fuel at the Tuff Repository, SAND84-2275, Sandia National Laboratories, Albuquerque, N. Mex.

Stinebaugh, R. E., I. B. White, and J. C. Frostenson, 1986. Disposal of Radioactive Waste Packages in Horizonal Boreholes--A Description of the Operations and Equipment for Emplacement and Retrieval, SAND84-2640, Sandia National Laboratories, Albuquerque, N. Mex.

Stock, J. M., and J. H. Healy, 1984. "Magnitudes and Orientations of Stress in an Extensional Regime, Yucca Mountain, Nevada," Geological Society of America, Abstracts with Programs, Vol. 16, No. 6, p. 669.

Stock, J. M., J. H. Healy, and S. H. Hickman, 1984. Report on Televiewer Log and Stress Measurements in Core Hole USW G-2, Nevada Test Site, October-November 1982, USGS-OFR-84-172, U.S. Geological Survey.

Stock, J. M., J. H. Healy, S. H. Hickman, and M. D. Zoback, 1985. "Hydraulic Fracturing Stress Measurements at Yucca Mountain, Nevada, and Relationship to the Regional Stress Field," Journal of Geophysical Research, Vol. 90, No. B10, pp. 8691-8706.

Stumpe, R., J. I. Kim, W. Schrepp, and H. Walther, 1984. "Speciation of Actinide Ions in Aqueous Solution by Laser-Induced Pulsed Photoacoustic Spectroscopy," Applied Physics, Vol. B34, pp. 203-206.

Sudicky, E. A., and E. O. Frind, 1982. "Contaminant Transport in Fractured Porous Media: Analytical Solutions for a System of Parallel Fractures," Water Resources Research, Vol. 18, No. 6, pp. 1634-1642.

Sun, R. J. (ed.), 1986. Regional Aquifer-System Analysis Program of the U.S. Geological Survey, Summary of Projects, 1978-84, U.S. Geological Survey Circular 1002, Reston, Va.

Suppe, J., 1985. Principles of Structural Geology, Prentice-Hall, Englewood Cliffs, New Jersey, pp. 198-201.

Sutton, V. D., 1984. Data Report for the 1983 Seismic-Refraction Experiment at Yucca Mountain, Beatty and Vicinity, Southwestern Nevada, USGS-OFR-84-661, Open-File Report, Menlo Park, Calif.

Sutton, V. D., 1985. Data Report for the 1985 Seismic-Refraction Experiment at Yucca Mountain and Vicinity, Southwestern Nevada, USGS-OFR-85-591 Open File Report, U.S.Geological Survey, Menlo Park, Calif.

Svalstad, D. K., 1983. User's Manual for SPECTROM-41: A Finite-Element Heat Transfer Program, ONWI-326, RE/SPEC, Inc., for the Office of Nuclear Waste Isolation, Columbus, Ohio.

Swadley, W C, D. L. Hoover, and J. N. Rosholt, 1984. Preliminary Report on Late Cenozoic Faulting and Stratigraphy in the Vicinity of Yucca Mountain, Nye County, Nevada, USGS-OFR-84-788, Open-File Report, U.S. Geological Survey.

Swadley W C, J. C. Yount, and S. T. Harding, 1988. Reinterpretation of the Beatty Scarp, Nye County, Nevada, Investigations of a Potential Nuclear Waste Disposal Site at Yucca Mountain, Southern Nevada, M. D. Carr, and J. C. Yount (eds.), U.S. Geological Survey Bulletin 1790, U.S. Geological Survey.

Sylvester, A. G., and S. W. Bie, 1986. "Geodetic Monitoring of Fault Movements in Death Valley, 1970-1985," Quaternary Tectonics of Southern Death Valley, California Field Trip Guide, B. W. Troxel (ed.), pp. 41-44.

Szabo, B. J., W. J. Carr, and W. C. Gottschall, 1981. Uranium-Thorium Dating of Quaternary Carbonate Accumulations in the Nevada Test Site Region, Southern Nevada, USGS-OFR-81-119, Open-File Report, U.S. Geological Survey.

Taranik, J. V. and C. M. Trautwein, 1977. "Integration of Geological Remote-Sensing Techniques in Subsurface Subsurface Geology L. W. LeRoy, D. O. LeRoy and J. W. Raese,(eds.), Fourth Edition, Colorado School of Mines, Golden, Colorado, pp. 767-786.

Tasooji, A., R. E. Einziger, and A. K. Miller, 1984. Modeling of Zircaloy Stress-Corrosion Cracking: Texture Effects and Dry Storage Spent Fuel Behavior, Special Technical Publication 824, American Society for Testing & Materials, Philadelphia, Penn., pp. 595-626.

Taylor, H. P., Jr., 1979. Oxygen and Hydrogen Isotope Relationships in Hydrothermal Mineral Deposits, Geochemistry of Hydrothermal Ore Deposits, H. L. Barnes (ed.), 2nd Edition, John Wiley & Sons, pp. 236-277.

Terzaghi, K., 1943. Theoretical Soil Mechanics, John Wiley & Son, New York, 510 p.

Terzaghi, K., and R. B. Peck, 1967. Soil Mechanics in Engineering Practice, John Wiley & Sons, Inc., New York, pp. 361-379.

Teufel, L. W., and N. R. Warpinski, 1984. "Determination of In Situ Stress from Anelastic Strain Recovery Measurements of Oriented Core: Comparison to Hydraulic Fracture Stress Measurements in the Rollins Sandstone, Piceance Basin, Colorado," in Rock Mechanics in Productivity and Protection, Proceedings of the 25th Symposium on Rock Mechanics, Evanston, Ill., June 25-27, 1984, C. H. Downing and M. M. Singh (eds.), Society of Mining Engineers, New York, pp. 176-185.

Theis, C. V., 1935. "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage," Transactions of the American Geophysical Union, Sixteenth Annual Meeting, April 25-26, 1935, Washington, D.C., Part I, pp. 519-524.

Theobald, P. K., 1987. "Exploration in Desert Environments," Geoexpo/86; Exploration in the North American Cordillera, May 12-14, 1986, Vancouver, British Columbia, I. L. Elliot and B. W. Smee (eds.), The Association of Exploration Geochemists, pp. 213-214.

Thomas, R. K., 1980. A Material Constitutive Model for Jointed Rock Mass Behavior, SAND80-1418, Sandia National Laboratories, Albuquerque, N. Mex.

Thomas, R. K., 1982. A Continuum Description for Jointed Media, SAND81-2615, Sandia National Laboratories, Albuquerque, N. Mex.

Thomas, R. K., 1987. Near Field Mechanical Calculations Using a Continuum Jointed Rock Model in the JAC Code, SAND83-0070, Sandia National Laboratories, Albuquerque, N. Mex.

Thomson, I., 1986. "Getting It Right," Exploration Geochemistry: Design and Interpretation of Soil Surveys, J. M. Robertson (ed.), Vol. 3, Society of Economic Geologists, pp. 1-18.

Thorstenson, D. C., E. P. Weeks, H. Haas, and D. W. Fisher, 1983. "Distribution of Gaseous 12CO2, 13CO2 and 14CO2 in the Sub-Soil Unsaturated Zone of the Western U.S. Great Plains," Radiocarbon, Vol. 25, No. 2, pp. 315-346.

Throckmorton, C. K., 1987. Photogeologic Study of Small-Scale Linear Features Near a Potential Nuclear-Waste Repository Site at Yucca Mountain, Southern Nye County, Nevada, USGS-OFR-87-409, Open File Report, U.S. Geological Survey.

Till, J. E., and H. R. Meyer, (Eds.), 1983. Radiological Assessment: A Textbook on Environmental Dose Analysis, NUREG/CR-3332, U.S. Nuclear Regulatory Commission, Washington, D.C.

Tingley, J. V., and B. R. Berger, 1985. Lode Gold Deposits of Round Mountain, Nevada, Nevada Bureau of Mines & Geology Bulletin 100, University of Nevada, Reno, 62 p.

Torgersen, T., W. B. Clarke, and M. A. Habermehl, 1987. "Helium Isotopic Evidence for Recent Subcrustal Volcanism in Eastern Australia," Geophysical Research Letters, Vol. 14, No. 12, pp. 1215-1218.

Travis, B. J., 1984. TRACR3D: A Model of Flow and Transport in Porous/Fractured Media, LA-9667-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Travis, B. J., 1985. WAFE: A Model for Two-Phase, Multicomponent Mass and Heat Transport in Porous/Fractured Media LA-10488-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Travis, B. J., and L. E. Greenwade, 1985. "A One-Dimensional Numerical Model of Two-Phase Flow and Transport in Porous Media Using the Dynamics of Contours Methodology, NNWSI Milestone C717, Los Alamos National Laboratory, Los Alamos, N. Mex.

Treher, E. N., and N. A. Raybold, 1982. The Elution of Radionuclides Through Columns of Crushed Rock from the Nevada Test Site, LA-9329-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

URS/John A. Blume & Associates, 1986. Ground Motion Evaluations at Yucca Mountain, Nevada with Applications to Repository Conceptual Design and Siting, SAND85-7104, Sandia National Laboratories, Albuquerque, N. Mex.

URS/John A. Blume & Associates, 1987. Technical Basis and Parametric Study of Ground Motion and Surface Rupture Hazard Evaluations at Yucca Mountain, Nevada, SAND86-7013, Sandia National Laboratories, Albuquerque, N. Mex.

USBM/USGS (U.S. Bureau of Mines/U.S. Geological Survey), 1980. Principles of a Resource/Reserve Classification for Minerals, Geological Survey Circular 831, U.S. Geological Survey.

USGS (U.S. Geological Survey), 1954. Bare Mountain Quadrangle, Nevada, U.S. Geological Survey 15 Minute Series (Topographic), 1:62,500, U.S. Geological Survey.

USGS (U.S. Geological Survey), 1978. Geologic Survey Research 1978, Geological Survey Professional Paper 1100, U.S. Government Printing Office, Washington, D.C.

USGS (U.S. Geological Survey) (comp.), 1984. A Summary of Geologic Studies through January 1, 1983, of a Potential High-Level Radioactive Waste Repository Site at Yucca Mountain, Southern Nye County, Nevada, USGS-OFR-84-792, Open-File Report, U.S. Geological Survey.

Van Konynenburg, R. A., C. F. Smith, H. W. Culham, and C. H. Otto, Jr., 1984. Behavior of Carbon-14 in Waste Packages for Spent Fuel in a Repository in Tuff, UCRL-90855, Rev. 1, Lawrence Livermore National Laboratory, Livermore, Calif.

Van Konynenburg, R. A., C. F. Smith, H. W. Culham, and H. D. Smith, 1986. "Carbon-14 in Waste Packages for Spent Fuel in a Tuff Repository," Materials Research Society December 1986 Meeting, UCRL-94708, preprint, Boston, Mass.

Van Schilfgaarde, J. (ed.), 1974. Drainage for Agriculture, No. 17, American Society of Agronomy, Inc., Madison, Wisc.

Van Spronsen, E., 1982. "Three-Phase Relative Permeability Measurements Using the Centrifuge Method," Third Joint Symposium on Enhanced Oil Recovery of the Society of Petroleum Engineers, Tulsa, Ok., April 4-7, 1982, pp. 217-240.

Vaniman, D. T., B. M. Crowe, and E. S. Gladney, 1982. "Petrology and Geochemistry of Hawaiite Lavas from Crater Flat, Nevada," Contributions to Mineralogy and Petrology, Vol. 80, Springer-Verlag, pp. 341-357.

Vaniman et al, 1988.

Vetter, U. R., and A. S. Ryall, 1983. "Systematic Change of Focal Mechanism with Depth in the Western Great Basin," Journal of Geophysical Research, Vol. 88, No. B10, pp. 8237-8250.

Vortman, L. J., 1980. Prediction of Ground Motion from Underground Nuclear Weapons Tests as It Relates to Siting of a Nuclear Waste Storage Facility at NTS and Compatibility with the Weapons Test Program, SAND80-1020/1, Sandia National Laboratories, Albuquerque, N. Mex.

Vortman, L. J., 1986. Ground Motion Produced at Yucca Mountain from Pahute Mesa Underground Nuclear Explosions, SAND85-1605, Sandia National Laboratories, Albuquerque, N. Mex.

Waddell, R. K., 1982. Two-Dimensional, Steady-State Model of Ground-Water Flow, Nevada Test Site and Vicinity, Nevada-California, USGS-WRI-82-4085, Water-Resources Investigations Report, U.S. Geological Survey.

Waddell, R. K., J. H. Robison, and R. K. Blankennagel, 1984. Hydrology of Yucca Mountain and Vicinity, Nevada-California--Investigative Results Through Mid-1983, USGS-WRI-84-4267, Water-Resources Investigations Report, U.S. Geological Survey.

Wagner, H., 1975. "Determination of the Complete Load-Deformation Characteristics of Coal Pillars," in Proceedings of the Third Congress of the International Society for Rock Mechanics September 1-7, 1974, Denver, Colorado, Vol. 2, pp. 1076-1083.

Walck, M. C., 1988. "Three-Dimensional Vp/Vs Variations for the Coso Region, California," Journal of Geophysical Research, Vol. 93, B3, pp. 2047-2052.

Walker, G. E., and T. E. Eakin, 1963. Geology and Ground Water of Amargosa Desert, Nevada-California, Department of Conservation and Natural Resources, Ground-Water Resources Reconnaissance Series Report 14, State of Nevada, Carson City.

Wallace, R. E., 1978. "Patterns of Faulting and Seismic Gaps in the Great Basin Province," in Proceedings of Conference VI: Methodology for Identifying Seismic Gaps and Soon to Break Gaps, B. L. Isacks and G. Plafker (comps.), USGS-OFR-78-943, Open-File Report, U.S. Geological Survey, pp. 857-868.

Walter, A. W., and C. S. Weaver, 1980. "Seismicity of the Coso Range, California," Journal of Geophysical Research, Vol. 85, No. B5, pp. 2441-2458.

Wang, J. S. Y., and T. N. Narasimhan, 1985. Hydrologic Mechanisms Governing Fluid Flow in Partially Saturated, Fractured Porous Tuff at Yucca Mountain, SAND84-7202, Sandia National Laboratories, Albuquerque, N. Mex.

Wang, J. S. Y., and T. N. Narasimhan, 1986. Hydrologic Mechanisms Governing Partially Saturated Fluid Flow in Fractured Welded Units and Porous Non-Welded Units at Yucca Mountain, SAND85-7114, Sandia National Laboratories, Albuquerque, N. Mex.

Water, Waste & Land, Inc., 1986. Analyses of Observed Flow Between Test Wells USW G-1 and USW UZ-1, NRC Mini Report 6, U.S. Nuclear Regulatory Commission, Washington, D.C.

Watson, K. K., 1965. "Some Operating Characteristics of a Rapid Response Tensiometer System," Water Resources Research, Vol. 1, No. 4, pp. 577-586.

Webb, T., III, F. A. Street-Perrott, and J. E. Kutzbach, 1987. "Late-Quaternary Paleoclimatic Data and Climate Models," Episodes, Vol. 10, No. 1, pp. 4-6.

Weeks, E. P., 1978. "Barometric Fluctuations in Wells Tapping Deep Unconfined Aquifers," Water Resources Research, Vol. 15, No. 5, pp. 1167-1176.

Weeks, E. P., 1986. "Effect of Topography on Gas Flow in Unsaturated Fractured Rock--Concepts and Observations," EOS, Vol. 67, No. 44, pp. 962-963.

Weeks, E. P., 1987. "Effect of Topography on Gas Flow in Unsaturated Fractured Rock: Concepts and Observations," Geophysics Monograph 42, D. D. Evans, and T. J. Nicholson (eds.), pp. 165-170.

Weeks, E. P., and W. E. Wilson, 1984. Preliminary Evaluation of Hydrologic Properties of Cores of Unsaturated Tuff, Test Well USW H-1, Yucca Mountain, Nevada, USGS-WRI-84-4193, Water-Resources Investigations Report, U.S. Geological Survey.

Weeks, E. P., H. L. Weaver, G. S. Campbell, and B. D. Tanner, 1985. Water Use by Saltcedar and by Replacement Vegetation in the Pecos River Floodplain Between Acme and Artesia, New Mexico, U.S. Geologial Survey Professional Paper 491-G, U.S. Government Printing Office, Washington, D.C., 33 p.

Wells, S. G., L. D. McFadden, C. Renault, and B. M. Crowe, 1988. "A Geomorphic Assessment of Quaternary Volcanism in the Yucca Mountain Area, Nevada Test Site, Southern Nevada," Geological Society of America, Cordilleran Section, Vol. 20, No. 3 p. 242.

West, K. A. 1988. Exploratory Shaft Facility Fluids and Materials Evaluation, LA-11398-MS, Los Alamos National Laboratory, Los Alamos, N. Mex.

Westsik, J. H., F. N. Hodges, W. L. Kuhn, and T. R. Myers, 1983. "Water Migration Through Compacted Bentonite Backfills for Containment of High Level Nuclear Waste," Nuclear and Chemical Waste Management, Vol. 4, pp. 291-299.

Wheelwright, E.J., F. N. Hodges, L. A. Bray, J. J. Westic, and D. H. Lester, T. L. Nakai, M. E. Spaeth, R. t. Stula, 1981. Development of Backfill Material as an Engineered Barrier in the Waste Package System - Interim Topical Report, PNL-3873, Pacific Northwest Laboratory, Richland, Wash.

Whitfield, M. S., 1985. "Vacuum Drilling of Unsaturated Tuffs at a Potential Radioactive-Waste Repository, Yucca Mountain, Nevada," Characterization and Monitoring of the Vadose Zone, National Water Well Association Symposium, Denver, Colorado, November 19-21, 1985.

Whitney, J. W., R. R. Shroba, F. W. Simonds, and S. T. Harding, 1986. "Recurrent Quaternary Movement on the Windy Wash Fault, Nye County, Nevada [abs.]," Geological Society of America, Abstracts with Programs, Vol. 18, No. 6, p. 787.

Wilcox, T., 1972. MORSE-L, A Special Version of the MORSE Program Designed to Solve Neutron, Gamma, and Coupled Neutron-Gamma Penetration Problems, UCID-16680, Lawrence Livermore National Laboratory, Livermore, Calif.

Williams, D. J., 1987. Mining-Related and Tectonic Seismicity in the East Mountain Area, Wasatch Plateau, Central Utah, M.S. thesis, Department of Geology and Geophysics, University of Utah.

Wilson, C. N., 1985b. Results from NNWSI Series 1 Spent Fuel Leach Test, HEDL-TME-84-30, Hanford Engineering Development Laboratory, Richland, Wash.

Wilson, M. L., and A. L. Dudley, 1987. Flow and Transport through Unsaturated, Fractured Rock, D. D. Evans and T. J. Nicholson (eds.), Geophysical Monograph 42, American Geophysical Union, Washington, D.C., pp. 23-29.

Winograd, I. J., and B. J. Szabo, 1986. Water-Table Decline in the South-Central Great Basin during the Quaternary Period: Implications for Toxic-Waste Disposal, USGS-OFR-85-697, Open-File Report, U.S. Geological Survey.

Winograd, I. J., and W. Thordarson, 1975. Hydrogeologic and Hydrochemical Framework, South-Central Great Basin, Nevada-California, with Special Reference to the Nevada Test Site, U.S. Geological Survey Professional Paper 712-C, U.S. Geological Survey, pp. C1-C126.

Winograd, I. J., B. J. Szabo, T. B. Coplen, A. C. Riggs, and P. T. Kolesar, 1985. "Two-Million-Year Record of Deuterium Depletion in Great Basin Ground Waters," Science, Vol. 227, pp. 519-522.

Winter, C. L., S. P. Neuman, and C. M. Newman, 1984. Prediction of Far-Field Subsurface Radionuclide Dispersion Coefficients from Hydraulic Conductivity Measurements, NUREG/CR-3612, U.S. Nuclear Regulatory Commission, Washington, D.C., 56 p.

Winterkorn, H. F., and H. V. Fang (eds.), 1975. Foundation Engineering Handbook, Van Nostrand Reinhold Co., New York, pp. 37, 117, 156.

Wolery, T. J., 1979. Calculation of Chemical Equilibrium Between Aqueous Solution and Minerals: The EQ3/6 Software Package, UCRL-52658, Lawrence Livermore National Laboratory, Livermore, Calif.

Wolery, T. J., 1983. EQ3NR, A Computer Program for Geochemical Aqueous Speciation-Solubility Calculations: User's Guide and Documentation, UCRL-53414, Lawrence Livermore National Laboratory, Livermore, Calif.

Woods, R. D., 1978. "Measurement of Dynamic Soil Properties," in Proceedings of the ASCE Geotechnical Engineering Division Specialty Conference, Earthquake Engineering and Soil Dynamics, 1978, Pasadena, California, American Society of Civil Engineers, New York, pp. 158-159.

Wu, S. S. C., 1985. Topographic Maps of Yucca Mountain Area, Nye County, Nevada, USGS-OFR-85-620, Open-File Report, Scale 1:5,000, U.S. Geological Survey.

Yeh, T. -C. J., L. W. Gelhar, and A. L. Gutjahr, 1985. "Stochastic Analysis of Unsaturated Flow in Heterogeneous Soils, 1. Statistically Isotopic Media," Water Resources Research, Vol. 21, No. 4, pp. 447-471.

Zablocki, C. J., 1979. Some Reconnaissance-Type Electrical Surveys of Timber Mountain Caldera, Nye County, Nevada, USGS-OFR-79-1695, Open-File Report, U.S. Geological Survey.

Zimmerman, R. M., and R. E. Finley, 1987. Summary of Geomechanical Measurements Taken In and Around the G-Tunnel Underground Facility, NTS, SAND86-1015, Sandia National Laboratories, Albuquerque, N. Mex.

Zimmerman, R. M., R. L. Schuch, D. S. Mason, M. L. Wilson, M. E. Hall, M. P. Board, R. P. Bellman, M. L. Blanford, 1986a. Final Report: G-Tunnel Heated Block Experiment, SAND84-2620, Sandia National Laboratories, Albuquerque, N. Mex.

Zimmerman, R. M., M. L. Blanford, J. F. Holland, R. L. Schuch, and W. H. Barrett, 1986b. Final Report, G-Tunnel Small-Diameter Heater Experiments, SAND84-2621, Sandia National Laboratories, Albuquerque, N. Mex.

Zimmerman, R. M., R. Bellman, K. Mann, D. Zerga, and M. Fowler, 1988. G-Tunnel Welded Tuff Mining Experiment Data Summary SAND87-1433, Sandia National Laboratories, Albuquerque, N. Mex.

Zyvoloski, G., and S. Kelkar, 1987. Preliminary Investigation into Coupled Heat/Mass/Stress Effects at Yucca Mountain, NNWSI Milestone R346, Los Alamos National Laboratory, Los Alamos, N. Mex.

CODES AND REGULATIONS

3 CFR (Code of Federal Regulations), 1987. Title 3, "The President," Washington, D.C.

10 CFR Part 20 (Code of Federal Regulations), 1987. Title 10, "Energy," Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, D.C., pp. 247-285.

10 CFR Part 50, Appendix B (Code of Federal Regulations), 1987. Title 10, "Energy," Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 50, Appendix A (Code of Federal Regulations), 1987. Title 10, "Energy," Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 50, Appendix I (Code of Federal Regulations), 1987. Title 10, "Energy," Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 60 (Code of Federal Regulations), 1987. Title 10, "Energy," Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," U.S. Government Printing Office, Washington, D.C., pp. 627-658.

10 CFR Part 72 (Code of Federal Regulations), 1987. Title 10 - "Protection Environment", Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)," U.S. Government Printing Office, Washington, D.C., pp. 756-780.

10 CFR Part 960 (Code of Federal Regulations), 1984. Title 10, "Energy," Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories; Final Siting Guidelines," 49 FR 47714, Vol. 49, No. 236, December 6, 1984, pp. 47714-47769.

10 CFR Part 960 (Code of Federal Regulations), 1987. Title 10, "Energy," Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," U.S. Government Printing Office, Washington, D.C., pp. 518-551.

29 CFR Part 1926 (Code of Federal Regulations), 1987. Labor,

30 CFR Part 57 (Code of Federal Regulations), 1986. Title 30, "Mineral Resources," Subchapter N, "Metal and Nonmetal Mine Safety and Health," Part 57, "Safety and Health Standards - Underground Metal and Nonmental Mines," U.S. Government Printing Office, Washington, D.C.

40 CFR Part 58 (Code of Federal Regulations), 1987. Title 40, Protection of Environment, Part 58, Ambient Air Quality Surveillance, The Bureau of National Affairs, Inc., Washington, D.C., pp. 37-82.

40 CFR Part 190 (Code of Federal Regulations), 1986. Title 40, "Protection of Environment," Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," U.S. Government Printing Office, Washington, D.C., p. 6.

40 CFR Part 191 (Code of Federal Regulations), 1986. Title 40, "Protection of Environment," Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," U.S. Government Printing Office, Washington, D.C., pp. 7-16.

49 CFR Part 171 (Code of Federal Regulations), 1985. Title 49, "Transportation," Part 171, "General Information, Regulations, and Definitions," U.S. Government Printing Office, Washington, D.C.

SDRD APPENDIX E

APPLICABLE REGULATIONS, CODES, AND SPECIFICATIONS

CODES, STANDARDS, AND REGULATIONS

APPLICABLE CODES, STANDARDS, AND REGULATIONS

General

The design and construction of the ESF shall be in accordance with all applicable parts of the following:

CODE OF FEDERAL REGULATIONS (CFR)

- 10 CFR 20, Standards for Protection Against Radiation
- 10 CFR 50, Domestic Licensing of Production and Utilization Facilities, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants
- 10 CFR 51, Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions
- 10 CFR 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories
- 10 CFR 71, Packaging and Transportation of Radioactive Material
- 10 CFR 73, Physical Protection of Plants and Materials
- 10 CFR 960, General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories
- 29 CFR 1910, Occupational Safety and Health Standards (OSHA)
- 30 CFR CHAPTER I , Mine Safety and Health Administration (MSHA)
- 30 CFR 57, Safety and Health Standards, Underground Metal and NonMetal Mines (Except Subpart T)
- 40 CFR 61, National Emission Standards for Hazardous Air Pollutants
- 43 CFR 23, Surface Exploration, Mining and Reclamation of Lands

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 1200, External Relationships
- DOE Order 1300, Management Systems and Standards
- DOE Order 1500, Travel and Transportation
- DOE Order 1800, Privacy Act

CODES, STANDARDS, AND REGULATIONS (Continued)

- DOE Order 2100, Financial Management -- General
- DOE Order 2200, Accounting
- DOE Order 3200, Personal Provisions -- General
- DOE Order 3300, Employment
- DOE Order 3400, Employee Performance and Utilization
- DOE Order 3700, Personnel Relations and Services
- DOE Order 4200, Procurement
- DOE Order 4300, Real Property Management
- DOE Order 5000, Program Planning and Management
- DOE Order 5100, Planning, Programing, and Budgeting
- DOE Order 5300, Telecommunications
- DOE Order 5400, Environmental Quality and Impact
  - DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards
  - DOE Order 5481.1B, Safety Analysis and Review System
  - DOE Order 5484.1, Environmental Protection, Safety and Health Protection Information Reporting Requirements
- DOE Order 5500, Emergency Preparedness
  - DOE Order 5500.3, Reactor and Nonreactor Nuclear Facility Emergency Planning, Preparedness and Response Program for DOE Operations
- DOE Order 5700, Energy Programs and Policies -- General
  - DOE Order 5700.6A, Quality Assurance
- DOE Order 5900, Energy Information
- DOE Order 6400, Construction and Engineering
  - DOE Order 6410.1, Management of Construction Projects
  - DOE Order 6430.1A, General Design Criteria (Draft 12-25-87)
- DOE/RW-0090 , OGR-B-2), Generic Requirements for a Mined Geologic Disposal System (Appendix E)
- DOE/RW-0005, Mission Plan for the Civilian Radioactive Waste Management Program

CODES, STANDARDS, AND REGULATIONS (Continued)

- o DOE/AD/06212-1, Site Development Planning Handbook
- o DOE/RW-0073, Environmental Assessment, Yucca Mountain site, Nevada Research and Development Area, Nevada
- o NNWSI/88-9, Nevada Nuclear Waste Storage Investigations Project Quality Assurance Plan
- o WMPO/88-1, Management and Overview Quality Assurance Program Plan & Quality Management Procedures
- o DOE/NVO-222, Nevada Nuclear Waste Storage Investigations Management Plan for the Exploratory Shaft at Yucca Mountain
- o DOE/NVO/00410-77, Reynolds Electrical and Engineering Company Safety and Health Program Plan, Nevada Nuclear Waste Storage Investigations Exploratory Shaft at Yucca Mountain
- o DOE/NVO/5480.1A-9, Environmental Protection, Safety, and Health Protection Program for DOE Operations, May 4, 1983
- o DOE/NVO/5480.4-17, Environmental Protection, Safety, and Health Protection Standards, July 2, 1986
- o DOE/NVO/5481.1B-21, Safety Analysis and Review System, January 25, 1988

U.S. NUCLEAR REGULATORY COMMISSION (NRC) REGULATORY GUIDES

- o 1.23, Onsite Meteorological Programs
- o 1.92, Combining Modal Responses and Spatial Components in Seismic Response Analysis

STATE OF NEVADA

- o Nevada Revised Statutes (NRS) Title 40, Public Health and Safety
  - Chapter 444, Sanitation
  - Chapter 445, Water Controls , Air Pollution
- o 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
- o Nevada Administrative Code
  - Chapter 445, Water Pollution Control, Air Pollution
- o Department of Transportation (DH)
  - Standard Specifications for Road and Bridge Construction
  - Standard Plans for Road and Bridge Construction

CODES, STANDARDS, AND REGULATIONS (Continued)

- 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

PRESTRESSED CONCRETE INSTITUTE

- o Standards

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

- o Manual of Steel Construction

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- o A58.1, Minimum Design Loads for Buildings and Other Structures
- o B31.3, Chemical Plant and and Petroleum Refinery Piping
- o C2 , National Electrical Safety Code
- o NQA-1, Quality Assurance program Requirements for Nuclear Facilities
- o ANS-2.3, Standard for Estimating Tornado and Extreme Wind Characteristics at Nuclear Power Sites
- o ANS-2.5, Standard for Determining Meteorological Information at Nuclear Power Sites
- o ANS-2.8, Standard for determining Design Basis Flooding at Power

CODES, STANDARDS, AND REGULATIONS (Continued)
Reactor Sites

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, Energy Conservation in New Building Design

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

- Boiler and Pressure Vessel Code: Section VIII, Division I, Unfired Pressure Vessel Code

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

CODES, STANDARDS, AND REGULATIONS (Continued)

- Uniform Building Code (UBC)
- Uniform Mechanical Code (UMC)
- Uniform Plumbing Code (UPC)

NATIONAL ASSOCIATION OF PLUMBING-HEATING-COOLING CONTRACTORS

- National Standard Plumbing Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- National Fire Codes
- 22, Water Tanks for Private Fire Protection
- 20, Centrifugal Fire Pumps

SDRD APPENDIX F

CROSS REFERENCES NUMBER 1

ESF SDRD TO SOURCE DOCUMENTS

The following Appendix G.1, Cross Reference of the Individual Requirements in the ESF SDRD to Source Documents, reflects the Benchmark 1 issue of the draft SDRD. This cross reference will be updated following completion of the QMP-02-08 technical review of the ESF SDRD.

SDRD REFERENCE	GR APPENDIX E REFERENCE Appendix E, Section 6.0
1.2.6.0FR1	[E6.0FR1]
1.2.6.0FR2	[E6.0FR2]
1.2.6.0FR3	[E6.0FR3]
1.2.6.0FR4	[E6.0FR4]
1.2.6.0FR5	[E6.0FR5]
1.2.6.0FR6	[E6.0FR6]
1.2.6.0PC1a	[E6.0PC1a]
1.2.6.0PC1b	[E6.0PC1b]
1.2.6.0PC1c	[E6.0PC1c]
1.2.6.0PC1e	[E6.0PC1d]
1.2.6.0PC2a	[E6.0PC2]
1.2.6.0PC3a	[E6.0PC3a]
1.2.6.0PC3b	[E6.0PC3b]
1.2.6.0PC3c	[E6.0PC3c]
1.2.6.0PC3d	[E6.0PC3d]
1.2.6.0PC3e	[E6.0PC3e]
1.2.6.0PC4a	[E6.0PC4a]
1.2.6.0PC4c	[E6.0PC4b]
1.2.6.0PC5a	[E6.0PC5a]
1.2.6.0PC5b	[E6.0PC5b]
1.2.6.0PC6a	[E6.0PC6a]
1.2.6.0PC6c	[E6.0PC6b]
1.2.6.0PC6d	[E6.0PC6c]
1.2.6.0PC6e	[E6.0PC6d]
1.2.6.0PC6f	[E6.0PC6e]
1.2.6.0PC6g	[E6.0PC6f]
1.2.6.0PC6h	[E6.0PC6g]
1.2.6.0PC6i	[E6.0PC6h]
1.2.6.0PC6j	[E6.0PC6i]
1.2.6.0PC6k	[E6.0PC6j]
1.2.6.0CA	[E6.0CA]
1.2.6.0CB	[E6.0CB]
1.2.6.0CC	[E6.0CC]
1.2.6.0CD	[E6.0CD]
1.2.6.0CE	[E6.0CE]
1.2.6.0CG	[E6.0CF]
1.2.6.0CH	[E6.0CG]
1.2.6.0CI	[E6.0CH]
1.2.6.0CJ	[E6.0CI]
1.2.6.0CL	[E6.0CJ]
1.2.6.0CM	[E6.0CK]
1.2.6.0CN	[E6.0CL]
1.2.6.0CO	[E6.0CM]
1.2.6.0CP	[E6.0CN]
1.2.6.0CQ	[E6.0CO]
1.2.6.0CR	[E6.0CP]
1.2.6.0CS	[E6.0CQ]
1.2.6.0CT	[E6.0CR]
1.2.6.0CU	[E6.0CS]
1.2.6.0CV	[E6.0CT]
1.2.6.0CW	[E6.0CU]
1.2.6.0CX	[E6.0CV]

SDRD REFERENCE	GR APPENDIX E REFERENCE
1.2.6.0CY	[E6.0CW]
1.2.6.0CZ	[E6.0CX]
1.2.6.1FR1	[E6.2FR1]
1.2.6.1FR2	[E6.2FR2]
1.2.6.1FR3	[E6.2FR3]
1.2.6.1FR4	[E6.2FR4]
1.2.6.1FR5	[E6.2FR5]
1.2.6.1PC1	[E6.2PC1]
1.2.6.1PC2a	[E6.2PC2a]
1.2.6.1PC2b	[E6.2PC2b]
1.2.6.1PC3a	[E6.2PC3a]
1.2.6.1PC3b	[E6.2PC3b]
1.2.6.1PC3c	[E6.2PC3c]
1.2.6.1PC3d	[E6.2PC3d]
1.2.6.1PC4a	[E6.2PC4d]
1.2.6.1PC4b	[E6.2PC4e]
1.2.6.1PC4c	[E6.2PC4n]
1.2.6.1PC5a	[E6.2PC5]
1.2.6.1.1PC1b	[E6.2PC4c]
1.2.6.1.1PC1c	[E6.2PC4o]
1.2.6.1.2PC1c	[E6.2PC4k]
1.2.6.1.2PC1d	[E6.2PC4l]
1.2.6.1.2PC1e	[E6.3PC1h]
1.2.6.1.3PC1a	[E6.2PC4a]
1.2.6.2PC1a	[E6.2PC4b]
1.2.6.2PC1b	[E6.2PC4f]
1.2.6.2PC1c	[E6.2PC4i]
1.2.6.2PC1d	[E6.2PC4j]
1.2.6.2.1PC1b	[E6.3PC1l]
1.2.6.2.1PC1d	[E6.3PC1m]
1.2.6.2.1PC1e	[E6.2PC4m]
1.2.6.2.1CE	[E6.2CB]
1.2.6.2.1CH	[E6.3CC]
1.2.6.2.2CA	[E6.2CA]
1.2.6.2.3CA	[E6.2CC]
1.2.6.2.3PC1d	[E6.2PC4g]
1.2.6.2.3PC1e	[E6.2PC4h]
1.2.6.2.5PC1a	[E6.3PC1o]
1.2.6.3FR1	[E6.3FR1]
1.2.6.3FR2	[E6.3FR2]
1.2.6.3FR3	[E6.3FR3]
1.2.6.3FR4	[E6.3FR4]
1.2.6.3FR5	[E6.3FR5]
1.2.6.3FR6	[E6.3FR6]
1.2.6.3PC1a	[E6.3PC1a]
1.2.6.3PC1b	[E6.3PC1b]
1.2.6.3PC1c	[E6.3PC1c]
1.2.6.3PC1d	[E6.3PC1d]
1.2.6.3PC1e	[E6.3PC1i]
1.2.6.3PC1f	[E6.3PC1j]
1.2.6.3PC2a	[E6.3PC2a]
1.2.6.3PC2b	[E6.3PC2b]
1.2.6.3PC3	[E6.3PC3]
1.2.6.3PC4a	[E6.3PC4]

SDRD REFERENCE	GR APPENDIX E REFERENCE
1.2.6.3PC5	[E6.3PC5]
1.2.6.3PC6	[E6.3PC6]
1.2.6.3CA	[E6.3CA]
1.2.6.3CB	[E6.3CB]
1.2.6.3.1PC1a	[E6.3PC1k]
1.2.6.3.6PC1d	[E6.3PC1f]
1.2.6.3.7PC1b	[E6.3PC1e]
1.2.6.4FR1	[E6.4FR1]
1.2.6.4FR2	[E6.4FR2]
1.2.6.4FR3	[E6.4FR3]
1.2.6.4FR4	[E6.4FR4]
1.2.6.4FR5	[E6.4FR5]
1.2.6.4PC1a	[E6.4PC1a]
1.2.6.4PC1b	[E6.4PC1b]
1.2.6.4PC1f	[E6.4PC1d]
1.2.6.4PC1g	[E6.4PC1e]
1.2.6.4PC1h	[E6.4PC1g]
1.2.6.4PC1k	[E6.4PC1i]
1.2.6.4PC1l	[E6.4PC1j]
1.2.6.4PC1m	[E6.4PC1k]
1.2.6.4PC1n	[E6.4PC1l]
1.2.6.4PC1o	[E6.4PC1c]
1.2.6.4PC2a	[E6.4PC2]
1.2.6.4PC3a	[E6.4PC3]
1.2.6.4PC4a	[E6.4PC4]
1.2.6.4PC4e	[E6.4PC1f]
1.2.6.4PC5a	[E6.4PC1h]
1.2.6.4PC5c	[E6.4PC5]
1.2.6.4CA	[E6.4CA]
1.2.6.4CB	[E6.4CB]
1.2.6.4CC	[E6.4CC]
1.2.6.4CD	[E6.4CD]
1.2.6.4CG	[E6.4CE]
1.2.6.4.1PC1f	[E6.3PC1n]
1.2.6.4.5PC1k	[E6.4PC1m]
1.2.6.5FR1	[E6.5FR1]
1.2.6.5FR2	[E6.5FR2]
1.2.6.5FR3	[E6.5FR3]
1.2.6.5FR4	[E6.5FR4]
1.2.6.5FR5	[E6.5FR5]
1.2.6.5PC1a	[E6.5PC1a]
1.2.6.5PC1b	[E6.5PC1i]
1.2.6.5PC1c	[E6.5PC1j]
1.2.6.5PC2	[E6.5PC2]
1.2.6.5PC3a	[E6.5PC1b]
1.2.6.5PC3b	[E6.5PC1c]
1.2.6.5PC3c	[E6.5PC1d]
1.2.6.5PC3d	[E6.5PC1f]
1.2.6.5PC3f	[E6.5PC1h]
1.2.6.5PC3g	[E6.5PC1g]
1.2.6.5PC3g	[E6.5PC1k]
1.2.6.5PC3h	[E6.5PC3]
1.2.6.5PC4a	[E6.5PC1e]
1.2.6.5PC4b	[E6.5PC4]

SDRD REFERENCE	GR APPENDIX E REFERENCE
1.2.6.5CA	[E6.5CA]
1.2.6.5CB	[E6.5CB]
1.2.6.5CC	[E6.5CC]
1.2.6.5CD	[E6.5CD]
1.2.6.5CE	[E6.5CE]
1.2.6.6FR1	[E6.6FR1]
1.2.6.6FR2	[E6.6FR2]
1.2.6.6PC1a	[E6.6PC1a]
1.2.6.6PC1b	[E6.6PC1b]
1.2.6.6PC1c	[E6.6PC1c]
1.2.6.6PC1d	[E6.6PC1d]
1.2.6.6PC1e	[E6.6PC1e]
1.2.6.6PC1f	[E6.6PC1f]
1.2.6.6PC1h	[E6.6PC1h]
1.2.6.6PC1i	[E6.6PC1i]
1.2.6.6PC1j	[E6.6PC1j]
1.2.6.6PC1k	[E6.6PC1k]
1.2.6.6PC1l	[E6.6PC1l]
1.2.6.6PC1m	[E6.6PC1m]
1.2.6.6PC1n	[E6.6PC1n]
1.2.6.6PC1o	[E6.6PC1o]
1.2.6.6PC1p	[E6.6PC1p]
1.2.6.6PC1q,1.2.6.6PC3	[E6.6PC1g]
1.2.6.6PC2	[E6.6PC2]
1.2.6.6CA	[E6.6CA]
1.2.6.6CB	[E6.6CB]
1.2.6.6CC	[E6.6CC]
1.2.6.6CD	[E6.6CD]
1.2.6.6CE	[E6.6CE]
1.2.6.6CF	[E6.6CF]
1.2.6.6CG	[E6.6CG]
1.2.6.6CH	[E6.6CH]
1.2.6.6CI	[E6.6CI]
1.2.6.7FR1	[E6.7FR1]
1.2.6.7FR2	[E6.7FR5]
1.2.6.7FR3	[E6.7FR6]
1.2.6.7PC1a	[E6.7PC1a]
1.2.6.7PC1b	[E6.7PC1b]
1.2.6.7PC1c	[E6.7PC1c]
1.2.6.7PC2	[E6.7PC5]
1.2.6.7PC3a	[E6.7PC6a]
1.2.6.7PC3b	[E6.7PC6b]
1.2.6.7CA	[E6.7CA]
1.2.6.7CB	[E6.7CB]
1.2.6.7.4FR1	[E6.7FR3]
1.2.6.7.4FR2,1.2.6.7.9FR2	[E6.7FR4]
1.2.6.7.4PC1a	[E6.7PC3a]
1.2.6.7.4PC1b	[E6.7PC3b]
1.2.6.7.4PC1c	[E6.7PC3c]
1.2.6.7.4PC1d	[E6.7PC3d]
1.2.6.7.4PC2	[E6.7PC4]
1.2.6.7.4CA	[E6.7CC]
1.2.6.7.5FR1,1.2.6.7.6FR1	[E6.7FR2]
1.2.6.7.6PC1a	[E6.7PC2a]

SDRD REFERENCE	GR APPENDIX E REFERENCE
1.2.6.7.6PC1b	[E6.7PC2b]
1.2.6.7.6PC1c	[E6.7PC2c]
1.2.6.8FR1	[E6.9FR1]
1.2.6.8FR2	[E6.9FR2]
1.2.6.8PC1a	[E6.9PC1a]
1.2.6.8PC1b	[E6.9PC1b]
1.2.6.8PC1b	[E6.3PC1g]
1.2.6.8PC1c	[E6.9PC1c]
1.2.6.8PC1d	[E6.9PC1d]
1.2.6.8PC1e	[E6.9PC1e]
1.2.6.8PC1f	[E6.9PC1f]
1.2.6.8PC1g	[E6.9PC1g]
1.2.6.8PC1h	[E6.9PC1h]
1.2.6.8PC1i	[E6.9PC1i]
1.2.6.8PC2	[E6.8PC2]
1.2.6.8CA	[E6.8CA]
1.2.6.8CB	[E6.8CB]
1.2.6.8CC	[E6.8CC]
1.2.6.8CD	[E6.8CD]
1.2.6.8CE	[E6.8CE]
1.2.6.9FR1,1.2.6.9.1FR1,1.2.6.9FR1	[E6.10FR1]
1.2.6.9PC1a	[E6.10PC1a]
1.2.6.9PC1b	[E6.10PC1b]
1.2.6.9PC1c	[E6.10PC1c]
1.2.6.9CA	[E6.10CA]

