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U.S. DEPARTMENT OF ENERGY

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YUCCA MOUNTAIN

YUCCA
MOUNTAIN
PROJECT

YUCCA MOUNTAIN PROJECT EXPLORATORY SHAFT FACILITY TITLE I DESIGN

SUMMARY REPORT

VOLUME I

NARRATIVE REPORT

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

UNITED STATES DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE/YUCCA MOUNTAIN PROJECT OFFICE

YUCCA MOUNTAIN PROJECT OFFICE

EXPLORATORY SHAFT FACILITY

TITLE I

DESIGN SUMMARY REPORT

Prepared by the Yucca Mountain Project participants as part of the Civilian Radioactive Waste Management Program. The Yucca Mountain Project is managed by the Yucca Mountain Project Office of the U.S. Department of Energy, Nevada Operations Office.

Prepared for

U.S. Department of Energy
Nevada Operations Office
Yucca Mountain Project Office

Compiled by

Yucca Mountain Project Technical & Management Support Services Contractor

From input developed by

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Los Alamos National Laboratory

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DECEMBER 21, 1988

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EXECUTIVE SUMMARY

In compliance with U.S. Department of Energy (DOE) Order 4700.1, Project Management System, dated March 6, 1987, this Title I report is an overview of preliminary engineering and project management planning for the Title I design of the Exploratory Shaft Facility (ESF) of the Yucca Mountain Project.

The report provides the Yucca Mountain Project Office with summary design information for approval prior to authorizing the start of definitive design, and provides the DOE/Headquarters Program Office with the necessary project information to assist in program planning, policy improvement, and criteria guidance for future projects.

This report presents a general description of the overall ESF design effort, the site geology, and the general arrangement of the ESF, including its major facilities. A review of the environmental, safety, and health aspects is included. The report presents a justification for the Title I design concepts, reviews the proposed testing requirements, identifies repository requirements for the ESF, and reviews the plans for closure and decommissioning. The report also discusses the approach to the Title II design, construction, Title III inspection, and operations and testing in the ESF. The report concludes with ESF Title I design drawings and specifications, and cost and schedule information.

PURPOSE AND SCOPE

The ESF will be constructed to meet a 10 CFR Part 60 requirement to perform a program of in situ exploration and testing at the depths at which wastes would be emplaced prior to submittal for a construction authorization for a repository. The DOE Yucca Mountain Project Office is responsible for the design, construction, and operation of the ESF. The general objectives of the ESF at Yucca Mountain are to acquire access to underground tuff horizons and to obtain the necessary technical data regarding the unsaturated zone to assist in determining the suitability of the Yucca Mountain tuff media for the construction of an underground high-level nuclear waste repository. The ESF consists of two exploratory shafts (ES-1 and ES-2) available for testing, construction, and operational support; underground testing areas to characterize the proposed repository site; and surface and underground facilities.

The Yucca Mountain site is in southern Nevada, approximately 90 miles northwest of Las Vegas. The site is located on three adjacent parcels of U.S. Government land: the Nellis Air Force Range, the Nevada Test Site, and land administered by the Bureau of Land Management.

Support to the Yucca Mountain Project Office for the management, direction, and coordination of the ESF Title I design effort is provided by the participating organizations. The Technical & Management Support Services contractor is responsible for supporting the Yucca Mountain Project Office in management and integration. Holmes & Narver, Inc. (H&N) is responsible for the Title I engineering and design for the surface facilities and utilities; subsurface utilities related to testing; communications; data facilities; and life safety systems.

Fenix & Scisson, Inc. (F&S) is responsible for the Title I engineering and design for the ESF underground facilities and utilities, and the surface hoisting systems. Los Alamos National Laboratory (Los Alamos) managed and integrated the testing design requirements and definitive design criteria on testing for the ESF Title I design and provided designs and design requirements for the Integrated Data System (IDS). Sandia National Laboratories (SNL) is responsible for ensuring that the ESF is compatible with the planned repository. The United States Geological Service (USGS) is in charge of shaft wall mapping, photography and hand specimen sampling, rock matrix tests, hydrologic properties, intact fractures test, infiltration test, bulk permeability test, radial boreholes test, hydrochemistry tests, excavation effects tests, perched water tests, overcore stress tests and vertical seismic profiling. Lawrence Livermore National Laboratory (LLNL) is in charge of the waste package environment test. Reynolds Electrical & Engineering Company, Inc. (REECo) is the construction manager for the ESF and provides technical advice on its constructibility.

The Quality Assurance program for the Title I design phase and subsequent phases of the Exploratory Shaft Facility is described in the Project Quality Assurance Plan (QAP) (NNWSI/88-9). The QAP provides direction to the Yucca Mountain Project participants and Architect/Engineers (A/Es) for the content of their Quality Assurance Program Plans (QAPPs) and internal implementing procedures, which describe how the technical disciplines implement the QA requirements.

GEOLOGY

Yucca Mountain is underlain by more than 1,800 m of Miocene ash-flow tuffs, volcanic breccias, and volcaniclastic sediments. Yucca Mountain is divided into a number of structural blocks by a set of faults. Lateral exploratory drifts are constructed in the ESF to examine the subsurface nature of these faults and fractures, which are ubiquitous in the tuffaceous units at Yucca Mountain.

ESF DESCRIPTION

The ESF is located on Yucca Mountain, approximately 90 miles northwest of Las Vegas. The shafts ES-1 and ES-2 are located on the main pad at an elevation of 4,130 feet. The main pad contains the shafts, hoist house, and facilities for shaft sinking and operations development. The main pad encompasses nominally 5.5 acres; the structures required for mining and scientific investigation are located there. All utilities are trenched and routed to the required areas. An area is designated for the shaft sinking subcontractor operations. On a corner of the pad is the surface data building that contains the Integrated Data System (IDS).

There are several auxiliary pads at the ESF site, including the booster pump station pad, batch plant and aggregate stockpile pad, topsoil pad, equipment storage pad, muck storage pad, substation and compressor pad, explosives storage pad, G-4 pad, water tank pad, and parking pads.

Roadways are provided to access the ESF from offsite locations and to interconnect the main pad with the auxiliary pads, storage areas and disposal areas.

The ESF surface buildings consist of pre-engineered metal structures on concrete slabs or portable double-wide trailer units. The surface buildings are complete with heating, ventilating and air conditioning (HVAC), plumbing and sanitary facilities, fire protection systems, lighting, communications, and compressed air. The test support facilities consist of office and laboratory space, areas to store equipment and supplies, a shop building, a warehouse, a hoist building for the ES-1 and ES-2 hoist systems, a communications shelter, a surface data building, and staging areas. The ventilation system features ES-1 and ES-2 as both intake and exhaust air shafts. The surface ventilation arrangement has two similarly sized primary exhaust fans for each shaft. Each shaft is provided with a duct acting as a separate exhaust airway, with transition exhaust ducting from the collars of ES-1 and ES-2 to the surface fans.

The electrical power distribution system supplies power for construction and operational requirements for the surface and subsurface, and standby and Uninterruptible Power Supply (UPS) systems. The water distribution system supplies and distributes the potable, fire protection, and process water required for construction and operation of the site. The sanitary water sewage system provides for the collection, treatment, and disposal of sanitary waste generated at the site. The communications system consists of the telephone system, mine plant intercom, public address, experimenters intercom, and closed-circuit television. The surface mine waste water system handles non-sanitary industrial mine waste water. The compressed air system provides compressed air to the ESF underground and surface facilities.

ES-1 is 12 feet in diameter and consists of the following: a concrete collar structure that serves as the headframe foundation; a 12-inch thick concrete liner; shaft stations at the Upper Demonstration Breakout Room (UDBR) and the Main Test Level (MTL); furnishings for a single deck shaft conveyance, utilities and ventilation ducts; a hoisting system for ES-1 personnel transport and emergency egress; a sump to collect and contain mine waste water; and sinking arrangements to provide work platforms above the shaft bottom.

ES-2 is 12 feet in diameter and consists of a collar and lining similar to ES-1. ES-2 has only one station at the MTL and provides furnishings for a double deck cage and skip arrangement, utilities and ventilation ducts. The ES-2 hoisting system transports personnel, materials, and construction equipment and is considered as the main construction shaft for the underground facilities. The ES-2 sump and the sinking arrangement are similar to ES-1.

The ESF underground facilities consist of the UDBR, which is used for observation and demonstration; the MTL operations area for access, transport space for men and materials, operational space, and storage space; the MTL test area for subsurface testing; and long exploratory drifts to access potential important geological features for characterization.

The underground utilities consist of the power distribution system, the communications system, the life safety monitoring and alarm system, the conduit and cable tray system, the lighting system, the ventilation system, the water distribution system, the mine waste water collection system, the compressed air system, the fire protection system, the rock handling system, sanitary facilities, and the monitoring and warning system.

The various tests in the ESF are designed to acquire data on geologic, hydrologic, geomechanical, geochemical, and waste package environment characteristics. Although all tests performed in the ESF are done in situ, the DOE has classified test activities initiated during the construction of ES-1 as construction phase tests and tests initiated after the connection of ES-1 with ES-2 as in situ phase tests. There are 34 tests presently planned in the ESF.

ENVIRONMENTAL ASPECTS

The environmental aspects associated with ESF activities include air quality, water quality, land disturbances, hazardous and solid wastes, and construction permitting. The regulatory framework for the ESF is based on the environmental requirements set forth in the Nuclear Waste Policy Act of 1982, the Nuclear Waste Policy Amendments Act of 1987, DOE Orders, the National Environmental Policy Act, and applicable federal and state statutes and regulations. The DOE will comply with the applicable environmental statutes and regulations.

SAFETY AND HEALTH ASPECTS

The design, construction, and operation of the ESF conforms to the applicable requirements of federal regulations, DOE Orders, and miscellaneous safety and health codes and regulations. The design is subject to review, which will ensure that conformance to the codes and regulations can be achieved during construction and operation of the facility. Representatives of the Mine Safety Health Administration (MSHA) are responsible for onsite inspections. The DOE has the ultimate responsibility to ensure that all health and safety requirements are adhered to during the life of the project.

A safety and health program plan drafted by REECo provides safety and health plans, procedures, and practices for the overall surface and underground construction effort, and operational safety and health responsibilities for the duration of the ESF.

DESIGN ASPECTS

The following information justifies the selection of specific design features in the Title I design of the ESF.

The design speed for the main ESF access road is 35 mph, based on the Nevada Department of Transportation standards which take into account the traffic volume and type of terrain. Included in the road calculations and volumes are heavy loaded vehicles such as water trucks, concrete trucks, and tractor-trailer rigs. The haul road is designed for 35-ton dump trucks, requiring extra width and a thicker base. The ESF design provides similar treatment for all access roads.

All pads are constructed in a similar manner. Topsoil is removed and stored and the area is brought to grade. Type II material is placed in two lifts. The first lift is a leveling course and the second course is full depth, up to grade and compacted. Pads used for heavy traffic such as vehicle turnarounds or access to the main pad have double surface treatment.

Several methods are used to protect side slopes from erosion. Ditches, which are adjacent to berms and built on fill, are concrete-lined. Runoff is diverted and piped down the slopes. Concrete grouted riprap is used for erosion control. Side slopes are sprayed with soil stabilizer, trimmed and compacted during construction.

The goal of the site drainage system design is to protect the site against potential floodwaters and control the runoff. Drainage channels and ditches are used to control flows in the existing water courses. The main pad is protected from the probable maximum flood by deepening and widening the existing wash above the pad, and a berm is added on the upper side of the pad to deflect any possible uncontained floodwaters.

ES-1 and ES-2 are protected from the probable maximum flood as defined in the U.S. Bureau of Reclamation Probable Maximum Flood Study 6R-87-8. Auxiliary pads are protected from the waters of a 100-year flood. All roads, parking areas, and related improvements are protected from the effects of a 25-year flood.

Space requirements for surface buildings are obtained from projected staffing requirements by the participants. Pad areas around the buildings allow sufficient space for access to mechanical equipment, materials delivery and storage, limited vehicle parking, and pedestrian circulation. Trailers are used for the office and laboratory space requirements to allow portability and flexibility. Activities requiring special or unique features such as computer facilities, high ceilings, or heavy equipment/cranes are housed in pre-engineered metal buildings.

The ES-1 shaft finished cross section has a 12-foot diameter, developed from an analysis that considered the known subsurface program requirements, industry construction practices and the in-shaft test equipment special requirements. The diameter is the smallest envelope that permits efficient construction and drilling of test-related horizontal holes. The excavation method selected for shaft construction is the controlled drill and blast method. This method is intended to reduce overbreak, original crack dilation and new crack development.

The ES-1 ground support and shaft liner designs take into consideration the various loads and construction-related requirements. The shaft collar and liner are designed for a competent rock foundation, considering thermal and seismic stresses, and authorized design input. The thickness of the liner takes into consideration the stresses to which it is subjected and the methods available for concrete placement, embedment item clearances, and other working spaces indicated by testing needs. This results in a 12-inch minimum liner thickness. Preliminary analysis indicates that a lining thickness of 12 inches of 5,000 psi concrete is adequate for the ES-1 shaft. Implementation of the final liner may be preceded by installation of the primary ground support. Depending on the rock conditions encountered at various depths, a range of primary ground support schemes including rock bolts of suitable lengths in combination with wire mesh and shotcrete, if necessary, are considered.

In general, the ES-1 shaft is used for in situ measurements associated with site characterization. The design of the ground support encompasses provisions for testing activities, including (1) the safety of personnel involved both in mining and research activities, and (2) a minimum interference with testing activities where ground support would lead to distortion of the results of measurements.

Station cross sections at the UDBR and MTL levels meet the sizes necessary to accommodate shaft and station furnishings and the requirements of the test configuration.

The hoisting system for ES-1 provides safe and controlled access for personnel and equipment to the UDBR and MTL levels of the ESF. The primary function of the hoist system is to service in-shaft testing for site characterization, and to provide a second means of egress for both of the levels serviced by ES-1. The system is not intended for hoisting MTL rock, nor is it intended for primary underground operations support.

The hoist used for the ES-1 hoisting system (sinking and operations) is existing government furnished equipment (GFE) presently located on the Nevada Test Site. Preliminary evaluation and analysis of the hoist data reveals that it has adequate capacity to support and satisfy the ESF requirements for sinking, operations and underground site characterization needs. The conveyance consists of an unbalanced single deck cage with a maximum capacity of 17 people. The cage is capable of evacuating all underground personnel to safety within one hour in the event of an emergency. The headframe is designed to accommodate all the sinking and operational phase requirements.

The shaft sinking equipment configurations and the sinking methods are based upon the ESF Subsystems Design Requirements Document (SDRD) stated shaft size of 12 feet, the expected conditions as expressed in the Reference Information Base (RIB), the planned activity that occurs in the shaft as described in the SDRD, and other concerns created by proposed activity that occurs during the shaft construction period. A platform on which people can stand and work safely is required to support shaft sinking and mapping operations. The platform is called a galloway, work deck, or sinking stage. The galloway provides a platform from which men and equipment can be hoisted from the shaft bottom to the surface. Space on the decks is provided for men to stand, handle equipment, and perform tasks such as rock bolting and concrete placement.

The upper deck of the galloway (which can be detached) is used as a platform to support the installation, maintenance and monitoring of test equipment in ES-1 at various depths in the shaft. The bottom decks of the galloway support geological mapping and photography activity.

The ES-2 shaft finished cross section has a 12-foot diameter, developed from an analysis that considered the known subsurface program requirements and industry construction practices. The diameter is the smallest envelope that permits efficient implementation of the drill and blast methods selected for shaft construction. This method is intended to reduce overbreak, original crack dilation and new crack creation.

The ES-2 ground support and shaft liner designs take into consideration the various loads and construction-related requirements. The shaft collar and liner are designed for a competent rock foundation, considering thermal and seismic stresses, and authorized design input.

The thickness of the liner takes into consideration the stresses to which it might be subjected and the methods available for concrete placement, embedment item clearances, and other working spaces indicated by testing needs. The resulting liner thickness is a minimum of 12 inches, depending on overbreak.

The shaft station sizing in ES-2 deals only with the MTL level, where a rock handling facility is planned. In this location of the shaft, cross-sectional configuration is dictated by the spatial requirements of the loading pocket, measuring bin, and rock chute. Additional depth of the shaft is required to accommodate these mechanical systems, but is not influenced by testing needs as experienced in ES-1 shaft sizing.

Dimensional similarities between ES-1 and ES-2 result in the application of identical approaches to the assessment of ES-2 shaft stability. Since in the ES-2 shaft only a minor interference with underground measurements is expected, the primary support needs are determined on the basis of the rock mass classification encountered at the given location.

The ES-2 hoisting system is intended to function as the primary system for transferring personnel, equipment and excavated rock between the surface and underground. The hoist system is comprised of individual components, each installed separately, but acting as a single unit.

The hoist used for the ES-2 hoisting system is existing GFE. Preliminary evaluation of performance characteristics indicates this hoist is capable of fulfilling the requirements for sinking, operations, and underground site characterization needs. The headframe is designed to satisfy all the sinking and operational phase hoisting requirements.

The conveyance for the ES-2 shaft consists of a double deck cage over skip combination in balance with a counterweight. The cage has a maximum capacity of 17 persons per deck, while the skip has a capacity of 10 tons. The size of the cage provides adequate capacity to transport personnel, material and equipment to the MTL, completely independent of the science activities planned in ES-1, and provides adequate capacity for total underground personnel evacuation in the event of an emergency.

The shaft sinking equipment, configurations, and methods are based upon the SDRD stated shaft size of 12 feet, the expected conditions as expressed in the RIB, the planned activity that occurs in the shaft as described in the SDRD and other concerns created by proposed activity that occurs during the shaft construction period. The sinking arrangement for the ES-2 shaft is virtually the same as for ES-1, except for the fact that ES-2 is not encumbered by testing considerations.

The ESF has four major areas of subsurface development: shafts, UDBR, MTL, and exploratory drifts. Each construction center is designed both to the individual requirements of the area, and as a part of a larger overall system. The total system also conforms to the conceptual design aspects of a repository as known at the time of Title I ESF design.

As ES-1 is sunk, a station is established at the UDBR level, approximately 600 feet from the surface. The size of the UDBR is determined by the Principal Investigator's requirements to test in a full-sized repository-type opening with a high lithophysae content. After the UDBR is completed, ES-1 progresses at its normal sinking pace until the MTL is reached. At that time, excavation of the MTL is initiated.

ES-2 is sunk at a normal rate, unencumbered by planned testing delays. When ES-2 is completed, a shaft connection is established. The remaining drifting on the MTL is then excavated according to priority needs, with full capabilities of facility support and data retrieval. Following the development of the MTL, three exploratory drifts are driven to predetermined areas of the repository. These drifts are driven along the grade and heading of potential repository drifts.

Size of underground openings and the general form of the MTL level layout is based on two major criteria: safety of operation, which dictates the minimum opening dimensions necessary to accommodate mining equipment used in the MTL development and workers' safety; and needs associated with testing and site characterization. For personnel safety, stability implies that no localized rock fall of a size sufficient to cause serious personnel injuries occurs, and no catastrophic failure of the openings that could block personnel access or egress occurs.

The size of the larger openings of the MTL is equal to the full-scale openings for the future repository. In addition, the sizes of pillars separating various testing areas are based on testing requirements and the need to protect specific structures vital to operation of the ESF (e.g., shaft stations).

In general, three types of loads are considered during analysis of the underground opening stability at the MTL and UDBR levels: geostatic loads, seismic loads, and thermal loads. The conclusion resulting from the design of the underground openings is that they are stable and usable for the life of the repository.

The MTL mine power center is the main subsurface electrical power supply for all MTL underground electrical loads. The rationale for choosing the mine power center configuration is based on the SDRD criteria stating that redundant 4,160 V armored power cables are supplied down each shaft feeding a substation or power center with adequate capacity to supply all construction, operations and testing loads for site characterization and adequate redundancy for acceptable system reliability. The general subsurface MTL mine lighting system consists primarily of incandescent, fluorescent and emergency lighting.

The system designed for the subsurface communication and subsurface to surface communication is a dual function dial/page type mine telephone system. It combines the capability of a regular rotary dial operated public telephone exchange with a page-all paging system. Permanent stations are installed where operational, maintenance or testing personnel are located, such as IDS, shop, and shaft stations. Where personnel can be located for performing different temporary work tasks, a plug-in telephone jack is installed.

The mine dial/page phone system provides the convenience of a telephone station plus additional paging facilities in dusty locations where standard telephone equipment is considered not suitable for the environment. In addition to the mine dial/page telephone system, the audio alarm communicators of the fire detection and alarm system are utilized as emergency communication speakers for the public address system.

The ventilation features pertaining to both the ES-1 and ES-2 shafts are a combination of intake and exhaust air systems. Each shaft is essentially split with metal ducts, primarily used as a separate exhaust airway. The main exhaust fan for each shaft is located at the surface. The intake air flows down each shaft and into the MTL, and exhausts to the surface through the metal ducts. Air distribution into the various MTL development and test areas is controlled by a combination of fans/ducts, regulators and doors. General implementation of dust suppression techniques includes the use of water, biodegradable and nontoxic chemical additives, and dust collectors.

The mine water supply system design features all relate to the demand requirements, which vary with the fire protection needs and equipment spreads required of various phases of construction, testing, and operation. Reliability and safety features of the mine water supply system include distribution looping, pressure regulators, excess floor (line break) valves, relief valves, and water hammer dampening.

The mine waste water system design incorporates both collection and transfer features. The sources of mine waste water for collection include water from construction, testing, operation, fire-protection, and possibly naturally occurring ground-water inflow. The pumping system consists of various types of drift or shaft bottom pump units feeding into one main mine sump with a pump unit capable of transferring all waste water inflows to the surface.

The compressed air system design features are developed to meet the demand requirements for ESF construction, testing, and operation. The equipment utilizing compressed air includes pneumatic rock drills, blast face sprays, blowpipes, diaphragm pumps, pneumatic test drill equipment, tuggers, air door cylinders, muckers, and pneumatic wrenches and chipping hammers.

The fire protection system design features are developed by H&N. F&S interfaces with H&N on the fire protection water supply, system monitoring and control, fire doors, fire dampers and portable extinguisher units. Fire doors at the shaft station are provided to environmentally isolate the shafts from the MTL in case of an emergency.

Automatic water sprinklers are required for primary fire protection by DOE Order 5480.7 Fire Protection. The requirements pertain to all surface structures. The hoist house has a freeze-proof preaction sprinkler system because the building is not heated. The surface data building has a heat detector activated Halon 1301 system that provides the initial protection in the computer area.

The rock handling system consists of underground transportation with load-haul-dump (LHD) units; a dump station adjacent to the ES-2 shaft, equipped with a grizzly, surge bin, measuring flask and loading chute on the MTL; and the loading pocket cutout immediately below the MTL. At this point, the rock is transferred to the ES-2 hoisting system, consisting of the hoist, rock skip, and headframe with dump scrolls. On the surface, the skip discharges into an area next to the shaft collar, from where it is transferred to a permanent storage area by haul trucks.

The sanitary facilities design includes portable toilet unit construction, location determinations, and maintenance operating procedures.

During Title I, many items of operational monitoring and control were added to the life safety system, including power monitoring; ventilation monitoring and control; hoist operations monitoring; air compressor monitoring; and water system monitoring. Monitor and control points are controlled by software and can be changed as criteria become better defined or as field operations change.

The life safety monitoring and alarm system allows for the subsurface monitoring of noxious and toxic gases. Gases monitored, according to SDRD requirements, are carbon monoxide, carbon dioxide, nitric oxide, nitrous oxide, hydrogen sulfide, sulfur dioxide, and oxygen.

Test constraints are requirements imposed on the ESF design that must be satisfied to ensure that the test can be located properly. Constraints that impact the underground layout can be classed into three types: (1) sequencing constraints; (2) physical location constraints; (3) construction and operational constraints.

The zone of influence also becomes an important consideration because of the requirement to separate tests sufficiently so there is no unacceptable test-to-test interference and the requirement to limit, as much as possible, the construction influence to the dedicated testing area.

Selection of specific design features to accommodate the planned testing in the ESF is the result of work performed by the Interface Control Working Group and incorporated into the SDRD. The test plans are the result of several years of work by the ESF Test Plan Committee and are documented in the Project Site Characterization Plan (SCP), the SDRD Appendix B, and the associated test study plans. Section 8.4 of the SCP discusses the ESF testing with respect to the facility design.

REPOSITORY REQUIREMENTS FOR THE ESF

The ESF facilities support the repository in three ways: (1) the shafts and MTL drifting supply ventilation air to support waste emplacement operations, (2) the exploratory drifting on the MTL accesses waste emplacement areas, and (3) the shafts and drifting support early repository construction.

Permanent items are items or facilities constructed or installed as part of the ESF that are converted for operational use by the repository. These items are underground openings, shaft liners, operational seals, and ground support.

Two repository preclosure performance objectives are defined in 10 CFR Part 60: (1) protection against radiation exposures and releases of radioactive material (10 CFR 60.111a), and (2) retrievability of waste (10 CFR 60.111b). As part of the repository during preclosure activities, the ESF will be capable of meeting these same performance objectives.

Because no radioactive waste is handled or transported in the exploratory shafts, a concrete liner or drift collapse is not likely to lead to any radiological release. Where waste is transported through the access drifts in the event of retrieval, the waste is located in a container surrounded by a transfer cask. The cask is designed to meet radiation shielding requirements and maintain its structural integrity during a drift collapse with no release of radioactivity.

During retrieval, specific drifts may be used for transportation of waste. Waste is neither transported nor retrieved through the ESF shafts. Structural failure in any of the access drifts is accommodated either by cleanup or by seeking alternate transportation routes using existing adjacent or newly mined drifts.

The repository facilities, including the exploratory shafts, are designed to withstand the effects of surface flooding. The shaft collars are located above the height of the probable maximum flood, and the surface around the facilities is graded with flood protection as a requirement. Additionally, any water entering the shafts is collected in a sump below repository level and any water entering the ESF drains to a low point in the ESF and is then pumped to the surface.

The approach taken to evaluate potential impacts of site characterization activities on postclosure performance is to determine how each category of activity in both the surface-based testing and ESF testing programs affects the thermal, mechanical, geochemical, and hydrological conditions of the site, and then determine the potential impacts on the performance objectives from these modified conditions.

All steps in the development of the ESF, i.e., planning, development of design requirements, design, performance evaluation, and supporting analysis, have considered the ESF to be an integral part of the repository. This approach assures that the requirements imposed on the repository for public safety and waste isolation are also considered in the design of the ESF.

CLOSURE AND DECOMMISSIONING

Closure and decommissioning of the ESF takes place under one of the following scenarios: (1) Yucca Mountain is not selected as the repository site and the repository is not constructed, or (2) Yucca Mountain is selected as the repository site and the repository is constructed.

If Yucca Mountain is not selected for the repository site, the ESF is recommended for closure and decommissioning. The subsurface closure activities begin with the withdrawal of all testing and drilling equipment. The subsurface drifts and shafts are then backfilled to minimize subsidence effects on the surface from the previous underground activities and to protect and preserve adjacent stratigraphic features. Previously excavated and stored mined material from the surface rock pile is pneumatically stowed in these areas. The headframe foundation, structural steel supports and shaft collars are then removed and a final concrete plug is constructed.

When the shaft backfilling operations are complete, all remaining equipment in the shaft collar areas and the hoists and associated outfitting are disassembled and removed from the site. The equipment and building salvage operations are then initiated. The site is then restored and contoured using stockpiled topsoil, and the native vegetation is replaced.

If the Yucca Mountain site is acceptable, then during the initial phase of repository construction, ES-1 and ES-2 provide the ventilation intake and exhaust. In addition, ES-1 provides access for people, materials, utilities, and supplies, and ES-2 is used for muck hoisting. When the repository men and materials shaft and tuff ramp are completed and become operational, ES-1 and ES-2 are converted to provide intake air to the repository emplacement ventilation systems.

The repository preclosure period begins after completion of the repository Phase I construction and continues through the repository operational phase, caretaker phase, and closure and decommissioning phase. Because the ESF is part of the repository, ESF closure and decommissioning activities are consistent with the overall repository closure and decommissioning program.

The repository postclosure period begins after completion of the repository closure and decommissioning activities (10 CFR 960.2). Because the ESF remains part of the repository, the postclosure performance of the ESF is consistent with the postclosure performance of the overall repository.

ADVANCE PROCUREMENT ITEMS

Advance procurement items are equipment and systems that require more than three months for manufacture and delivery after receipt of a purchase order. Each Yucca Mountain Project procurement, regardless of estimated cost, is planned and documented to assure a systematic approach.

TITLE II DESIGN

The Yucca Mountain Project Office is the organization in the DOE Nevada Operations Office that is responsible for the overall management of the ESF Title II Design. The Project Office is assisted in this management function by the T&MSS Management and Integration group and Quality Assurance group. The Management and Integration group coordinates the activities associated with engineering analysis, technical assessment, project studies, project participant integration and project task management. The Quality Assurance group is an autonomous organization, reporting directly to the Project Office, which is responsible for the overall project quality as it relates to facility licensability.

Development of the ESF design and test program is divided into three areas, each the responsibility of a separate organization. Each organization has a design responsibility, and reports directly to the Project Office. The three design areas are surface facilities, underground facilities and underground testing. The ESF surface and underground testing for Title II design is based on the approved ESF Title I design and the design-related requirements and guidance documents of the Project as interpreted by the design basis documents of the responsible individual design participant. Surface facility design is the responsibility of H&N, an A/E firm experienced in nuclear industry related civil-structural work. Underground facility design is the responsibility of F&S, an A/E firm experienced in nuclear industry related work in underground design and development. Los Alamos is responsible for integrating the testing requirements with the design.

The underground testing program development and design is coordinated by Los Alamos. The test design and facility development is produced through the cooperative efforts of the participants delegated the responsibility for conducting the individual tests. In addition, the designated construction organization (REECo), reports directly to the Project Office, and participates in a design oversight capacity during the Title II design process to ensure constructibility and worker health and safety.

The ESF Title II design phase QA program is governed by the Yucca Mountain Project QAP, as is the Title I design phase. The use of QA levels continues, with QA Level I items and activities requiring the highest degree of quality because of their relationship to the radiological health and safety of the public in the preclosure and postclosure phases of the repository. QA Level II is assigned to items and activities that are associated with public and worker nonradiological health and safety. QA Level III items and activities are those having no major function in the characterization of the site, but which require good professional and industrial practice for their intended use.

In the process of performing Title I design, the documentation and traceability of interface requirements and other design information was based on existing QA requirements. ESF design decisions for Title II will be as rigorous as those required for a licensable activity. A readiness assessment review board and team provide the Project Office with an independent evaluation of the management and quality assurance activities necessary, and provide insight into the risks associated with alternate courses of action.

The bases for design for the Title II ESF design are Project-level documents and A/E documents. Other information may be provided as design input by the Project Office in the form of letters. Design criteria exist as a result of ESF planning activities, correspondence, meetings and special studies; and the criteria further defines the ESF or performance requirements, and are included in the basis for design.

TITLE III CONSTRUCTION

The Project Office is responsible for the management, direction, and coordination of the overall ESF construction, inspection, and acceptance testing effort. The T&MSS supports the Project Office in the management and integration of ESF construction, operations, and testing. Duties include project management and integration; technical review/analysis of project construction and operations progress and results; evaluation of project reports; and ongoing regulatory, institutional, quality assurance, socioeconomic, transportation, and environmental studies. MACTEC provides quality assurance support to the Project Office. H&N is responsible for surveying, and inspection of their design for surface facilities and utilities, subsurface utilities related to testing, communications, data facilities, and life safety systems. F&S is responsible for the engineering and design-related technical support on the ESF underground facilities and utilities, and the surface hoisting systems. Los Alamos manages and integrates the efforts of the PIs of the participating organizations with the designers, constructors, and operators, and the resulting overall site characterization testing program at the ESF site.

SNL is responsible for ensuring that the ESF is compatible with the planned repository. The USGS is in charge of shaft wall mapping, photography and hand specimen sampling, rock matrix tests, hydrologic properties, intact fractures test, infiltration test, permeability testing, radial boreholes, hydrochemistry tests, excavation effects tests, perched water tests, overcore stress tests, seismicity, and climatology. LLNL is in charge of the waste package environment test. REECo is the construction manager for the ESF.

The ESF Title III phase follows the requirements of the Yucca Mountain Project QAP with emphasis on the QA criteria associated with inspection of construction. Administrative procedures are developed to enforce criteria involving procurement, control of processes (blasting, welding, etc.), and inspection. These requirements are imposed upon the A/Es and construction contractors who develop and issue quality control operating procedures for inspections and construction operations including welding, stress relieving, warehousing and testing.

The QA levels are applied with Quality Level Assignment Sheets (QALAS) made during the Title II phase. The performance of a construction or inspection operation is governed by the QA classifications assigned to an item, and includes all phases of construction from qualification of personnel to inspection documentation.

During Title III, QA emphasizes achievement of actual quality in the construction process in addition to the meeting of programmatic requirements such as record keeping. The QA program concentrates on the actions and processes that directly affect quality of construction by specifying training of all personnel whose workmanship capabilities contribute to the construction of the ESF and its eventual operation.

The majority of the construction is completed by REECo as the constructor using direct hire labor. The only work to be subcontracted by REECo is the sinking of the ES-1 and ES-2 shafts and the construction of the 150,000-gallon and 10,000-gallon water tanks. The possibility of REECo sinking the two shafts using direct hire labor is being evaluated now.

The readiness review process is conducted and documented in accordance with the Administrative Procedure 5.13Q. DOE/Headquarters and the Project Office have agreed to hold readiness reviews before the start of site preparation, the start of multipurpose borehole testing, and the start of the shafts.

OPERATIONS AND TESTING

The Title I design of the ESF is sufficiently flexible to provide space for the conduct of performance confirmation tests. The performance confirmation tests are defined in 10 CFR Part 60 as a "program of tests, experiments, and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objectives for period after permanent closure will be met." Details of such tests are not available at this time. However, it is anticipated that the site characterization tests, for which the ESF is being designed, such as seal tests, the room heater experiment, and engineered barrier field system tests, may become performance confirmation tests.

CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

This report complies with U.S. Department of Energy (DOE) Order 4700.1 Project Management System dated March 6, 1987. The Title I report is an overview and record document of preliminary engineering and project management planning, reflecting completed Title I design for the Exploratory Shaft Facility (ESF) of the Yucca Mountain Project.

The report serves two purposes: (1) to provide the Yucca Mountain Project Office with summary design information for approval prior to authorizing the start of definitive design, and (2) to provide the DOE/Headquarters Program Office with the necessary project information to assist in program planning, policy improvement, and criteria guidance for future projects.

The report gives a general description of the work, the overall concept and layout, and the types of facilities. A brief analysis of environmental and safety aspects is included. The justification for the design concepts chosen is given, along with the Title I design drawings and outline specifications. Cost and schedule information are also included as recommended in the Order.

Title I design is a preliminary design that continues the design effort utilizing the conceptual design and the project design criteria as a basis for project development. Title I design develops topographical and subsurface data and determines requirements and criteria that will govern the definitive design. Tasks include the preparation of preliminary planning and engineering studies, preliminary drawings, outline specifications, life-cycle cost analysis, preliminary cost estimates, and scheduling for project completion. Preliminary design provides identification of long lead procurement items and analysis of risks associated with continued project development. For a detailed description of the services provided during preliminary design, refer to DOE Acquisition Regulation (DEAR) 936.605c and DEAR 952.236.70.

Title II design is the definitive design that continues development of the project based on approved preliminary design (Title I). Definitive design includes any revisions required of the Title I effort; preparation of final working drawings, specifications, bidding documents, cost estimates, and coordination with all parties who might affect the project; development of firm construction and procurement schedules; and assistance in analyzing proposals or bids. For a detailed description of the services provided during definitive design, see DEAR 936.605c and DEAR 952.236.70.

1.2 ORGANIZATION OF THE REPORT

This report is organized into the benchmarks that are being reached for the Title I design of the ESF. Chapter 1 begins with introductory remarks about the purpose and scope of the report; the organization of the report; a recap of the role of the ESF in the Yucca Mountain repository and site characterization programs; the participant organizations and their responsibilities; and the quality assurance program for the Title I design. Chapter 2 describes the site and geology, including possible borrow areas for the construction of the ESF. Chapter 3 describes the general arrangement and layout of the ESF and its major facilities and utilities. Chapter 4 covers the regulatory, environmental and construction permitting concerns for the ESF. Chapter 5 deals with the safety and health facets and strategy of the ESF. Chapter 6 explains the design approaches and practices used in the preparation of the Title I ESF design and the proposed testing. Chapter 7 relates the repository interfaces with the ESF, and describes the plan to satisfy the requirements of OGR/B-2, Generic Requirements for a Mined Geologic Disposal System, Appendix E, for those portions of the ESF that are incorporated into the repository as permanent items. Chapter 8 discusses incorporation of the ESF into the repository and its closure; support to Phase I repository construction, preclosure and postclosure facets of the ESF; and potential decommissioning strategies for the ESF. Chapter 9 enumerates the material and equipment items identified as long lead procurement items and their acquisition strategy. Chapter 10 talks about the approach to Title II ESF design. Chapter 11 covers the Title III ESF management, construction, and inspection plans. Chapter 12 conceptualizes the operational phase of the ESF, including the long range testing plans. Chapter 13 proposes schedules for the long lead procurement, Title II design, and construction, testing, and operations. Chapter 14 covers the cost estimates. Chapter 15 contains the ESF Title I design drawings. Chapter 16 contains the ESF Title I outline specifications. The appendices hold the supporting documentation.

1.3 ROLE OF THE ESF

The Yucca Mountain location is being prepared for site characterization. The DOE Yucca Mountain Project Office is responsible for the design, construction, and operation of the ESF to provide access for detailed study of the potential host rock as well as the overlying geologic strata. The general objectives of the ESF at Yucca Mountain are to acquire access to underground tuff horizons and to obtain the necessary technical data regarding the unsaturated zone to assist in determining the suitability of the Yucca Mountain tuff media for the construction of an underground high-level nuclear waste repository.

The ESF will be constructed to meet a 10 CFR Part 60 requirement to perform a program of in situ exploration and testing at the depths at which wastes would be emplaced prior to submittal for a construction authorization for a repository.

The Yucca Mountain site is in southern Nevada, about 90 miles northwest of Las Vegas. The site is on three adjacent parcels of land owned by the U.S. Government. Most of the site is on the Nellis Air Force Range, managed by the U.S. Air Force; a smaller portion is part of the Nevada Test Site and is managed by DOE; and the remainder is administered by the Bureau of Land Management (Figure 1-1).

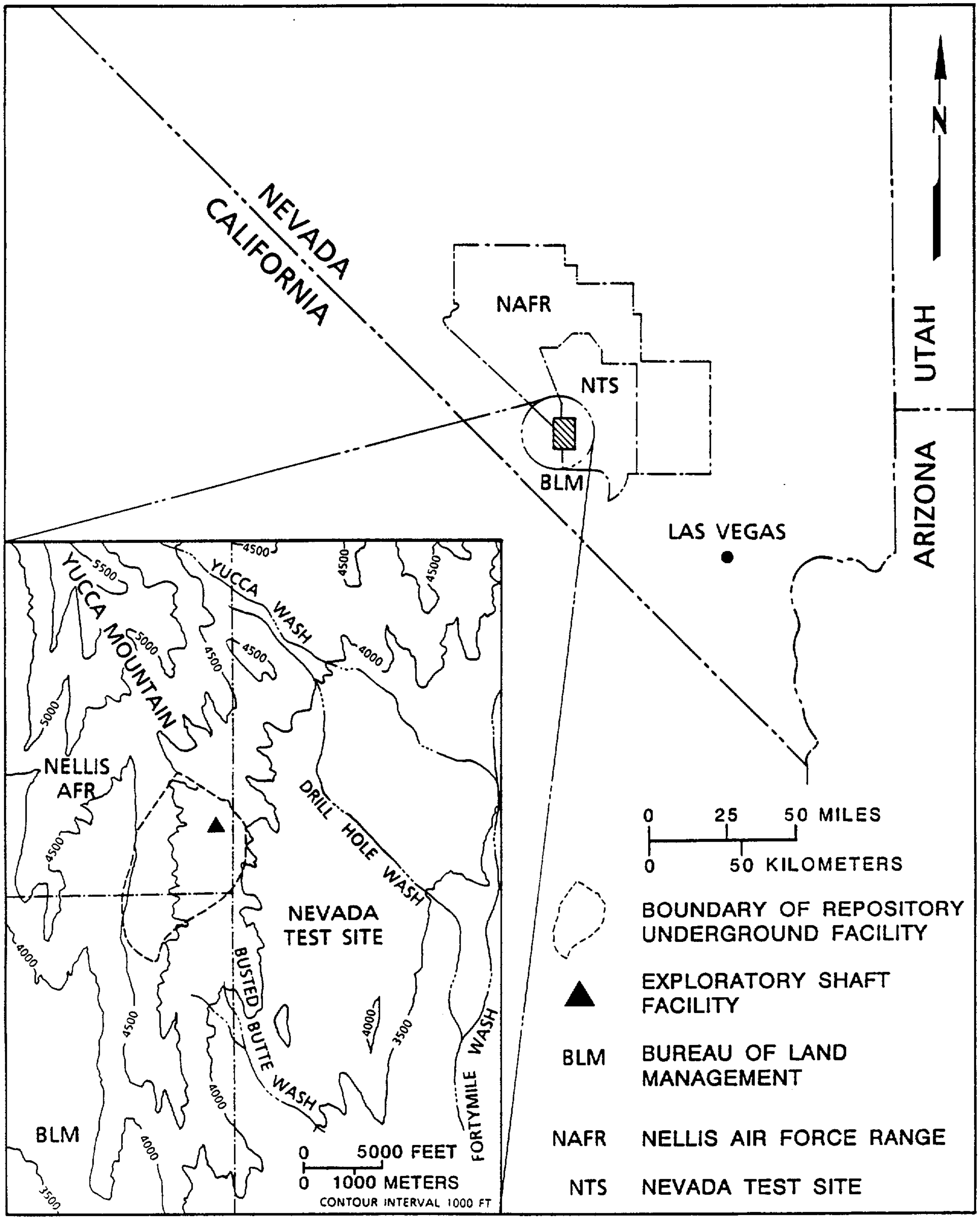


Figure 1-1. Exploratory shaft facility location.

The ESF consists of an exploratory shaft (ES-1) available for testing and site characterization; a second shaft (ES-2) available for construction and operational support; underground testing areas to characterize the proposed repository level (Main Test Level) and one area near the upper boundary of the proposed repository horizon (Upper Demonstration Breakout Room); and utilities and facilities both on the surface and underground to support the construction and operations of the ESF.

The tests performed underground in the ESF operational areas permit the Principal Investigators (PIs) from the participating organizations to perform in situ testing to determine the suitability of the Yucca Mountain site.

The ESF can be used by the repository for performance confirmation if the Yucca Mountain selection process is affirmed. The operational areas of the ESF are not envisioned for waste emplacement for the repository. ES-1 and ES-2 are envisioned for use by the repository, but only to aid its construction. In the event the repository is built at Yucca Mountain, ES-1 and ES-2 will be used operationally only as ventilation shafts and will not be used to emplace waste.

In the event Yucca Mountain is not suitable for siting a repository, the closure and decommissioning of the ESF can be accomplished as discussed in Chapter 8.

1.4 PARTICIPANT ORGANIZATIONS

YUCCA MOUNTAIN PROJECT OFFICE

The Yucca Mountain Project Office manages, directs, and coordinates the ESF Title I design effort.

TECHNICAL & MANAGEMENT SUPPORT SERVICES (T&MSS) CONTRACTOR

The T&MSS contractor supports the Yucca Mountain Project Office in the management and integration of the ESF.

HOLMES & NARVER, INC. (H&N)

H&N is responsible for the Title I engineering and design for the ESF surface facilities and utilities; subsurface utilities related to testing; communications; data facilities; and life safety systems. The H&N Title I ESF design includes the main pad, auxiliary pads, roads, site drainage, surface power system, surface water system, sewage system, surface mine waste water system, communication system, surface structures, subsurface data building, life safety system, uninterruptible power systems for the surface and underground testing, and provisions for the Integrated Data System (IDS) design.

FENIX & SCISSON, INC. (F&S)

F&S is responsible for the Title I engineering and design for the ESF underground facilities and utilities, and the surface hoisting systems. The F&S Title I ESF design includes the ESF shaft collars, shaft excavation and lining, hoists and headframes, subsurface excavations, shaft internals and conveyances, and in-shaft and underground utilities including the underground ventilation system, underground water system, underground mine waste water system, compressed air supply and underground distribution, subsurface power system, and portions of the underground instrumentation system.

LOS ALAMOS NATIONAL LABORATORY (LOS ALAMOS)

Los Alamos manages and integrates the testing design requirements, plans, and definitive design criteria on testing for the ESF Title I for the PIs from Los Alamos, Sandia National Laboratories, the United States Geological Survey, and Lawrence Livermore National Laboratory. Los Alamos provides technical assistance to coordinate the underground testing requirements and data acquisition portions of the ESF Title I design effort with H&N and F&S. In addition, Los Alamos is in charge of the testing for the chlorine-36 test, diffusion test, and IDS.

SANDIA NATIONAL LABORATORIES (SNL)

SNL is responsible for ensuring that the ESF is compatible with the planned repository. SNL is also in charge of the shaft convergence tests, the demonstration breakout room, sequential drift mining, the heated block test, the canister scale heater experiment, the plate loading tests, the small scale heater slot strength test, development of the prototype boring machine, heated thermal stress measurements, and performance assessment.

UNITED STATES GEOLOGICAL SURVEY (USGS)

The USGS is in charge of shaft wall mapping, photography and hand specimen sampling, rock matrix tests, hydrologic properties, intact fractures test, infiltration test, bulk permeability test, radial boreholes test, hydrochemistry tests, excavation effects tests, perched water tests, overcore stress tests and vertical seismic profiling.

LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL)

LLNL is in charge of the engineered barrier design test.

REYNOLDS ELECTRICAL & ENGINEERING COMPANY, INC. (REECO)

REECo is the construction manager for the ESF and provides technical advice on the constructibility of the ESF. In addition, REECo assists in the development, implementation, and control of a personnel health and safety program for the ESF.

1.5 QUALITY ASSURANCE

The Quality Assurance program for the Title I design phase and subsequent phases of the ESF, is described in the Project Quality Assurance Plan (QAP). The QAP provides direction to the Yucca Mountain Project participants and Architect/Engineers (A/Es) for the content of their Quality Assurance Program Plans (QAPPs) and internal implementing procedures which describe how the technical disciplines implement the QA requirements. Because each organization has different responsibilities, these QAPPs may differ in prescribing how some of the basic 10 CFR Part 50, Appendix B criteria are to be applied.

All Yucca Mountain Project participants utilize a graded approach to quality assurance as directed by the QAP. This system incorporates three quality assurance levels selectively assigned to the items and activities constituting the design, construction and operation of the ESF. QA Levels I, II, and III are the levels assigned to ESF associated items and activities.

QA Level I is assigned to those radiological health and safety related items and activities that are related to either safety or waste isolation and are associated with the ability of a geological waste repository to function in a manner that prevents or mitigates the consequences of a process or event that could cause undue risk to the radiological health and safety of the public.

QA Level II is assigned to those items and activities important to the reliability and maintainability of the ESF, public and worker nonradiological health and safety, and other operational factors of the ESF.

QA Level III is assigned to those items and activities that are not classified as QA Levels I or II.

QA levels of the items or activities of the ESF were defined by Quality Assurance Level Assignment Sheets (QALAS), forms required by NNWSI Standard Operating Procedure-02-02. This procedure justifies the QA level assignment by means of a checklist of quality-related characteristics and selection of applicable Appendix B criteria. The QALAS issued by the Yucca Mountain Project Office were applied to activities such as design, procurement and maintenance.

Prior to the start of Title I design, the Yucca Mountain Project Office assigned a blanket QA Level II QALAS to the Title I design work. The justification for this is that Title I is a comparative technical analysis of alternate designs. This QALAS covered all Title I design efforts, but is replaced partially by the individual ESF-QALAS as they were released.

In addition to the Quality Assurance review of the design output during and after the Technical Assessment Reviews of the Title I design, QA also performed official audits of the A/Es to confirm implementation of their QAPPs in the design effort. No major deficiencies were reported during these audits, indicating that the A/Es were aware of their QA responsibilities relative to the Title I design phase.

CHAPTER 2

GEOLOGY

2.1 GEOLOGY

The following summary of the geologic and structural setting of ES-1 is based primarily on two sources: Chapter 1 of the Site Characterization Plan Consultation Draft (SCP CD) (DOE, 1988) for formal geology and structure and Nimick et al. (in preparation) for the thermal/ mechanical units. The reader is referred to these two documents, as well as Spengler et al. (1979, 1981), Maldonado and Koether (1983), Scott et al. (1983), Scott and Castellanos (1984), Spengler and Chornack (1984), and Ortiz et al. (1985) for additional details.

2.1.1 GEOLOGIC UNITS

Yucca Mountain is underlain by more than 1,800 m of Miocene ash-flow tuffs, volcanic breccias, and volcaniclastic sediments. Approximately the upper half of this material is represented in the column headed "Geologic Stratigraphy" in Figure 2-1. Because engineering properties are associated with specific thermal/mechanical units, the formal geologic stratigraphy is not discussed in detail here.

2.1.2 THERMAL/MECHANICAL UNITS

Each of the thermal/mechanical units shown in Figure 2-1 has been defined according into thermal properties, mechanical properties, or both, (e.g., compressive strength, grain density, porosity, thermal expansion) that are statistically distinguishable from the same properties in adjacent units. The following subsections provide very brief descriptions of the thermal/mechanical units that are expected to be penetrated during ESF construction.

2.1.2.1 Unit TCw

Unit TCw consists of the welded ash flows that comprise most of the Tiva Canyon Member. These ash flows contain variable amounts of lithophysae (Scott et al., 1983). At ES-1, this unit is expected to be approximately 47 m thick, compared to a thickness range inside the boundary of the underground facilities of 0 to 159 m.

2.1.2.2 Unit PTn

This unit is a collection of nonwelded ash-flow tuffs and bedded tuffs. In general, the unit thins to the south across Yucca Mountain. The expected thickness at ES-1 is 38 m, compared to a thickness range inside the boundary of the underground facilities of 18 to 62 m, except in a small area near the extreme southwest part of the boundary.