CROSS REFERENCE - SDRD to 10 CFR 60

SDRD REFERENCE	10 CFR 60 REFERENCE
1.2.6.0PC1g	[NEV,10 CFR 60.131(a)(1)]
1.2.6.0PC1i.	[NEV,10 CFR 60.131(b)(2)]
1.2.6.0PC1k.	[NEV,10 CFR 60.131(b)(20]
1.2.6.0CK.	[NEV,10 CFR 60.131(b)(4)]
1.2.6.0CAA.	[NEV,10 CFR 60.131(b)(3)]
1.2.6.0CDD.	[NEV,10 CFR 960.5-2-5(d)(2)]
1.2.6.0CGG.	[NEV,10 CFR 960.5-2-6(d)]
1.2.6.0CJJ.	[NEV,10 CFR 60.131(b)(9)]
1.2.6.0CMM.	[NEV,10 CFR 60.131(b)(9)]
1.2.6.0CNN.	[NEV,10 CFR 60.131(b)(5)]
1.2.6.0CSS.	[NEV,10 CFR 60.112, .113, .133, and .134]
1.2.6.0CBA.	[NEV,10 CFR 60.15(d)(2)]
1.2.6.0CBC.	[NEV,10 CFR .15(d)(4)]
1.2.6.0CBD.	[NEV,10 CFR 60.74 and 60.75]
1.2.6.1CA.	[NEV,10 CFR 60.15(d)(1)]
1.2.6.1CD.	[NEV,10 CFR 60.21(c)(11)]
1.2.6.1CI.	[NEV,10 CFR 60.137]
1.2.6.1CK.	[NEV,10 CFR 60.130]
1.2.6.1CL.	[NEV,10 CFR 60.133(d)]
1.2.6.1CM.	[NEV,10 CFR 60.133(d)]
1.2.6.1CN.	[NEV,10 CFR 60.133(d)]
1.2.6.1CO.	[NEV,10 CFR 60.133(d)]
1.2.6.1CP.	[NEV,10 CFR 60.133(d)]
1.2.6.1CQ.	[NEV,10 CFR 60.133(d)]
1.2.6.1CR.	[NEV,10 CFR 60.133(d)]
1.2.6.1CS.	[NEV,10 CFR 60.133(d)]
1.2.6.1CT.	[NEV,10 CFR 60.133(f)]
1.2.6.1.4PC1.	[NEV,10 CFR 60.133(a)(2)]

SDRD REFERENCE	10 CFR 60 REFERENCE
1.2.6.2CB.	[NEV,10 CFR 60.15(d)(1)]
1.2.6.2CC.	[NEV,10 CFR 60.133(a)(2)]
1.2.6.2CD.	[NEV,10 CFR 60.133(a)(2)]
1.2.6.2CE.	[NEV,10 CFR 60.133(d)]
1.2.6.3.2PC1b.	NEV,10 CFR 60.141(c)]
1.2.6.3.3PC1c.	[NEV,10 CFR 60.141(c)]
1.2.6.3.9PC1c.	[NEV,10 CFR 60.141(c)]
1.2.6.4CO	[NEV,10 CFR 60.133(d)]
1.2.6.4CP	[NEV,10 CFR 60.141(c)]
1.2.6.4CR	[NEV,10 CFR 60.15(d)(3)]
1.2.6.4CS	[NEV,10 CFR 60.15(d)(3)]
1.2.6.4CT	[NEV,10 CFR 60.12(c)(1)(ii)(D)]
1.2.6.4CU	[NEV,10 CFR 60.21(c)(1)(ii)(d)]
1.2.6.4CV	[NEV,10 CFR 60.21(c)(1)(ii)(D)]
1.2.6.4CW	[NEV,10 CFR 60.21(c)(1)(ii)(D)]
1.2.6.4CX	[NEV,10 CFR 60.21(c)(1)(ii)(D)]
1.2.6.4CY	[NEV,10 CFR 60.21(c)(11)]
1.2.6.4CZ	[NEV,10 CFR 60.21(c)(11)]
1.2.6.4CAA	[NEV,10 CFR 60.21(c)(11)]
1.2.6.4CBB	[NEV,10 CFR 60.112]
1.2.6.4CCC	[NEV,10 CFR 60.130]
1.2.6.4CDD	[NEV,10 CFR 60.130]
1.2.6.4CEE	[NEV,10 CFR 60.130]
1.2.6.4CFF	[NEV,10 CFR 60.130]
1.2.6.4CGG	[NEV,10 CFR 60.130]
1.2.6.4CII	[NEV,10 CFR 60.130]
1.2.6.4CJJ	[NEV,10 CFR 60.130]
1.2.6.4CKK	[NEV,10 CFR 60.130]

SDRD REFERENCE	10 CFR 60 REFERENCE
1.2.6.4CLL	[NEV,10 CFR 60.133(a)(1)]
1.2.6.4CMM	[NEV,10 CFR 60.133(a)(2)]
1.2.6.4CNN	[NEV,10 CFR 60.133(d)]
1.2.6.4COO	[NEV,10 CFR 60.133(d)]
1.2.6.4CPP	[NEV,10 CFR 60.133(d)]
1.2.6.4CQQ	[NEV,10 CFR 60.133(d)]
1.2.6.4CRR	[NEV,10 CFR 60.133(d)]
1.2.6.4CSS	[NEV,10 CFR 60.133(d)]
1.2.6.4CTT	[NEV,10 CFR 60.133(d)]
1.2.6.4CUU	[NEV,10 CFR 60.133(d)]
1.2.6.4CVV	[NEV,10 CFR 60.133(d)]
1.2.6.4CWW	[NEV,10 CFR 60.133(d)]
1.2.6.4CXX	[NEV,10 CFR 60.133(d)]
1.2.6.4CYY	[NEV,10 CFR 60.133(e)(2)]
1.2.6.4CZZ	[NEV,10 CFR 60.133(e)(2)]
1.2.6.4CAB	[NEV,10 CFR 60.133(f)]
1.2.6.4CAC	[NEV,10 CFR 60.133(f)]
1.2.6.4CAD	[NEV,10 CFR 60.133(f)]
1.2.6.4CAE	[NEV,10 CFR 60.133(f)]
1.2.6.4CAF	[NEV,10 CFR 60.133(h)]
1.2.6.4CAG	[NEV,10 CFR 60.133(i)]
1.2.6.4CAH	[NEV,10 CFR 60.74]
1.2.6.4CAI	[NEV,10 CFR 60.133(a)(2)]
1.2.6.4CAJ	[NEV,10 CFR 60.133(b)]
1.2.6.4CAK	[NEV,10 CFR 60.133(b)]
1.2.6.4CAL	[NEV,10 CFR 60.133(d)]
1.2.6.4CAM	[NEV,10 CFR 60.133(d)]
1.2.6.4CAN	[NEV,10 CFR 60.133(e)(2)]

SDRD REFERENCE	10 CFR 60 REFERENCE
1.2.6.4CAO	[NEV;10 CFR 60.133(e)(2)]
1.2.6.4CAP	[NEV,10 CFR 60.133(d)]
1.2.6.4CAQ	[NEV,10 CFR 60.137]
1.2.6.4CAR	[NEV,10 CFR 60.137]
1.2.6.4CAS	[NEV,10 CFR 60.137]
1.2.6.4CAT	[NEV,10 CFR 60.15(b)]
1.2.6.4CAU	[NEV,10 CFR 60.15(b)]
1.2.6.4CAV	[NEV,10 CFR 60.15(d)(2)]
1.2.6.4CAW	[NEV,10 CFR 60.133(b)]

SDRD APPENDIX F

CROSS REFERENCES NUMBER 2

SOURCE DOCUMENTS TO ESF SDRD

The following Appendix G.2, Cross Reference of the Source Documents to the Individual Requirements in the SDRD, reflects the Benchmark 1 issue of the draft SDRD. This cross reference will be updated following completion of the QMP-02-08 technical review of the SDRD.

GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
Appendix E, Section 6.0	
[E6.0FR1]	1.2.6.0FR1
[E6.0FR2]	1.2.6.0FR2
[E6.0FR3]	1.2.6.0FR3
[E6.0FR4]	1.2.6.0FR4
[E6.0FR5]	1.2.6.0FR5
[E6.0FR6]	1.2.6.0FR6
[E6.0PC1a]	1.2.6.0PC1a
[E6.0PC1b]	1.2.6.0PC1b
[E6.0PC1c]	1.2.6.0PC1c
[E6.0PC1d]	1.2.6.0PC1e
[E6.0PC2]	1.2.6.0PC2a
[E6.0PC3a]	1.2.6.0PC3a
[E6.0PC3b]	1.2.6.0PC3b
[E6.0PC3c]	1.2.6.0PC3c
[E6.0PC3d]	1.2.6.0PC3d
[E6.0PC3e]	1.2.6.0PC3e
[E6.0PC4a]	1.2.6.0PC4a
[E6.0PC4b]	1.2.6.0PC4c
[E6.0PC5a]	1.2.6.0PC5a
[E6.0PC5b]	1.2.6.0PC5b
[E6.0PC6a]	1.2.6.0PC6a
[E6.0PC6b]	1.2.6.0PC6c
[E6.0PC6c]	1.2.6.0PC6d
[E6.0PC6d]	1.2.6.0PC6e
[E6.0PC6e]	1.2.6.0PC6f
[E6.0PC6f]	1.2.6.0PC6g
[E6.0PC6g]	1.2.6.0PC6h
[E6.0PC6h]	1.2.6.0PC6i
[E6.0PC6i]	1.2.6.0PC6j
[E6.0PC6j]	1.2.6.0PC6k
[E6.0CA]	1.2.6.0CA
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[E6.0CD]	1.2.6.0CD
[E6.0CE]	1.2.6.0CE
[E6.0CF]	1.2.6.0CG
[E6.0CG]	1.2.6.0CH
[E6.0CH]	1.2.6.0CI
[E6.0CI]	1.2.6.0CJ
[E6.0CJ]	1.2.6.0CL
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[E6.0CL]	1.2.6.0CN
[E6.0CM]	1.2.6.0CO
[E6.0CN]	1.2.6.0CP
[E6.0CO]	1.2.6.0CQ
[E6.0CP]	1.2.6.0CR
[E6.0CQ]	1.2.6.0CS
[E6.0CR]	1.2.6.0CT
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[E6.0CU]	1.2.6.0CW
[E6.0CV]	1.2.6.0CX

GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
[E6.0CW]	1.2.6.0CY
[E6.0CX]	1.2.6.0CZ

GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
Appendix E, Section 6.2	SDRD Reference
[E6.2FR1]	1.2.6.1FR1
[E6.2FR2]	1.2.6.1FR2
[E6.2FR3]	1.2.6.1FR3
[E6.2FR4]	1.2.6.1FR4
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[E6.2PC2b]	1.2.6.1PC2b
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[E6.2PC4m]	1.2.6.2.1PC1e
[E6.2PC4n]	1.2.6.1PC4c
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GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
Appendix E, Section 6.3	SDRD Reference
[E6.3FR1]	1.2.6.3FR1
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[E6.3FR4]	1.2.6.3FR4
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[E6.3PC1e]	1.2.6.3.7PC1b
[E6.3PC1f]	1.2.6.3.6PC1d
[E6.3PC1g]	1.2.6.8PC1b
[E6.3PC1h]	1.2.6.1.2PC1e
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[E6.3PC1n]	1.2.6.4.1PC1f
[E6.3PC1o]	1.2.6.2.5PC1a
[E6.3PC2a]	1.2.6.3PC2a
[E6.3PC2b]	1.2.6.3PC2b
[E6.3PC3]	1.2.6.3PC3
[E6.3PC4]	1.2.6.3PC4a
[E6.3PC5]	1.2.6.3PC5
[E6.3PC6]	1.2.6.3PC6
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GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
Appendix E, Section 6.4	
[E6.4FR1]	1.2.6.4FR1
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GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
Appendix E, Section 6.5	
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[E6.5PC3]	1.2.6.5PC3h
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GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
Appendix E, Section 6.6	
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[E6.6CI]	1.2.6.6CI

Appendix E, Section 6.7

GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
[E6.7FR1]	1.2.6.7FR1
[E6.7FR2]	1.2.6.7.5FR1,1.2.6.7.6FR1
[E6.7FR3]	1.2.6.7.4FR1
[E6.7FR4]	1.2.6.7.4FR2,1.2.6.7.9FR2
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[E6.7PC2c]	1.2.6.7.6PC1c
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[E6.7PC3c]	1.2.6.7.4PC1c
[E6.7PC3d]	1.2.6.7.4PC1d
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[E6.7PC6a]	1.2.6.7PC3a
[E6.7PC6b]	1.2.6.7PC3b
[E6.7CA]	1.2.6.7CA
[E6.7CB]	1.2.6.7CB
[E6.7CC]	1.2.6.7.4CA

GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
Appendix E, Section 6.9	
[E6.9FR1]	1.2.6.8FR1
[E6.9FR2]	1.2.6.8FR2
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[E6.9PC1b]	1.2.6.8PC1b
[E6.9PC1c]	1.2.6.8PC1c
[E6.9PC1d]	1.2.6.8PC1d
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[E6.8CE]	1.2.6.8CE

GR APPENDIX E REFERENCE	ESF SDRD REFERENCE
Appendix E, Section 6.10	
[E6.10FR1]	1.2.6.9FR1,1.2.6.9.1FR1,1.2.6.9.2FR1
[E6.10PC1a]	1.2.6.9PC1a
[E6.10PC1b]	1.2.6.9PC1b
[E6.10PC1c]	1.2.6.9PC1c
[E6.10CA]	1.2.6.9CA

SDRD APPENDIX G

ESF FUNCTIONAL ANALYSIS LOGIC TREE

FUNCTIONAL ANALYSIS LOGIC TREE FOR THE EXPLORATORY SHAFT FACILITY AT YUCCA MOUNTAIN

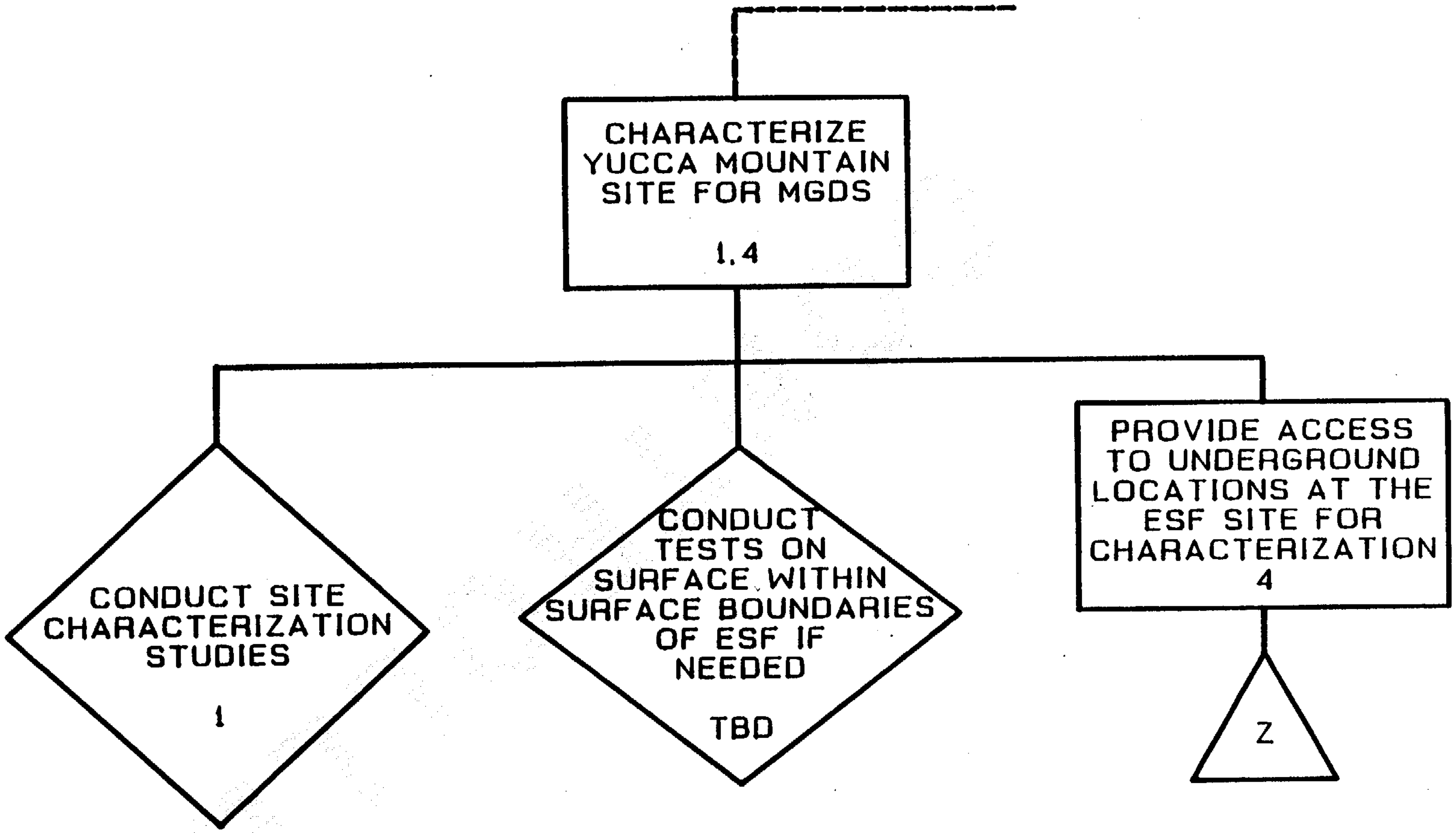
The functional analysis logic tree for the Yucca Mountain Exploratory Shaft Facility (ESF) may be viewed as a success tree. That is, those functions and their interactions necessary for the ESF to accomplish its mission are depicted graphically. At any particular level in the tree, a function is placed immediately above and connected to one or more subfunctions necessary to accomplish this superior function. (The logical AND gate is implied.)

Each function is stated within a rectangle or a diamond. Just below the text a number (or a group of numbers) is shown. This number identifies the physical system or subsystem to which the function is allocated. That is, those physical systems or subsystems that will accomplish the stated functions are indicated. Thus, the function of the ESF (4) is stated as "Provide access to underground locations at the ESF site for characterization-4". This is a subfunction of the superior function "Characterize Yucca Mountain site for MGDS-1,4". A list of identifying numbers for ESF subsystems is provided.

Functions stated within rectangles are always superior to other functions. A function stated within a diamond is not developed any further. This termination of a tree branch occurs either because there is insufficient information available relative to subfunctions or because the intended "level of detail" has been reached or exceeded. With the ESF functional analysis tree, the intended "level of detail" was to encompass all the functions stated in the Exploratory Shaft Facility Subsystem Design Requirements Document, NVO-309, and also to approximate the level of the Repository Code of Accounts.

Numerous triangles containing one or more letters of the alphabet occur throughout the tree. These are "transfer symbols". As one proceeds downward from the top of the tree, a transfer symbol means that the tree is continued on another page at the corresponding set of alphabet letters.

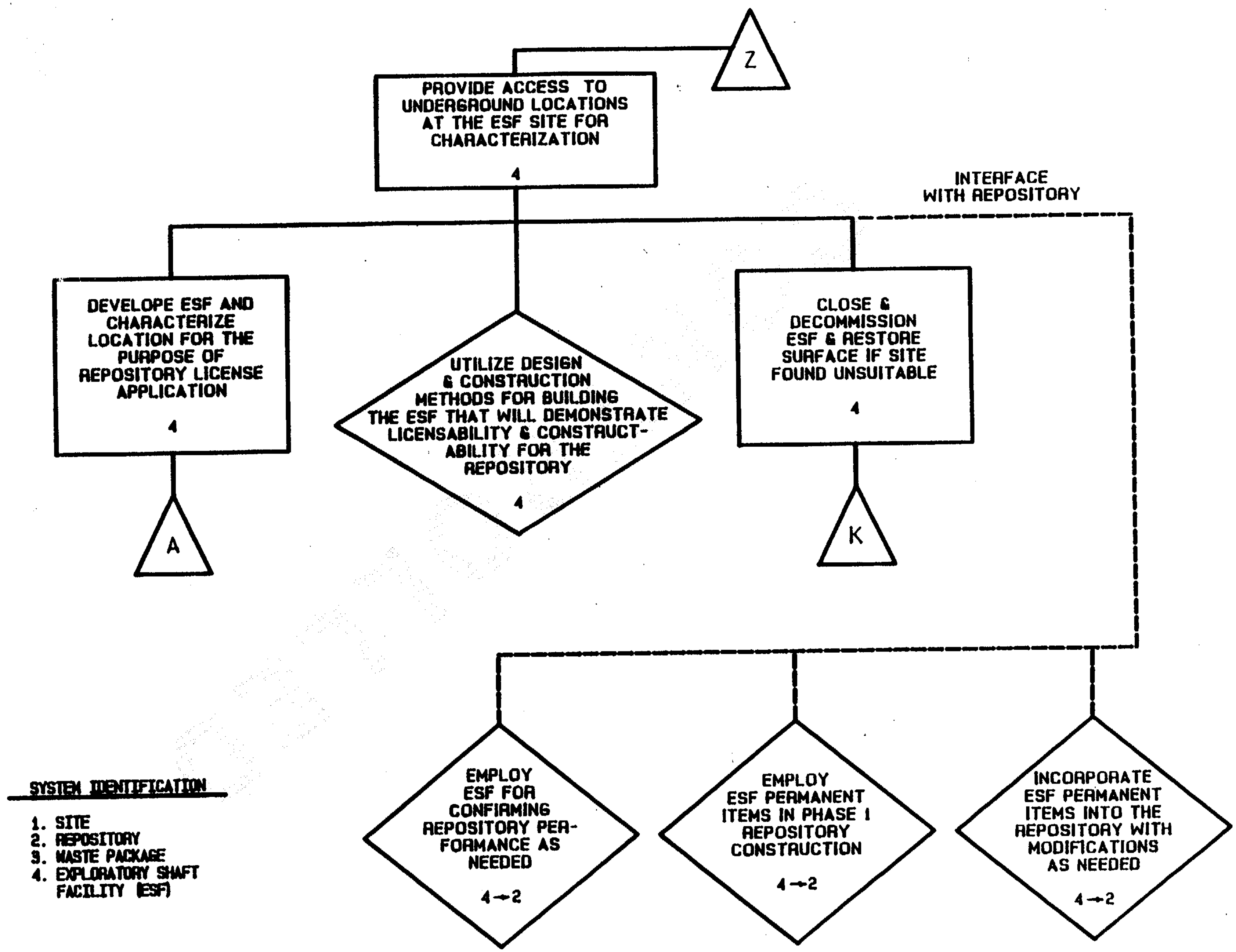
One other symbol has been used. This is a rectangle with a triangle resting on top like a roof. This symbol is called an "external event" or sometimes a "house event". (See transfer symbol FD again.) The house symbol is used to signify a function that is normally expected to occur, but that is not necessarily essential for the completion of the superior function within which it resides. Thus, under transfer symbol FD, the house symbol denotes that the testing of the ES-2 shaft walls will occur simultaneously with the excavation.



SYSTEM IDENTIFICATION

1. SITE
2. REPOSITORY
3. WASTE PACKAGE
4. EXPLORATORY SHAFT
   FACILITY (ESF)

MGDS1/12-14-88



MGDS2/12-14-88

EXPLORATORY SHAFT FACILITY

IDENTIFICATION OF SUBSYSTEMS

4-A **ESF SITE**

- 4-1 MAIN PAD
- 4-2 AUXILIARY PADS
- 4-3 ACCESS ROADS
- 4-4 SITE DRAINAGE

4-B SURFACE UTILITIES

- 4-5 POWER SYSTEMS
- 4-6 WATER SYSTEMS
- 4-7 SEWAGE SYSTEMS
- 4-8 COMMUNICATION SYSTEM
- 4-9 MINE WASTEWATER SYSTEM
- 4-10 COMPRESSED AIR SYSTEM

4-C **SURFACE FACILITIES**

- 4-11 VENTILATION SYSTEM
- 4-12 TEST SUPPORT FACILITIES
- 4-13 TRAILER SPACES
- 4-14 PARKING AREAS
- 4-15 MATERIALS STORAGE FACILITIES
- 4-16 SHOP
- 4-17 WAREHOUSE
- 4-18 TEMPORARY FACILITIES
- 4-19 INTEGRATED DATA SYSTEM (IDS) BUILDING
- 4-20 COMMUNICATIONS BUILDING

EXPLORATORY SHAFT FACILITY

IDENTIFICATION OF SUBSYSTEMS
(CONTINUED)

4-D FIRST SHAFT

4-21 COLLAR
4-22 LINING
4-23 STATIONS
4-24 FURNISHINGS
4-25 HOIST SYSTEM
4-26 SUMP

4-E SECOND SHAFT

4-27 COLLAR
4-28 LINING
4-29 STATION
4-30 FURNISHINGS
4-31 HOIST SYSTEM
4-32 SUMP

4-F UNDERGROUND EXCAVATIONS

4-33 OPERATIONS SUPPORT AREAS
4-34 TEST AREAS

EXPLORATORY SHAFT FACILITY

IDENTIFICATION OF SUBSYSTEMS
(CONTINUED)

4-G UNDERGROUND UTILITY SYSTEMS

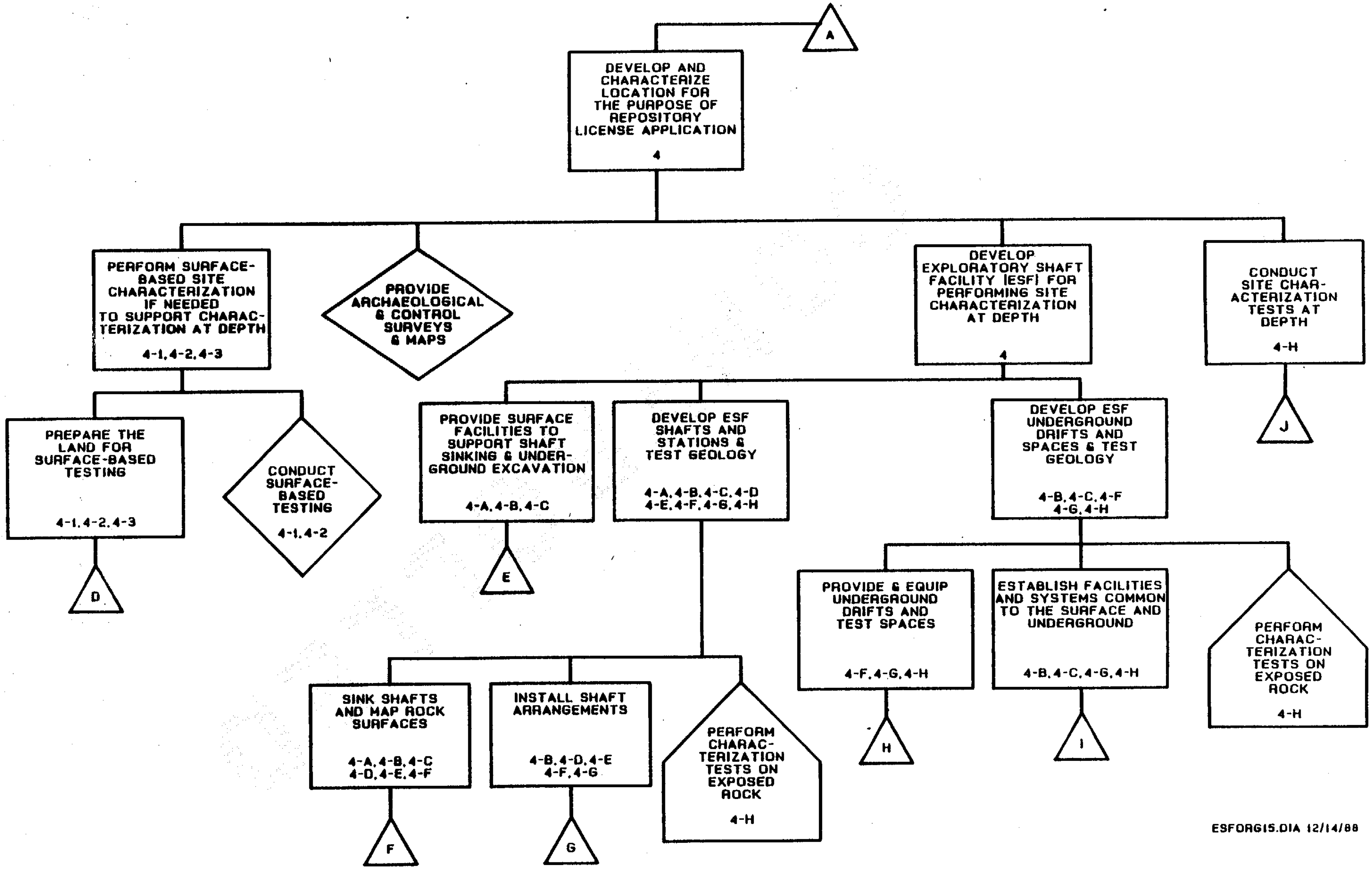
- 4-35 POWER DISTRIBUTION SYSTEM
- 4-36 COMMUNICATIONS SYSTEM
- 4-37 LIGHTING SYSTEM
- 4-38 VENTILATION SYSTEM
- 4-39 WATER DISTRIBUTION SYSTEM
- 4-40 MINE WASTEWATER COLLECTION SYSTEM
- 4-41 COMPRESSED AIR DISTRIBUTION SYSTEMS
- 4-42 FIRE PROTECTION SYSTEM
- 4-43 MUCK HANDLING SYSTEMS
- 4-44 SANITARY FACILITIES
- 4-45 MONITORING AND WARNING SYSTEMS

4-H UNDERGROUND TESTS

- 4-46 INTEGRATED DATA ACQUISITION SYSTEM (IDS)
- 4-47 GEOLOGICAL TESTS
- 4-48 GEOMECHANICS TESTS
- 4-49 NEAR-FIELD AND THERMALLY PERTURBED TESTS
- 4-50 HYDROLOGIC AND TRANSPORT PHENOMENA TESTS
- 4-51 PROTOTYPE TESTS

4-I ESF DECOMMISIONING STRATEGY

- 4-52 SURFACE FACILITIES
- 4-53 SHAFTS AND UNDERGROUND FACILITIES



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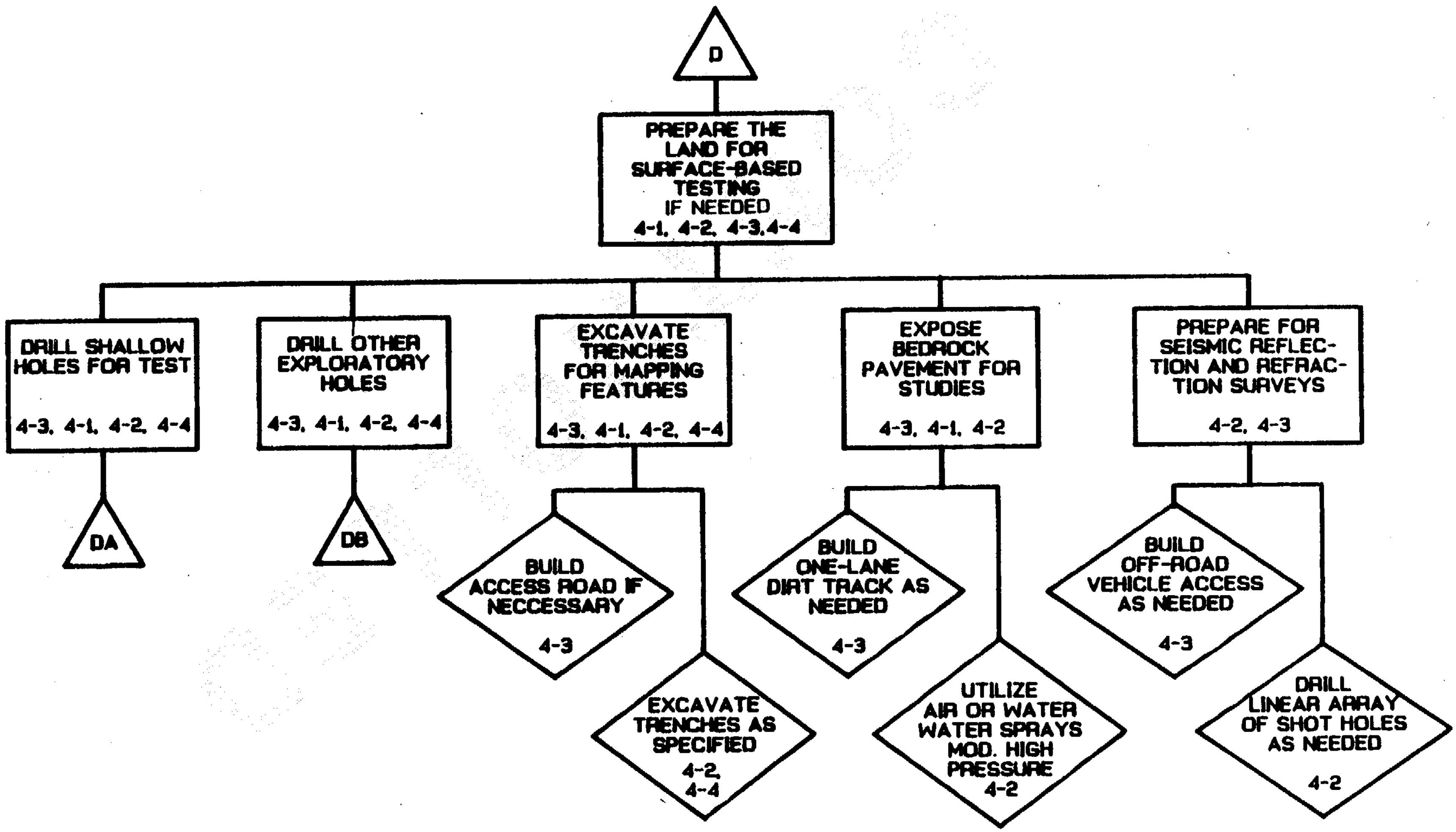

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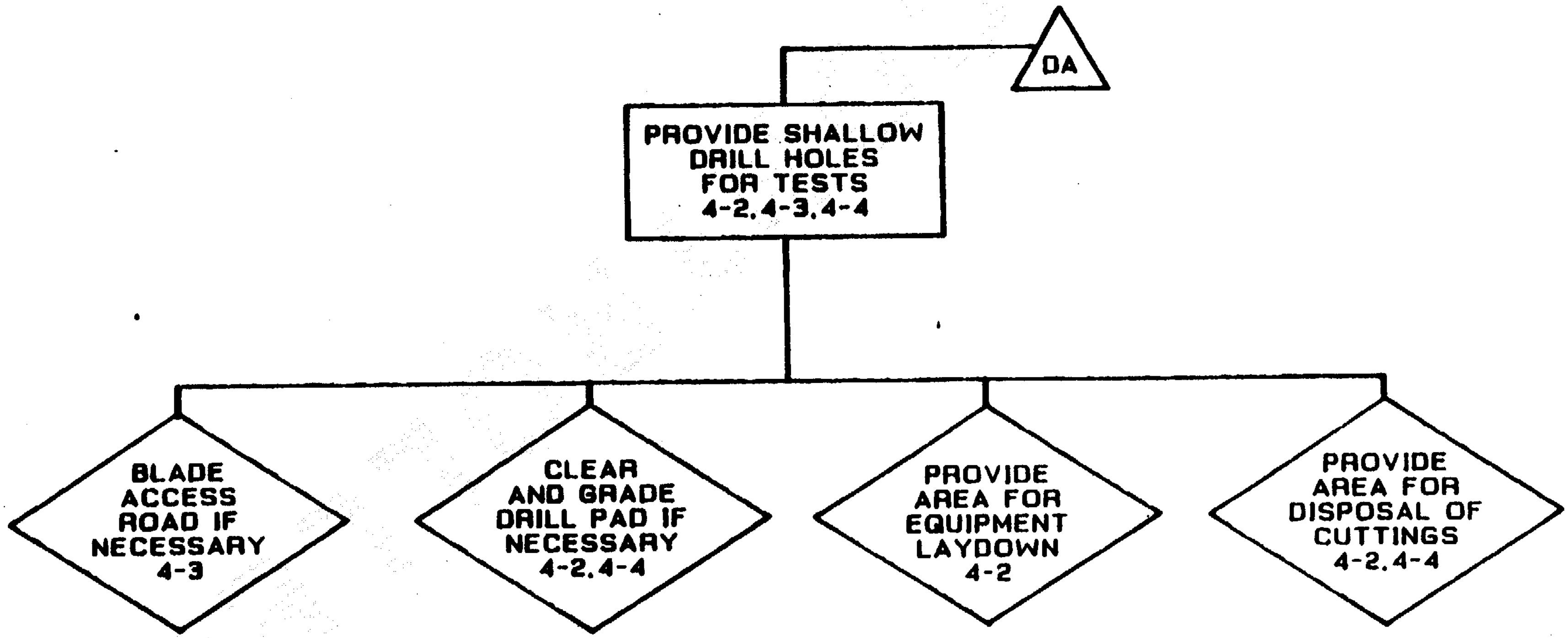
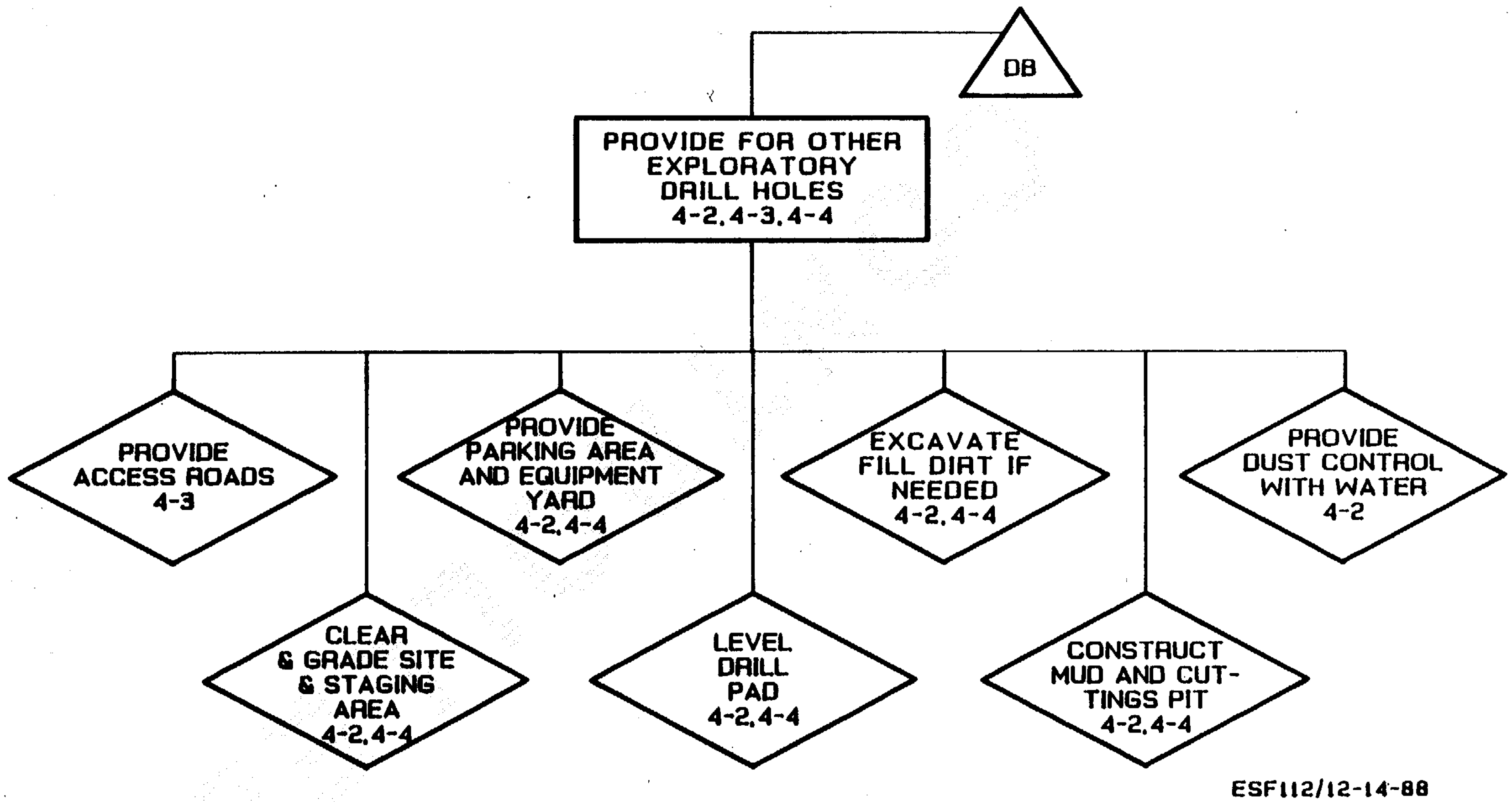
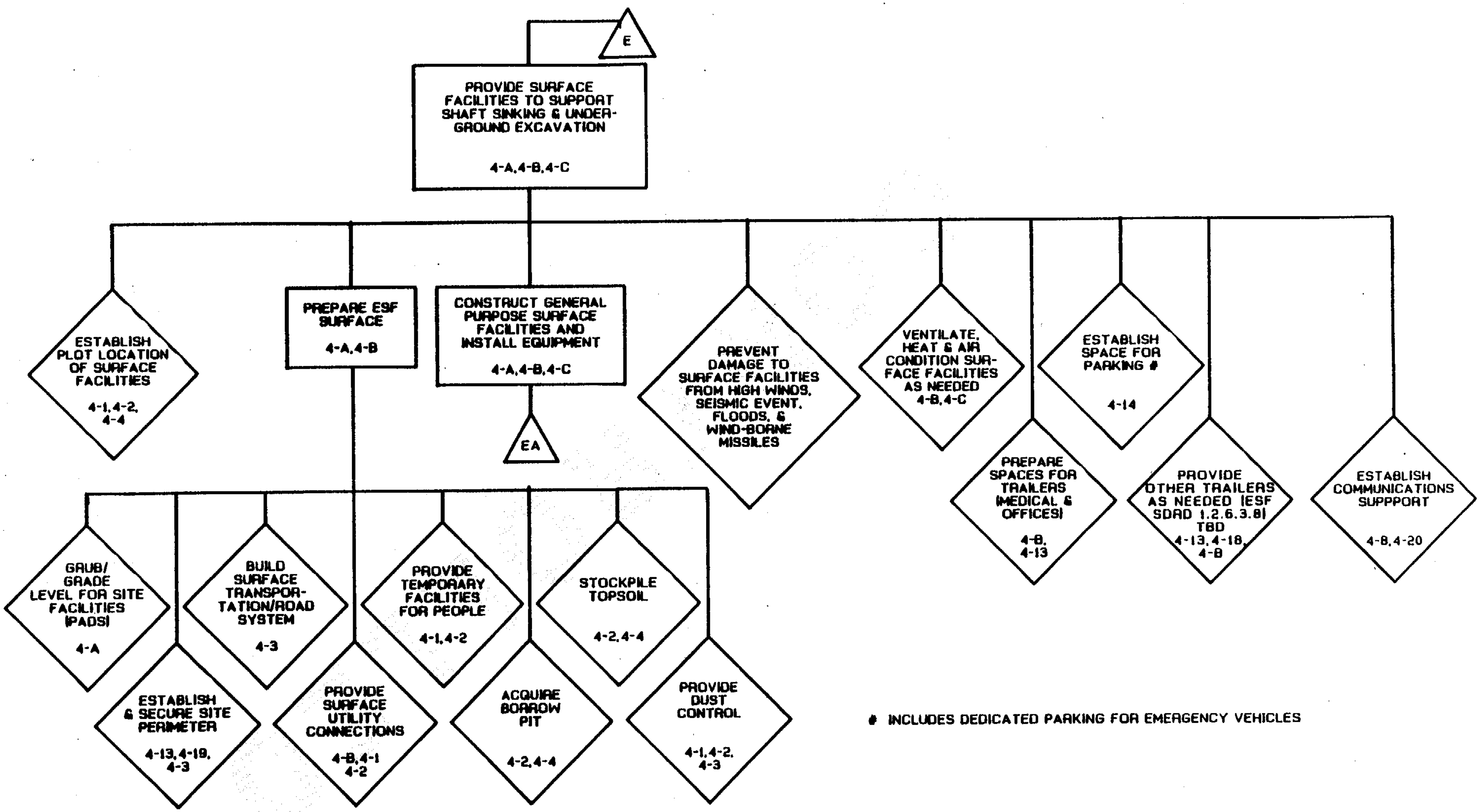