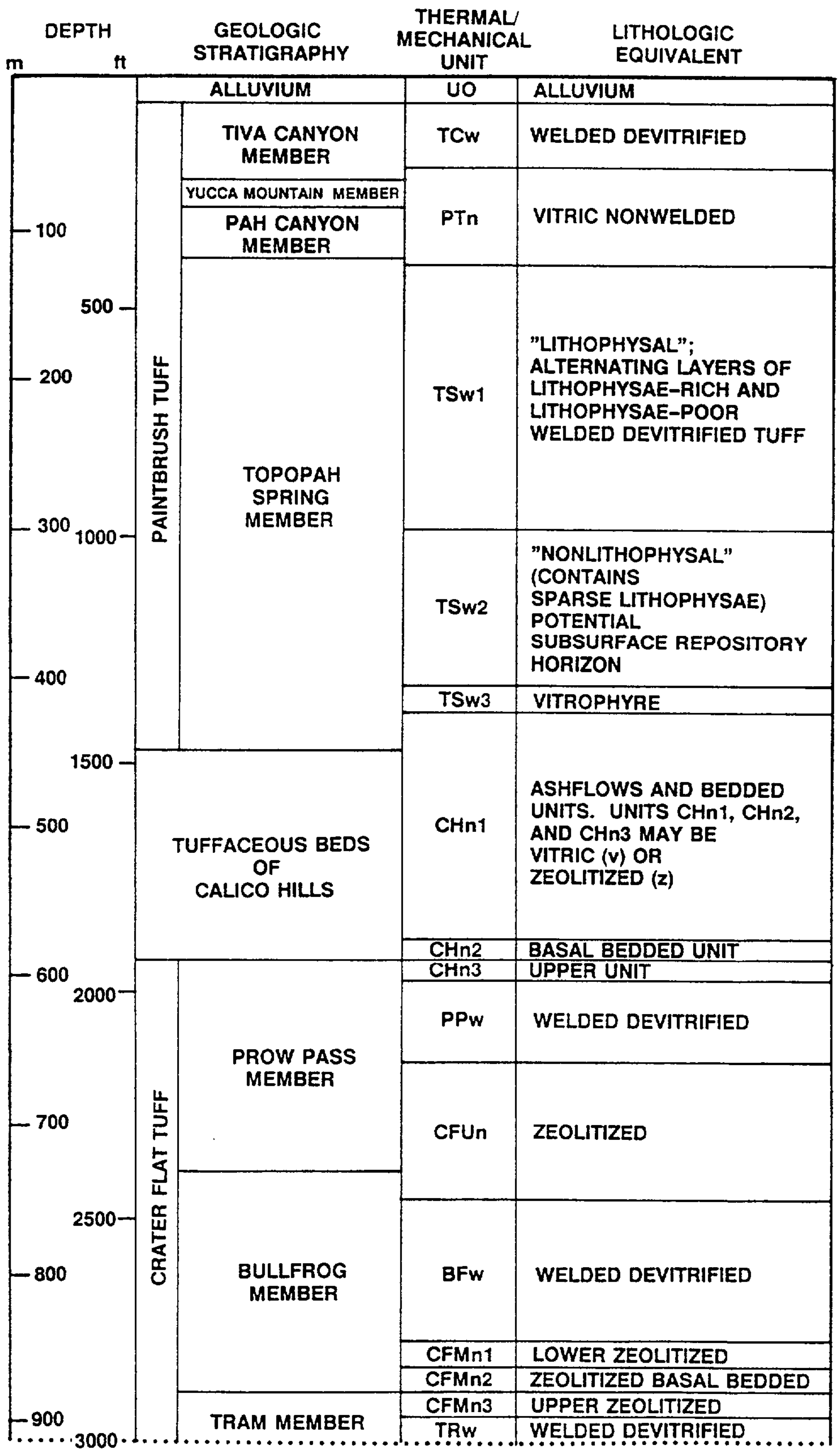


Figure 2-1. Thermal/mechanical and geologic stratigraphies.

2.1.2.3 Unit TSwl

Unit TSwl is comprised of welded, devitrified ash-flow tuffs of the upper part of the Topopah Spring Member of the Paintbrush Tuff. Characteristically, these ash flows contain more lithophysae than do the ash flows of unit TSw2 (Nimick and Schwartz, 1987; Nimick et al., in preparation); the base of unit TSwl is defined to be the base of the most lithophysae-rich zone in the Topopah Spring Member (the upper lithophysal zone of Byers and Moore (1987)). The thickness of this unit ranges from 25 to 147 m inside the boundary of the underground facilities, with an expected thickness of 126 m at ES-1.

2.1.2.4 Unit TSw2

Unit TSw2 consists of the welded, devitrified ash-flow tuffs of the Topopah Spring Member that occur between unit TSwl and the basal vitrophyre (unit TSw3). In general, the ash flows of this unit contain only sparse lithophysae. The expected thickness of the unit at ES-1 is 205 m, compared to a thickness range of 147 to 244 m inside the boundary of the underground facilities. This unit is the proposed repository horizon.

2.1.2.5 Unit TSw3

This unit is equivalent with the basal (moderately to densely welded) vitrophyre of the Topopah Spring Member. The expected thickness at ES-1 is slightly larger than 16 m. The thickness range inside the boundary of the underground facilities is not well quantified; the range in existing coreholes is 16 to 25 m.

2.1.3 FAULTING

Yucca Mountain is divided into a number of structural blocks by a set of north-trending, west-dipping, high-angle normal faults (Figure 2-2) with offsets that are generally greater than 100 m. Of these faults, Ghost Dance fault is the only one near the ESF; offset on this fault is expected to be approximately 20 m near the ESF. One of the lateral drifts to be constructed in the ESF is designed specifically to examine the subsurface nature of this fault.

Within each structural block are numerous west-dipping, high-angle normal faults that trend north to northwest, are closely spaced, and generally have small (<3 m) offsets. These imbricate normal faults are more common in the eastern portion of each structural block, and in the southern part of Yucca Mountain relative to the northern part.

In the northern part of Yucca Mountain (from the north edge of the site northward), vertical, right-lateral strike-slip faults transect the structural blocks. Offset on these faults generally is less than 100 m. The strike-slip faults may have associated breccia zones that are ≥20 m wide.

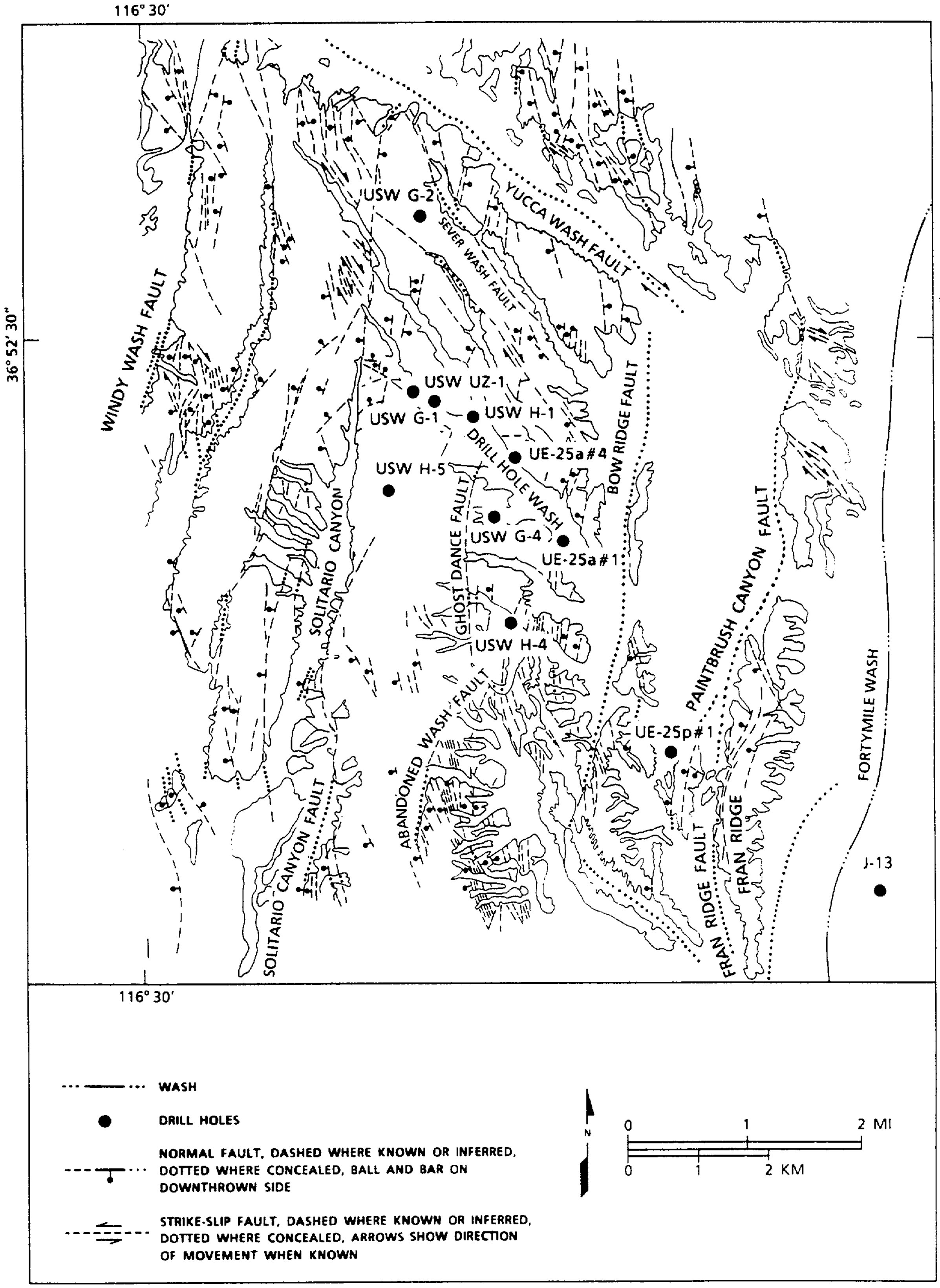


Figure 2-2. Structural features at Yucca Mountain (MacDougall et al., 1987).

2.1.4 FRACTURING

Fractures are ubiquitous in the tuffaceous units at Yucca Mountain; in general, fracture frequency is correlated with the degree of welding. The following reported fracture frequencies can be used for the different thermal/mechanical units: (1) TCw, 2-8 fractures/cubic meter; (2) PTn, 1-4 fractures/cubic meter; (3) TSw1, 14-20 fractures/cubic meter; (4) TSw2, 15-40 fractures/cubic meter; and (5) TSw3, 15-40 fractures/cubic meter. (These fracture densities are provided in Chapter 1 of the SCP CD for geologic units and have been assigned to thermal/mechanical units based on lithology.)

The fractures in unit TCw are divisible into three types. The first type is comprised of two sets of cooling fractures; one set trends N30° to 50°E, and the second set trends N35° to 55°W. Both sets are approximately perpendicular to foliation and have spacings of 150 to 200 m. The second and third types of fractures are of tectonic origin, and show small dip-slip or strike-slip displacements. These three types may apply to units TSw1 and TSw2 as well.

Fracture attitudes determined from oriented core are generally parallel to fault trends. For corehole USW G-4, attitudes are as follows: (1) TCw-N22°E, 65°NW; and (2) TSw1 and TSw2 - N12°W, 89° to 90°NE and SW.

2.2 ENGINEERING GEOLOGY

This section describes the rock properties, minerals, mineral surfaces, ground water and in situ conditions considered in the design of the ESF for Title I.

2.2.1 ROCK PROPERTIES

Rock Stratigraphy/Lithology

The Reference Information Base (RIB) indicates that at the indicated depth the rock strata are shown in Table 2-1 (USW G-4).

The depths to each unit are taken from the USW G-4 exploratory boring that is located at Nevada State coordinates N 765,807; E 563,082 (feet) at surface elevation 4,167 feet. Current plans call for ES-1 to be located at N 766,255; E 563,630 and ES-2 at N 766,337; E 563,918, both at surface elevation 4,130 feet.

Rock Mechanical Properties

The RIB specifies that the rock mass mechanical properties recommended and given in Table 2-2 are to be used for the stratigraphic units.

Table 2-1. Thermal/mechanical stratigraphy

Unit Designation	Depth Range (ft)	Formal Stratigraphy/Lithology
TCw	0–118	Tiva Canyon Member; welded, devitrified ashflows
PTn	118–243	Lower Tiva Canyon Member; Yucca Mountain and Pah Canyon Members, Upper Topopah Spring Member; vitric nonwelded ashflows and bedded tuffs
TSw1	243–670	Topopah Spring Member; welded, devitrified ashflows; "nonlithophysal" (alternating lithophysae-rich and lithophysae-poor ashflows)
TSw2	670–1291	Topopah Spring Member; welded, devitrified ashflows; "nonlithophysal" (sparsely distributed lithophysae)
TSw3	1291–1343	Topopah Spring Member; welded, vitric ashflow(s) (vitrophyre)
CHn1v	1343–1360	Topopah Spring Member; nonwelded to partially welded vitric ashflows
CHn2v	1360–1701	Lower Topopah Spring Member and rhyolite of Calico Hills; zeolitized nonwelded and partially welded ashflows and bedded tuffs

Table 2-2. Recommended rock mass mechanical properties

Unit No.	Thermal/ Mechanical Unit (RIB)	Unit Designation (SNL)	Depth (m)	Depth (ft)
2	TCw	IA2	0.00 45.55	0.00 156.00
3	PTn	IB	45.55 85.34	156.00 280.00
4	TSw1b	II-L	85.34 211.23	280.00 693.00
5	TSw2	II-NL	211.23 416.05	693.00 1365.00
6	TSw3*	III	416.05 426.42	1365.00 1399.00
7	CHnlv	IVA-v	426.42 434.04	1399.00 1424.00
8	CHnlz	IVA-z	434.04 535.53	1424.00 1757.00

In Situ Ground Stresses

The stresses that exist in an undisturbed rock mass are related to the weight of the overlying strata and the geological history of the rock mass. As pointed out by Hoek and Brown (1980), the vertical stresses (σ^z) are in reasonable agreement with the simple prediction given by the following equation:

$$\sigma^z = \gamma z$$

where: γ = the unit weight of the rock, and
z = the depth at which the stress is required.

The estimation of lateral stresses is usually more complicated. It appears that at shallow depths there is a wide range of the horizontal stress values determined as a result of in situ measurements. In general, the magnitude of horizontal stresses may exceed that of the vertical stress at the given location. In situ stress measurements are necessary to obtain a good estimate of lateral stresses. Table 2-3 includes the best estimate currently available of values and ranges of principal stresses at Yucca Mountain.

2.2.2 SURFACE EXCAVATIONS

The construction and excavation for the surface facilities of the ESF is straightforward and standard. It is very unlikely that unusual or unexpected conditions related to rock physical properties or hydraulic phenomena will be encountered in the ESF surface construction. At this time there are no apparent constraints, either physical or regulatory, that would not permit the construction of the ESF surface facilities by standard or industry produced cut-and-fill methods of excavation and rock handling. The high wall blasting methods, which will assure a safe, stable long-term excavation, will be developed during the detailed design of Title I.

The surface pads and similar surface earth/rock work are constructed in a like manner. Topsoil covering the area to be excavated is removed and stored on the topsoil pad. The excavated areas are brought to grade as shown on the excavation/fill plans.

2.2.3 MATERIALS

Several sources for construction materials are available and accessible for use during ESF construction.

All aggregates for general concrete construction at the Nevada Test Site (NTS) are produced at the Area 1 pit. Area 1 currently produces one of the aggregates for NTS concrete and is probably the most available and usable source for ESF aggregates. The H&N Materials Testing Laboratory (H&N/MTL) has established four satisfactory concrete mixes using Area 1 aggregates. It is recommended that H&N/MTL continue testing and evaluating mix designs, aggregates and production concrete, and produce historic documentation from which approval of an ESF mix can be obtained.

Table 2-3. Values and ranges for principal stresses at Yucca Mountain

Parameter	Average Value*	Range
Vertical Stress (MPa)	7.0 (1,015 psi)	5.0 to 10.0
Ratio of Minimum Horizontal Stress to Vertical Stress	0.5	0.3 to 0.8
Ratio of Maximum Horizontal Stress to Vertical Stress		0.3 to 1.0
Bearing of Minimum Horizontal Stress	N57°W	N50°W to N65°
Bearing of Maximum Horizontal Stress	N32°	N25°E to N40°E

* Average value for a depth of approximately 1,000 ft.

The Area 5 gravel pit aggregate source has been abandoned to consolidate the aggregate source for the NTS at Area 1. However, this would be a ready source for fill material at the ESF.

The Area 25 Forty-Mile Wash area appears to have good material. However, additional testing of the product must be done to confirm that adequate materials are in fact available at the site. Additionally, clearances would be required prior to using this area as a source.

One borrow area is approximately 1,500 feet northeast of Drill Hole Wash. The aggregate in this wash contains material of which one or two percent passes the number 200 sieve. This soil does not have sufficient binder for the base course of a roadway or pad, but it is suitable for subgrade material. The material is well graded and produces a stable two horizontal to one vertical fill slope. The material is highly susceptible to erosion because of the absence of binder. Soil stabilization is required, which chemically bonds the larger grain sizes. Channelization routes water away from the loose soil. Embankment slopes that contact channeled water are riprapped for bank protection.

Other borrow areas in Forty-Mile Wash are available. The material in these areas has more binder, giving it greater resistance to wheel traffic and erosion, and is more suitable for surface courses.

2.2.4 GROUND WATER

Special analyses of ground-water flow and the characterization of rock permeability are beyond the scope of Title I work. However, qualitative consideration of these factors was included and will be further evaluated during Title II design.

Hydrologic Considerations

The RIB specifies the values for density and mean saturated hydraulic conductivity for the stratigraphic units indicated in Table 2-4.

Table 2-5 presents the matrix permeability specified in the RIB, along with porosity information derived from the densities specified in the RIB.

2.2.5 SEISMIC CONSIDERATIONS

Seismic considerations for the ESF design include the effects of underground nuclear blasts, earthquakes, and construction blasting. The RIB specifies the seismic events to be used in the ESF design as shown in Table 2-6.

The potential for damage to underground excavations caused by ground motions can be better assessed in terms of ground peak particle velocity (PPV) rather than ground acceleration. The Exploratory Shaft Seismic Design Basis report, from which the maximum accelerations of seismic events given above was taken, additionally specifies the ground PPVs shown in Table 2-7. The design earthquakes are the DE events and the design underground nuclear explosions are the "DUNE" events. The RIB defines a third design earthquake, referred to as the postclosure earthquake. The postclosure earthquake is proposed for evaluation of the long-term performance of the repository.

Table 2-4. Hydrologic considerations

Unit	K_s (mm/yr)	pm (g/cc)	pd (g/cc)	ps (g/cc)
TC	—	2.51	2.23	2.32
PT	—	2.37	1.31	1.86
TS1	—	2.53	2.15	2.29
TS2	0.128–4.07	2.55	2.24	2.36
TS3	0.128–4.07	2.39	2.28	2.33
CHlv	1.89–6090	2.34	1.49	1.85
CHlz	0.037–7.6	2.41	1.62	1.95

where:

K_s = mean saturated hydaulic conductivity.

This term and the associated units (mm/yr) are not standard. However, it is assumed herein that these values of K_s represent the permeability under a piezometric head. More standard units for this term are either the "darcy" (1 cm/sec at 1 bar/cm pressure gradient) or "cm/sec" (at 1 cm h_2O/cm pressure gradient).

pm = mineral (grain) density

pd = dry bulk density

ps = saturated bulk density

Table 2-5. Rock mass permeability and porosity

Unit	K (cm/sec)	N (%)	No. (%)
TC	–	11	9
PT	–	45	55*
TS1	–	15	14
TS2	2.3×10^{-7}	12	12
TS3	2.3×10^{-7}	5	5
CH1v	3.4×10^{-5}	36	36
CH1z	1.7×10^{-7}	33	33

where:

K = coefficient of matrix permeability under a piezometric head (1 cm H_2O per cm),

N = total porosity, (pm - pd) / pm x 100%,

N_o = interconnected porosity, (ps - pd) / 1 g/cc x 100%.

Table 2-6. Design ground accelerations

	Acceleration (g)		
Event	a_h	a_v	return period (yr)
DE-1	0.40	0.27	2000
DE-2	0.25	0.17	500
DUNE-1	0.15	0.18	2000
DUNE-2	0.125	0.15	500

Table 2-7. Peak particle velocities used for design

Event	PPV V (ips)	PPV V (m/s)	V (ips)	V (m/s)
DE-1	9.8	0.25	6.6	0.17
DE-2	5.3	0.13	3.5	0.09
DUNE-1	6.3	0.16	7.6	0.19
DUNE-2	4.7	0.12	5.7	0.14

CHAPTER 3

PROJECT DESCRIPTION

3.1 GENERAL ARRANGEMENT

The Exploratory Shaft Facility (ESF) is located on Yucca Mountain, about 90 miles northwest of Las Vegas. The shafts are approximately halfway up the south side of Dead Yucca Ridge, at elevation 4,130 mean sea level. The ridge lies between two washes, Coyote Wash to the south and Wren Wash to the north. Both of these washes drain into Drill Hole Wash approximately 1,500 feet downstream of the ESF.

Approaching the ESF from the south, on the east side of the road, is an area set aside for the batch plant and aggregate stockpiles. Below this area is the treatment and disposal of sewage and mine waste water (Figure 3-1).

To the east is an area designated as an equipment storage area. The area is approximately seven acres, and contains a warehouse and parking. All pads are surfaced with an oil and chip seal.

Continuing up Drill Hole Wash Road ("H" Road on the plans), on the west side and uphill is the main pad. The main pad contains the shafts, hoist house, and facilities for shaft sinking and operations development. The north side of the pad has an 80-foot cut blasted from rock. On the south and east side, the pad has a 60-foot fill. The main pad nominally encompasses 5.5 acres. The structures required for mining and scientific investigation are located on the main pad. All utilities are trenched and routed to the required areas. An area is designated for the shaft sinking subcontractor operations. On the southwest corner of the pad is the surface data building that contains the Integrated Data System (IDS). Eight double-wide support trailers, the change house, and the shop are on the south edge of the pad. The hoist house is between ES-1 and ES-2.

In front of the buildings and trailers are 43 parking spaces. Additional parking is provided on the auxiliary pads. At the northeast corner of the pad is the exit road to the muck storage pad. The muck hauling equipment utilizes this road.

East of the main pad is an area designated for the electrical substation. Alongside this area and to the south are the standby electrical generators and air compressors.

The muck storage facility is located approximately 1,000 feet northeast of the main pad. The muck storage pad lies in a northwest-southeast direction and is approximately 800 feet long and 260 feet wide. The storage facility slopes to the southeast at a 6 percent grade. Just below the muck storage pad is a 400-foot by 300-foot topsoil storage pad. These lie along the west side of Drill Hole Wash, with 100-year floodwaters being diverted to a channel along the east side of the wash.

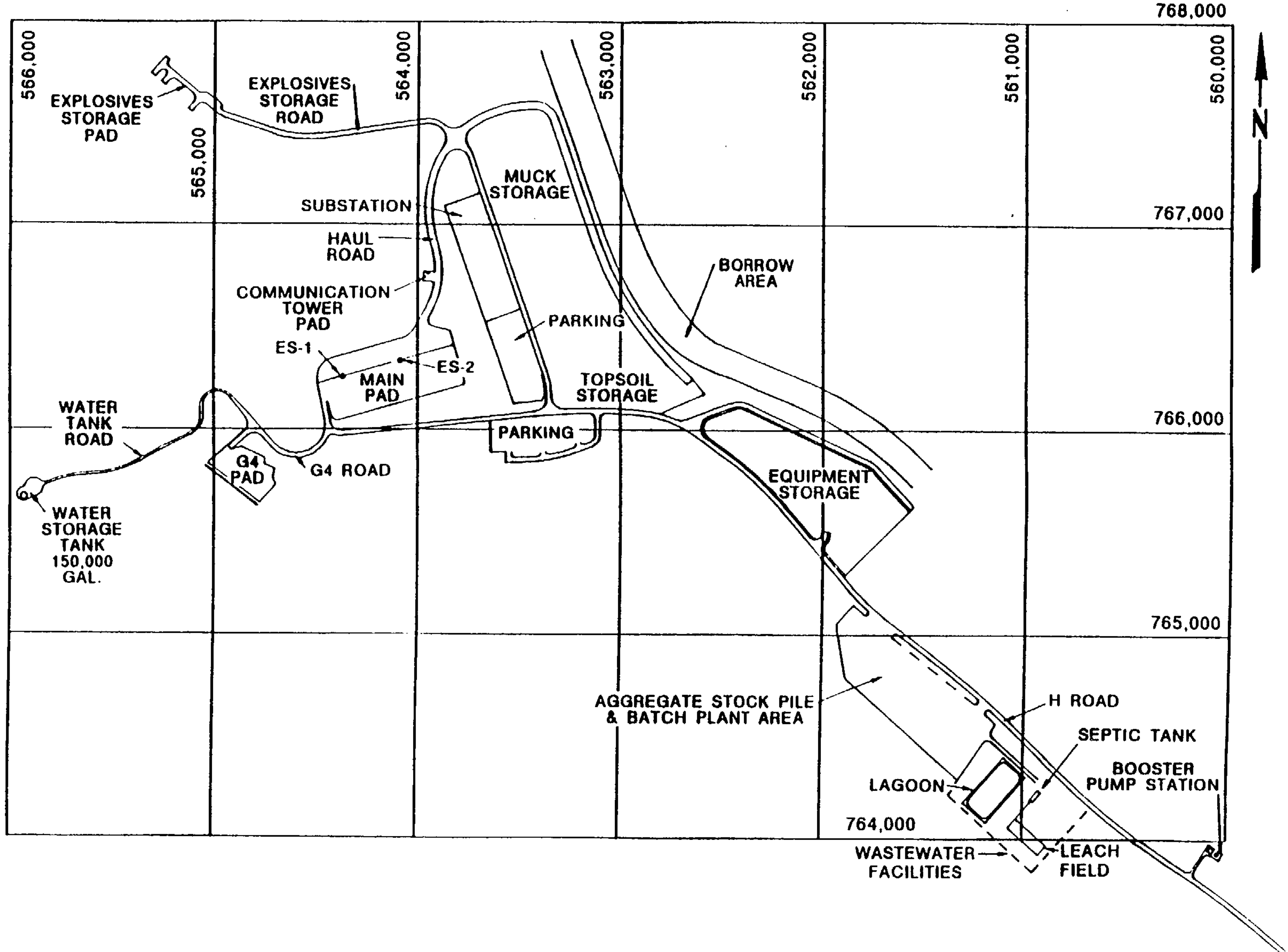


Figure 3-1. ESF overall site plan.

3.2 SITE PREPARATION

At the Yucca Mountain site, there are two areas that require different techniques for clearing and grubbing. The lower area is relatively flat, with very few large boulders and moderate to sparse grass. The higher areas along the sides of the ridges are heavily bouldered and have sparse vegetation. While the former can be cleared by blading, the latter must be drilled, blasted, and bulldozed.

The wash areas are sparsely vegetated, with moderate grass and single bushes sparsely located among river run rock and gravelly-sand surface. The root system of live and dead bushes generally penetrates the soil up to a foot in depth, while the grass root penetrates up to an inch. The surface is prepared by removing three inches of material from it and placing this in piles in an area of the topsoil storage. On the sidehill there are large boulders and rock outcroppings with some plants and grasses. The clearing and grubbing in these areas requires bulldozing off the large boulders in order to prepare the area for blasting.

3.2.1 ACCESS ROADS

The ESF is served from the southeast by Drill Hole Wash Road (the road name changes from Road H at Area 25 to Drill Hole Wash Road at Forty-Mile Canyon). Drill Hole Wash Road is an approximately 20-foot wide oil and chip roadway with 3-foot shoulders. However, the shoulders widen up to 15 feet in some areas. The road is built with increasing grades in the moderately rolling hills approaching the main pad. About three miles from the main pad the road grade changes to 6 percent, but in no case exceeds 7.5 percent.

Approximately 400 feet east of the main pad, Drill Hole Wash Road changes direction and goes north towards the upper washes of Yucca Mountain. The new road to Drill Hole Wash Road, built to reach the ESF, is called Water Tank Road. Water Tank Road continues past the main pad entrance and proceeds to the new water tank location, 1,500 feet northwest of the main pad. The roads are sized and surfaced based on loading and usage.

3.2.1.1 Main Access Road (Drill Hole Wash Road)

Approximately 5,200 linear feet of the Drill Hole Wash Road are improved from the main pad southeast to the vicinity of the existing substation (southeast of Batch Plant Road). Improvements consist of providing two 12-foot travel lanes with a 6-foot shoulder on each side. The last 1,000 linear feet, from the Nevada Test Site (NTS) boundary to the main pad, is new construction. The road is designed to accommodate a traffic capacity of 100 vehicles per day at a maximum speed of 35 miles per hour. The roadway is constructed on a natural material subbase compacted to 95 percent relative density. The base course is an 8-inch layer of type II aggregate base also compacted to 95 percent relative density. The wearing surface is a double application of oil and chips. The construction of Drill Hole Wash Road requires no excavation, but does require the importation of 41,000 cubic yards of fill material. This material is acquired from the borrow area shown on the ESF Overall Site Map, JS-025-ESF-C3.

3.2.1.2 Auxiliary Pad Access Roads

3.2.1.2.1 Drill Hole Wash Road (north of ESF)

This road is the continuation of the Main Access Road, providing access not only to the topsoil, parking, and substation pads, but also to the upper areas of the canyon. The area of improvement extends from its intersection with Water Tank Road to its common intersection with the Muck Haul Road, Muck Storage Area Road, and Explosives Storage Road.

3.2.1.2.2 Explosive Storage Road

This is an all-weather road that has two 12-foot lanes. For vehicular safety, the side slopes are at a 4 to 1 slope and the grade does not exceed 10 percent. The road is oiled and chipped for dust control.

3.2.1.2.3 Muck Haul Road

East of the main pad is a road that serves as a haul road for excavated material being removed from the shafts. The road is 40 feet wide, with a 3-foot berm on the edge. The width accommodates a 12-foot 8-inch wide 35-ton dump truck. The road grade does not exceed 4 percent, and the curve is designed for 25 mph.

3.2.1.2.4 Water Tank Road

Water Tank Road begins 400 feet southeast of the main pad and is connected to the Drill Hole Wash Road at that point. Although the name of the road changes from Drill Hole Wash Road to Water Tank Road, the surfacing and width remain the same as one drives to the main pad. The grade of the road to the main pad does not exceed 7.5 percent. The road is 24 feet wide with 6-foot shoulders. The side slopes are 4 to 1.

The Water Tank Road continues an additional 300 feet to the G-4 pad, after which it narrows to a 12-foot single lane with 2-foot shoulders. The side slopes have been steepened to 1½ to 1. The road cross-sectioned slope is a constant 2 percent sloping toward the cut slope. This reduces erosion of the roadway due to runoff.

3.2.2 PADS

3.2.2.1 Main Pad

The 5½ acre main pad has been designed to house major ESF facilities. In addition to the two shafts and associated headframes, hoist house, and ventilation fans, the main pad is the location for the surface data building, the change facility (including first aid, training, and walker's office), shop, eight office trailers, and the shaft sinking subcontractor area.

The pad is at a nominal elevation of 4,130 feet mean sea level. It sheet drains to the north and south, away from the shafts at a 2 percent grade. The cut side (northwest) of the pad is blasted out of rock, with a maximum cut of 80 feet at a one-foot horizontal to four-foot vertical slope.

There are two 12-foot benches, 30 and 60 feet above the main pad, serving as a catchment for rocks and access for maintenance. At the base of the high wall there is a 10-foot wide drainage channel that diverts runoff from the slope, off the main pad. The south and east side of the main pad is of fill material, with a maximum fill slope of 60 feet at a two-foot horizontal to one-foot vertical slope.

There are two roads accessing the main pad. The main access road for personnel vehicular traffic enters the main pad at the southwest corner. There is also a muck haul road that enters the pad at the northeast corner. Traffic from these two roads is always separated, with planned traffic patterns for the large muck haul trucks routed along the north side and personnel vehicles and parking along the south side near the office facilities.

3.2.2.2 Auxiliary Pads

There are several auxiliary pads at the ESF site, including the booster pump station pad, batch plant and aggregate stockpile pad, topsoil pad, equipment storage pad, muck storage pad, substation and compressor pad, explosives storage pad, G-4 pad, water tank pad, and parking pads.

3.2.2.2.1 Booster Pump Station Pad

The booster pump station pad is a small pad for the booster pump building and is located about halfway vertically from the J-13 well. It provides access for station maintenance and parking.

3.2.2.2.2 Batch Plant and Aggregate Stockpile Pad

Located about two-thirds of a mile southeast of the main pad is a pad that provides an area for the shaft sinking subcontractor's batch plant and aggregate stockpiles. This 5-acre pad is provided with utility stubouts for water, power, sewer and wash water disposal.

3.2.2.2.3 Topsoil Pad

The topsoil pad is a 1½ acre pad for storage of soil material that has been weathered by nature and contains minerals and seeds, that supports plant growth. The depth of topsoil varies from 0 inches to 2 feet, depending on location, and is removed from all affected areas and stored on the topsoil pad for later use in reclamation.

3.2.2.2.4 Equipment Storage Pad

About 750 feet east of the main pad is a 7-acre multipurpose pad. Though called the equipment storage pad, this pad is also the home for the warehouse, and has utility provisions for other facilities such as temporary office and laboratory trailers. There is also an area set aside for the shaft sinking subcontractor's use.

3.2.2.2.5 Muck Storage Pad

Approximately 166,000 cubic yards of muck are expected from the underground excavation at the ESF. This muck is placed on the muck storage pad.

In keeping with the requirement for a 100 percent uncertainty allowance, this pad has been designed with a capacity to store twice the expected muck. The muck storage pad design includes a 40-mil thick PVC liner with a 12-inch sand backfill. A perforated pipe collection system collects water from the muck and discharges it in a small, lined collection basin at the east end of the pad. The water can be tested here and released to the mine waste water disposal system if appropriate.

3.2.2.2.6 Substation and Compressor Pad

Just east of the main pad is the 2 1/3 acre pad for the 69-kV substation, standby generators, and compressors. This pad is the main source distribution point for these utilities. The pad also includes room for a buried standby generator fuel tank and maintenance equipment.

3.2.2.2.7 Explosives Storage Pad

The explosives storage pad is located up Wren Wash, on the north side of Dead Yucca Ridge, behind the ridge from the rest of the ESF. This pad has three storage areas, one each for Class A, Class B, and primer storage. Each area is separated by dirt berms. The pad is designed to accept mobile magazines hauled to the site by semi-trailers.

3.2.2.2.8 G-4 Pad

The G-4 pad is an existing pad that will have minor grading modifications. This pad can be utilized by the contractor for storage of supplies such as rock bolts and structural steel.

3.2.2.2.9 Water Tank Pad

The water tank pad is a small area for the siting, construction and maintenance of the 150,000-gallon water storage tank.

3.2.2.2.10 Parking Pads

In several locations around the ESF, parking areas have been provided with pads. These are located conveniently near office and work locations. Over 2½ acres are provided for parking at the site.

3.2.3 SITE DRAINAGE

The ESF lies on a steep hill or ridge separating two washes. The washes are at a moderate slope of around 5 to 9 percent and are normally dry, except for occasional storms. The drainage areas involved are usually small, but drainage flow velocities are relatively high due to the steep slopes. The general concept of protection encompasses drainage channels diverting the 100-year and probable maximum flood (PMF) waters from encroaching on the ESF.

The main pad and the exploratory shafts are important, and are protected from the PMF. The existing channel below the main pad is deepened and widened with a capacity to carry PMF waters safely by the main pad. A few hundred feet upstream, a dike diverts PMF waters from encroaching on the main pad.

The auxiliary pads do not require the same degree of protection because of their function. They are protected from a 100-year storm runoff. Roadways are protected from 25-year runoff events.

3.3 SURFACE FACILITIES

Surface buildings supporting the ESF phase of the Yucca Mountain Project are designed for a nominal 5-year life and are complete with heating, ventilation, and air conditioning (HVAC), plumbing and sanitary facilities, fire protection systems, lighting, communications, and compressed air where applicable. The buildings are all new and consist of pre-engineered metal structures on concrete slabs or portable double-wide trailer units. Building interiors are designed to provide optimum use of space with low maintenance finishes. All facilities are designed per DOE Standards, the Uniform Building Code, and National Fire Codes to meet the requirements for their intended use.

The individual buildings are described in detail below, with the Title I drawings showing the proposed designs in Volume 2, Chapter 15, and associated outline specifications in Volume 3, Chapter 16.

3.3.1 VENTILATION SYSTEM

The ventilation system features ES-1 and ES-2 as both intake and exhaust air shafts. General arrangements for subsurface air flow distribution, sizes of primary ventilation fans, and ducts are described in Section 3.8.4.

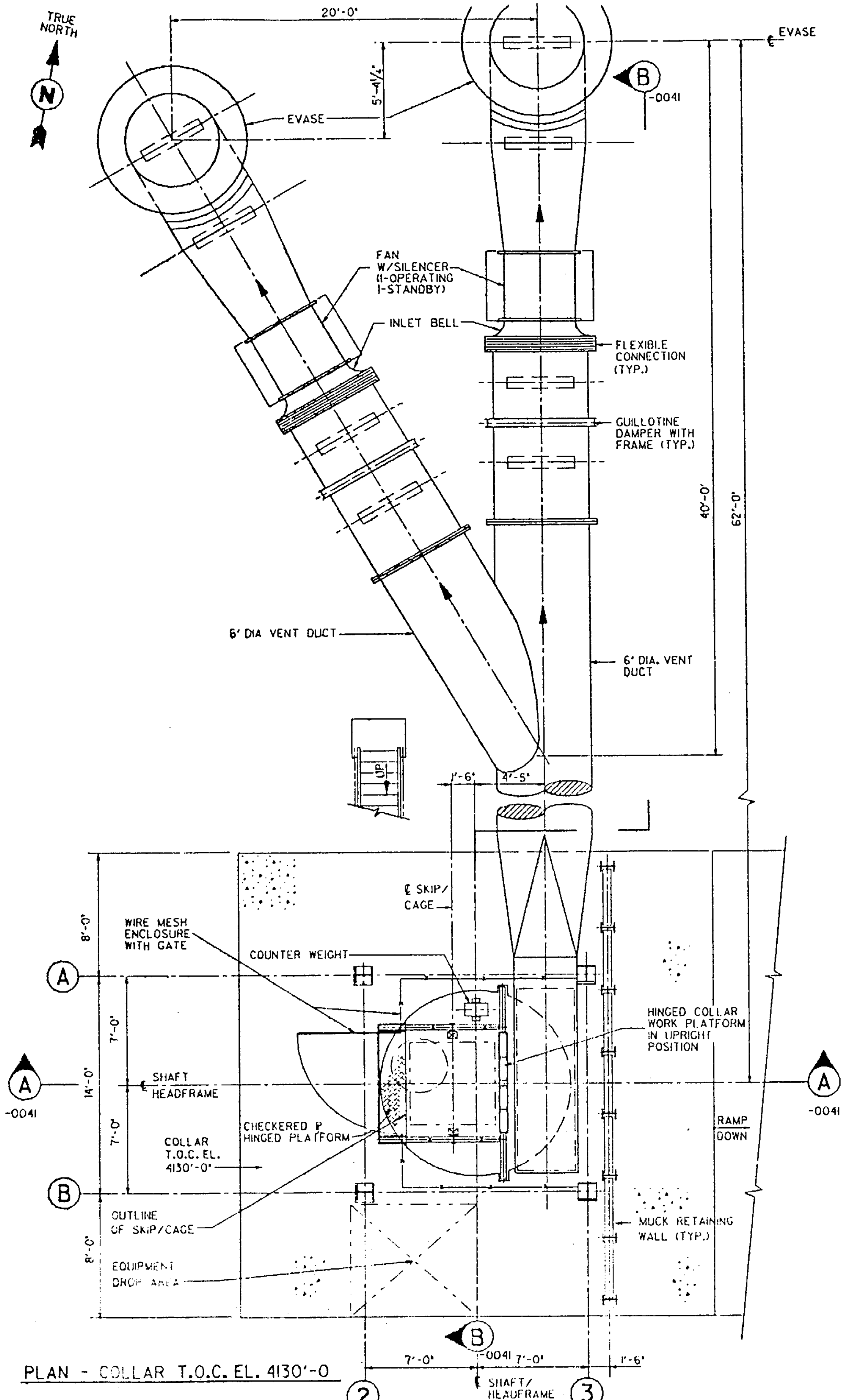
Each shaft is provided with a structurally reinforced metal duct acting as a separate exhaust airway. The transition exhaust ducts from the collars of ES-1 and ES-2 to the surface exhaust fans (axial vane type) are shown in Figures 3-2 and 3-3. Other views of ES-1 and ES-2 collar plans and sections are shown in Figures 3-4 and 3-5. The surface ventilation arrangement has two similarly sized primary exhaust fans for each shaft. One exhaust fan at each collar is in continuous operation, with a standby unit readily available for service if the operating unit fails.

All surface fans are provided with attenuators to reduce the fan noise output to below 85 dBA. All fans are located at a sufficient distance from the collar that the exhaust air from the shafts does not contaminate the intake air being drawn into the shaft collars. In addition, exhaust air is discharged vertically to avoid adverse air blast conditions affecting personnel and vehicle traffic. The fan area at each shaft is protected by barriers and/or gates to mitigate possible collision accidents and the attendant disruption of service, yet provides clear access for maintenance or replacement of fans.

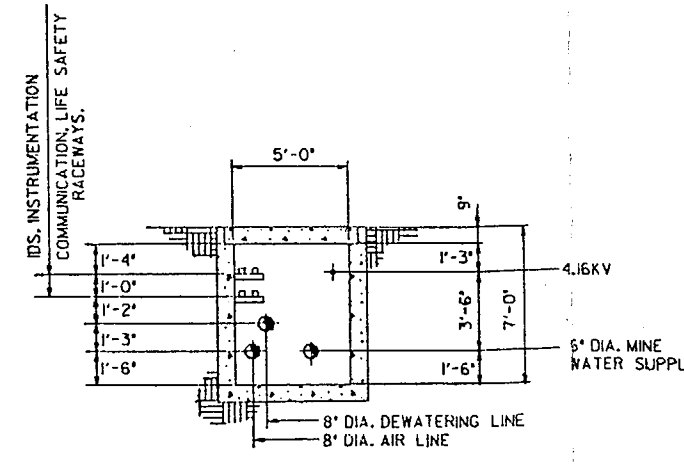
3.3.2 TEST SUPPORT FACILITIES

3.3.2.1 Temporary Facilities

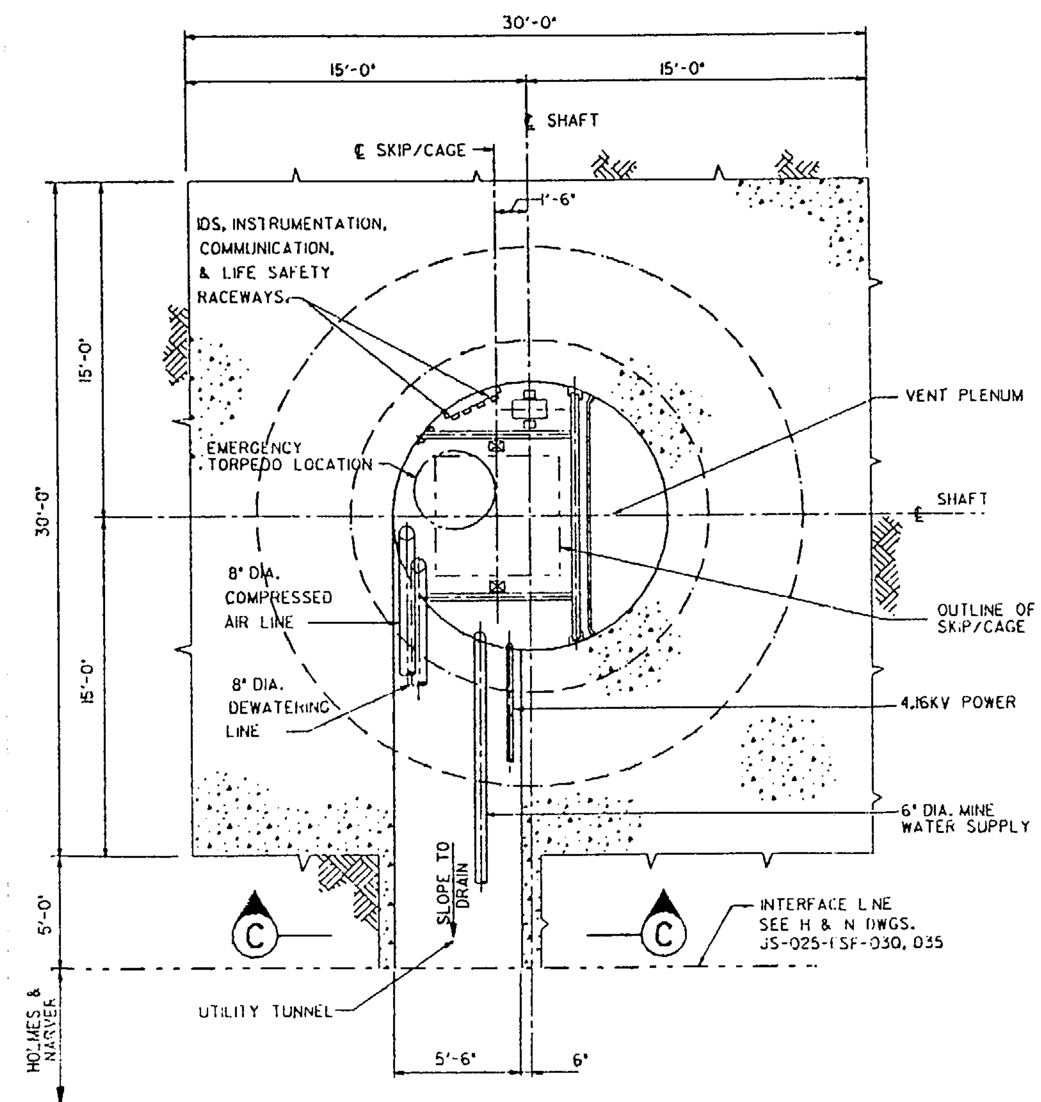
Temporary facilities provide office and laboratory space to support the ESF construction, operation, and maintenance personnel for the site characterization program. Facilities for change rooms, first aid, and training were planned to be in trailers but are now provided for in a pre-engineered metal building.



PLAN - COLLAR T.O.C. EL. 4130'-0



SECTION C-C



PLAN - HEADFRAME FOUNDATION

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Figure 3-5.
ES-2 surface shaft collar general ventilation arrangement.

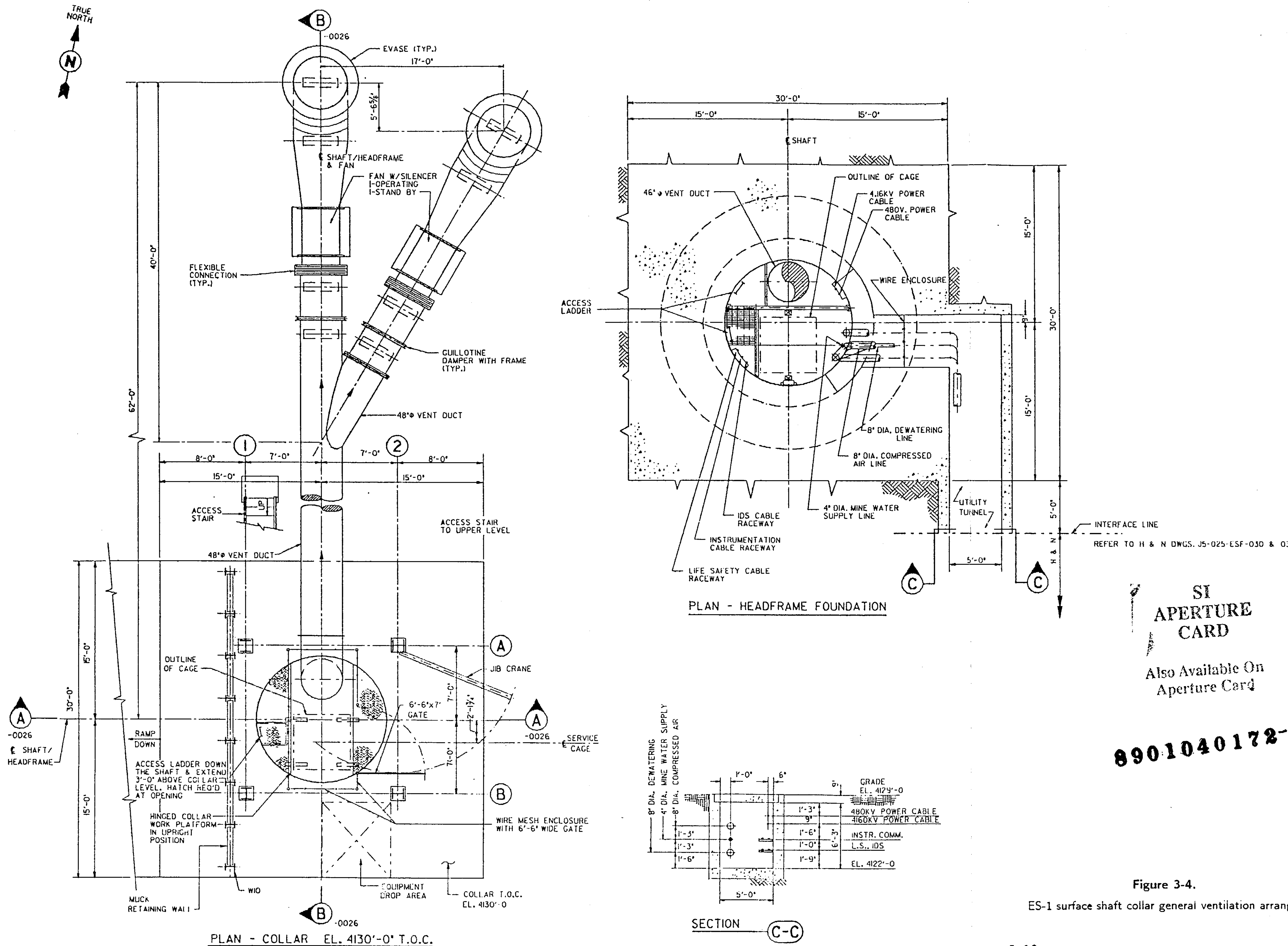

Figure 3-4.
ES-1 surface shaft collar general ventilation arrangement.

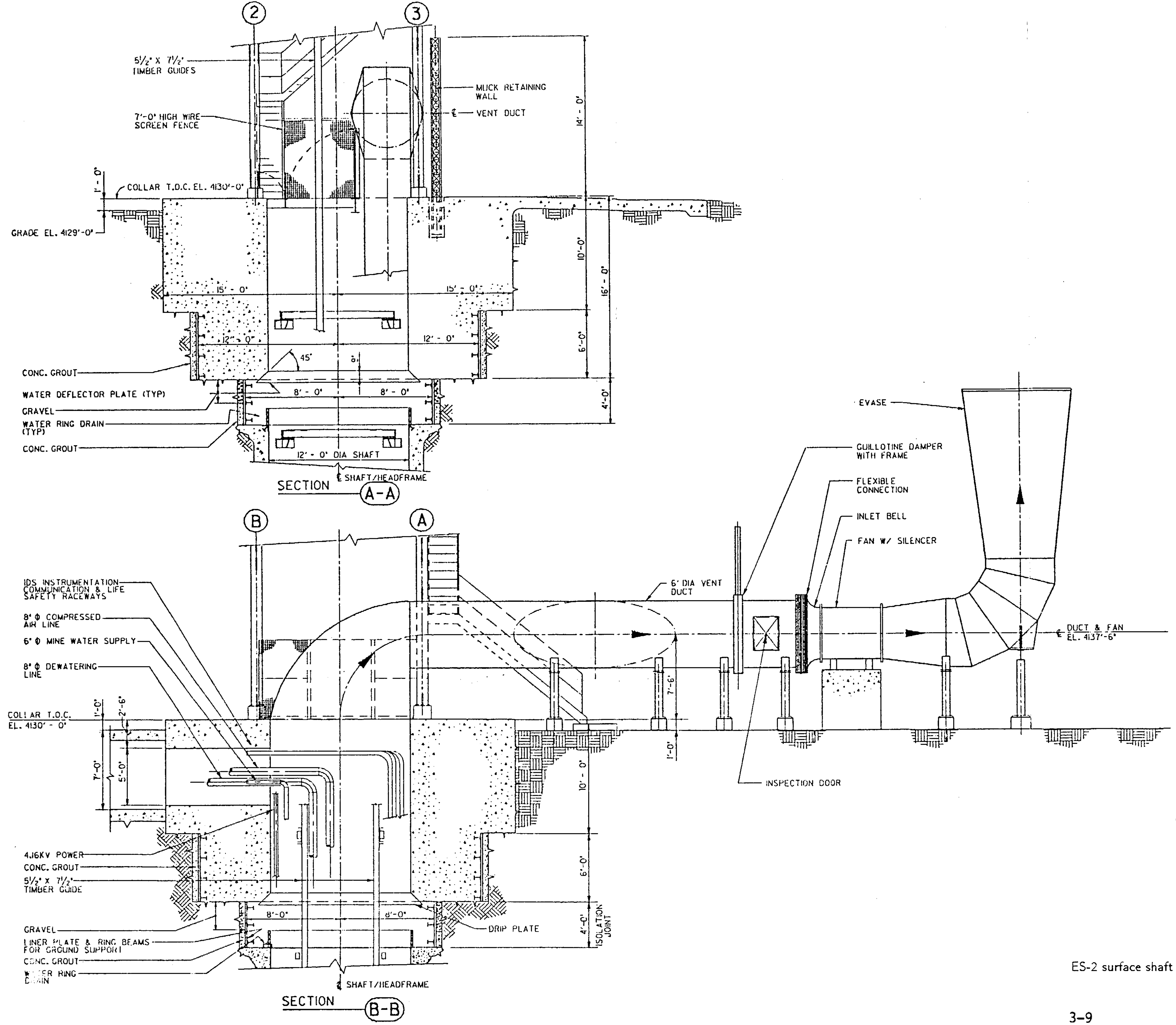

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Figure 3-3.
ES-2 surface shaft collar general ventilation arrangement.