DA
PROVIDE SHALLOW DRILL HOLES FOR TESTS 4-2,4-3,4-4
BLADE ACCESS ROAD IF NECESSARY 4-3
CLEAR AND GRADE DRILL PAD IF NECESSARY 4-2,4-4
PROVIDE AREA FOR EQUIPMENT LAYDOWN 4-2
PROVIDE AREA FOR DISPOSAL OF CUTTINGS 4-2,4-4

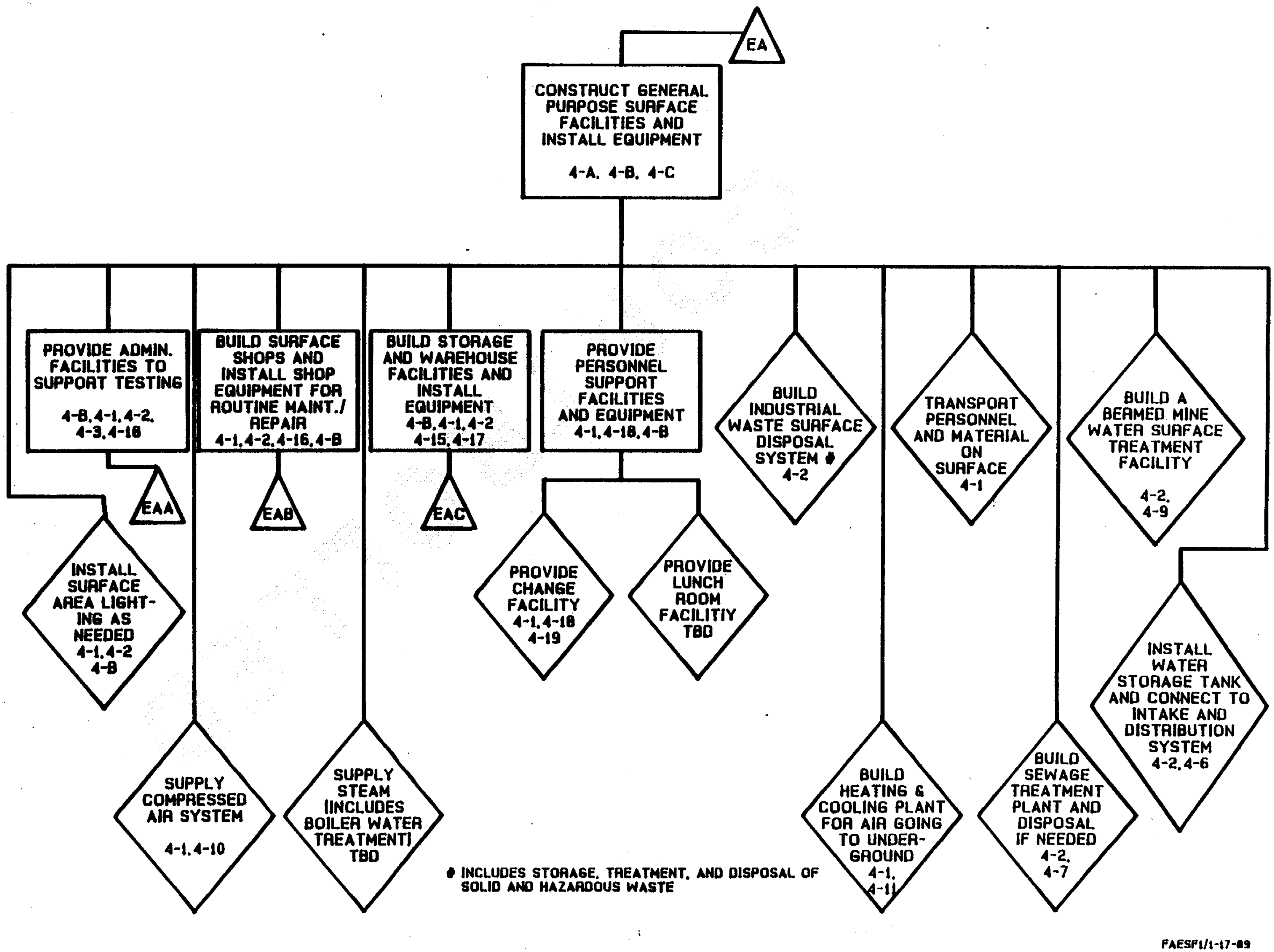
ESF111 - 8/9/88

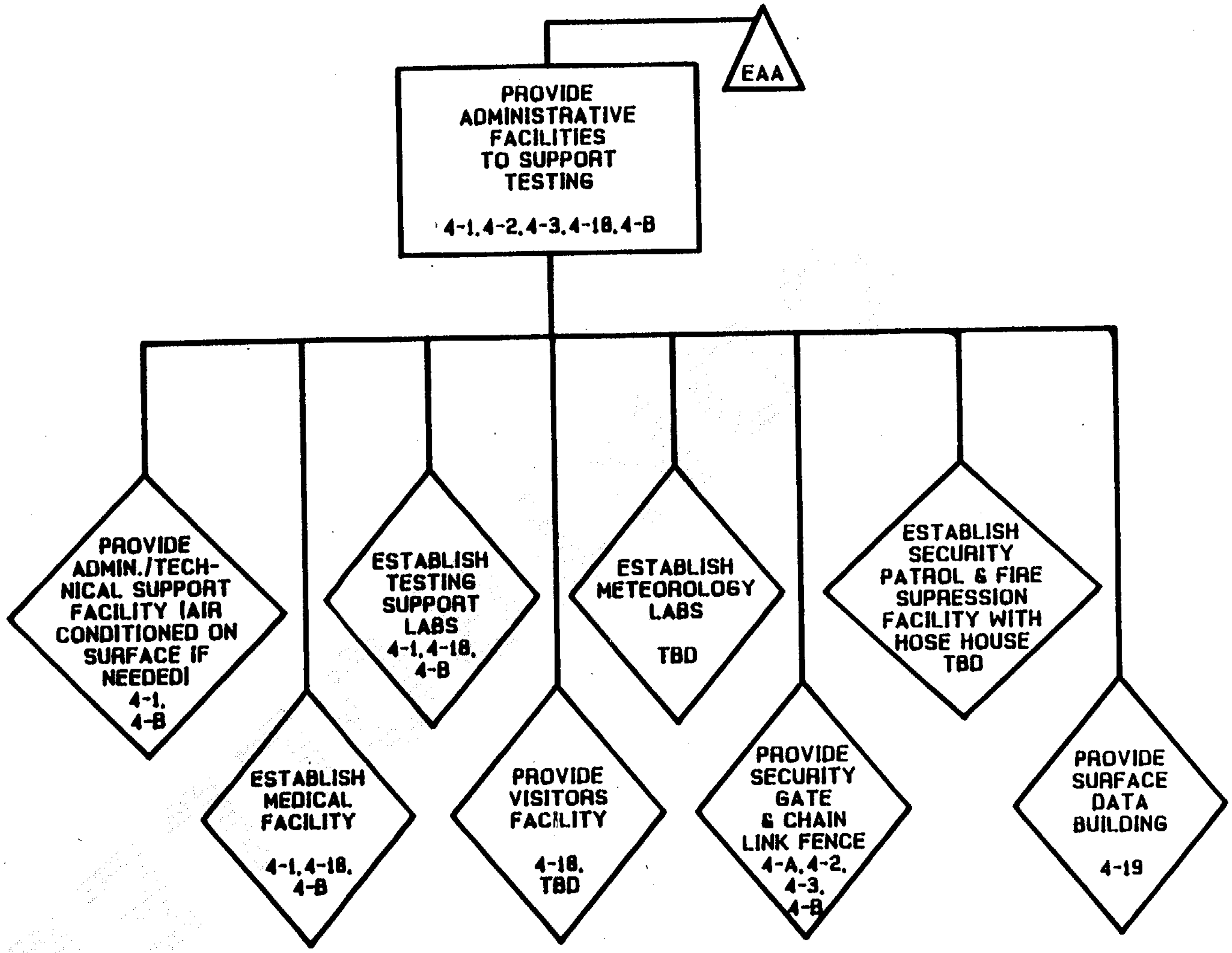

DB
PROVIDE FOR OTHER EXPLORATORY DRILL HOLES 4-2, 4-3, 4-4
PROVIDE ACCESS ROADS 4-3
CLEAR & GRADE SITE & STAGING AREA 4-2, 4-4
PROVIDE PARKING AREA AND EQUIPMENT YARD 4-2, 4-4
LEVEL DRILL PAD 4-2, 4-4
EXCAVATE FILL DIRT IF NEEDED 4-2, 4-4
CONSTRUCT MUD AND CUT-TINGS PIT 4-2, 4-4
PROVIDE DUST CONTROL WITH WATER 4-2
ESF112/12-14-88



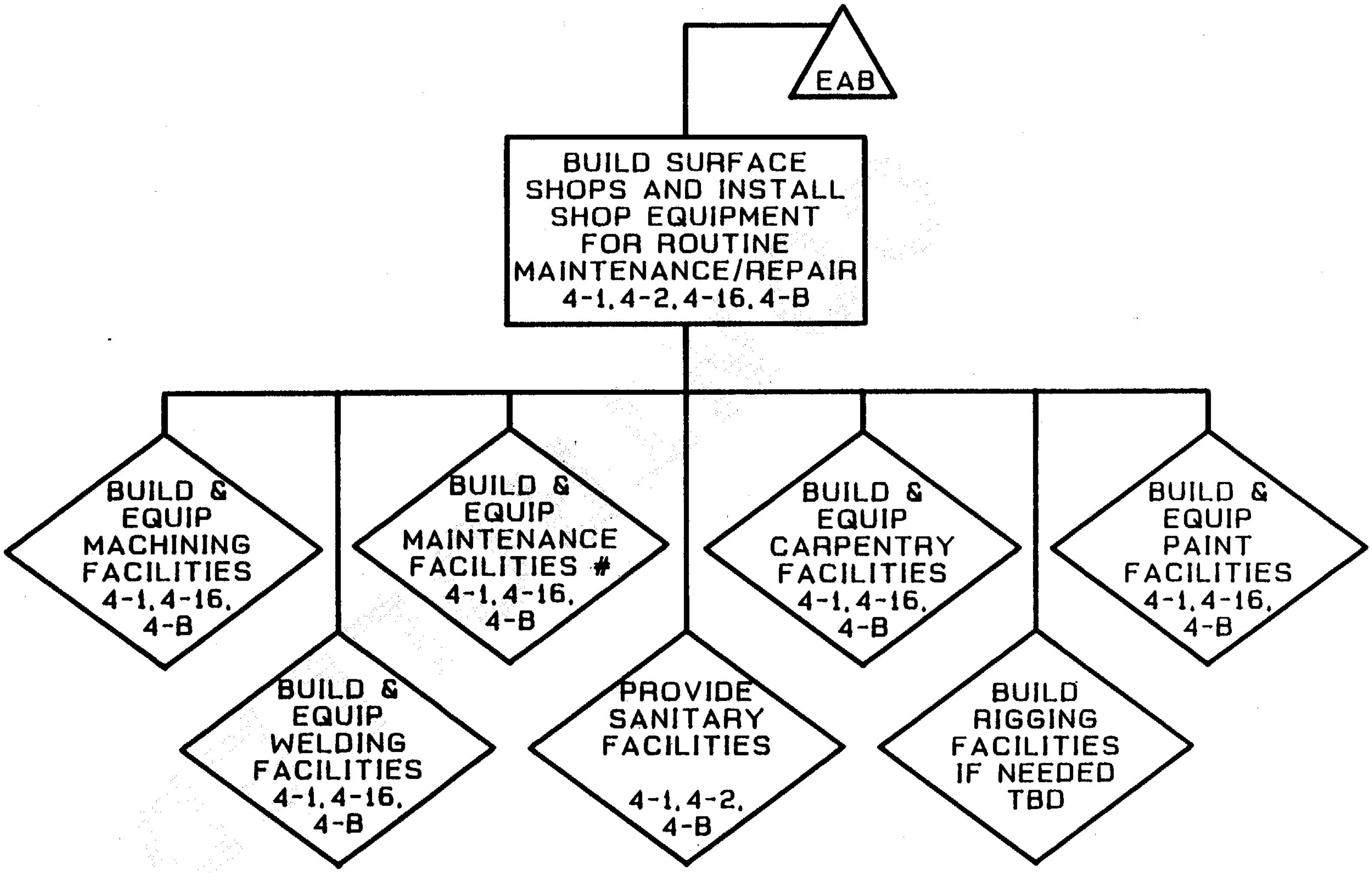
INCLUDES DEDICATED PARKING FOR EMERGENCY VEHICLES

ESFORG24/12-14-88


EA
CONSTRUCT GENERAL PURPOSE SURFACE FACILITIES AND INSTALL EQUIPMENT 4-A, 4-B, 4-C
PROVIDE ADMIN. FACILITIES TO SUPPORT TESTING 4-8, 4-1, 4-2, 4-3, 4-18
EAA
BUILD SURFACE SHOPS AND INSTALL SHOP EQUIPMENT FOR ROUTINE MAINT./ REPAIR 4-1, 4-2, 4-16, 4-B
EAB
BUILD STORAGE AND WAREHOUSE FACILITIES AND INSTALL EQUIPMENT 4-B, 4-1, 4-2 4-15, 4-17
EAC
PROVIDE PERSONNEL SUPPORT FACILITIES AND EQUIPMENT 4-1, 4-18, 4-B
BUILD INDUSTRIAL WASTE SURFACE DISPOSAL SYSTEM * 4-2
TRANSPORT PERSONNEL AND MATERIAL ON SURFACE 4-1
BUILD A BERMED MINE WATER SURFACE TREATMENT FACILITY 4-2, 4-9
INSTALL SURFACE AREA LIGHTING AS NEEDED 4-1, 4-2 4-8
PROVIDE CHANGE FACILITY 4-1, 4-18 4-19
PROVIDE LUNCH ROOM FACILITIY TBD
INSTALL WATER STORAGE TANK AND CONNECT TO INTAKE AND DISTRIBUTION SYSTEM 4-2, 4-6
SUPPLY COMPRESSED AIR SYSTEM 4-1, 4-10
SUPPLY STEAM (INCLUDES BOILER WATER TREATMENT) TBD
BUILD HEATING & COOLING PLANT FOR AIR GOING TO UNDER-GROUND 4-1, 4-11
BUILD SEWAGE TREATMENT PLANT AND DISPOSAL IF NEEDED 4-2, 4-7
* INCLUDES STORAGE, TREATMENT, AND DISPOSAL OF SOLID AND HAZARDOUS WASTE
FAESF1/1-17-89

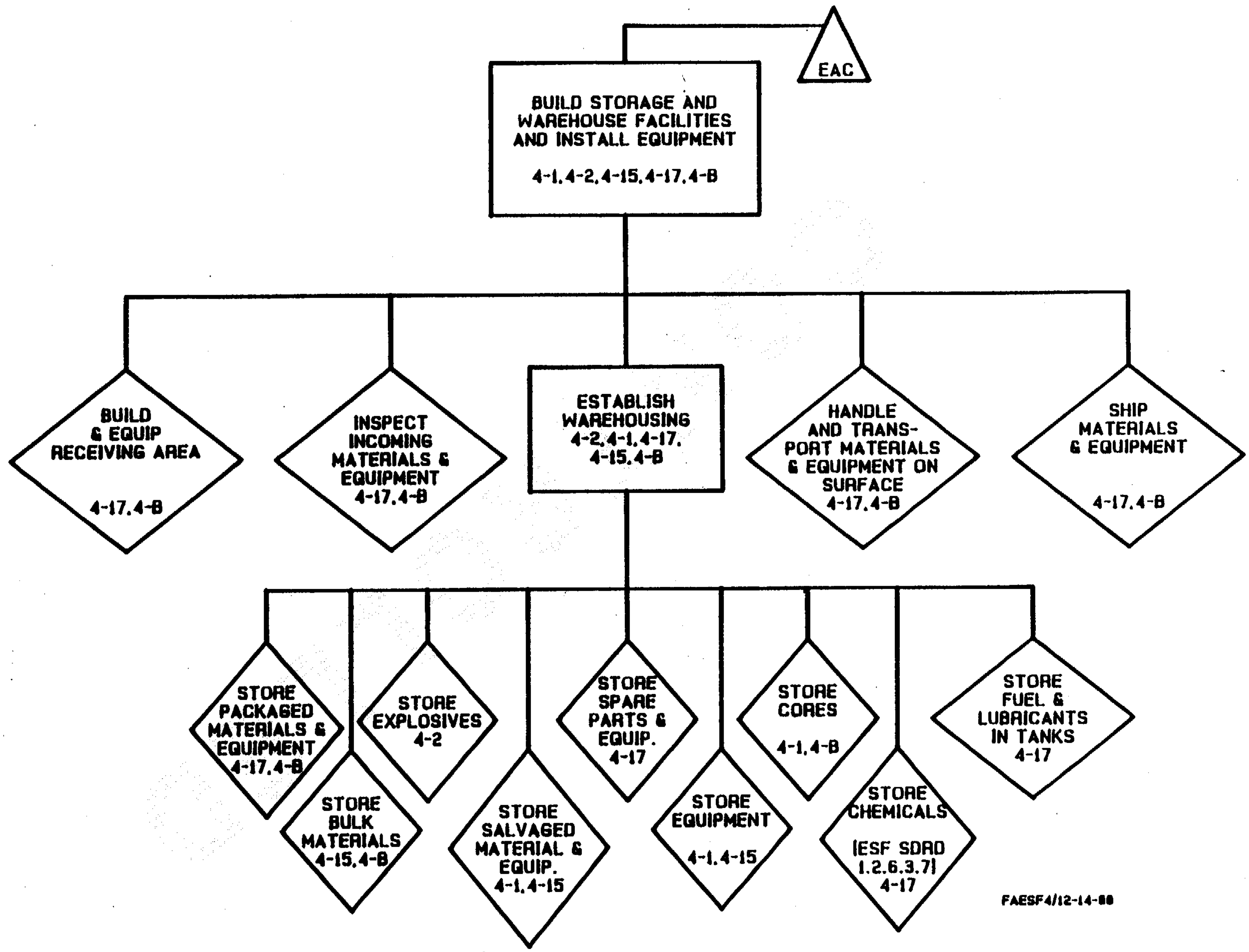


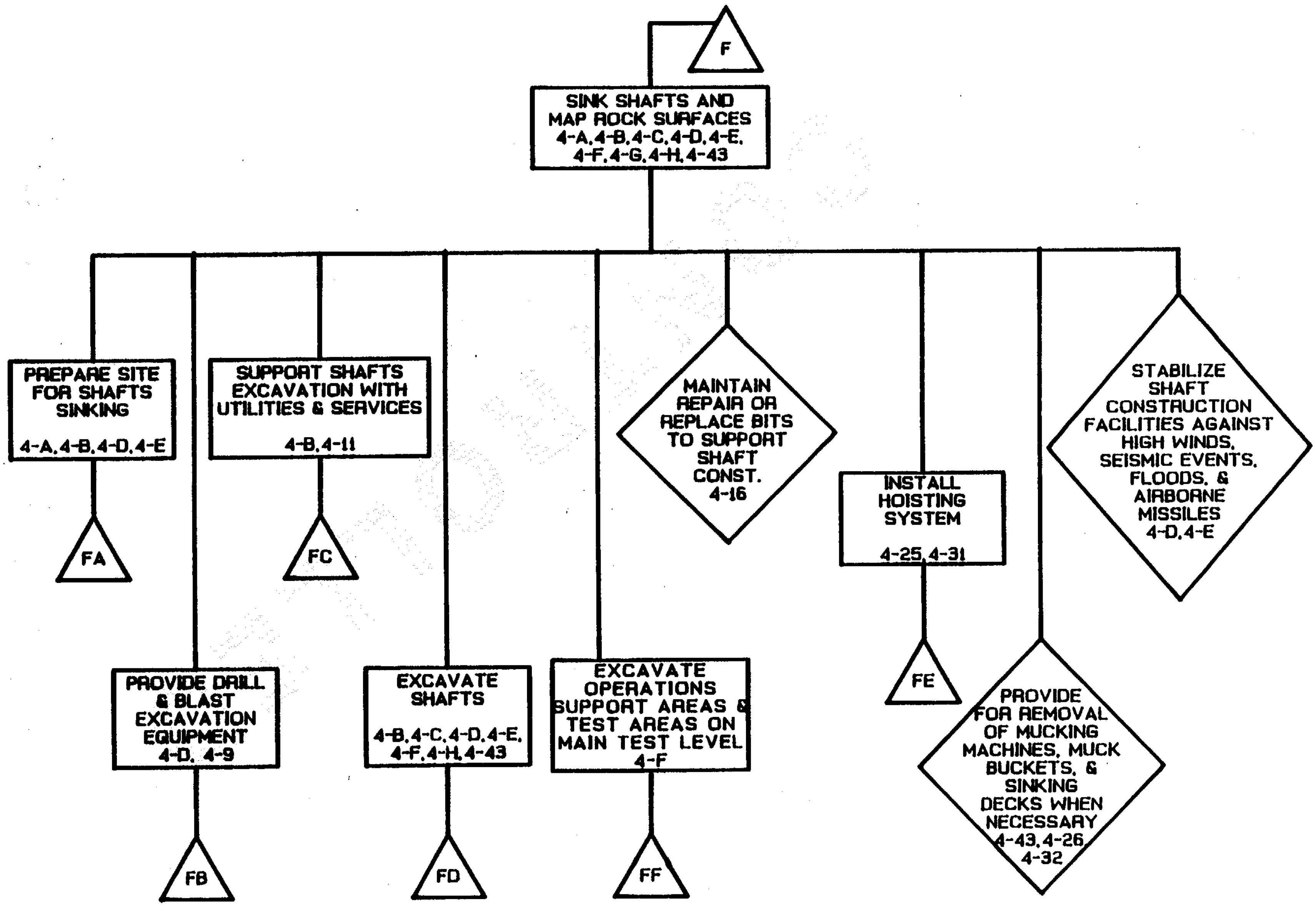
FAESF2/1-17-89



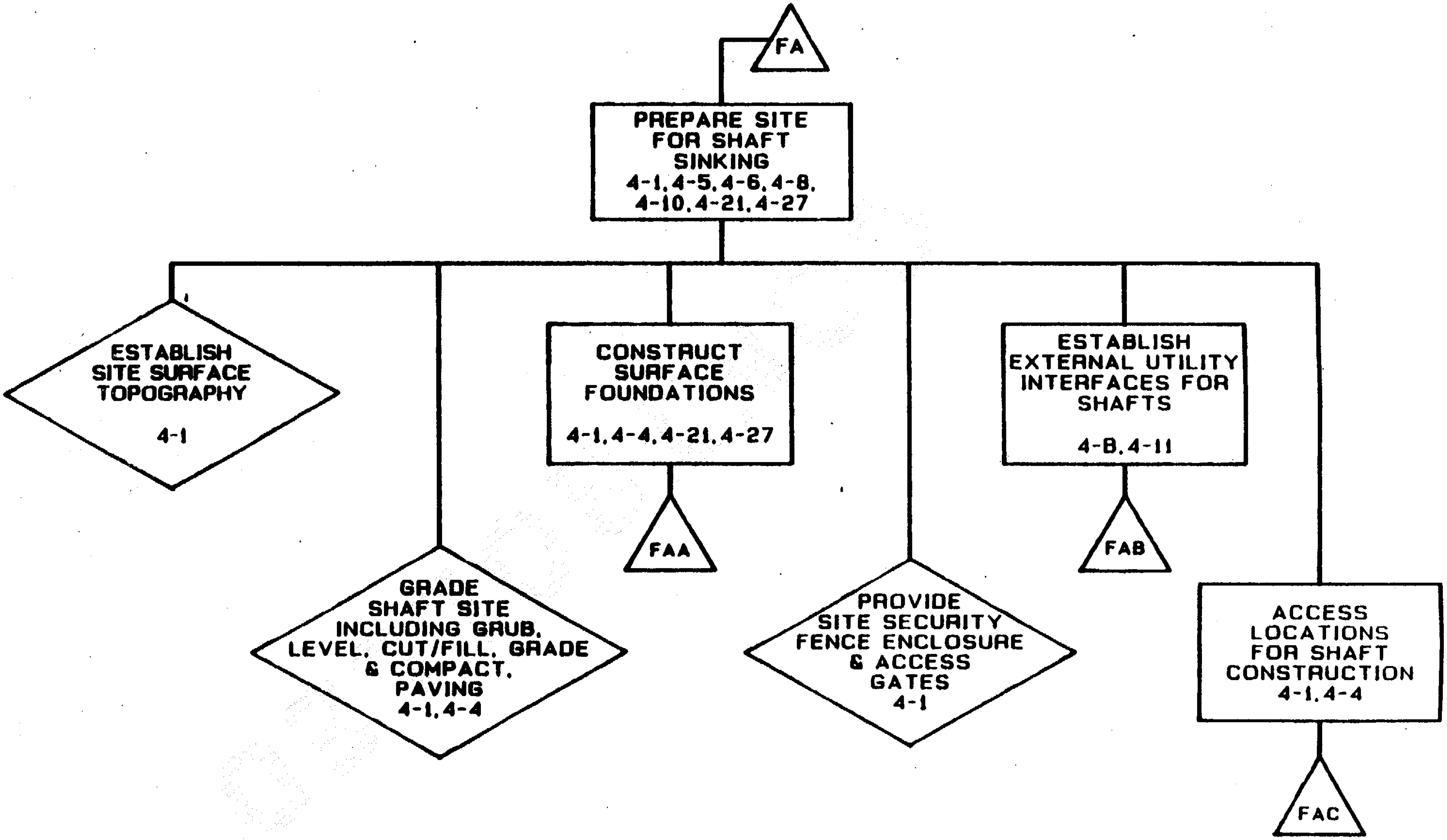
INCLUDES A CONCRETE WASH PAD WITH DRAINAGE TO SEWER

FAESF3/1-17-89

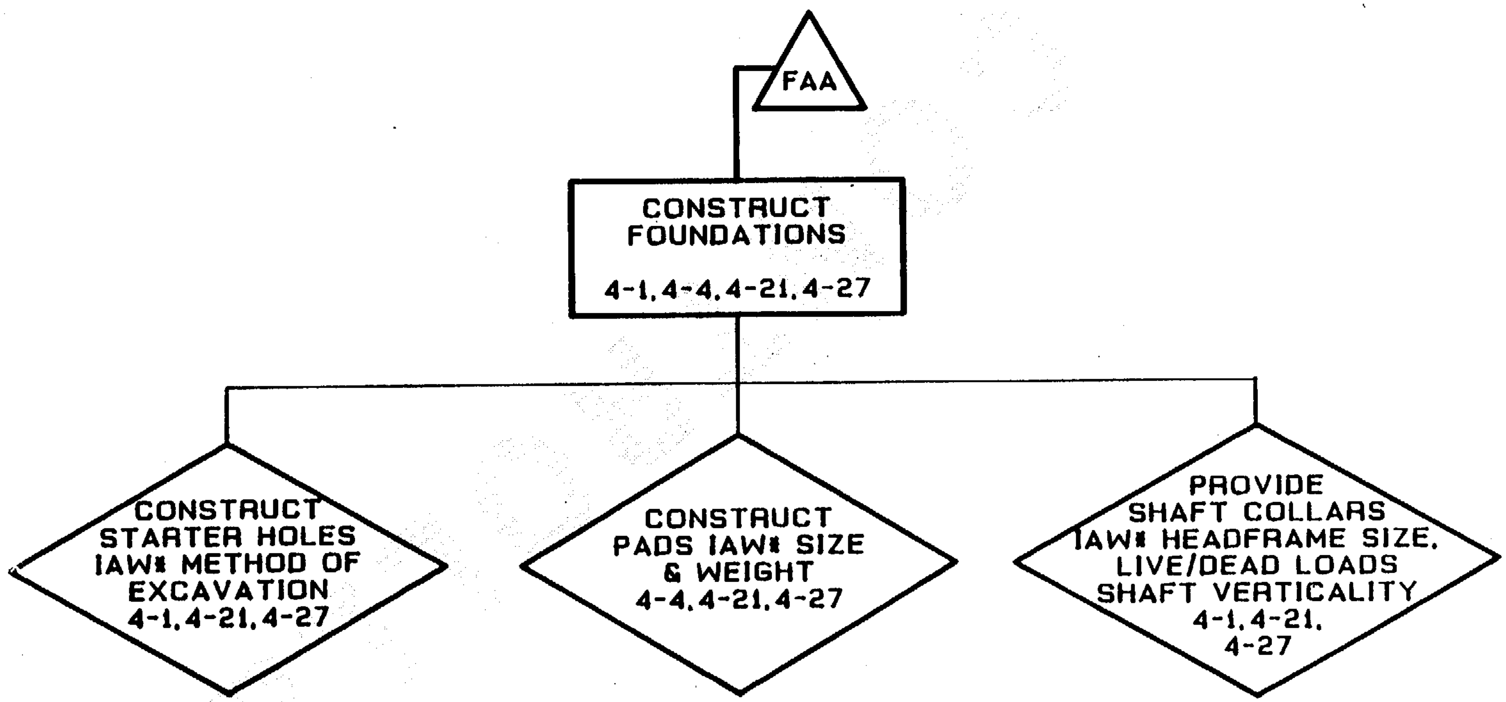

EAC
BUILD STORAGE AND WAREHOUSE FACILITIES AND INSTALL EQUIPMENT
4-1, 4-2, 4-15, 4-17, 4-B
BUILD & EQUIP RECEIVING AREA
4-17, 4-B
INSPECT INCOMING MATERIALS & EQUIPMENT
4-17, 4-B
ESTABLISH WAREHOUSING
4-2, 4-1, 4-17, 4-15, 4-B
HANDLE AND TRANS-PORT MATERIALS & EQUIPMENT ON SURFACE
4-17, 4-B
SHIP MATERIALS & EQUIPMENT
4-17, 4-B
STORE PACKAGED MATERIALS & EQUIPMENT
4-17, 4-B
STORE BULK MATERIALS
4-15, 4-B
STORE EXPLOSIVES
4-2
STORE SALVAGED MATERIAL & EQUIP.
4-1, 4-15
STORE SPARE PARTS & EQUIP.
4-17
STORE EQUIPMENT
4-1, 4-15
STORE CORES
4-1, 4-B
STORE CHEMICALS
[ESF SDRD 1.2.6.3.7]
4-17
STORE FUEL & LUBRICANTS IN TANKS
4-17
FAESF4/12-14-88



ESFORG5/12-14-88

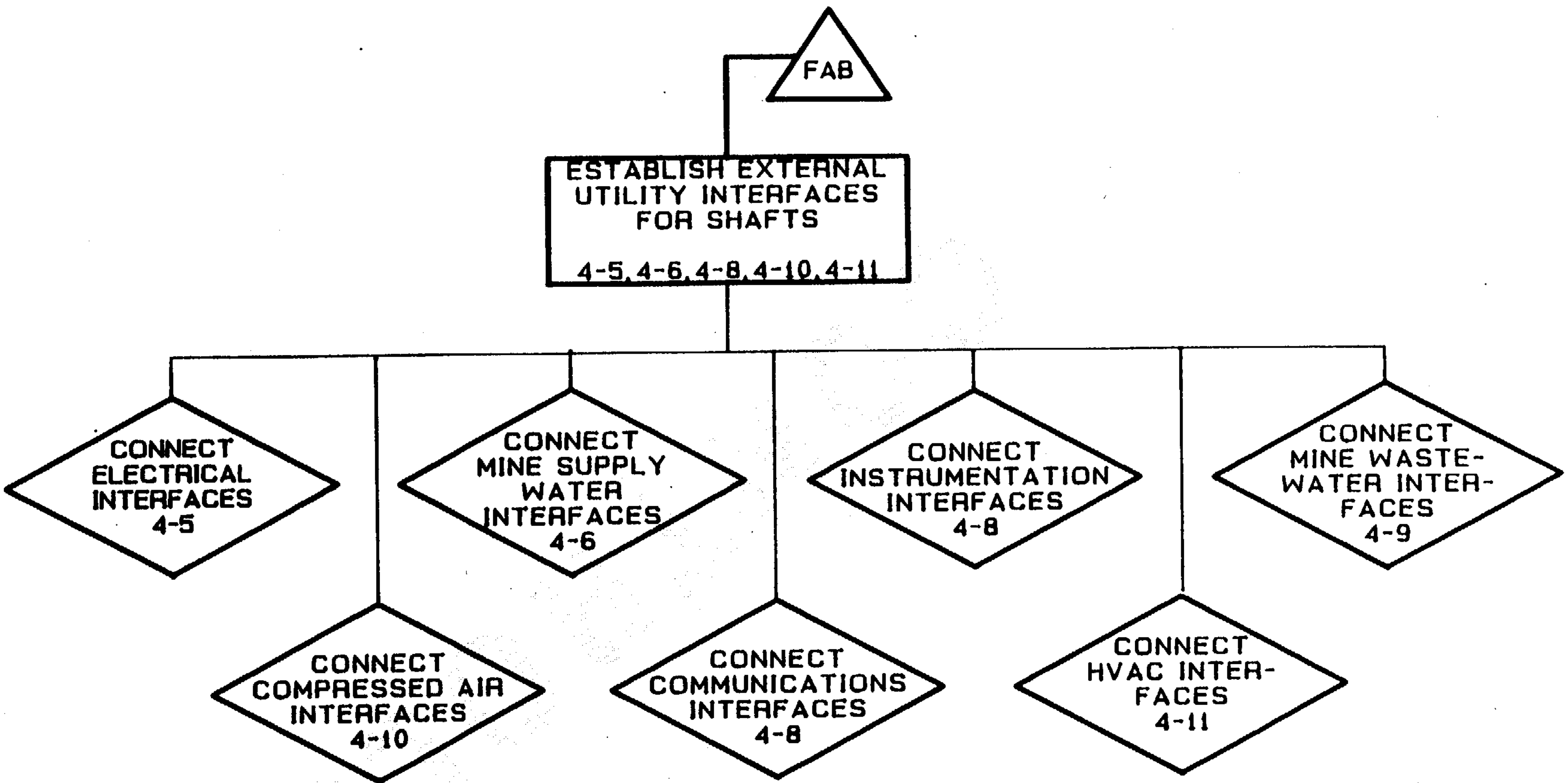

FA
PREPARE SITE FOR SHAFT SINKING 4-1, 4-5, 4-6, 4-8, 4-10, 4-21, 4-27
ESTABLISH SITE SURFACE TOPOGRAPHY 4-1
GRADE SHAFT SITE INCLUDING GRUB, LEVEL, CUT/FILL, GRADE & COMPACT, PAVING 4-1, 4-4
CONSTRUCT SURFACE FOUNDATIONS 4-1, 4-4, 4-21, 4-27
FAA
PROVIDE SITE SECURITY FENCE ENCLOSURE & ACCESS GATES 4-1
ESTABLISH EXTERNAL UTILITY INTERFACES FOR SHAFTS 4-8, 4-11
FAB
ACCESS LOCATIONS FOR SHAFT CONSTRUCTION 4-1, 4-4
FAC

ESF131 - 8/9/88

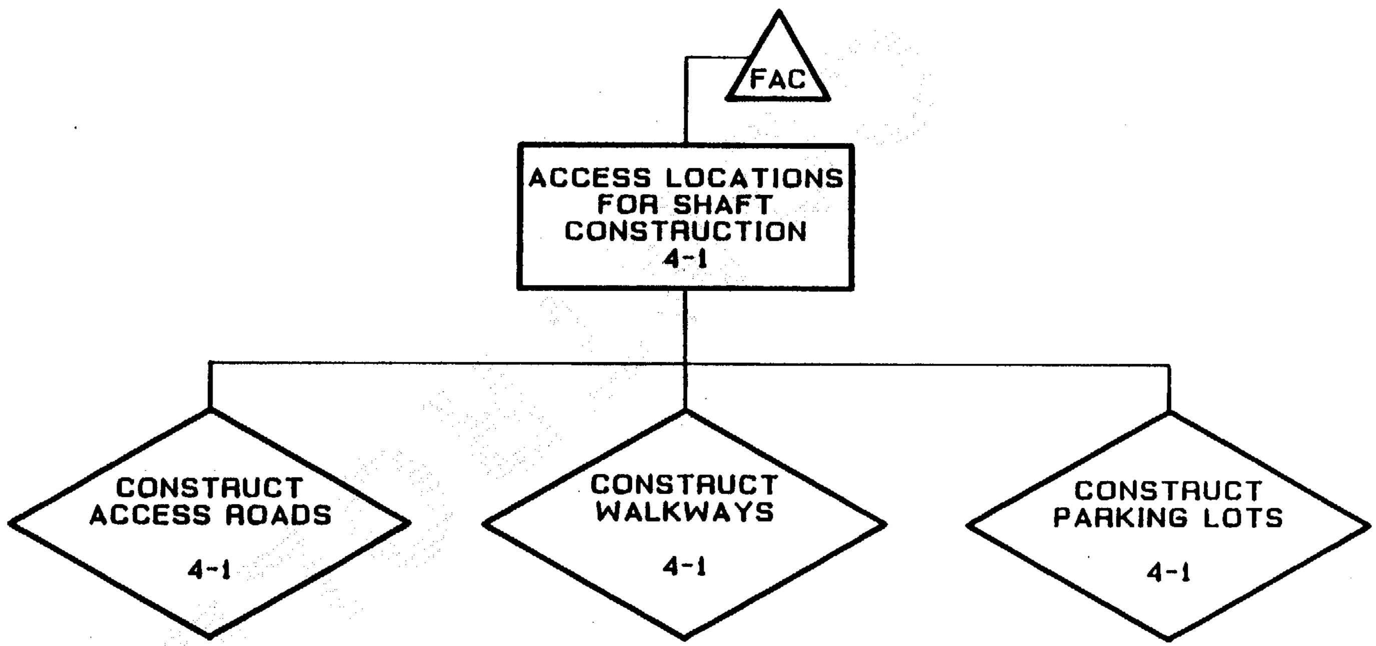


ESF1313/12-14-88

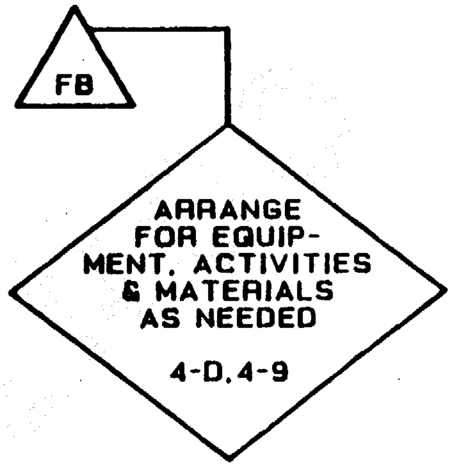
* IAW STANDS FOR 'IN ACCORDANCE WITH'



ESF1315/1-17-89



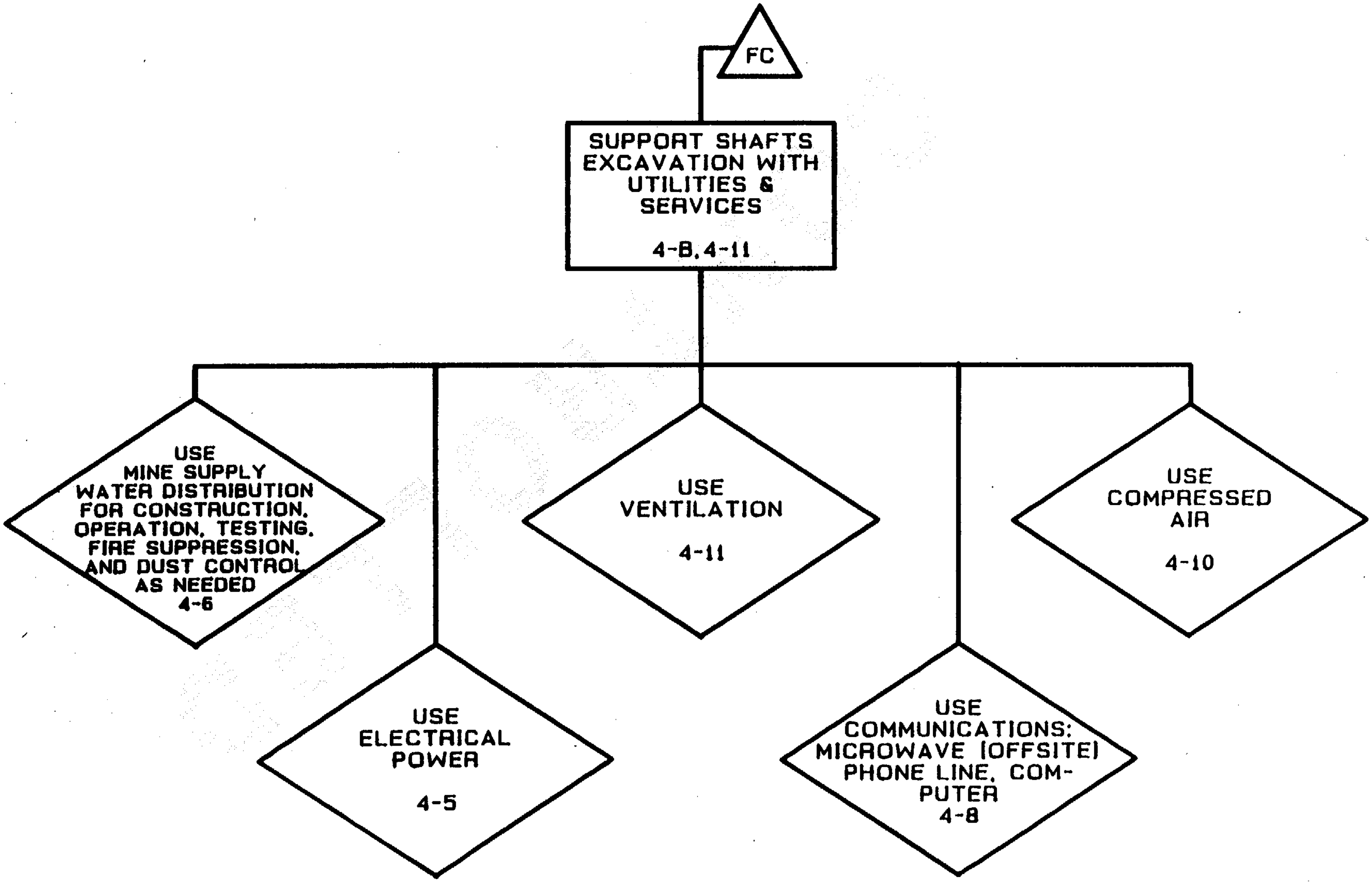
ESF1316/12-14-88



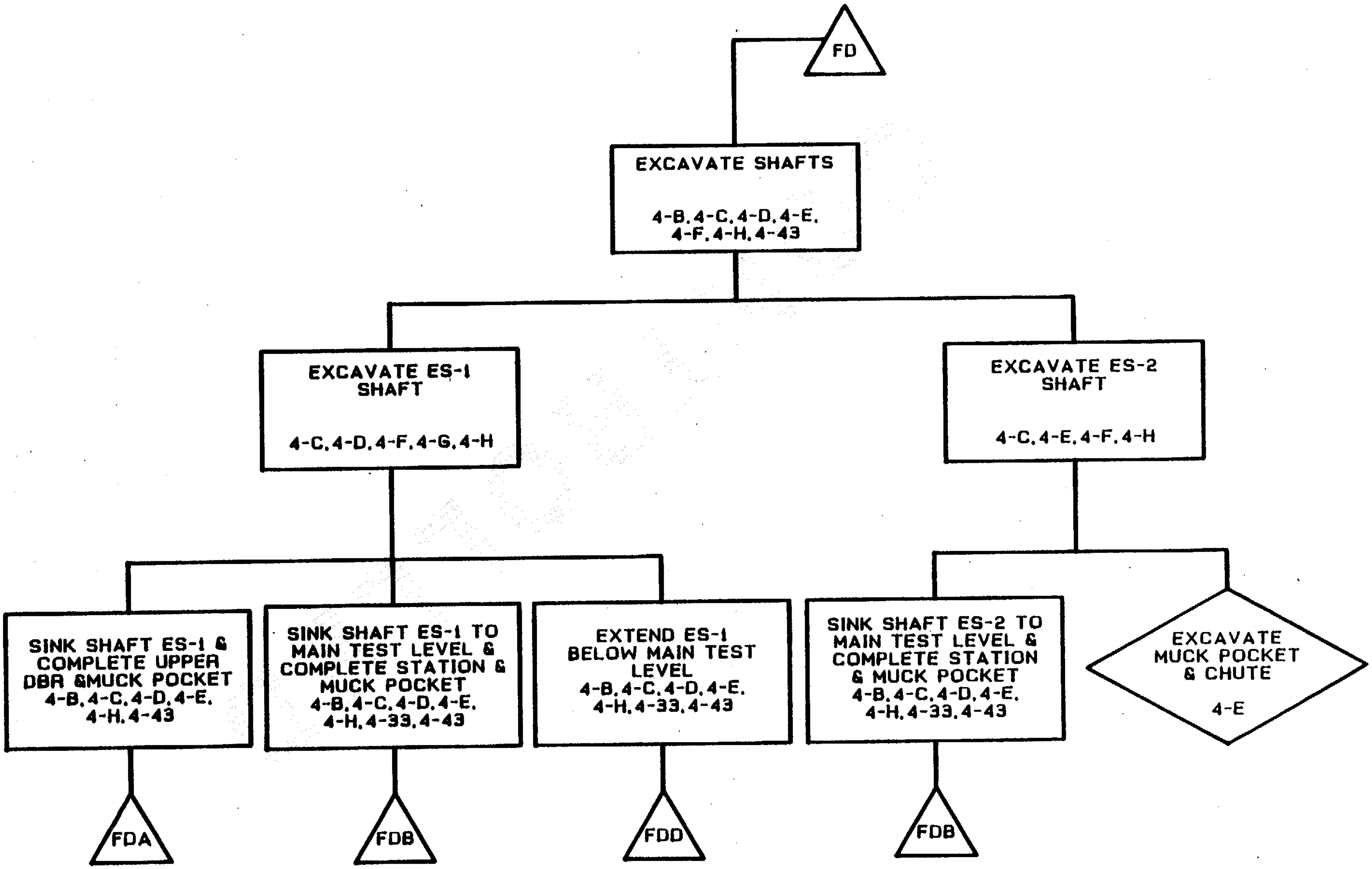
LIST OF EQUIPMENT, ACTIVITIES AND MATERIALS

1. SINKING DECK & ASSOCIATED EQUIPMENT
2. GROUNDWATER COLLECTION, MEASUREMENT AND DISPOSAL
3. PORTABLE WATER REMOVAL SYSTEM
4. WATER CONTROL FEATURES (e.g., WATER RINGS, SUMPS, DISCHARGE PUMPS)
5. BLAST HOLE DRILLS AND BITS
6. TRANSPORT FOR EXPLOSIVES
7. DETONATION SEQUENCE TIMER
8. SHAFT VENTILATION AIR
9. VENTILATION AIR HUMIDITY MONITORING AND CONTROL
10. TAGGED WATER FOR DUST CONTROL
11. MUCKING MACHINE
12. MUCK BUCKET
13. ROCK BOLTS
14. STEEL TENDON RODS
15. WIRE MESH
16. LAGGING
17. STEEL SETS
18. TRANSPORTATION FOR MUCK FROM DRIFTS TO SHAFTS