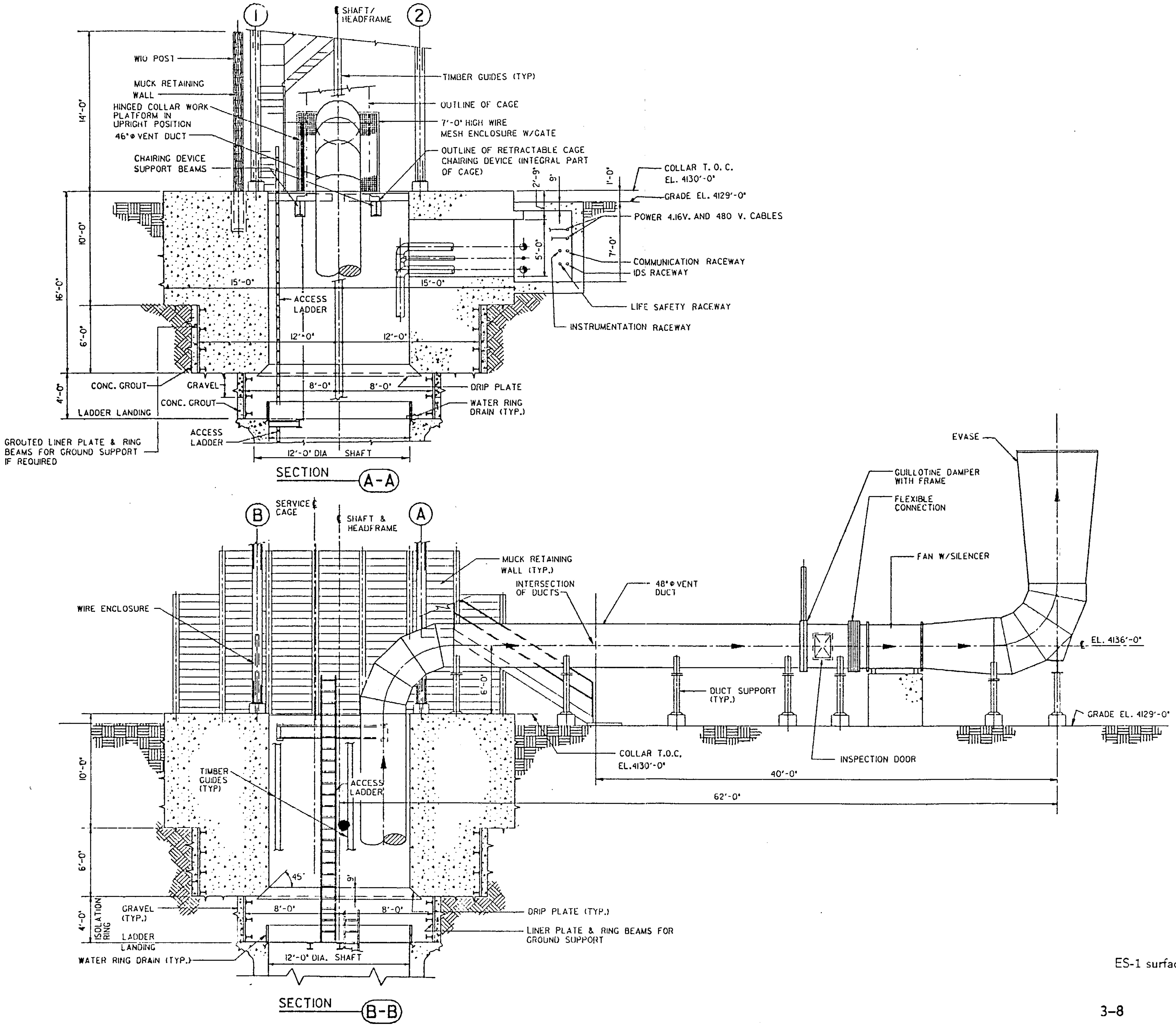


Figure 3-2.
ES-1 surface shaft collar general ventilation arrangement.

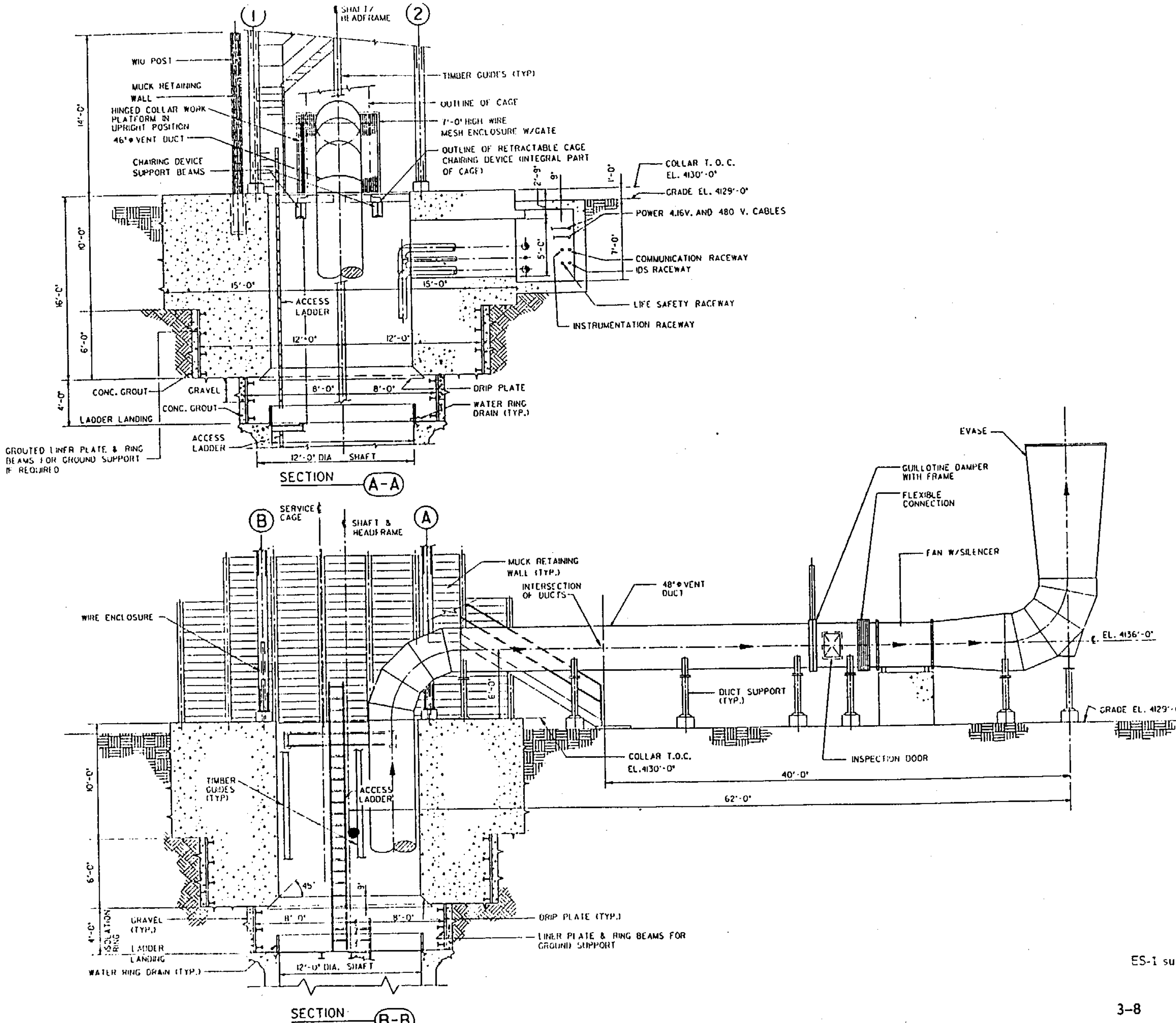


Figure 3-2.
ES-1 surface shaft collar general ventilation arrangement.

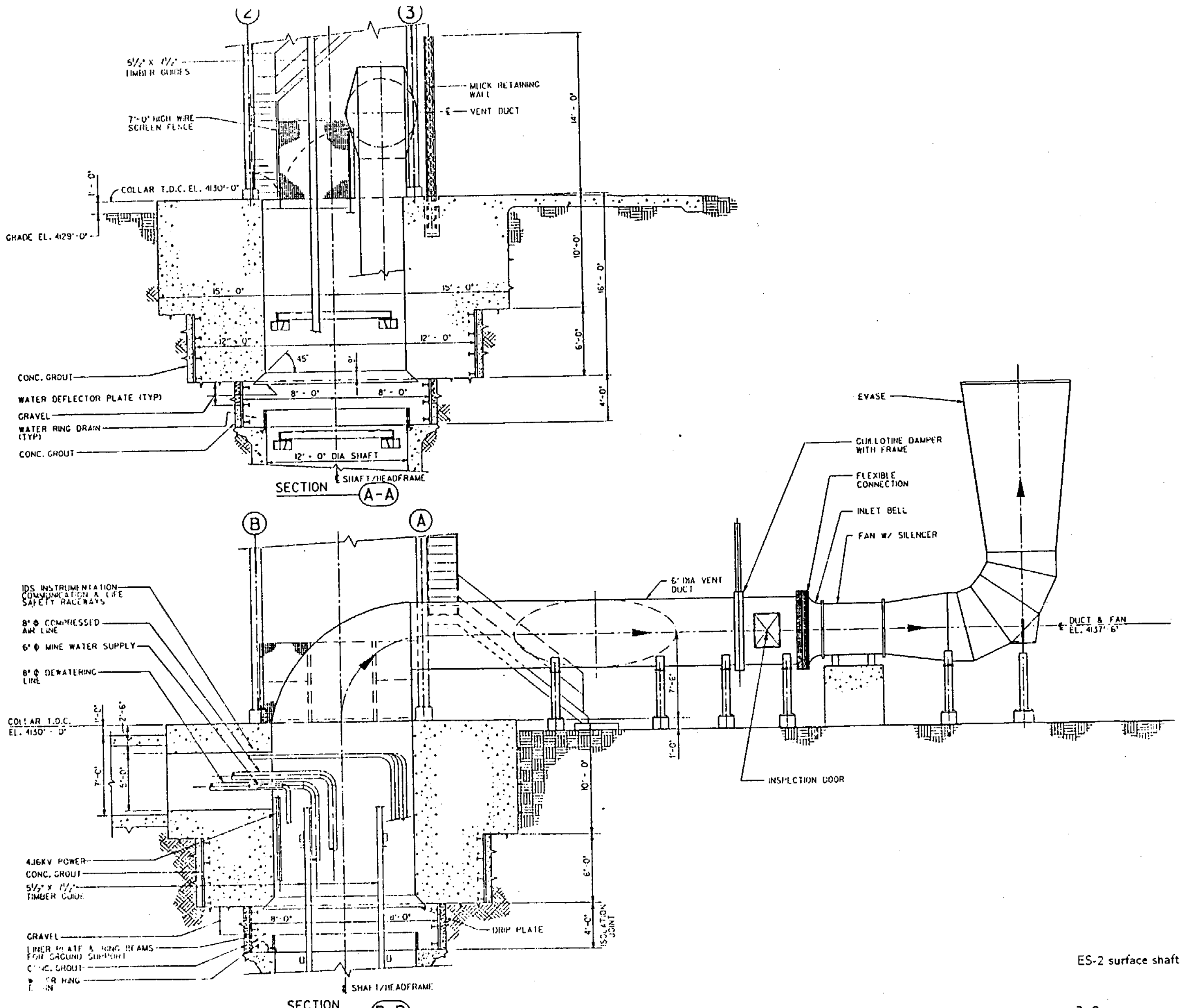
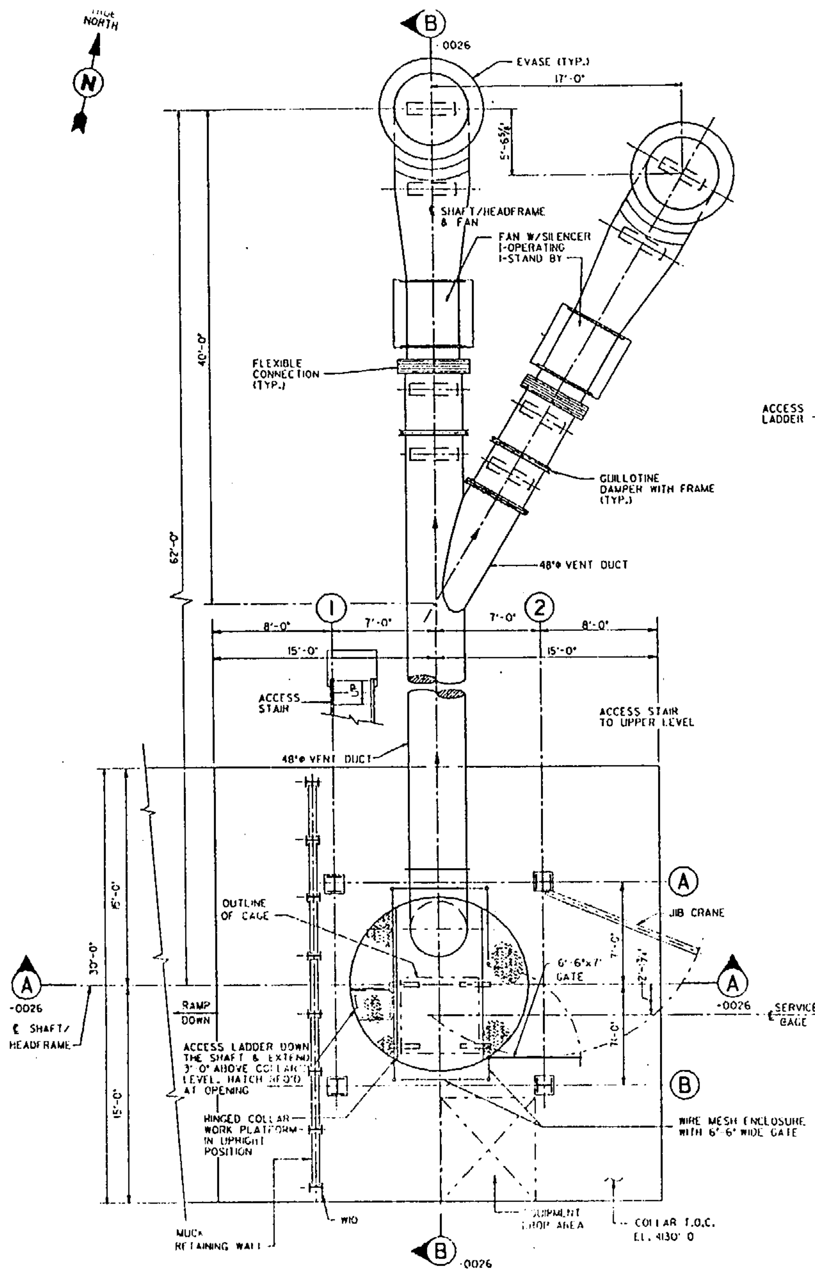
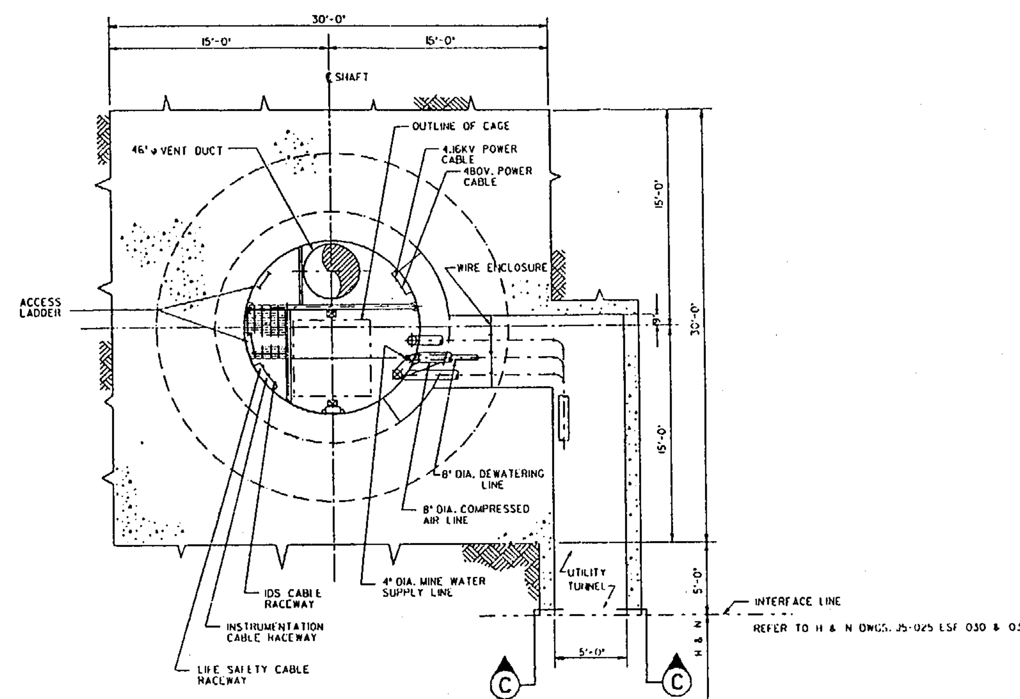


Figure 3-3.
ES-2 surface shaft collar general ventilation arrangement.





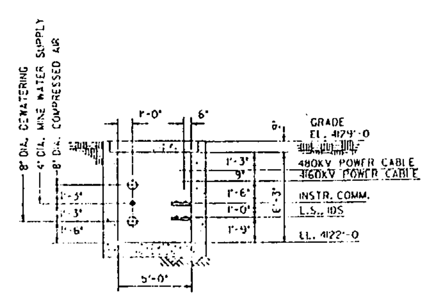


Figure 3-4.
ES-1 surface shaft collar general ventilation arrangement.

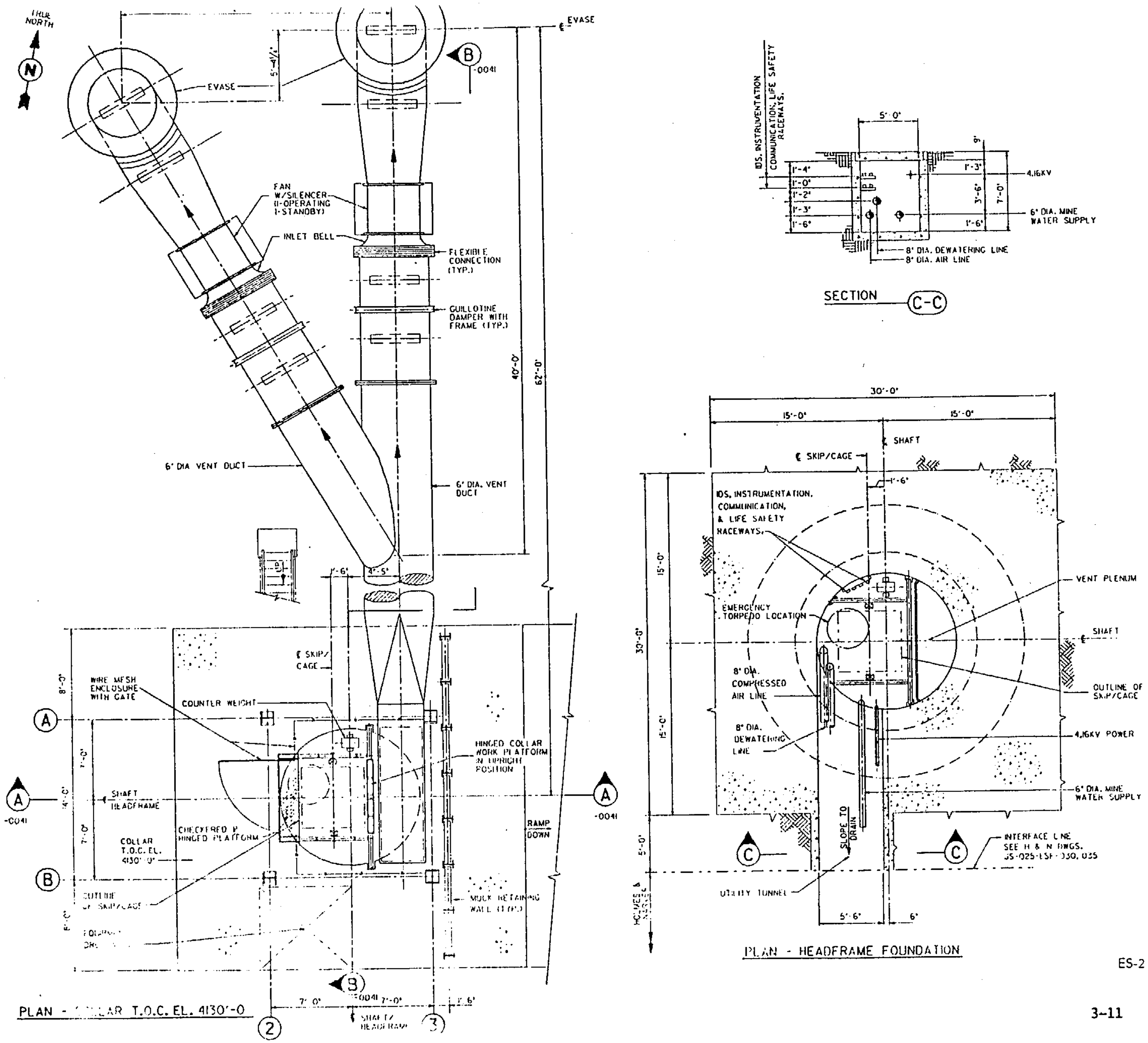


Figure 3-5.
ES-2 surface shaft collar general ventilation arrangement.

The 1,344 square feet provided by 24-foot by 56-foot double-wide trailer units is the optimum size to satisfy the office and laboratory requirements of participants in joint use or single occupancy. The users and their required square footage are USGS (1,400 square feet), LLNL (600 square feet), Los Alamos (1,400 square feet), SNL (2,700 square feet), H&N (600 square feet), F&S (600 square feet), REECo (2,700 square feet), SAIC (600 square feet), and DOE, Nuclear Regulatory Commission, and State of Nevada (1,400 square feet total).

The trailers are designed per the requirements of DOE/EV-0043 as non-combustible construction, fully sprinklered, and grouped as a single fire area. Each trailer has male and female toilet facilities, two or three offices, and general office space.

Wall mounted heat pumps specifically designed for trailer applications are used for HVAC because they are the most efficient form of heating and cooling available.

Each trailer is fully protected by an ordinary hazard, group 2 wet pipe sprinkler system, thereby allowing the trailers to be grouped close together and considered as one fire zone to meet DOE/EV-0043 requirements and the DOE improved risk concept. Each trailer has its own sprinkler system to enable possible building rearrangement during the course of the project.

The trailers do not require any special electrical equipment. General power is based on the use of 120-V, 20-A, duplex receptacles and ground fault circuit interrupter (GFCI) in the restrooms. For lighting, fluorescent luminaries with energy saving lamps and ballasts are used inside, and high pressure sodium luminaries are used outside. Emergency lighting and self-powered exit signs are also incorporated into the design.

The change house is a 3,600 square foot pre-engineered metal building designed to support the mining operation. The building provides 120 lockers and hanging baskets for miners, 13 lockers for visitors, and shower and toilet facilities based on 30 miners per shift. A non-skid surface finish is used in the locker room to prevent slipping on wet floors. The building also houses a first aid station, training room, lamp room, and life safety and fire control command post.

An emergency eye wash/shower is provided in the lamp room in the event of a battery acid spill. A 280 cfm exhaust fan is provided to vacate any hydrogen gas that may be emitted by the lamp batteries during recharging.

The HVAC system for the change house is divided into two zones, with the locker room/toilet in the first zone and all remaining areas in the second zone. A packaged air conditioning unit for cooling and electric infrared heating are used for the first zone. The required 15 cfm of outdoor air per locker results in a very significant 1,800 cfm of ventilation air for the room containing 120 lockers. The packaged air conditioning unit provides the necessary cooling without creating drafty and humid conditions that result from using an evaporative cooling system.

The 20-foot building eave height creates a large room volume in the locker room so infrared heating, which heats the objects in the room and not the air, is provided. The second HVAC zone uses a packaged heat pump.

The building is protected by an ordinary hazard, group 2 wet pipe sprinkler system in keeping with the DOE improved risk concept.

The electrical systems for the change house are divided into the same two zones as the HVAC systems. In zone one, receptacles are located where appropriate, using GFCI near the lavatory area. In zone two, standard 120-V, 20-A duplex receptacles are used since there is no special electrical equipment is required.

Interior lighting is provided by fluorescent luminaries with enclosed general use type fixtures. Exterior lighting is provided by high pressure sodium luminaries. Emergency lighting and self-powered exit signs are also incorporated into the design.

3.3.2.2 Parking Areas

Parking and bus turnarounds are provided for the construction and scientific personnel. On the lower parking area, there are sufficient spaces to park one hundred vehicles. On the main pad, there are 43 spaces for the scientific community. These spaces are in front of the trailers and within 200 feet of the shafts. Each structure has sufficient parking for maintenance and support personnel.

3.3.2.3 Materials Storage Facilities

During construction, the contractor requires areas to store equipment and supplies. These laydown areas store building components waiting to be erected. The main laydown area is 5 acres southeast of the main pad.

The G-4 pad is a 1-acre pad 500 feet to the west of the main pad. It can be used for equipment storage and a laydown area.

The explosives storage area is set away from populated areas as recommended by guidelines set by the Bureau of Alcohol, Tobacco, and Firearms. There is sufficient space to accommodate the explosives and related equipment, and to allow a tractor-trailer to turn around.

3.3.2.4 Shop

The shop building is a complete facility with all systems and services required to accomplish routine maintenance and repair of equipment. The shop is a 1,200-square foot, pre-engineered metal building purchased in 1984 with 12-foot by 12-foot roll-up doors at each end, personnel exit doors, office, and toilet, secure storage area, and is structurally designed to accommodate a 5-ton monorail crane.

Evaporative cooling is used in the shop because of the low relative humidity and the large building volume. This is the simplest and most cost-effective way to provide cooling for non-critical comfort applications. Electric infrared heating is used to provide heating in the building. The small office has a through-the-wall heat pump to provide both heating and cooling. An ordinary hazard, group 2 wet pipe sprinkler system is provided for the fire protection system.

The building is provided with general type duplex receptacles throughout, 3 each: 60-A, 208-V, 3-Ø receptacles; 30-A, 480-V, 3-Ø receptacles; quadraplex 120-V, 20-A, 1-Ø; and 20-A, 120-V single receptacles. The high bay area of the shop incorporates high output fluorescent luminaries, while the other areas use normal fluorescent luminaries with energy saving lamps and ballasts. High pressure sodium luminaries are used on the exterior.

3.3.2.5 Warehouse

The warehouse building provides a facility for the safe storage and handling of supplies and materials required to support the construction and operation of the ESF. The warehouse is a 5,000-square foot, pre-engineered metal building with offices, toilets, receiving area, high bay storage, secure storage, and miscellaneous storage. A 16-foot by 20-foot door provides access from the loading dock and a 10-foot by 12-foot door is provided for a fork lift. The offices and toilets have vinyl flooring while all other areas are concrete with hardener and sealer.

Evaporative cooling is used in the warehouse because of the low relative humidity and large building volume. Electric infrared heating is used to provide heating in the building. The offices have through-the-wall heat pumps to provide both heating and cooling. Additional exhaust fans are provided in the miscellaneous storage room as required for the chemical/flammable items stored there.

An ordinary hazard, group 2 wet pipe sprinkler system is provided in the building except that in the high bay storage area the sprinkler system complies with NFPA 231 for storage racks.

General type duplex receptacles are provided for the facility. The electrical power required for heating, ventilation, air conditioning and plumbing is sized and located based on the mechanical design.

The lighting is based on the use of high output fluorescent luminaries because of the high bay area. In other areas, fluorescent luminaries with energy saving lamps and ballasts are used. On the exterior of the building, high pressure sodium luminaries are used.

3.3.2.6 Hoist Building

The hoist house building is designed to house the ES-1 and ES-2 hoists and their associated relays and controls. Work areas for routine maintenance are provided. The building is a 7,200-square foot, pre-engineered metal building with a full height 12-inch reinforced concrete masonry unit wall separating the two hoists. This wall provides fire separation and a physical barrier for protection if a hoist cable should break. Additionally, fire walls are provided between the individual hoists and their associated support equipment.

Because of the heat that is produced from the hoist motors and relays, no additional heating is required for the building except in the toilet, fire riser room, and hoist cabs. Intake and exhaust fans are provided to create air movement over the motors and relays and exhaust the heat to ensure that the indoor temperature does not exceed 120°F.

An ordinary hazard, group 2 preaction sprinkler system is provided for the fire protection system. The preaction system is used since the building is not heated. It is activated by fixed temperature heat detectors that enable an automatic fire alarm to sound prior to flow of water.

The two hoists—one 900 HP and one 1,500 HP—both require 4,160-V, 3-Ø power, which is provided through power feeders in cable trenches in the floor. The separate feeders have main disconnects outside the building. Lighting for the high bay is provided by metal halide luminaries, with additional emergency lighting and self-powered exit signs.

3.3.2.7 Communications Shelter

The communications shelter contains the equipment required to operate the microwave system including the uninterruptible power supply (UPS). It is a 12-foot by 12-foot prefabricated building. The building comes equipped with halon fire suppression system, lighting, skirting and steps. The primary purpose is to house the electronic communication equipment used to transmit telephone, data and various alarm information. The electronic equipment includes the mine plant intercom system switch, electronic private automatic branch exchange (EPAB) and the UPS. The building is located adjacent to the microwave tower and has a concrete slab for a foundation.

3.3.2.8 Surface Data Building

The surface data building provides a controlled environment for the communications data collection and transmission equipment required to support construction, testing by all IDS users, and Centel communications systems. The facility is a 3,000-square foot, pre-engineered metal building with a raised computer floor for the IDS equipment. The computer room is separated from the rest of the building by a one-hour rated fire wall with vapor barrier and wire-glass observation windows. Fire rated corridors are not required due to building occupancy load, but all walls and partitions are of noncombustible construction. In addition to the computer room the facility provides a reception area, a fire rated records vault, restrooms, a fire riser room, a telephone equipment room, and a fire rated enclosure with sound batts for the UPS equipment.

Glycol-cooled process cooling units provide in excess of 12 tons cooling via underfloor air distribution, which allows full room flexibility for equipment. A separate package air conditioning unit with economizer, which allows free cooling using the outside air, is used for the UPS room because of the high equipment heat load. The remainder of the building is heated and cooled with a packaged heat pump.

An ordinary hazard, group 2 wet pipe sprinkler system is used throughout the building, with central quick-response on-off sprinklers in the computer room. The computer room also utilizes a Halon 1301 fire protection system and an automatic detection system for early warning via smoke detectors at the ceiling and in the underfloor air plenum. The halon system is activated by heat detectors.

The electrical requirements for the computer area, UPS power, and lighting are based on 50-kVA, 120/208-V, 3-Ø UPS power and lighting at 100 foot-candles (fc) with provision for emergency lighting. A power shutdown switch at each principal exit of the computer room cuts all power to computer equipment and related HVAC systems. The remainder of the building has general power using 120-V, 20-A duplex receptacles. The entire building is on standby power.

3.3.2.9 Staging Areas

A shaft subcontractor is to be utilized for sinking ES-1 and ES-2 shafts from a 100-foot depth to just below the main test level (MTL). Staging areas are incorporated into the design for the subcontractor.

The area on the main pad is approximately 7/10 acre. This allows the erection of a 1,400-square foot office trailer, a 1,400-square foot change house, and a shop and warehouse of approximately 1,000 square feet each. There is also area provided for parking of mobile equipment and storage of immediate and near term-use shaft sinking and outfitting equipment. Utility stubouts are provided for power, water, sewer, and compressed air.

An additional storage area is provided on an auxiliary pad located approximately 1/3 mile southeast of the main pad. This area, approximately one acre, is used for long-term storage of shaft sinking or outfitting equipment, materials or supplies. This might include structural steel, rockbolts, spare equipment, form parts, shaft utilities, and ventilation equipment. This area is provided with power, water and sewer stubouts.

An auxiliary pad of approximately 5 acres is provided for the erection of a batch plant and stockpile storage of aggregate. This pad has utility stubouts for power, water, and sewer, and a connection for aggregate wash water disposal into the mine waste water disposal system. There is ample area provided here for parking of mobile equipment.

3.3.2.10 Site Security

The primary security for the ESF is provided by an NTS security contractor. The single access road to the ESF for all personnel is through the main NTS Mercury guard gate. All personnel entering the NTS and ESF must pass through this guard gate. The ESF will be under the existing Area 25 security system.

3.4 SURFACE UTILITIES

3.4.1 POWER DISTRIBUTION

The surface electrical power distribution system provides sufficient electrical power for construction and operational requirements for the surface and subsurface. Standby and UPS systems are available for equipment required during any utility power outage. The main power source for the ESF site is a 69-kV transmission line fed from the existing Canyon Substation.

The design requires rerouting the existing 69-kV/12.47-kV underbuilt power line to the ESF site substation. The 69-kV transmission voltage feeds into the ESF substation where it is stepped down to 4,160 V. The distribution voltage is 4,160 V. The power cables are routed in a concrete-encased duct bank to the various facilities on the site, site lighting, ES-1, and ES-2 for the subsurface power.

The standby power is provided by diesel engine generators. During utility power outages, power is supplied to the 900-HP hoist or the 1,500-HP hoist if the 900-HP hoist is inoperable; the subsurface facility; ES-1 and ES-2 heaters; communication and security equipment; UPS; security lighting; life safety; and other required equipment.

The UPS power is used for communication, security, life safety, and data test equipment that must operate during any utility or standby power outage. The UPS is designed to operate for a minimum of 30 minutes.

3.4.2 WATER DISTRIBUTION SYSTEM

The water distribution system supplies and distributes the potable, fire protection and process water required for construction and operation of the site. The requirements for operations are 238 gpm for peak demand and 60 gpm for typical usage. The typical operational flow accommodates 200 personnel in a 24-hour period, with an average per person usage of 50 gallons/day. Peak domestic demand during a shift change is estimated to be 155 gpm. At the furthest point, the warehouse, a maximum fire fighting flow of 1,000 gpm for a 2-hour duration is required.

Supply water from existing well J-13 at the NTS is transmitted through 4.25 miles of existing 6-inch reinforced thermal-setting resin pipe (RTRP) to a new booster pumping station. The design of the pumping station incorporates dual 50-HP pumps and a 10,000-gallon storage tank for positive suction head. The booster station provides the necessary flow requirement to the site water distribution system.

The water system consists of an 8-inch pipe distribution line fed by 12-inch pipe and a 150,000-gallon storage tank. The storage tank supplies the water line with the needed capacity and capabilities for fire protection, construction and operations under routine and maximum emergency demands. The 10,000-gallon water storage tank at the booster station supplies water during construction. Backflow preventers and check valves ensure a supply of potable water. Gate valves, surge protectors, air release valves and blow-off valves are installed. The water used during operation and construction is metered, controlled, and chemically traced. The route of the water line is marked and protected to minimize the possibility of damage from future construction or operation activities.

3.4.3 SANITARY SYSTEM

The sanitary waste sewage system provides for the collection, treatment and disposal of sanitary waste generated at the site. The system collects, treats, and disposes of the sewage for 200 individuals in a 24-hour period. The waste system collects waste water from all buildings in an 8-inch main line.

Three 48-inch manholes are installed on the main pad. The 8-inch main line gravity feeds, with a minimum slope of 1 percent to a prepackage dual grinder pump and tank. The unit is located near the lower parking lot pad. Sewage is pumped through ½-HP grinder pumps into a 3-inch force main for approximately 3,900 feet. Cleanouts are installed at 150-foot intervals. Air release valves are installed as required.

The design of the holding tank and grinder pump system safeguards against any solids that enter the line. The force main increases the velocity so that the possibilities of sedimentation in the line going to the septic are minimal. The sanitary line becomes gravity flow near the equipment storage pad.

Two precast septic tanks, each with a 5,000-gallon capacity, are placed in series at the end of the sewer main. The leach area consists of 7 rows of 4-inch perforated PVC pipe, each 200 linear feet in length, on 6-foot spacing. Future expansion of the septic and leach field sanitary system is possible.

3.4.4 COMMUNICATIONS SYSTEM

The communication system design consists of the telephone system, mine plant intercom, public address, experimenters intercom, and closed-circuit television (CCTV).

The telephone system consists of standard telephone instruments that provide access to the FTS, the DOE/NV system, and long distance networks. The system provides voice communications from the surface facilities to subsurface locations, Area 25, Mercury, and Las Vegas, and long distance access. The system functions by using a microwave system connected to the existing NTS microwave system. The telephone system also supports alarm services for fire, medical, and security.

The locations of the mine plant intercom/experimenters intercom phones are in the ESF surface buildings and at each working level underground. There are 53 surface locations.

The last area of communications is the CCTV. This system allows the hoist operators to view their respective shaft collar and other critical underground locations. It also allows visual surveillance of personnel to ensure safe operations by the hoist operators.

3.4.5 MINE WASTE WATER COLLECTION SYSTEM

The surface mine waste water system handles non-sanitary industrial mine waste water. Mine water is delivered to the surface collar of the shaft under pressure through an 8-inch pressure rated pipe. Normal flow rate of 500 gpm for 15 minutes to 22 minutes on 3½ hour intervals are anticipated. The system is designed to handle full redundant capacity flow of 1,000 gpm. The 8-inch pressure pipe exiting the collar area of the shaft extends an additional 500 feet to the edge of the main pad.

The 8-inch pressure pipe runs approximately 3,800 feet with a static head of 236 feet. Cleanouts are located every 300 linear feet. Air release valves are located as required.

At the end of the 8-inch line, a 3 compartment oil water separator is installed. The separated oil is collected and periodically transported offsite for disposal. The mine waste water is then released into a pond for settling. The settling pond is sized for a 3 day detention time to settle suspended solids from the maximum design flow. The water is then released into the retention lagoon and finally discharged into the wash. This provides 30 days detention for normal expected flows.

3.4.6 COMPRESSED AIR SYSTEM

The compressed air system supplies compressed air for ESF construction, testing, and operation. The surface compressed air system consists of pad mounted compressor units producing the compressed air, as well as auxiliary equipment conditioning the compressed air.

The conditioning equipment includes oil separators and aftercoolers to provide a product safe for personnel use. The transfer of compressed air from the compressor units located off the main pad is accomplished using buried piping. The buried piping will utilize common utility line excavations and terminate at the collar in a utility trench accessible for inspection and monitoring as required. The surface compressed air system supplies compressed air to meet the large demands of subsurface construction and testing, as well as the much smaller requirements at the collar area. Air receivers assure a reserve supply of compressed air, and dampen the impact of large air users on the system pressure.

3.5 ES-1 SHAFT

3.5.1 COLLAR

Initial construction consists of excavating through the bedrock by controlled drilling and blasting to a depth of 20 feet below grade. Liner plate and ring beams are installed where necessary to support the wall of the excavation. Removal of broken rock during collar excavation is performed with a crane and clamshell.

The collar section of the shaft is constructed prior to the erection of the headframe and installation of the sinking stage and rock hoisting facilities. The upper part of the collar is designed to provide a sound foundation for the headframe structure and accommodate penetrations and structural mountings for the conveyance system, ventilation, utilities and instrumentation.

The concrete collar structure serves as headframe foundation and consists of a 30-foot square, 10-foot thick slab enclosing the 12-foot diameter shaft section, followed by a 24-foot diameter, 6-foot deep by 6-foot thick foreshaft section.

The lining section from depth 16 feet to 20 feet is constructed of liner plate and ring beams, and serves as an isolation joint separating the collar and foreshaft from the lining below.

Below 20 feet, the shaft is excavated by controlled drilling and blasting at a minimum diameter of 14 feet and continued until sufficient depth is obtained to safely assemble the sinking stage and erect the headframe. Temporary ground support is provided by pinning wire mesh with rock bolts to the excavated shaft wall. The 12-inch concrete lining in this section of the shaft is placed after the concrete batch plant is in place.

3.5.2 LINING

The shaft is lined with minimum 12-inch thick, 5,000-psi compressive strength, unreinforced concrete placed in contact with the wall of the excavation. Preliminary analysis has demonstrated that the shaft excavation is structurally stable under static and seismic loads (FS-GA-0004). Therefore, the principal function of the lining is to provide a safe and uniform cross section of shaft to facilitate installation of shaft sets and utilities.

A further benefit is realized by lower resistance to ventilation flow due to the smooth wall surface. Lining sections are installed in 20-foot lifts, with a minimum stand-off from the bottom of the lining pour to the blasting bench of 20 feet. The interval of exposed, unlined excavation wall varies from a minimum of 20 feet to approximately 40 feet.

Temporary ground support is installed as required by ground conditions. If necessary, a welded wire mesh (and/or straps) is pinned to the excavated shaft wall immediately by 5/8-inch diameter mechanical rock bolts after blasting and scaling. Controlled blasting is employed in the perimeter holes of the excavation to minimize fracturing outside the neat line.

Since instrumentation is installed during the sinking phase, it may at times be necessary to shorten a lining placement. However, the maximum length of exposed excavation surface is limited to approximately 40 feet. At certain elevations determined by the testing requirements, blockouts in the lining are formed between the outside surface of the shaft liner and the excavation wall to permit installation of instrumentation in the formations outside the lining. If conditions require, water collection rings are installed at the cold joint between two successive lining pours.

Provision for attachment of brackets for support of shaft outfitting can be made either by casting threaded inserts into the lining during placement, or by installing anchor bolts in holes drilled from the stage during final outfitting operations.

3.5.3 STATIONS

Two shaft stations are developed in ES-1, at the Upper Demonstration Breakout Room (UDBR), and at the MTL. These stations are constructed when shaft sinking reaches the respective levels. Because of space limitations, the stations are excavated by small equipment using a top slice and bench method. The ground support, consisting of rock bolts and accessories, is installed as required by ground conditions after each blasting round.

The shaft lining terminates at the station brow and resumes at the floor level at each station. A water ring is installed above the station brow. At the sill elevations a concrete floor is placed, and block-outs for station landing steel and a chairing device are incorporated in the lining.

Reinforced hitches (or foundations) in the shaft liner are placed above each station brow as shown on Title I drawings. These hitches ensure concrete liner support for the sections of liner below and above the hitch.

3.5.4 FURNISHINGS

An unbalanced (no counter-weight), single deck service conveyance travels in ES-1 on rigid timber guides. Timber conveyance guides are specified to conform to the Subsystems Design Requirements Document (SDRD) requirement. Supplied in 20-foot lengths, the guides are spliced at alternate shaft sets that are spaced at 10-foot intervals. Guides are supported at each set on one side by an adjustable bracket bolted directly to the shaft liner, and on the other side by a steel bunton which in turn is attached to a bracket bolted to the shaft liner. Alignment and adjustment of the guide system is maintained by the use of slotted holes at all steel-to-steel, and steel-to-concrete connections.

An access and emergency egress ladderway is provided along the entire shaft. Landings are staggered at 20-foot intervals allowing access to the cage every 40 feet. Additional platforms are provided at test locations allowing access to the total shaft perimeter. Expanded metal screening protects the ladderway compartment from the moving conveyance.

Suspension of utilities in the shaft falls into three basic groups. Power lines are suspended from the utility tunnel in the collar and at 20-foot intervals; air and water lines are supported at 20-foot intervals; and instrumentation, communication, and safety cables are supported in continuous raceways. All utility guys or supports are mounted to brackets bolted to inserts in the concrete liner. Alignment and adjustment is maintained by slotted holes in the brackets.

Because of the large diameter of the ventilation duct relative to the shaft size, the duct is supplied in 5-foot segments, bolted together in place with a sealing gasket to prevent air leakage. This length allows removal and replacement of a segment should it become damaged. At 20-foot intervals the ducts are clamped and suspension provided to brackets bolted on the shaft liner (Figure 3-6).

3.5.5 HOISTING SYSTEM

The hoisting system for ES-1 transports test support personnel and serves as the emergency egress from underground during shaft sinking, ESF construction and underground site characterization testing. The system is designed to support the hoisting activities during both the construction and operation phases of the program.

The major equipment utilized during the construction phase consists of a retractable rock loading chute, headframe, hoists and headsheaves for suspension of the sinking stage, concrete forms and cryderman loader.

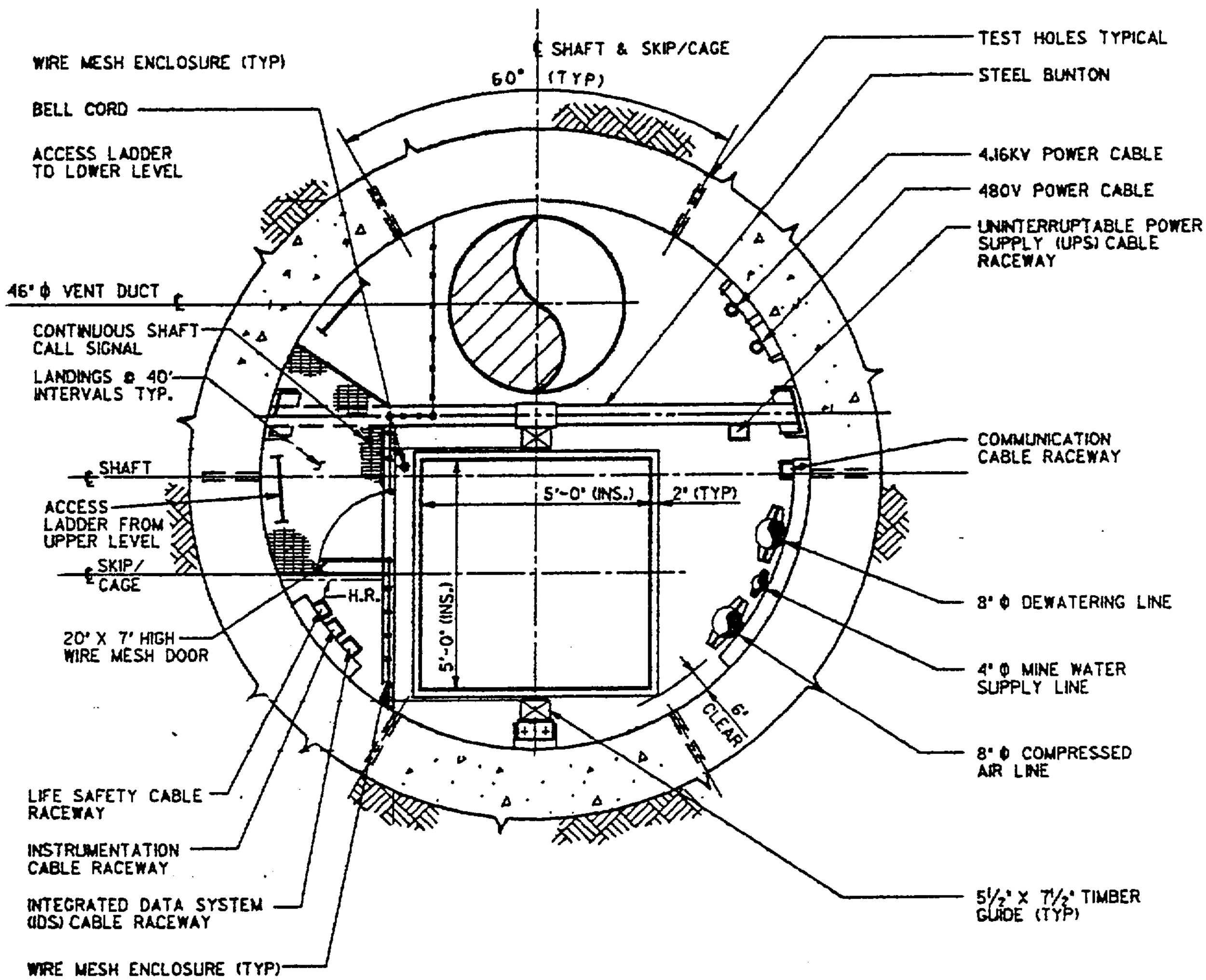


Figure 3-6. ES-1 shaft cross-section.

The four-deck sinking stage is suspended by two 1-3/8 inch diameter ropes that serve as the guide ropes for the sinking bucket crosshead. The topmost deck of the stage is designed to be detachable from the lower three decks to serve as a work platform for testing personnel at different levels of the shaft.

The deck is approximately 10 feet in diameter, with a center opening for passage of the sinking bucket. It is provided with four rubber tired guide wheels symmetrically located around the outside edge of the deck. During hoisting, this single deck is supported and securely locked to the sinking crosshead main structure, which is suspended by the 1-inch diameter main hoist rope.

The hoisting system for the operational phase includes the main hoist, hoist house, headframe, shaft furnishings (guides and buntons), ropes, conveyance, controls, and headsheaves. The system is powered by two 450-HP motors driving a 6-foot diameter single drum, to which is attached a 1-inch diameter hoist rope.

The description of ES-1 headframe and shaft outfitting is provided in Sections 3.5.5.2 and 3.5.4, respectively. The conveyance is an unbalanced (no counterweight) single deck, guided cage with a maximum capacity of 17 persons.

The hoisting system has a payload capacity of approximately 9,400 pounds. The hoist operates at a maximum speed of 1,350 feet/minute and a maximum acceleration of 2 feet/second/second and deceleration of 2.5 feet/second/second, to provide a total duty cycle time of approximately 394 seconds.

In addition a separate truck-mounted, self-contained escape hoist system (powered by a diesel engine) is provided, with an unguided conveyance that has a capacity of four people.

3.5.5.1 Hoist

The ES-1 hoist is described as follows:

Manufacturer	- Vulcan Denver Co.
Identification	- U.S. DOE Prop. No. 79755, Series No. 1389
Date of Manufacture	- 1944, Denver, CO
Configuration	- Single drum, six feet in diameter, seven-foot face width, non-grooved
Power System	- Two 450-HP, 4,160-V, wound rotor, induction motors
Controls	- Multi-step resistor grid, Model C Lilly
Brakes	- Weight actuated, double post, parallel motion pneumatic cylinder release
Maximum rope pull	- Single wrap @ 85 percent efficiency, 18,700 pounds
Maximum rope speed	- Single wrap, 1,350 feet/minute
Rope Size	- 1 inch maximum
Drum Capacity	- The usable rope on the first layer is 992.0 feet. The second layer could contain 1,105 feet of usable rope. This is sufficient for the intended application.

Refer to FS-GA-0045 for a general arrangement of the ES-1 hoist.

The Vulcan Denver hoist was purchased by the government for use at several shaft sites on the NTS during the 1960s. The hoist was inspected and refurbished by Lakeshore Inc. in 1983, and since that time has been stored at the NTS.

The refurbishment consisted of repairs of structural cracks, bushing replacements, motor voltage conversion and rewinding, new brake engine and linings, new power control console, new poured and refinished bearings, journal refinishing and brake surface refinishing. Future refurbishment consists of removal of the present steel subbase, the addition of modern brake force application controls, and air conditioning of the operator's cab. The depth indicator drive will also be modified.

The acceptance testing and commissioning plan is intended to permit designation of the hoist as a First Class Hoist as defined in the California Mine Safety Orders. The ES-1 hoist is designed to operate on either the regular or the standby power system.

The foundation of the ES-1 hoist is designed to withstand a force equal to the breaking strength of the hoist rope applied in the plane and direction of the rope during normal hoisting. The hoist foundation is founded on solid rock. The ES-1 hoist is capable of hoisting the planned subsurface population from a depth of 1,100 feet to the surface in less than one hour (FS-CA-0067).

3.5.5.2 Headframe

The headframe for ES-1 is to be designed to serve both the shaft sinking phase and the operational (testing) phase of the program. The requirement to use an existing government furnished equipment (GFE) headframe has been evaluated during the design process of Title I, and the conclusion reached that the modification of this headframe would not provide the necessary flexibility, and suitable safe accommodation of both hoisting systems. The headframe presented in Title I design is a rigid space frame structure with backlegs and vertical columns at 14-foot by 14-foot spacing located symmetrically to the shaft centerlines.

For the operational phase, an unbalanced single deck cage conveyance is used. The conveyance location is offset from the centerline of the headframe and shaft. An overtravel distance with limit switches, tapered guides and crash beams is provided for the safe stopping of the conveyance in case of accidental overhoisting. A five-ton jib crane is provided at the collar for material handling and for installation of the conveyance. The monorail at the top of the headframe is used for installation of sheaves. Stairs are provided for access to the headsheave platform (Figure 3-7).

The height of the headframe is determined by the arrangement required for the shaft sinking phase. The sinking phase equipment consists of a retractable rock chute and sheaves for the suspension of a work deck, concrete forms and cryderman loader. The area for dumping of rock into trucks is separated from the headframe and the shaft by a retaining wall that may be removed for the operational phase. Hoists and sheaves for the handling of the shaft concrete forms may be omitted by the sinking contractor if it is preferred to use the work deck for handling and relocation of the forms during the shaft sinking operation.

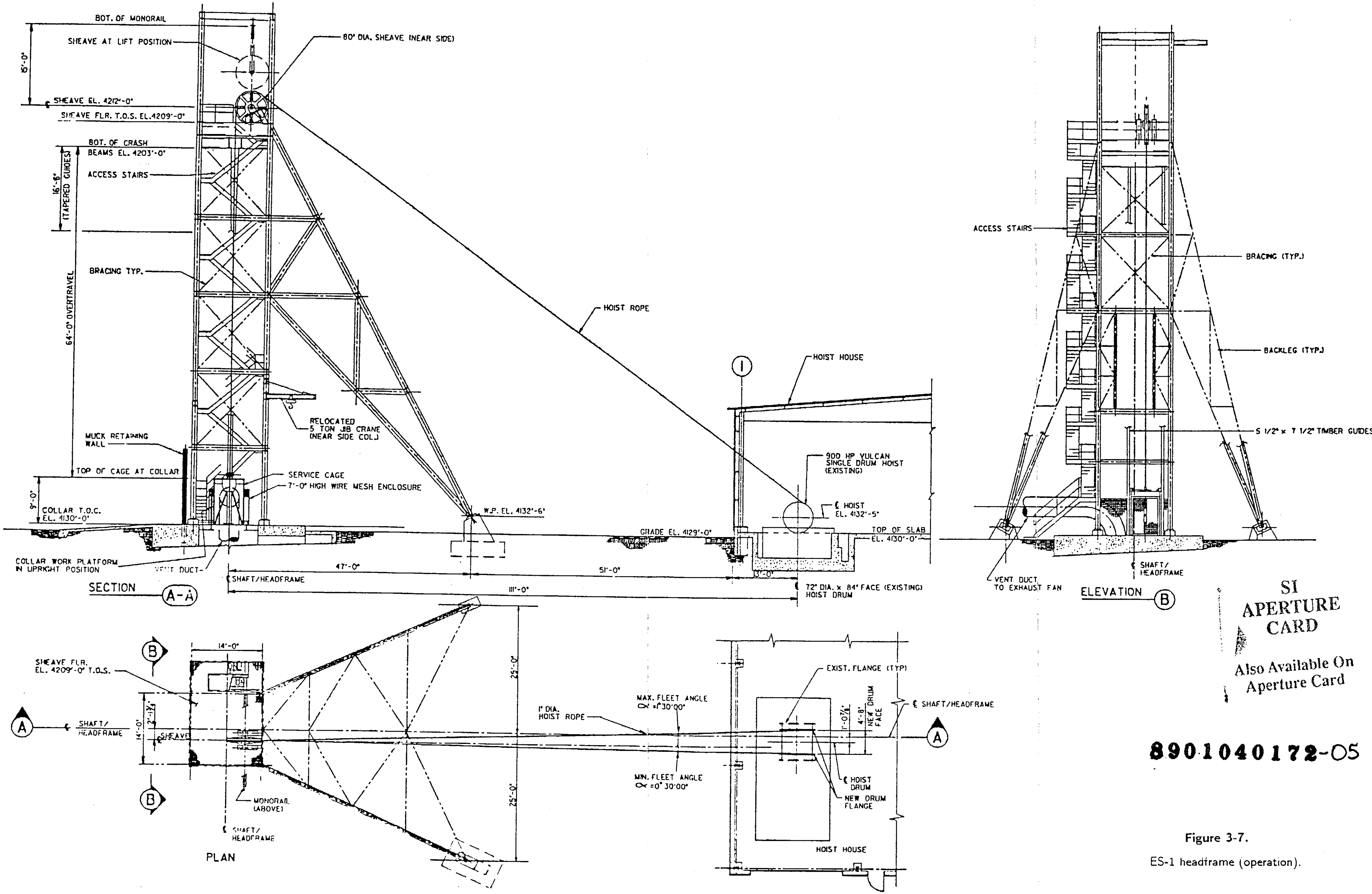


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Figure 3-7.
ES-1 headframe (operation).

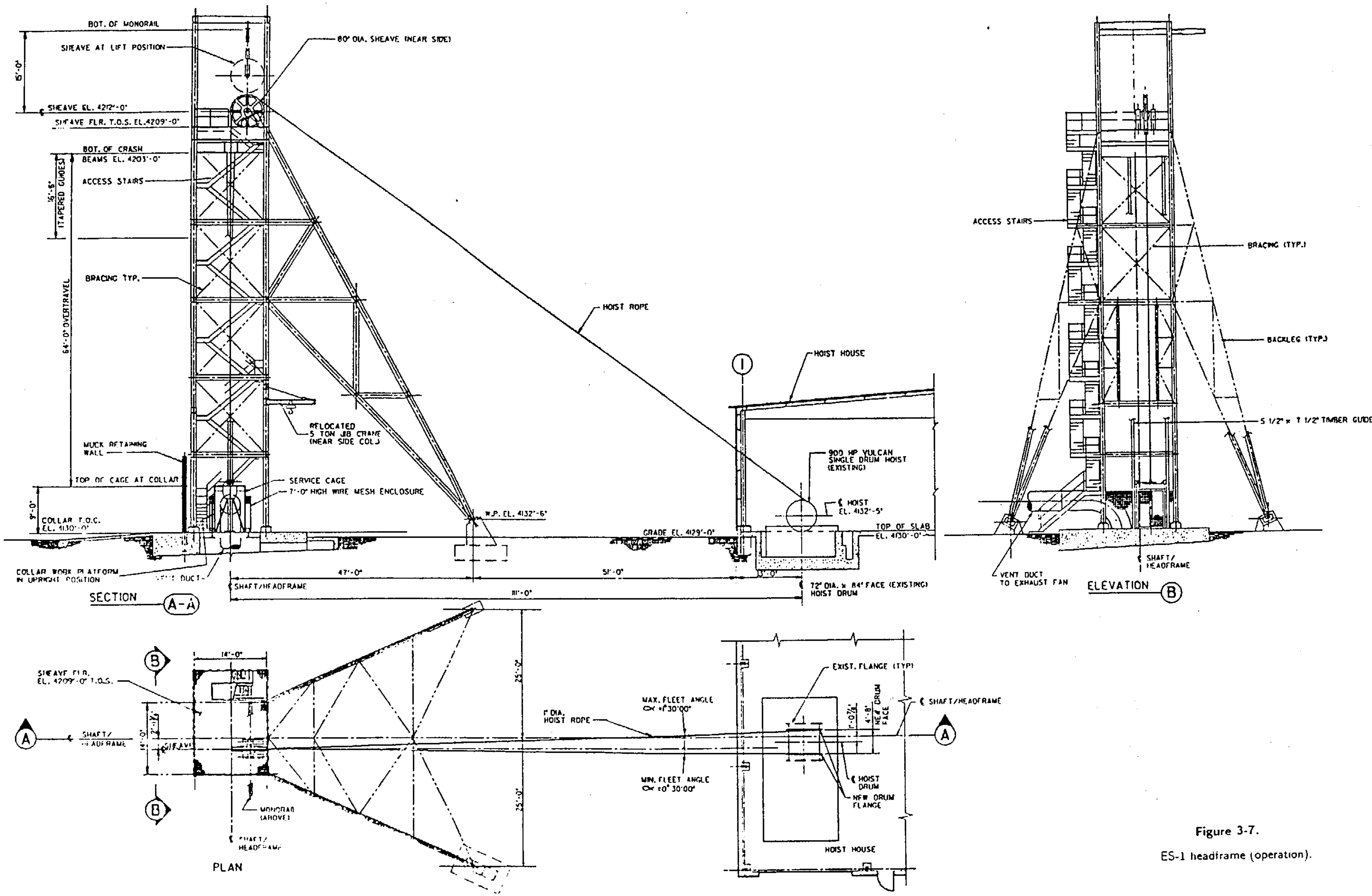

Figure 3-7.

ES-1 headframe (operation).

The Parsons Brinckerhoff proprietary design document entitled "Structural Design Guidelines for Steel Headframes" (S-1, Rev. 2, October 1985) has been used as a basis for structural analysis of the headframe in Title I design (Figure 3-7).

3.5.6 SUMP

The ES-1 sump is defined as part of the bottom of the shaft (below the MTL) that collects and contains mine waste water originating in the shaft and MTL.

The sump is designed to accommodate two electric submersible pumps to transfer the waste water to the MTL pump station for disposal to the surface. Only one of the two pumps is used during normal operation; the second pump serves as a standby.

The pumps are powered by electric motors, and are rated for a capacity of 250 gpm at a 110-foot discharge head. Automatic operation of the pumps is provided by a float switch in the sump. Watertightness of the sump is assured by a highly impact-resistant polyethylene membrane lining fastened to the shaft lining by thermally welding the liner to the studs embedded in the concrete. This membrane extends to a height of 8 feet above the shaft bottom. Since ES-1 is used principally as a service shaft after construction (no rock hoisting), no special provisions are necessary for sump cleaning.

3.5.7 SINKING ARRANGEMENTS

A four deck sinking stage (galloway) is suspended in the shaft on wire ropes attached to winches on the surface. This arrangement provides work platforms above the shaft bottom, and the suspension ropes act as guides for the sinking conveyance. This conveyance consists of a crosshead and a rock bucket. The crosshead is the guide support for the sinking bucket from the surface to the sinking stage. After the bucket reaches the sinking stage, it travels unguided through the stage to the shaft bottom. The galloway has a center opening (bucket well) to allow the sinking bucket, as well as a drill jumbo and other tools and equipment, to pass through to the shaft bottom. A cryderman loading machine is suspended by a wire rope from the surface. Hinged doors in the work deck permit lowering the cryderman to the shaft bottom for rock removal. The bottom deck of the stage has provisions for mounting geologic mapping and photography equipment. During shaft sinking, only temporary ventilation and utility lines are installed to allow the galloway to be moved up and down the shaft without interference. The galloway is also used as the work platform for test monitoring and other access requirements. FS-GA-0072 shows the sinking stage. FS-GA-0015 and FS-GA-0016 show the surface arrangement for the stage hoists and the other sinking hoists. Shaft sinking or excavation consists of repetitive drill, blast, and rock removal cycles, followed by a 20-foot concrete lining cycle.

A segmented steel cylinder, 12 feet in outside diameter by 20 feet high, is used for forming the concrete lining of the shaft. This form is lowered by wire ropes from surface hoists and attached to hanging rods that are embedded in the previous pour of the concrete lining. After stripping, lowering, and installing the form, concrete is lowered either in buckets or down a slick line and through a dash pot type remixer, then placed behind the form.

Lining placement proceeds from the top of the shaft downward in 20-foot increments. FS-GA-0063 illustrates this form.

Temporary ground support (rock bolts, mesh and/or straps) are installed when needed. Geologic mapping and photography of the shaft wall is done before concrete placement or obscuring temporary ground support is installed. Rock samples, for test purposes, are collected after each blast round. If ground water is encountered, perched-water testing is required. The temporary ventilation and utilities are extended in 20-foot lengths after each pour. FS-GA-0054 and FS-GA-0055 show the shaft sinking sequence.

At selected intervals, shaft excavation is stopped for the required time for testing. Once shaft excavation is resumed, periodic access to the test installations in the shaft is required. For test monitoring, the upper deck of the galloway (Section 3.5.5) is raised to the test elevations, with the bucket well covered, to provide a solid continuous work platform for test personnel. The approximate test locations are shown in FS-GA-0057, and FS-GA-0056 shows the sinking stage raised for test monitoring.

Other delays during shaft sinking occur when the UDBR level and MTL are reached. These delays are due to station excavation and preparation of special tests to monitor ground response during shaft sinking.

After the excavation, lining, and shaft wall mapping is completed to the final depth, the galloway is raised to the collar and used as the work platform to install permanent shaft internals, proceeding from collar to shaft bottom. When the shaft furnishing is completed, the galloway is disassembled and hoisted to the surface. The internals to be installed are shown in FS-GA-0050.

All structures, ropes and equipment meet the applicable codes and regulations, and meet or exceed required safety factors. Standby power is connected to the temporary ventilation system and work stage hoists, so that the galloway can be used for emergency egress. Also, an emergency hoist and escape capsule is available. Steel collar doors protect personnel from objects falling into the shaft. A safety crosshead with a steel bonnet provides overhead protection for people riding in the conveyance. The galloway is equipped with handrails and toe boards. The collar doors, emergency hoist and sinking bucket with crosshead are shown in FS-GA-0015.

3.6 ES-2 SHAFT

3.6.1 COLLAR

Initial construction consists of drilling and controlled blasting to a depth of 20 feet into the bedrock. Liner plate and ring beams are installed where necessary to support the wall of the excavation. Removal of broken rock during collar excavation is performed with a crane and clamshell.

The collar section of the shaft is constructed prior to the erection of the headframe and installation of the sinking stage and rock hoisting facilities. The upper part of the collar is designed to provide a sound foundation for the headframe structure and accommodate penetrations and structural mountings for the conveyance system, ventilation, utilities and instrumentation.

The concrete collar structure also serves as the headframe foundation and consists of a 30-foot square, 10-foot thick slab enclosing a 12-foot diameter shaft section, followed by a 24-foot diameter, 6-foot deep by 6-foot thick foreshaft section.

The lining section from the depth 16 feet to 20 feet is constructed of liner plate and ring beams, and serves as an isolation joint separating the collar and foreshaft from the lining below.

Below 20 feet, the shaft is excavated by controlled drilling and blasting at a minimum diameter of 14 feet and continued until sufficient depth is obtained to safely assemble the sinking stage and erect the headframe. Temporary ground support is provided by pinning welded wire mesh with rock bolts to the excavation wall.

3.6.2 LINING

The shaft is lined with minimum 12-inch thick, 5,000-psi compressive strength, unreinforced concrete placed in contact with the wall of the excavation.

Preliminary analysis has demonstrated that the shaft excavation is structurally stable under static and seismic loads (FS-CA-0004). Therefore the principal function of the lining is to provide a safe and uniform cross section of shaft to facilitate installation of shaft sets and utilities. A further benefit is realized by lower resistance to ventilation flow due to the smooth wall surface. Lining sections are installed in 20-foot lifts, with a minimum stand-off from the bottom of the lining pour to the blasting bench of 20 feet. The interval of exposed, unlined excavation wall varies from a minimum of 20 feet to approximately 40 feet.

Temporary ground support is installed as required by ground conditions. If necessary a welded wire mesh (and/or straps) is pinned to the excavated shaft wall immediately after blasting and scaling by 5/8-inch diameter mechanical rock bolts. Controlled blasting is employed in the perimeter holes of the excavation to minimize fracturing outside the neat line.

If conditions require, water collection rings are installed at the cold joint between two successive lining pours. Provision for attachment of brackets for support of shaft outfitting is made either by casting threaded inserts into the lining during placement, or by installing anchor bolts in holes drilled from the stage during final outfitting operations. Since the liner is unreinforced, it can be easily maintained and even replaced, if necessary, throughout the life of the project.

3.6.3 STATION

The ES-2 MTL is at elevation 3,079 feet (938.7 m) mean sea level on an approximately east-west alignment. The primary function is to accommodate loading/unloading of personnel, materials, and equipment from the shaft, and to provide areas for laydown and assembly of equipment and for a rock handling system.

The ES-2 station is approximately 22 feet wide and 21 feet high and is off the center of the shaft to allow a widened-out passageway at the north side of the shaft (Figure 3-8) for access by a small load-haul-dump (LHD) unit to transport rock to the dump pocket during the excavation of the demonstration breakout at the MTL. The station is equipped with structural steel around the vicinity of the shaft to provide supports for conveyance guides, utility piping, power and instrumentation lines and ventilation ducts. Below the station level is a loading pocket installed on two benched excavations in the rock. The upper excavation is approximately 15 feet wide by 17 feet long by 32 feet deep and the lower excavation is approximately 7 feet wide by 8 feet long by 13 feet deep. The loading pocket consists of a 150-ton surge bin and a 10-ton measuring flask equipped with an air cylinder operated gate (Figure 3-9). A description of the rock loading system is provided in Section 3.8.9.

When the shaft excavation reaches the MTL elevation, a station breakout excavation is made. First a 7-foot high pilot drift is driven in the top portion, then the floor is benched down to station sill elevation. Because of space limitations for large equipment, hand-held drills and a small air powered loader (or a slusher) is used. Rock bolts, mesh, and/or straps are installed as required by ground conditions after each blast round.

After completing the station breakout, shaft excavation below the station resumes. The loading pocket excavation is done by benching, concurrent with shaft sinking. The bench elevations remain one blast round or more above the shaft excavation, so that the bench rock can be shot into the shaft for loadout by the cryderman. The upper 17-foot long bench is excavated in two lifts (stair-stepped) to facilitate moving the rock to the shaft. Ground support is installed as required after each blast round.

A water ring is installed in the shaft lining above the station brow. The concrete lining ends at the station brow and resumes at the station floor. Through the loading pocket area, only the shaft wall opposite the loading pocket is lined. This uneven concrete loading requires that the shaft form be extensively braced from the outside and internally, to hold it in place. Station hitches in the concrete shaft liner are provided to ensure support for station brow concrete.

3.6.4 FURNISHING

The conveyance in ES-2 is a double deck cage over a 10-ton capacity skip in balance with a counterweight. Chairing is accomplished by slinging either at the MTL or in the headframe. Timber guides are provided for the cage/skip to allow the use of safety dogs, while tubular steel guides are used for the counterweight to save space.

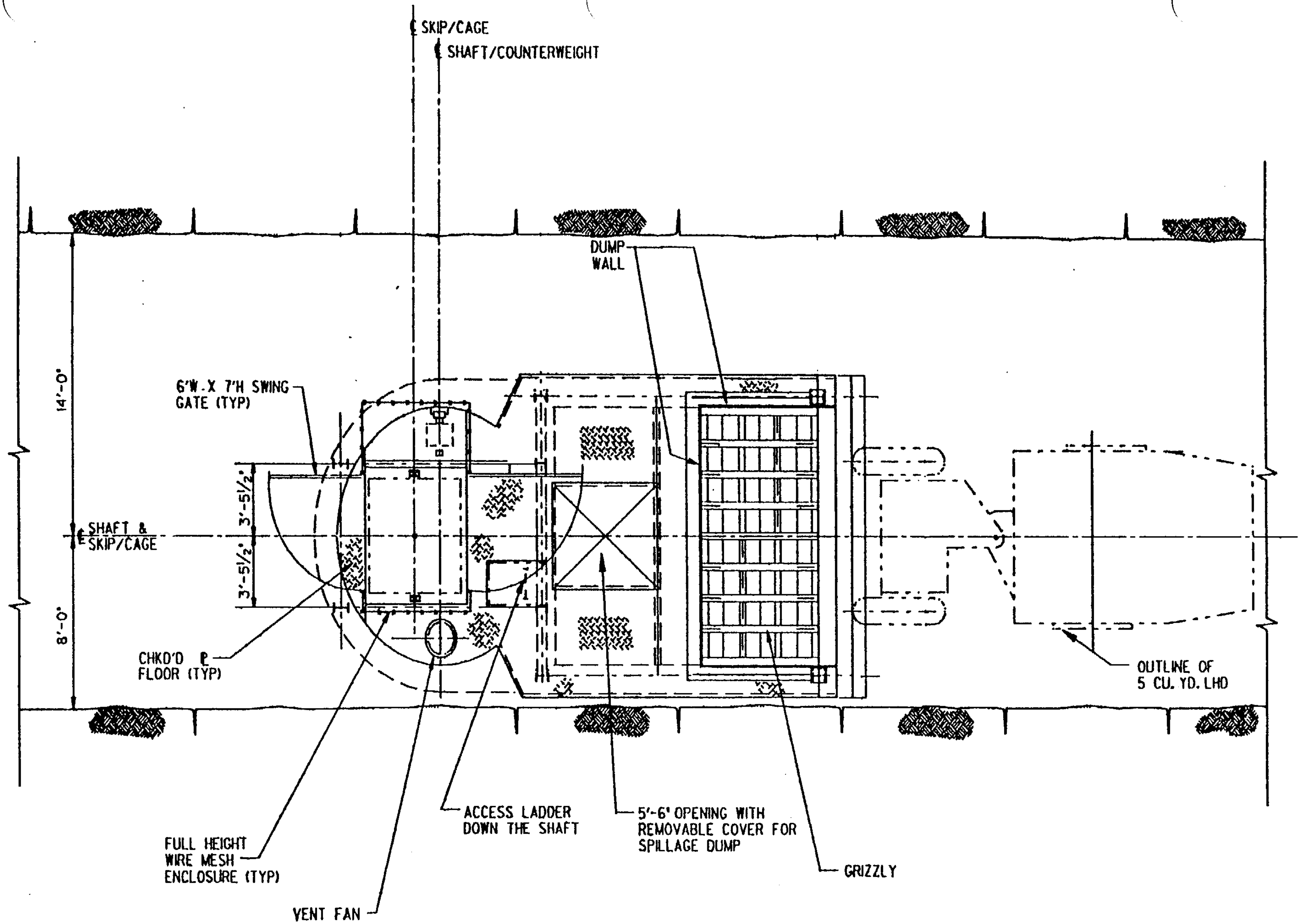

Figure 3-8. MTL dump pocket — plan view.

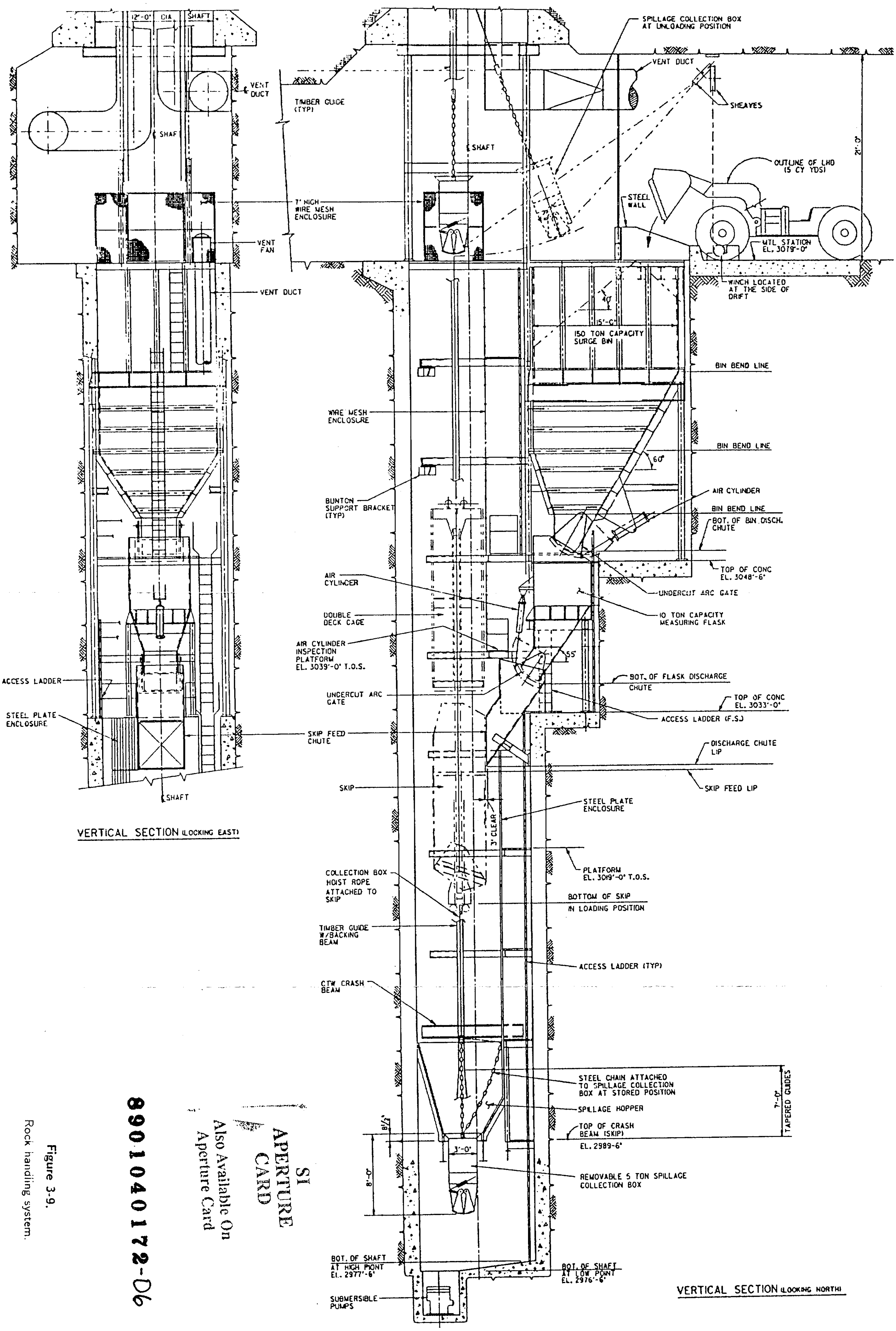

Figure 3-9. Rock handling system.

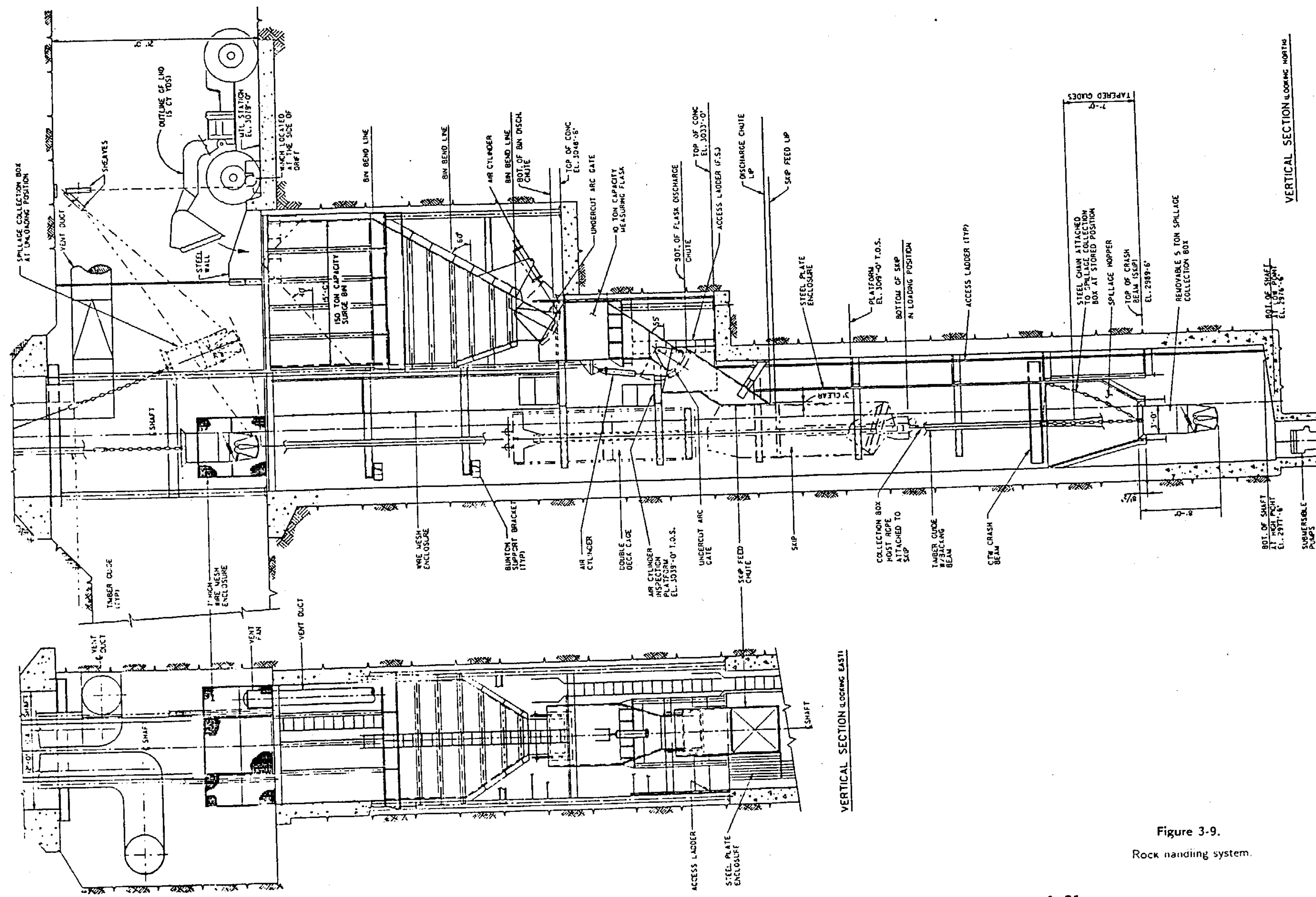

Figure 3-9.

Rock handling system.

Timber guides are mounted to steel buntons with adjustable shelf angles at shaft sets that are spaced at 10 feet vertically. The buntons are attached via slotted holes to brackets bolted on inserts in the concrete shaft lining. Tubular steel guides for the counterweight are mounted on one side to a steel bunton, and or the other to a bracket bolted to the shaft lining. Alignment and adjustment of the guide system is maintained by the use of slotted holes at all steel-to-steel and steel-to-concrete connections. A second means of egress as required by 30 CFR Part 57 is provided by an emergency conveyance. Ventilation of ES-2 is accomplished by partitioning a section of the shaft, creating an air plenum. This is accomplished with a continuous stiffened plate that is installed prior to other shaft outfitting.

Suspension of utilities in the shaft falls into three basic groups. Power lines are suspended from the utility tunnel at the collar and attached at 20-foot intervals; air and water lines are supported at 20-foot intervals; and instrumentation, communication, and safety cables are supported in continuous raceways. All utility supports are mounted to brackets bolted to inserts in the concrete liner. Alignment and adjustment is maintained by slotted holes in the brackets (Figure 3-10).

3.6.5 HOISTING SYSTEM

The hoisting system for ES-2 transports personnel, material and construction equipment between the surface and subsurface for shaft sinking, construction and underground site characterization testing. It serves as the primary rock hoisting system for test area development. The major equipment for the sinking phase consists of a retractable rock loading chute, headframe, hoists and headsheaves for suspension of a sinking stage, concrete forms, and cryderman loader. The 3-deck sinking stage is suspended by two 1 3/8 inch diameter ropes that also serve as the guide ropes for the sinking bucket-crosshead.

The hoisting system for the operational phase includes the main hoist, hoist house, headframe, shaft furnishings (guides and buntons), ropes, conveyances, controls, headsheaves, counterweight and loading pocket. The system is powered by a 1,500-HP motor driving a 12-foot diameter by 6-foot face width, grooved, double drum hoist with a 1½ inch diameter hoist rope. The hoist house is common for both ES-1 and ES-2 hoisting systems, accommodating the necessary equipment and instrumentation for the hoist, air compressor system, control room, electrical and motor control centers, and repair and laydown area. The descriptions of ES-2 headframe and shaft outfitting are provided in Sections 3.6.5.2 and 3.6.4, respectively.

The permanent conveyance consists of a double deck man cage over skip combination in balance with a counterweight. The cage has a maximum capacity of 17 persons per deck, the skip has a capacity of 10 tons. The counterweight is made of steel plates and lead in combination to comprise an approximate weight of 27,350 pounds. The loadout system, located at the MTL, consists of a surge bin and measuring flask and is described in detail in Sections 3.6.3 and 3.8.9.

The hoisting system is capable of transporting rock from the subsurface loading area to the surface at a maximum rate of approximately 249 tons per hour. The hoist operates at a maximum speed of 2,000 feet/minute and a maximum acceleration of 2.0 feet/second/second and maximum deceleration of 2.5 feet/second/second to provide a total duty cycle time of approximately 144 seconds.

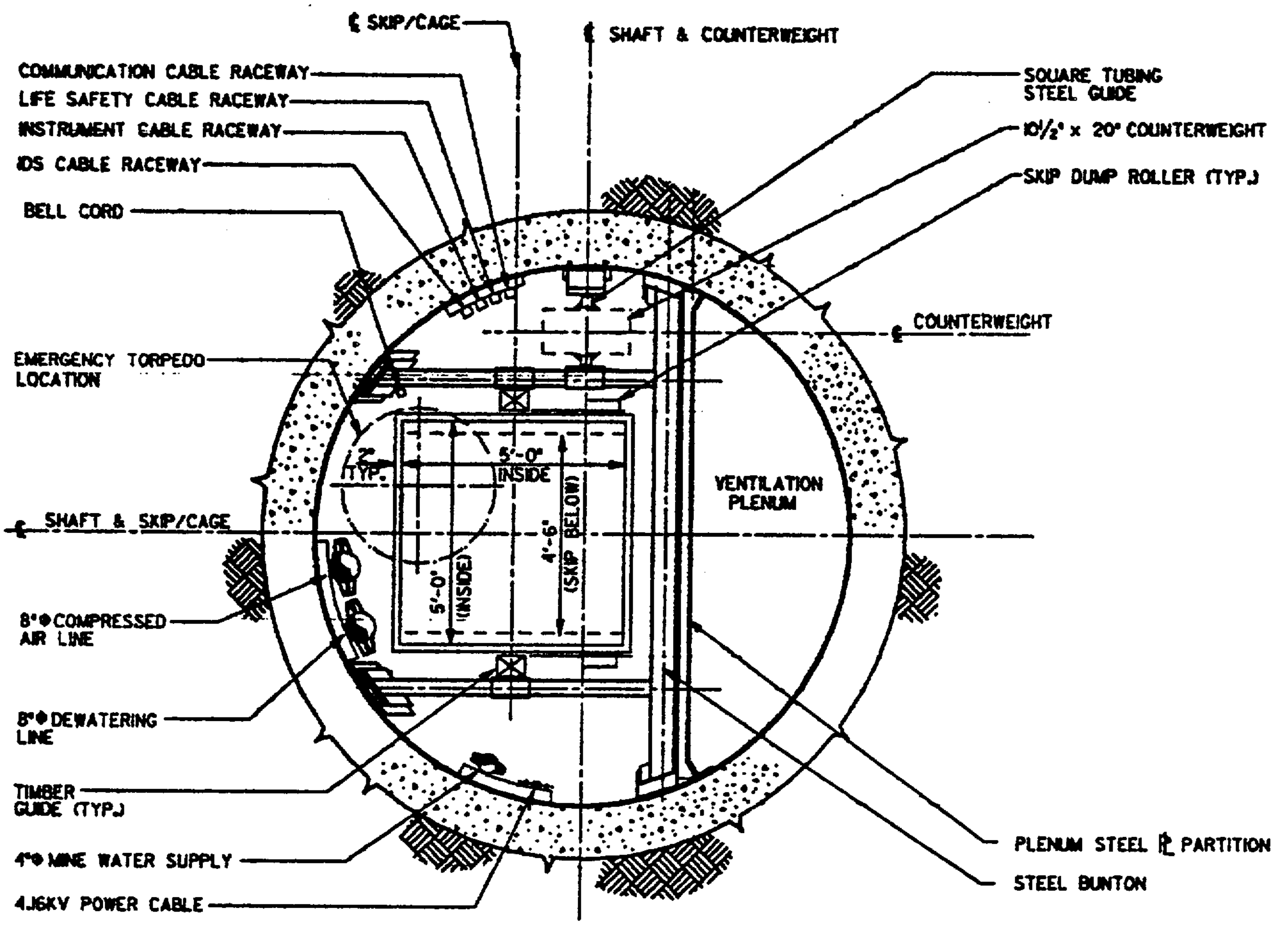

Figure 3-10. ES-2 shaft cross-section.

A separate truck-mounted, self-contained escape hoist system (powered by a diesel engine) with an unguided conveyance with a capacity of four people is available to transport personnel out of the shaft in case of an emergency condition during the sinking and operational phases.

3.6.5.1 Hoist

The ES-2 Hoist is described as follows:

Manufacturer	-	Allis-Chalmers Corp. Milwaukee, Wis.
Date of Manufacture	-	1930
Configuration	-	Double Drum, double clutched, 12 feet in diameter, 6 feet long, grooved drums on a single shaft
Power System	-	One 1,500-HP 4,160-V, wound rotor, induction motor driving a herring bone pinion/final drive
Controls	-	Multistep resistor grid & Lilly Model D
Brakes	-	Weight actuated double post parallel motion, hydraulic cylinder release
Maximum rope pull	-	Single wrap at 85 percent efficiency, 21,112 pounds at 200 percent of continuous rated torque
Maximum rope speed	-	Single wrap, 2,000 feet per minute
Rope Size	-	1½ inch diameter
Drum Capacity	-	The first layer contains 2,337.2 feet of usable rope. This is sufficient for this application.

The DOE purchased the Allis-Chalmers hoist in 1987 for ES-2. Tosco Corporation, the previous owner, inspected the hoist in 1982 and found it in good condition with the exception of some structural defects that have not been repaired to date. A general arrangement of the ES-2 hoist appears in FS-GA-0045. An outline program of inspection, repair and modernization is part of Title I design (FS-ST-0016). A consultant inspects the hoist and recommends repairs and additions so that the hoist can be commissioned as a First Class Hoist as defined by the California Mine Safety Orders.

Planned work includes, but is not limited to the drum spider and clutch spider repair or replacement, replacement or repair of the hydraulic brake engine, addition of a power control system and operator's cab, brake force application controls, Lilly controller repair or refurbishment, and bearing replacement as required, and an additional brake attachment to the pinion shaft. Additional functions are included on the console and modern brake force application equipment will be added reflecting recent developments in hoisting technology.

Emergency hoisting in the ES-2 shaft is accomplished with a portable truck-mounted hoist and boom that lowers and raises a torpedo shaped cage capable of retrieving persons stranded in a conveyance in the shaft bringing them safely to the surface.

3.6.5.2 Headframe

The headframe for ES-2 is designed to serve both the shaft sinking and the operational phases of the program. The headframe presented in Title I design is a rigid space frame structure with backlegs and vertical columns at 14-foot by 14-foot spacing located symmetrically to the shaft centerlines.

For the operational phase, the combined skip/cage conveyance is being hoisted in balance with a counterweight. The skip/cage location is at the centerline of the headframe and the shaft. An overtravel distance with limit switches, tapered guides and crash beams is provided for the safe stopping of the conveyance in case of accidental overhoisting. The five-ton jib crane is provided at the collar for material handling and for installation of the conveyance. The monorail at the top of the headframe is for installation of sheaves. Stairs are provided for access to the headsheave platform (Figure 3-11).

The height of the headframe is determined by the operational requirements of the skip. The shaft sinking phase equipment consists of a fixed and retractable rock chute and sheaves for suspension of the work deck, concrete forms and cryderman loader. The area for dumping of rock into dump trucks is separated from the headframe and the shaft by a retaining wall that is also used during the operational phase.

Hoists and sheaves for handling of the shaft concrete forms may be omitted by the sinking contractor if it is preferred to use the work deck for handling and relocating the forms during the shaft sinking operation.

The design document entitled "Structural Design Guidelines for Steel Headframes" (S-1, Rev. 2, October 1985) is used as a basis for structural analysis of the headframe in Title II design (Figure 3-11).

3.6.6 SUMP

The sump is defined as the section at the bottom of the shaft, below the MTL, that serves to collect waste water originating in the shaft above, and from the MTL.

The shaft bottom accommodates two electric submersible pumps for transferring the accumulated mine waste water to the MTL pump station for disposal to the surface. Only one of the two pumps is used during normal operations; the second pump serves as a standby.

The pumps are powered by electric motors, and are rated for a capacity of 250 gpm at a 110-foot discharge head. Automatic operation is provided by level control by means of a float switch in the sump. Watertightness of the sump is provided by a highly impact-resistant polyethylene membrane fastened to the shaft lining by thermally welding the liner to the studs embedded in the concrete. This membrane extends to a height of 8 feet above the shaft bottom.

A rock spillage hopper with a spillage collection box is installed at the crash beam level above the sump to collect incidental rock overflow from the skip-loading operation, which minimizes spillage into the sump. If occasional cleanup of the sump becomes necessary, it can be accomplished by hand methods.

3.6.7 SINKING ARRANGEMENT

The ES-2 GFE headframe arrangement and surface pad has provisions for the shaft subcontractor to mount wire rope sheaves and hoists to suspend the shaft sinking work stage.

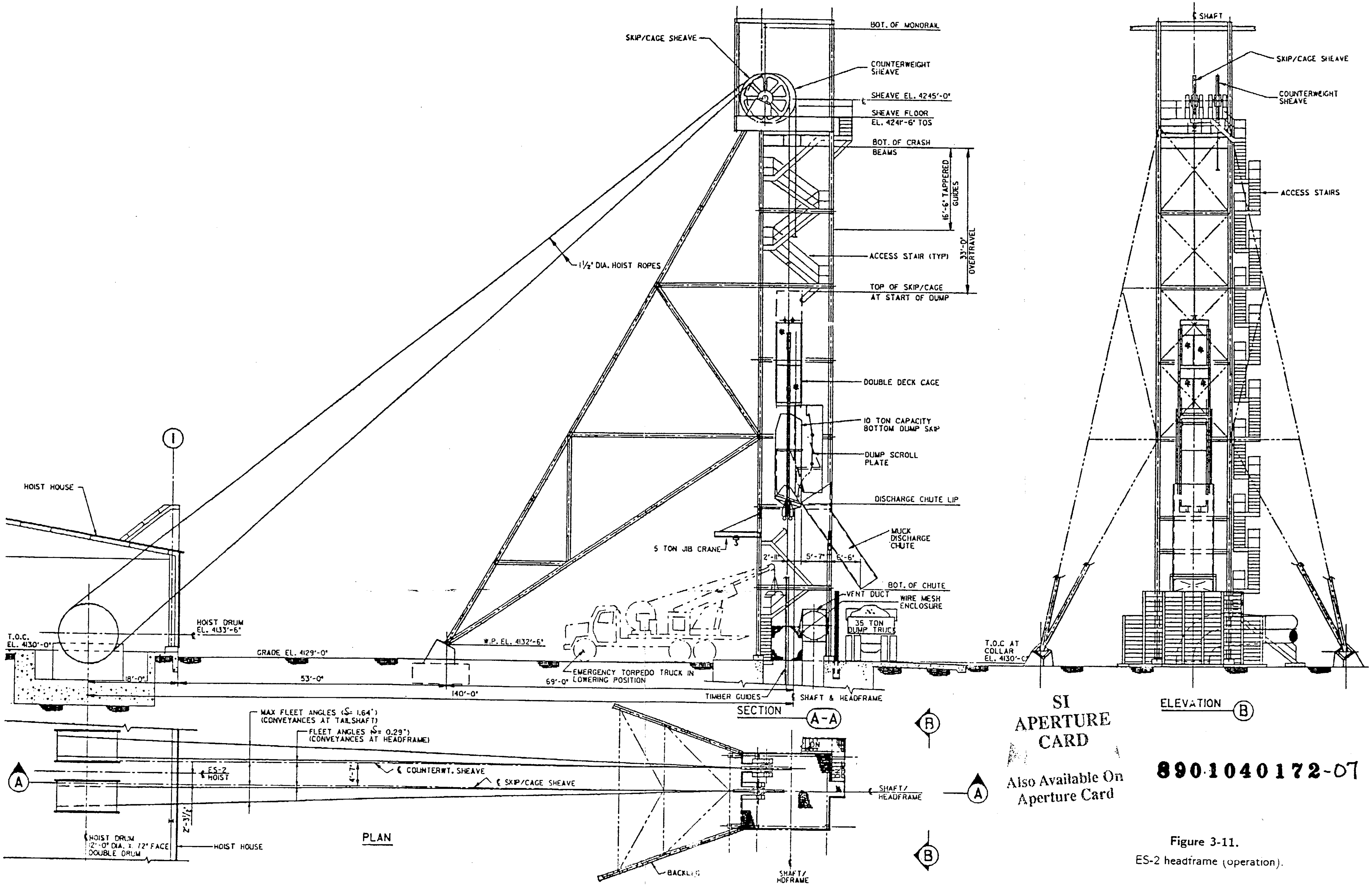

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Figure 3-11.
ES-2 headframe (operation).

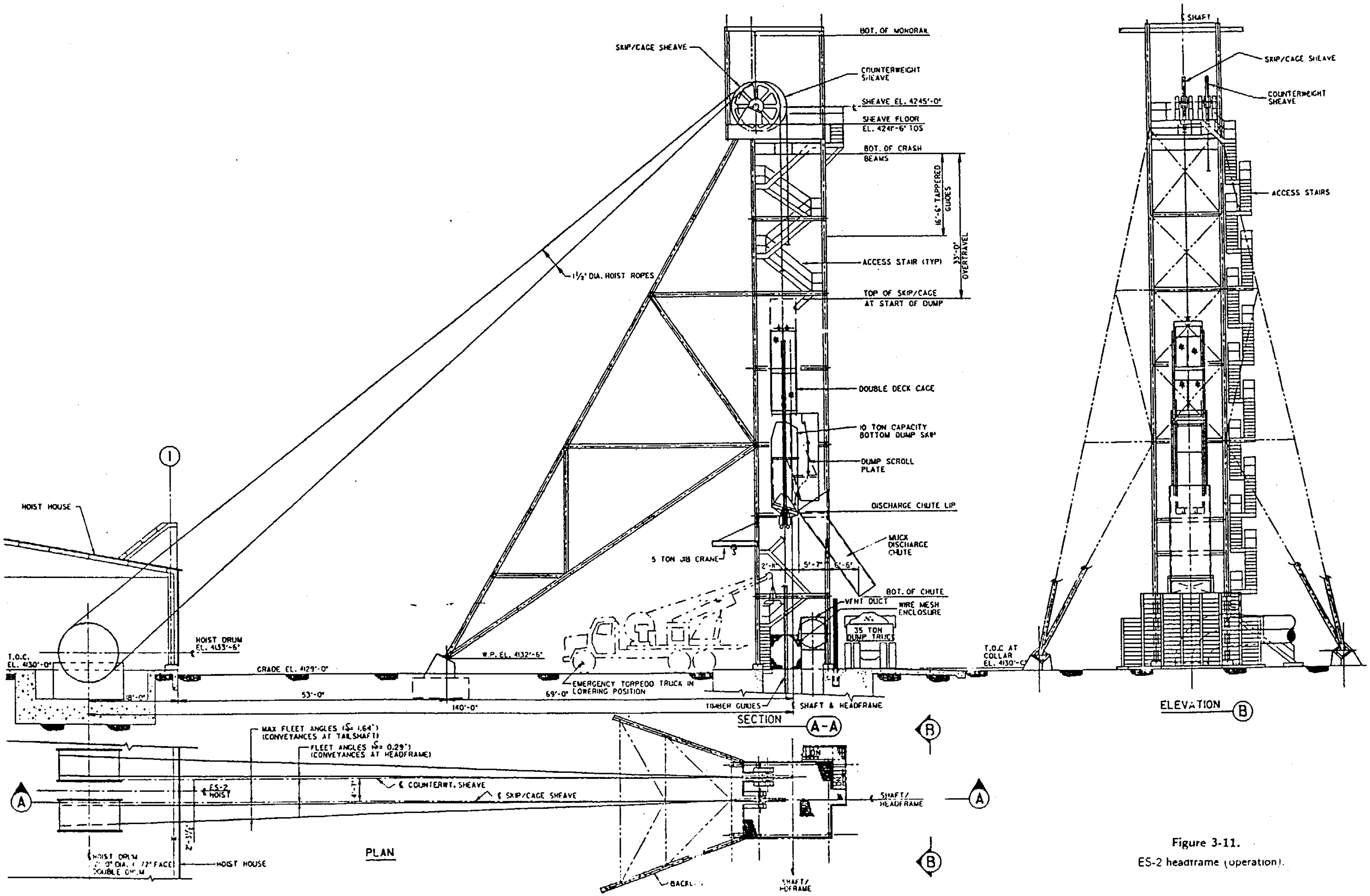

Figure 3-11.
ES-2 headframe (operation).

Facilities are also provided for concrete form hoists, a cryderman hoist, and a rock dump. FS-GA-0033 and FS-GA-0034 show the surface arrangement for sinking.

A three deck sinking stage (galloway) similar to the one used in ES-1 is suspended in the shaft on wire ropes attached to winches on the surface. This arrangement provides work platforms above the shaft bottom, and the suspension ropes act as guides for the sinking conveyance. This sinking conveyance consists of a crosshead and a rock bucket. The crosshead is the guide support for the sinking bucket from the surface to the sinking stage. After the bucket reaches the sinking stage, it travels unguided through the stage to the shaft bottom.

The galloway has a center opening (bucket well) to allow the sinking bucket, as well as a drill jumbo and other tools and equipment, to pass through to the shaft bottom. A cryderman loading machine is suspended by a wire rope from the surface. Hinged doors in the work deck permit lowering the cryderman to the shaft bottom for rock removal. The bottom deck of the stage has provisions for mounting geologic mapping and photography equipment if required. During shaft sinking, only temporary ventilation and utility lines are installed to allow the galloway to be moved up and down the shaft without interference. The galloway is also used as the work platform for test monitoring and other access requirements. Shaft sinking or excavation consists of repetitive drill, blast, and rock removal cycles, followed by a 20-foot concrete lining cycle.

A segmented steel cylinder, 12 feet in diameter by 20 feet high, is used for forming the concrete lining of the shaft. This form is lowered by wire ropes from surface hoists and attached to hanging rods that are embedded in the previous pour of the concrete lining. After stripping, lowering, and installing the form, concrete is lowered either in buckets or down a slick line and through a dash pot type remixer, then placed behind the form. Lining placement proceeds from the top of the shaft downward in 20-foot increments. This form is shown in FS-GA-0063.

Temporary ground support (rock bolts, mesh and/or straps) are installed when needed. Geologic mapping and photography of the shaft wall must be done before concrete placement or obscuring temporary ground support is installed. Rock samples, for test purposes, are collected after each blast round. If ground water is encountered, perched-water testing is required. The temporary ventilation and utilities are extended in 20-foot lengths after each concrete placement.

Delays during shaft sinking occur when the MTL is reached. Delays are due to station excavation and preparation of special tests to monitor ground response during shaft excavation.

After the excavation and lining of the shaft is completed to final depth, the galloway is raised to the collar and used as the work platform to install permanent shaft internals, proceeding from the collar to the shaft bottom. When the shaft furnishing is completed, the galloway is disassembled and hoisted to the surface. The internals to be installed are shown in FS-GA-0100.

All structures, ropes and equipment meet the applicable codes and regulations, and meet or exceed required safety factors. Standby power is connected to the temporary ventilation system and work stage hoists, so that the galloway can be used for emergency egress. Also, an emergency hoist and escape capsule is available. Steel collar doors protect personnel from objects falling into the shaft. A safety crosshead with a steel bonnet provides overhead protection for people riding in the conveyance. The galloway is equipped with handrails and toe boards. The collar doors, emergency hoist and sinking bucket with crosshead are shown in FS-GA-0015.