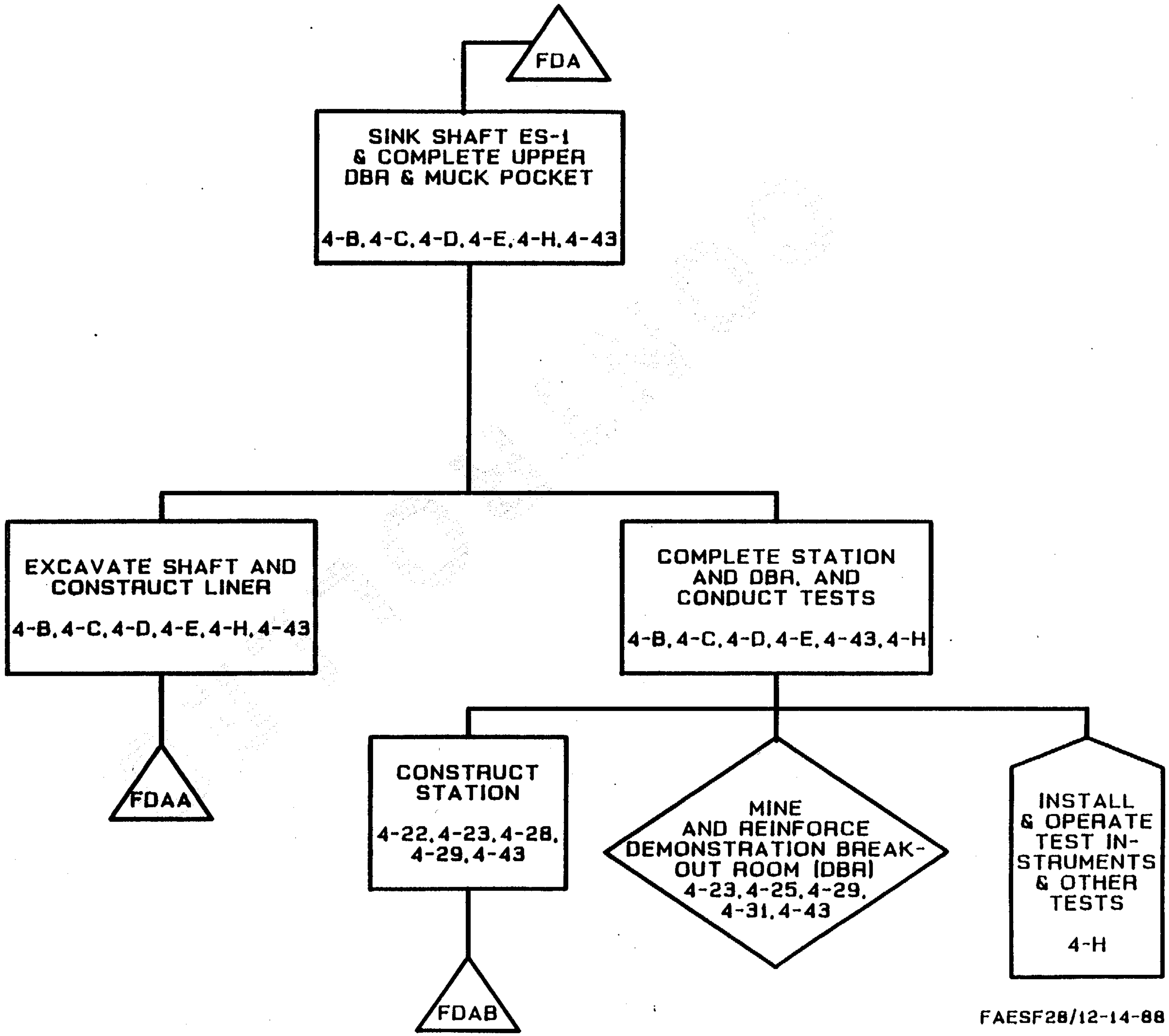
FAESFFB 8/9/88



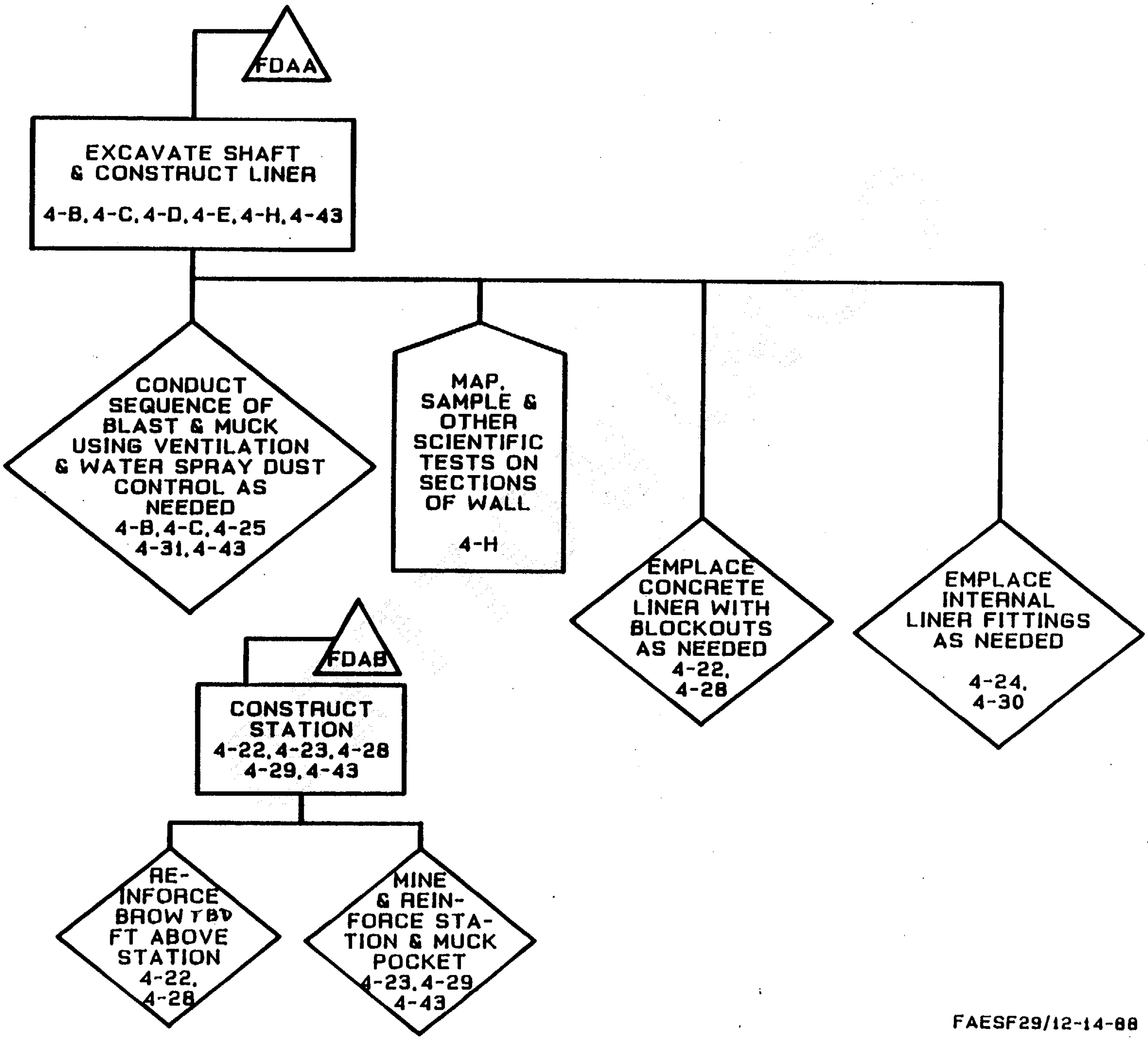
ESF133/1-17-89



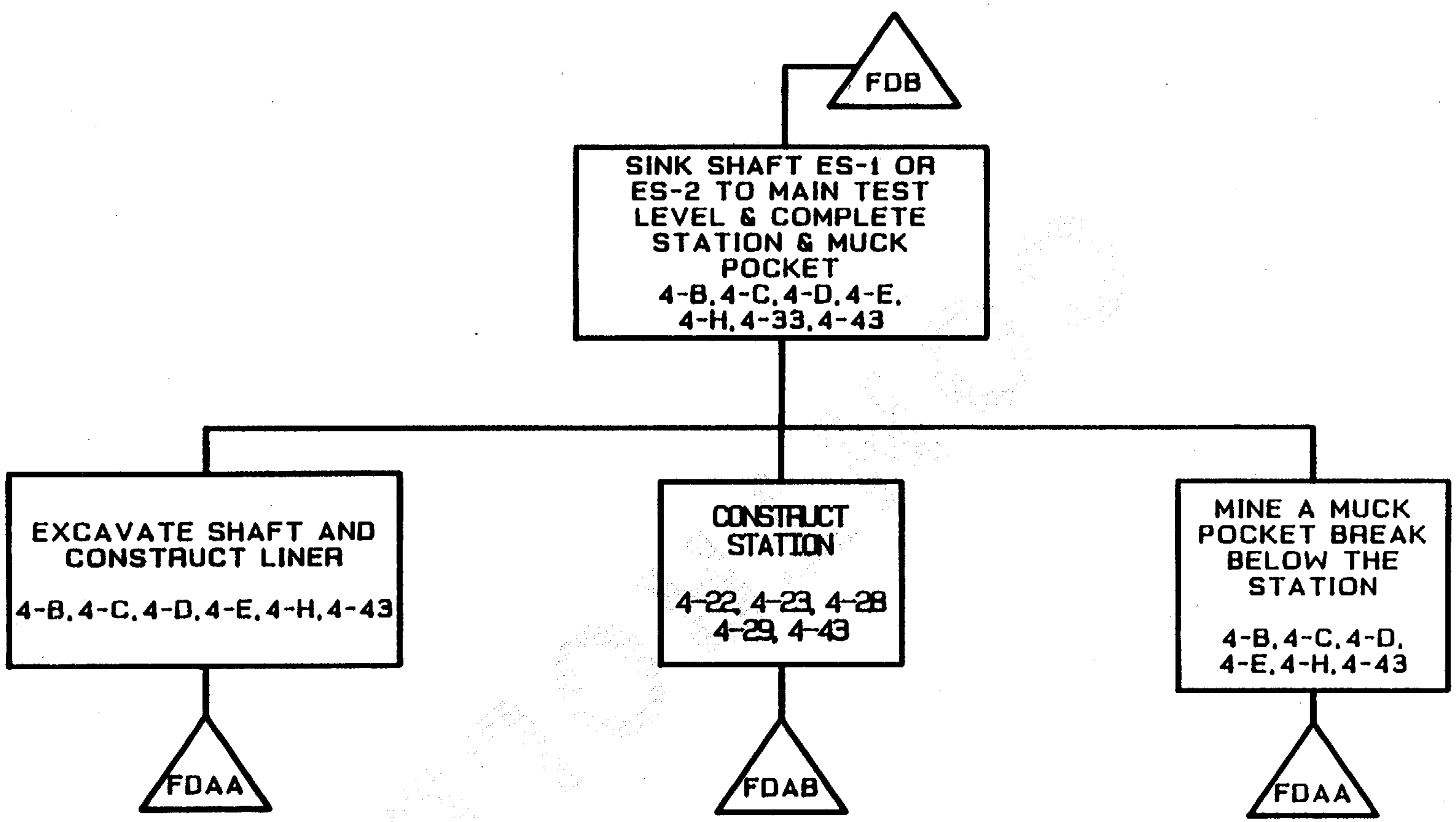
FAESF45/12-14-88



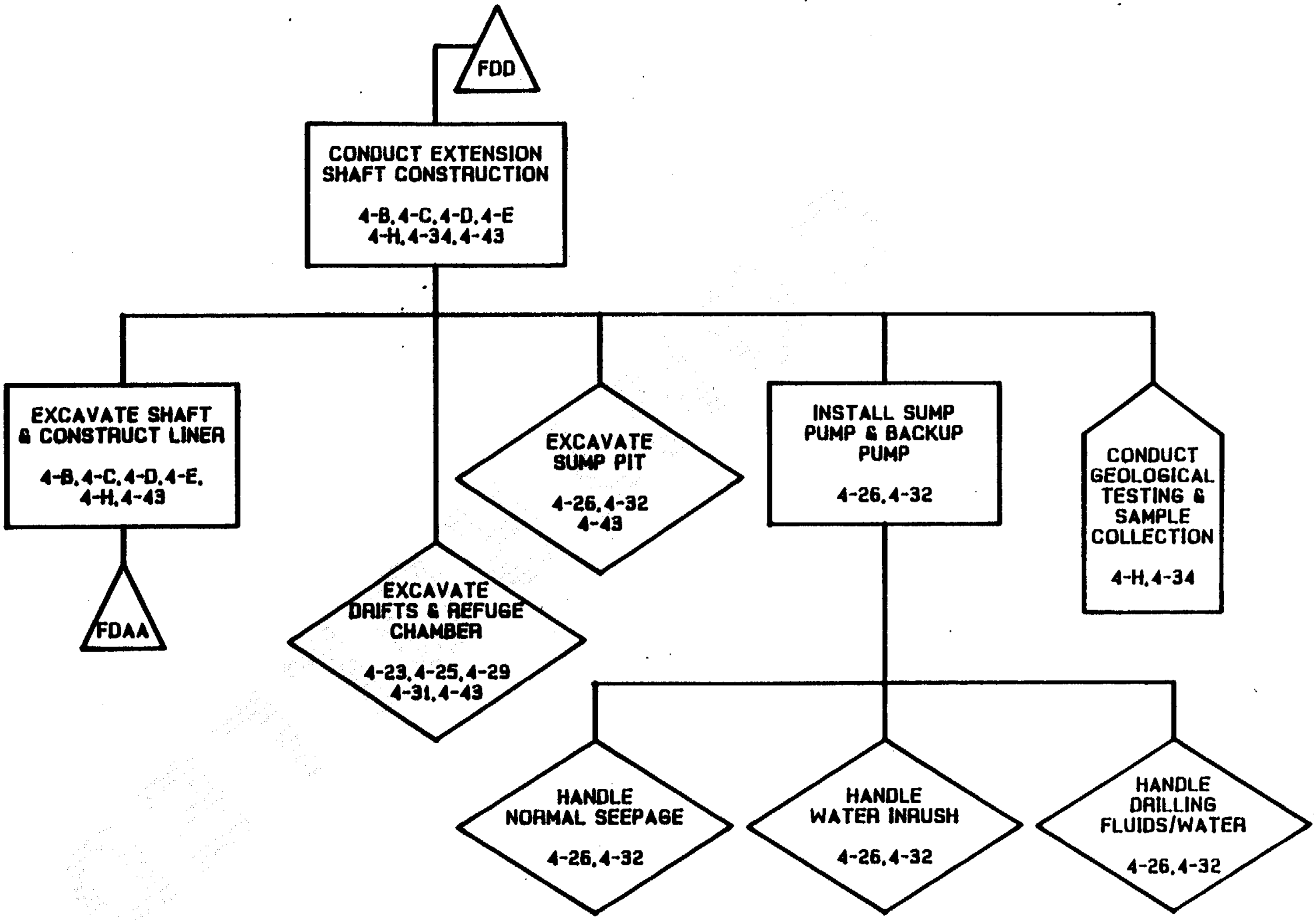
FAESF28/12-14-88



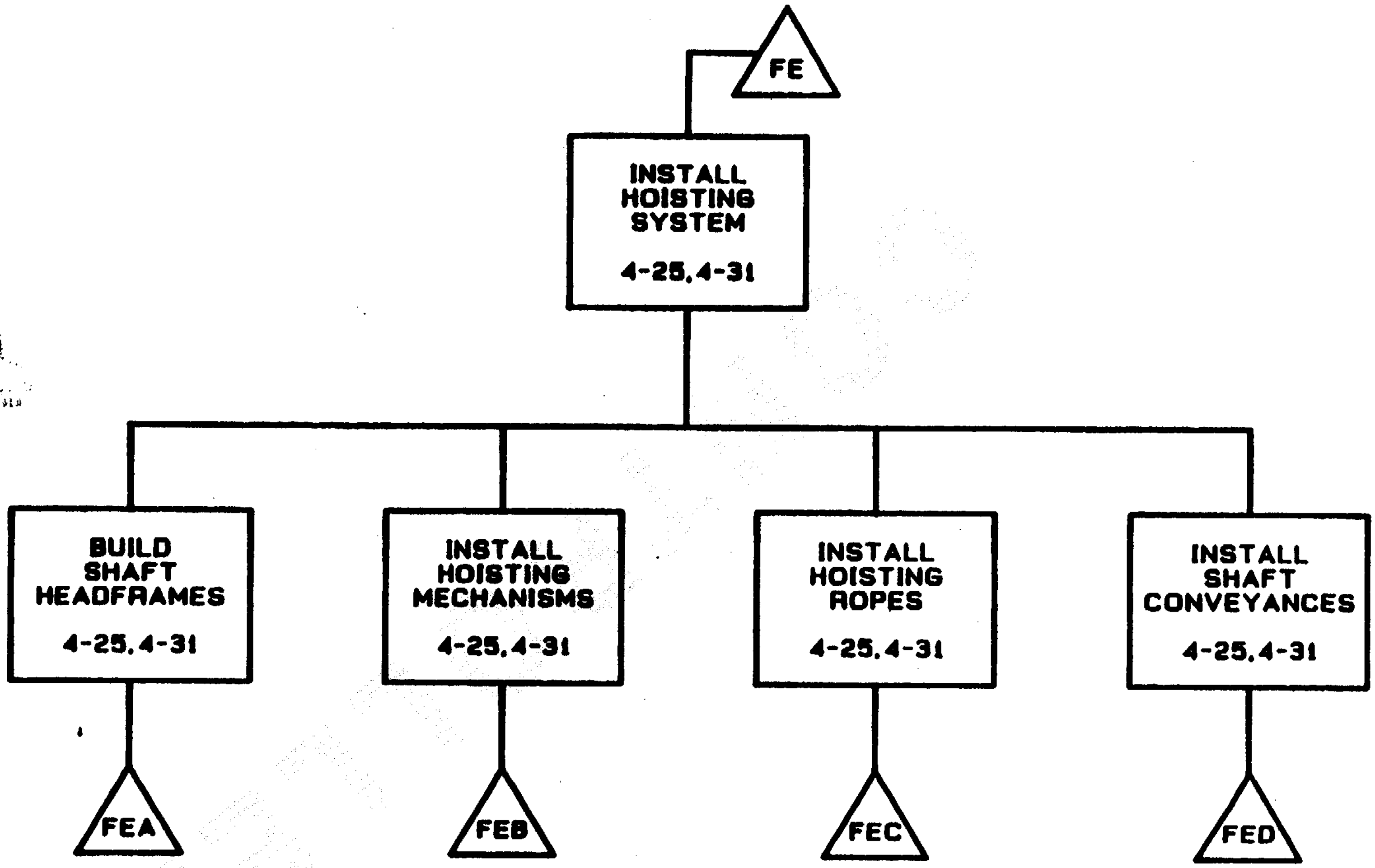
FAESF29/12-14-88



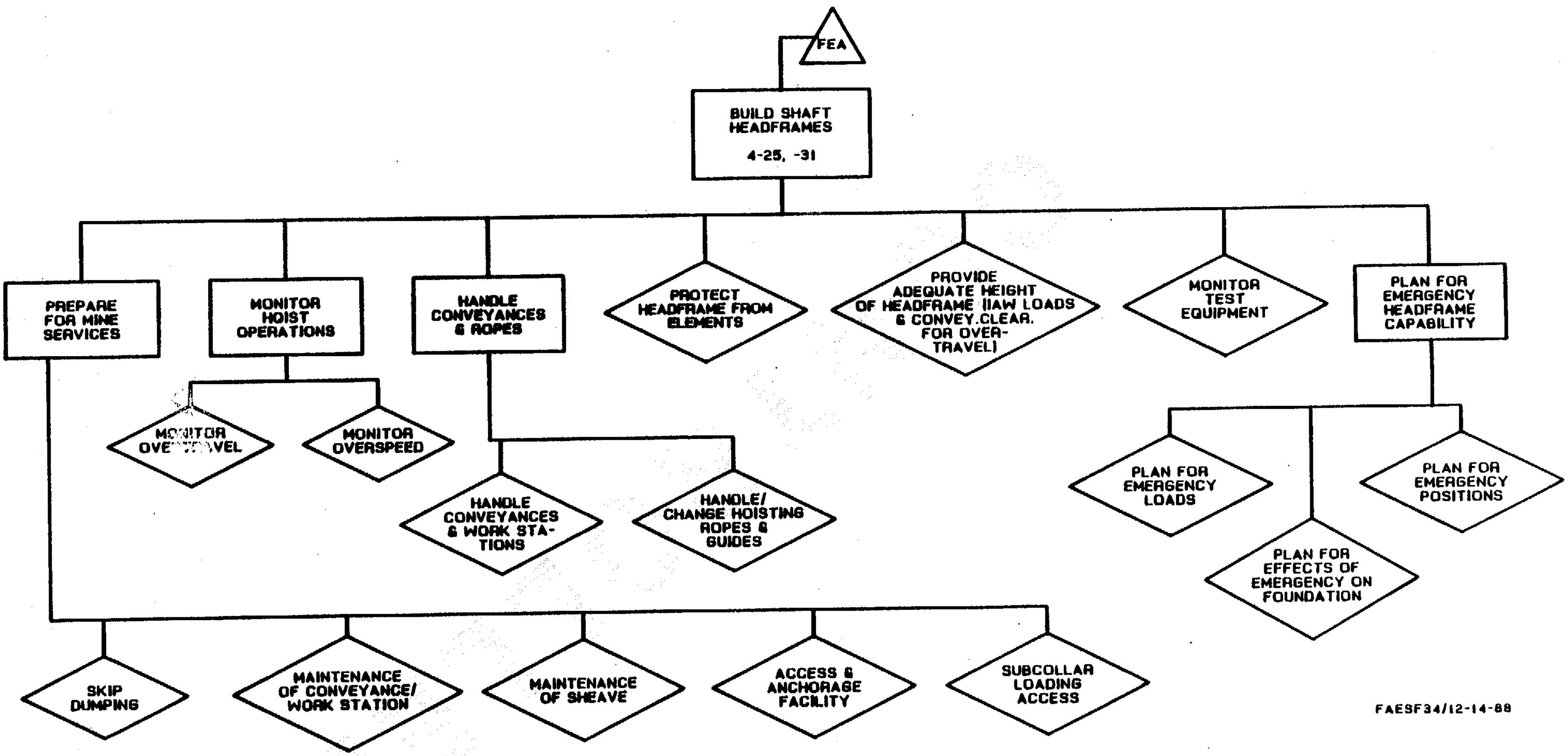
FAESF30/12-14-88



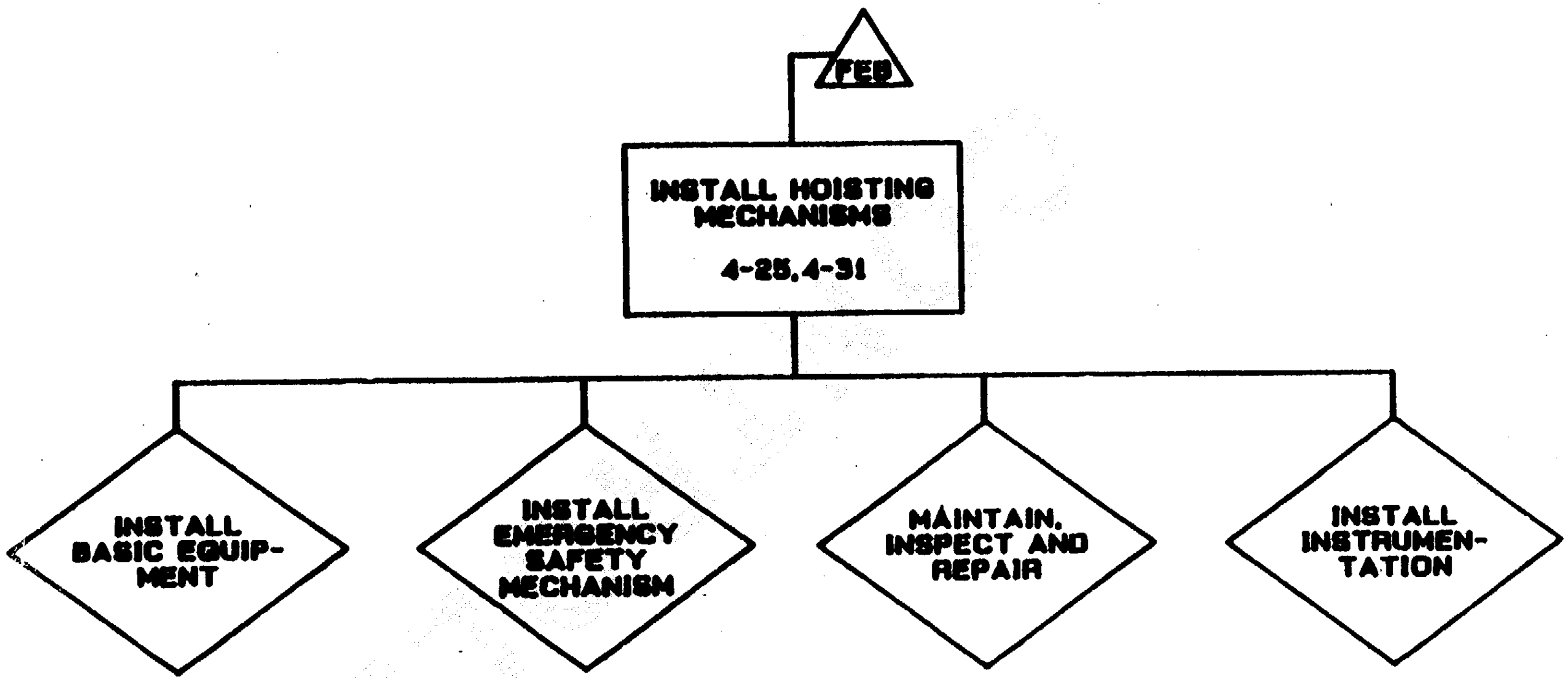
FAESF32/12-14-88

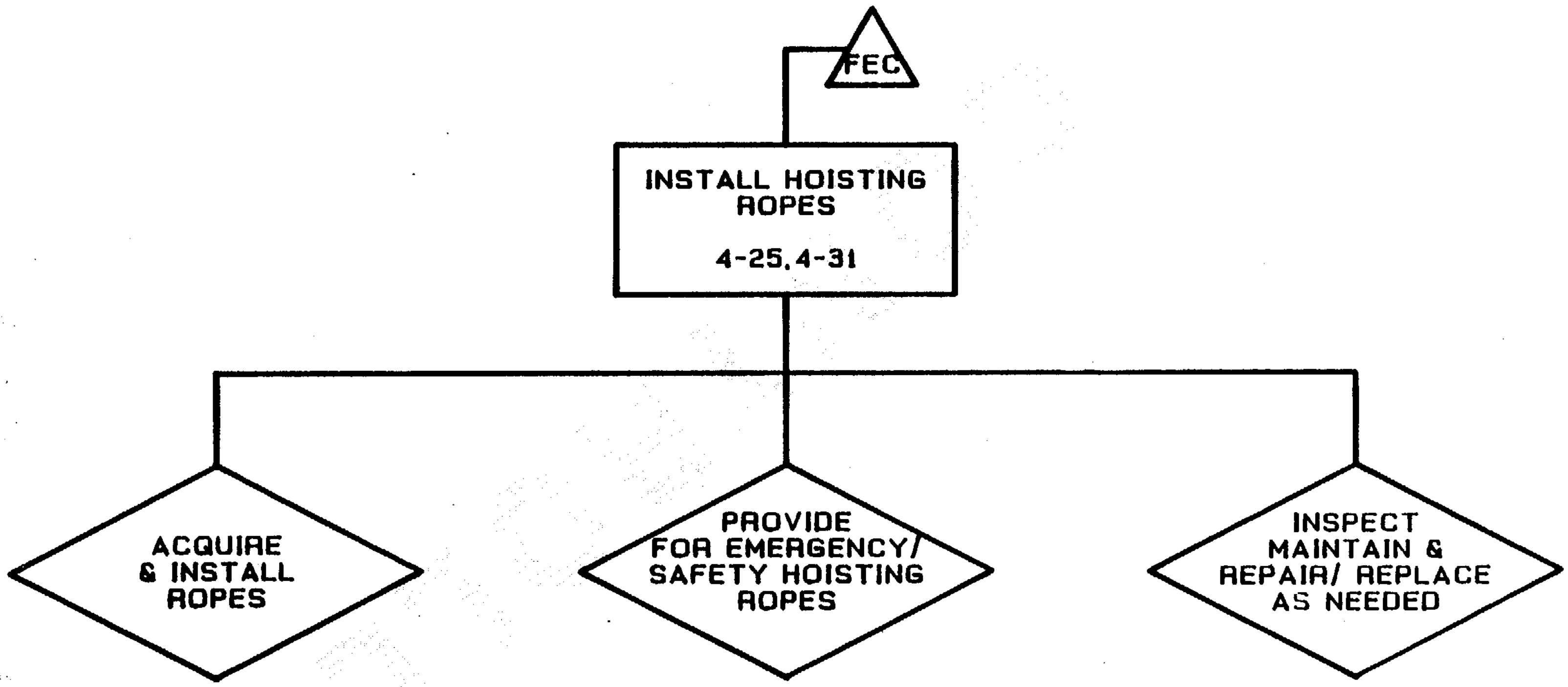


FAESF33 8/9/88



FAESF34/12-14-88


FES
INSTALL HOISTING MECHANISMS
4-25, 4-31
INSTALL BASIC EQUIP-MENT
INSTALL EMERGENCY SAFETY MECHANISM
MAINTAIN, INSPECT AND REPAIR
INSTALL INSTRUMEN-TATION



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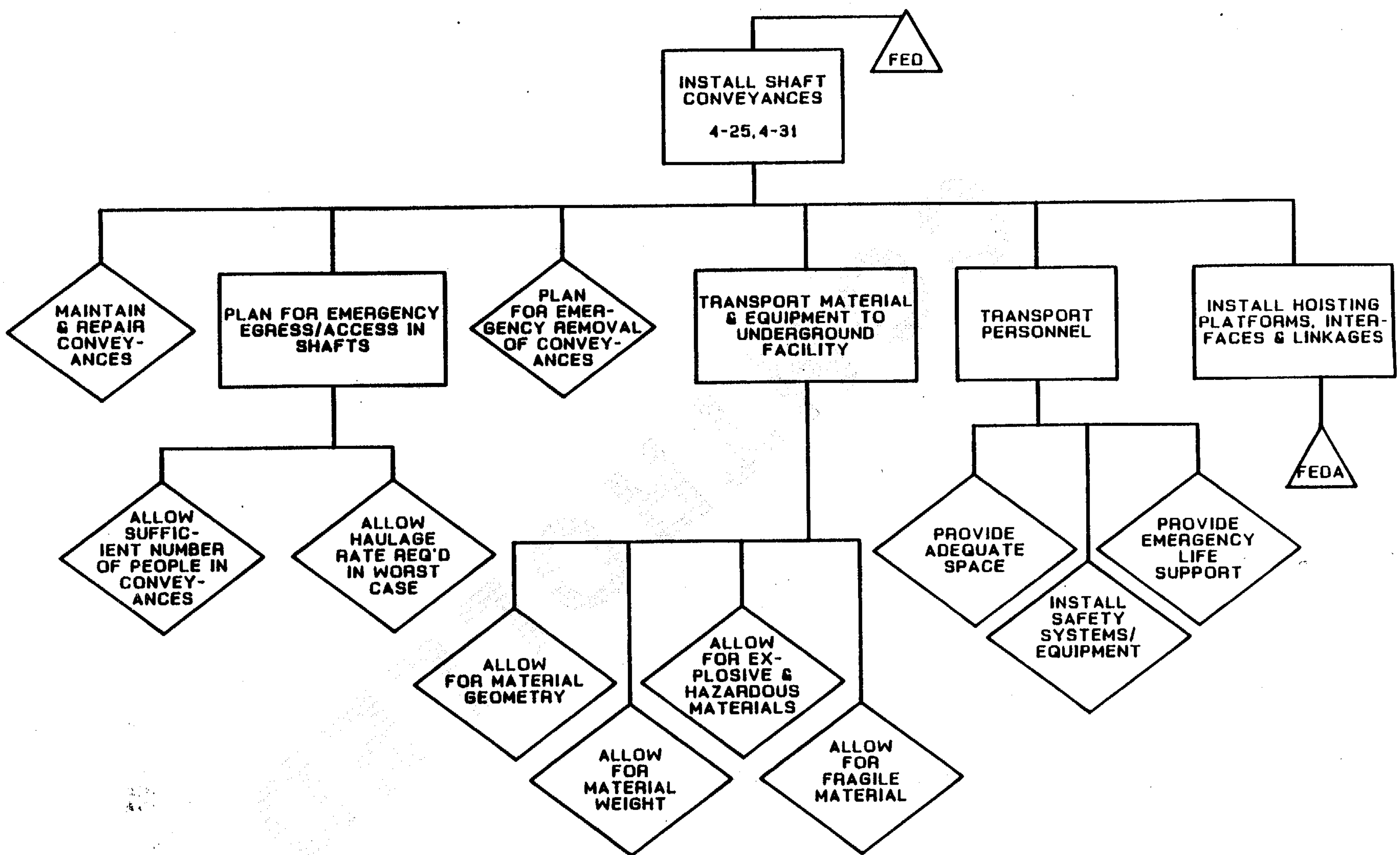
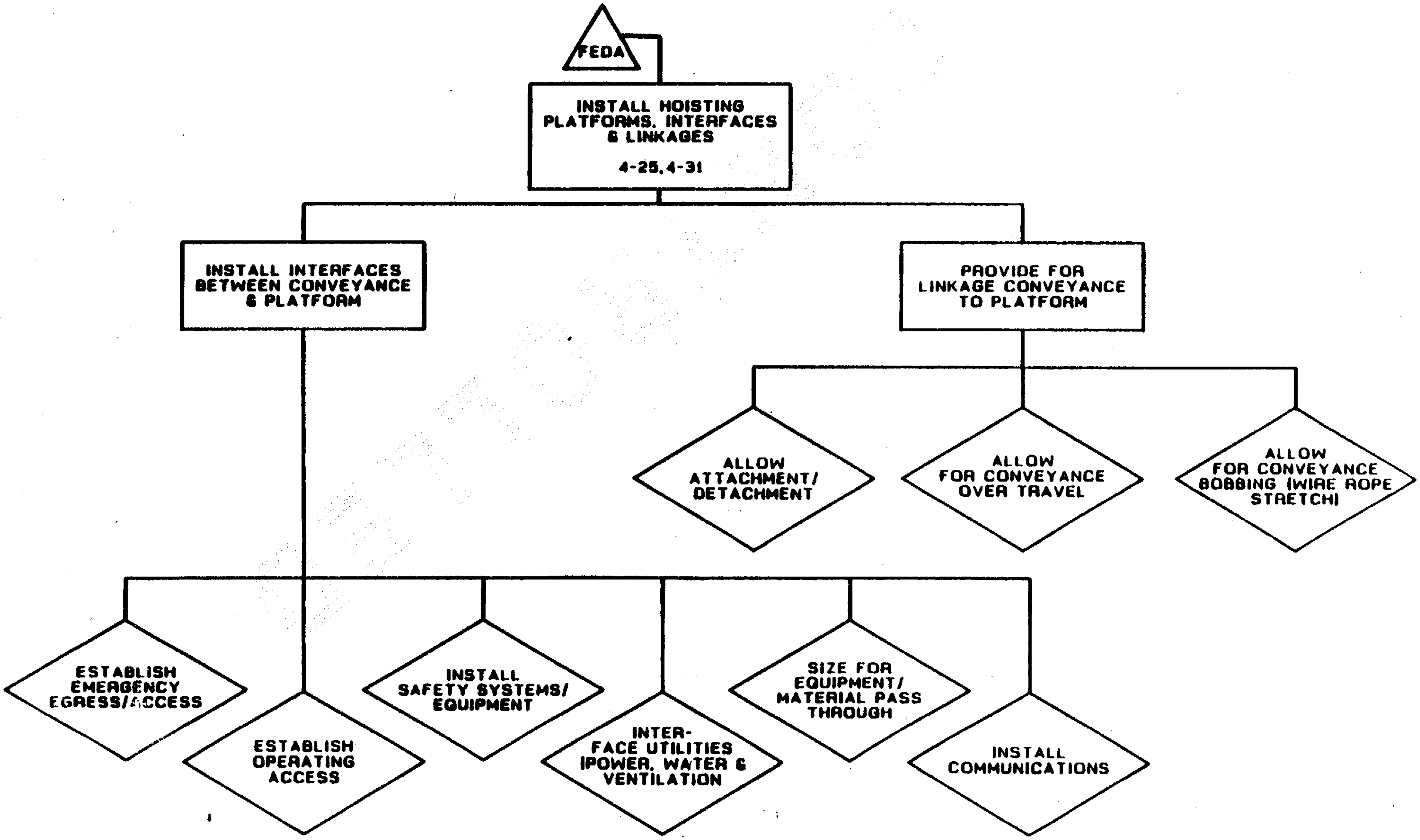
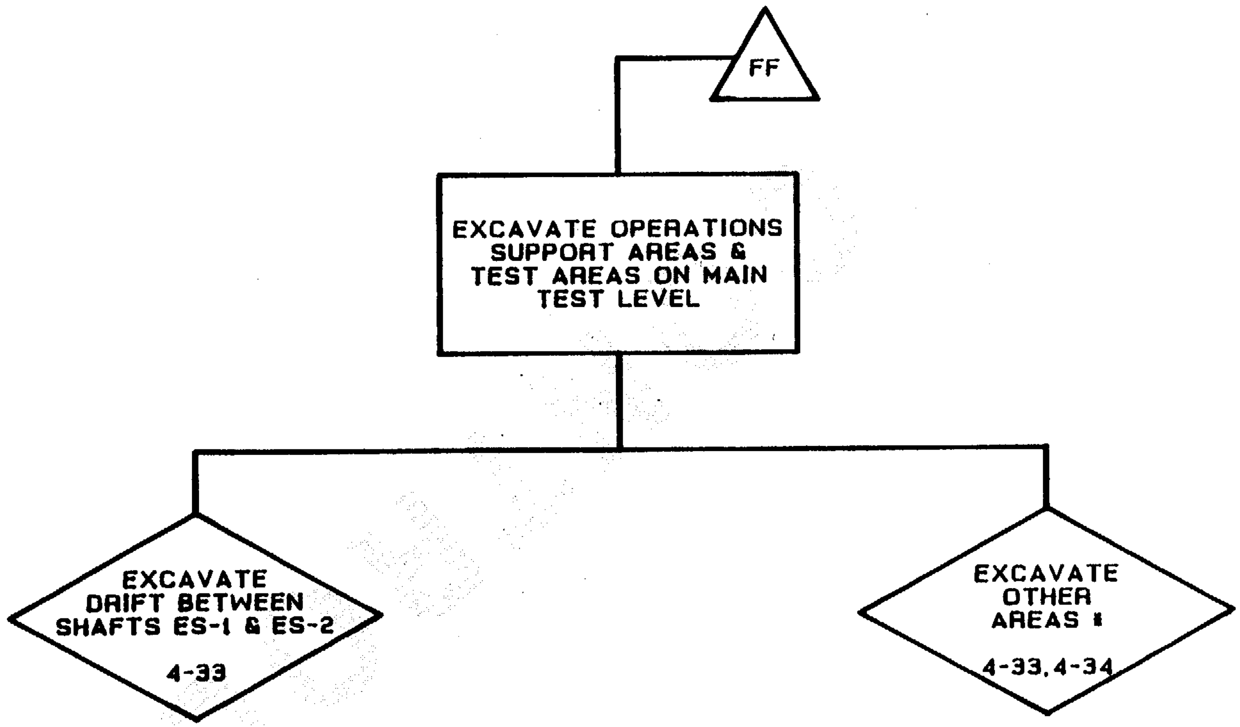


FAE9F37/12-14-88

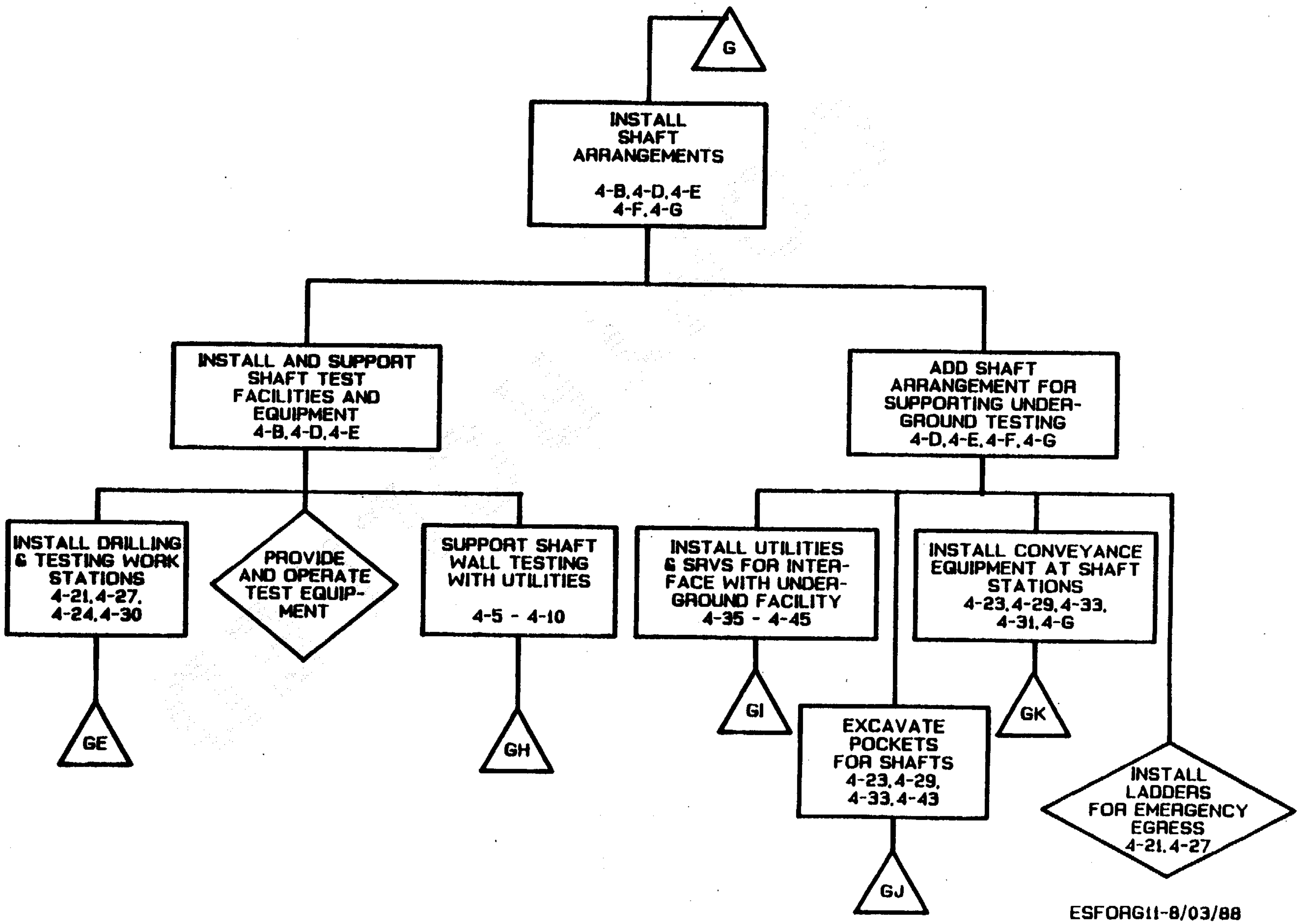


FAESF38 8/9/88

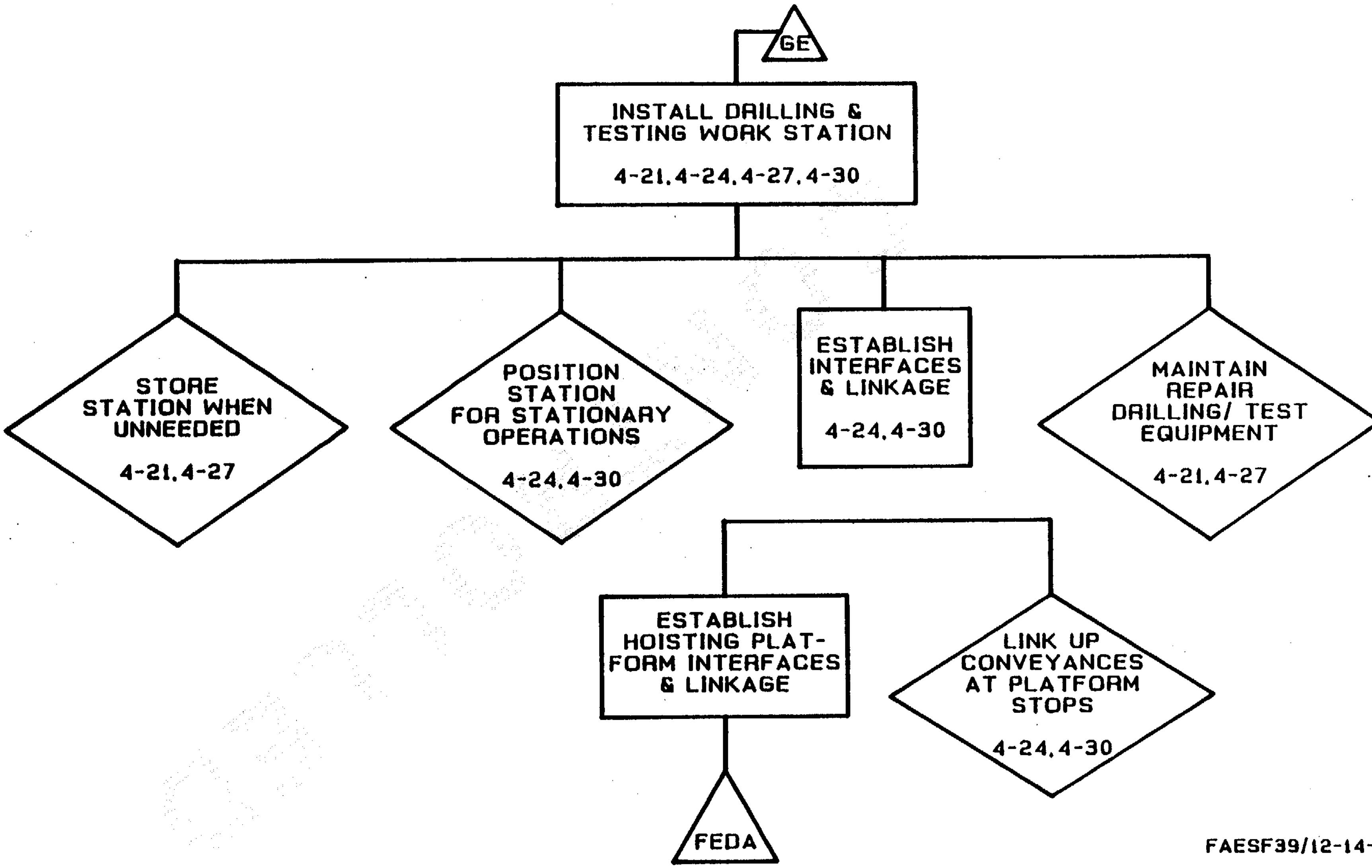


* OTHER AREAS INCLUDE DRIFTS, REFUGE ROOM(S), UNDERGROUND SHOP(S), LUNCH ROOM(S), STORAGE FACILITIES, MAINTENANCE SHOP(S), POWER DISTRIBUTION, FUEL STORAGE, EQUIPMENT STORAGE, TEST AREAS, AND OTHER UNDERGROUND OPENINGS.