3.7 UNDERGROUND FACILITIES

3.7.1 UPPER DEMONSTRATION BREAKOUT ROOM (UDBR)

The purpose of the UDBR is to provide a space in which to observe drift convergence and demonstrate constructibility of repository size openings in rock containing 10-15 percent cavity (lithophysae) content. The UDBR is located off ES-1 at a depth of 600 feet (FS-GA-0150). The design of the UDBR does not preclude future expansion of this level if it becomes necessary. The basic ground support system consists of rock bolts and wire mesh supplemented with steel sets in the immediate station area. The 19-foot by 25-foot cross section dimension is used to simulate some proposed repository openings. The area is ventilated by an exhaust system pulling fresh air descending the ES-1 shaft (FS-GA-0225).

Power, compressed air, and water are supplied by utility lines in the ES-1 shaft; redundancy of these systems is achieved through looping into the MTL (FS-GA-0230, FA-GA-0234, and FS-GA-0205). Waste water and spills generated during construction are removed by the shaft sinking bucket. Any spills or natural water occurring on the UDBR level are drained in a pipe to the MTL sump after ES-1 has been completed. UDBR safety features consist of steel barriers around ES-1 to prevent falls; fire doors on either side of the shaft; and alternate means of egress such as the shaft primary hoist and cage, an emergency hoist, and a fixed ladderway to the surface or to the MTL.

3.7.2 MAIN TEST LEVEL

The MTL is constructed approximately 1,050 feet below the surface, and is the only level at which both ES-1 and ES-2 are connected. The MTL consists of an operations area and a testing area, as shown on FS-GA-0160, and exploratory drifts as shown in FS-GA-0194. FS-GA-0161 delineates between the operations area and the test areas. FS-GA-0162 shows typical drift cross sections for the MTL.

The operations area provides space for all the support activities and installations necessary to do the mining and construction and to perform the test program. This includes the mine and equipment shop, scientific equipment shop, IDS room, electrical power center, uninterruptible power source (UPS), explosives storage areas, and haulage ways connecting the support and testing areas. FS-GA-0171 and FS-GA-0172 show some operations area details.

The testing areas are the alcoves and drifts, excluding the exploratory drifts described in the next paragraph, in which site characterization tests are conducted (FS-GA-0163, FS-GA-0164, FS-GA-0165, and FS-GA-0166).

Exploratory drifts (FS-GA-0195, FS-GA-0196, FS-GA-0197, FS-GA-0198, and FS-GA-0199) are driven to explore the Ghost Dance fault, Drill Hole Wash, and the suspected imbricate fault zone. These drifts are driven on alignments coincident with possible future repository drifts, but are smaller in cross section. Several short increments of each exploratory drift are enlarged to repository size for full-scale ground stability evaluation.

3.7.2.1 Operations Area

The MTL operations area provides access to various site characterization test areas; space for conducting construction, drilling, maintenance and equipment assembly operations; and space in which to store equipment and materials (FS-GA-0160, FS-GA-0162, FS-GA-0171, FS-GA-0172 and FS-GA-0195).

The subsurface data building is an 816-square foot load bearing wall structure built in the IDS room excavation of the MTL to support the IDS as the central data gathering point for underground testing. The building is a computer facility with raised flooring and exterior walls, and ceiling/roof assemblies designed for one hour rated fire separation.

Because of the relatively stable 60°F to 70°F underground air temperature, an air-cooled process cooling unit is used with underfloor air distribution to allow full room equipment flexibility.

An ordinary hazard, group 2 wet pipe sprinkler system is used with central quick-response on-off sprinklers for the fire protection system. Also provided are a Halon 1301 fire protection system and an automatic detection system for early warning via smoke detectors at the ceiling and in the underfloor air plenum. The halon system is activated by heat detectors.

The electrical requirements for the computer area, UPS power and lighting are based on 35-kVA, 120/208-V, 3-Ø UPS power and lighting at 100 fc with provision for emergency lighting. A power shutdown switch at each principal exit of the computer room cuts all power to computer equipment and related HVAC systems. General power for the building is provided by 120-V, 20-A duplex receptacles and the entire building is on standby power. The subsurface data building requires a 100-fc lighting level.

The mobile equipment is refueled in the area shown in FS-GA-0160, Sector D-5. Fuel is lowered to the area through a pipe placed in the ES-2 shaft to a tank located in the fueling area. Adequate containment of spills is provided by concrete lined sumps; potential fire and fire gaseous products are contained by automatically closing fire doors.

Explosives are delivered each day to the MTL. The explosives needed daily are stored in approved containers located in unused and unoccupied single ended drifts away from active mining.

The haulage of rock from active excavation areas to the ES-2 dump is via panel access drift 2 (FS-GA-0160). Rock haulage traffic in all other areas is restricted to the absolute minimum required for construction and maintenance. Rock handling in the MTL operations area is done by a fleet of diesel-powered, rubber tired, load-haul-dump (LHD) equipment supported by similarly powered service vehicles.

The ground (rock) support system utilizes rock bolts to reinforce the excavated arches shown in the various cross sections. Rock bolt length, diameter and spacing is designed to provide a safety factor of 1.5 to 2 or more with respect to the calculated stresses. Shotcrete and steel sets in the station area supplement, when necessary, the primary rock bolt reinforcement system.

Ventilation ducting and fans are located in the operations area; the locations in the drift cross section are designed to make best use of the available space and to provide protection to the ventilation equipment.

Safety features of the MTL operations area include the following: barriers located at the shaft stations to prevent falls; fire doors at strategic places (FS-GA-0228) which contain fire and fire gaseous products; two directional or bypass approaches to either ES-1 or ES-2 for escape; and a refuge chamber. The ventilation system is designed for removal of airborne toxic materials. The drift widths are designed to comply with applicable safety regulations governing clearances of pedestrians and mobile machinery.

3.7.2.2 Test Areas

The MTL contains areas that have been dedicated to subsurface testing (Figure 3-12). Approximately 4,000 feet of drift mining are required for the dedicated test area. An additional 5,000 feet of drift mining are required to construct the long lateral drifts.

The current general arrangement of the MTL is given in FS-GA-0160. The arrangement, dimensions, and orientations may change as additional design analyses are completed and as testing activities and construction requirements are considered further. For some tests, confirmation of a particular location in the MTL is made based on the results of physical examination of the local rock features exposed in the main access drifts. The final locations are determined based on specific test criteria. The design considerations may include such variables as the mining method used (wet vs. dry); blast damage; proximity to operations (muck hauling); test-to-test interference; test duration; geologic features; fracture frequency; and drift and fracture orientation. This approach requires substantial flexibility to locate the tests within the MTL.

ES-1 and the UDBR also contain test areas. In ES-1, the shaft wall is mapped, and at certain elevations in this shaft, experiments are installed.

3.7.2.3 Long Exploratory Drifts

The long exploratory drifts shown on FS-GA-0194 extend outward from the ESF to the imbricate normal fault zone to the east, Drill Hole Wash to the north, and the Ghost Dance fault to the west.

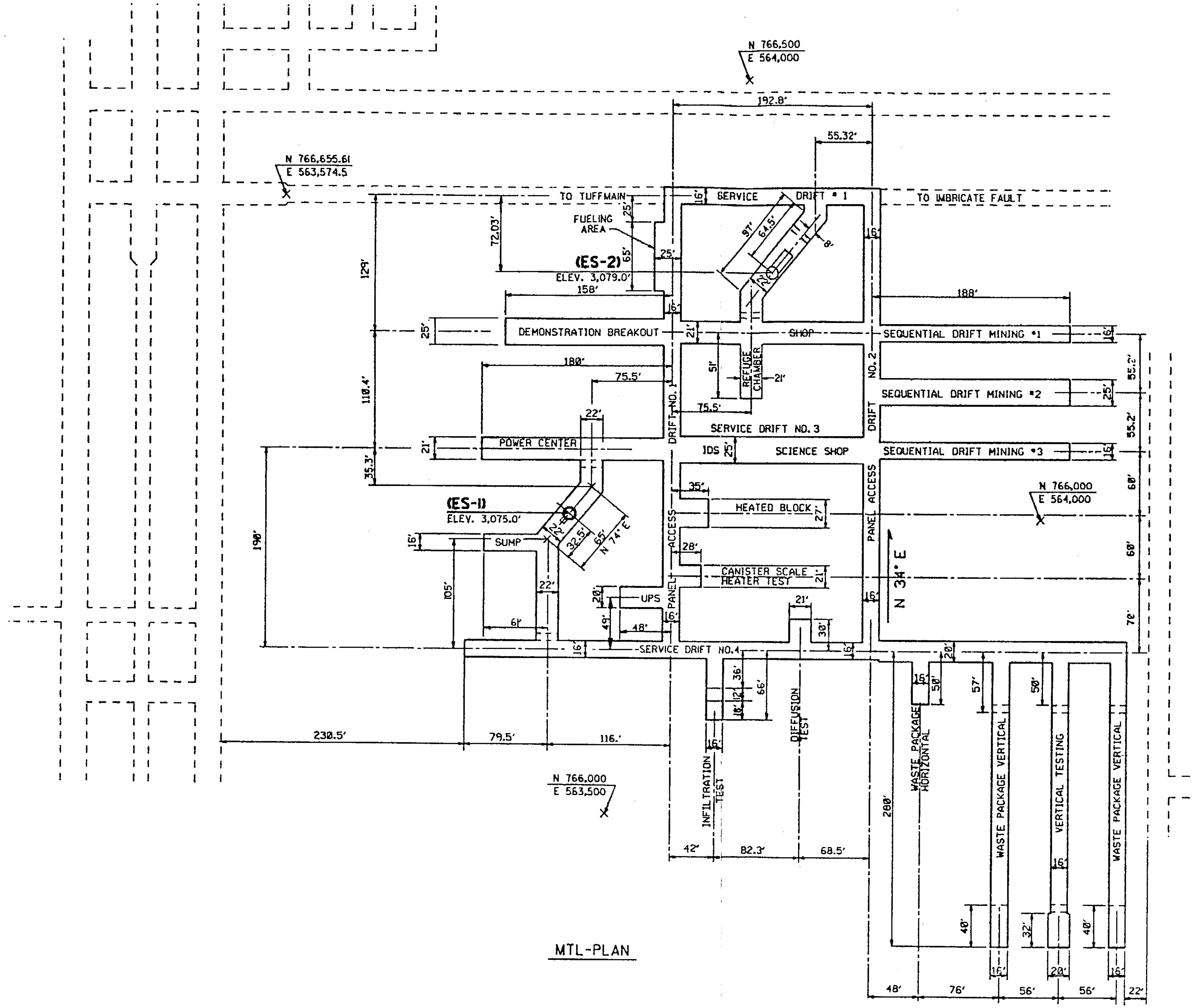

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Figure 3-12.
MTL plan.

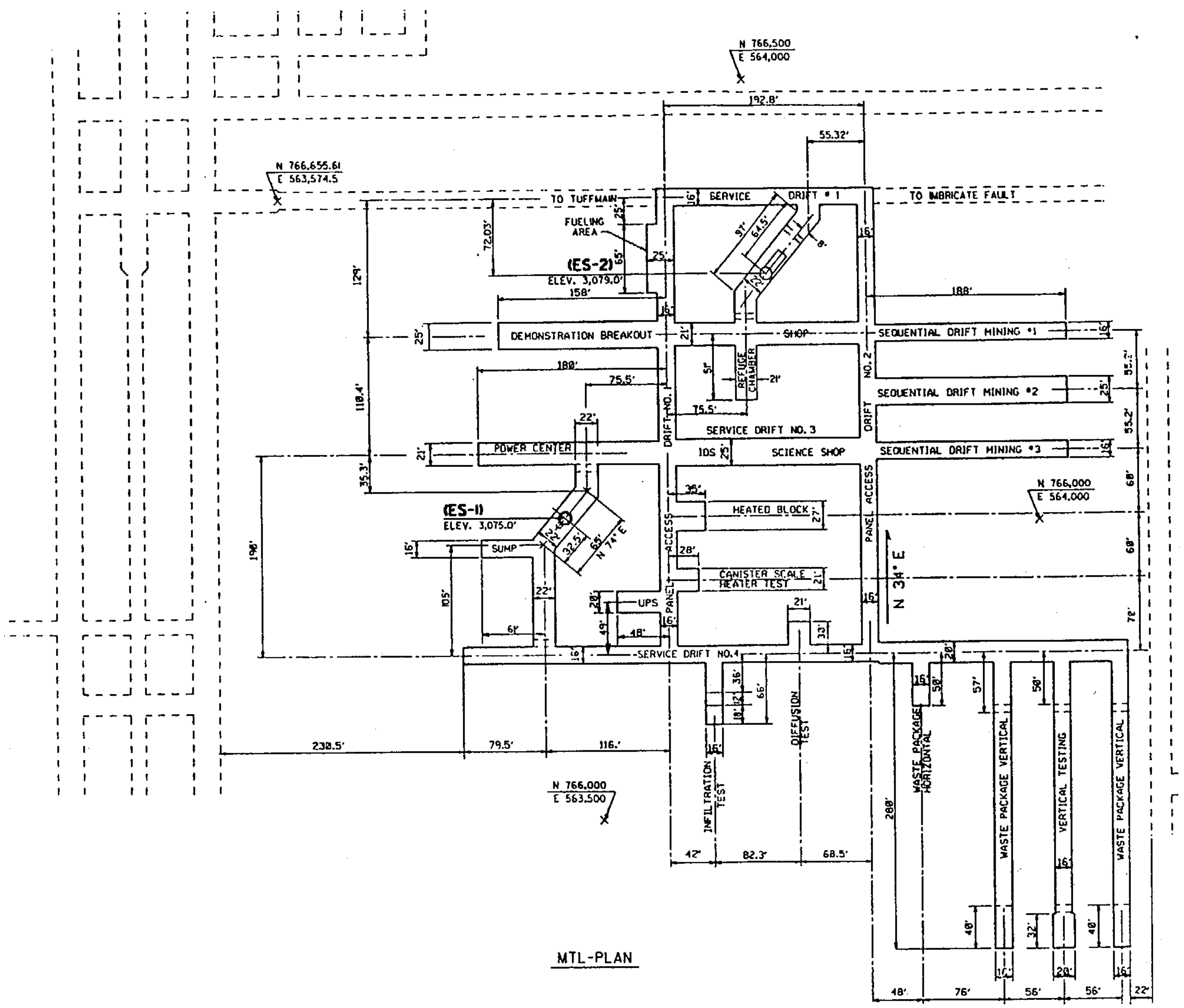


Figure 3-12.
MTL plan.

Access to the long drifts is from the dedicated test area. The drifts are compatible with the conceptual repository design and access potential important geologic features for characterization.

The drift to the Ghost Dance fault examines features potentially important to the design and performance of the repository. The fault is a potential transmissive zone for water from the surface to the water table. The drift allows direct observation, collection of samples, and other measurements to model the hydrologic environment. Other information obtained in this drift include the nature of the fault zone, the time of last movement, and the magnitude and direction of fault offset.

The drift to the Drill Hole Wash examines characteristics important to the construction and performance of the repository. Structural features, such as faulting, that are postulated based on surface mapping and drillholes are examined. If the examination shows little or no faulting, then the area north of Drill Hole Wash might be suitable for repository use should contingency emplacement space be needed sometime in the future. The hydrologic character of the structural features is also studied. If the wash tends to concentrate surface waters and channel along a specific path, higher than average infiltration rates could occur. Possible movement of water and any seasonal change in flow rates at this fault zone are to be investigated in this area.

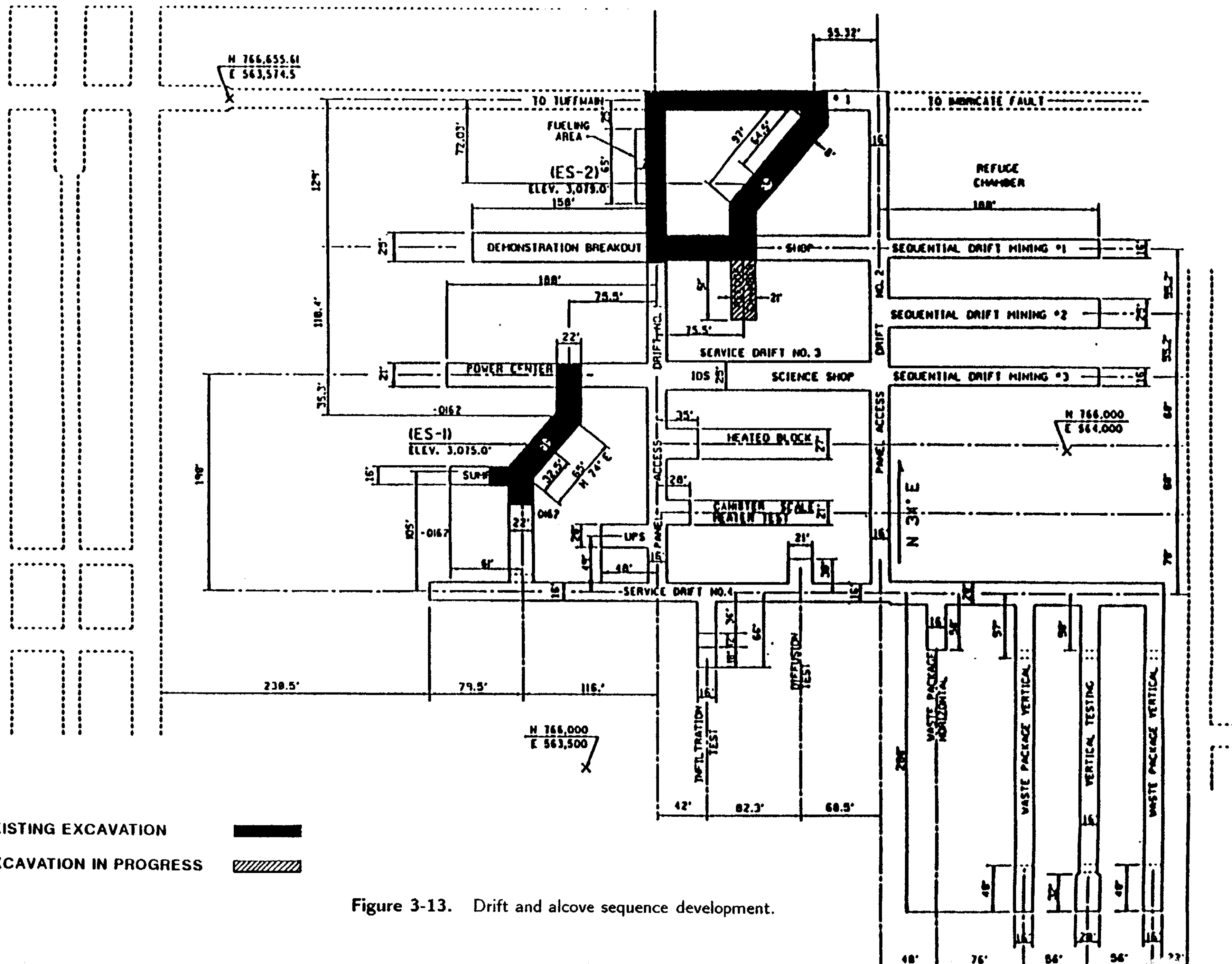
The drift to the suspected imbricate normal fault zone (if these faults exist at depth) studies the fault zone characteristics at the proposed repository depth. The studies aid in the determination of the eastern boundary of the repository block. Hydrologic studies are also performed to determine if this fault zone is transmitting water.

3.7.2.4 Development of the MTL

The sequence of drift and alcove development is shown in Figures 3-13 through 3-23. This sequence is designed to permit efficient excavation and to develop such items as the MTL DBR, the power center, and the IDS, which are required as soon as possible after the start of the MTL construction. The sequence of development constructs test areas in a logical order in accordance with the ability of the subsurface infrastructure to support the various tests.

The spread of excavation and construction equipment gradually increases in number as space for additional units is developed. The shaft sinking spread develops the MTL. A one-cubic yard capacity LHD and a small electric-hydraulic jumbo are used for the drifting from ES-2 to ES-1. As electric power capacity and space permits, a larger electric-hydraulic jumbo and a 5-cubic yard capacity loader are used to complete the excavations of the MTL core area and the test alcoves. A service vehicle and self-propelled scissors lift truck for the mapping and utility installation crews are employed when space is available. When the exploratory drifts are being driven, three excavation equipment spreads are used, one in the core area and two in the exploratory drifts.

The contemplated equipment may be lowered in the ES-2 hoisting compartment, either in the man cage or slung on cables under the conveyance. The maximum component weight is less than the calculated hoist rope pull capacity.



EXISTING EXCAVATION

EXCAVATION IN PROGRESS

Figure 3-13. Drift and alcove sequence development.

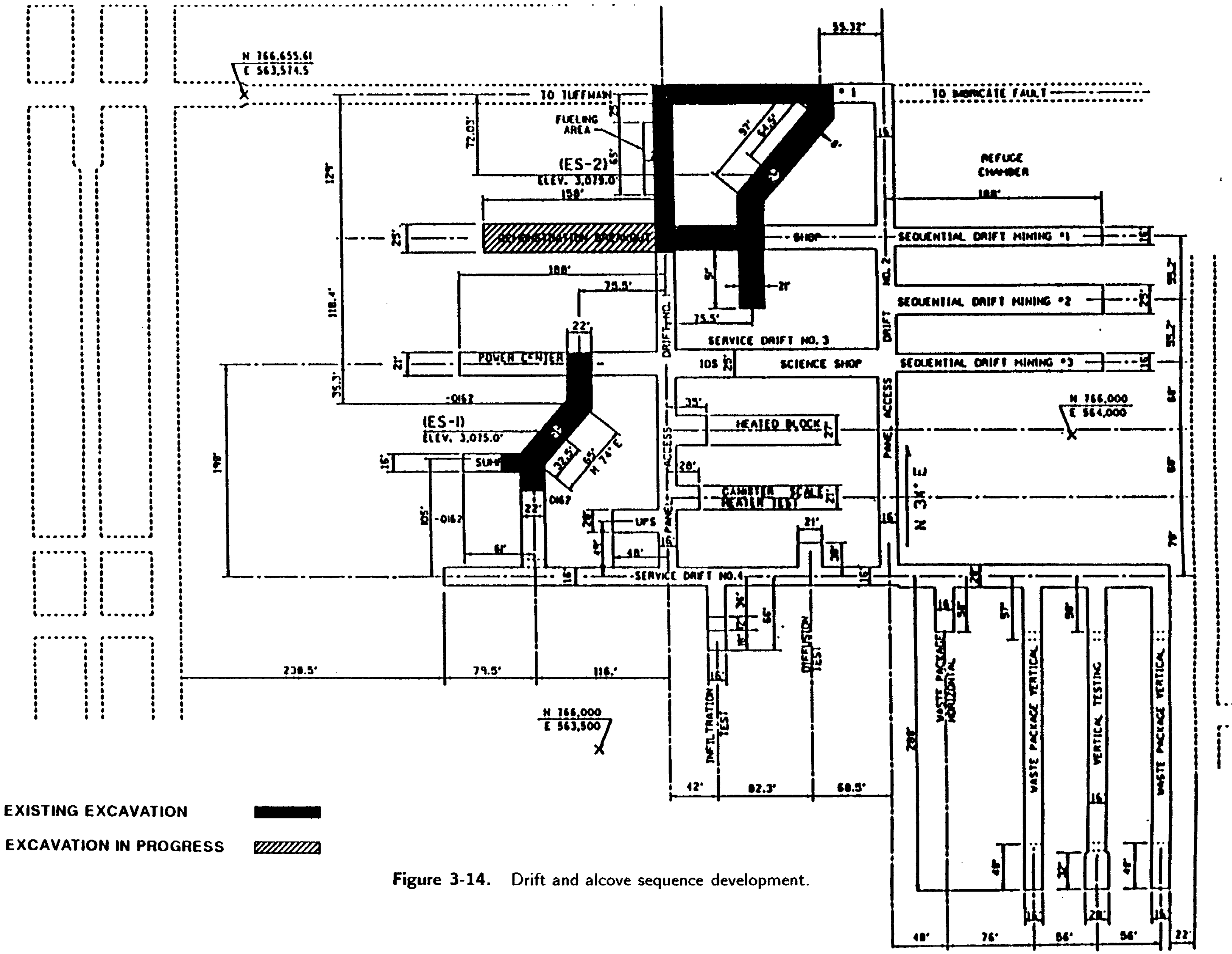
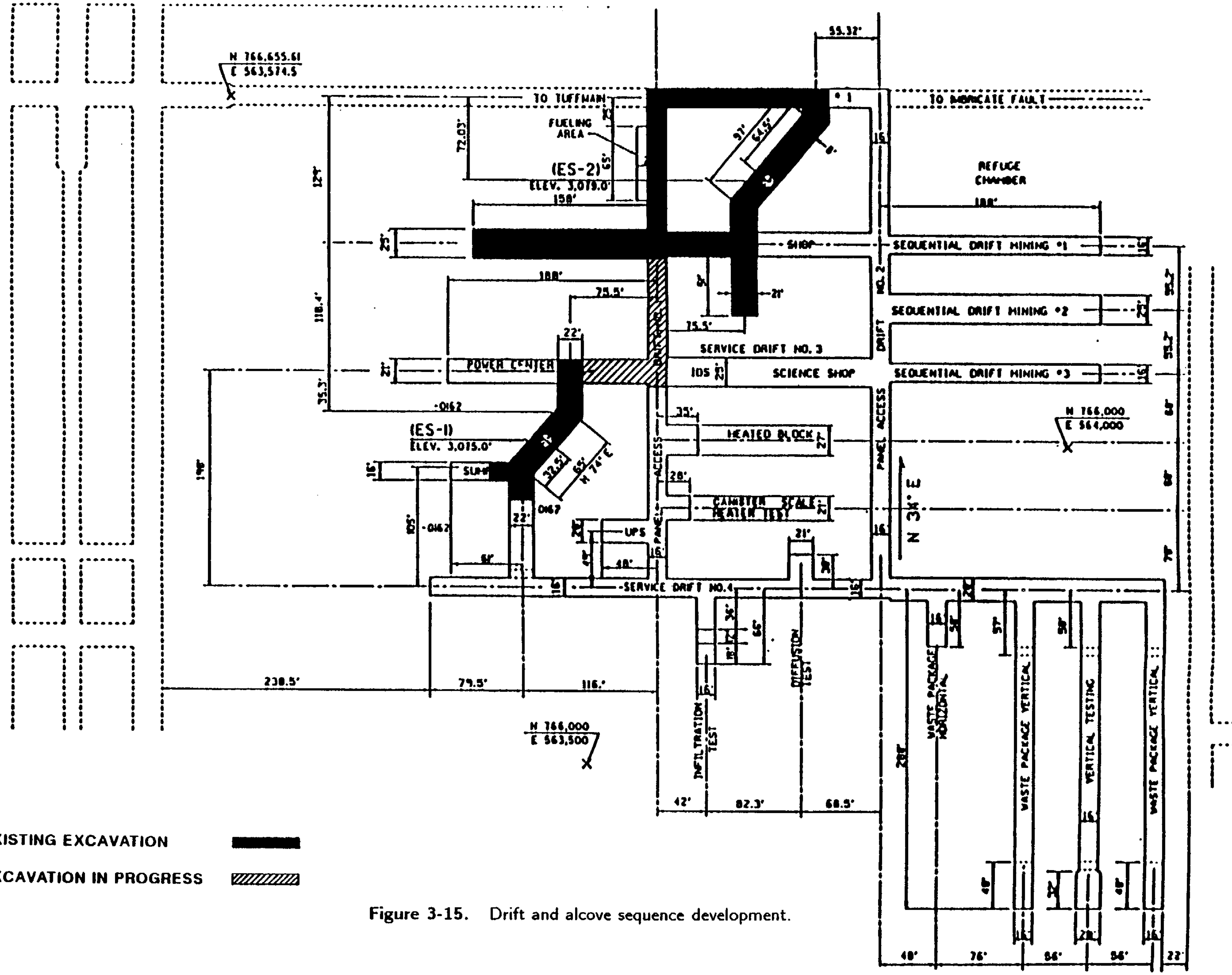


Figure 3-14. Drift and alcove sequence development.



EXISTING EXCAVATION

EXCAVATION IN PROGRESS

Figure 3-15. Drift and alcove sequence development.

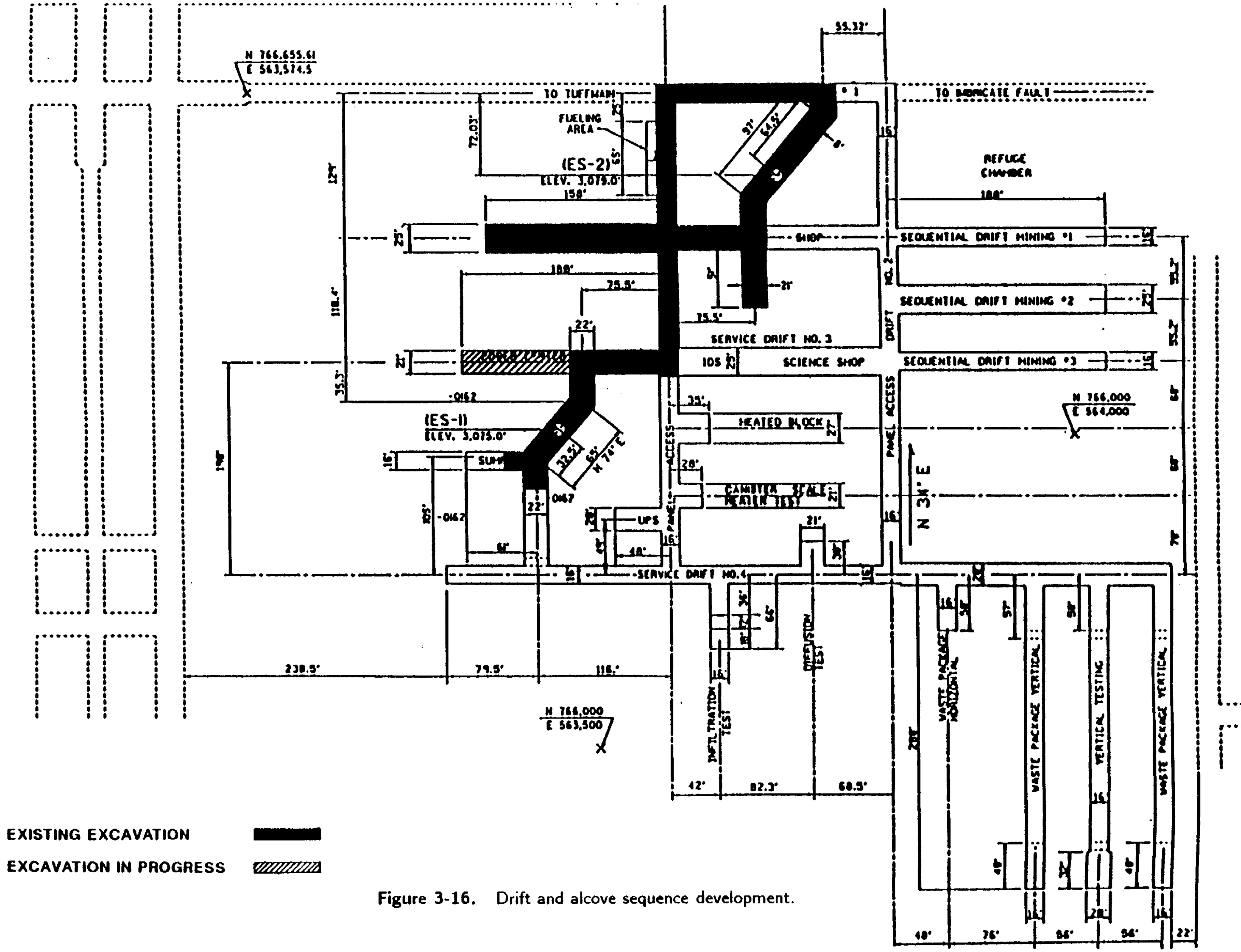


Figure 3-16. Drift and alcove sequence development.

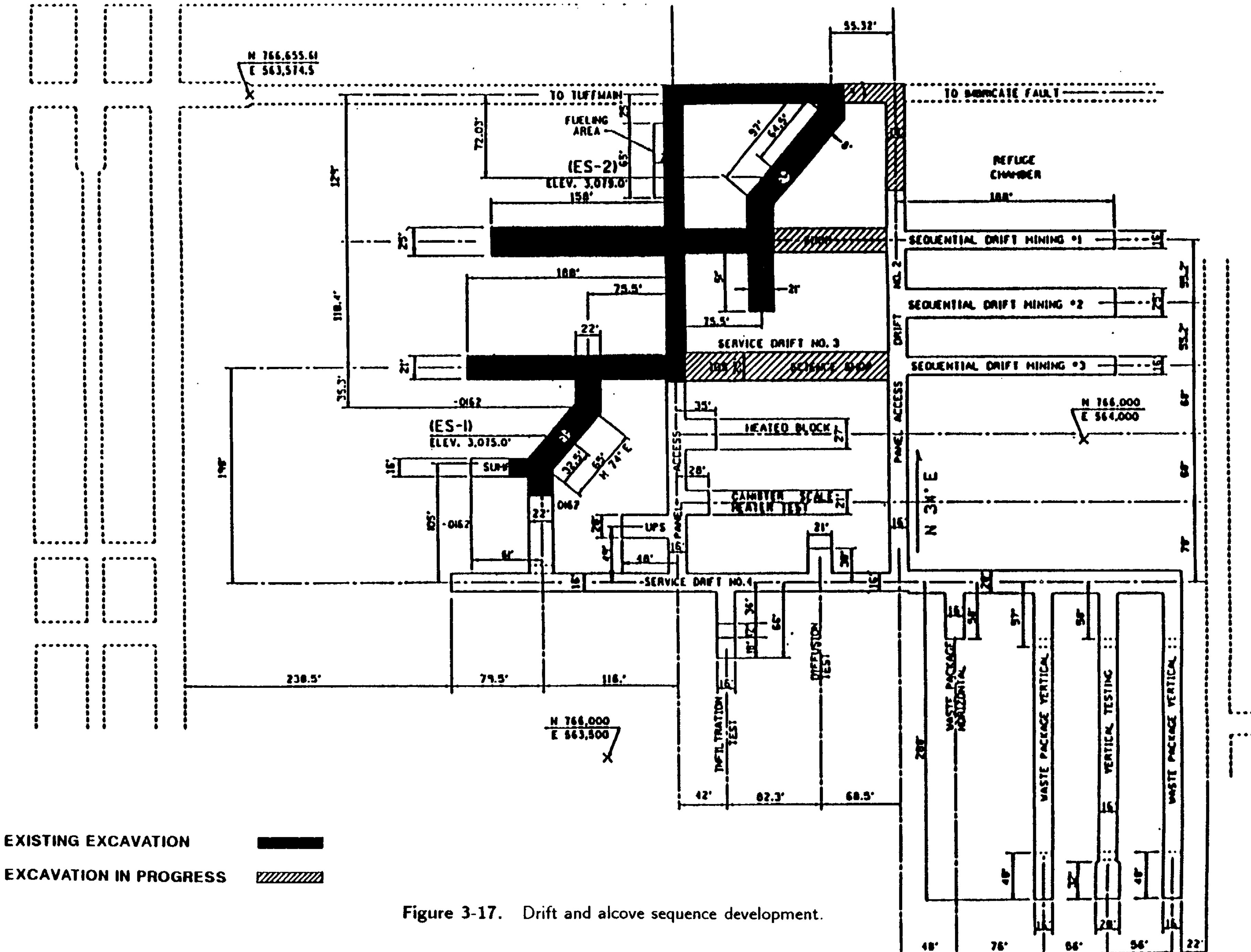


Figure 3-17. Drift and alcove sequence development.

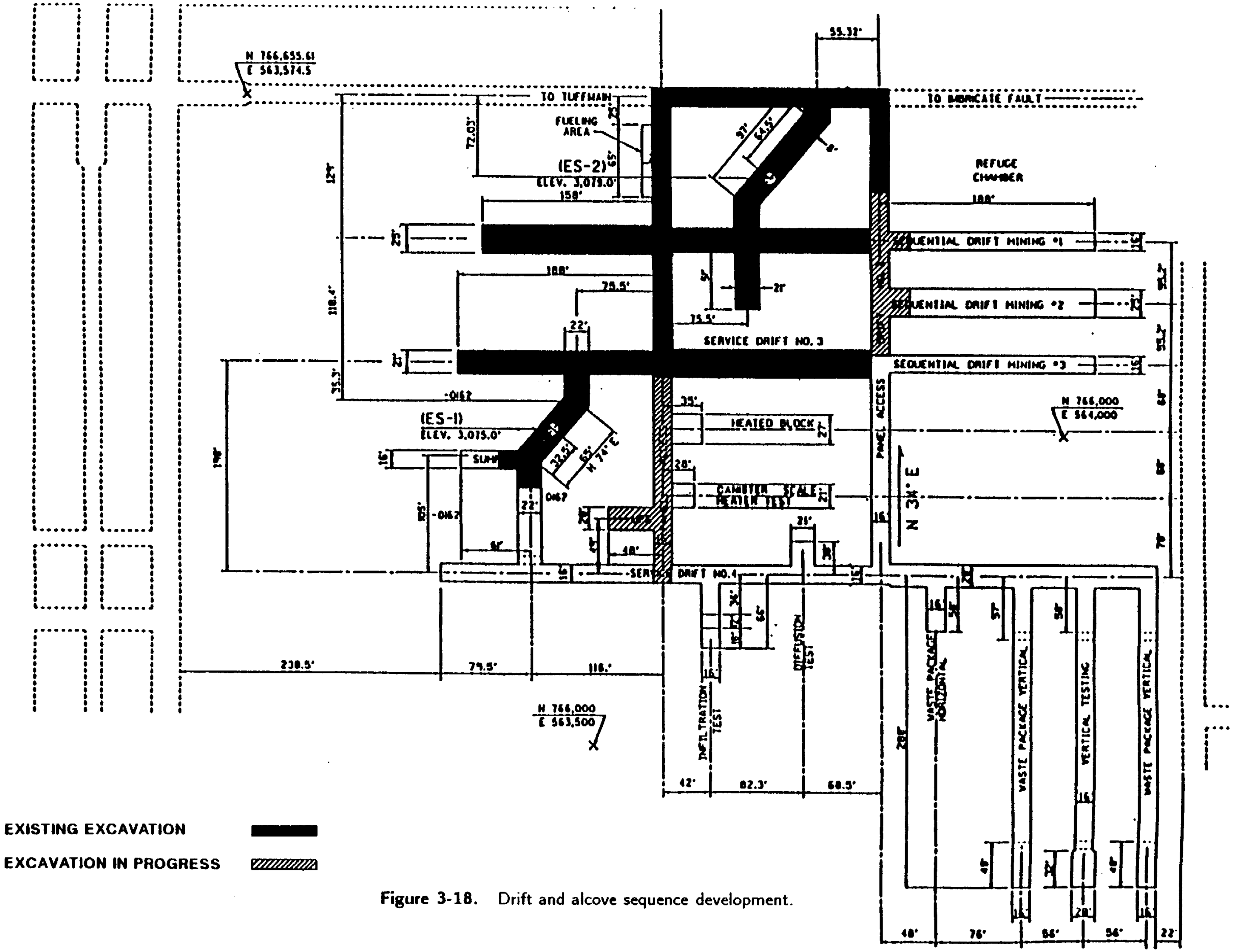


Figure 3-18. Drift and alcove sequence development.

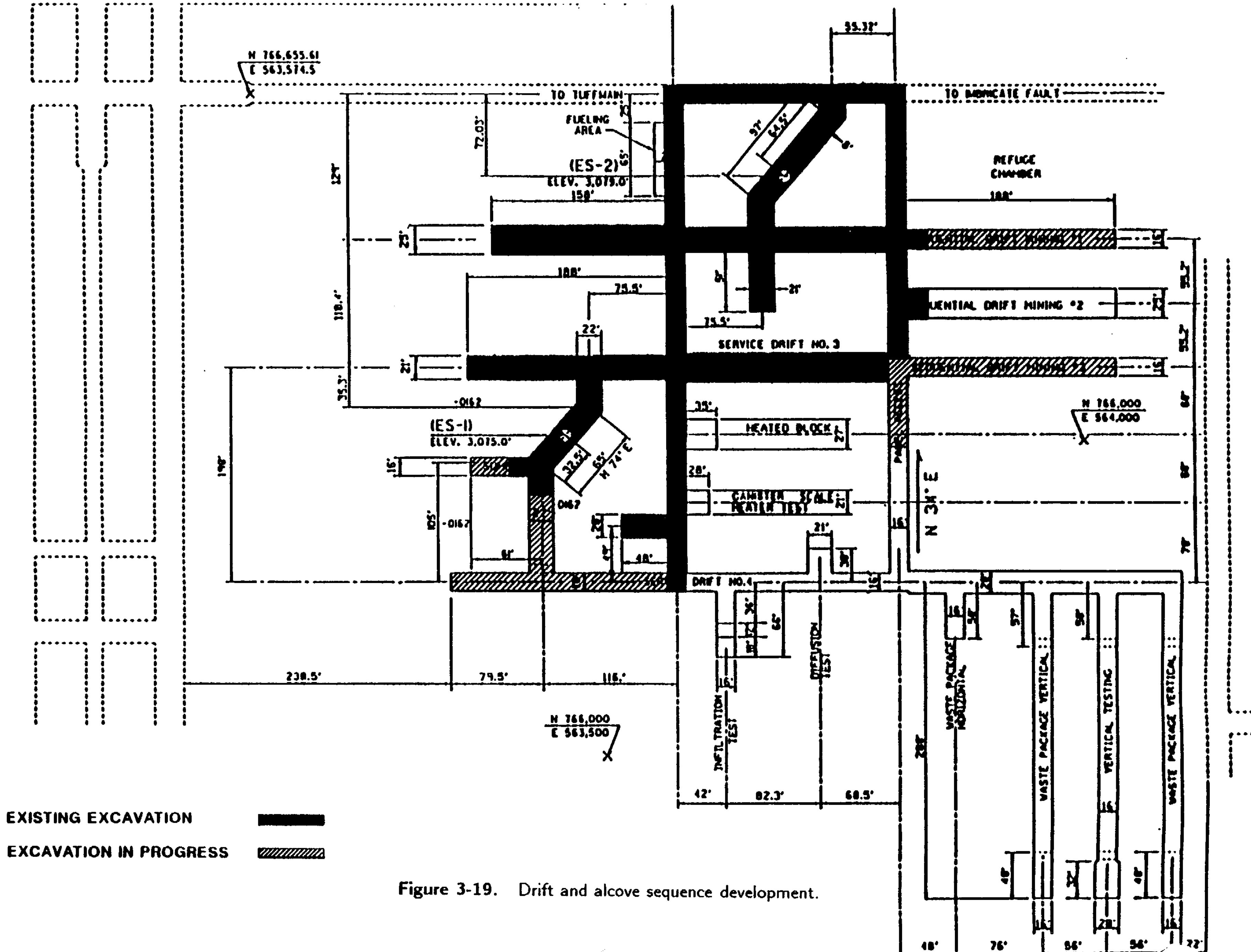


Figure 3-19. Drift and alcove sequence development.

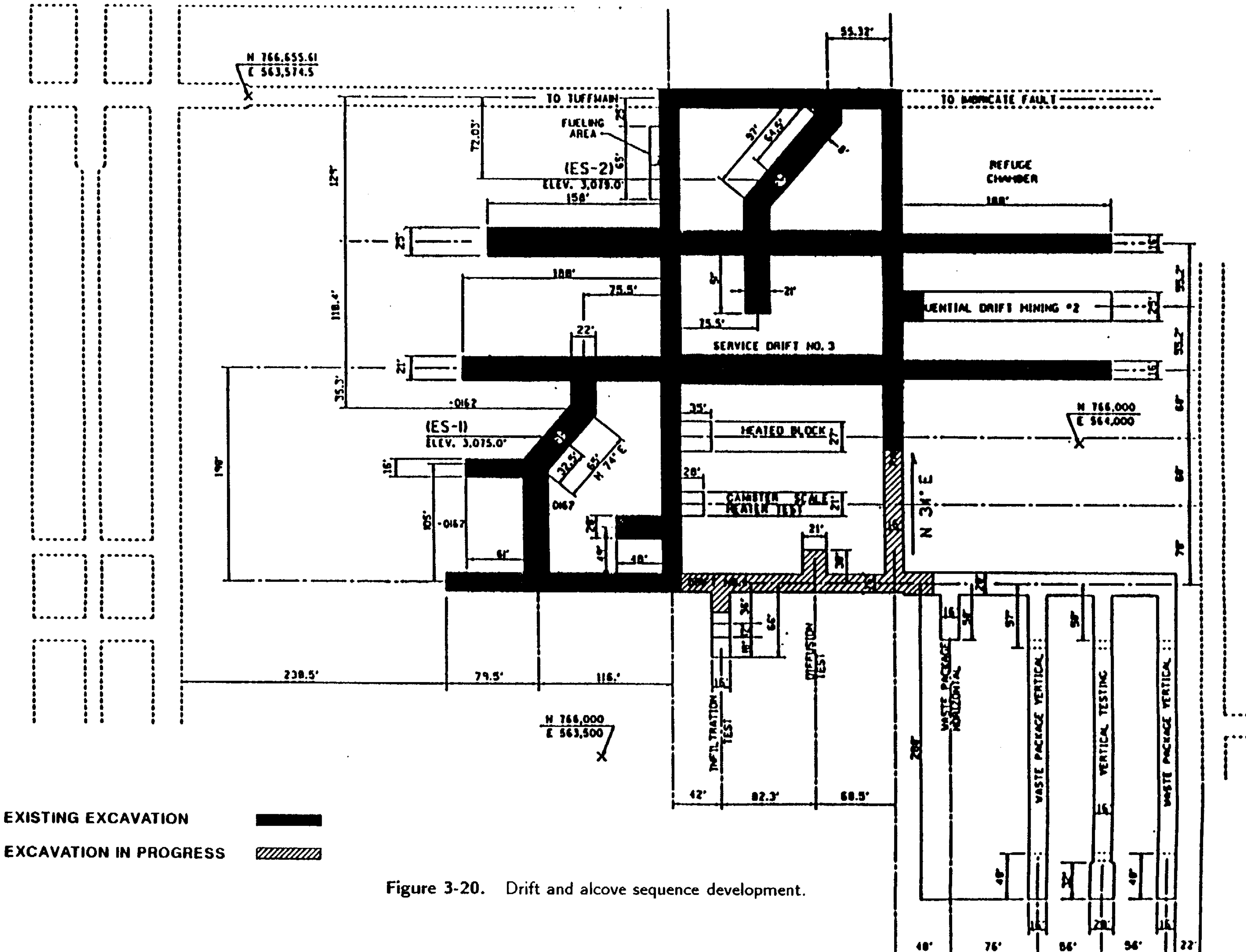
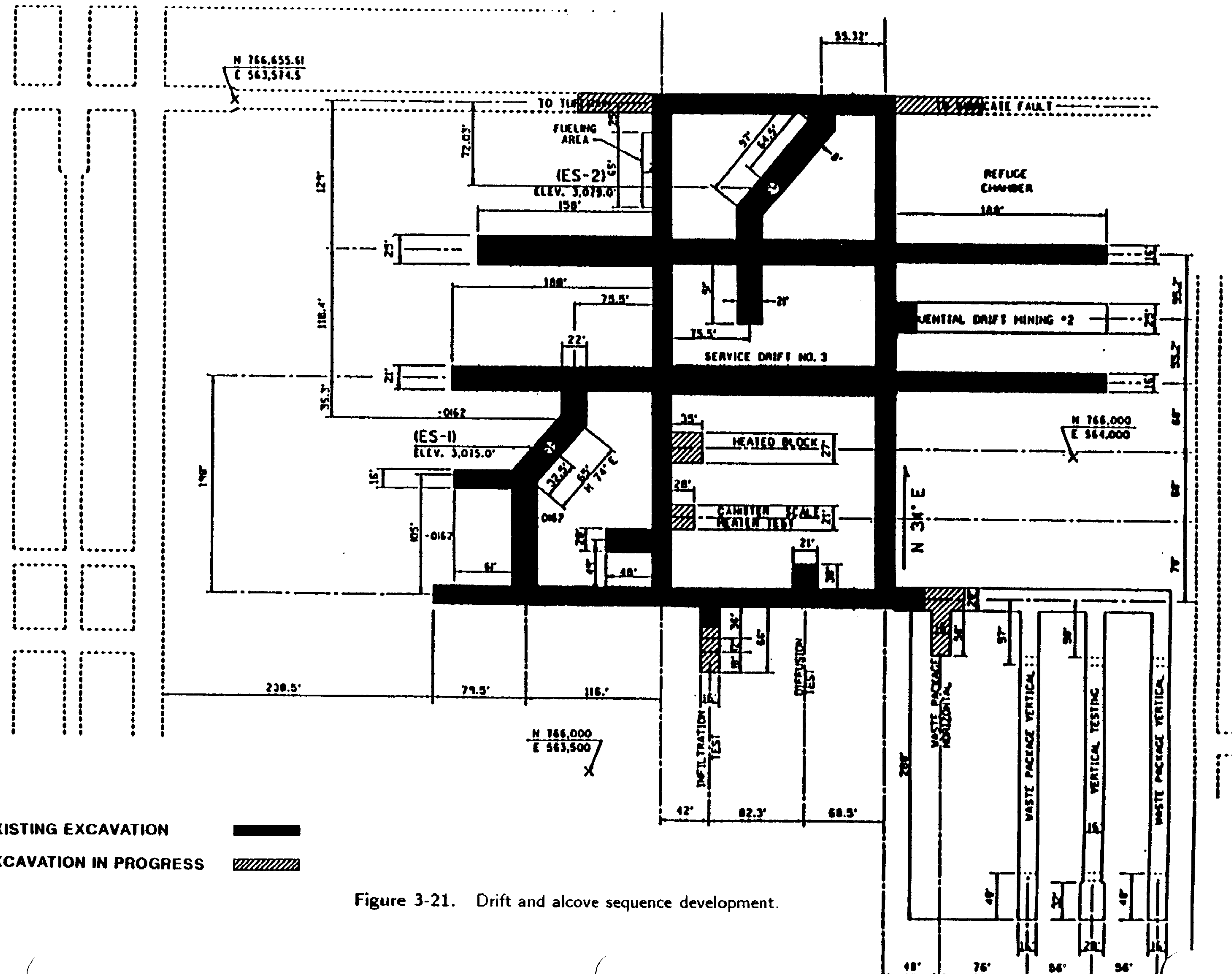


Figure 3-20. Drift and alcove sequence development.



EXISTING EXCAVATION

EXCAVATION IN PROGRESS

Figure 3-21. Drift and alcove sequence development.

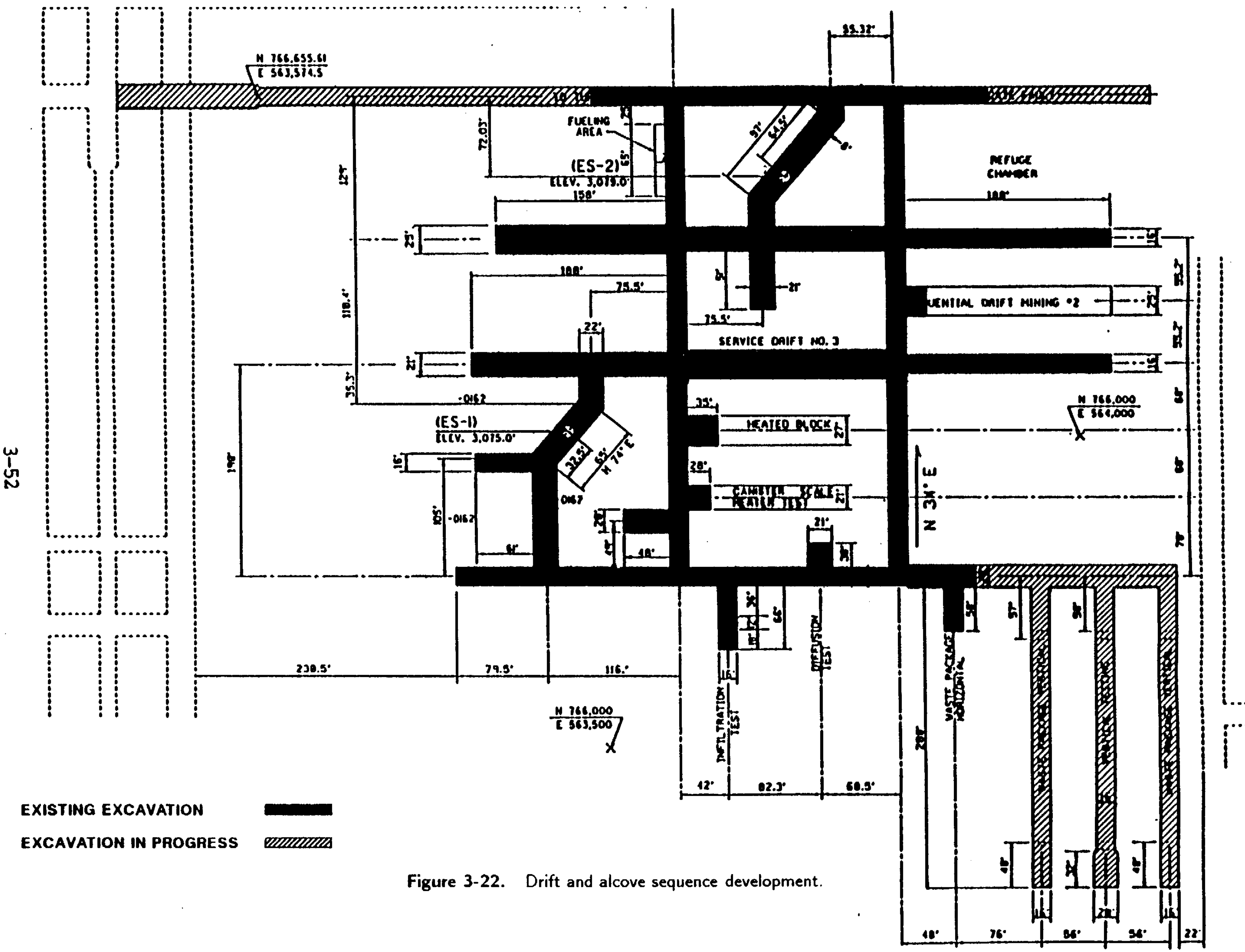


Figure 3-22. Drift and alcove sequence development.

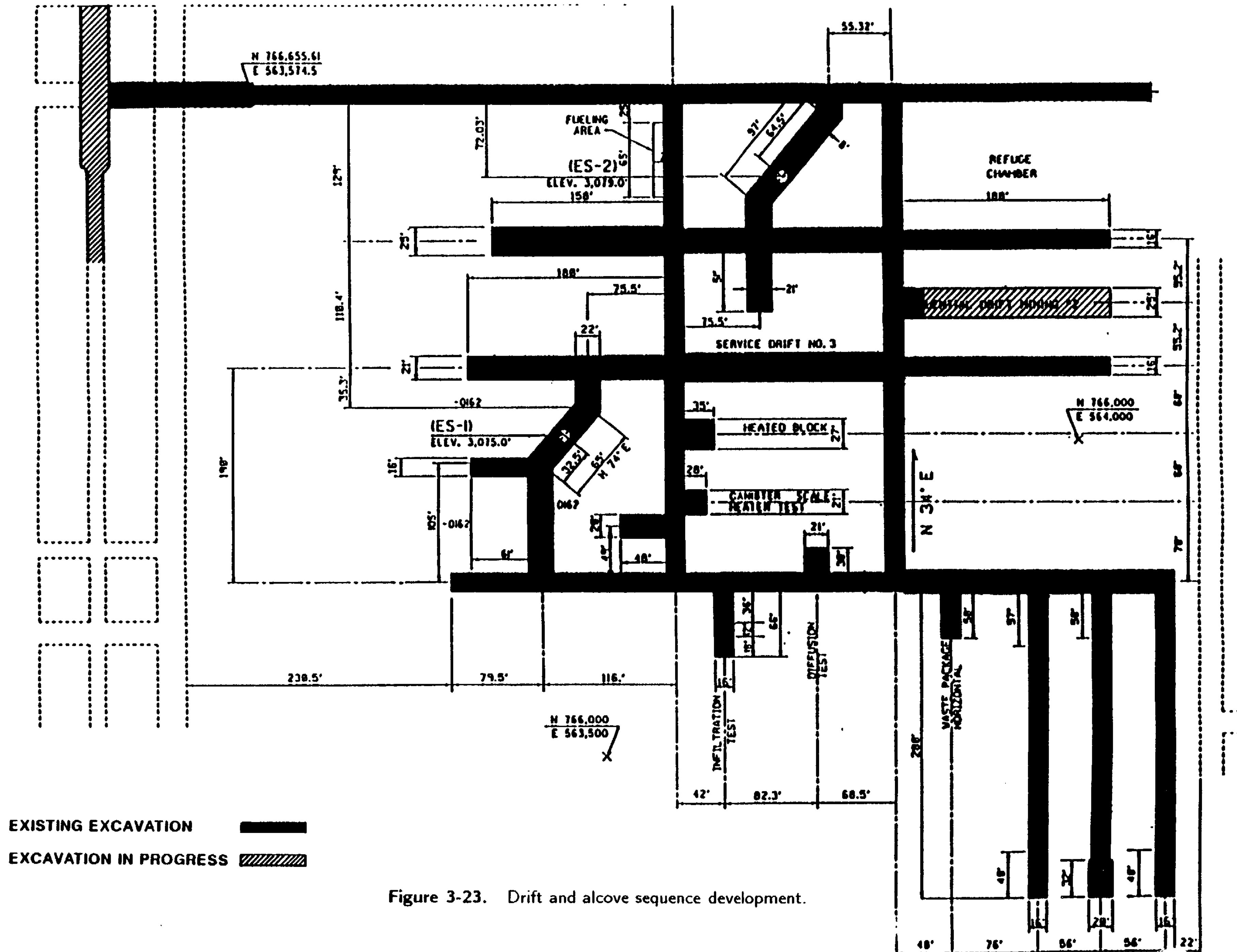


Figure 3-23. Drift and alcove sequence development.

During the initial MTL excavation, electrical power is supplied down ES-2 to a portable mine power center of 300-kVA capacity to service operations and testing until the permanent mine power center is constructed. Compressed air and water are supplied by a permanent pipe line and valves, which are usually carried to within 100 feet of the active heading. Waste water is handled by a portable steel tank and submersible pump arrangement feeding waste water to the ES-2 pump column. Once the permanent sump is established, the portable tank and pump unit may be used to pump waste water from the exploratory drifts to the permanent sump.

A typical excavation cycle in a 16-foot wide by 14-foot high cross section heading is as follows:

Drill 57 holes	-	235 minutes
Blast	-	128 minutes
Rock Removal	-	952 minutes
Ground Support & Utilities	-	192 minutes
Mapping	-	200 minutes
Total Cycle one round	=	1,707 minutes/60 minutes/hour
	=	28.45 hours/round

Testing is delayed until excavation and other construction activity is far enough advanced that interference does not occur. Wire mesh is not placed over unmapped drift sections unless there is a safety hazard. If necessary, temporary stulls and headboards or other support may be used. Test hole drilling starts in the various alcoves and test locations as soon as space and utilities are available and it is safe to do so.

Once the active excavation has advanced away from the IDS, power center and shop areas, permanent electrical and mechanical construction begins. The power center, IDS, DAS and UPS construction work is of the highest priority since a majority of tests cannot be started or safely operated until all IDS support is in place and functioning.

The hoisting capacity provides for personnel removal from the subsurface in one hour, and the ventilation system is designed on the basis of a subsurface maximum population of 87. During testing operations after all excavation and electrical and mechanical construction is completed, this subsurface population may decline; however, support systems are designed to support the maximum population, with a 35 percent uncertainty factor.

3.8 UNDERGROUND UTILITIES

3.8.1 POWER DISTRIBUTION SYSTEMS

The subsurface MTL electrical general arrangement consists of the mine power center; the various motor control centers for pumps and fans; and the associated power and lighting panels for overall MTL lighting and shop loads.

The 4,160-V, 480/277-V mine power center or unit substation is an integral, totally enclosed unit arranged as a double-ended or secondary selective substation. This arrangement consists of redundant 5-kV primary switch gear and cabling feeding two 4,160-V, 480/277-V, 1,500-kVA dry-type transformers that supply the 480-V secondary circuit breakers.

Both the 5-kV primary switchgear and 480-V circuit breaker installation utilize a tie switch and a tie breaker for the purpose of increasing the overall power reliability to the 480-V system. One power cable run from the surface supply down each shaft feeds each transformer in the mine power center. The cable is a special armored 350-MCM, 5-kV cable designed for vertical suspension. This type of mine power arrangement allows for electrical system reliability in case of failure to one section of the unit substation.

FS-GA-0201 shows the power center one-line schematic layout. FS-GA-0204 and FS-GA-0206 shows the mine power center MTL location and physical equipment layout.

The 480-V electrical equipment includes the motor control centers and starters for controlling ventilation fans, waste water pumps and exploratory drilling equipment, and a dedicated feeder supplying the UPS for critical loads. Also included are the power panels for supplying shop and miscellaneous loads, and the lighting panels for supplying MTL area lighting (FS-GA-0201, FS-GA-0202, FS-GA-0204, and FS-GA-0207).

The mine power center is fully backed up by the surface standby generators; therefore, if utility power is lost, all 480-V subsurface loads can be supplied through the power center from the generators. This in turn is backed up by the UPS system feeding all subsurface critical loads.

FS-GA-0201 designates the protective relaying system for the distribution system, including overcurrent, ground-fault, undervoltage protection and ground-check capability. The UPS power system is used for the data test equipment, communication, life safety, and computers that cannot tolerate a power outage.

3.8.2 COMMUNICATIONS SYSTEM

The subsurface communications system consists of the telephone system, mine plant intercom, public address, experimenters intercom and closed-circuit television (CCTV).

The telephone system provides access to the FTS, the DOE/NV system and long distance networks. The system provides voice communications from the subsurface facilities to surface locations, Area 25, Mercury, and Las Vegas, and access to long distance.

The mine plant intercom system and the experimenters intercom system provide paging capability from a conventional telephone. The paging phone system permits personnel and station areas to be paged.

This system allows: (1) selective paging capability to any single, specific underground station; (2) a dial-access, all-station paging capability to call personnel not at their normal location or to alert all underground personnel; and (3) automatic switching to a pushbutton operated page partyline mode in the event of a telephone equipment power failure or severance of the cable interconnecting the standard telephone equipment through the interface unit. The mine plant intercom stations are equipped with speaker phone jacks to allow a hands-free operation or with headsets to use in high noise area. The mine plant intercom system provides multi-channel capability. When connected to the conventional telephone system through a 12-V to 48-V circuit provided for each line, this system provides any underground mine plant intercom station with the ability to call another underground mine plant intercom station directly, call any standard telephone at surface locations, or receive calls from any surface standard telephone.

The locations of the mine plant intercom/experimenters' intercom phones are at each working level underground. There are 67 intercom subsurface locations. When the experiments/tests are performed during shaft or drift construction, a multi-channel intercom system provides separate and simultaneous communications for both the mining operation and the scientific personnel.

The CCTV system allows the hoist operators to view their respective shaft collar and other critical underground locations. This system allows visual surveillance of personnel to ensure safe operations by the hoist operator.

3.8.2.1 Life Safety Monitoring and Alarm System

The life safety monitoring and alarm system allows for the subsurface monitoring of the noxious and toxic gases. Gases monitored are carbon monoxide, carbon dioxide, nitric oxide, nitrous oxide, hydrogen sulfide, sulfur dioxide, and oxygen. Sensor-transmitters are located throughout the drifts and in both shaft collars, and connected to the signal gathering and processing stations. Multiplexed signals from the stations are sent to the computer in the central control room (CCR) for monitoring and alarm.

The setpoint limits for alarm are set at the sensor-transmitters in such a way as not to exceed the Threshold Limit Value (TLV) defined by the American Conference of Governmental Industrial Hygienists (ACGIH). The design includes the system of sensor-transmitters, cabling system and interface at the field data stations.

3.8.2.2 Environmental Monitoring and Alarm System

Environmental monitoring consists of monitoring of temperature, relative humidity and barometric pressure. Temperature and humidity are monitored on the surface, in exhaust ducts of both shafts at the collar level, in both shaft stations at the MTL, at the primary booster fans, in the UDBR, at the skip loader station in ES-2 and at five different locations throughout the MTL drifts. Barometric pressure is monitored on the surface in the intake air flow at ES-2 and in shaft stations at the MTL. Air velocity (and mass air flow as a derivative) is monitored in the intake air of both shaft stations at the MTL, and in the exhaust duct at the collar level at both shafts.

The environmental parameters are monitored continuously by respective sensor-transmitters connected to the data gathering multiplexer stations and to the computer in the CCR. A host of other environmental conditions such as dust pollution, noise level, presence of radon daughters in air, and gamma radiation background are monitored periodically by portable hand-held sensors and meters in different locations throughout the shafts and mine (FS-GA-0222).

3.8.2.3 Conduit and Cable Tray Arrangement

In all subsurface areas used for environmental air handling, the power, control and communication cables are placed in metal cable trays with solid bottom and solid covers to comply with NFPA-70, NEC Art. 300-22(c).

All branch connections to local devices are made of solid or flexible metal conduit. Power, control and lighting cable trays and IDS instrumentation cable trays run on the opposite sides of the tunnels and drifts. The crossovers between cable trays are made as close to right angles as possible. The cable tray supports are made as trapeze type hangers attached to the roof or as wall brackets. A minimum distance of 11 feet between the bottom of the tray and the drift floor is provided (FS-GA-0207).

3.8.3 LIGHTING SYSTEM

The general subsurface mine lighting system consists of incandescent, fluorescent and emergency lighting. Incandescent fixtures are primarily utilized in the main access drift area, shaft stations, test and equipment alcoves as necessary. The incandescent illumination level for the drift areas is a minimum of 3.0 fc on a plane 30 inches above the floor level. The lamp fixtures are a simple pigtail socket arrangement stagger mounted on either side of the drift or alcove. The lamp itself is rated 120 V, 150 watt frosted to allow for good color rendition, good light control for zoned lighting, instant start capability, and low noise emission for shop and test alcoves as necessary.

Fluorescent lighting is utilized in the test areas, shop areas, power center and refuge chamber in the various MTL locations. The fluorescent illumination level for the areas mentioned above is 50 fc on a plane 30 inches above the floor level, using 90-watt preheat fixtures. The fixtures are direct diffusion, pendant type with 4 lamps per fixture, primarily hung from the ceiling on each side of the vent duct system. They have high efficiency, high power factor ballasts and low electrical noise emission capability.

The emergency lighting system for the subsurface layout is located in each shop area, testing area, power center, shaft station and access drift as necessary. The fixture consists of two poly-carbonate lamp heads of 30 watts each in a noncorrosive molded thermoplastic enclosure. Input voltage rating is 120 VAC with a back-up 12 VDC 90-minute rate battery (FS-GA-0201, FS-GA-0202, FS-GA-0204, FS-GA-0205, and FS-ST-0047).

3.8.4 VENTILATION SYSTEM

3.8.4.1 Airflow and Distribution

The ventilation system supplies and exhausts adequate air quantities of acceptable quality to and from the underground working areas to ensure personnel safety and health.

The system is designed, constructed and maintained in accordance with applicable federal, state and local regulations. The primary ventilation system is designed using ES-1 and ES-2 as both intake and exhaust air shafts. To accomplish this, each shaft has a structurally reinforced metal duct used as a separate exhaust airway, as shown in Figure 3-24.

Primary exhaust fans installed on the surface and underground are shown in Figure 3-25, a diagram of the ESF Ventilation Schematic, which pulls the fresh air supply down the shafts and into the various areas of the MTL.

Exhaust air returns to the surface through the metal ducts. Air flow rates are controlled so that air quantities are distributed to satisfy the following design criteria: (1) shaft and drift air velocities shall not exceed 2,000 fpm and 1,500 fpm respectively; (2) a minimum of 60 fpm air velocity shall be maintained in any active airway, to avoid air stagnation or toxic gas accumulation; (3) areas with operating diesel equipment are ventilated with at least 100 cubic feet per minute per brake horsepower; and (4) personnel working underground shall be provided with at least 200 cubic feet of air per minute per person.

The airflow available for the ESF ventilation is about 220,000 cfm to 234,000 cfm at the shaft collar. After allowing for leakages, the effective air quantities are distributed to the following areas: (1) MTL-60,000 to 65,000 cfm; (2) imbricate drive-45,000 to 50,000 cfm; (3) Ghost Dance and Drill Hole Wash drives-57,000 to 66,000 cfm; and (4) equipment maintenance shop-19,000 to 20,000 cfm for a total of 181,000 to 201,000 cfm.

FS-GA-0225 shows the details of the ESF subsurface airflow distribution in various shops and test areas, along with the location of primary and auxiliary fans. The available air quantity of 45,000 to 50,000 cfm during development of a typical exploratory drift supports the operation of diesel equipment, up to a total of 400 brake horsepower.

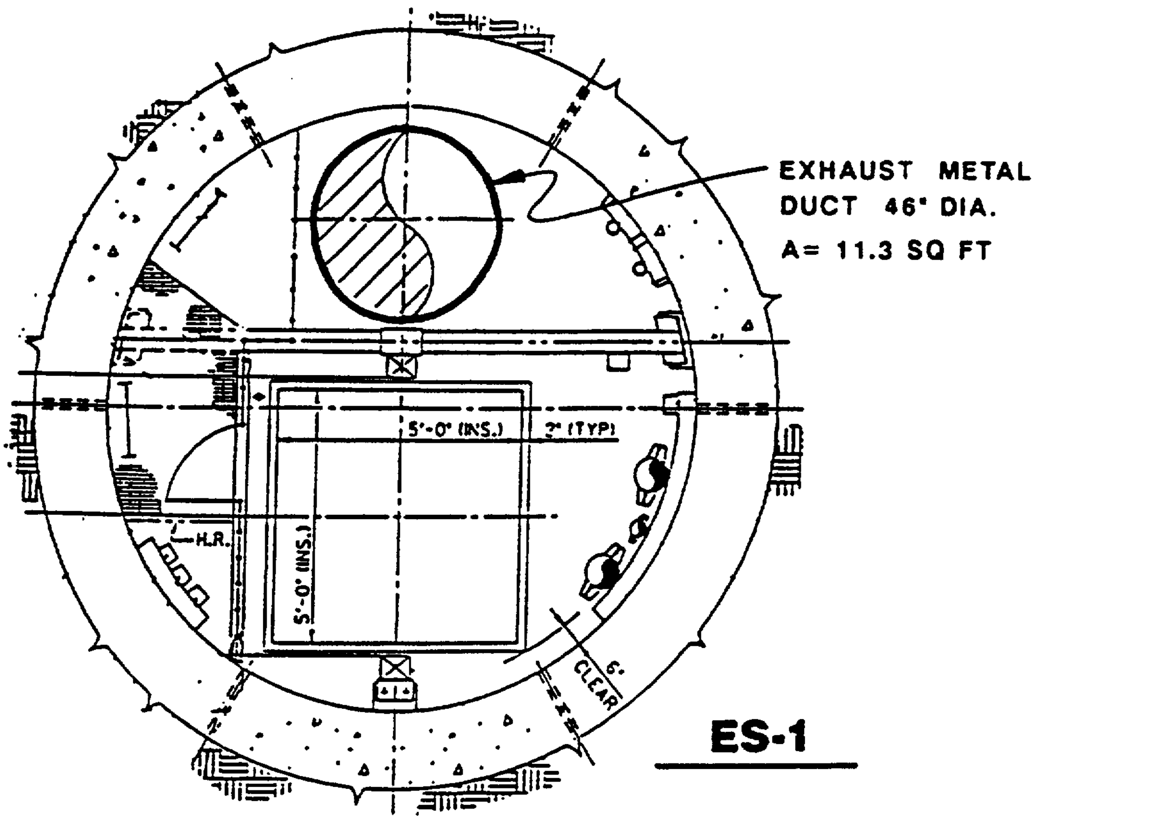
3.8.4.2 Primary and Auxiliary Fans

Primary exhaust fans installed on the surface and as underground boosters operate at pressures ranging from 9.6 to 11.5 inches of water gauge. Fan power ranges from 200 to 350 BHP. Primary and auxiliary fans are provided with attenuators to limit the sound pressure level which is not to exceed 85 dBA, the 8-hour exposure TLV required by the ACGIH.

Active drifts away from the primary airways are ventilated by appropriate auxiliary fans and ducting to satisfy the required airflow in the drifts. FS-GA-0228 shows the mine ventilation of the MTL and the location of fans and ducting. Table 3-1 lists the sizes and performance specifications of all primary and auxiliary fans for the ESF final operating mode.

3.8.4.3 Dust Control

Airborne dust from roadways, rock transfer points, drilling, bolting and after-blasting is controlled to concentrations below the threshold limit values. Dust suppressants consisting of water and biodegradable/nontoxic chemical additive is applied regularly to subsurface roadways.



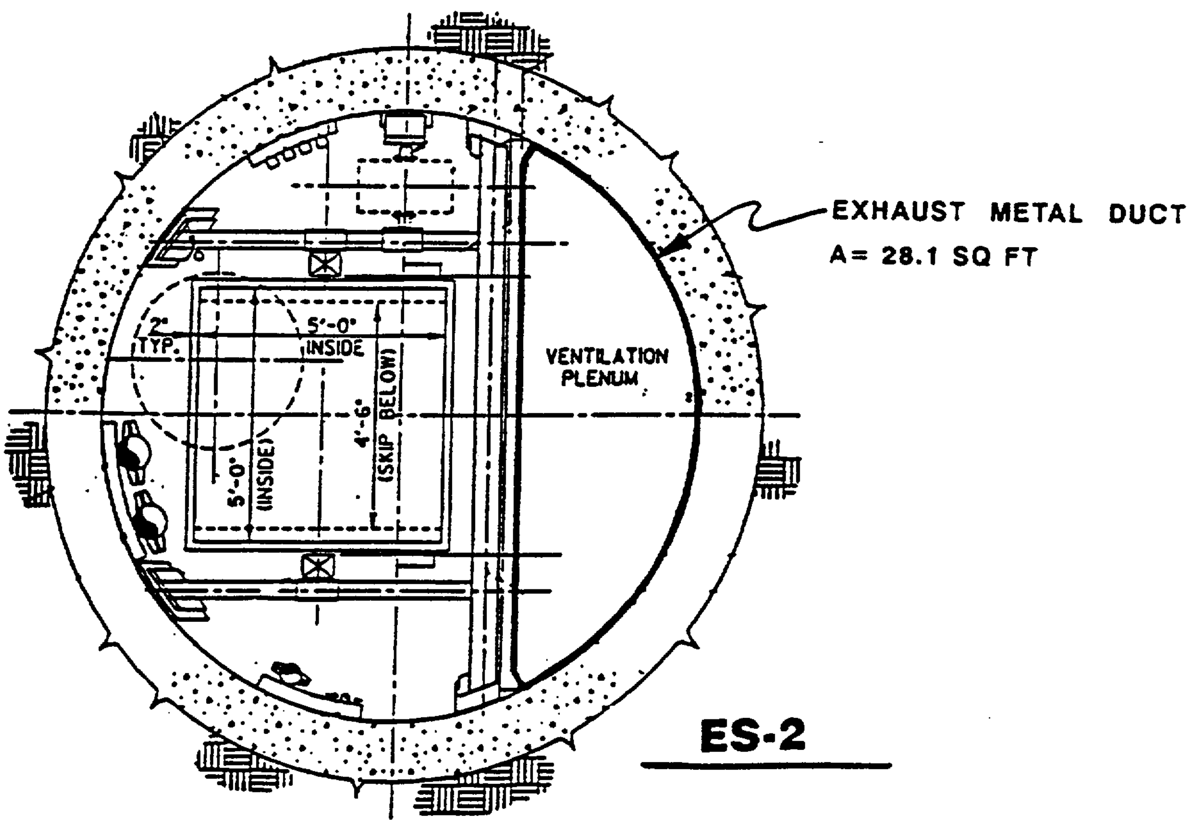


Figure 3-24. Shaft area.

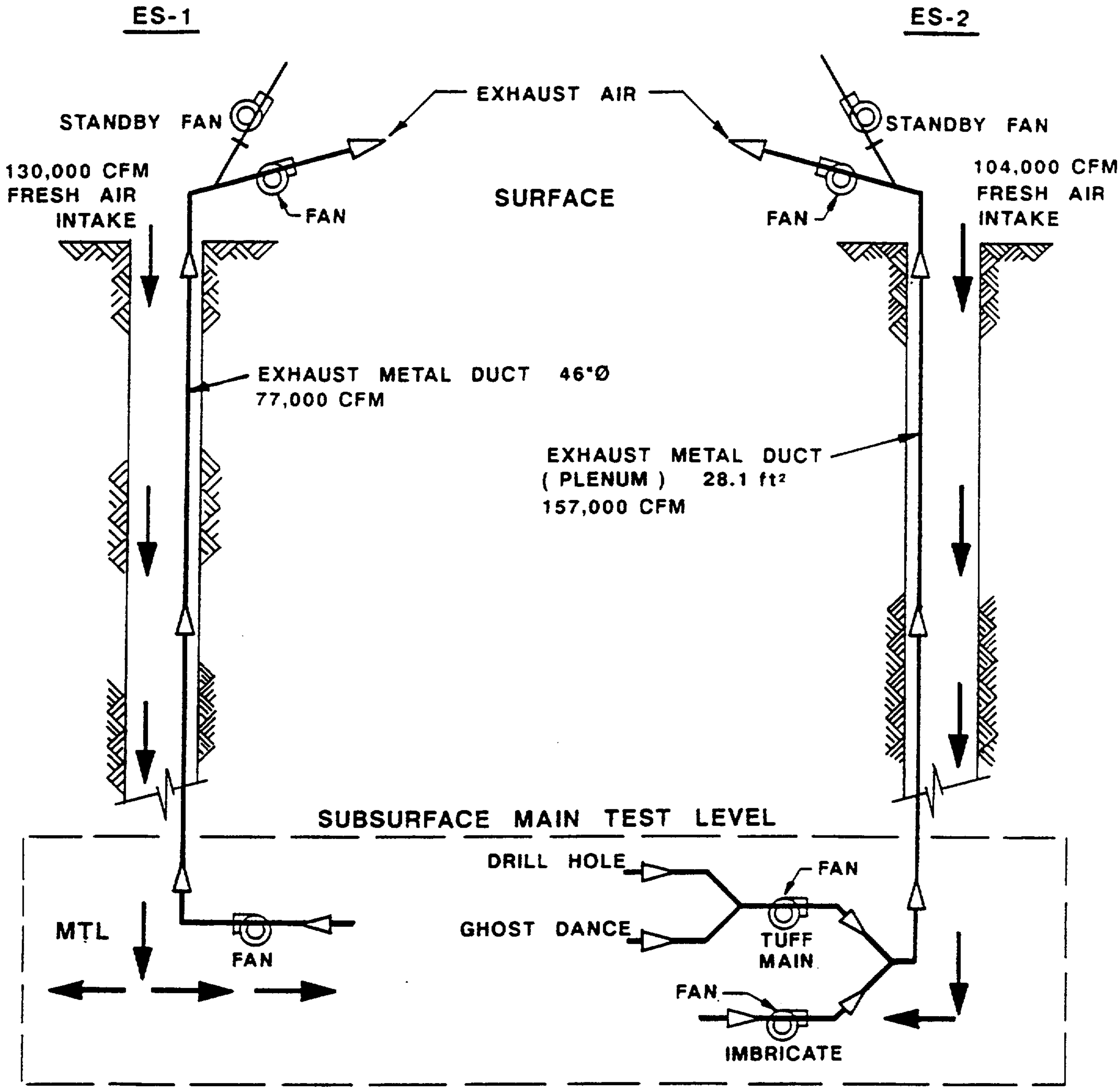


Figure 3-25. ESF ventilation schematic.

Table 3-1. Fan size and performance specifications

Location	Duct Size Inch	Required Cfm	Total Pressure	Fan Size	Motor BHP
PRIMARY FANS					
ES-1 Surface		82400.00	11.00	48-30-1770	@200 BHP
ES-2 Surface		162000.00	9.80	60-36-1770	@350 BHP
ES-1 Underground Booster		82400.00	11.00	48-30-1770	@200 BHP
ES-2 Underground Booster #1		82400.00	11.00	48-30-1770	@200 BHP
ES-2 Underground Booster #2		82400.00	11.00	48-30-1770	@200 BHP
AUXILIARY FANS					
UDBR	36.00	28000.00	1.50	32-17-1770	@15 BHP
ES-1 Tail Shaft	30.00	28000.00	1.50	32-17-1770	@15 BHP
ES-2 Tail Shaft	30.00	28000.00	1.50	32-17-1770	@15 BHP
ES-1 Pumps & Test DRIFT	42.00	28000.00	1.50	32-17-1770	@15 BHP
Power Center	30.00	28000.00	1.50	32-17-1770	@15 BHP
Demonstration Breakout	42.00	28000.00	1.50	32-17-1770	@15 BHP
Sequential Drift 1	30.00	28000.00	1.50	32-17-1770	@15 BHP
Sequential Drift 2	42.00	28000.00	1.50	32-17-1770	@15 BHP
Sequential Drift 3	30.00	28000.00	1.50	32-17-1770	@15 BHP
IDS & Science Shop	30.00	28000.00	1.50	32-17-1770	@15 BHP
Vertical Testing	30.00	28000.00	1.50	32-17-1770	@15 BHP
Waste Package (Vertical) 3	30.00	28000.00	1.50	32-17-1770	@15 BHP
Waste Package (Vertical) 1	42.00	45000.00	5.00	42-26-1770HB	@50 BHP
Infiltration/UPS/ Heaters	42.00	45000.00	5.00	42-26-1770HB	@50 BHP
UPS Backup	30.00	18000.00	0.90	32-17-1170	@5 BHP
Diffusion Test	30.00	18000.00	0.90	32-17-1170	@5 BHP
Waste Package Horiz.)	30.00	18000.00	0.90	32-17-1170	@5 BHP
Refuge Chamber	36.00	18000.00	0.90	32-17-1170	@5 BHP
Imbricate	42.00	45000.00	10.00	42-26-1770	@100 BHP
Drill Hole Wash	42.00	45000.00	10.00	42-26-1770	@100 BHP
Ghost Dance	42.00	45000.00	10.00	42-26-1770	@100 BHP

A 500-gallon mobile tank with a spray applicator is used for the application of dust suppressants to the roadways. Water is used to suppress dust during blasthole drilling, rock bolting, rock excavation and after-blasting. Where the use of water or other wetting agents is not feasible or is limited, a mobile dust collector is provided.

Permanent rock transfer points such as loading/unloading pockets and dump stations are provided with enclosures and water sprays for dust control. Where the use of water or other wetting agents is not feasible or is limited, a stationary dust collector is installed.

A typical dust collector unit consists of a series of cyclones and fabric filters. This combination effectively removes airborne dust at an efficiency of 99 percent of particles greater than three microns and 96 percent of particles down to one micron. A mobile dust collector follows the mining activity. The unit has an extendible inlet hood with high volume suction capacity of 10,000 to 16,000 cfm. Dust control is applied as near as possible to every dust source.

3.8.4.4 Heating and Cooling

The subsurface environmental temperature is maintained to generate a minimum air cooling power (ACP) of 260 watts per square meter. This ACP is attained without using mechanical air cooling or refrigeration, since the virgin rock temperature of the MTL is below 80°F.

During extended periods of cold weather, portable shaft air heaters for both ES-1 and ES-2 can be installed at the collar areas to increase the ventilating intake air temperature. The heaters prevent freezing of utility lines and possible accumulation of ice in the upper shaft.

3.8.4.5 Control and Monitoring

The ventilation system has an operational control and monitoring network that continually indicates the primary fan operating status. The system also includes switches for forward and reverse airflow and sensors for fan-bearing temperature and vibration monitoring. Airflow quality and quantity are monitored separately and are discussed in Section 3.8.11, Monitoring and Warning System.

3.8.4.6 Temporary Ventilation During Early Development

FS-GA-0227 shows Phase 1 and Phase 2 ventilation during the early ESF development. Phase 1 is the temporary ventilation before the shafts are connected and supplies about 56,000 to 101,000 cfm of air to support two or three development/test areas. Phase 2 starts after ES-1 and ES-2 are connected, and requires about 156,000 cfm of air. The ES-2 plenum with a surface exhaust fan is the primary return airway during Phase 1 development and test activities. The exhaust dust system in both shafts supports ventilation for Phase 2.

3.8.4.7 Preliminary Acceptance Test

Primary fans designed and procured for the ESF project pass a preliminary acceptance test at the manufacturer's test location.

Fans are not shipped to the ESF site until performance requirements for design air volumes, pressures and horsepower have been satisfactorily met. Actual performance tests are conducted after each primary fan is placed in operation.

3.8.5 WATER DISTRIBUTION SYSTEM

The mine water supply system originates at the supply source connections at the shaft collar area and distributes water throughout the ESF for construction, testing, and operation. Since operational requirements include fire protection demands, a single piping system provides both mine supply water and fire protection water. The mine water distribution system is not suitable for drinking purposes (non-potable). To provide reliable water distribution and system safety, a distribution loop is utilized, and supply pressure is regulated at the station levels to 80 psig, ensuring user protection.

The mine water system line sizes are developed based upon a design velocity of 4 fps to 10 fps. The flow rates and corresponding line sizes are shown on FS-GA-0230. The mine water distribution system includes a 35 percent uncertainty allowance to account for possible increases in mining activity. A metering and monitoring system for mine water distribution is provided. For system reliability, automatic, excess flow (line break) valves are utilized at strategic locations in the piping system to limit the amount of water being introduced into the ground structure, since this uncontrolled loss of water could have an adverse affect on site characterization testing. The mine water distribution system includes 2-inch utility hose connections spaced at 100-foot intervals so hoses reach all areas. The drift piping and hose connections are installed during the construction phase as the various drifts are driven.

3.8.6 MINE WASTE WATER COLLECTION SYSTEM

The mine waste water system collects mine waste water used in the ESF for construction, testing, and operation, then transfers the combined inflow from all sources to a surface disposal system. The possible sources of mine waste water include water used in construction and testing (such as drilling, washing, dust suppression, mine supply water inflow due to pipe line breakage, fire protection system runoff, and naturally occurring ground water). Water from sources containing petroleum products passes through a skimmer prior to entering the mine waste water collection system. The petroleum products are collected and transferred offsite for disposal. These sources use different methods of transfer to an MTL sump, located near ES-1 (FS-GA-0160), where all waste water is collected for transfer to the surface. Where possible, such as in the case of shaft liner water rings, mine waste water flows by gravity to the MTL sump. Drill water from exploratory drift construction is collected with diaphragm pumps and skid mounted tanks. The tanks contain submersible pumps that transfer the mine water to the MTL sump. Each shaft bottom acts as a sump, with primary and backup sump pumps sized to transfer the mine waste water to the MTL sump.

The mine waste water system is fully redundant in that each MTL sump pump is duplicated, and each shaft discharge pipe is capable of the 500-gpm design flow compared to the 250-gpm expected flow. In addition, a third identical standby pump is recommended for the MTL sump to ensure system reliability. The anticipated flow rates and corresponding line sizes are shown in FS-GA-0235.

3.8.7 COMPRESSED AIR DISTRIBUTION SYSTEM

The compressed air system supplies and distributes compressed air throughout the ESF for construction, testing, and operation. The peak compressed air demand varies with surface needs and mining equipment fleet activity required at various phases of construction and testing. The major consumers are pneumatic rock drills for shaft excavation, and test drilling/coring equipment. The compressed air supply system is maintained at 90 psig at the takeoff.

The total peak demand value from the construction and testing schedule and corresponding equipment spread is corrected for altitude and leakage. Additionally, a 35 percent uncertainty allowance is added to account for a possible increase in mining activity. Details are completed in Title II.

Booster compressors increasing the ESF supply system pressure to higher levels are required for some test drilling equipment. A typical booster compressor unit is portable, and is relocated as required for some test drilling equipment or for high pressure test drill operations. The compressed air system pipe sizes are based upon maximum velocities of 2,000 feet per minute for primary air supply piping and 3,000 feet per minute for branch piping.

Anticipated flow rates and corresponding line sizes are shown in FS-GA-0240. Air receivers are be included in the compressed air system to ensure reliability under varying conditions. Aftercoolers are required on compressors to reduce the air temperature to a level safe for personnel protection. The compressed air piping test requirements are developed in Title II when appropriate QA levels are established.

3.8.8 FIRE PROTECTION SYSTEM

The subsurface fire protection consists of portable fire extinguishers in the data acquisition areas, the UDBR, the MTL, and exploratory drifts. A sprinkler system is incorporated in specific drift locations and refuge areas, consisting of an on-off, quick-response wet pipe system.

The fueling/lube/high pressure wash area is equipped with a curtain/fire door automatically activated by a fire water flow switch. The sprinklers in this area are the on-off, foam-water, closed-head, quick-response, wet pipe system.

Areas considered to be high hazard areas such as the mine shop and science shop are equipped with one-hour rated fire walls and class B fire doors. The subsurface data building is equipped with a Halon 1301 system and an on-off sprinkler system.

Other areas with combustible hazards such as staging/storage/multiple purpose areas are sprinkled with on-off, quick-response heads on a wet pipe system.

3.8.9 ROCK HANDLING SYSTEM

Except for initial ES-1 and ES-2 station breakout rock, all MTL rock is delivered to the ES-2 loading pocket described in Section 3.6.3. Initial rock haulage utilizes a small (1- or 2-yard) LHD that can pass by the shaft along the north wall of the station to reach the rock dump northeast of the shaft.

Early development includes completing a loop that circumscribes the north shaft pillar, providing access to the rock dump through service drift 1 (SD 1). Five- yard LHDs are used for the remainder of the development. The remaining core area development rock uses panel access drift 1 (PA 1) or PA 2 to reach SD 1, depending on the location of the development.

As soon as possible, haulage through PA 1 ceases, avoiding interference with the IDS and other critical installations in this area. PA 2 then becomes the main haul route for the remaining test bed work (FS-GA-0160). All exploratory drift rock is hauled directly to the rock dump station through SD 1, totally by-passing the service and test areas.

The MTL rock loading system is used for sizing and storing rock in the loading pocket, and also measures and loads a 10-ton capacity bottom dump skip. The system consists of an approximately 12-foot long by 9-foot wide steel bar grizzly with a maximum 12-inch clear opening, installed on top of a 150-ton capacity surge bin. The bin has vertical walls in the upper section and a 60° sloping bottom, with an abrasion resistant liner, complete with stiffeners and support brackets and an air cylinder operated, undercutting arc gate. The surge bin discharges into a 10-ton capacity volumetric measuring flask, also provided with an air cylinder operated, undercutting arc gate. The flask discharges into a fixed chute leading to the skip. Access ladders and platforms are provided from the bottom of the measuring flask to the top of the surge bin for periodic inspection and maintenance (Figure 3-9).

Dust is held below TLVs by application of chemical dust suppressants on the roadways. At the dump station, an airborne dust capturing system consisting of a sheet metal suction hood or enclosure draws dust into a dust collection system. Dust collection openings are also located to pick up any dust generated in the loading pocket and skip loader. The dust collection system, consisting of a series of cyclones and filters, removes 99 percent of particles greater than three microns, and 96 percent of particles down to one micron.

Rock excavation rates vary from approximately 90 to 100 tons per day, when development is started, to a planned full-scale development rate of about 800 tons per day, with allowances up to a maximum of 1,100 tons per day when a 35 percent uncertainty allowance is applied. The hoist system is capable of hoisting over 300 tons per hour, with contingencies and interference factors reducing this to 135 tons per hour average. The system hoists the maximum daily production in slightly more than 8 hours (FS-CA-0068).

The ES-2 spillage collection and handling system consists of a steel spill collection hopper, approximately 10 feet high with a 60° sloping bottom, complete with stiffeners and support brackets. The hopper is supported on top of the crash beams at approximately 13 feet above the shaft bottom.

It is designed to hold 10 tons of rock, accommodating one skip load in the event the skip is overloaded or accidentally dumped to the bottom of the shaft due to operator error or malfunction of rock loading system controls. During normal loading operation, the hopper collects dribble spillage in a nominal 3-ton capacity spillage collection box located at the bottom of the 10-ton hopper. The box is 3 feet by 3 feet by 8 feet, steel construction, provided with an air cylinder operated clamshell gate at the bottom and lifting lugs on top.

To prevent overloading of the box, a high level alarm or load cell is installed at the support level to alarm the hoist operator. When full, the spillage collection box is attached underneath the skip with a wire rope or steel chain and hoisted to the MTL station where it is pulled into position by a winch and discharged into an opening on top of the surge bin. If the hopper is overloaded due to accidental dumping of the measuring flask, the rock is shoveled to a bucket by hand and hoisted back to the loading pocket (Figure 3-9).

3.8.10 SANITARY FACILITIES

The underground sanitary facilities consist of strategically located portable toilet units and a mobile collection/storage unit to facilitate sanitary waste removal. The portable toilet locations are developed as ESF construction proceeds. Final locations on the MTL are determined when the MTL level layout is complete. Use of portable toilets is enforced, and maintenance and service must be provided to keep the units clean. Upon removal or relocation, the affected area shall be disinfected.

3.8.11 MONITORING AND WARNING SYSTEM

Subsurface continuous gas monitoring includes carbon dioxide, carbon monoxide, oxygen, air volume flow, hydrogen, sulfur dioxide and oxides of nitrogen and monitoring of temperature, humidity and barometric pressure. Equipment monitoring is designed for water supply pumps, ventilation, mine waste water, power, hoist alarms and air compressors. The central surface control room for the monitoring of the systems provides a central location for instrument readouts, alarms, equipment status and automatic and/or manual override equipment controls. H&N interfaces with the F&S design at the transducer or sensor. REECo periodically monitors for dust, radon, methane and noise.

The detection system provides fire and smoke detection. The alarm system indicates when monitored conditions exceed pre-determined limits so that personnel are notified of hazardous conditions. The ESF emergency and evacuation alarm system has both audio and visual notification tied in with the public address system and the central reporting station. Redundant systems are installed for all systems that monitor potential life-threatening conditions per National Fire Protection Association (NFPA) codes.

The detectors and alarms are located in the ES-1 shaft at data acquisition stations as required by code. The UDBR and MTL have detectors and alarms near the shaft breakout area and at 100-foot and 400-foot spacing in the testing and extension drift areas. Visual indicators and speakers are spaced every 100 feet.

3.9 UNDERGROUND TESTS

The various tests in the ESF are designed to acquire data on geologic, hydrologic, geomechanical, geochemical, and waste package environment characteristics.

Although all tests performed in the ESF are done in situ, the DOE has classified test activities initiated during construction of ES-1 as construction phase tests and tests initiated after the construction of ES-1 as in situ phase tests. There are 34 tests presently planned in the ESF. Seventeen tests are classified as construction phase tests and 25 are considered in situ phase tests. Some tests are classified as both construction and in situ phases because they are performed in the shafts and the MTL. Changes to these plans could occur. Any changes are documented and approved through the Project baseline change process described in other Project-level documents.

3.9.1 INTEGRATED DATA SYSTEM

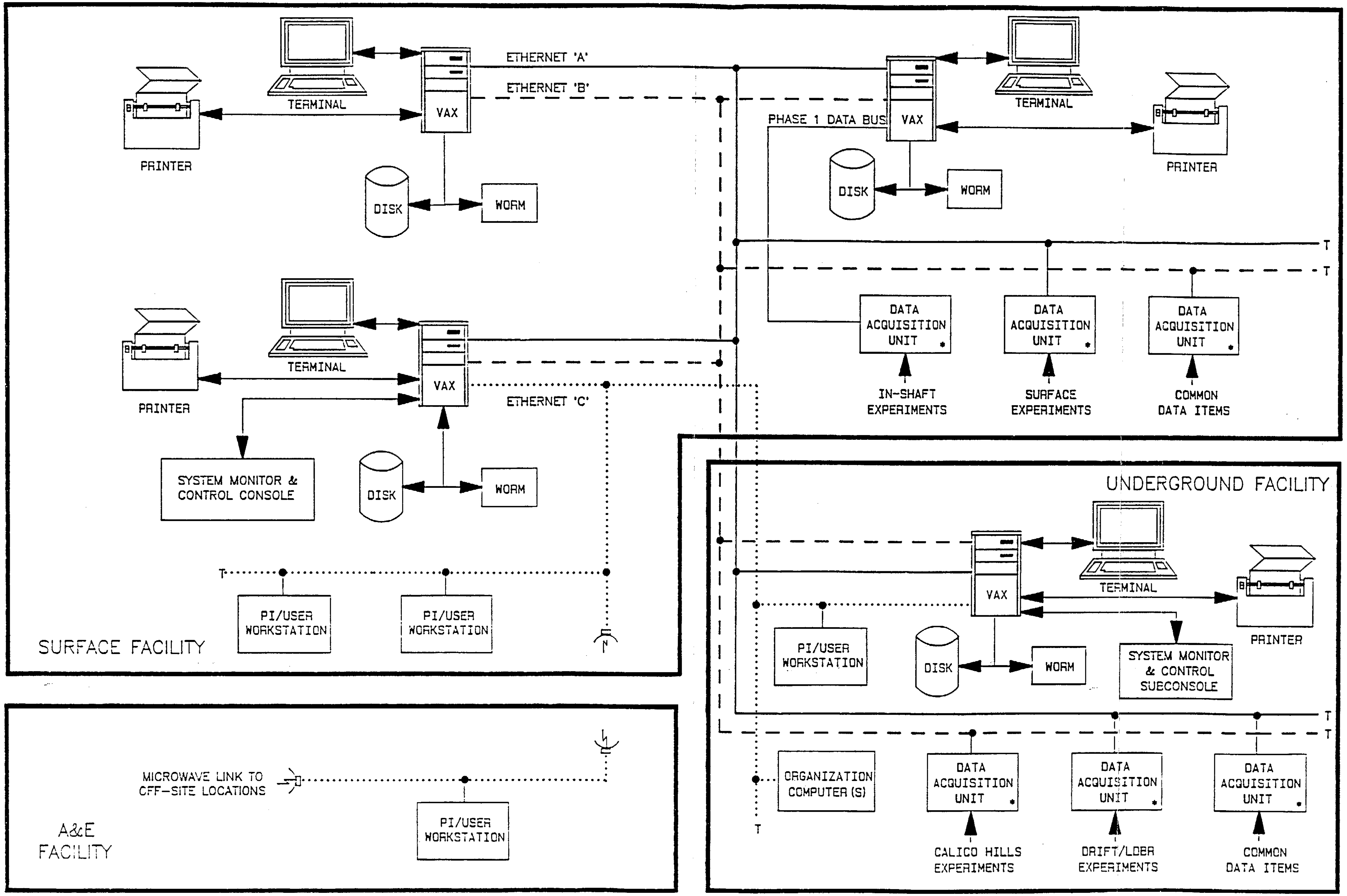
Approximately 20 tests generate electronic data that must be collected, stored, and distributed from the ESF. A computer-based central data collection system, the IDS, supports the data acquisition and recording needs.

The IDS design provides an interface to offsite communication facilities through which each PIs test data, all common data, and experiment statuses are distributed. The IDS acquires, records, and provides certified copies of site characterization data to each investigating organization for data management and analyses. The IDS allows the PIs to control and monitor their tests. The primary purpose of the IDS is to provide the PIs with a uniform, controlled, and verifiable data acquisition and recording system that functions reliably and efficiently.

The IDS requires both surface and underground facilities (Figure 3-26). The surface data building located near ES-1, is equipped with two MicroVAX computers for data acquisition and system control and a VAX Series 600 computer for data archiving and user interface requirements. The subsurface data building, located in the IDS alcove, provides a MicroVAX computer workstation and a backup for up to five days of normal data acquisition in case of a failure of the data transmission lines to the surface facility. Data acquisition stations are used to collect signals from the tests. Signals are transmitted from the test to the computers through data transmission cables. These data transmission lines are separated into three subsystems, Ethernets A, B, and C. Ethernets A and B are redundant data acquisition links between the data acquisition stations and the computers; Ethernet C is the administrative data link that allows PIs to enter data and perform limited analyses to data in the system at that point, but prevents changes to raw data collected by the IDS. The system also allows the PIs to connect organizational computers to control their tests and analyze the data from their tests.

The physical extent of the IDS responsibility starts at the interface between the test instruments and the data acquisition hardware. This is normally a wire connection box or a zone box that contains a thermal reference plate for thermocouple measurements. The PIs are responsible for installing, calibrating, and maintaining their own instruments, associated local support equipment, and experiment control needed for measurements.

The IDS is installed in phases. For the first tests in ES-1, a PC-based Data Logger Control is used. Next, the tests in ES-1, the UDBR, and the MTL Demonstration Breakout Room are supported from a single VAX computer on the surface.



* – REDUNDANT ACQUISITION UNITS WILL BE USED FOR HIGH-RELIABILITY CHANNELS

SI APERTURE CARD

Also Available On Aperture Card

Figure 3-26.
IDS block diagram.

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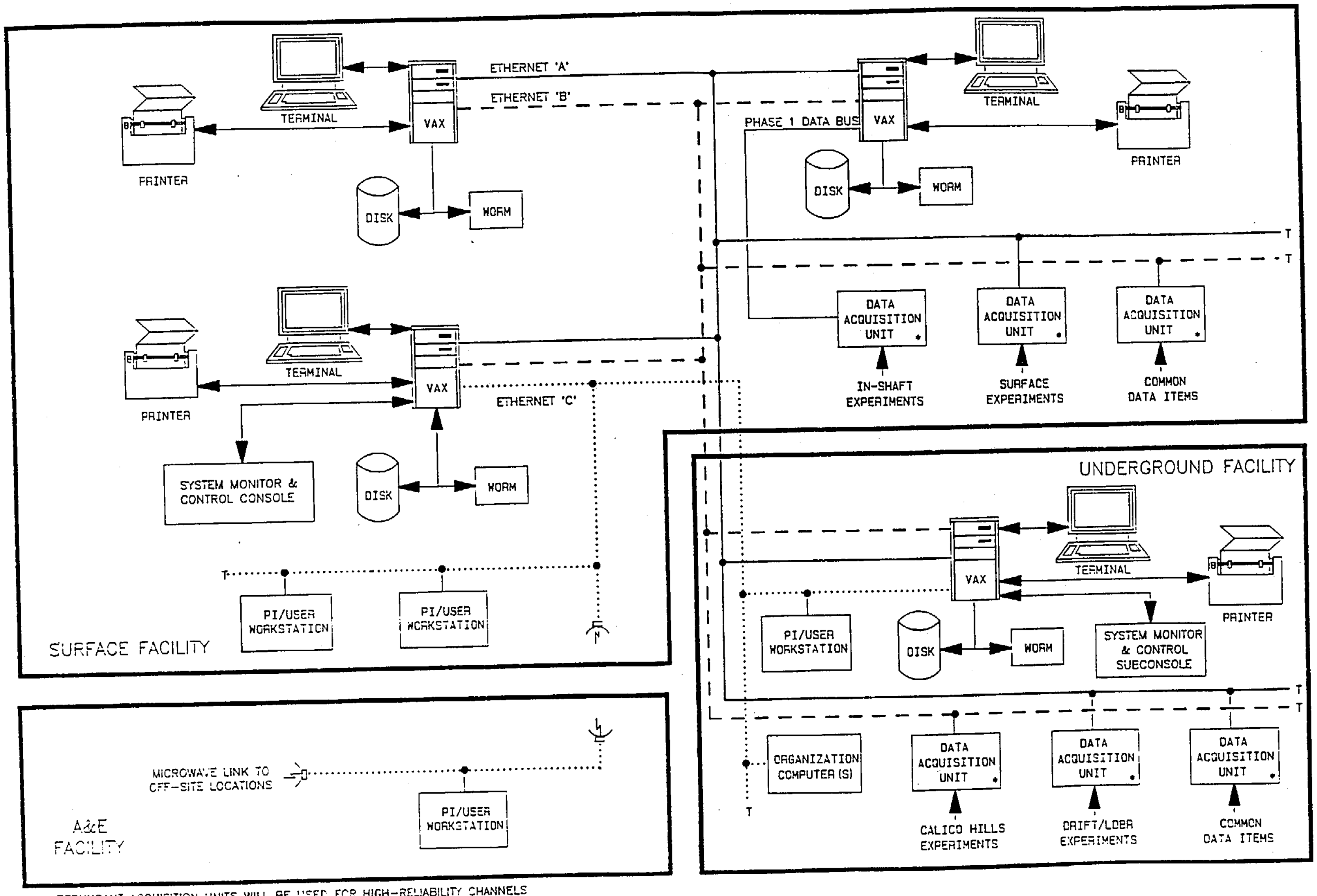


Figure 3-26.
IDS block diagram.