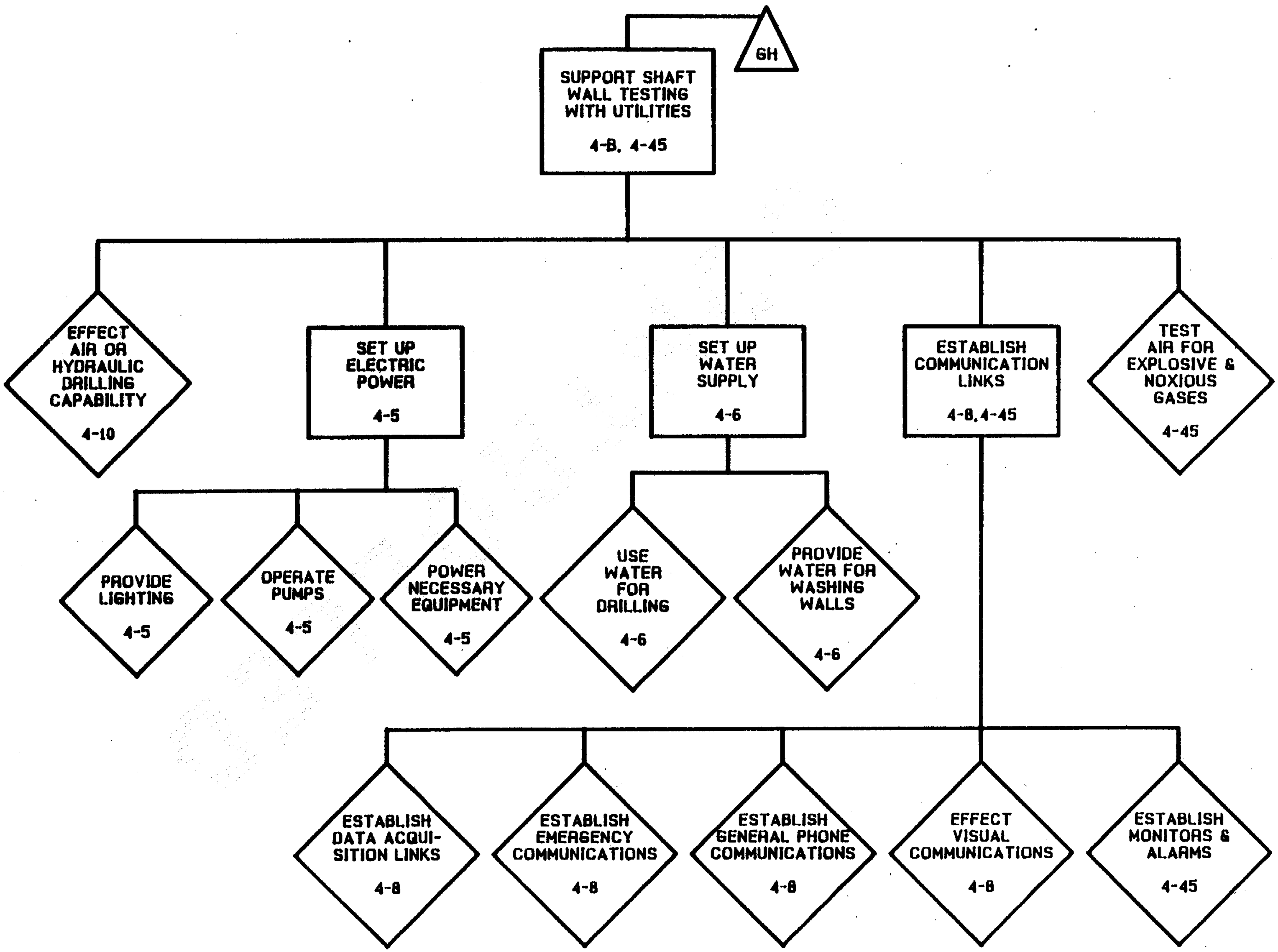
FAESF46/12-14-88



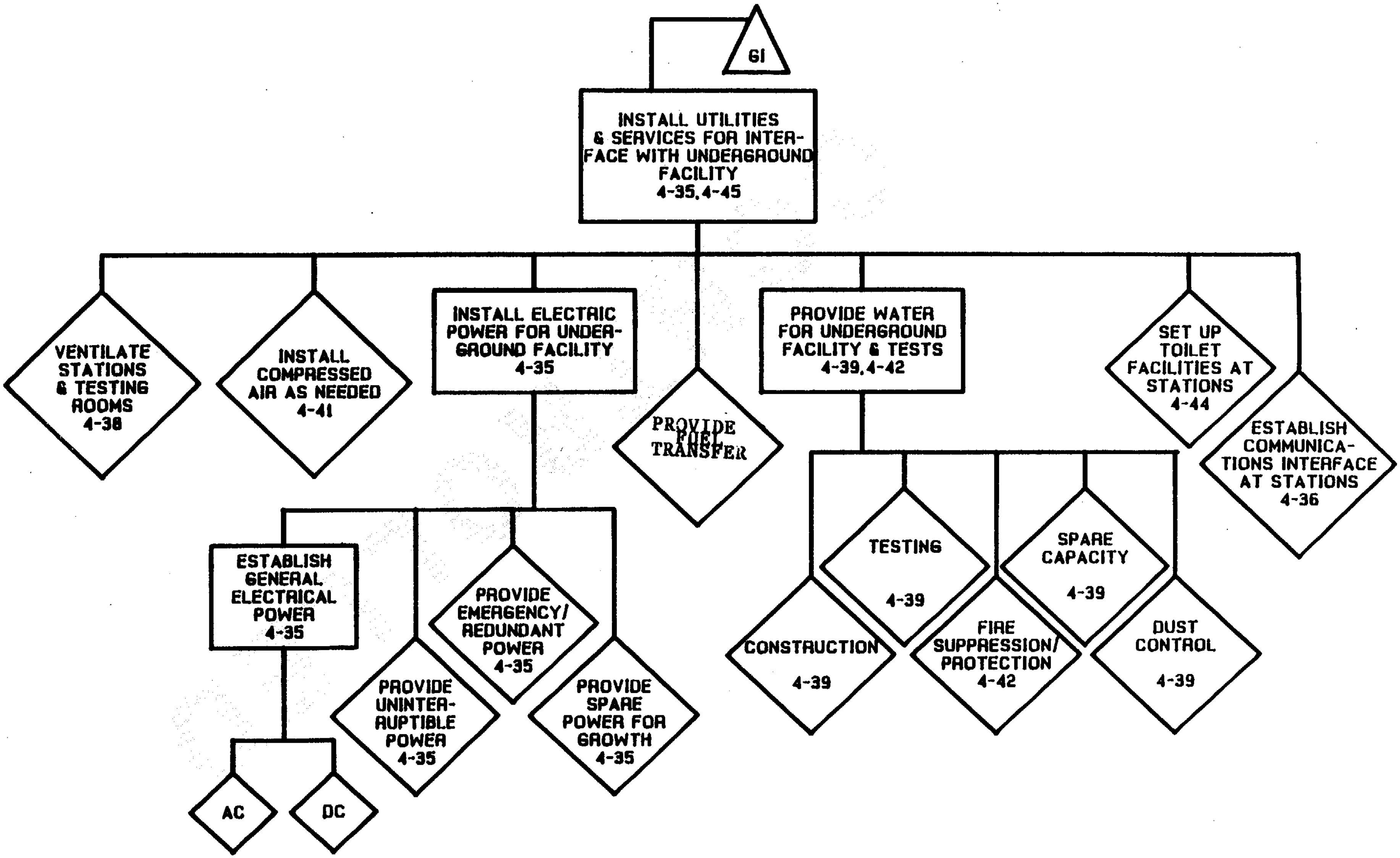
ESFORG11-8/03/88



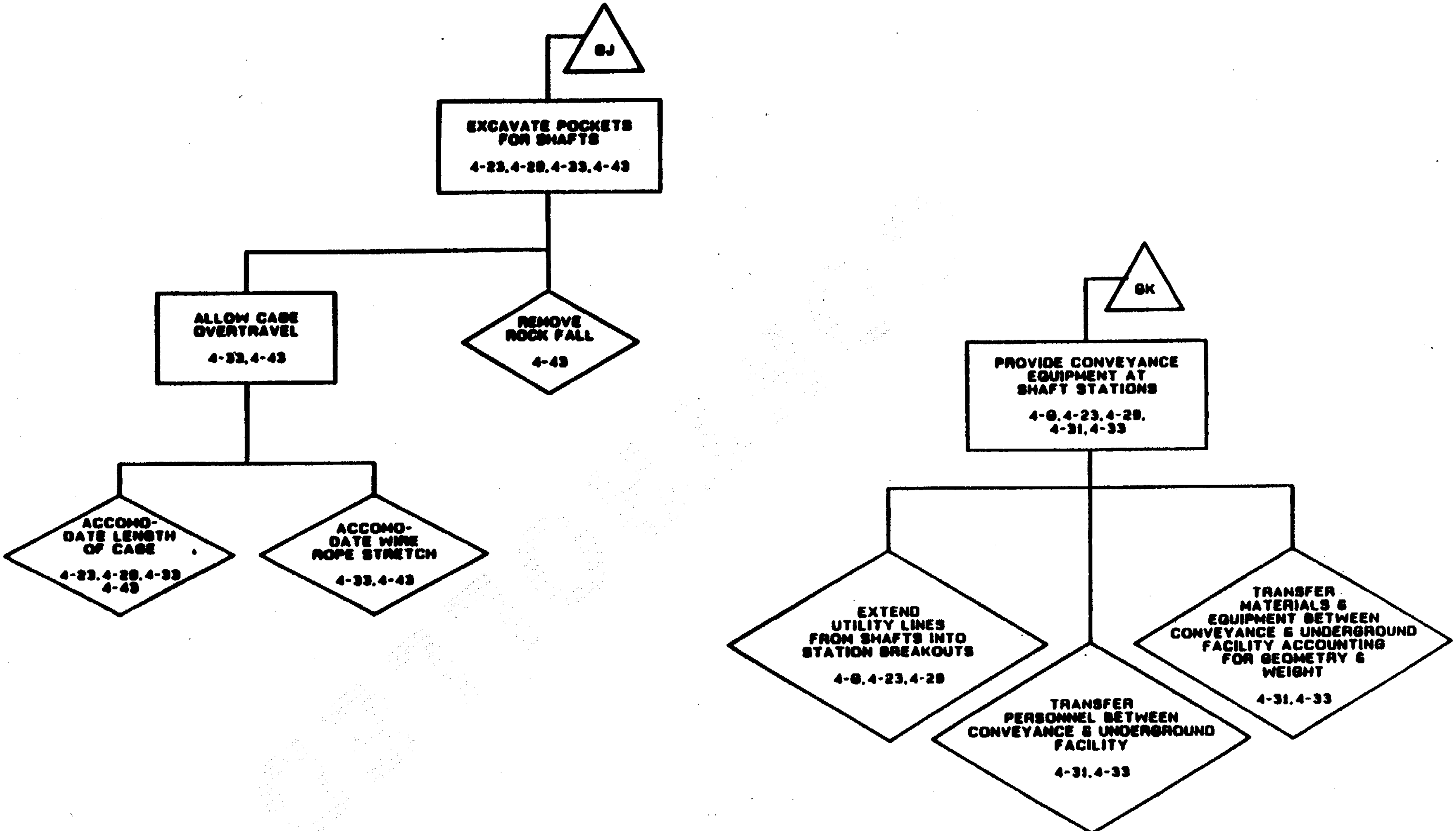
FAESF39/12-14-88



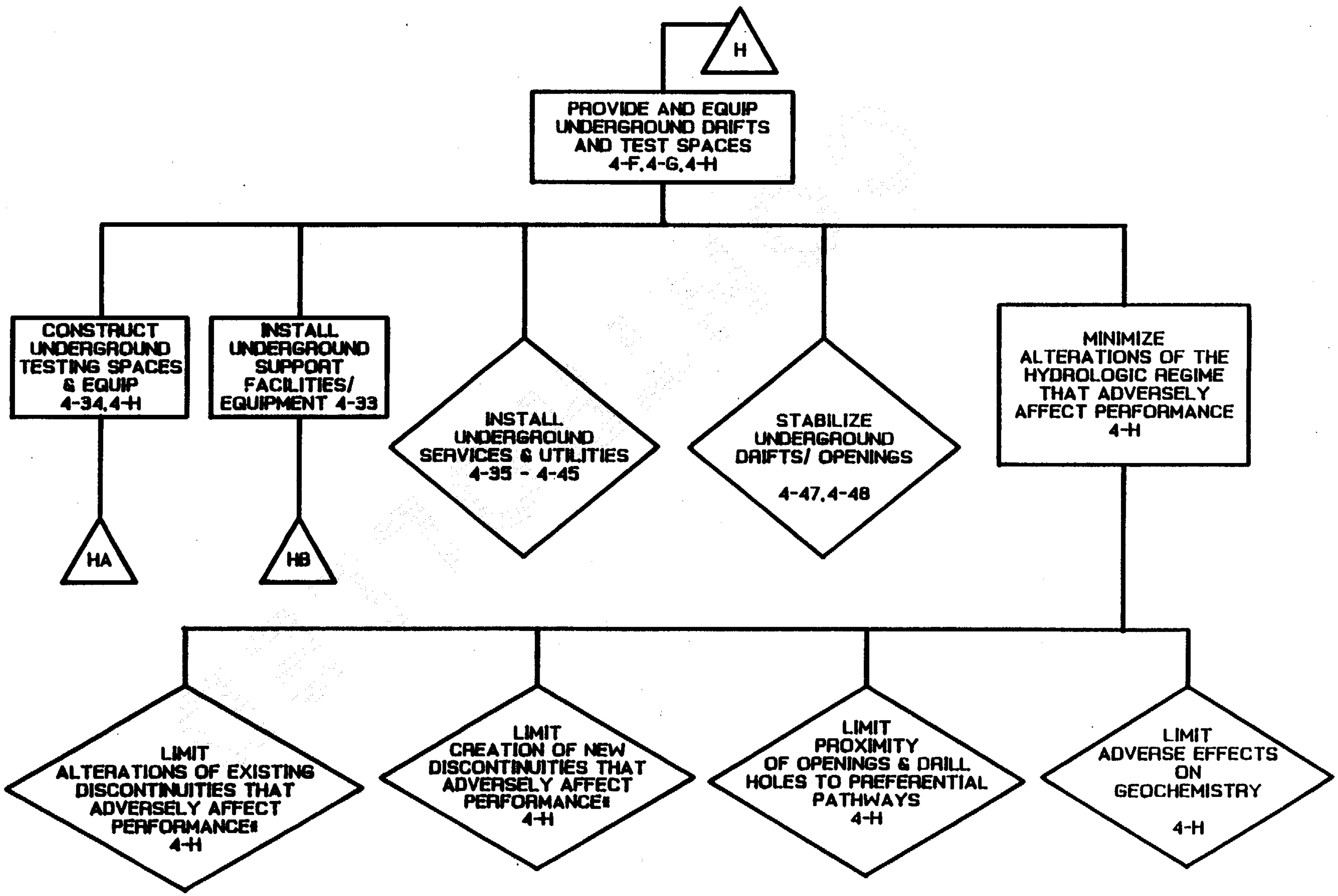
FAESF40/1-17-89



FAESF41/1-17-89

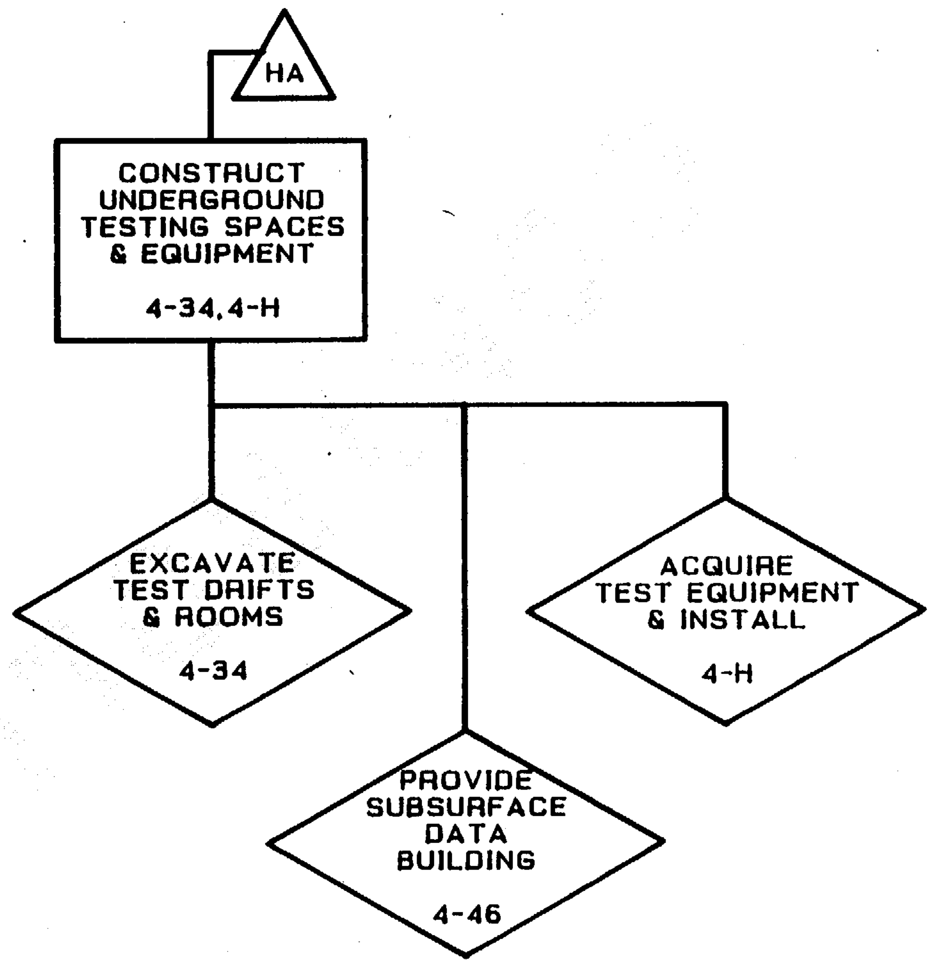


FAESF42 8/9/88

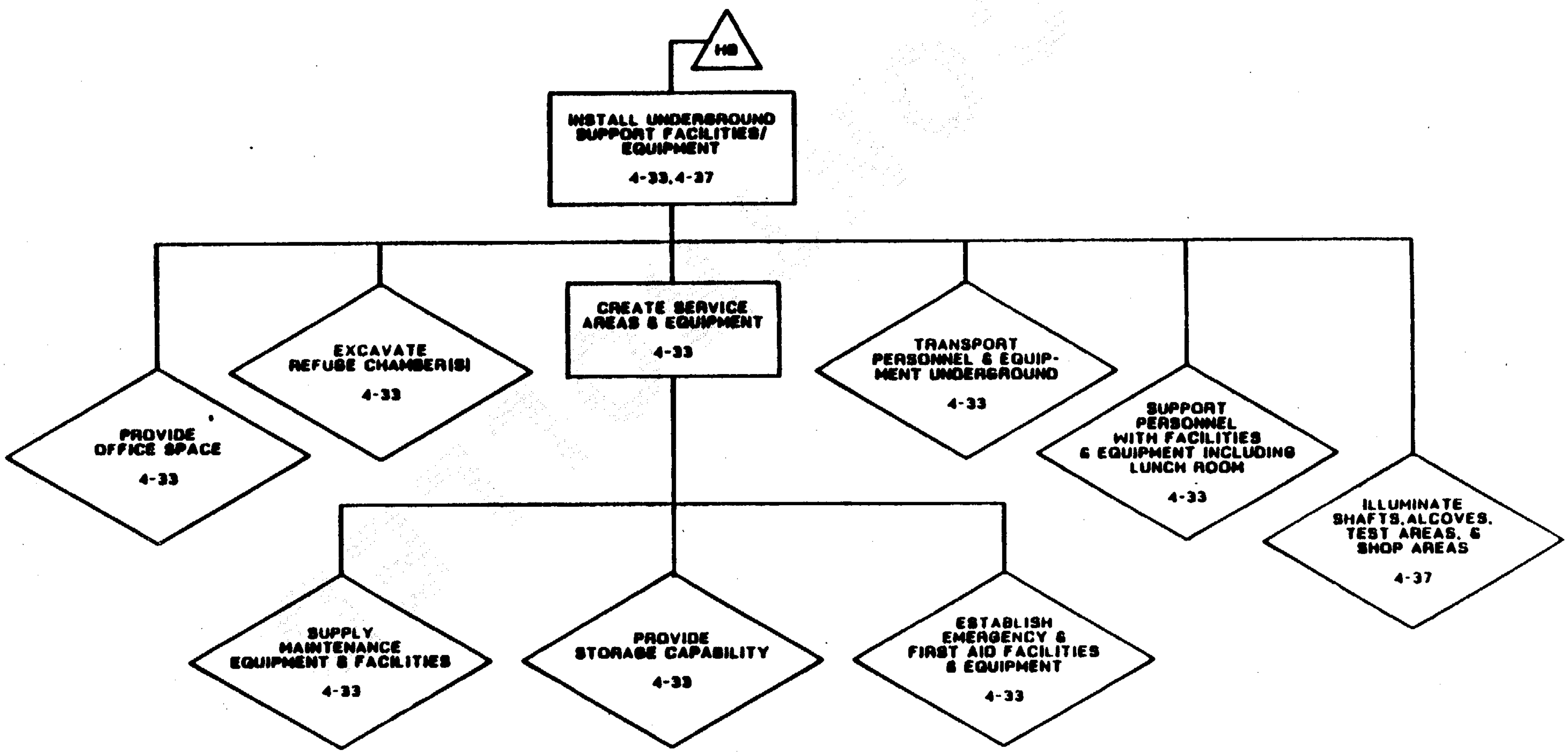


PREFERENTIAL PATHWAYS TO THE ACCESSIBLE ENVIRONMENT

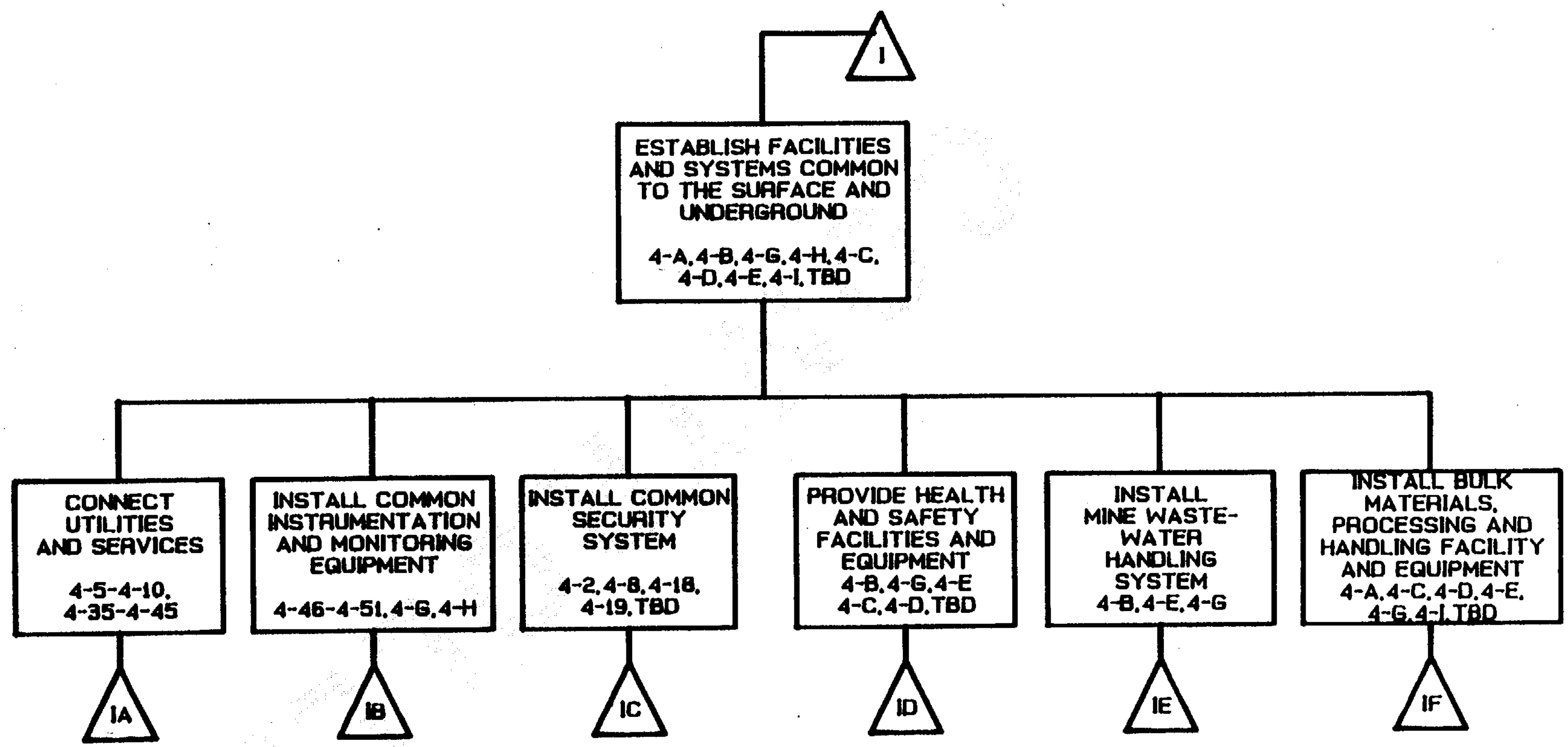
ESFORG6/12-14-88



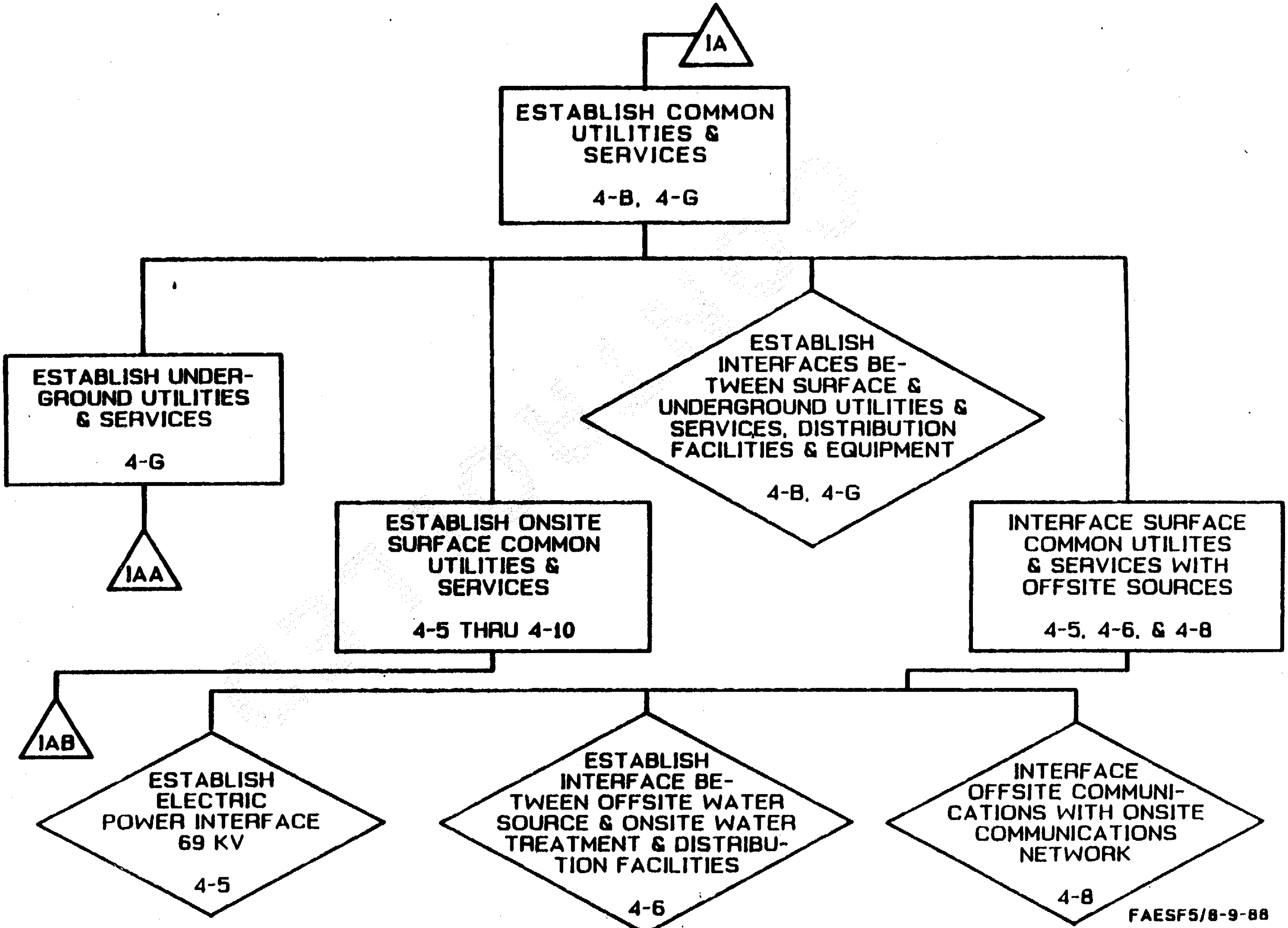
FAESF43/1-17-89

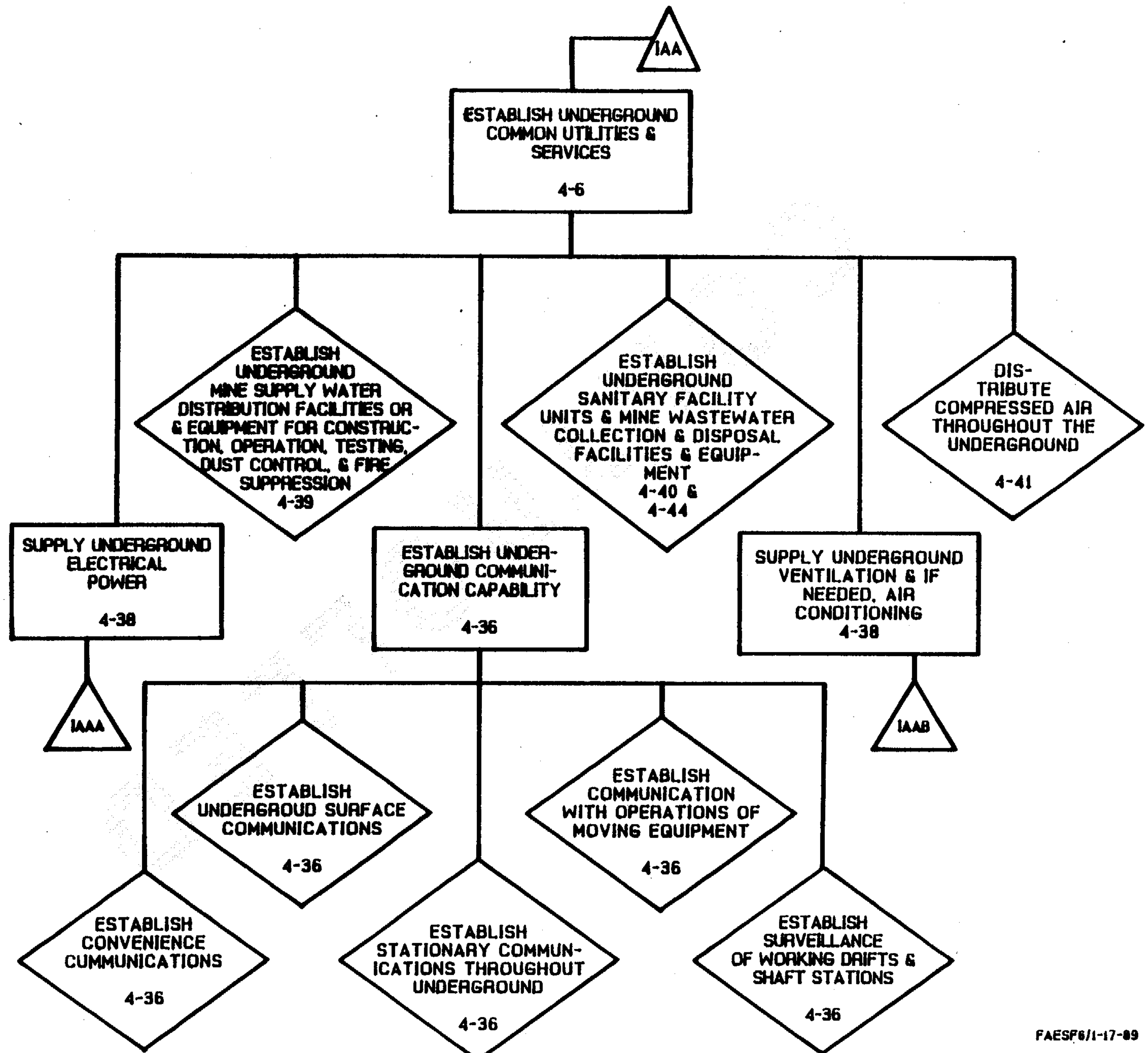


HB
INSTALL UNDERGROUND SUPPORT FACILITIES/ EQUIPMENT
4-33,4-37
PROVIDE OFFICE SPACE
4-33
EXCAVATE REFUSE CHAMBER(S)
4-33
CREATE SERVICE AREAS & EQUIPMENT
4-33
TRANSPORT PERSONNEL & EQUIP-MENT UNDERGROUND
4-33
SUPPORT PERSONNEL WITH FACILITIES & EQUIPMENT INCLUDING LUNCH ROOM
4-33
ILLUMINATE SHAFTS,ALCOVES, TEST AREAS, & SHOP AREAS
4-37
SUPPLY MAINTENANCE EQUIPMENT & FACILITIES
4-33
PROVIDE STORAGE CAPABILITY
4-33
ESTABLISH EMERGENCY & FIRST AID FACILITIES & EQUIPMENT
4-33

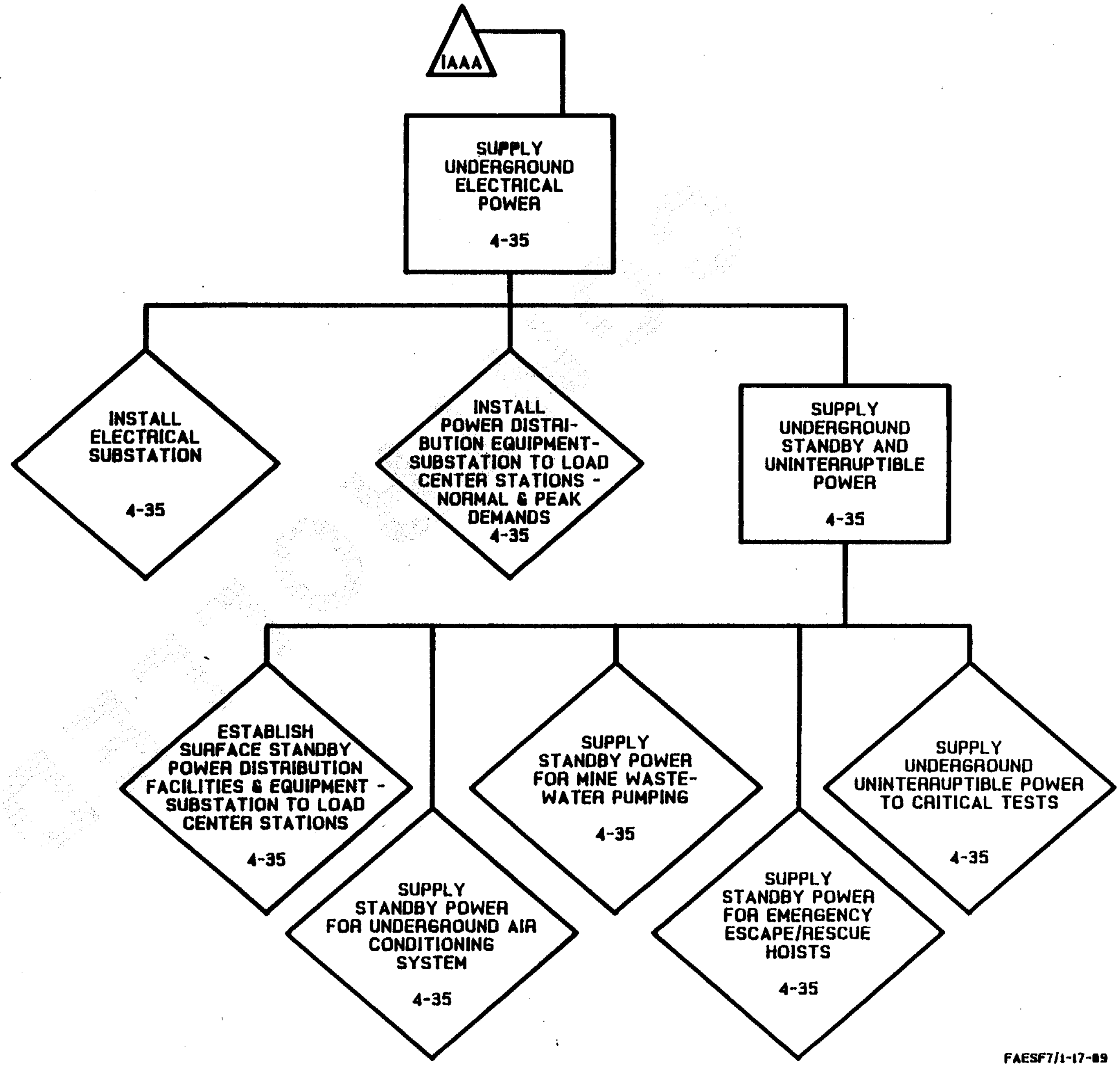


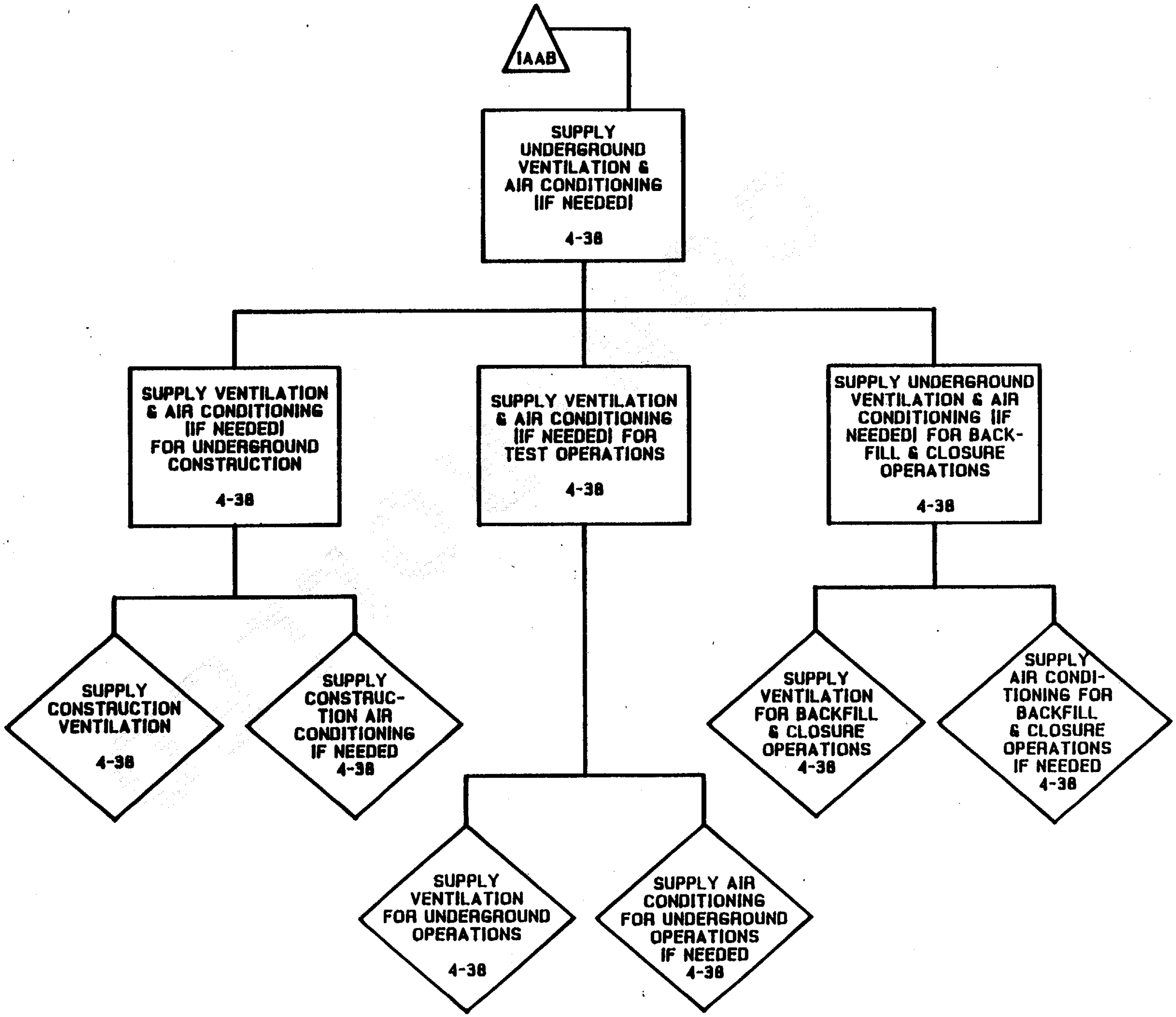
ESFORG10/1-17-89


IA
ESTABLISH COMMON UTILITIES & SERVICES
4-B, 4-G
ESTABLISH UNDERGROUND UTILITIES & SERVICES
4-G
IAA
ESTABLISH ONSITE SURFACE COMMON UTILITIES & SERVICES
4-5 THRU 4-10
ESTABLISH INTERFACES BETWEEN SURFACE & UNDERGROUND UTILITIES & SERVICES, DISTRIBUTION FACILITIES & EQUIPMENT
4-B, 4-G
INTERFACE SURFACE COMMON UTILITES & SERVICES WITH OFFSITE SOURCES
4-5, 4-6, & 4-8
IAB
ESTABLISH ELECTRIC POWER INTERFACE 69 KV
4-5
ESTABLISH INTERFACE BETWEEN OFFSITE WATER SOURCE & ONSITE WATER TREATMENT & DISTRIBUTION FACILITIES
4-6
INTERFACE OFFSITE COMMUNICATIONS WITH ONSITE COMMUNICATIONS NETWORK
4-8
FAESF5/8-9-88