When the subsurface data building is available, the entire system is available for use as tests come online.

The IDS provides excitation sources as required. The IDS has responsibility for common data items such as plate temperature, IDS housekeeping monitors, calibration standards, ventilation mass balance, water in/out flow, and surface weather data.

IDS data recording and distribution responsibilities include providing all tests and common data with accurate time references; protecting records for long term storage; and distributing test and common data to PIs in a uniform format at required intervals.

All raw data collected by the IDS is archived on optical disk (Write Once, Read Many)(WORM) media. The master disks are retained as system records. Each PI's data, plus the common data, is separated, certified, and transmitted to the PI at regular intervals. This data is certified for site characterization purposes.

The software requirements for the IDS are not available at this time. The preliminary acceptance test requirements for the IDS are also not available at this time.

3.9.2 GEOLOGIC MAPPING OF EXPLORATORY SHAFTS AND DRIFTS

Geologic mapping and photogrammetry is done at intervals (approximately every 6.5 feet) in ES-1, the UDBR, and the MTL, and possibly to a lesser extent in ES-2. It is intended that all excavated surfaces be mapped and photographed. The test equipment used is provided by the PI and includes the radial arm strike rail and the camera pedestal. Utilities required at the test locations include compressed air/mist and voice communications to the lower deck of the galloway. Support facilities include a secure, locked underground storage space (200 square feet minimum) and a surface staging structure (200 square feet minimum) equipped with HVAC, electricity, and water. Also required are access to a shaft sinking galloway in ES-1 and ES-2; access to a stable platform in the drifts; and mounting provisions for test equipment to the platforms. Normal mapping takes two hours after the surface is cleaned and the test equipment is in place. This test is not connected to the IDS.

3.9.3 FRACTURE MINERALOGY STUDIES OF EXPLORATORY SHAFTS AND DRIFTS

Muck samples are collected and transported to the Sample Management Facility from muck removed during underground construction. No ESF-related utilities or support are required except for the access to the muck handling facilities at the headframes and underground. The time to perform the tests has minimal impact on the ESF. The test is not connected to the IDS.

3.9.4 SEISMIC TOMOGRAPHY AND VERTICAL SEISMIC PROFILING

Blockouts and radial instrument holes are placed at regular intervals in both ES-1 and ES-2 and aligned on the center line between the shafts for accessing geophones for the test. Utility and support requirements are being identified and will be available before the completion of the Title II design.

The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is not connected to the IDS.

3.9.5 SHAFT CONVERGENCE

Boreholes and convergence anchors are installed at three depths in ES-1. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.6 DEMONSTRATION BREAKOUT ROOMS

The demonstration breakout rooms (DBRs) are 19 feet high by 25 feet wide by 150 feet long. The upper room is located off the ES-1 shaft approximately 600 feet deep. The lower DBR is at the MTL. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.7 SEQUENTIAL DRIFT MINING

Two instrumentation drifts are 14 feet high by 16 feet wide by 150 feet long. A third drift, 14 feet high by 25 feet wide by 150 feet long, is excavated after the instrumentation drifts are completed. These drifts are located on the MTL. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.8 HEATER EXPERIMENT IN UNIT TSw1

In the UDBR, a heater emplacement hole is drilled about 8 feet into the drift wall at an undetermined location. Several instrumentations holes are drilled parallel to the heater hole. The heater and instruments are then installed. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.9 CANISTER-SCALE HEATER EXPERIMENT

At a location on the MTL, a 13-inch diameter hole is drilled 20 feet into a drift wall. Parallel small diameter instrumentation holes are drilled. The instrumentation is then installed. Utility ana support requirements are being identified and will be available before the completion of the Title II design. The test takes approximately 30 months. The test is connected to the IDS.

3.9.10 YUCCA MOUNTAIN HEATED BLOCK

At a location on the MTL, a 27-foot by 27-foot alcove is mined and a 6-foot by 6-foot block is defined. Slots are cut on each side of the block and flatjacks are inserted.

Heaters are installed in holes on opposite sides of the block. Other instrumentation holes are drilled and instrumented. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.11 THERMAL STRESS MEASUREMENTS

In both the UDBR and the MTL DBR, single slots are cut in both the back and rib, 6 feet long and 6 feet deep after reference pins are established on either side. Flatjacks are installed in the slots and heaters are installed in holes drilled on either side of the slots. An insulating blanket is installed over the test area to reduce heat loss. Utility and support requirements are being identified and will be available before the completion of the Title II design. The test takes 3 to 4 months. The test is connected to the IDS.

3.9.12 HEATED ROOM EXPERIMENT

On the MTL at an undetermined location, a repository sized drift is excavated and the rock around it heated. The drift is instrumented. More than one drift opening may be required. The room is isolated by a thermal barrier. Personnel access requires special controls. Utility and support requirements are being identified and will be available before the completion of the Title II design. The test may take 40 months. The test is connected to the IDS.

3.9.13 DEVELOPMENT AND DEMONSTRATION OF REQUIRED EQUIPMENT

A prototype boring machine for the repository may be tested by drilling and lining two 250-foot long horizontal boreholes. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is not connected to the IDS.

3.9.14 PLATE LOADING TESTS

Plate loading tests are performed at selected locations in the upper DBR and the MTL to measure the rock mass deformation modulus and evaluate the fracture zone adjacent to mined openings. Utility and support requirements are being identified and will be available before the completion of the Title II design. The test takes a minimum of 15 days at each location. The test is connected to the IDS.

3.9.15 ROCK MASS STRENGTH EXPERIMENT

Tests are conducted on the MTL in several areas representative of the repository. The joint shear strength stage measures field scale sized samples, and the random jointing stage characterizes a block of jointed rock for joint spacing, aperture and properties. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.16 EVALUATION OF MINING METHODS

Mining methods in ES-1 and in the long exploratory drifts are monitored. The observations are concentrated in the widened (repository sized) portions of the long drifts and include particle velocity measurements, segmented blasting of rounds, and examination of blast-induced damage in boreholes. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.17 EVALUATION OF GROUND SUPPORT SYSTEMS

The test on the MTL monitors the selection, installation, and performance of ground supports, including rock bolt pull tests, observation of unsupported rock, strength measurements on shotcrete cores, and trials of alternate ground support configurations. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.18 MONITORING DRIFT STABILITY

Drift convergences and drift maintenance activities are monitored around the MTL. Instrumentation is concentrated in the long drifts, although convergence measurement stations can be set up anywhere around the MTL. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.19 AIR QUALITY AND VENTILATION EXPERIMENT

These tests measure radon emanation; survey airflow pressure, temperature, and humidity; determine air resistance factors; and characterize dust at various locations in the ESF. Utility and support requirements are being identified and will be available before the completion of the Title II design. Measurements are performed with portable instruments over several days for each location. The test is connected to the IDS.

3.9.20 IN SITU TESTING OF SEAL COMPONENTS

The occurrence or absence of water at the repository horizon defines this test. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. It is unknown whether the test will be connected to the IDS. The test is still undergoing definition and is not included in the ESF Title I design effort.

3.9.21 OVERCORE STRESS EXPERIMENTS

Small diameter drillholes are drilled above and within the repository horizon at prescribed orientations and lengths. A sensor is installed and the instrumented center hole is overcored in stages. Strain data are taken as the instrumentation of each stage is overcored. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.22 MATRIX HYDROLOGIC PROPERTIES TESTING

Bulk and core samples are collected after selected blasting rounds during ES-1 and drift construction and from core holes. The samples are sent to a laboratory for analysis. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.23 INTACT FRACTURE TEST

At fracture sampling locations at each breakout horizon (12 locations), a small pilot hole is drilled across a fracture, a rock bolt anchor installed, the pilot hole overcored and a sample withdrawn. The sample is sent to a laboratory for analyses. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is not connected to the IDS.

3.9.24 INFILTRATION TESTS

A large block of rock on the MTL between two drifts is instrumented to monitor fluid flow. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.25 BULK PERMEABILITY TEST

At four locations on the MTL, small diameter holes are air cored and logged. Air permeability is measured. Pressure, temperature, and humidity sensors are installed. Selected holes are pressurized, and the air movement to the other holes is monitored. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.26 RADIAL BOREHOLE TESTS

At eight locations in ES-1, two small diameter holes are air cored radially from the shaft. Core is collected and sent to a laboratory for hydrologic analysis.

The holes are logged and surveyed for fracture and moisture data. Nitrogen injection tests are conducted to obtain gas permeability data. Cross- hole permeability tests are run. Moisture resulting from shaft mining, matrix water potential, pressure and temperatures are monitored. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.27 EXCAVATION EFFECTS TEST

At the UDBR and MTL, small diameter holes are drilled parallel or subparallel to the unexcavated shaft wall but set back from it. Holes are air drilled, cored, logged, and surveyed. Some holes are instrumented to monitor stress changes and permeability changes. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.28 PERCHED WATER TEST

If perched water is encountered in ES-1, ES-2, or any drift, small diameter holes are drilled to enhance drainage, facilitate collection of water samples, and measure flow and/ or pressure. The holes are instrumented and sealed during testing to obtain data on hydraulic pressure and water potential over time. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.29 HYDROCHEMISTRY TESTS

During shaft sinking, samples are collected from the blast rubble and sent to a laboratory for analysis. In addition, gas samples are drawn using vacuum pumps from the radial borehole test holes and analyzed. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is not connected to the IDS.

3.9.30 DIFFUSION TESTS

At four locations on the MTL, small diameter holes are air drilled and a nonsorbing tracer deposited at the bottom in a packed-off zone. The holes are capped and left undisturbed from 3 to 12 months. The areas are overcored, and the core removed for laboratory analyses. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.31 CHLORIDE AND CHLORINE-36 MEASUREMENTS OF PERCOLATION

As the ES-1 shaft is excavated, large bulk samples of rock are removed to a laboratory for analysis. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is not connected to the IDS.

3.9.32 ENGINEERED BARRIER SYSTEM FIELD TESTS

In test alcoves on the MTL, horizontal and vertical heater emplacement holes are drilled. Heater canisters and associated instrumentation packages are inserted to monitor thermal, moisture, and stress and strain parameters. Water is injected during heating and cooling stages while monitoring takes place. Core from the adjacent heater hole is recovered and laboratory analyses performed. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is connected to the IDS.

3.9.33 LABORATORY TESTS USING SAMPLES OBTAINED FROM THE ESF

Samples collected from the ESF are sent to laboratories for bulk, thermal, and mechanical property determinations. Utility and support requirements are being identified and will be available before the completion of the Title II design. The time to perform the test is also being identified and will be available before the completion of the Title II design. The test is not connected to the IDS.

3.9.34 MULTIPURPOSE BOREHOLE TESTING NEAR THE EXPLORATORY SHAFTS

This test is still being defined and is not included in the Title I design.

CHAPTER 4

ENVIRONMENTAL ASPECTS

4.1 REGULATORY FRAMEWORK

The regulatory framework for the Exploratory Shaft Facility (ESF) is based on the environmental requirements set forth in the following documents: the Nuclear Waste Policy Act (NWPA), the Nuclear Waste Policy Amendments Act (NWPAA), Department of Energy Orders, the National Environmental Policy Act (NEPA), and applicable federal and state statutes and regulations.

The DOE is committed to conduct its operation in an environmentally safe and sound manner. The DOE complies with the letter and spirit of applicable environmental statutes and regulations. These objectives are described in DOE Order 5400.1 (General Environmental Protection Program Requirements).

Environmental regulations and statutes applicable to activities at Yucca Mountain can be broken down into three areas; (1) Federal and federally delegated environmental regulatory requirements, (2) State and local environmental administered regulatory requirements, and (3) DOE Orders.

The Federal and federally delegated State of Nevada environmental regulatory requirements applicable to the repository program at Yucca Mountain are shown in Table 4-1. The table contains information from the draft Environmental Regulatory Compliance Plan (ERCP) for Site Characterization of the Yucca Mountain Site (DOE, 1988).

The ERCP also lists regulatory requirements administered solely by the State of Nevada in that there are no Federal laws that mandate compliance with these State requirements by Federal agencies. The DOE, as a matter of comity, addresses the concerns evidenced by State and local laws for which Federal sovereign immunity has not been waived to the extent that these regulations are not inconsistent with the DOE's responsibilities under the NWPA, the NWPAA, the Atomic Energy Act (AEA), and other Federal statutes.

The DOE Orders that relate to environmental protection, safety, and health are listed in the ERCP, and must also be considered when determining the environmental requirements that apply to the environmental program. In most instances, by complying with the Federal, State, and local regulations, the DOE is in compliance with these Orders. However, the Orders are periodically reviewed to determine whether additional DOE self-imposed standards, requirements, or procedures apply to the Yucca Mountain site.

Orders addressing occupational radiological protection, occupational health and safety, fire protection, building and safety codes, contractor licensing and bonding, and other registration requirements are addressed in the Office of Civilian Radioactive Waste Management's Safety Plan (DOE/RW-0119) and the health and safety plans for the Yucca Mountain site.

The ERCP is one of the documents that describe how the policy set forth in DOE Order 5400.1 is being implemented. Specifically, the ERCP describes the Yucca Mountain Project strategy for compliance with applicable environmental statutes and regulations and how the DOE addresses State and local environmental statutes and regulations. This document is developed in phases. The first phase is the Yucca Mountain Project Office's understanding of environmental regulatory requirements for site characterization.

DOE Order 4700.1 calls for an Environmental, Safety and Health Protection Implementation Plan (ES&H Plan) to be prepared as part of the Project Management Plan. An ES&H Plan is being written. The environmental regulatory compliance requirements for site characterization identified in the ES&H Plan are the same requirements described in the ERCP. The ES&H Plan also includes discussions of radiological health and safety requirements, as well as organization, training, documentation, and implementation requirements for the environmental, safety, and health program. The ES&H Plan was not specifically addressed in Title I. The following environmental aspects have been addressed in the Title I design.

4.2 AIR QUALITY

Since the Yucca Mountain Project is in an area where existing air quality is better than state and federal air quality standards, emissions associated with site characterization activities are subject to examination under the Clean Air Act regulations on Prevention of Significant Deterioration (PSD). Pollutant emissions, however, should be considerably less than the 250 tons per year individual pollutant and threshold level (Environmental Assessment of Yucca Mountain, DOE, 1986).

The most significant pollutant emitted during site characterization is fugitive particulate matter. Other pollutants from operating equipment (primarily nitric oxides and nitrous oxides) also affect air quality. The amount of emissions produced has not been quantified. Nevada Air Quality Operating Permit requirements may dictate emission limits.

Construction on the ESF can cause impacts to air quality. Activities that may contribute to air quality impacts include surface disturbances, ES shafts, standby generators, and the concrete batch plant facility. These impacts are minimal and short term. This type of facility does not generate significant emissions that would cause air quality problems.

The plan to control fugitive particulate emissions involves the use of water and other dust suppressants along roads, parking areas, muck storage areas, laydown areas and borrow areas. Water spray and a cyclone/centrifuge and bag system are used to control dust in the shafts. The manufacturer's guaranteed control efficiency for the dust in-shaft collection system is 99.8 percent. Particulate emissions from the standby generators are controlled through the use of pollution control equipment incorporated into the facility design. Periodic emission equipment checks help preclude accidental releases.

The Nevada Division of Environmental Protection is the agency responsible for implementing and enforcing the Clean Air Act at the state level. Air quality requirements include registration certificates and operating permits for surface disturbances, shafts, standby generators and the concrete batch plant. The ERCP provides more information on air quality requirements.

4.3 WATER QUALITY

The great depth to ground water and the lack of surface water in the ESF area reduces the potential for water quality degradation (DOE, 1986a). Potential sources that affect water quality are the mine waste water system, sewage leachate system, muck storage pond, and land disturbing activities.

Discharge of effluents from ESF construction activities into dry stream beds or leach fields could impact water quality if not properly controlled and monitored. This includes water used for dust control, mining and construction activities, fire fighting, and human consumption. The majority of water is released from the mine waste water system settling pond into the dry streambed. Discharge rates for the mine waste water system are estimated at 50 gallons per minute, with peak flows of up to 500 gallons per minute in the event of fire or perched water. Sewage is handled using a leachate field, that is expected to have an average flow of 10,000 gallons per day. Water from natural runoff is not contained, but directed away from facilities into dry drainage channels.

Control measures are planned to minimize potential impact to water quality from ESF discharges. Effluent water quality is expected to be good and complies with the Clean Water Act and applicable state standards.

Comprehensive plans and use of pollution control equipment (i.e., oil-water separators, settling basins) are used to reduce pollutants in the discharge waters. Liners are used in the muck storage area and the muck storage pond to capture the leachate and runoff water from that area. Nonradioactive tracers are injected into all waters used in the ESF to assure traceability of the water. The potential for accidental releases is reduced by oversizing holding ponds, inspection of facilities, and utilizing good operations and maintenance practices and procedures.

Water handling activities for the ESF require compliance with several regulations and statutes. Applicable requirements include the Safe Drinking Water Standards, Federal Water Pollution Control Act (including National Pollution Discharge Elimination System), Resource Conservation and Recovery Act, Requirements for Constructing and Operating a Sewage System, Underground Injection Control Requirements and Floodplain Management. The draft ERCP is available for more detailed information on permitting requirements.

4.4 LAND DISTURBANCES

Proposed construction activities for the ESF could create land disturbances. Land disturbances include manmade changes affecting vegetation, wildlife habitat, soil stability, archaeological sites and site access and control. Site characterization activities for the ESF should not create major land disturbance impacts. Remedial action for these land disturbances is based on requirements of the responsible agency (DOE, Bureau of Land Management (BLM), U.S. Air Force, and U.S. Fish and Wildlife Service). Plans call for reclamation of disturbed sites when all studies or work is completed.

Site access and control is affected by a land withdrawal. A land withdrawal of the the BLM portion of the Yucca Mountain site would change how the BLM handles any proposed activities on the site. Site characterization activities take precedence over any other proposed activities (i.e., new mining claims affecting the site characterization activities are not allowed).

The majority of the land disturbance involves construction activities. The ESF construction disturbs approximately 45 acres. Proposed activities for the ESF that cause disturbances are construction and improvement of access roads, utility services, surface support services, shafts, and underground rooms; and land transportation, storage, and disposal of mined materials.

Actions are planned to reduce land disturbance impacts. These actions include dust control measures, reclamation of disturbed sites, surveying and preserving archaeological sites, vegetation and wildlife studies, employee environmental awareness training and compliance with applicable federal and state requirements.

A reclamation plan for the Yucca Mountain Project is being developed. This plan incorporates data from vegetation, soils, and reclamation feasibility studies conducted onsite.

Land disturbance activities comply with various federal and state requirements. Areas addressed include Endangered Species, Farmland Protection, Wetlands Protection, NEPA, Federal Land Policy and Management, Land Status, Material Use Permits, and Wildlife and Vegetation Statutes. The ERCP provides for a complete description of the required permits and compliance actions.

4.5 HAZARDOUS AND SOLID WASTES

The handling, storage, treatment, and disposal of hazardous solid waste and disposal of non-hazardous waste is regulated by a complex and interrelated array of state and federal laws. The Resource Conservation and Recovery Act (RCRA) requires the cradle to grave management of hazardous wastes as well as the management of underground petroleum storage tanks and non hazardous solid waste. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (amended by the Superfund Amendments Reauthorization Act (SARA)) provides for the clean up and emergency response for hazardous substances released into the environment and for the clean up of hazardous waste sites that present a substantial danger to the public health and welfare.

CERCLA also requires the notification of the National Response Center and appropriate agencies and officials when a release of a reportable quantity of a hazardous substance occurs. Title III (Emergency Planning and Community Right-to-Know Act, 1986) was added to SARA as a free-standing law to address emergency planning and community right-to-know reporting for extremely hazardous substances and reporting on Occupational Safety and Health Act (OSHA) defined hazardous chemicals. The State of Nevada was granted final authority to to administer Subtitle C of RCRA (management and disposal of hazardous waste) on November 1, 1985. CERCLA is administered by the Environmental Protection Agency (EPA) with significant state involvement and responsibility.

Proposed waste streams are being investigated to determine if they contain hazardous wastes, and to determine the cumulative weight of the various hazardous wastes generated each month. Regulated hazardous wastes are listed in 40 CFR Part 261. Even though a waste is not listed in 40 CFR Part 261, it may still be considered a hazardous waste if it meets the requirements of any of the following characteristics: ignitable, corrosive, reactive, or toxic. Hazardous wastes that are generated by site characterization activities have not yet been fully identified.

Initial reviews of planned site characterization activities indicate that hazardous substances may be used in amounts that meet reportable quantities under CERCLA. Spills of reportable quantities, which can be as little as one pound for acutely toxic substances requires immediate notification of the National Response Center. The use of extremely hazardous materials is not anticipated but if planning thresholds are net, community right-to-know planning and training programs are required. Worker safety and training programs and emergency spill response and contingency plans are being developed.

If RCRA and CERCLA requirements are administered properly, no impacts are expected. Accidental spills will be cleaned up. Impacts associated with non-compliance result in costly clean-up operations, criminal and civil penalties, fines, and stop work orders.

Compliance with the applicable hazardous and nonhazardous solid waste regulations requires a coordinated program encompassing all field activities. All field activities and proposed import and usage of materials onsite are reviewed and checked against a comprehensive listing of regulated materials. If a proposed material is regulated, a nonhazardous substitute is requested. If a substitute is not available, the requester is provided with a requirements list including waste management plans, emergency reporting and response, personal safety and handling, monitoring, transportation, and other applicable requirements outlined in the preceding summary and the ERCP. All hazardous waste generated during site characterization is closely managed from "cradle to grave." Field contractors are required to adopt specific waste minimization, handling, accumulation, storage and disposal practices, which are outlined in the ERCP and which comply with the state hazardous waste program. Those requirements include provisions for worker safety and transportation.

The ESF activities must comply with Subtitle I which regulates underground storage tanks (USTs) and requires notification of existing and new tanks. It also establishes minimum tank standards and leak detection and monitoring requirements. The Nevada Department of Environmental Protection administers the UST program and is notified before USTs are installed. Final Subtitle I tank requirements for installation, leak detection, and monitoring were issued in September 1988. If Nevada adopts the final requirements, state compliance may be required in mid-1989. All UST designs are reviewed to ensure that Subtitle I criteria are met. State requirements are reviewed to determine if additional measures are needed to meet state standards.

Used oil is regulated under Subtitle C and is not considered to be a hazardous waste if it is to be "recycled." All used oil is recycled as outlined under RCRA and the state hazardous waste program. Land disposal of used oil, such as road oiling, is banned under both RCRA and the Clean Water Act.

Nonhazardous waste is regulated under Subtitle D and a State Solid Waste Disposal Program. Subtitle D encourages recycling of nonhazardous solid waste and non-landfill disposal options. The existing Nevada Test Site landfill is utilized for the disposal of nonhazardous solid waste. Waste reduction, recycling and environmentally sound disposal methods are utilized to reduce solid waste volume. If wastes are taken offsite, they are taken to a licensed disposal facility. If an onsite facility is required, it is permitted and operated in accordance with state and federal requirements.

An impermeable liner is incorporated in the mine muck storage pile and leachate collection and evaporation ponds. The evaporation pond is designed to meet Clean Water Act standards. Leachate and pond residue are sampled as outlined in the Environmental Monitoring and Mitigation Plan to determine if hazardous materials are being generated and accumulated. Accumulated wastes are managed in accordance with state and federal requirements as outlined in the ERCP.

Implementation of the materials review and compliance steps which are outlined in the ERCP provide compliance monitoring and mitigation options for hazardous and solid waste handling. Field activities that do not comply with the state and federal hazardous and solid waste programs are not permitted.

4.6 CONSTRUCTION PERMITTING

ESF construction activities require compliance with permitting requirements and obtaining applicable federal and state permits. These items are addressed in previous sections. Permits or actions requiring long lead times are being prepared first. Permits are filed as the required specifications and design criteria becomes available.

The schedule for obtaining the required permits is shown in Table 4.1-1. The time frame for obtaining a permit includes review time by the Yucca Mountain Project Office and DOE/Headquarters. Actual time requirements by the permitting agency to grant the permit varies depending on additional information requests and political influences.

Table 4-1. Environmental regulatory compliance for site characterization of Yucca Mountain

STATUTE	COMPLIANCE ACTION	AGENCY	APPLICATION FILED	AGENCY APPROVAL GRANTED (EXPECTED)
AMERICAN ANTIQUITIES ACT	PROGRAMMATIC AGREEMENT	ACHP/SHPO	12/86	(9/88)
AMERICAN INDIAN RELIGIOUS FREEDOM ACT	PROGRAMMATIC AGREEMENT	ACHP/SHPO	12/86	(9/88)
ARCHAEOLOGICAL RESOURCES PROTECTION ACT	PROGRAMMATIC AGREEMENT	ACHP/SHPO	12/86	(9/88)
COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT	CERCLA COMPLIANCE	DOE	N/A	N/A
ENDANGERED SPECIES ACT	ENDANGERED SPECIES COMPLIANCE	USFWS	1/88	2/23/88
FARMLAND PROTECTION POLICY ACT	FARMLAND PROTECTION	SCS	1/88	3/1/88
FEDERAL LAND POLICY AND MANAGEMENT ACT	RIGHT-OF-WAY AGREEMENT			
BLM LAND		BLM	11/23/87	1/8/88
AIR FORCE LAND		BLM/AIR FORCE	3/25/87	(11/88)
HAZARDOUS MATERIAL TRANSPORTATION ACT	CARRIER COMPLIANCE	DOT	N/A	N/A

SITE PREPARATION FOR THE ESF IS PRESENTLY SCHEDULED TO BEGIN IN JANUARY 1989. SURFACE-BASED INVESTIGATIONS WILL BEGIN AS STUDY PLANS ARE REVIEWED BY NRC AND THE STATE OF NEVADA, AND APPROPRIATE QUALITY ASSURANCE PROGRAMS ARE IN PLACE.

Table 4-1. Environmental regulatory compliance for site characterization of Yucca Mountain (continued)

STATUTE	COMPLIANCE ACTION	AGENCY	APPLICATION FILED	AGENCY APPROVAL GRANTED (EXPECTED)
MATERIALS ACT	FREE USE PERMIT	BLM	TBD	TBD
NATIONAL ENVIRONMENTAL POLICY ACT	NEPA COMPLIANCE	CEQ	N/A	N/A
NATIONAL HISTORIC PRESERVATION ACT	PROGRAMMATIC AGREEMENT	ACHP/SHPO	12/86	(9/88)
NOISE CONTROL ACT	NOISE CONTROL COMPLIANCE	DOE	N/A	N/A
EXECUTIVE ORDER 11988; FLOODPLAIN MANAGEMENT	FLOODPLAIN MANAGEMENT COMPLIANCE	DOE	(11/88)	(2/89)
EXECUTIVE ORDER 11990; PROTECTION OF WETLANDS	WETLANDS COMPLIANCE	USFWS	1/88	3/1/88
CLEAN AIR ACT	SURFACE DISTURBANCE	NDEP	1/20/88	(9/88)
	SOURCE REGISTRATION PERMIT	NDEP	(10/88)	(4/89)
	OPERATING PERMIT	NDEP	(5/89)	(6/89)
FEDERAL WATER POLLUTION CONTROL ACT	NPDES PERMIT (ZERO DISCHARGE DEMONSTRATION)	NDEP	(11/88)	(12/88)
RESOURCES CONSERVATION AND RECOVERY ACT	RCRA PERMIT (I.D. NUMBER)	NDEP	(12/88)	(2/89)

Table 4-1. Environmental regulatory compliance for site characterization of Yucca Mountain (continued)

STATUTE	COMPLIANCE ACTION	AGENCY	APPLICATION FILED	AGENCY APPROVAL GRANTED (EXPECTED)
SAFE DRINKING WATER ACT	WATER TREATMENT SYSTEM PERMIT	NDH	(12/88)	(2/89)
NEVADA UNDERGROUND INJECTION CONTROL PROGRAM	PERMIT TO INJECT TRACERS	NDEP	(11/88)	(6/89)
NEVADA APPROVAL OF PLANS TO CONSTRUCT SANITARY AND SEWAGE COLLECTION SYSTEM AND PERMIT TO OPERATE SYSTEM	PERMIT TO CONSTRUCT AND OPERATE A SEWAGE COLLECTION SYSTEM	NDEP	(11/88)	(1/89)
PERMIT TO APPROPRIATE PUBLIC WATERS OF NEVADA	WATER APPROPRIATION PERMIT	NV STATE ENGINEER	7/21/88	(10/88)
NEVADA WATER POLLUTION CONTROL LAW	WATER POLLUTION CONTROL PERMIT	NDEP	(11/88)	(1/89)

CHAPTER 5

SAFETY AND HEALTH ASPECTS

5.1 APPLICABLE CODES AND REGULATIONS

The design construction and operation of the ESF conforms to the applicable requirements of the following safety and health codes and regulations.

Code of Federal Regulation (CFR)

Code of Federal Regulations, Title 10, Part 60, Disposal of High Level Radioactive Wastes in Geologic Repositories, Nuclear Regulatory Commission (NRC)

Code of Federal Regulations, Title 29, Part 1926, OSHA Safety and Health Standards, Occupational Safety and Health Administration (OSHA)

Code of Federal Regulations, Title 30, Part 57, Safety and Health Standards Underground Metal and Non-Metal Mines, Mine Safety and Health Administration (MSHA)

U.S. Department of Energy (DOE)

DOE Order 6430.1A, Draft, dated 12/25/87, General Design Criteria Manual

DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards

EV-0043, Standard on Fire Protection for Portable Structures

EP-0108, Standard for Fire Protection of DOE Electronic Computer/Data Processing System

NNWSI ESF Health and Safety Plan (NV046-77)

NNWSI Exploratory Shaft at Yucca Mountain, Safety and Health Program Plan, March 1983 (DOE/NV/00410-77)

State of Nevada Regulations

Nevada Revised Statutes, Title 46, Chapter 512, Mine Safety and Health Standards for Open Pit and Underground Metal and Nonmetal Mines and Sand, Gravel and Crushed Stone Operations (46 NRS 512)

California Administrative Code (CAC)

Title 8. Industrial Relations. Chapter 4, Division of Industrial Safety

Subchapter 17, Mine Safety (8 CAC 4.17)
Subchapter 20, Tunnel Safety Orders (8 CAC 4.20)

Electrical Safety Orders and Part 3, Title 24 and 8

American Concrete Institute (ACI)

American Conference of Government Industrial Hygienists (ACGIH)

American Institute of Steel Construction (AISC)

American Iron and Steel Institute (AISI)

American National Standards Institute (ANSI)

ANSI C2	National Electrical Safety Code
ANSI A117.1	Specifications for Making Buildings and Facilities Accessible to and Usable by Physically Handicapped People

American Society for Testing and Materials (ASTM)

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

American Welding Society (AWS)

Factory Mutual Research and Engineering Association (FM)

Factory Mutual Approval Guide

Institute of Electrical and Electronic Engineers (IEEE)

International Conference of Building Officials (ICBO)

Uniform Building Code
Uniform Plumbing Code

Manufacturers Standardization Society (MSS)

National Association of Plumbing, Heating, Cooling Contractors (PHCC)

National Fire Protection Association (NFPA)

National Fire Codes
National Electrical Code (NEC)

Steel Structures Painting Council (SSPC)

United States Department of the Interior Bureau of Mines (USBM)

Underwriters' Laboratories, Inc. (UL)

UL Building Materials Directory
UL Fire Resistance Directory

5.1.1 EXCEPTIONS TO SAFETY REGULATIONS

DOE Order 5480.4 establishes DOE policy concerning applicability of regulations and standards promulgated by other organizations. This policy includes the principle that when conflicts occur between different standards, the criteria providing the greater degree of protection shall apply. Authority to interpret and enforce standards applicable to the Yucca Mountain Project, rests with the DOE (Memorandum of Understanding between the DOE and the Department of Labor, 12/23/86). Consequently, situations where differing requirements can be cited as applicable to an aspect of the Exploratory Shaft Facility (ESF) design need to be reviewed by the DOE organization with enforcement authority. This review will establish an interpretation of the applicability of each standard or code and a determination of which standard provides the greater degree of protection. Exceptions will be requested when compliance with the requirement affording the greater degree of protection cannot be accomplished. Conflicting requirements have been identified for the following cases:

8 CAC 4.17, Article 7044 (j) and 30 CFR Part 57 Article 19111. The California code requires fixed ladders from the shaft collar during sinking operations. With the proposed sinking arrangement, this requirement cannot be met. It is possible to conform to 30 CFR 57.19111 which offers the alternative of an emergency hoist in place of fixed ladders.

8 CAC 4.17, Article 7076 (c) and 30 CFR Part 57 Article 11053 (a). An exception from the CAC will be sought to permit posting of the safety diagram in work areas where persons regularly congregate, rather than at every working station in the mine.

8 CAC 4.1, Article 7099 (c). The California code requires that the main fan or fans shall be installed so that the ventilating current can be quickly reversed in direction. A variance will be sought from the California code to allow for non-reversible main ventilation, for safety reasons.

8 CAC 4.17, Article 7147 (b) and 30 CFR Part 57 Article 19076. There are conflicting requirements for maximum hoisting speed. The allowable speed when hoisting men in a bucket varies from the CAC requirement of 200 feet per minute to the 30 CFR Part 57 maximum of 500 feet per minute.

46 NRS 512 11-(b) and 30 CFR Part 57, Article 11050. An exception will be sought from the Nevada requirement for ladderways in both shafts in favor of conforming with 30 CFR Part 57 which requires two separate escapeways from the lowest level. The provision of emergency power to either of the two main hoists, together with the ladderway in ES-1, and the availability of the emergency hoist for either shaft adequately satisfies the requirements of 30 CFR 57.11050.

5.2 SAFETY AND HEALTH STRATEGY

Design activities of the Yucca Mountain Project and its contractors are conducted in accordance with DOE policy to protect the health and safety of its employees, contractors and the public by complying with the spirit as well as the letter of applicable health and safety statutes, regulations, orders, and standards.

This has been accomplished during Title I design by selecting a design team with extensive experience in the design of mines and other underground facilities, initiating a safety analysis process, and reviewing the design to identify potential safety concerns. Safety analysis and review activities will continue throughout Title II. The results of these efforts to incorporate safety into the design will be carried forward into the construction and operation phases of the ESF.

5.2.1 RESPONSIBILITIES

The DOE has the ultimate responsibility to ensure that all health and safety requirements are adhered to during the life of the project.

The Architect/Engineer (A/E) has a responsibility to ensure that the design is free of recognized hazards that can be mitigated through design changes, and that the design conforms to the codes and regulations outlined in Section 5.1.

During ESF construction, representatives of MSHA conduct onsite inspections to ensure compliance with the provisions of 30 CFR Part 57 with regard to working conditions and operations per the memorandum of understanding between the DOE and the MSHA. Such inspections include monitoring of ventilation, construction methods, personnel qualifications and performance, methods of ground control, general housekeeping and working environment. Nonconformance with safety or health requirements will be brought to the attention of Reynolds Electrical & Engineering Company, Inc. (REECo) and the DOE for remedial action.

REECo is responsible for onsite monitoring of compliance with applicable safety requirements during construction and operation of the ESF, including compliance with DOE Orders and procedures as well as requirements of the REECo Safety and Health Department.

Any construction subcontractor will be familiar with, and comply with, all applicable safety and health procedures prior to commencing work. The subcontractor is responsible for prompt remedial measures upon notification by REECo of any non-conformance with requirements. Subcontractors institute a safety program to be followed by work crews, and periodically conduct safety meetings to ensure compliance with this program.

5.2.2 HAZARDS ANALYSIS

An industrial hazard analysis of the design was initiated during Title I. Fenix & Scisson, Inc. (F&S), Holmes & Narver, Inc. (H&N), and Los Alamos National Laboratory (Los Alamos) were required to develop internal design procedures to apply safety and reliability analyses to the ESF design. These safety and reliability analyses document the technical basis for the conclusions reached regarding the overall safety and reliability of the ESF and its operations.

F&S has hired a risk and safety analysis engineer to implement the safety and reliability analysis for the underground portion of the design. They have also engaged Arthur D. Little, Inc. (ADL), a firm with substantial experience in risk analysis and system safety, to assist them in the preparation of safety and reliability analyses.

The work scope for ADL includes designing a safety review procedure, training F&S personnel in risk analysis techniques, and participating in working sessions to develop credible accident scenarios, evaluate risks, and determine risk mitigation approaches.

Potential accident and failure scenarios and their initiators have been identified for the ESF design. Some preliminary analysis of these scenarios has been performed; these are scheduled for completion during Title II. Subsequent stages of the safety analysis include developing frequency estimates for potential failures and defining potential consequences of each failure type. Frequency estimates are based on engineering experience, historical operating data, and, when practical, engineering calculations. Consequences are identified and assigned a rating using a scale ranging from negligible effect to possible fatality. The level of risk associated with each accident/failure mode is assigned based on both the frequency estimate and the possible consequence. This systematic process provides reasonable assurance that all potentially hazardous processes and operations are identified and that appropriate mitigation measures are selected for the design.

Assurance that the design complies with applicable health and safety standards has been enhanced by the technical assessment review process. Technical assessment reviews were conducted at both the 50 percent and 100 percent Title I design levels. At the 50 percent review, the design documents were reviewed by representatives from the MSHA, the U. S. Bureau of Mines, the U.S. Army Corps of Engineers, the DOE Safety and Health Division, DOE/Headquarters, REECo, the Nevada Test Site Operations Office, Science Applications International Corporation, and other organizations. Approximately 200 comments were related to safety aspects of the design. The issues raised were considered by the A/Es and agreements were reached to make appropriate design changes.

At the 100 percent technical assessment review, comments from the 50 percent design were checked to verify that the design had been modified as agreed. Where the comment was not addressed, the comment was repeated as a 100 percent design comment. It was evident that the A/Es had revised the design to address comments related to safety that were developed during the 50 percent review. Notably, both the surface and underground layouts were modified to improve safety. Tapered guides were added to the headframe, a truck-mounted emergency hoist was added, the hoist house was divided with a barrier wall to isolate the hoists from each other, fire protection capability underground was augmented, and a dust collection system was added to the ventilation underground. The additional detail in the 100 percent design resulted in approximately 240 additional comments related to safety. Agreements were reached to make appropriate design changes to address these comments, either as revisions to Title I drawings, or during Title II design.

The safety analysis process performed by the A/Es focuses on mitigation of hazards by design. All significant risks are mitigated by the design, construction, or operational processes. When the mitigation must be supported by construction or operations, the necessary action must be referred to the constructor/operator by a documented and controlled process. This process is supported in part by existing safety operating procedures already in effect at the Nevada Test Site as part of the REECo Health and Safety Program.

REECo has a comprehensive Safety Manual establishing Safety Codes and Procedures and Job Safety Analyses (JSA). This manual is a loose-leaf binder, with each page being devoted to a single subject. The manual is organized into separate sections covering the following types of activity, equipment, and materials: administration; construction and maintenance; drilling operations; explosives; general work place requirements; heavy equipment and material handling; pressure systems and compressed gas; shop operations, equipment and tools; underground operations; fire protection; industrial hygiene; and hazardous materials control. Detailed instructions and precautions are presented in this manual which are followed to assure safe performance of each task or activity.

5.2.3 SAFETY PLANS

The Safety and Health Program Plan drafted by REECo for the Yucca Mountain Project ESF, represents a coordinated approach that tailors all aspects and disciplines of a comprehensive safety program. The plan provides safety and health plans, procedures, and practices for the overall surface and underground construction effort, and operational safety and health responsibilities for the duration of the ESF. The plan includes safety and health considerations (consistent with DOE procurement regulations) for use as provisions and/or special conditions for subcontract solicitations.

The plan results in the maintenance of a suitable environment for employees and visitors at the ESF. In addition, the plan provides further assurance that all facilities are properly designed and maintained, and that there is a minimum of adverse environmental impact.

REECo and subcontractor miner and underground worker training is in accordance with applicable MSHA standards, California Division of Industrial Safety Mine Safety Orders, and REECo Occupational Safety Codes.

Mine rescue team members hold a current certification for use of National Institute for Occupational Safety and Health (NIOSH)/MSHA approved two- to four-hour self-contained breathing apparatus. All training is in accordance with the current MSHA Mine and Rescue Apparatus and Auxiliary Equipment Handbook, and conducted by an MSHA Certified Mine Rescue Instructor. Certification is by a REECo mine rescue examiner.

Surface and underground emergency and evacuation plans reflect the requirements of DOE 5500.3, Emergency Preparedness Program and Notification Systems, dated March 23, 1988.

Other safety plan elements address the balance of the spectrum of relative functional considerations such as:

(1) Employment of detailed procedures that include safety steps, usually as checklists, although they may be augmented by Job Safety Analyses (JSAs).

(2) Accident and incident investigation and reporting at all levels of severity in compliance with DOE and REECo reporting requirements.

(3) Assurance that all procedures are reviewed for safety considerations in accordance with the hazard present. Such reviews ensure the acceptance of risk at the proper level of management.

(4) Recognition of formal design and facility readiness reviews as a vital element of the safety program.

(5) Inclusion of adequate safety requirements in all work orders, subcontracts, and similar documents. Briefings are recognized as essential to safety on all hazardous work with documentation required for enforcement.

(6) Provision of thorough and in-depth surveillance of all subcontract work with special awareness to unusual situations in which work patterns are out of the ordinary. Applicable safety codes, standards and regulations are enforced.

(7) Provision for continued awareness and control of such concerns as ventilation, dust control and airborne contaminants, explosives and blasting, first aid, personal protective equipment, self-rescue devices, specialized equipment, underground work procedures, ground control, and lock and tag procedures. Corrective action in any of these areas is prompt and complete.

The essence of the plan is that safety is the responsibility of each worker while implementation of safety procedures and controls is the responsibility of line management. To this end, execution of this program is coordinated with all participants.

5.2.4 DESIGN BASIS EVENTS

The basis for design of the structures and facilities for the support of the site characterization program conducted at Yucca Mountain considers a host of natural and man-made events. A summary of natural events and characteristics that are being considered in the design are discussed here.

5.2.4.1 Soils

An investigation of the soils at the Nevada Test Site (NTS) has been performed using standard soil-test procedures. The studies (H&N, 1983) indicate that there should be no problems with soil shrinkage, swelling, freezing, or thawing and that all components are excellent for use as foundation materials. The study recommends that all foundations be compacted to a minimum of 95 percent relative compaction. The following values are recommended for use in conceptual design and estimating calculations: bearing capacity after compaction - 6,000 pounds/square foot; California bearing ratio - 35; R-value - 65; and modulus of soil reaction - 400.

Percolation tests have confirmed that the soil is sufficiently absorptive to permit the use of drainage tile and/or seepage pits that are used in conjunction with individual sanitary sewage disposal functions at offsite facilities.

5.2.4.2 Wind

Seasonal wind roses showing fractions of time relative to three wind speed classes are shown in Figure 5-1. The charts indicate a predominately southerly wind direction in summer and a northerly direction in winter. Distribution of wind speeds above Jackass Flats (about 7 miles southeast of the surface facilities) are available and are used as design data. Diurnal wind reversal and seasonal directional shifts were noted based on data taken in the Jackass Flats area.

5.2.4.3 Tornadoes and High Winds

Tornadoes and high winds for the NTS have been characterized by Fujita (1981). The probabilities for these events are summarized in Figure 5-2 (Fujita, 1981). The design basis tornadoes (DBT) were characterized in the Fujita report: (1) DBT-77, an axisymetric tornado; and (2) DBT-78, the DBT-77 tornado with suction. The parameters associated with these two design basis tornadoes are shown in Table 5-1.

5.2.4.4 Hailstorms

One hailstorm per year can be expected for design purposes. Hailstones with diameters of 0.5 to 1 inch have been reported (Houghton et al., 1975).

5.2.4.5 Thunderstorms

The frequency of thunderstorms was compiled by the Yucca Flats Weather Station between 1962 and 1968 and is shown in Table 5-2. The Yucca Flats Weather Station is located approximately 28 miles east of the surface facilities site.

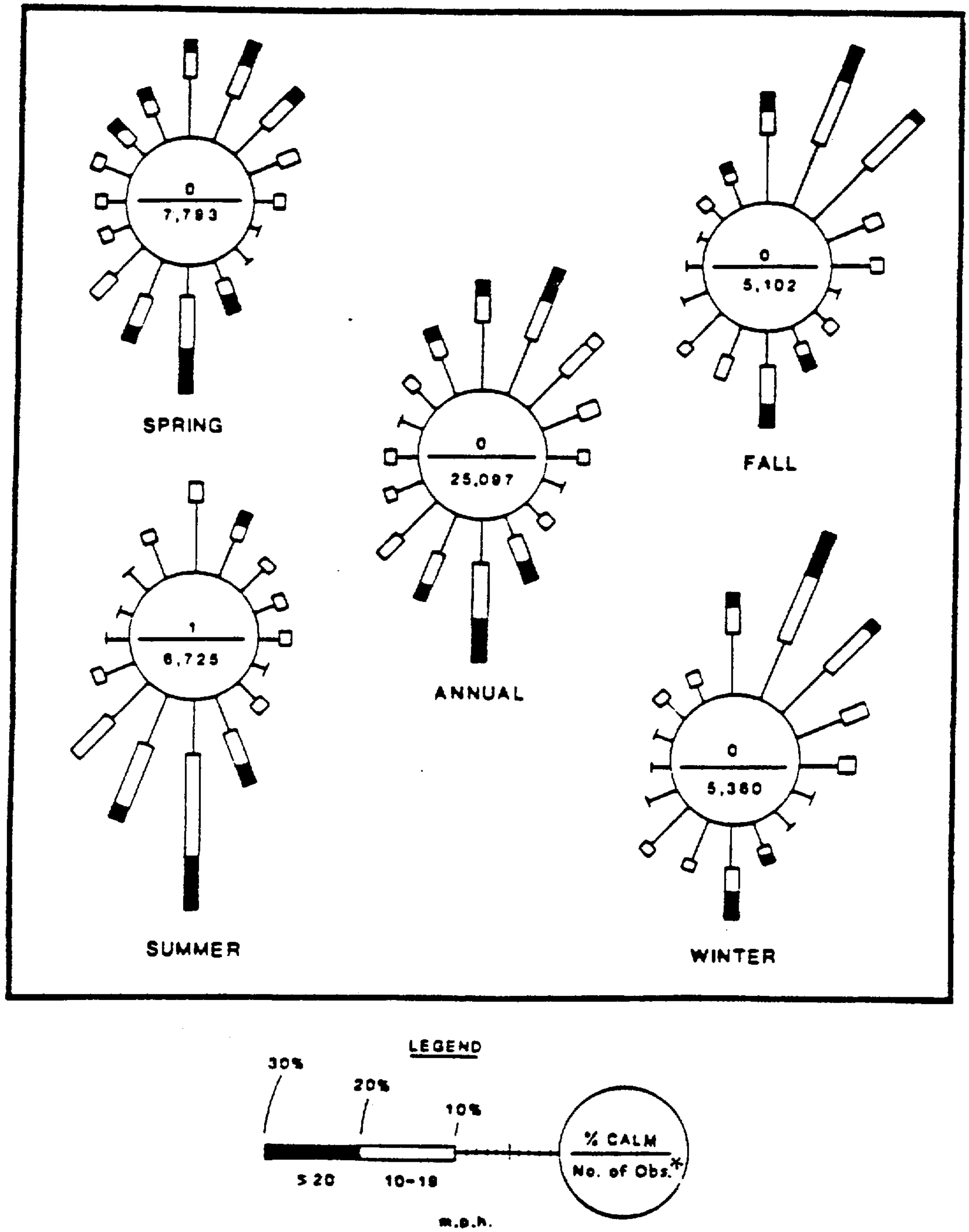
5.2.4.6 Temperature and Humidity

Temperature extremes of -30°F and 115°F have been observed on the NTS. The temperature conditions, including the daily ranges, are shown in Table 5-3. Dry bulb temperature values decrease 3°F per 1,000 feet increase in elevation.

5.2.4.7 Precipitation

Precipitation summaries for weather stations near Yucca Mountain are available and are incorporated in the design. All amounts are expressed in inches and include the water equivalent of snowfall during that period. Rainfall probability for durations from 5 minutes to 24 hours at the NTS were reviewed (Quiring, 1978). Snowfall is usually light and melts quickly.

Fog is a somewhat rare cold-weather phenomenon in Nevada. When it occurs, it is usually confined to the night and morning hours between November and March, when relative humidities are highest. As defined by the National Weather Service, fog is a condition that reduces the visibility to ¼ mile or less. Heavy fog occurs approximately 2 days per year. Light ground fog (visibility greater than ¼ mile) occurs occasionally. Poor visibility may also be caused by heavy blowing snow (Houghton et al., 1975).



*Obs. - observations

Figure 5-1. Wind speed classes.

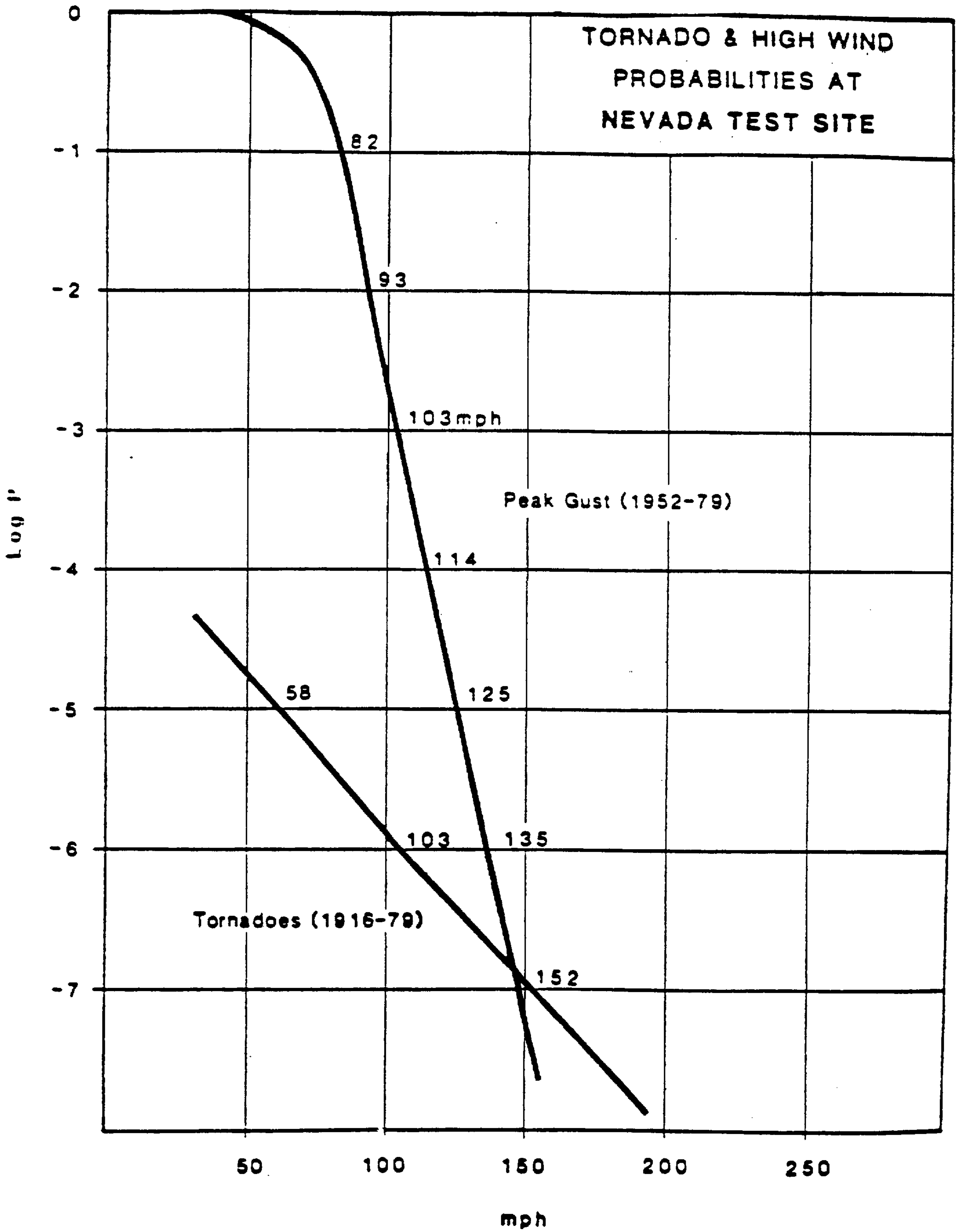


Figure 5-2. Tornadoes and high wind probabilities.