FAESF6/1-17-89


IAAA
SUPPLY UNDERGROUND ELECTRICAL POWER 4-35
INSTALL ELECTRICAL SUBSTATION 4-35
INSTALL POWER DISTRIBUTION EQUIPMENT-SUBSTATION TO LOAD CENTER STATIONS - NORMAL & PEAK DEMANDS 4-35
SUPPLY UNDERGROUND STANDBY AND UNINTERRUPTIBLE POWER 4-35
ESTABLISH SURFACE STANDBY POWER DISTRIBUTION FACILITIES & EQUIPMENT - SUBSTATION TO LOAD CENTER STATIONS 4-35
SUPPLY STANDBY POWER FOR UNDERGROUND AIR CONDITIONING SYSTEM 4-35
SUPPLY STANDBY POWER FOR MINE WASTE-WATER PUMPING 4-35
SUPPLY STANDBY POWER FOR EMERGENCY ESCAPE/RESCUE HOISTS 4-35
SUPPLY UNDERGROUND UNINTERRUPTIBLE POWER TO CRITICAL TESTS 4-35
FAESF7/1-17-89



FAESF8/12-14-88

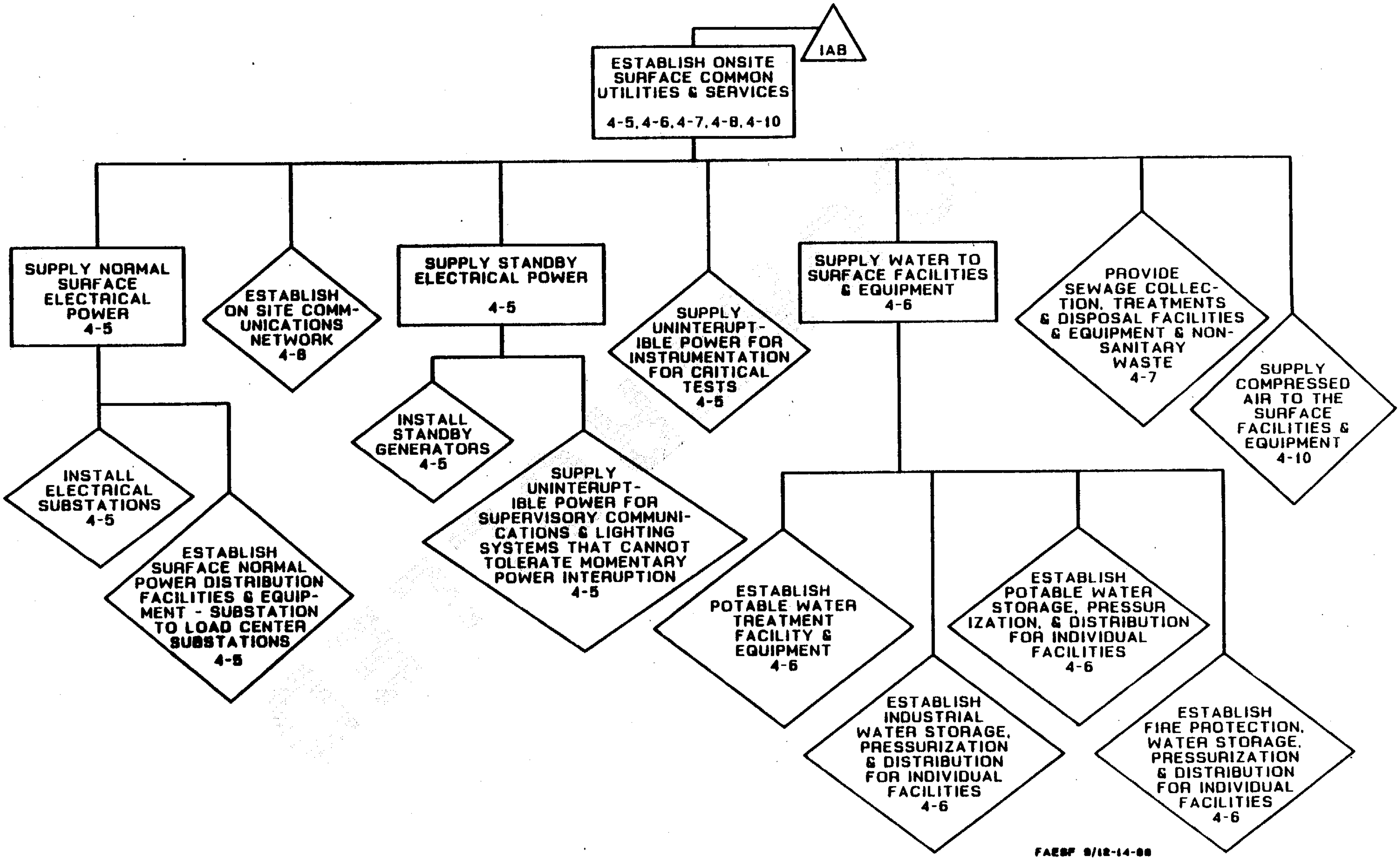
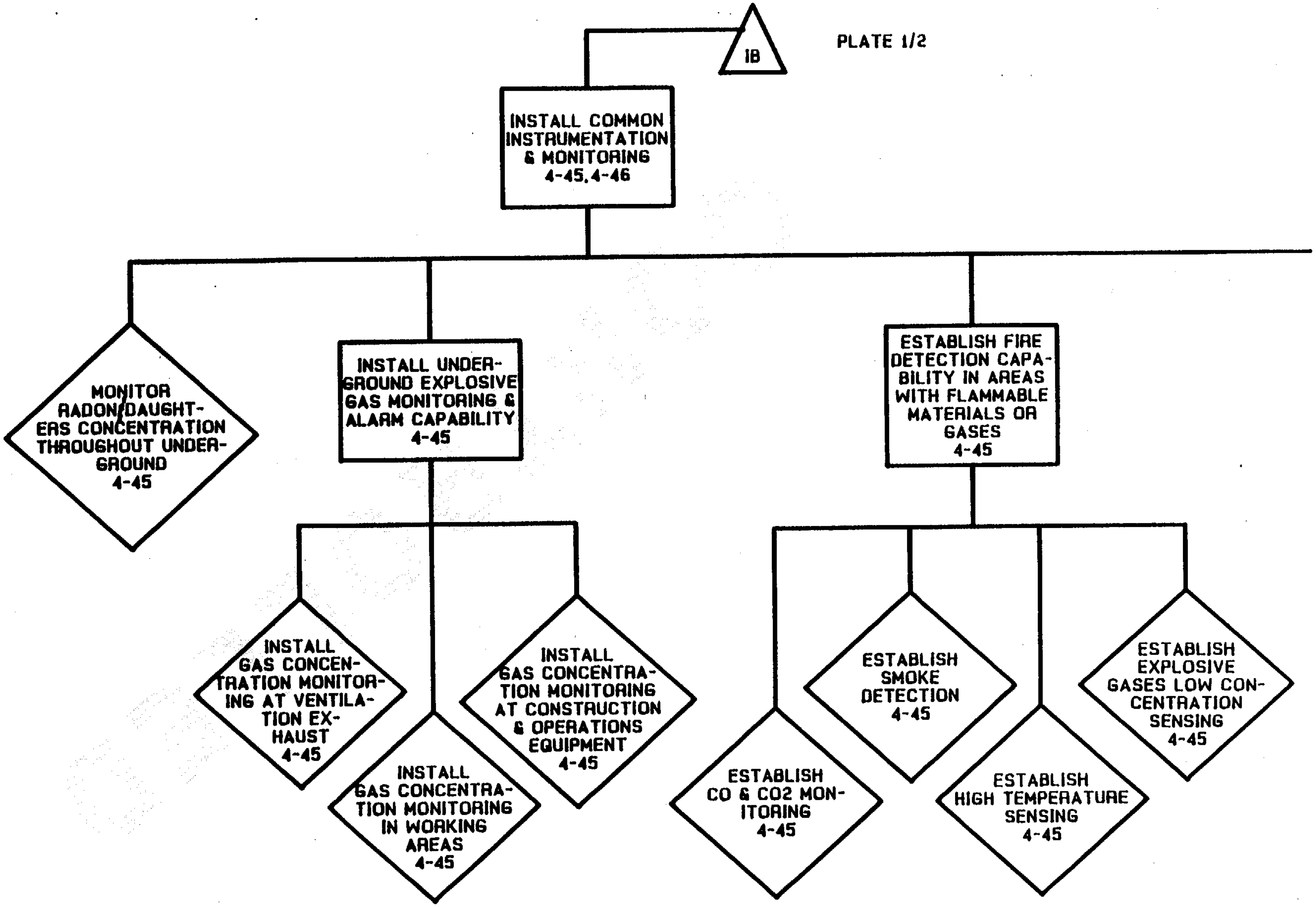
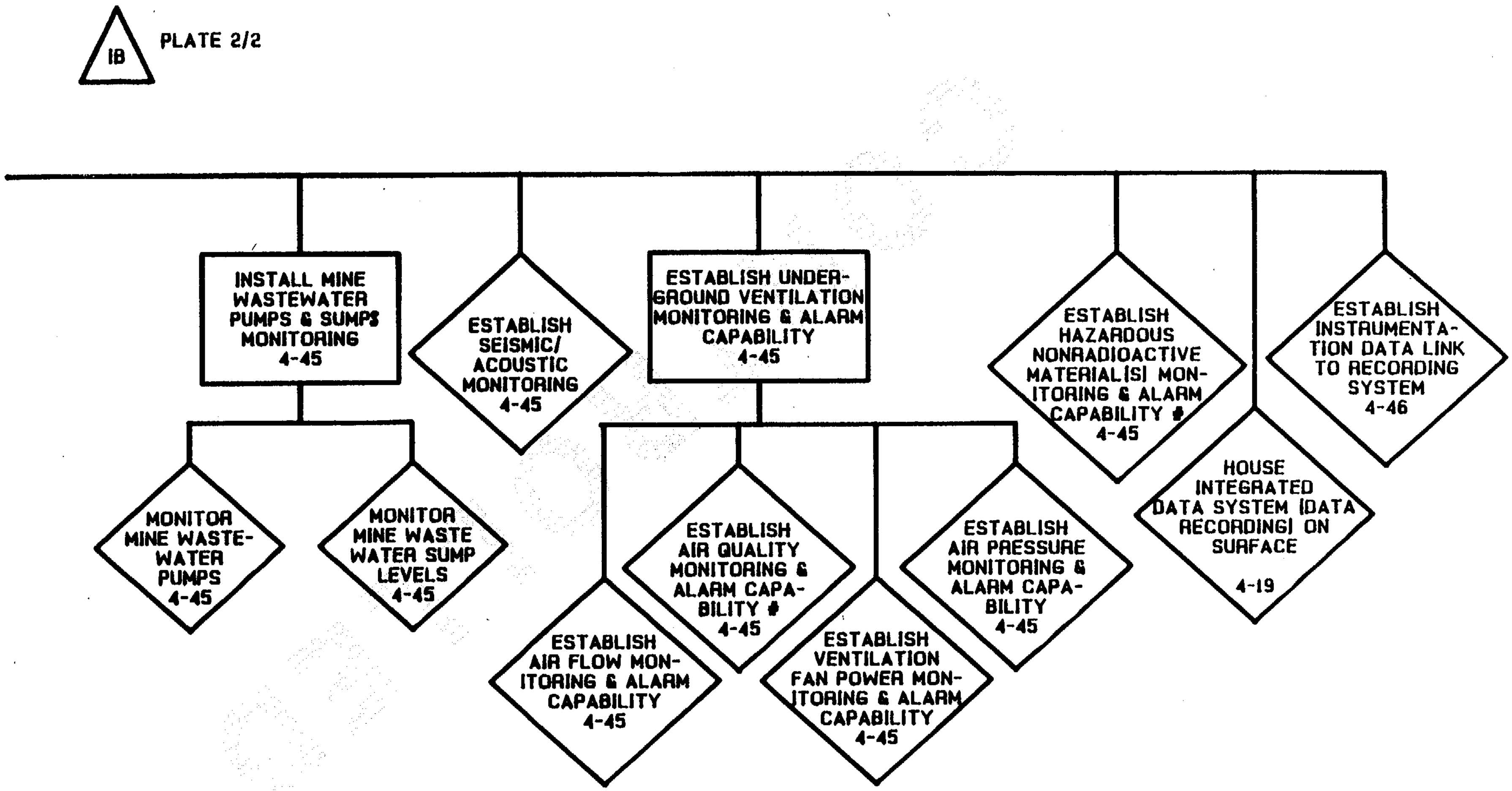

IAB
ESTABLISH ONSITE SURFACE COMMON UTILITIES & SERVICES 4-5, 4-6, 4-7, 4-8, 4-10
SUPPLY NORMAL SURFACE ELECTRICAL POWER 4-5
ESTABLISH ON SITE COMMUNICATIONS NETWORK 4-8
SUPPLY STANDBY ELECTRICAL POWER 4-5
SUPPLY UNINTERUPTIBLE POWER FOR INSTRUMENTATION FOR CRITICAL TESTS 4-5
SUPPLY WATER TO SURFACE FACILITIES & EQUIPMENT 4-6
PROVIDE SEWAGE COLLECTION, TREATMENTS & DISPOSAL FACILITIES & EQUIPMENT & NON-SANITARY WASTE 4-7
SUPPLY COMPRESSED AIR TO THE SURFACE FACILITIES & EQUIPMENT 4-10
INSTALL ELECTRICAL SUBSTATIONS 4-5
ESTABLISH SURFACE NORMAL POWER DISTRIBUTION FACILITIES & EQUIPMENT - SUBSTATION TO LOAD CENTER SUBSTATIONS 4-5
INSTALL STANDBY GENERATORS 4-5
SUPPLY UNINTERUPTIBLE POWER FOR SUPERVISORY COMMUNICATIONS & LIGHTING SYSTEMS THAT CANNOT TOLERATE MOMENTARY POWER INTERUPTION 4-5
ESTABLISH POTABLE WATER TREATMENT FACILITY & EQUIPMENT 4-6
ESTABLISH INDUSTRIAL WATER STORAGE, PRESSURIZATION & DISTRIBUTION FOR INDIVIDUAL FACILITIES 4-6
ESTABLISH POTABLE WATER STORAGE, PRESSURIZATION, & DISTRIBUTION FOR INDIVIDUAL FACILITIES 4-6
ESTABLISH FIRE PROTECTION, WATER STORAGE, PRESSURIZATION & DISTRIBUTION FOR INDIVIDUAL FACILITIES 4-6
FAESF 9/12-14-88

PLATE 1/2

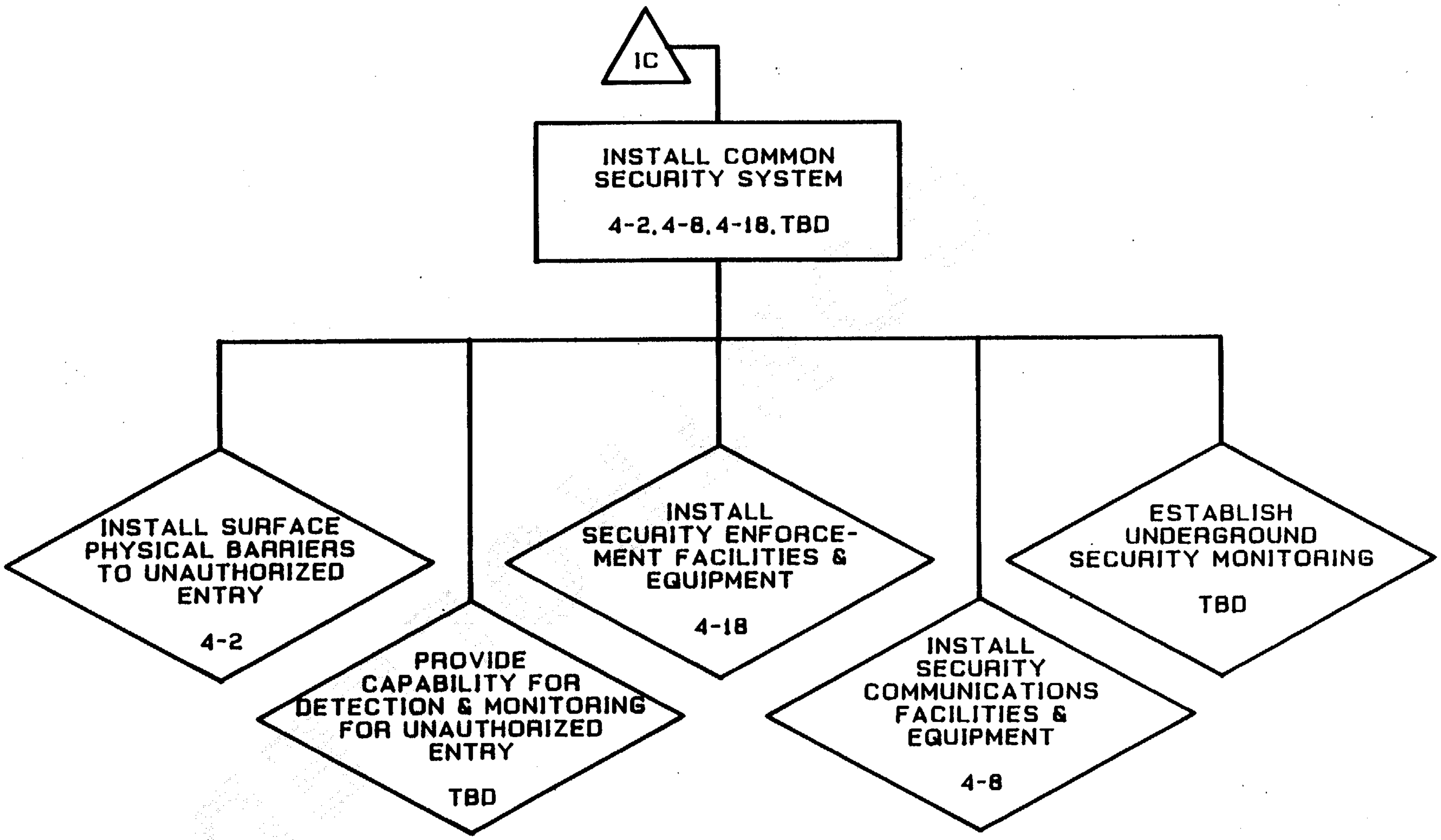


FAESF10A/1-17-89

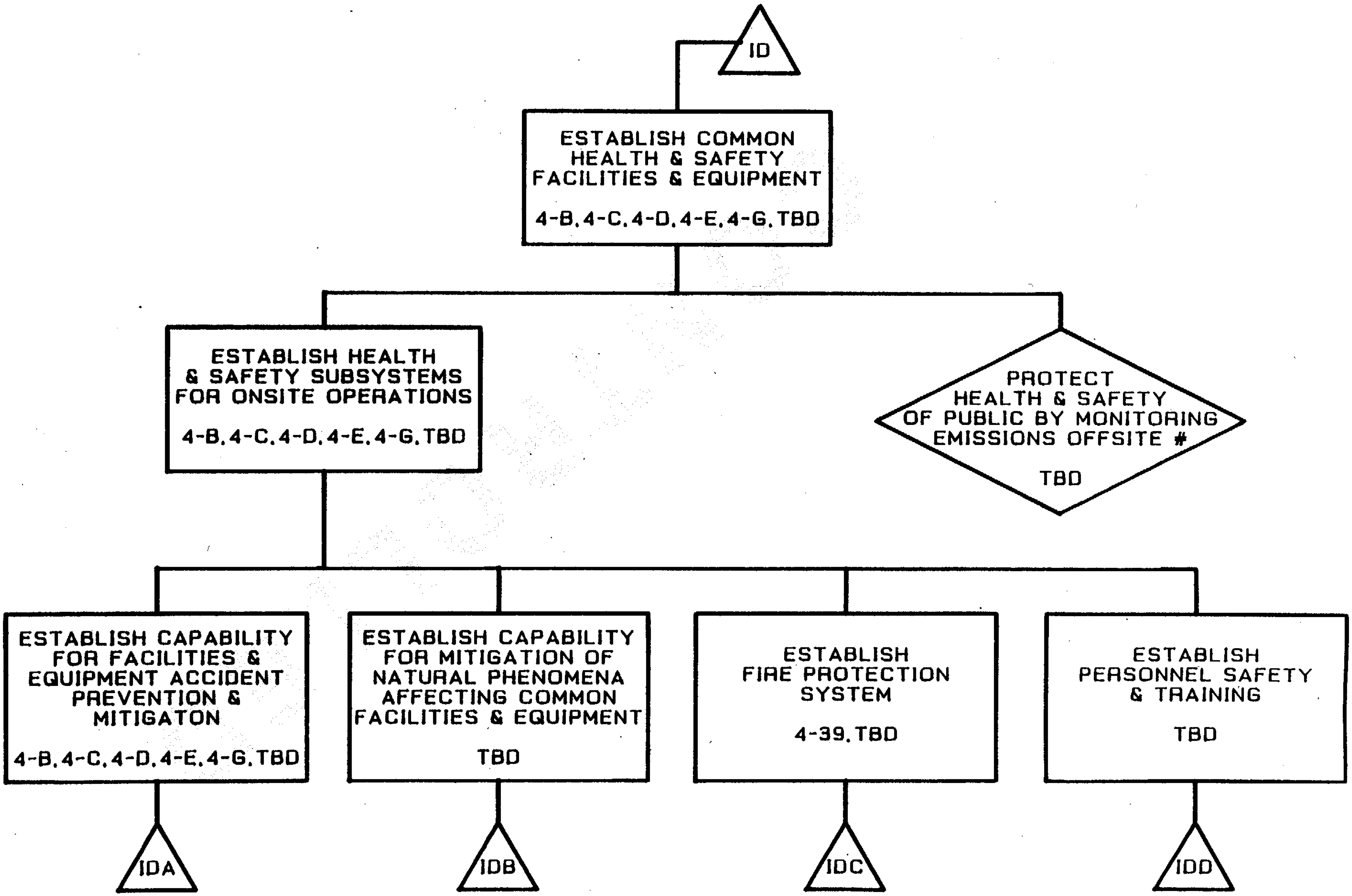


FAESF10B/1-17-89

INCLUDES DUST CONCENTRATION

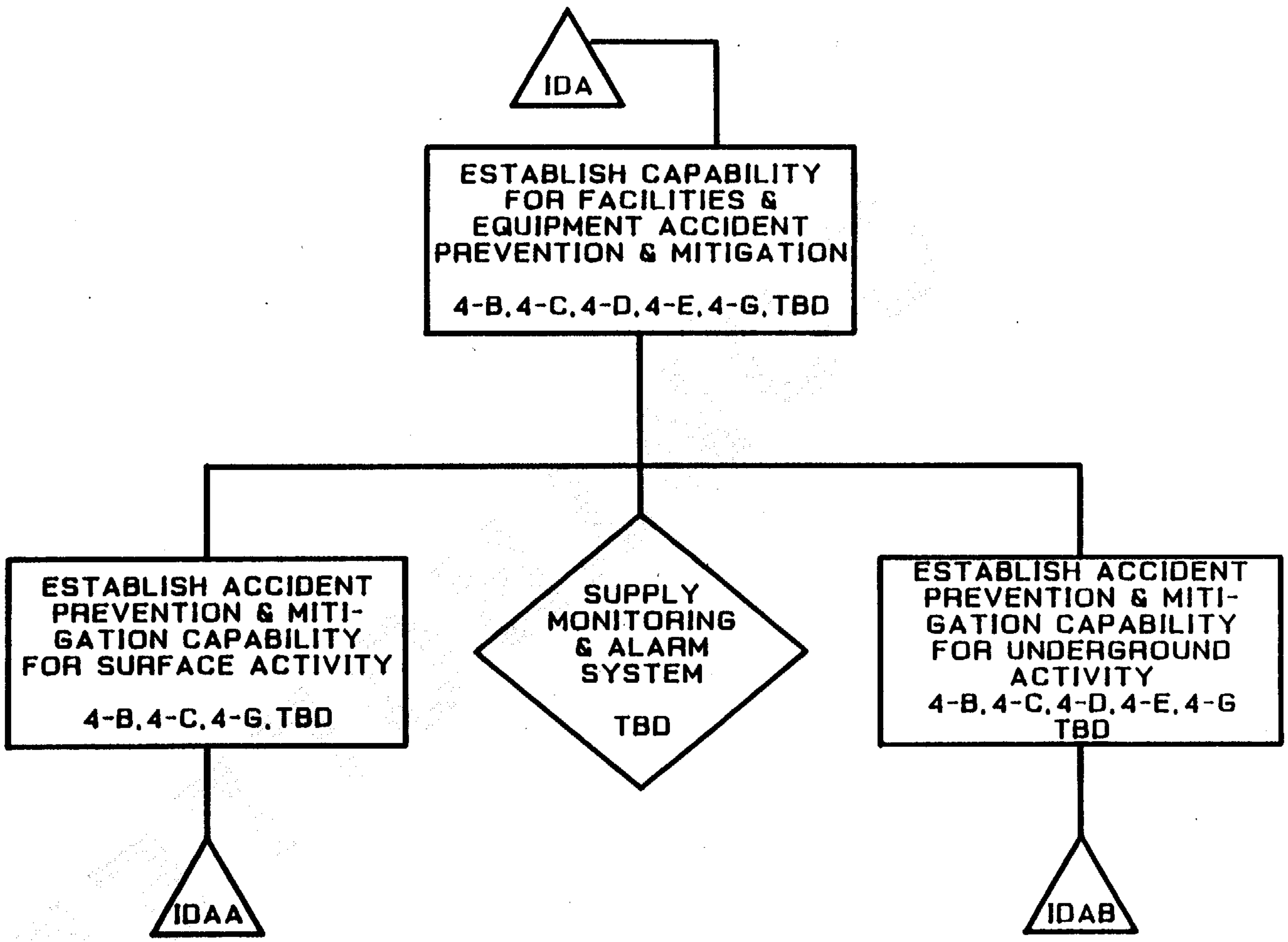


FAESF11/12-14-88

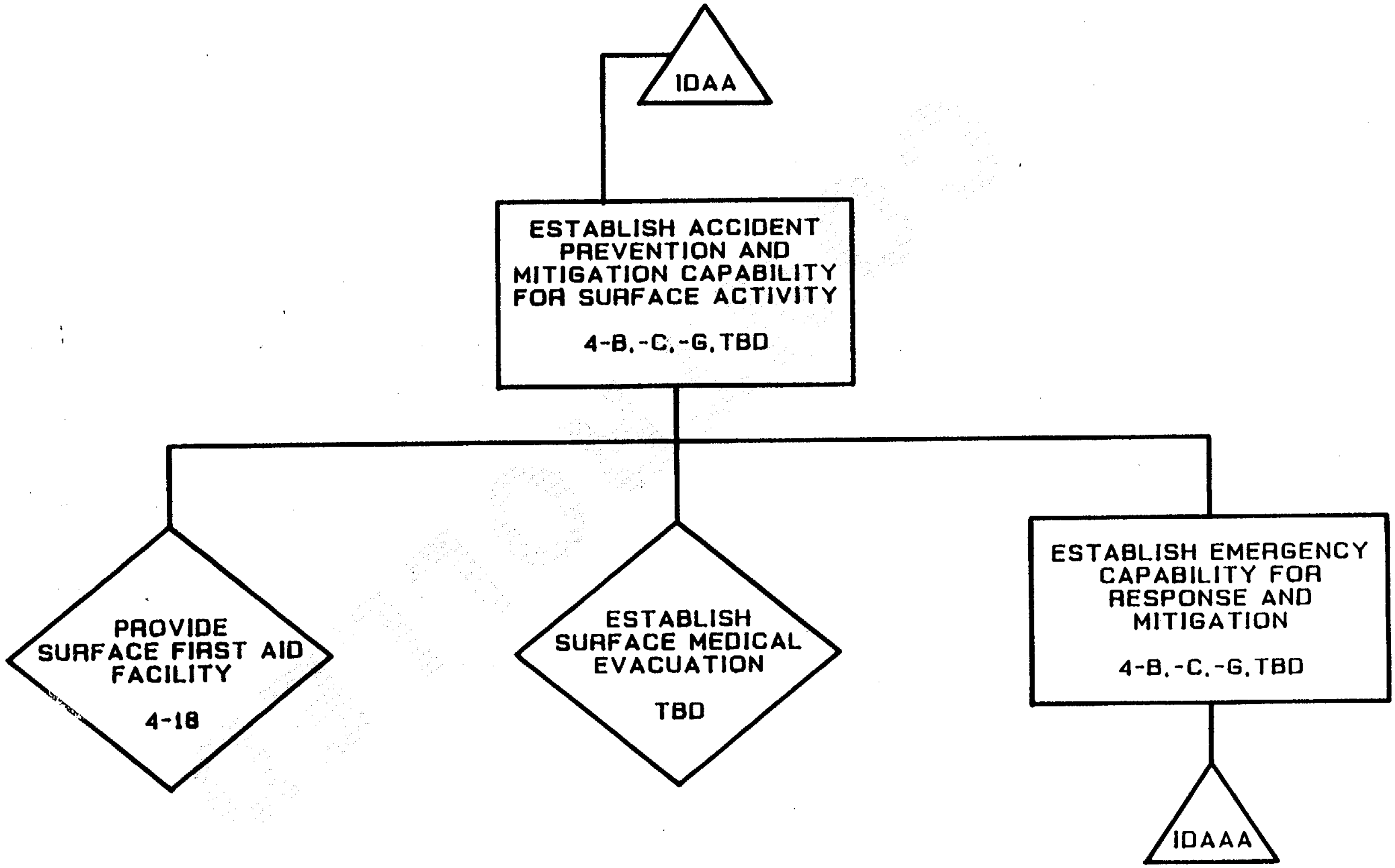


INCLUDES AIR MONITORING AND OTHER FUNCTIONS AS REQUIRED

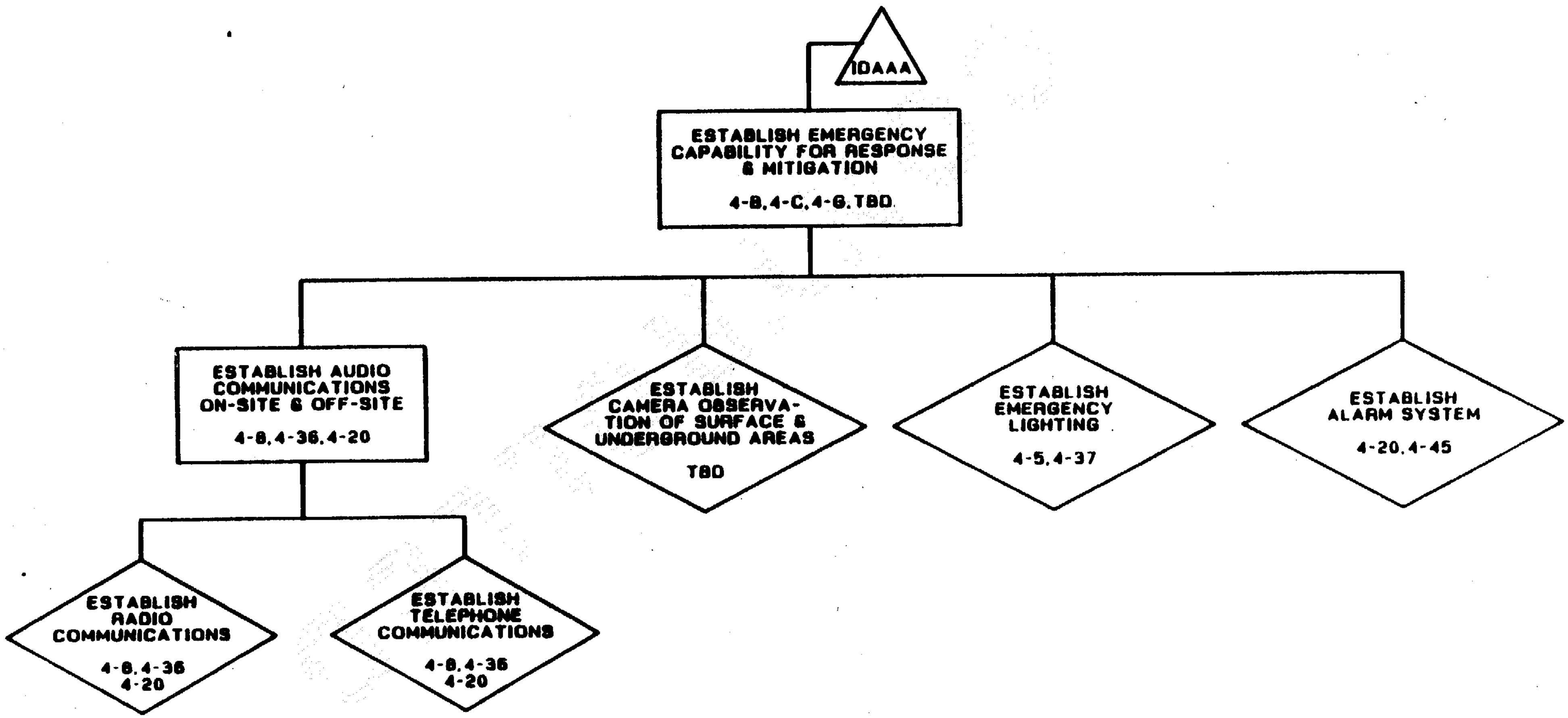
FAESF12/1-17-89



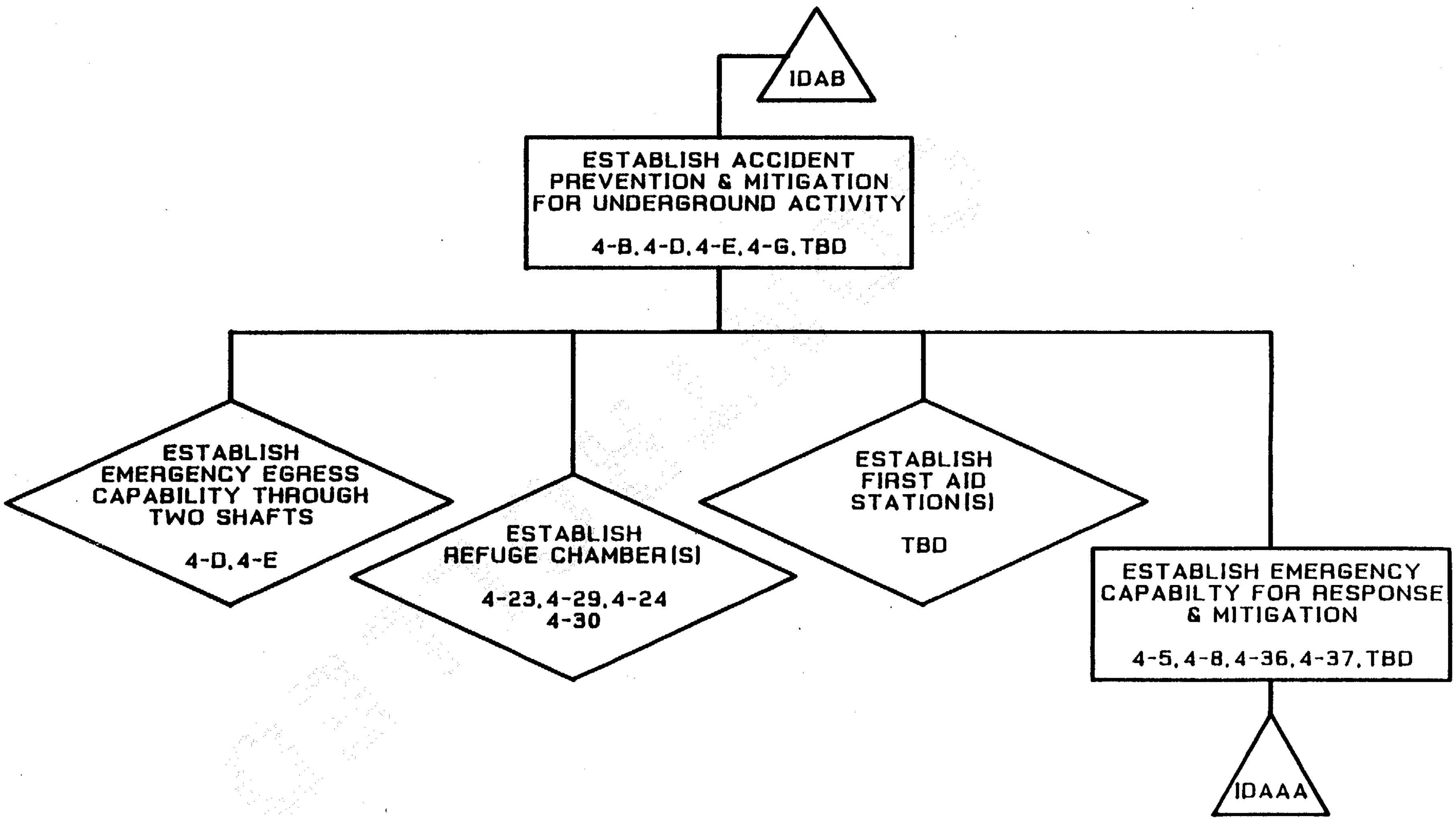
FAESF13/12-14-88



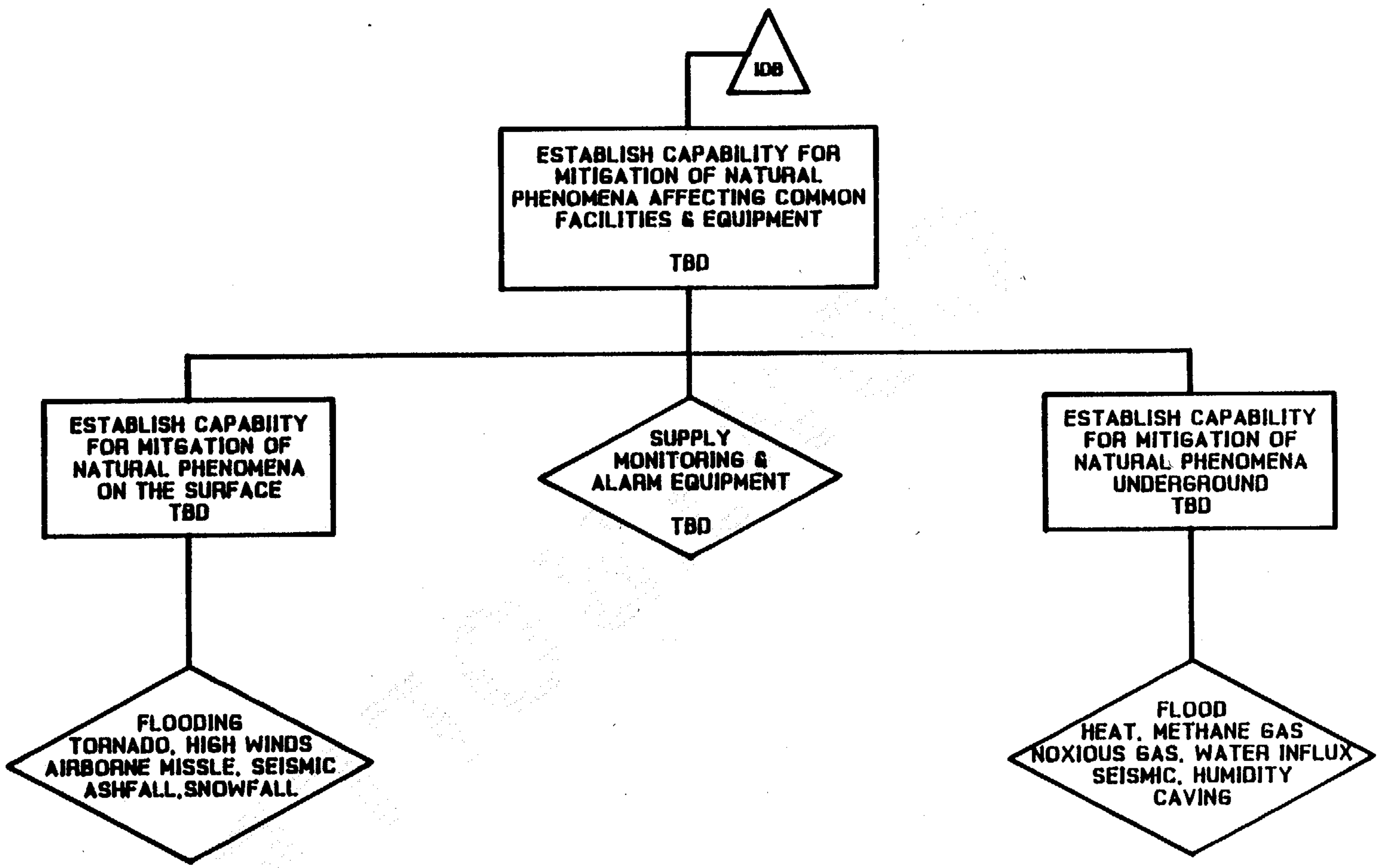
FAESF14/12-14-88



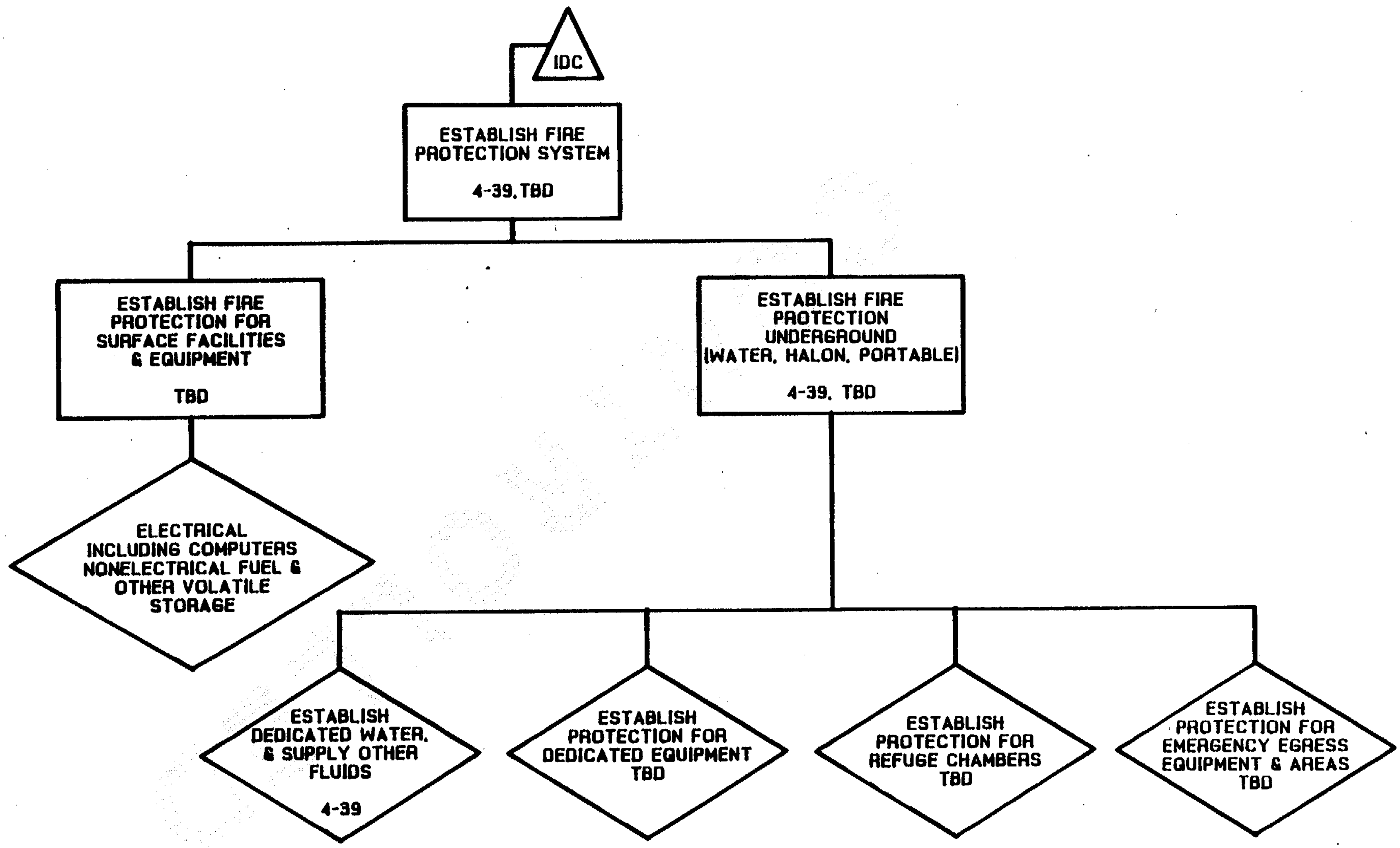
FAESF15 8/9/88



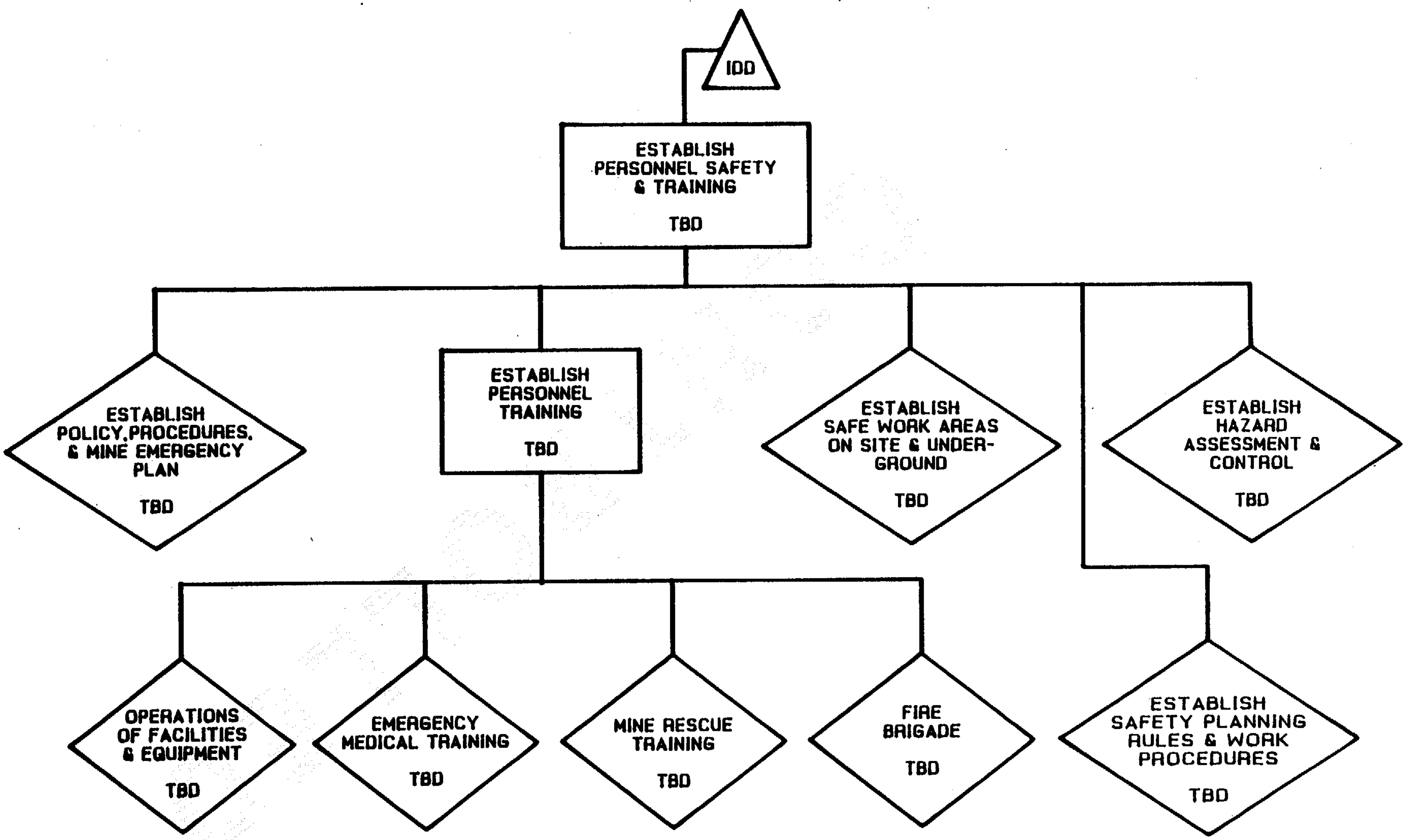
FAESF16/12-14-88



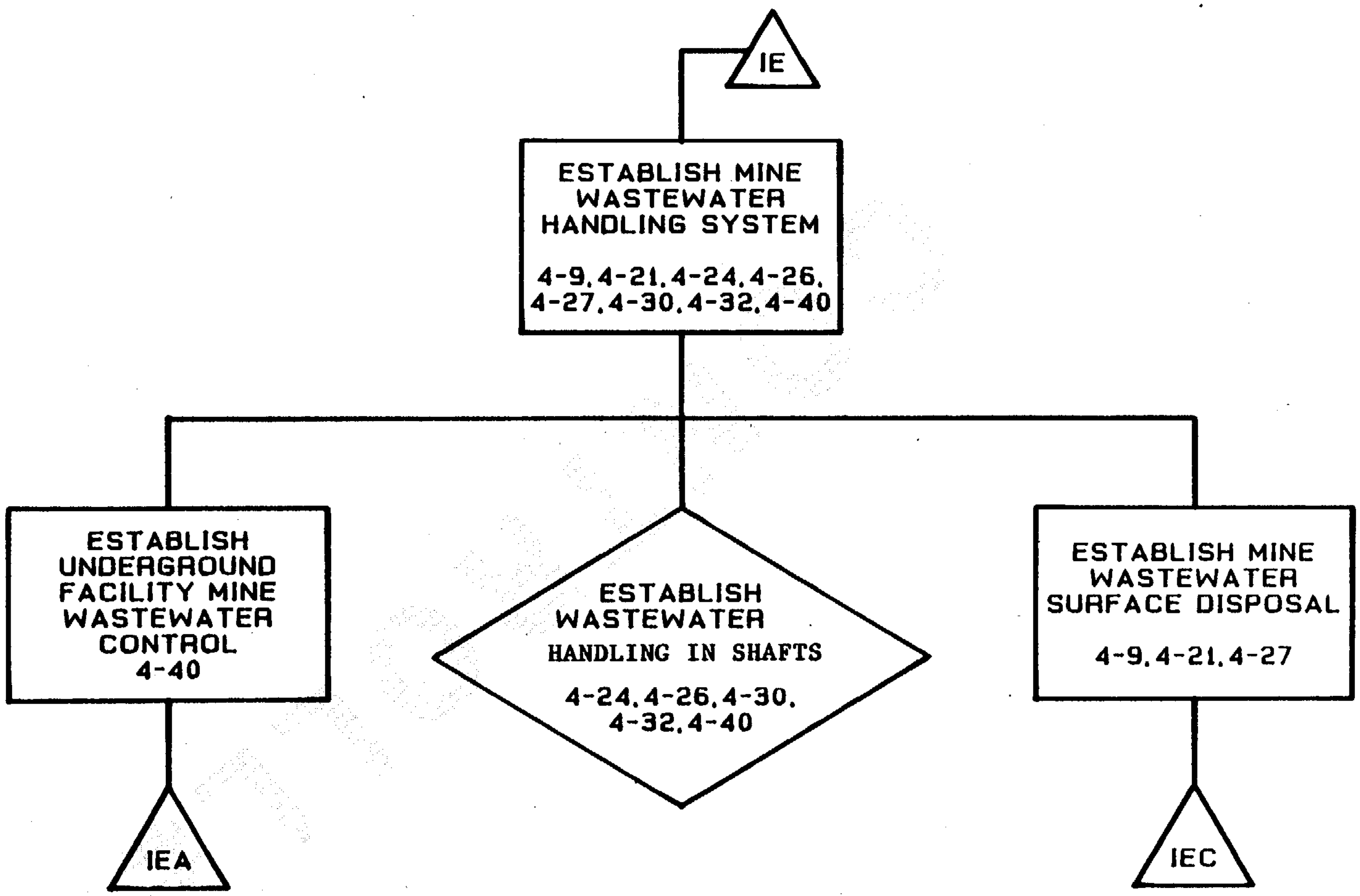
FAESF17/12-14-88



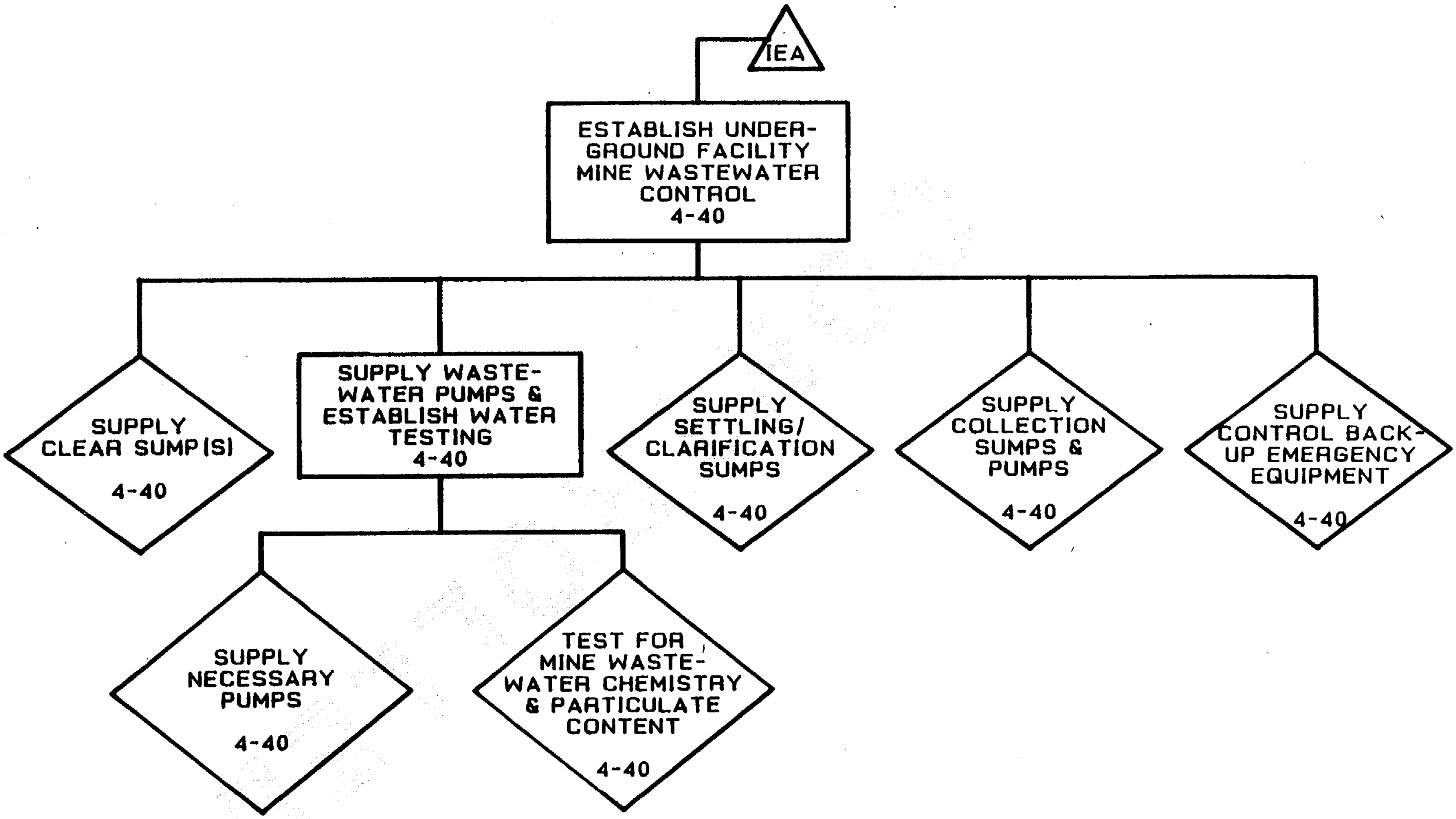
FAESF18/1-17-89



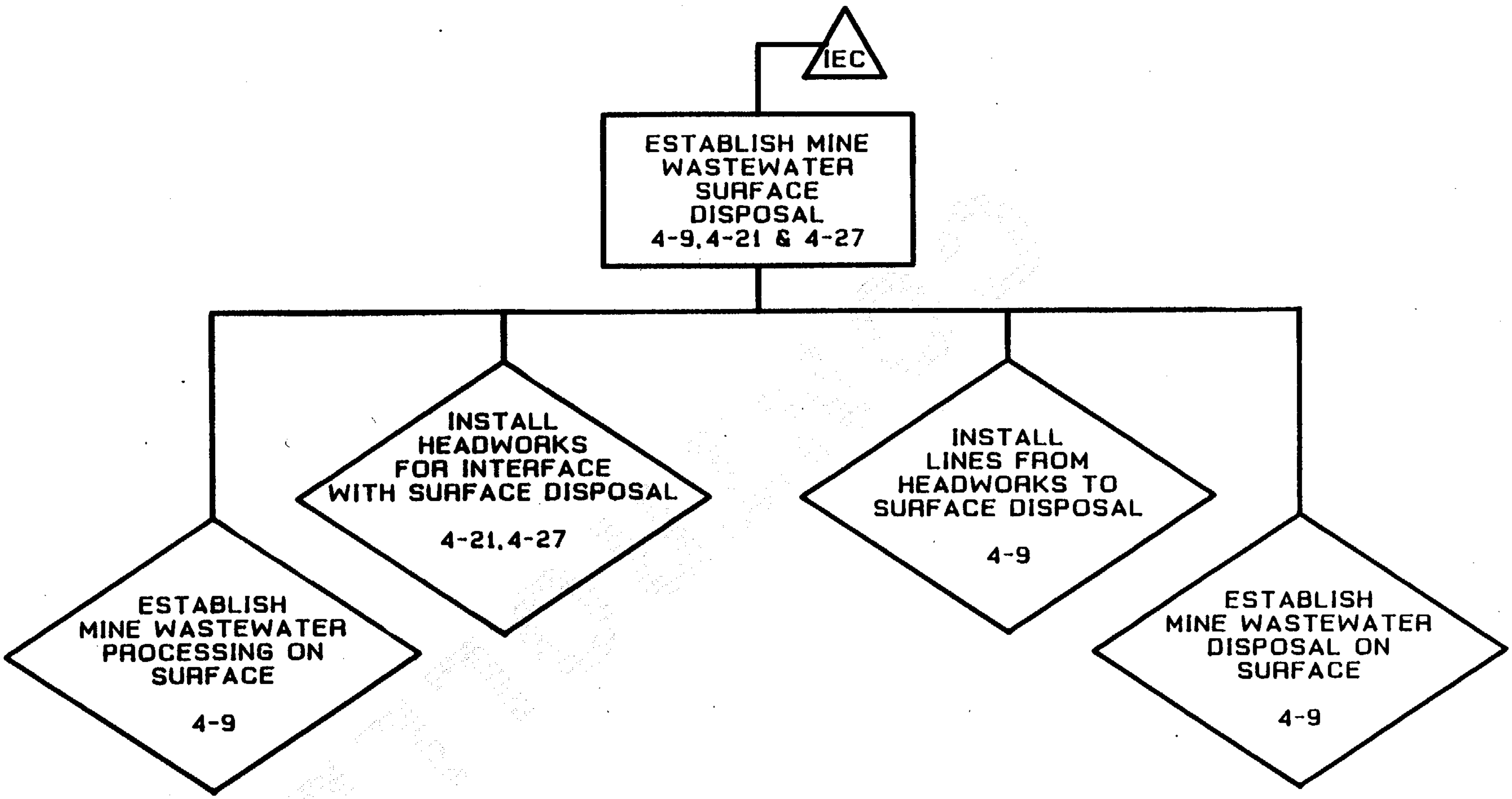
FAESF19/1-17-89



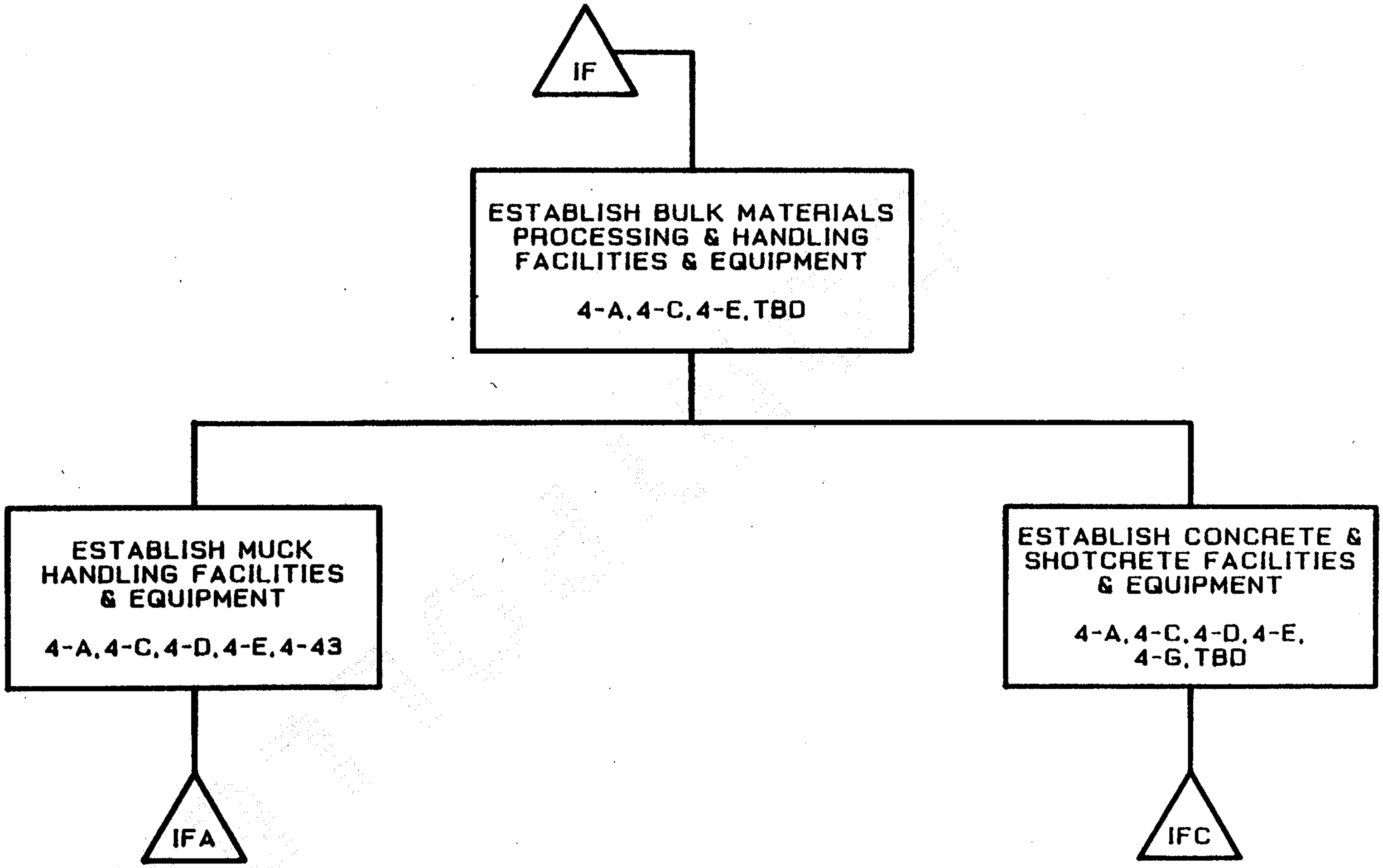
FAESF20/1-17-89



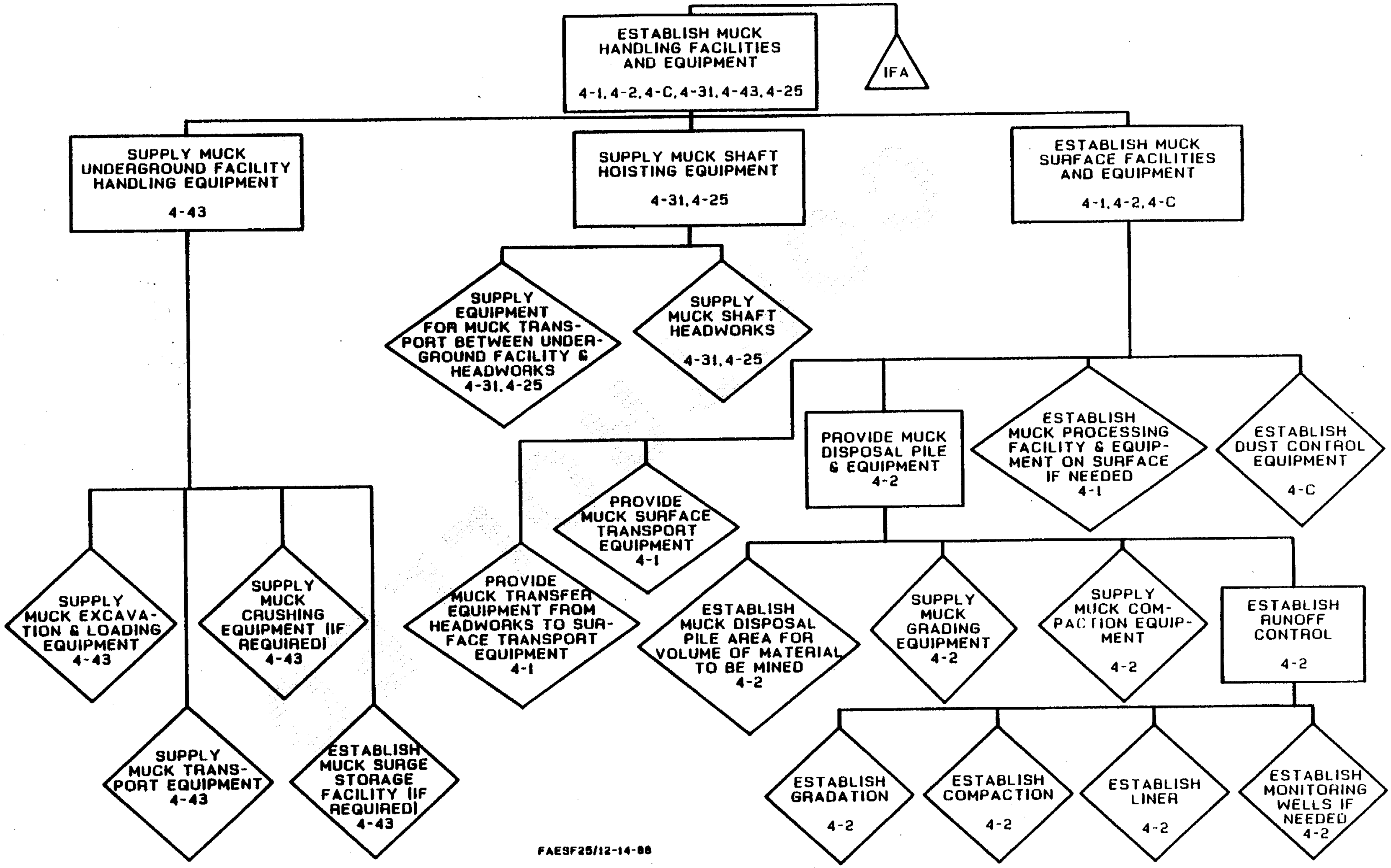
FAESF21/1-17-89



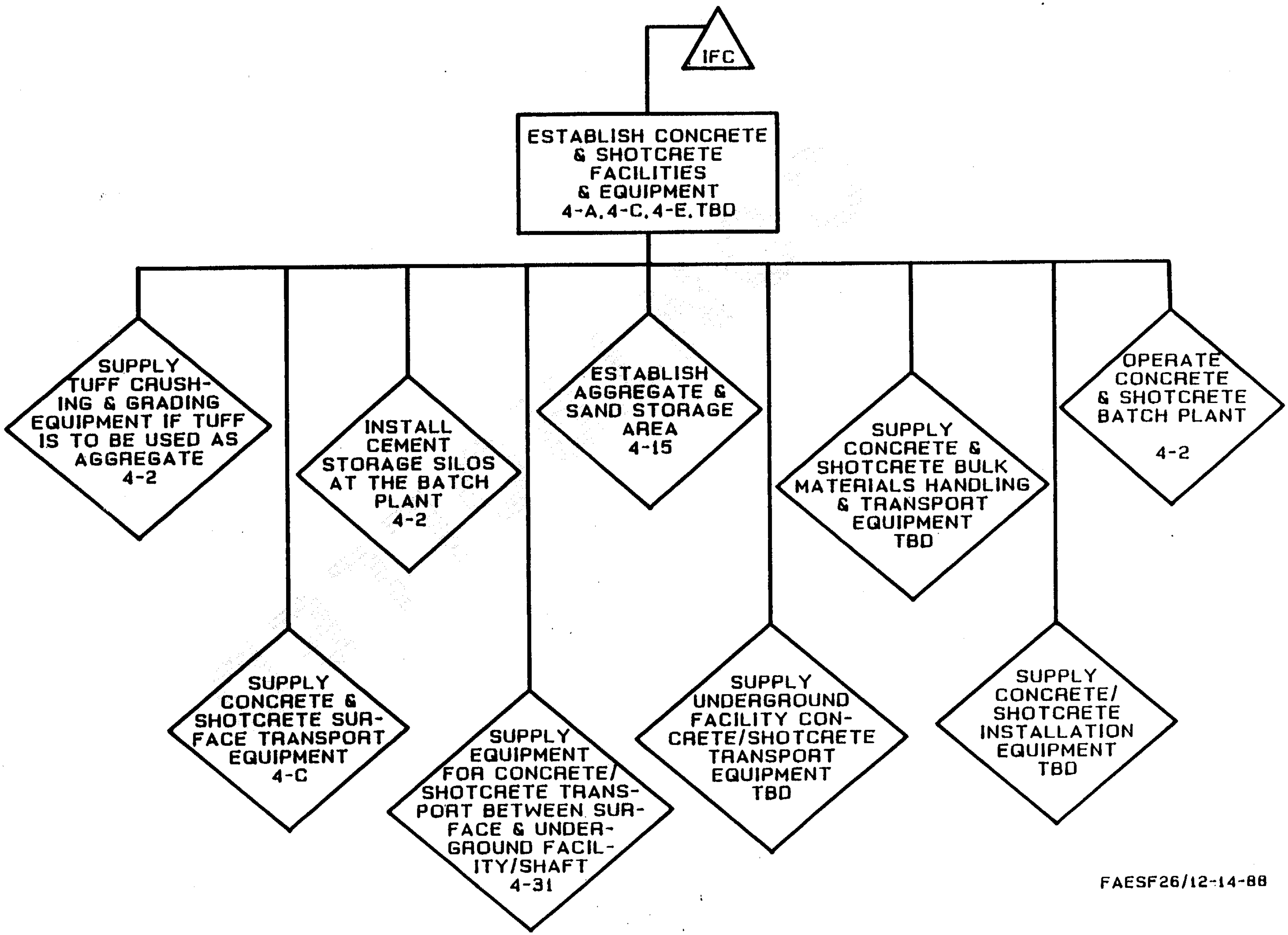
FAESF23/1-17-89



FAESF24/1-17-89



FAESF25/12-14-88



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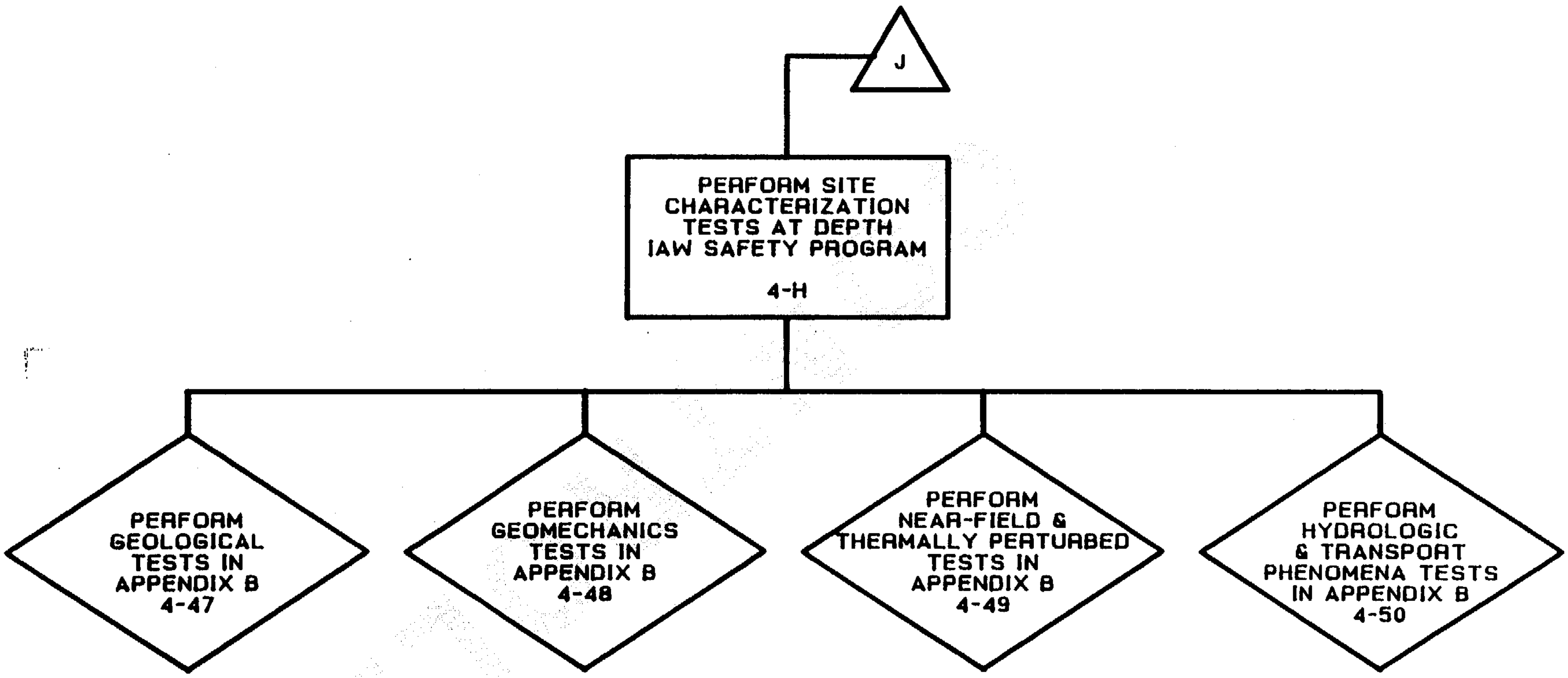

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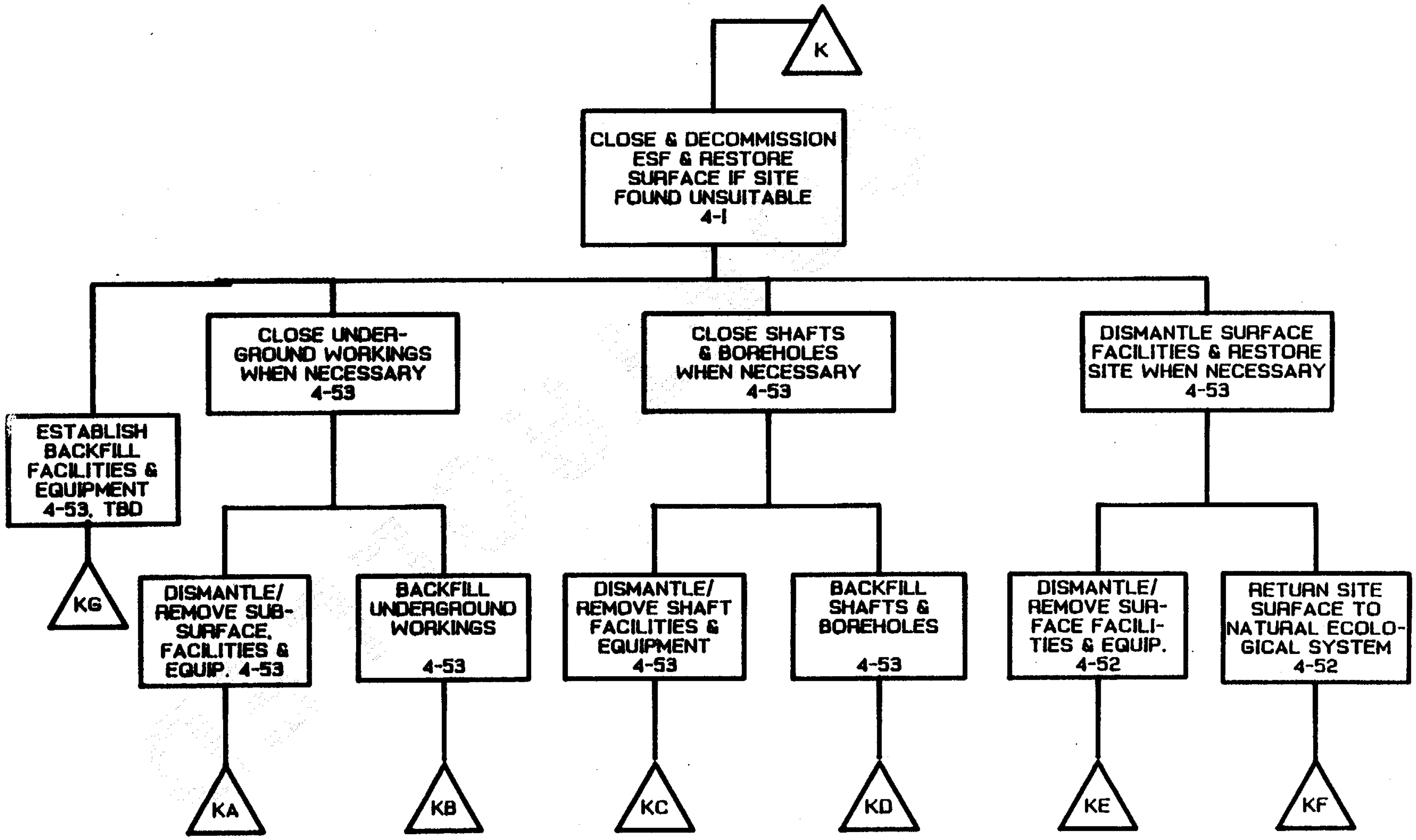

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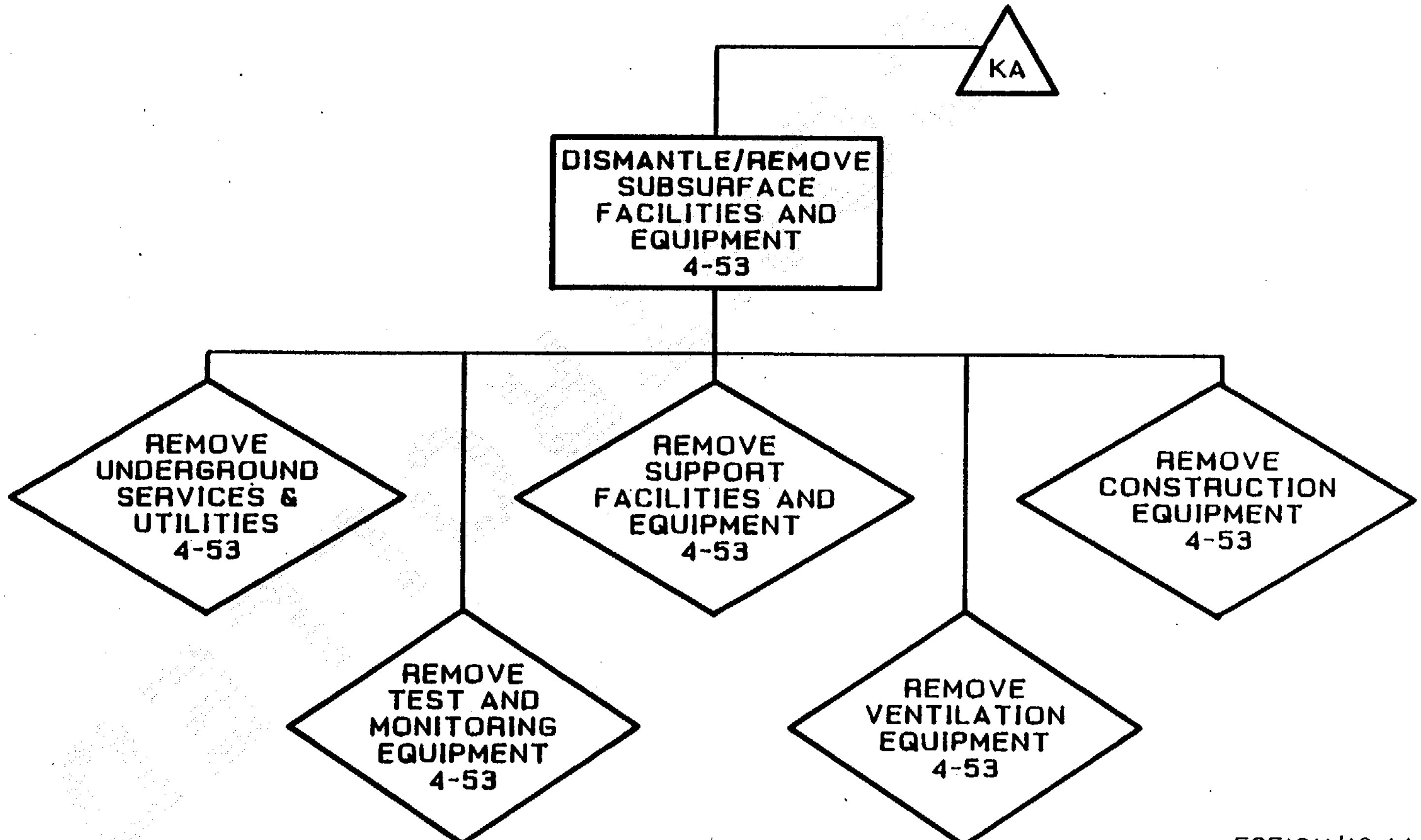

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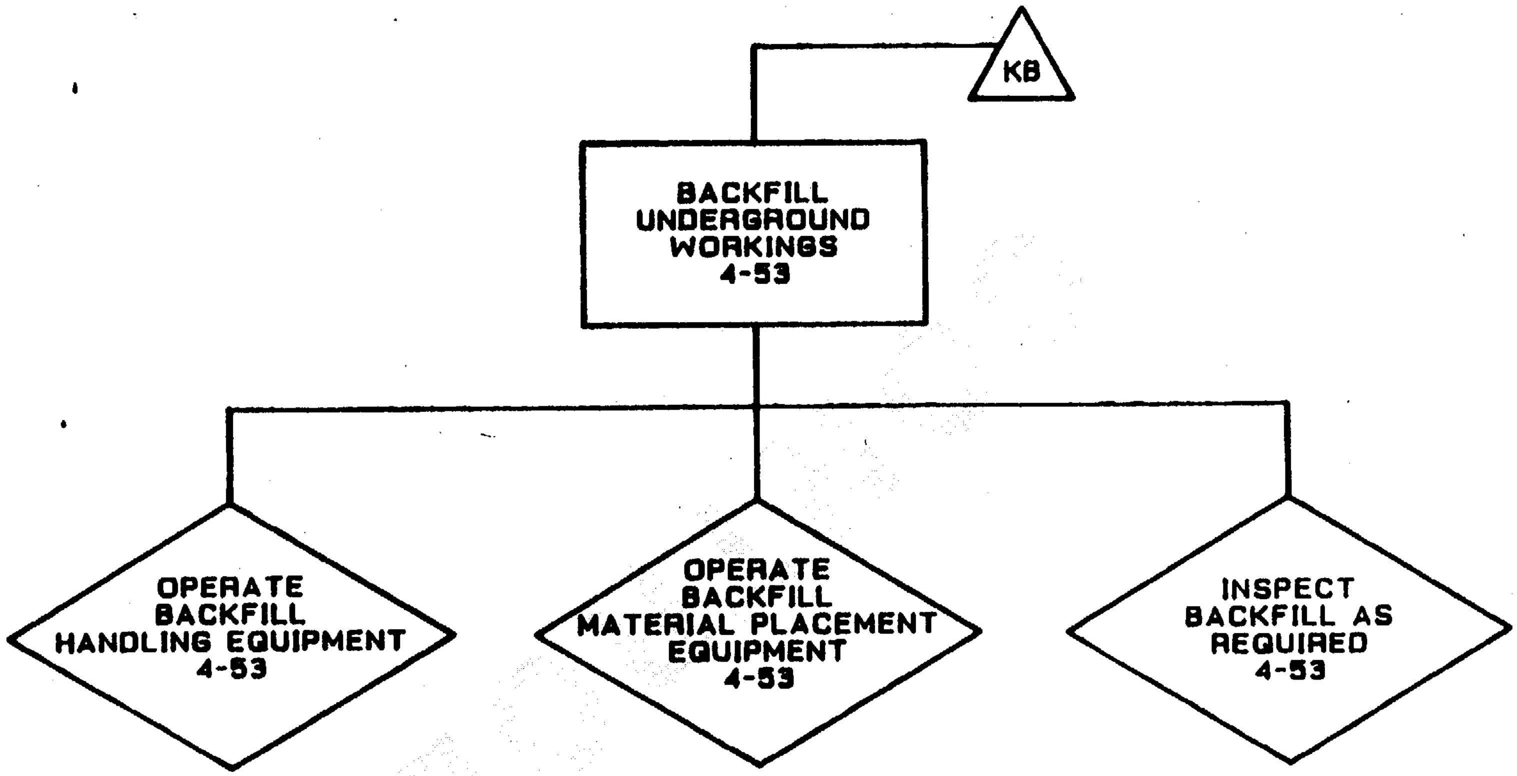

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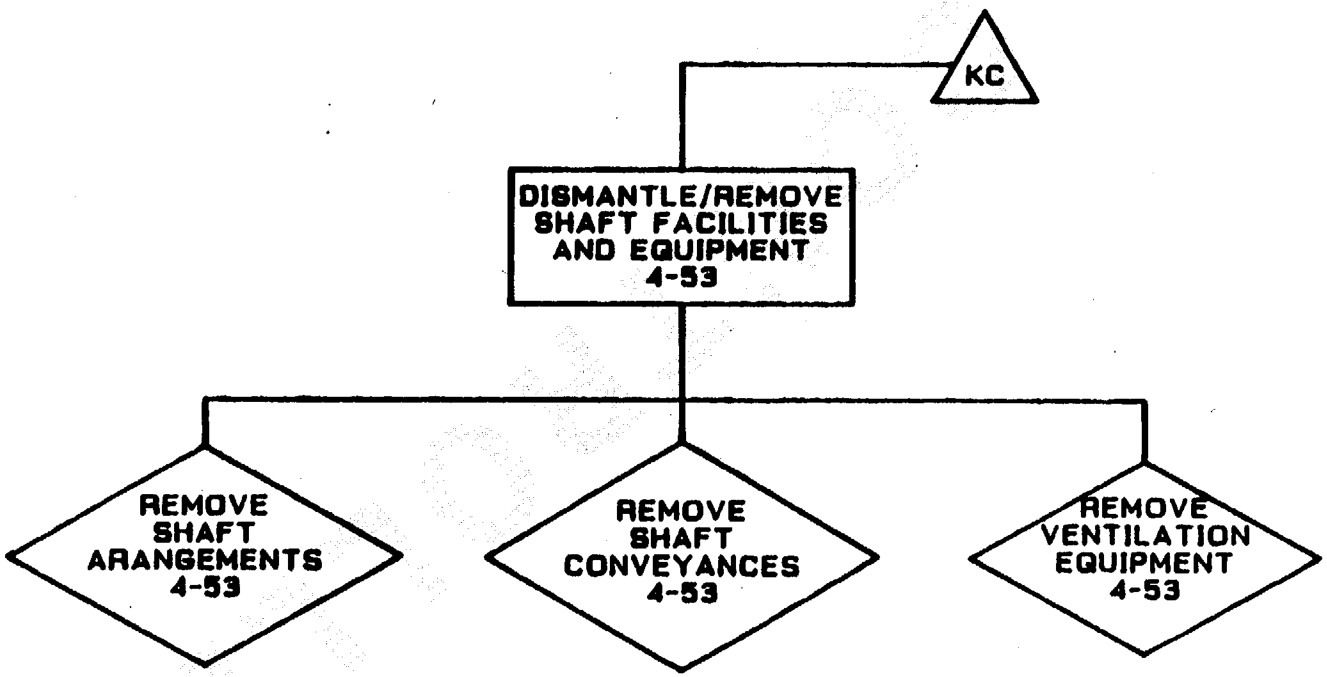

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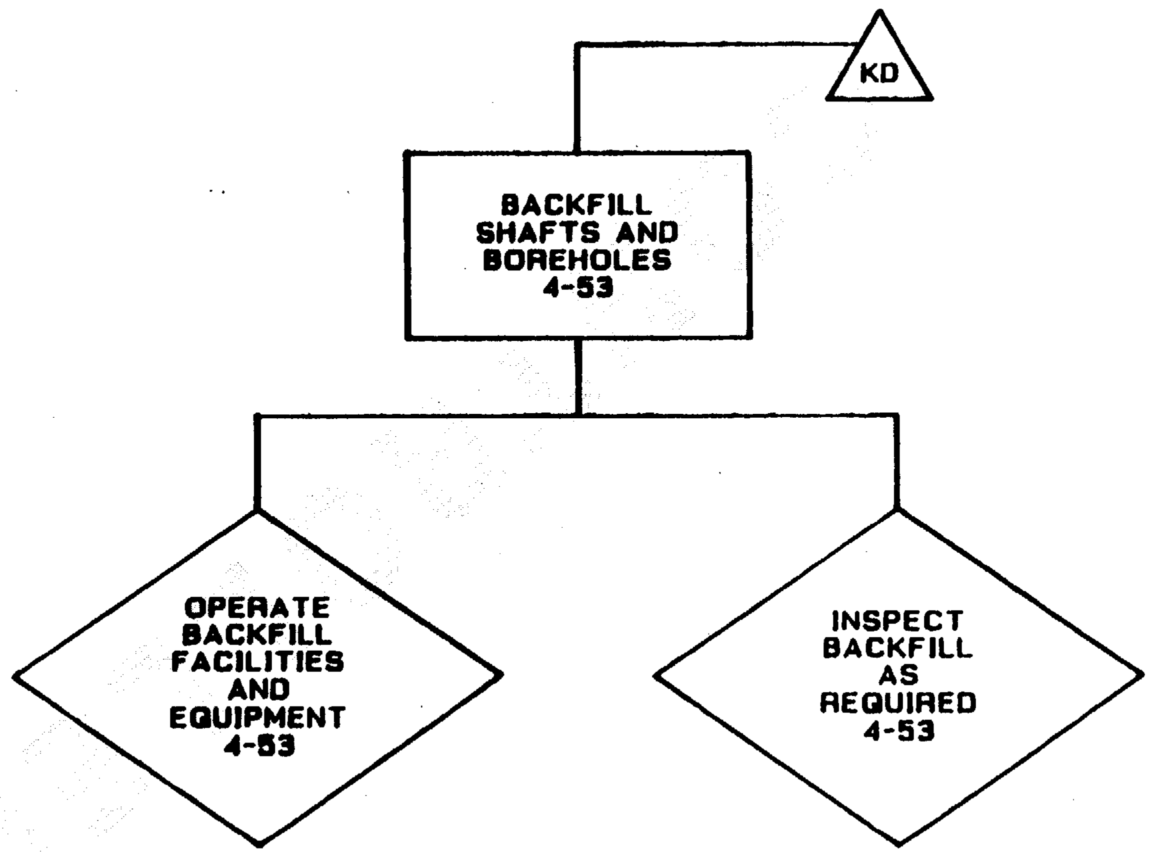

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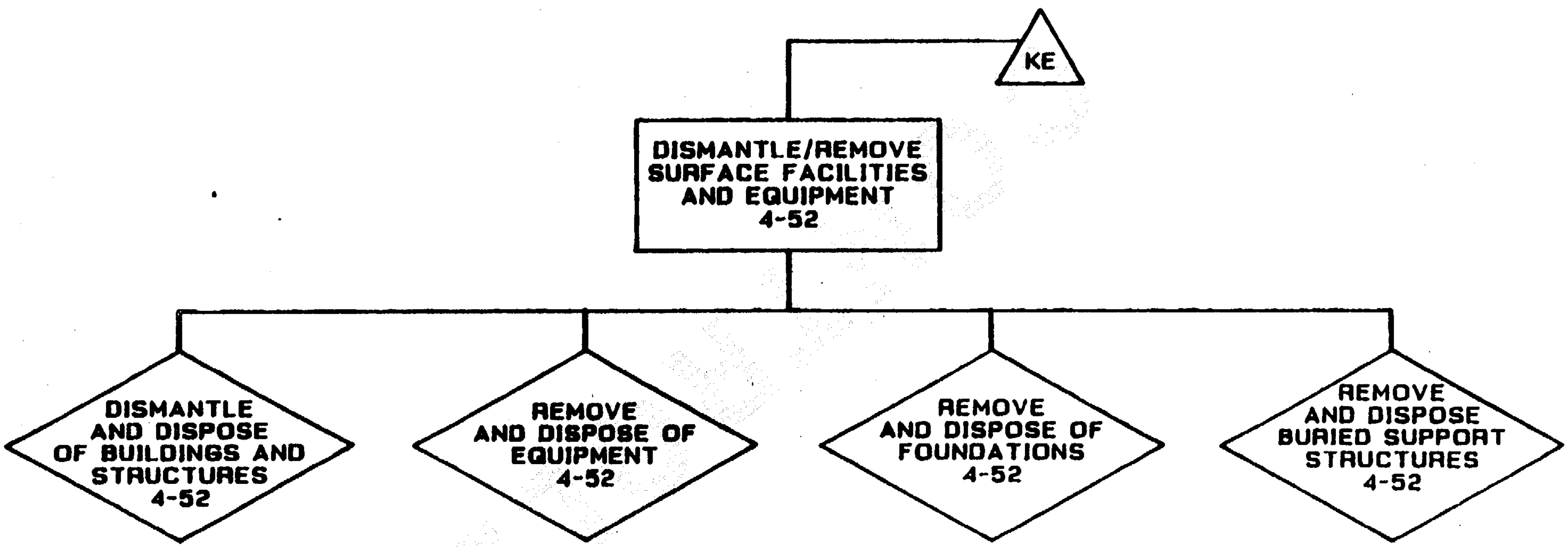
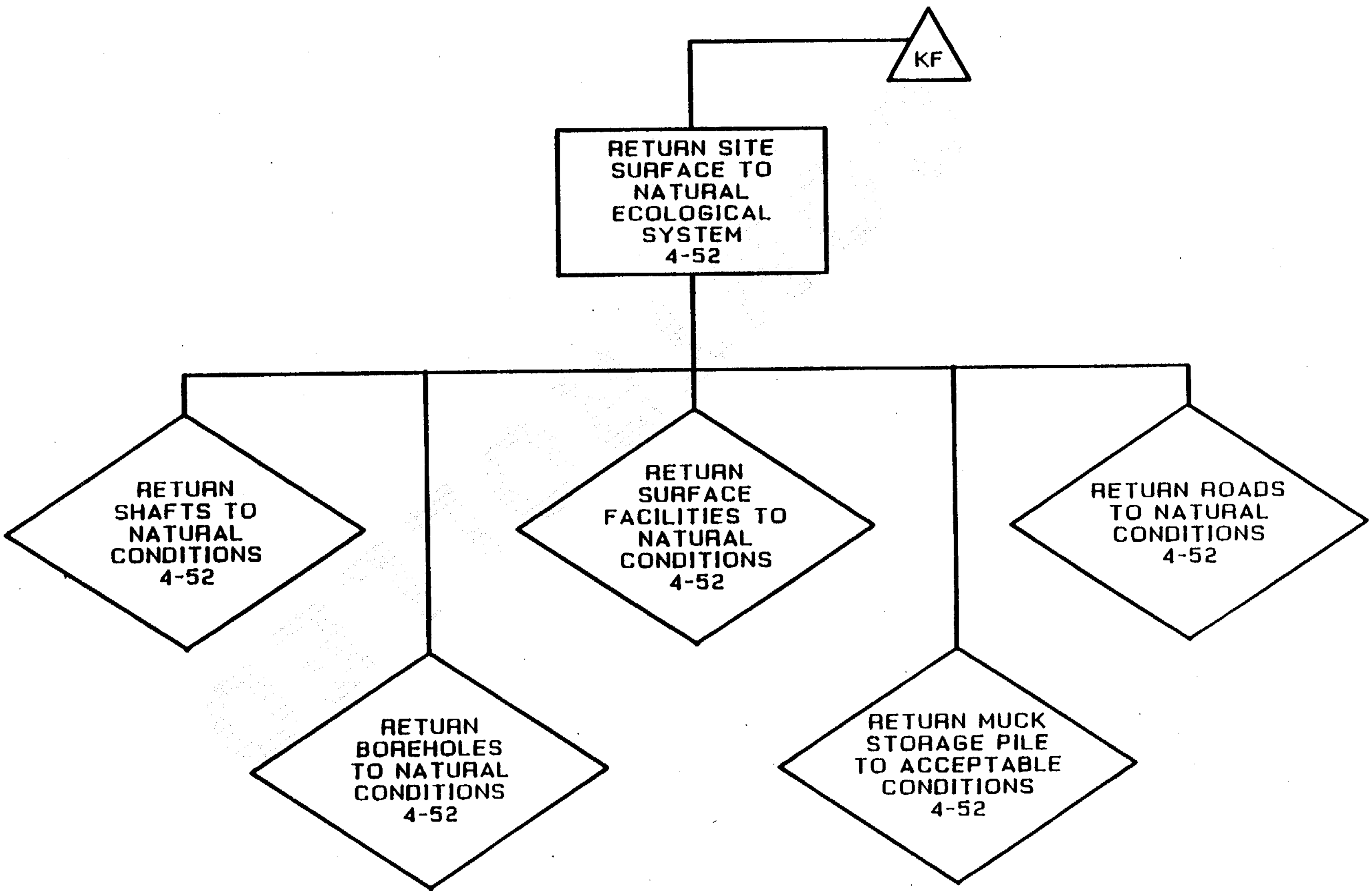

KE
DISMANTLE/REMOVE SURFACE FACILITIES AND EQUIPMENT 4-52
DISMANTLE AND DISPOSE OF BUILDINGS AND STRUCTURES 4-52
REMOVE AND DISPOSE OF EQUIPMENT 4-52
REMOVE AND DISPOSE OF FOUNDATIONS 4-52
REMOVE AND DISPOSE BURIED SUPPORT STRUCTURES 4-52

ESF1831 - 8/9/8(



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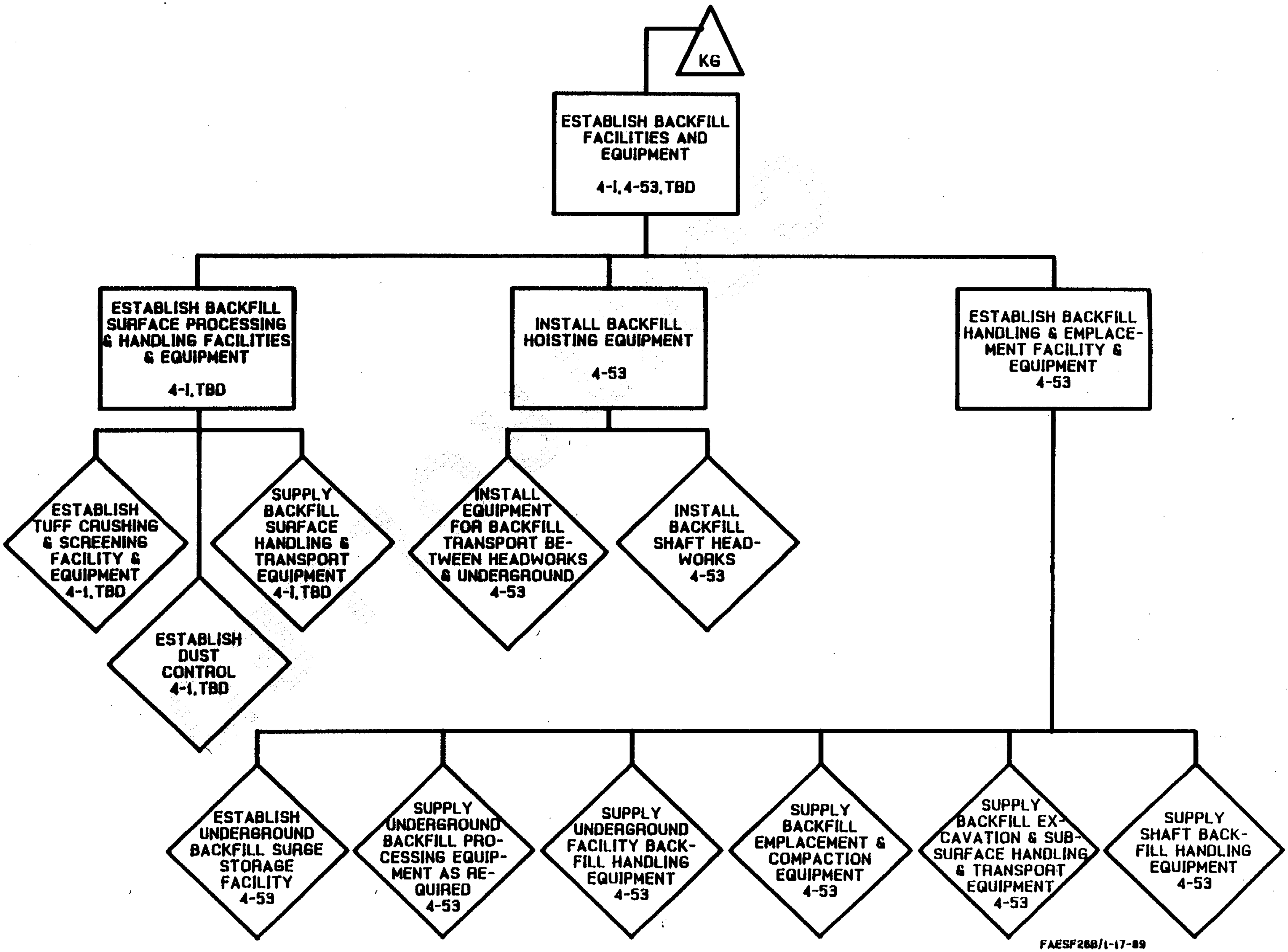
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ESTABLISH BACKFILL FACILITIES AND EQUIPMENT 4-1, 4-53, TBD
ESTABLISH BACKFILL SURFACE PROCESSING & HANDLING FACILITIES & EQUIPMENT 4-1, TBD
INSTALL BACKFILL HOISTING EQUIPMENT 4-53
ESTABLISH BACKFILL HANDLING & EMPLACEMENT FACILITY & EQUIPMENT 4-53
ESTABLISH TUFF CRUSHING & SCREENING FACILITY & EQUIPMENT 4-1, TBD
ESTABLISH DUST CONTROL 4-1, TBD
SUPPLY BACKFILL SURFACE HANDLING & TRANSPORT EQUIPMENT 4-1, TBD
INSTALL EQUIPMENT FOR BACKFILL TRANSPORT BETWEEN HEADWORKS & UNDERGROUND 4-53
INSTALL BACKFILL SHAFT HEADWORKS 4-53
ESTABLISH UNDERGROUND BACKFILL SURGE STORAGE FACILITY 4-53
SUPPLY UNDERGROUND BACKFILL PROCESSING EQUIPMENT AS REQUIRED 4-53
SUPPLY UNDERGROUND FACILITY BACKFILL HANDLING EQUIPMENT 4-53
SUPPLY BACKFILL EMPLACEMENT & COMPACTION EQUIPMENT 4-53
SUPPLY BACKFILL EXCAVATION & SUBSURFACE HANDLING & TRANSPORT EQUIPMENT 4-53
SUPPLY SHAFT BACKFILL HANDLING EQUIPMENT 4-53
FAESF26B/1-17-89

VERIFICATION OF FUNCTIONAL ANALYSIS COMPLETENESS RELATIVE TO SDRD OCTOBER 1988 REVISION

SDRD NUMBER	FUNCTION NUMBER	FUNCTIONAL ANALYSIS PLATE	LOCATION ON PLATE
1.2.6.			
0	1	1	RIGHT
0	2	OF	RIGHT
0	3	1	MISSION
		A	LEFT
		E	LEFT
0	4	QD	
0	5	GH	RIGHT
		IAA	RIGHT
		IB	
		IDA	
		IDAAA	RIGHT
		IDB	CENTER
0	6	1	RIGHT
1.0	1	A	LEFT
1.0	2	E	LEFT
1.0	3	E	LEFT
1.0	4	E	LEFT
1.0	5	E	LEFT
1.1	1	E	
1.2	1	E	
1.3	1	E	LEFT
1.4	1	IDB	LEFT
2.0	1	EA	
		IA	
2.1	1	IAB	
2.2	1	IA	CENTER
2.3	1	EA	RIGHT
2.4	1	IAA	RIGHT
		IAB	LEFT
		IC	RIGHT
		IDAAA	LEFT
		E	RIGHT
		FAB	CENTER
		FC	RIGHT
		FEDA	CENTER

VERIFICATION OF FUNCTIONAL ANALYSIS COMPLETENESS
RELATIVE TO SDRD

SDRD NUMBER	FUNCTION NUMBER	FUNCTIONAL ANALYSIS PLATE	LOCATION ON PLATE
2.4	1	GH	RIGHT
2.5	1	IE	
		EA	RIGHT
2.6	1	EA	LEFT
3.0	1 (ALL)	E	
		EA	
	2	IB	RIGHT
	3	IB	CENTER
		EA	RIGHT
	4	FC	LEFT
		FB	
		GI	RIGHT
		IAA	LEFT
		IFA	RIGHT
		~~IFB~~ KG	LEFT
	5	IAB	RIGHT
		IB	LEFT/RIGHT
		ID	CENTER
		IDD	CENTER
	6	E	LEFT
		FAC	RIGHT
		EA	RIGHT
3.1	1	E	RIGHT
		EA	RIGHT
3.2	1	EAA	LEFT
3.3	1	E	RIGHT
3.4	1	E	RIGHT
3.5	1	EAC	
3.6	1	EAB	
3.7	1	EAC	
3.8	1	EAA	LEFT
3.9	1	E	RIGHT
		EAA	LEFT
		GI	LEFT
		HA	
		IAAA	RIGHT
		IAB	CENTER
		IB	RIGHT (2/2)
		IDC	LEFT

VERIFICATION OF FUNCTIONAL ANALYSIS COMPLETENESS RELATIVE TO SDRD

SDRD NUMBER	FUNCTION NUMBER	FUNCTIONAL ANALYSIS PLATE	LOCATION ON PLATE
3.10	1	E	RIGHT
		EAA	LEFT
		FC	RIGHT
		FEDA	RIGHT
		GI	RIGHT
		IA	RIGHT
		IAA	CENTER
		IAB	LEFT
		IC	RIGHT
		IDAAA	LEFT
4.0	1	A	CENTER
		FED	RIGHT
	2	A	RIGHT
	3	FEC	CENTER
		FED	RIGHT
		FEDA	LEFT
		G	RIGHT
	4	FB	
		FC	
	5	FDD	RIGHT
		IAAA	RIGHT
		IB	LEFT
		IE	
		~~IEB~~	
		IEC	
4.1 & 5.1	1	FAA	RIGHT
4.2 & 5.2	1	FDAA	CENTER
4.3 & 5.3	1	FDAB	RIGHT
4.4 & 5.4	1	G	
4.5 & 5.5	1	F	RIGHT
		FE	
4.6 & 5.6	1	FDD	RIGHT
		IAAA	RIGHT
		IB	LEFT
		IE	
		IEB	
		IEC	

VERIFICATION OF FUNCTIONAL ANALYSIS COMPLETENESS
RELATIVE TO SDRD

SDRD NUMBER	FUNCTION NUMBER	FUNCTIONAL ANALYSIS PLATE	LOCATION ON PLATE
5.0	1	A	CENTER
		FED	RIGHT
	2	FDD	RIGHT
		IAAA	RIGHT
		IB	LEFT
		IE	
		IEB	
		IEC	
	3	A	RIGHT
6.0	1	H	
	2	H	
	3	IFA	
6.1	1	H	
		HA	
		HB	
		FD	
6.2	1	HA	
7.0	1	IA	
		IAA	
		IAAA	
		IAAB	
		IAB	
	2	HB	
	3	IAB	
7.1	1	IAAA	
	2	IAAA	
	3	IAAA	
7.2	1	IAA	RIGHT
		IAB	LEFT
7.3	1	IAAA	
		IAB & HB	CENTER
7.4	1	IAAB	
7.5	1	IAB	RIGHT
7.6	1	IE	
		IEA	
		IEB	
		IEC	
7.7	1	IAA	RIGHT
7.8	1	IB	LEFT
		IDC	

VERIFICATION OF FUNCTIONAL ANALYSIS COMPLETENESS RELATIVE TO SDRD

SDRD NUMBER	FUNCTION NUMBER	FUNCTIONAL ANALYSIS PLATE	LOCATION ON PLATE
7.9	1	IFA	
7.10	1	H	CENTER
		IAA	CENTER
7.11	1	IB	
8.0	1	A	RIGHT
		HA	
9.0	1	Z	RIGHT
		K	
9.1	1	KE	
		KF	
9.2	1	KA	
		KB	
		KC	
		KD	

SDRD APPENDIX H

COMPILATION OF ESF RELATED PERFORMANCE ASSESSMENT REQUIREMENTS

APPENDIX H

Site Performance Assessment

The information contained in this appendix shows traceability of performance assessment requirements/constraints from 10 CFR 60 to the elements of the ESF system. All statements included in this appendix also appear in the appropriate subsections of the ESF SDRD.

Section I.1

The statements in this subsection of Appendix I are related to the concern about potential ESF impacts on the ability of the site to isolate waste.

1. Requirement 60.15(d)(1): Investigations to obtain the required information shall be conducted in such a manner as to limit adverse effects on the long term performance of the geologic repository to the extent practicable.

1. Site

   1. The design of the main pad shall incorporate aspects specifically directed at limiting the potential for adverse impacts on the long term performance of the repository, and construction and operation of the main pad shall be performed in a manner that limits the potential for adverse impacts on the long term performance of the repository

2. Surface Utilities

   1. The design of the surface utilities, including the waste water ponds and water handling system, shall incorporate aspects specifically directed at limiting the potential for adverse impacts on the long term performance of the repository, and construction and operation of the surface utilities shall be performed in a manner that limits the potential for adverse impacts on the long term performance of the repository

4. First shaft

   1. The design of the first shaft shall incorporate aspects specifically directed at limiting the potential for adverse impacts on the long term performance of the repository, and construction and operation of the first shaft shall be performed in a manner that limits the potential for adverse impacts on the long term performance of the repository

5. Second shaft

   1. The design of the second shaft shall incorporate aspects specifically directed at limiting the potential for adverse impacts on the long term performance of the repository, and construction and operation of the second shaft shall be performed in a manner that limits the potential for adverse impacts on the long term performance of the repository

6. Underground excavation

   1. The design of the underground excavation shall incorporate aspects specifically directed at limiting the potential for adverse impacts on the long term performance of the repository, and construction and operation of the underground excavation shall be performed in a manner that limits the potential for adverse impacts of the long term performance of the repository

Requirement 60.15(d)(1) (continued)

7. Underground utilities

   1. The design of the underground utilities shall incorporate aspects specifically directed at limiting the potential for adverse impacts on the long term performance of the repository, and construction and operation of the underground utilities shall be performed in a manner that limits the potential for adverse impacts on the long term performance of the repository

8. Underground testing

   1. The design of the underground testing program shall incorporate aspects specifically directed at limiting the potential for adverse impacts on the long term performance of the repository, and implementation and operation of the underground testing program shall be performed in a manner that limits the potential for adverse impacts on the long term performance of the repository

   2. Prior to implementing the underground testing program, or prior to implementing additional tests, an evaluation of the potential impacts of such testing on the waste isolation capability of the site shall be performed.

9. Decommissioning

   1. The first shaft, second shaft, all underground excavations, and all boreholes shall be constructed to allow backfilling and sealing as necessary to limit the release of radioactive material to the environment

2. Requirement: 60.15(d)(3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for underground facility construction and operation or where large unexcavated pillars are planned.

4. First shaft

   1. The shaft pillar is the buffer zone surrounding the shaft beyond which any instability of other underground openings has a negligible effect on shaft stability. Within the shaft pillar area, all facilities and openings shall be designed to be stable for a 100 year life and to limit any adverse effects on the stability of the shafts that could impact the ability of the site to isolate waste

   2. The exploratory shafts shall be located, to the extent practicable, where shafts are planned for the repository facility

5. Second shaft

   1. The shaft pillar is the buffer zone surrounding the shaft beyond which any instability of other underground openings has a negligible effect on shaft stability. Within the shaft pillar area, all facilities and openings shall be designed to be stable for a 100 year life and to limit any adverse effects on the stability of the shafts that could impact the ability of the site to isolate waste

   2. The exploratory shafts shall be located, to the extent practicable, where shafts are planned for the repository facility

6. Underground excavation

   1. Exploratory boreholes shall be located so that they do not intersect any underground openings

   2. For sealing purposes, exploratory boreholes shall be located a minimum distance of 15 m from any underground opening

   3. Borehole alignments and location shall be monitored, surveyed, and the results included on all underground working maps

8. Underground testing

   1. MPBH boreholes shall be located in pillars to the extent practicable.

   2. MPBH boreholes should be surveyed as drilling proceeds and the option to cease drilling may be invoked if insufficient separation from the proposed shaft location is observed

   3. Boreholes drilled from the underground portion of the ESF shall not penetrate significantly below the base of the TsW2 host rock, unless the impacts of doing so, on the waste isolation performance of the site, have been evaluated and found to be acceptable

3. Requirement: 60.21(c)(1)(ii)(D) The effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to waste isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

4. First shaft

   1. The exploratory shaft locations should be selected, consistent with other goals of site characterization, to limit impacts on isolation.

   2. The exploratory shaft ground support system should be selected, consistent with other goals of site characterization, to limit impacts on isolation. If the support system is determined to be important to waste isolation a comparative evaluation of alternatives shall be performed.

   3. The exploratory shaft shaft diameter should be selected, consistent with other goals of site characterization, to limit impacts on isolation. If the diameter is determined to be important to waste isolation a comparative evaluation of alternatives shall be performed.

   4. The exploratory shaft liner should be designed, consistent with other goals of site characterization, to limit impacts on isolation. If the liner is determined to be important to waste isolation a comparative evaluation of alternatives shall be performed.

   5. The exploratory shaft operational seals should be designed, consistent with other goals of site characterization, to limit impacts on isolation. If the seals are determined to be important to waste isolation a comparative evaluation of alternatives shall be performed

5. Second shaft

   1. The exploratory shaft locations should be selected, consistent with other goals of site characterization, to limit impacts on isolation.

   2. The exploratory shaft ground support system should be selected, consistent with other goals of site characterization, to limit impacts on isolation. If the support system is determined to be important to waste isolation a comparative evaluation of alternatives shall be performed.

Requirement 60.21(c)(1)(ii)(D) (continued)

3. The exploratory shaft shaft diameter should be selected, consistent with other goals of site characterization, to limit impacts on isolation. If the diameter is determined to be important to waste isolation a comparative evaluation of alternatives shall be performed.

4. The exploratory shaft liner should be designed, consistent with other goals of site characterization, to limit impacts on isolation. If the liner is determined to be important to waste isolation a comparative evaluation of alternatives shall be performed.

5. The exploratory shaft operational seals should be designed, consistent with other goals of site characterization, to limit impacts on isolation. If the seals are determined to be important to waste isolation a comparative evaluation of alternatives shall be performed

6. Underground excavation

   1. The Exploratory Shaft Underground Facility layout, including drift size, should be designed, consistent with other goals of site characterization, to limit impacts on isolation. If the layout is determined to be important to waste isolation a comparative evaluation of alternatives shall be performed

   2. The Exploratory Shaft Underground Facility support system should be designed, consistent with the other goals of site characterization, to limit the impacts on isolation. If the support system is determined to be important to waste isolation a comparative evaluation of alternatives shall be performed

   3. The Exploratory Shaft Underground Facility operational seals should be designed, consistent with other goals of site characterization, to limit impacts on isolation. If the seals are determined to be important to waste isolation a comparative evaluation of alternatives shall be performed

4. Requirement: 60.21(c)(11) A description of design consideration that are intended to facilitate permanent closure and decontamination or dismantlement of surface facilities.

1. Site

   1. The pad shall be designed to permit the ground to be restored to a contour compatible with its initial conditions.

4. First shaft

   1. The shaft liner shall be designed to be removable prior to permanent closure

   2. To prevent complications of seal evaluations and emplacement and limit chemical alteration in future seal environments, no pressure grouting shall take place during the construction period of the shaft at locations of potential seal testing or emplacement. Specifically, no pressure grouting shall be performed within 50 feet of the original ground surface and within 50 feet (above and below) the contact of the Pah Canyon and Topopah Spring tuffs

   3. Furnishings in the shafts shall be designed to be removable, if necessary, prior to permanent closure

5. Second shaft

   1. Shaft liners shall be designed to be removable prior to permanent closure

   2. To prevent complications of seal evaluations and emplacement and limit chemical alteration in future seal environments, no pressure grouting shall take place during the construction period of the shaft at locations of potential seal testing or emplacement. Specifically, no pressure grouting shall be performed within 50 feet of the original ground surface and within 50 feet (above and below) the contact of the Pah Canyon and Topopah Spring tuffs

   3. Furnishings in the shafts shall be designed to be removable, if necessary, prior to permanent closure

6. Underground excavation

   1. The drainage plan for the ESF and long exploratory drift should be consistent with postclosure sealing concerns

   2. Nonpermanent components in the underground openings shall be designed to be removable, if necessary, prior to permanent closure

Requirement: 60.21(c)(11) (continued)

9. Decommissioning

   1. The first shaft, second shaft, all underground excavations, and all boreholes shall be constructed to allow backfilling and sealing as necessary to limit the release of radioactive material to the environment

6. Requirement: 60.112 The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated processes and events.

1. Site

   1. The Exploratory Shaft Facility pad shall be designed and constructed so that it does not lead to creation of pathways that compromise the repository's capability to meet the performance objective of 10 CFR Part 60.112

4. First shaft

   1. The shaft opening shall be designed and constructed so that, following permanent closure, it does not become a pathway that compromises the repository's ability to meet the performance objectives of 10 CFR Part 60.112

5. Second shaft

   1. The shaft opening shall be designed and constructed so that, following permanent closure, it does not become a pathway that compromises the repository's ability to meet the performance objectives of 10 CFR Part 60.112

6. Underground excavation

   1. The Exploratory Shaft Facility underground excavation shall be designed and constructed so that, following permanent closure, it does not become a pathway that compromises the repository's ability to meet the performance objective of 10 CFR Part 60.112

8. Underground testing

   1. The testing program shall not affect the capability of the underground repository to meet the performance objective of 10 CFR 60.112

   2. Borehole openings shall be designed so that, following permanent closure, they do not become pathways that compromise the repository's ability to meet the performance objectives of 10 CFR Part 60.112

9. Decommissioning

   1. The first shaft, second shaft, all underground excavations, and all boreholes shall be constructed to allow backfilling and sealing as necessary to limit the release of radioactive material to the environment

7. Requirement 60.113(a)(1)(i): The engineered barrier system shall be designed so that, assuming anticipated processes and events: (A) Containment of HLW will be substantially complete during the period when radiation and thermal conditions in the engineered barrier system are dominated by fission product decay; and (B) any release of radionuclides from the engineered barrier system shall be a gradual process which results in small fractional releases to the geologic setting over long times.

6. Underground excavation

   1. The underground excavation shall be designed to assist or not detract from the capability of the repository to ensure substantially complete containment and a release of radionuclides that is a gradual process after the containment period, and construction and operation of the underground excavation shall be performed in a manner designed to assist or not detract from the capability of the repository to ensure substantially complete containment and a release of radionuclides that is a gradual process after the containment period.

8. Underground testing

   1. The underground testing program shall be designed to assist or not detract from the capability of the repository to ensure substantially complete containment and a release of radionuclides that is a gradual process after the containment period, and construction and operation of the underground excavation shall be performed in a manner designed to assist or not detract from the capability of the repository to ensure substantially complete containment and a release of radionuclides that is a gradual process after the containment period.

8. Requirement 60.113(a)(1)(ii)(A): Containment of HLW within the waste packages will be substantially complete for a period determined by the commission taking into account the factors specified in 60.113 (b) provided that such period shall not be less than 300 years nor more than 1000 years after the permanent closure of the repository.

6. Underground excavation

   1. The underground excavation shall be designed to assist or not detract from the capability of the repository to ensure substantially complete containment for a period not less than 300 years nor more than 1000 years after the permanent closure of the repository, and construction and operation of the underground excavation shall be performed in a manner designed to assist or not detract from the capability of the repository to ensure substantially complete containment for a period not less than 300 years nor more than 1000 years after the permanent closure of the repository.

8. Underground testing

   1. The underground testing program shall be designed to assist or not detract from the capability of the repository to ensure substantially complete containment for a period not less than 300 years nor more than 1000 years after the permanent closure of the repository, and implementation and operation of the underground testing program shall be performed in a manner designed to assist or not detract from the capability of the repository to ensure substantially complete containment for a period not less than 300 years nor more than 1000 years after the permanent closure of the repository.

9. Requirement 60.113(a)(1)(ii)(B): The release rate of any radionuclide from the engineered barrier system following the containment period shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1000 years following permanent closure.

6. Underground excavation

1. The underground excavation shall be designed to assist or not detract from the capability of the repository to ensure that the release of radionuclides does not exceed a rate of one part in 100,000 per year of the inventory of radionuclides calculated to be present at 1000 years following permanent closure, and construction and operation of the underground excavation shall be performed in a manner designed to assist or not detract from the capability of the repository to ensure that the release of radionuclides does not exceed a rate of one part in 100,000 per year of the inventory of radionuclides calculated to be present at 1000 years following permanent closure.

8. Underground testing

1. The underground testing program shall be designed to assist or not detract from the capability of the repository to ensure that the release of radionuclides does not exceed a rate of one part in 100,000 per year of the inventory of radionuclides calculated to be present at 1000 years following permanent closure, and construction and operation of the underground excavation shall be performed in a manner designed to assist or not detract from the capability of the repository to ensure that the release of radionuclides does not exceed a rate of one part in 100,000 per year of the inventory of radionuclides calculated to be present at 1000 years following permanent closure.

19. Requirement: 60.137 The geologic repository operations area shall be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F of this part.

6. Underground excavation

   1. The underground excavations shall be designed to accommodate the performance confirmation tests required by 60.141 and 60.142, and taking into account any potentially adverse impacts these excavations could have on the waste isolation capabilities of the site

8. Underground testing

   1. The testing program shall accommodate the performance confirmation tests required by 60.141 and 60.142, and taking into account any potentially adverse impacts these tests could have on the waste isolation capabilities of the site

20. Requirement 60.140(d): The program shall be implemented so that: (1) it does not adversely affect the ability of the natural and engineered elements of the geologic repository to meet the performance objectives.

8. Underground testing

   1. The design of the performance confirmation testing program shall incorporate aspects specifically directed at limiting the potential for adverse impacts on the long term performance of the repository, and implementation of the performance confirmation testing program and operation of the facility shall be performed in a manner that limits the potential for adverse impacts on the long term performance of the repository

Section I.2

The statements in this subsection of Appendix I are related to the concern that ESF construction, operation, and testing could result in interferences which adversely affect the ability to gather quality data to support the license application.

8. Requirement: 60.137 The geologic repository operations area shall be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F of this part.

1. Site

   1. The ESF site shall be designed to facilitate appropriate performance confirmation measurement and monitoring to obtain adequate and reliable information about the site. The performance confirmation program shall include measurement and monitoring of the performance of the ESF site to the extent that aspects of the site are part of the geologic setting that could contribute to the waste isolation performance of a repository.

4. First shaft

   1. The configuration of the shaft shall be adequate to support performance confirmation testing, and future performance confirmation testing that may be reasonably expected for site characterization. This shall include an allowance to accommodate site specific conditions encountered in the shaft without adversely affecting testing that is planned or ongoing

   2. The shafts of the ESF shall be designed to facilitate performance confirmation testing to obtain adequate and reliable information about the site, during and after construction, as required for the geologic repository by 10 CFR 60, Subpart F

   3. The shafts of the ESF shall be designed so that baseline performance confirmation data can be acquired, pertaining to parameters and natural processes that may be significantly altered by site characterization. In addition, the ESF shall be designed to facilitate monitoring of changes to the baseline condition of parameters that could affect performance of a geologic repository.

5. Second shaft

   1. The configuration of the shaft shall be adequate to support site performance confirmation testing, and future perefromance confirmation testing that may be reasonably expected for site characterization. This shall include an allowance to accommodate site specific conditions encountered in the shaft without adversely affecting testing that is planned or ongoing

   2. The shafts of the ESF shall be designed to facilitate performance confirmation testing to obtain adequate and reliable information about the site, during and after construction, as required for the geologic repository by 10 CFR 60, Subpart F

Requirement 60.137 (continued)

3. The shafts of the ESF shall be designed so that baseline performance confirmation data can be acquired, pertaining to parameters and natural processes that may be significantly altered by site characterization. In addition, the ESF shall be designed to facilitate monitoring of changes to the baseline condition of parameters that could affect performance of a geologic repository.

6. Underground excavation

   1. The shaft breakouts and main test level of the ESF shall be designed to facilitate performance confirmation testing, during and after construction, as required for the geologic repository by 10 CFR 60, Subpart F

   2. The shaft breakouts and main test level of the ESF shall be designed so that baseline performance confirmation data can be acquired, pertaining to parameters and natural processes that may be significantly altered by site characterization. In addition, the ESF shall be designed to facilitate monitoring of changes to the baseline condition of parameters that could affect performance of a geologic repository.

   3. The ESF underground excavation shall be of adequate size to support pefromance confirmation testing and future testing that may be reasonably expected for performance confirmation. This shall include an allowance to accommodate site specific conditions encountered in the dedicated test area.

   4. The design of the shaft breakouts and main test level of the ESF shall: limit the extent of interference between characterization tests, performance confirmation tests and ESF construction and operation activities

   5. The design of the shaft breakouts and main test level shall have sufficient flexibility to: (1) relocate experiments as necessary to limit interference between tests, (2) incorporate additional performance confirmation tests, as needed, in the dedicated test area, and, (3) accommodate schedule changes as required

7. Underground Utilities

   1. The design of underground utilities for the ESF shall be capable of supporting the performance confirmation testing

   2. The underground utilities for the ESF shall not preclude monitoring and investigation of in situ conditions, and shall be designed to accommodate site specific conditions, construction, and operation of the ESF.

Requirement: 60.137 (continued)

8. Underground testing

   1. Performance confirmation testing shall be conducted in the ESF during and after construction, to meet the requirements which pertain to such testing in the geologic repository as stated in 10 CFR 60, Subpart F

Section I.3

The statements in this subsection of Appendix I are related to the concern that ESF testing provide quality data representative of the site conditions needed to support the license application.

1. Requirement: 60.15(b) Unless the Commission determines with respect to the site described in the application that it is not necessary, site characterization shall include a program of in situ exploration and testing at the depths that wastes would be emplaced.

4. First shaft

   1. Shaft design and construction shall provide access for site characterization activities to be performed at the planned waste emplacement horizon

   2. Selection of the horizon for the main test level shall be based on evaluation of stratigraphic information sources available during construction (e.g., from the MPBH activity, geologic mapping of the shafts, and a probe corehole drilled ahead of the shaft face in portions of the shaft) with respect to explicit horizon criteria

5. Second shaft

   1. Shaft design and construction shall provide access for site characterization activities to be performed at the planned waste emplacement horizon

   2. Selection of the horizon for the main test level shall be based on evaluation of stratigraphic information sources available during construction (e.g., from the MPBH activity, geologic mapping of the shafts, and a probe corehole drilled ahead of the shaft face in portions of the shaft) with respect to explicit horizon criteria

6. Underground excavation

   1. The ESF main test level shall be constructed at the planned repository horizon,

8. Underground testing

   1. Underground testing shall be conducted in a facility constructed at the planned repository horizon

2. Requirement: 60.15(d)(2) The number of exploratory boreholes and shafts shall be limited to the extent practical consistent with obtaining the information needed for site characterization.

4. First Shaft

   1. The number and depth of exploratory shafts shall be consistent with obtaining needed information for site characterization, while contributing to acquisition of representative data

5. Second Shaft

   1. The number and depth of exploratory shafts shall be consistent with obtaining needed information for site characterization, while contributing to acquisition of representative data

8. Underground testing

   1. The number and length of exploratory and monitoring boreholes drilled from the underground portion of the ESF shall be consistent with obtaining the needed information for site characterization

3. Requirement: 60.15(d)(3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for underground facility construction and operation or where large unexcavated pillars are planned.

8. Underground testing

- Exploratory, monitoring and testing boreholes shall be located where pillars are planned in the repository underground facility to the extent practicable. Implementation of this criterion within the designated test area of the ESF shall be consistent with obtaining the needed information for site characterization