Table 5-1. Parameters of design-basis tornadoes applicable to the Nevada Test Site[a,b]

	Design-Basis Tornado	Tornado Probabilities Per Year 10^{-5}	10^{-6}	10^{-7}	Unit
Maximum Windspeed (F-scale wind)		58.0	103.0	152.0	miles per hour
Maximum Tangential Velocity (tornado)	DBT-77	44.3	83.9	129.7	miles per hour
	DBT-78	41.2	71.7	103.9	miles per hour
Core Radius (tornado)	DBT-77	35.4	67.1	103.8	meters
	DBT-78	33.0	57.4	83.1	meters
Translational Velocity (tornado)	DBT-77	14.8	28.0	43.2	miles per hour
	DBT-78	13.7	23.9	34.6	miles per hour
Maximum Pressure Drop (tornado)	DBT-77	4.2	15.1	36.3	millibars
	DBT-78	3.7	11.9	23.2	millibars
Maximum Tangential Velocity (suction vortex)	DBT-77	--	--	--	
	DBT-78	20.6	35.8	51.9	miles per hour
Core Radius (suction vortex)	DBT-77	--	--	--	
	DBT-78	11.4	17.9	23.4	meters
Translational Velocity (suction vortex)	DBT-77	--	--	--	
	DBT-78	23.1	42.3	64.1	miles per hour
Maximum Pressure Drop (center vortex)	DBT-77	--	--	--	
	DBT-78	0.9	2.7	5.8	millibars

[a] Air density = 1.079 kg/m^3.

[b] Fujita, 1981.

Table 5-2. Thunderstorm occurrence at Yucca Flat[a]

Thunderstorm Days[b]	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Average Number	c	0	1	c	1	2	3	4	2	c	c	c	14
Greatest Number	1	0	2	3	4	4	8	9	6	1	1	1	22

[a]Holmes and Narver, Inc., and Fenix and Scisson, Inc., 1970.

[b]A thunderstorm day is one in which thunder was heard at the station.

[c]Indicates less than 1 occurrence in 2 yr.

Table 5-3. Temperature and humidity tabulations at the Nevada Test Site Jackass Flats (Station 4JA)[a]

	Daily Temperature °F[b]			Daily	Hourly Relative Humidity (%)			
Month	Max.	Min.	Avg.	Range	0400	1000	1600	2200 PST
Jan.	72	8	40	22	67	49	35	60
Feb.	76	14	50	22	67	45	32	56
Mar.	80	23	52	25	58	31	23	44
Apr.	91	28	60	26	52	27	21	38
May	97	32	65	27	46	22	17	31
Jun.	109	43	76	29	39	19	14	25
Jul.	109	53	81	28	40	20	15	28
Aug.	106	50	78	27	44	23	16	30
Sept.	100	45	73	27	43	21	17	32
Oct.	94	34	64	25	46	24	19	36
Nov.	83	22	53	23	61	39	31	52
Dec.	73	20	53	23	68	50	49	69

[a]Based on data taken between May 1956 and December 1966.

[b]Quiring, 1968.

5.2.4.8 Solar

The monthly solar radiation for the Las Vegas area is shown in Figure 5-3 (Houghton et al., 1975). Peak radiation occurs in May, June, and July. The cloudiness, expressed in percentage of the sky covered, for the Yucca Flat area from 1962 to 1968 was also reviewed. The amount of solar energy received in a day can be expected to fall within the lines of 1 standard deviation 68 percent of the time (Houghton et al., 1975).

5.2.4.9 Tectonics/Seismicity

Tectonic activity in the region has decreased markedly during the past 10 million years (Carr, 1982). The pattern of tectonism appears to be responding to a cooler, more stable crust in which deformation now tends to be concentrated in relatively narrow zones. Localization and slowing of tectonic activity has allowed areas such as Yucca Mountain to remain relatively stable during the past few million years.

Stress measurements and modeling indicate a stress field with minimum principle stress in a northwest direction in the vicinity of Yucca Mountain. Hydrofracture experiments in one drillhole at Yucca Mountain show a low least-principal-stress value that is one-third of the effective confining pressure and effective vertical load. This state of stress warrants careful evaluation with respect to the possibility of incipient normal faulting at Yucca Mountain.

Yucca Mountain has been seismically quiet for even very small earthquakes over the 3½ year monitoring period. A maximum probable magnitude of 7+ was calculated for potential earthquakes occurring on active faults in the Yucca Mountain region. The most probable peak acceleration at Yucca Mountain for a 6.8 event on a nearby fault is 0.4 g, assuming faults at Yucca Mountain itself are inactive. A probability of 4 percent was calculated that a peak acceleration of 0.4 g would be exceeded in a 30-year period at any given location in the region.

Seismic studies at the NTS performed to date have evaluated the adequacy of available data pertaining to the ground motion that results from underground nuclear explosions and earthquakes for use in evaluating the stability of the site, in designing the waste disposal facility, and in meeting the licensing requirements of the NRC. Other major components of the seismic design criteria have been reviewed, including the identification of structures, systems, and components that are important to safety; establishment of performance criteria; and prediction of seismic effects.

Recent studies on the potential for volcanic activity in the area (Crowe et al., 1983) have shown that the hazards of large volume silicic volcanism are negligible because of the absence of this type of volcanism in the region during the past 6 to 8 million years. Crowe's calculations have also shown that the probability of a basaltic eruption is extremely low. The low probability of a basaltic eruption and the limited consequences of a radionuclide release indicate that the risk of locating a repository at Yucca Mountain is extremely low.

5.2.4.10 Flood Potential at the Yucca Mountain Site

The mean annual rainfall for the region is less than 4 inches; however, the potential for severe rainstorms exists as indicated in a U.S. Weather Bureau tabulation (Table 5-4) of expected maximum rainfall in Nye County for 100-year occurrence intervals.

The U.S. Geological Survey has performed an analysis of the flood plain hazards in Forty-Mile Wash and its principal tributaries (Squires and Young, 1982) in which data from 12 peak-flow gauging stations adjacent to the NTS were used as the basis for an estimation of the magnitude of the 100-year and 500-year flood peaks and regional maximum flood in cubic feet per second.

The maximum flood inundation limits for the 100-year and regional maximum flood do not reach the exploratory shaft area. The 100-year flood is that magnitude of flood that will be equaled or exceeded once, on the average, during any 100 year period. The regional maximum flood is estimated from records (or estimates) of floods of unusually large magnitude in a five-state region (Arizona, California, Nevada, New Mexico, and Utah) that encompasses the site without reference to recurrence interval.

5.2.4.11 Credible Accidents

The ESF Title I design has considered the occurrence of various credible accidents. Each area of the facility has been examined for possible accidents, fire, explosions, structural failures, operator errors, system failures, and other disasters indigenous to mining-related activity. Table 5-5 lists the scenarios identified to date, categorized by location. The issue of safety and examination of all design features relative to safety is an ongoing task that extends from conceptual design through final construction. During design, each of the listed accident events is documented using an outline approach. This examination delineates the following: accident/failure scenario, structure/system/component failure causing the event, mitigation design features or options; mitigation reference documentation, frequency and consequence evaluation rationale; risk designation after mitigation, and quality assurance classification/criteria.

By considering every possible credible event on an individual basis, property damage, potential injury, predicted consequences, and risk reduction methods are clearly and thoroughly documented. This exercise often exposes new or hidden scenarios through the interaction of events and systems that create an accident potential environment. Further amplification of these interactions may expose additional potential problem areas to be examined, thereby establishing a comprehensive and dynamic program to effectively mitigate the likelihood of hazardous occurrences throughout the life of the design. A Safety and Reliability Report which summarizes and consolidates these studies is available as a Title I document.

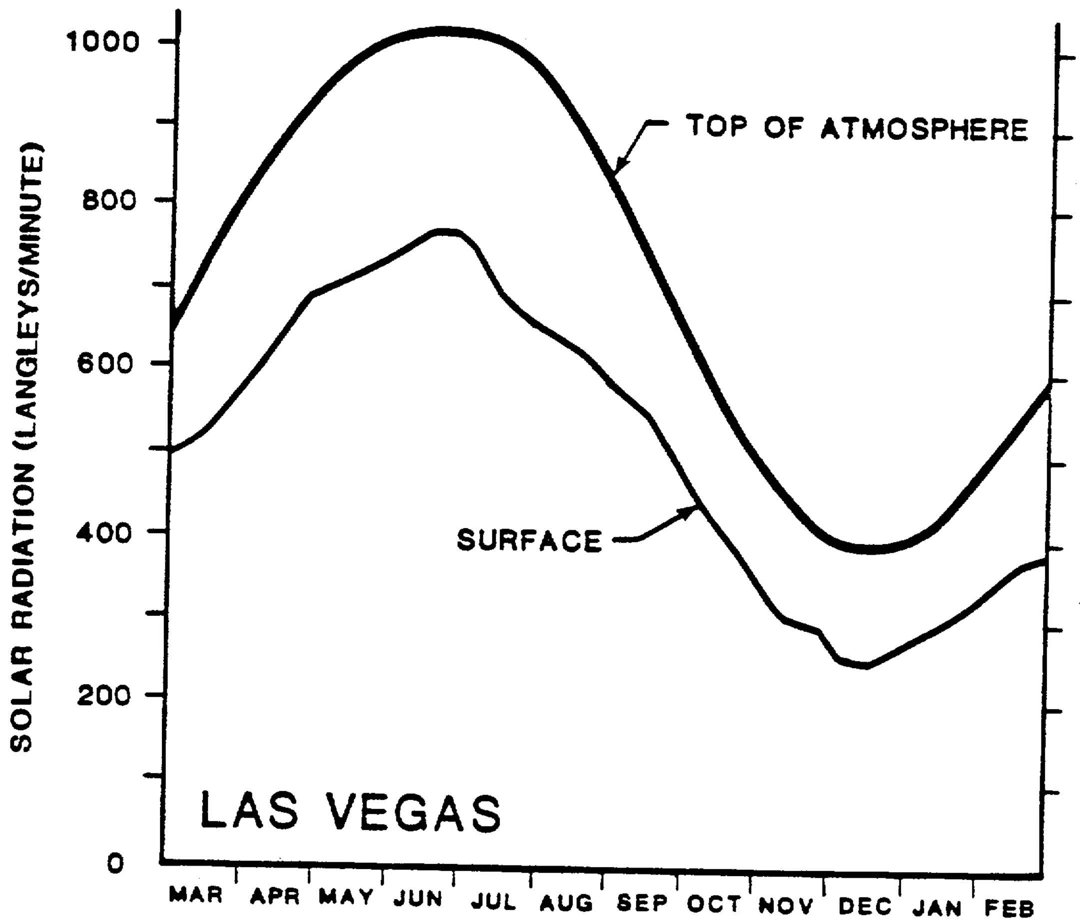
5.2.4.12 Life Safety Systems

Offsite support services are provided by contacting NTS Guard Station 900 by dialing 1-2-3. This call notifies the fire department, medical, mine rescue, industrial safety, Nye County sheriff, DOE operations, and the security system. A response time of from 80 minutes to 120 minutes is anticipated to mobilize and get these services to the ESF.

Table 5-4. Expected maximum rainfall occurrence for 100 years in Nye County*

Duration (hr)	Total Rainfall (in.)	Intensity (in./hr)
0.5	0.75	1.5
1.0	1.0	1.0
2.0	1.25	0.6
3.0	1.5	0.5
6.0	1.8	0.3
12.0	2.0	0.2
24.0	2.5	0.1

* DOE, 1980.



NOTE: A LANGLEY EQUALS ONE CALORIE OF HEAT RECEIVED ON A SURFACE AREA OF ONE SQUARE CENTIMETER, OR 3.69 BRITISH THERMAL UNITS (BTU) PER SQUARE FOOT. THE LATITUDE AT LAS VEGAS (McCARREN INTERNATIONAL AIRPORT) IS 36° -05'N.

Figure 5-3. Monthly solar radiation levels.

Table 5-5. Preliminary safety analysis credible accident list

1. Compressed Air Plant

Pipe rupture on surface - shrapnel, dust & rocks
Filter fire with subsequent oil explosion
Compressor explosion - shrapnel
Compressed air explosion due to failed pressure relief valve

2. Hoist (ES-1 and ES-2

Rope Failure at Hoist
Loss of 4160V Power
Hoist Electrical Equipment Failure
Hoist Hydraulic System Failure
Hoist Operator Loses Consciousness
Brake Failure
Clutch Failure
Communication Failure
Speed Control Failure
Fire in hoist house
Slack rope indicator failure
Level indicator failure

3. Headframe

Low flying aircraft hits headframe
Cage into crash beams - overturn headframe
Lighting strike on headframe
Windstorm - headframe destroyed or disabled
Loaded muck truck crashes into headframe
Earthquake - headframe destroyed or disabled
Head Sheave failure - rope jumps groove
Fire at collar disables headframe, guide, etc.
Skip hangs in scrolls
Man falls from headframe

Table 5-5. Preliminary safety analysis credible accident list (continued)

4. Collar

Man falls into shaft
Material or vehicle falls into shaft
Muck falls from skip dump
Flood waters enter shaft
Pipe rupture at collar
Waste water pipe rupture at collar/in shaft
Compressed air line rupture
Fan blows up - throws parts around collar
Muck barrier fails - dumps muck into shaft
Uncontrolled vent air recirculation
Fire near collar - to contaminate fresh air intake
Dust storm
Improper loading and unloading of supplies

5. Shaft

Conveyance stuck in shaft
Broken hoist rope
Suspended equipment drops from below conveyance
Equipment protruding form cage - knocks out sets, vent plenum/ducts, cables, pipes and guides
Personnel injury - part of body protruding from cage
Fire in shaft - (power cable, grease, etc.)
Tools dropped by work crew in shaft
Skip loses muck load during travel in shaft
Broken water line or compressed air line in shaft
Power failure to hoist
Broken guide, or conveyance jumps guides
Load shift in cage
Premature engagement of safety dogs during down travel
Personnel injury from material falling in ladderway
Communication line failure to hoist operator
Detonation of explosives transported in shaft
Seismic dislocation of shaft
Chairing device malfunction blocks conveyance travel
Sinking doors fail to open or partially open - cage or bucket crashes into doors
Skip loader lip fails to retract-cause wreck
Over travel limit failure - causes wreck.
Power cable grounds to structural steel
Overload of equipment or supplies - rope break, conveyance hang-up

Table 5-5. Preliminary safety analysis credible accident list (continued)

6. Stations

Personnel injury - material falling from shaft
Personnel falls into sump or grizzly
Material or equipment falls into sump
Personnel injury - object projecting into hoisting compartment, sticking limbs out of cage
Mobile equipment runs into shaft or tears out ground support, vent ducting, power, fans, communications
Tugger overhead crane cable break - personnel injury
Fire in station area
Personnel injury - breaking or moving boulders on the sizing grizzly

7. ES-1 Sump

Conveyance crash into crash beams in tail shaft
Flooding of sump
Muck spillage
Falling objects

8. ES-2 Loading Pocket and Sump

Loading flask dumps into sump
Loading flask overload
Loading flask fills an already full skip
Failure of surge bin gate - muck into sump
Conveyance crash into crash beams in tail shaft
Flooding of sump - pump failure
Falling objects

9. All Underground Areas

Ground support failure - fall of ground
Personnel injury - while scaling or removing rock slabs
Vehicular accidents, pinches, crashes, fires
Uncontrolled explosive detonations
Explosive release of bottled compressed gases
Failure of high speed rotating equipment - parts scatter
Concrete spills, burns and form failures
Suspended load support failures
Chemical spills, toxic fumes and burns
Electrical hazards
Accumulation of toxic fumes and gases, or oxygen deficient air
Runaway vehicle on slopes
Compressed air hose break
Fire/air door collapse or open prematurely causing personal injury
Hydraulic failure of support or lifting equipment
Main ventilation system failure
Electrical transformer or box/wire fire
Slips and falls

Table 5-5. Preliminary safety analysis credible accident list (continued)

10. MTL Power Center

Ventilation system failure and overheating
Fire
Personnel injury due to electric shock
Short circuit to ground
Explosion and fire of 4160V main cable

11. Equipment Repair Shop

Pinches, sprains, cuts, abrasions and contusions
Failure of hoists or rigging dropping suspended loads
Equipment falls off jacks/supports
Compressed gas tank ruptures or the valve is broken - creates a missile or projectile
Vaccination by high pressure hydraulic fluid
Electrical hazards
Tripping/slipping hazards
Rotating machinery hazard/failure - winding of hair and clothing, shedding of parts and flying pieces
Tire handling accidents
Fire (trash, electrical, oil and tires)
Chemical spills, toxic fumes and burns
Compressed air accident (tools, tire rims, horse-play etc.)
Welding - fire, burns, eye injuries
Slips and falls

12. Equipment Fueling Area

Fire
Equipment crash into storage,oils and grease
Valving/pipe failure
Slips and falls

13. Architectural

Battery acid spill
Battery explosion
Hydrogen explosion
Slipping hazard
Low head room hazard
Chemical spill
Fire
High winds - building failure

Table 5-5. Preliminary safety analysis credible accident list (continued)

14. Electrical

Lighting of substation
Unauthorized access and tampering of personnel at substation
Tampering of generators and automatic transfer switch
Ground fault
Equipment failure resulting in loss of power and lights

15. Mechanical

HVAC breakdown
Fire in surface facilities
Hoist rope failure

16. Civil

Vehicle accident at intersections
Explosion of explosive material
Flood deposits debris on road

CHAPTER 6

DESIGN ASPECTS

6.1 INTRODUCTION

Chapter 6 presents information to justify the selection of specific design features in the Title I design of the ESF. Key factors used in establishing the design are presented for each major subsystem. Alternatives evaluated are described, where appropriate. Studies, calculations, analyses, and/or reports addressing flexibility of various ESF components were performed.

6.2 SITE PREPARATION

6.2.1 ACCESS ROADS

The Subsystems Design Requirements Document (SDRD) requires a design basis of 200 construction and support personnel using the ESF. Transportation to the ESF is by bus, private, and government vehicles. Most personnel utilize bus transportation to the ESF, although some use private or government vehicles.

The design speed is 30 mph based on Nevada Department of Transportation (NDOT) standards. The standards take into account traffic volume and type of terrain. Though the maximum or peak traffic volume is not expected during shift change, the NDOT standard governs. Included in the road calculations and volumes are heavy loaded vehicles such as water trucks, concrete trucks, and tractor-trailer rigs. The road grade to the main pad is limited to 7.5 percent and the estimated speed up this grade is 20 mph.

The haul road is designed for 35-ton dump trucks, requiring extra width and a thicker base. The width of a 35-ton dump truck is 12 feet, 8 inches. The road surface is a double treatment of light oil and small chips. The base course is compacted type II material that is stabilized to bind the fine aggregate and produces a very high compaction ratio. The curves and stopping sight distance are designed for 25 mph. The maximum grade on the haul road is 4 percent. The explosives storage road is designed to handle tractor-trailer use. The explosives are delivered once a month in a tractor-trailer; however a pickup truck or some other light vehicle transports explosives to the shaft. The roadway is 24 feet wide, with 4 to 1 side slopes.

The existing H Road and Drill Hole Wash Road now has a surface treatment (inverse penetration of oil and chip) to the Nevada Test Site (NTS) boundary. The durability of the road appears very good and it has held up well for the loading it has received. The design provides similar treatment for all roads.

6.2.2 PADS

All pads are constructed to minimize the effects of pad construction on site integrity. Topsoil is removed and stored on the topsoil pad.

The area is brought to grade as shown on plans. Excavation is below grade about 9 inches, ±3 inches.

Type II material is placed in two lifts. Each lift is 6 inches (±1 inch) and compacted to 95 percent at optimum moisture. The first lift is a leveling course. The second course is full depth, brought up to grade and compacted to 95 percent at optimum moisture.

In fill subgrade, after removal of topsoil, the surface is compacted to 95 percent and select material from the borrow pit is brought in and mixed by alternate loading and blading with blasted rock if available. The lifts are ideally 8 inches, ±2 inches and compacted to 95 percent at optimum moisture. The procedure continues until the base course.

The depth of base course is determined by the California Bearing Ratio (CBR) and is a Type II material placed in 6 inch (±1 inch) lifts compacted to 95 percent at optimum moisture.

Several methods have been considered and are used to protect side slopes from erosion, depending on the fill slope characteristics. Ditches adjacent to berms and built on fill are concrete lined if velocities are greater than 4 feet/second. Runoff is placed in catch basins and piped down slopes where concrete grouted riprap is used for erosion control. Side slopes are sprayed with soil stabilizer and compacted and trimmed with side rolling during their construction. Site drainage and flood protection is discussed in Section 6.2.3.

Pads used for heavy traffic such as vehicle turnarounds or access to main pads have double surface treatment. Lightly traveled areas such as parking or personnel vehicle traffic areas are lightly oiled and sand blotted if required.

6.2.3 SITE DRAINAGE

The goal of the site drainage system design is to protect the site against potential floodwaters and control the runoff. Drainage channels and ditches are used to control flows in the existing water courses. Channeling is designed to contain a 100-year flood, and the 25-year flood is controlled by ditches. Minimum side slopes of 2 to 1 are used on all ditches and channels. Culvert design incorporates corrugated metal pipes (CMP) with end sections or concrete headwall and tailwall. Riprap protection is added as necessary. Though the grades of both channels and ditches conform with the general slopes of the existing water courses, scouring and erosion still takes place. Protection and control of erosion is done by reduced channel gradient, structures at abrupt changes in gradient and entrance of water course branches, drop spillways, energy dissipaters and riprap protection at key points.

The main pad is protected from the probable maximum flood by deepening and widening the existing wash above the pad. Added protection by way of an earth berm is added on the upper side of the pad to deflect any possible uncontained flood waters. Due to the extreme volume of flow by a probable maximum precipitation, culverts and roadways do not back water more than a 6-foot depth to prevent flash flooding produced by retention failure.

The ES-1 and ES-2 shafts are protected from the probable maximum flood as defined in the U.S. Bureau of Reclamation Probable Maximum Flood Study 6R-87-8. Auxiliary pads are protected from the waters of a 100-year flood. All roads, parking areas, and related improvements are protected from the effects of a 25-year flood.

6.3 SURFACE FACILITIES

Space requirements for surface buildings are obtained from projected staffing requirements by the participants. Their space and staffing projections are the basis of design for individual buildings. Pad space around the buildings is determined by the operational requirements of each facility to allow sufficient space for access to mechanical equipment, materials delivery and storage, limited vehicle parking, and pedestrian circulation.

To allow portability and flexibility during the 5-year life of the ESF study, trailers are used for the office and laboratory space requirements. Activities requiring special or unique features such as computer facilities, high ceilings, or heavy equipment/cranes are housed in pre-engineered metal buildings.

The structural criteria for all surface buildings are based on the Uniform Building Code requirements for live loads, allowable stresses, wind loads of 20 pounds per square foot (70 mph), and seismic zone 3.

6.4 SHAFTS

6.4.1 ES-1 SHAFT

The ES-1 shaft finished cross section has a 12-foot diameter. This is the smallest diameter that permits efficient construction and drilling of test-related horizontal holes. The excavation method selected for shaft construction is the drill and blast method. This selection is based upon program requirements to use industry proven methods and various characteristics of the shaft site rock. The requirements of 10 CFR Part 60 have been interpreted to mean that the effects of excavation on the rock mass should be minimized. This influenced the decision to adapt one of the controlled blasting techniques known as smooth blasting, selected on the basis of relatively low wall rock impact, safety, and constructibility. This method is intended to reduce overbreak, original crack dilation and new crack creation. The blast round is also designed to achieve sufficient rock fragmentation to permit efficient excavation of the blasted material, and to reduce vibrations that could damage the liner.

The ES-1 ground support and the shaft liner design take into consideration the various loads and construction-related requirements. The shaft collar and liner is designed on a competent rock foundation, considering thermal and seismic stresses, and authorized design input. Peak particle velocities generated by the shaft excavation blasting are considered, resulting in a recommended minimum separation of 20 feet from the blast surface to the bottom of the freshly poured concrete lining. This separation is sufficient to prevent structural weakening of the liner.

The separation of the liner bottom for the excavation bottom varies from 20 to 40 feet. This area of excavated rock wall may require temporary support to prevent blast loosened rock fragments from falling and injuring persons working on the shaft bottom. The method for support (short rock bolts and wire mesh) is selected because protection is required only from falling rock and because the rock is not stressed to a degree requiring structural support to prevent excavation collapse prior to placement of the concrete liner.

The thickness of the liner takes into consideration the stresses to which it is subjected and the methods available for concrete placement, embedment item clearances, and other working spaces indicated by testing needs. Resulting liner thickness is a minimum of 12 inches.

6.4.1.1 Shaft Sizes - ES-1

In April 1987, a study selected a suitable shaft location and diameter for the ESF. Results of this study are available in Sandia National Laboratory, memo to D. Vieth (DOE/NV) and a DOE/NV white paper. This study considered shaft diameters of 8, 10, 12, 14, and 15 feet, and produced an acceptability matrix based upon the following considerations: construction, ventilation, hoisting of broken rock, handling of material and equipment, personnel hoisting capabilities, and site characterization test support.

Based upon the requirements, the results indicate that the minimum shaft diameter that satisfies all the considerations is 12 feet. Additionally, the 12-foot diameter is the minimum size that can efficiently use conventional mechanical shaft sinking equipment and techniques. This factor alleviated many of the negative features associated with drilled shafts (i.e., loss of drilling fluid and the subsequent alteration of rock mass which would complicate proper site characterization).

Adequacy of the 12-foot diameter size is further supported in following analyses to determine the effects of predicted geostatic and seismic loads on the shaft. Preliminary results show that a 12-inch thick lining of unreinforced 5,000-psi strength concrete would be adequate for support. Since it is considered that the liner need not be watertight, and that it functions mainly to enhance ventilation qualities, prevent spalling of the rock wall, and support the shaft furnishings, the liner needs only to consist of the single 12-inch thickness. Therefore, finished inside shaft diameter is chosen to be 12 feet, while the minimum total excavated diameter is 14 feet to allow for lining thickness.

Shaft station cross sections at the Upper Demonstration Breakout Room (UDBR) and Main Test Level (MTL) meet the requirements of test configuration and configuration sizes necessary to accommodate shaft and station furnishings. Stability of the shaft brow is ensured by sizing the station in a manner that can be efficiently supported and satisfy the necessary testing program goals.

6.4.1.2 Design Loads

To evaluate the liner stresses for the ES-1 shaft, the three major sources of loading are considered: the ground pressure (geostatic load), seismic loads, and induced thermal loads.

Ground pressure or geostatic load is the term used here to describe loads imposed on the liner due to rock relaxation. Ground pressure may result from either elastic behavior, such as the elastic convergence phenomenon or inelastic behavior resulting from the formation and dilation of a relaxed zone around the shaft. Rock relaxation and the shaft convergence associated with shaft sinking is elastic if the elastic limit of the rock around the opening is not exceeded by the ground stresses. The extent and shape of the inelastic zone can be estimated by extending the analysis used to determine the mode of rock behavior. Such an estimate is useful because it gives an indication of size and shape of the regions that may require initial support before the liner is installed.

A seismic event, whether associated with an earthquake or a UNE, generates elastic waves that propagate outward from the source. The elastic waves from a seismic event induce transient stresses and strains in a rock mass and hence in any embedded structure, such as a shaft. Therefore, seismic loads are defined as the loads caused by a seismic event.

Thermal loads are the result of thermal expansion of the rock as it is heated by emplaced waste, artificial means associated with site characterization testing, or natural environmental conditions. It should be noted that the thermal loads are important in the full scale of the operations of the repository. Loads resulting from thermal effects occurring during the operations of the repository are discussed in more detail in Section 7.1.

6.4.1.3 Analyses

Radial and shear tractions develop on the outer surface of a liner as it offers passive resistance to distortions of the surrounding rock mass. Tractions resulting from this interaction between the liner and the rock mass are often used as loads in liner calculations. However, they differ from classic engineering loads in that their magnitude depends on the liner-to-rock stiffness ratio. In the methodology used to calculate the liner thickness, the free-field stresses, strains and displacements are collectively termed loads. The term free-field refers to effects in the ground that occur if the shaft opening is not present. By defining loads in this manner, they can be calculated independently without specifying opening shape, liner thickness and properties, and phenomena occurring at the interface of the liner and the rock.

Although numerous technical articles have been written about determining ground pressures on shaft and tunnel liners, there is no universally accepted method for calculating this component of liner load.

Design analyses of the shaft liner involve several steps. The first step includes calculations of the stresses and strains (or displacements) of the rock mass surrounding the liner. Two zones around the shaft are considered: the nonlinear (relaxed/plastic) zone adjacent to the opening, and the elastic zone extending further away from the shaft into the rock mass. Evaluation of the extent of the plastic zone is based on material properties assigned to the rock within this zone.

Material parameters for the nonelastic zone are derived by derating the Reference Information Base (RIB) data provided for an undisturbed rock mass at the horizon of interest, using a predetermined value of the derating factors.

Based on geostatic load calculations only, the value of the derating factor equal to 17.3 (Gleser, 1988) is required to generate rock failure at the depth corresponding to the MTL level at 1,050 feet and rock mass properties given in the RIB for the Topopah Springs Member (TSw2). The recommended percentage of such calculated radial displacements of the rock face corresponding to the associated rock strength derating factors are used as an input (free-field load) to calculate stresses within the concrete liner. In general, liner stresses due to geostatic stresses are performed according to the procedure used by Hustrulid (1984b).

Unlike surface structures such as buildings that tend to move and deform independently when excited by earthquake-induced ground motions, shaft liners move and distort compatibly with the ground in which they are embedded. Hence, static analysis is appropriate. Preliminary analyses involving calculation of seismic loads induced in the liner by earthquakes or UNEs are performed according to recommendations provided in the Draft Report by the Exploratory Shaft Seismic Design Basis Working Group (1988). The results (Mrugala 1988a; Gleser, 1988) indicate that generally, liner stresses generated by seismic loads are higher than the loads induced by ground pressure. Combined effects of geostatic and seismic stresses are evaluated using the principle of linear superposition.

Because the shafts are designed for use during the operational phase of the repository, the load induced as a result of thermal expansion of the rock as it is heated by emplaced waste is an important component of the total load on the shaft liner. Due to the complexities of the waste emplacement geometry relative to the shaft location, computer modeling is used to assess the induced thermal loads. Preliminary efforts in this field have been completed by Sandia National Laboratories (St. John, 1987). The general procedure for solution of the problem comprises the following four steps: (1) determination of the appropriate type of analysis; (2) preparation of the input data; (3) establishing boundary and initial conditions and model development; and (4) computation of temperature distribution and thermally induced stresses (strains) at the shaft location.

An example of the analysis performed to investigate the long-term thermal effects resulting from waste emplacement is presented in Appendix B.2 (Asgian, 1988). The synopsis of various studies performed to assess the stability of underground excavations at Yucca Mountain are provided in Appendix B.1 (Ehgartner and Kalinski, 1988). Further discussion of the analyses of shaft performance in conjunction with the performance of the repository are presented in Section 7.1.

6.4.1.4 Ground Support

Preliminary analysis to date (e.g., Hustrulid, 1984b) indicates that a lining thickness of 12 inches of 5,000-psi concrete is adequate for the ES-1 shaft. Implementation of the final liner may be preceded by installation of the primary ground support. To determine ground support requirements in the shaft, a modified rock mass classification is being developed, which involves an adaptation of the empirical methods originally developed for civil engineering tunnels.

In particular, the Norwegian Geotechnical Institute (NGI) Tunnel Quality Index (Barton et al., 1974) and the South African Council for Scientific and Industrial Research Classification System (CSIR) (Bieniawski, 1974) are applied to obtain the rock mass characteristics of the emplacement horizon (Langkopf and Gnirk, 1986). These rock mass classification methods do not include thermally-induced loads on the underground openings.

After waste emplacement, the thermally-induced loads are expected to be several times greater than the overburden loads; therefore, it is necessary to use thermomechanical models (i.e. numerical methods mentioned earlier) to estimate the forces applied to the underground excavations. In this regard, advantage is taken of the various analyses performed to date in which thermal effects were investigated (Ehgartner and Kalinski, 1988) to provide the ground support system necessary to accommodate these thermal effects.

Depending on the rock conditions encountered at various depths, a range of primary ground support schemes, including rock bolts of suitable lengths in combination with wire mesh and shotcrete, if necessary, are considered. In general, the ES-1 shaft is used for in situ measurements associated with site characterization. The design of the ground support encompasses provisions for testing activities, including (1) the safety of personnel involved both in mining and research activities; and (2) a minimum interference with testing activities wherever ground support would lead to distortion of the results of measurements.

6.4.1.5 Hoisting System for the ES-1 Shaft

The hoisting system for ES-1 provides safe and controlled access for personnel, equipment, and underground utilities to the UDBR and MTL of the ESF. The primary function of the hoist system is to service site characterization in shaft testing, and to provide a second means of egress for both levels serviced by ES-1. The system is not intended for hoisting MTL development rock, nor is it intended for primary underground operations support.

The hoist used for the ES-1 hoisting system (for both sinking and operations) is existing government furnished equipment (GFE) presently located on the Nevada Test Site (NTS). Evaluation and analysis of the hoist data, reveals that it has adequate capacity to support and satisfy the ESF requirements for sinking, operations and underground site characterization needs. The hoist is driven by two 450-HP 710-rpm GE motors with AC wound rotor induction and a 6-foot diameter by 7-foot face smooth single drum with 1-inch diameter hoist rope, giving it a design rated load capacity of 18,600 pounds.

The headframe is designed to accommodate all the sinking and operational phase requirements. The height of the headframe is determined by the arrangement of sinking phase equipment, which includes allowances for rock loading chutes, sinking bucket crosshead and headsheaves. The headframe is a rigid space frame structure with backlegs and vertical columns located symmetrically to the shaft centerlines.

The conveyance consists of an unbalanced single deck cage with a maximum capacity of 17 persons. The cage is sized to provide adequate capacity to transport personnel and material between the surface and subsurface levels.

In addition, the cage is capable of evacuating all underground personnel to safety within one hour in the event of an emergency.

The design loads for the headframe must satisfy the requirements of different phases of operations. The design loads acting on the headframe are dead load, floor live load, equipment live load, rope operating load, rope breaking load, the load attributed to overhoisting into crashbeams, jamming or colliding of the upcoming conveyance in the shaft, and snow load. Wind and earthquake loads on the headframe are treated similarly to any other structural analysis. In designing the overall headframe structure and its individual structural members, all the above-mentioned loads are considered in whatever combination produces the most unfavorable effect on the headframe.

The rationale for using the GFE hoist is its availability and the capability of supporting the hoisting requirements for both sinking and operational phases of the program. An existing GFE headframe was evaluated during the early phases of Title I. The original GFE headframe cannot be modified to provide the necessary flexibility and suitable accommodation for both hoisting systems, and required safety. Additional description of the ES-1 hoisting system is provided in Section 3.5.5.

6.4.1.6 Sinking Arrangement

The design of the shaft sinking equipment, methods and configurations is based upon the SDRD stated shaft size of 12 feet, the expected conditions as expressed in the RIB, the planned activity that occurs in the shaft as described in the SDRD and other concerns created by proposed activity that occurs during the shaft construction period. The shaft dimensions are as follows:

Finished diameter	-	12 feet
Excavation diameter	-	14 feet (minimum)
Attitude	-	Vertical
Ground Support	-	Unreinforced concrete

The construction and operating methods are adapted after analysis of alternatives. The drill and blast method is utilized for shaft sinking. This decision is based upon RIB data showing that the rock is highly fractured and has compressive strengths ranging above 20,000 psi.

The rock is too hard, and of a nature that does not permit efficient fragmentation by commercially available mechanical methods adaptable to the shaft sinking environment. The requirement for minimization of disturbance to the excavation perimeter by blasting indicates that one of the controlled blasting techniques should be employed for rock fragmentation.

The initial blast round is designed as a double pyramid cut, full bottom type, intended to pull a minimum round depth of 7 feet. This round depth is a practical maximum that can achieve acceptable fragmentation in the 14-foot diameter excavation. Full bottom, selected instead of a bench round, considers factors such as drill set-up time, the expected absence of flowing water, and the relative difficulty of drilling a bench round in a circular cross section. The smooth blasting technique is adapted to adequately control overbreak and reduce the blast energy transmitted to the perimeter rock.

The presplit method is not suitable because a hazard might be created by undetectable, unexploded perimeter charges. In order to obtain the desired results from the blasting methods, the drillholes must be accurately located and drilled. This requirement indicates that a shaft drill jumbo should be employed to better ensure drillhole accuracy. Likewise, the explosive charging or loading of the perimeter holes must be explicitly specified and controlled.

The shaft liner is placed by the jump form method as sinking progresses for worker safety. The shaft is lined with the permanent unreinforced concrete liner concurrently with sinking because of the program concern for compliance with the Project mandate to minimize the effects of excavation on the adjacent rock mass. To allow the rock to stand unlined and temporarily unsupported may have resulted in excessive rock destressing, along with crack and permeability increases and attendant safety hazards.

Various methods for excavated rock handling and removal are considered. Standard practice in shafts being sunk using the drill and blast method is to pick up the fragmented rock with small air powered trackmounted, overshot excavators; cable operated clamshell; orangepeel excavators or a boom-mounted, pneumatic cylinder-operated excavator called a cryderman loader. The overshot loader requires more space to operate than is available; the cable operated excavator needs more space and is inherently slow. The cryderman excavator is selected because of its ability to work in the 14-foot diameter excavation and its relative high rate of production. The cryderman requires a surface mounted hoist and a headframe mounted sheave to move it up and down the shaft during operation. The excavator loads the fragmented rock into a steel bucket hoisted by the main hoist, which is also the permanent hoist. Because space is available for only one bucket in the shaft, a single drum hoist can be used for the shaft sinking purposes.

The shaft is not equipped with its internal hoisting system structure until excavation and lining are complete to total depth. This assumption considers the alternatives of equipping as sinking progresses, or equipping in stages such as from the surface to the UDBR and then from the UDBR to the MTL.

Safety, efficiency and access to test locations indicate that the preferred time for equipping is after the completion of the excavation and lining of the shafts. This decision influences the design of the galloway and the man and material hoisting equipment, i.e. personnel are hoisted and lowered in the bucket used for material hoisting. The permanent hoist and headframe is used to support the shaft sinking operation.

The ropes supporting the galloway (see below) are supported from sheaves mounted in the headframe, with these ropes also serving as guides for the crosshead and bucket arrangement. This system is designed in compliance with the various federal and state codes governing shaft sinking activity.

The headframe permits the dumping of the shaft bucket by means of a large retractable pivoted dump chute mounted in the headframe designed to allow overturning and dumping of the shaft bucket. This item follows designs used worldwide in the shaft sinking industry.

The headframe design considers the ultimate hoisting load (breaking strength of the hoist rope); additional loads on the systems are galloway/guide ropes, dumping mechanism, and cryderman (excavator). A third set of loads is developed from the concrete shaft liner steel forms which are also suspended from ropes traveling over sheaves mounted in the headframe.

The shaft sinking activity also influenced the collar design. Applicable regulations require that the shaft collar be covered at all times when men are working in the shaft except when a conveyance is passing through the collar. The shaft collar is designed to comply with these regulations by including an air cylinder operated, solid steel door designed to cover the shaft and prevent objects from falling into it. The design of all collar barriers is intended to prevent persons and materials from falling into the shaft.

The shaft design provides for a continuous concrete lining from the collar to the bottom. Compliance with the Project requirement for minimization of rock disturbance and permeability increases require that the liner must be installed as the excavation progresses. The shaft liner concrete is placed in lengths of 20 feet or less, following the advancing shaft bottom at a distance of 30 or more feet. Past experience indicates that 20 feet is a practical and manageable pour length. The separation of the liner from the excavated bottom is intended to mitigate the damage from blasting on the uncured concrete.

The concrete forms are lowered by surface mounted winches with ropes traveling on headframe mounted sheaves. The forms are designed considering the hydrostatic pressure of a 20-foot height of fresh concrete, the rough service conditions and the impact loading of nearby blasting operations, a requirement to embed various structural steel and test-related items in the concrete shaft lining pour, and the need for a smooth, plumb, and round concrete lining surface. The forms are designed to resist warping and to be easily aligned.

Since the liner bottom is above the excavated bottom, fixtures known as scribing pins designed to support the formed bottom, provide a seal to prevent concrete loss. The 6-inch deep bottom form section is designed to be removed from the form body and lowered separately on the hanging rods to facilitate the alignment and sealing of the pour base.

The hanging rods are designed to support the initial load of the liner pour on the form bottom by transferring the load to previously embedded rods in the liner sections above. This feature requires that brackets and penetrations suitable to this purpose be designed into the form bottom.

Two methods of concrete transport from the surface to the lining location are commonly used: vertical pipe and a standard concrete construction bucket (the concrete transport method also influences the galloway design). Doors are placed at strategic locations in the shaft liner form to permit the placement of concrete and the use of vibrators for consolidation of the pour.

To break the forms away from the cured concrete surface and lower them to the succeeding location, the forms are designed with a vertical door running the length of the form barrel (exclusive of the bottom ring). When the door is opened, the form can be closed in upon itself a sufficient distance to allow it to break away from the cured concrete surface and be lowered. The door can then be closed by means of integral mounted screw jacks, which also return the form to its round cross section.

The forms are designed to permit reduction of pour lengths to accommodate such items as field-located test fixtures, and station brows and sills located at uneven multiples of 20 feet from the preceding liner bottoms.

A platform on which personnel can stand and work safely is required to support shaft sinking and mapping operation. The platform is called a galloway, work deck, or sinking stage. The galloway is designed to support a variety of activities during shaft construction.

The galloway provides a platform from which men and equipment can be hoisted from the shaft bottom to the surface. The galloway is designed with a well of sufficient size to permit the safe passage of the bucket through its decks and into the crosshead located on chairs positioned above the top deck. Additional space on the decks is provided for men to stand, handle equipment, and perform tasks such as rock bolting and concrete placement.

The upper deck of the galloway (which can be detached) is planned to be used as a platform to support the installation, maintenance and monitoring of test equipment located in ES-1 at various depths in the shaft. This activity requires several and perhaps frequent visits to some of the test fixture locations.

The ES-1 galloway conceptual design considers this requirement by providing guide wheels, a diameter sufficient to allow safe passage through the liner forms, adjustable railings, cutouts in the galloway perimeter to allow passage by installed pipes, ventilation tubes, and cabling brackets. In addition, to qualify the galloway as a man-carrying conveyance and be in compliance with applicable regulations, folding barriers, overhead protections, communications, safety catches and other features are added to the standard galloway design.

The bottom decks of the galloway support geological mapping and photography activity. This activity requires that the galloway be rigidly aligned in the shaft vertical center line while mapping and photography is in progress. The galloway is designed with positioning jacks to accomplish this. The bottom decks also have removable floors to allow work in and through the bucket well area. The design considers the requirement for camera mounting and strike rail operations by keeping the visual obstructions to an absolute minimum.

If the decision is made to transport concrete from the surface to the liner forms by means of a vertical pipe, fixtures are designed into the deck of the galloway to support a remix pot and concrete distribution hose and swivel. The present conceptual design provides structural and space capability for this equipment if it is required.

Upon completion of the shaft excavation and lining activity, the galloway may serve as a platform for installation of the shaft steel internal framework and conveyance guides. The galloway design accommodates this possibility.

As described above, the shaft sinking arrangement is the result of a blend of program and regulating requirements combined with industry experience and commercially available equipment. The conceptual drawings and specifications are amplified as refinements in plans are developed.

6.4.2 ES-2 SHAFT

The ES-2 shaft finished cross section dimension of a 12-foot diameter is developed from the same study discussed in Section 6.4.1.1, an analysis that considered the known subsurface program requirements, and industry construction practices. Twelve feet is the smallest diameter that permits efficient implementation of the drill and blast methods selected for shaft construction. This selection is based upon program requirements to use industry proven methods and various characteristics of the shaft site rock. Project requirements to minimize the effects of excavation on the rock mass influence the decision to adapt one of the controlled blasting techniques, known as smooth blasting. This technique has relatively low wall rock impact, safety, and constructibility. This method is intended to reduce overbreak, original crack dilation and new crack development. The blast round is also designed to achieve sufficient rock fragmentation to permit efficient excavation of the blasted material, and to reduce vibrations that could damage the liner.

The ES-2 ground support and shaft liner take into consideration the various loads and construction-related requirements. The shaft collar and liner are designed for a competent rock foundation, considering thermal and seismic stresses, and authorized design input. Vibration and flyrock effects resulting from the shaft excavation blasting are considered. Past experience indicates that vibration effects due to blasting can be reduced to acceptable levels if the base of the concrete pour is 20 or more feet from the blast surface. The steel forms provide protection for the fresh concrete from flyrock damage.

The separation of the liner bottom from the excavation bottom varies from 20 to 40 feet. This area of excavated rock wall sometimes requires temporary support to prevent blast-loosened rock fragments from falling and injuring persons working on the shaft bottom. Short rock bolts and wire mesh provide protection only from falling rock, because the rock is not stressed to a degree requiring structural support to prevent excavation collapse prior to placement of the concrete liner.

The thickness of the liner takes into consideration the stresses to which it might be subjected and the methods available for concrete placement, embedment item clearances, and other working spaces indicate by testing needs. Resulting liner thickness is a minimum of 12 inches.

6.4.2.1 Shaft Size of ES-2

The shaft diameter is based upon construction, ventilation, hoisting of broken rock, handling of material and equipment, personnel hoisting capabilities, and site characterization test support.

Based upon these requirements, the minimum shaft diameter that satisfies all of the considerations is 12 feet. Additionally, the 12-foot diameter is the minimum size that can be sunk efficiently using conventional mechanical shaft sinking equipment and techniques. This factor alleviates many of the negative features associated with drilling shafts (i.e., loss of drilling fluid and the subsequent alteration of rock mass which complicate site characterization).

Adequacy of the 12-foot diameter size is further supported in analyses to determine the effects of predicted geostatic and seismic loads on the shaft. Conceptual results show that a 12-inch thick lining of unreinforced 5,000-psi strength concrete is adequate for support and compliance with 10 CFR Part 60. By lining concurrently with the excavation of the shaft, excessive destressing, secondary crack formation, and the attendant permeability increase is reduced. It is not necessary that the liner be designed to withstand hydrostatic loads. However, additional benefits are gained from the lining, such as the smooth wall to minimize ventilation air friction. The lining also prevents spalling of the wall rock, and provides a support for the shaft furnishings and fixtures. Therefore, finished inside shaft diameter is chosen to be 12 feet, while the minimum total excavated diameter is 14 feet to allow for lining thickness.

The shaft station sizing in ES-2 deals only with the MTL level where an excavated rock handling facility is planned. In this location of the shaft, cross sectional configuration is dictated by the spatial requirements of the loading pocket, measuring bin, and rock chute. Additional depth of the shaft is required to accommodate these mechanical systems, but is not influenced by testing needs as experienced in ES-1 shaft sizing.

6.4.2.2 Design Loads

The discussions for ES-2, as well as the relative position of the ES-2 shaft with respect to the future repository, are similar to those of the ES-1 shaft. Hence, the relative design loads are identical to those used for the ES-1 shaft (Section 6.4.1.2).

6.4.2.3 Analyses

Dimensional similarities between the ES-1 and ES-2 shafts results in the application of identical approaches to the assessment of the ES-2 shaft stability. For a more detailed discussion of the methods used to assess the performance of the shafts in the ESF, refer to Section 6.4.1.3.

6.4.2.4 Ground Support

As discussed earlier, a lining thickness of 12 inches of 5,000-psi concrete is adequate for a 12-foot diameter shaft (ES-2). Since in the ES-2 shaft only a minor interference with underground measurements is expected, the primary support needs are determined on the basis of the rock mass class encountered at the given location. For a more detailed discussion, refer to Section 6.4.1.4.

6.4.2.5 Hoisting System for the ES-2 Shaft

The hoisting system for the ES-2 shaft is intended to function as the primary system for transferring personnel, equipment and excavated rock between the surface and underground. The hoist system is made up of individual components, each installed separately, but acting as an entity. The components include headframe, hoist and hoist controls, ropes and attachments, conveyances, and shaft furnishings (guide system).

Each component of the system is designed taking into account all of the discipline requirements (mechanical, structural, electrical, etc.), and is designed to fit such that the overall system performs as required.

The hoist to be used for the ES-2 hoisting system is existing GFE, with performance characteristics capable of fulfilling the requirements for sinking, operations, and underground site characterization needs. The hoist is a double drum double clutch type, driven by a 4,160-V, 1,500-HP AC wound rotor motor. The drums are 12-foot diameter by 6-foot face, parallel grooved, and utilize a 1½ inch diameter flattened strand hoist rope. Additional hoist details are provided in Section 3.5.5.

The headframe is designed to satisfy all the sinking and operational phase hoisting requirements. The height of the headframe is based on the operational phase skip dumping arrangement, which includes allowances for dump scrolls, surface rock loading chute, conveyance overtravel, crash beams and headsheaves. The headframe is a rigid space frame structure with backlegs and vertical columns located symmetrically to the shaft centerline.

The conveyance for the ES-2 shaft consists of a double deck cage over skip combination in balance with a counterweight. The cage has a maximum capacity of 17 persons per deck, while the skip has a capacity of 10 tons. The size of the cage provides adequate capacity to transport personnel, material and equipment to the MTL, completely independent of the science activities planned to be conducted in ES-1, and provides adequate capacity for total underground personnel evacuation in the event of an emergency. The capacity of the skip is based on the maximum anticipated underground rock removal rates during the ESF construction and underground testing phases.

The design loadings for the headframe must satisfy the requirements of both the developmental and final operational phases. The design loads considered in the headframe design are dead load, floor live load, equipment live load, rope operating load, rope breaking load, the load attributed to overhoisting into crash beams, jamming or colliding of the upcoming conveyance in the shaft, and snow load. Wind and earthquake loads on the headframe are treated similar to any other structural analysis. All of the above-mentioned loads are considered in whatever combination produces the most unfavorable effect on the headframe.

6.4.2.6 Sinking Arrangement

The design of the shaft sinking equipment, methods and configurations is based upon the SDRD stated shaft size of 12 feet, the expected conditions as expressed in the RIB, the planned activity that occurs in the shaft as described in the SDRD and other concerns created by proposed activity that occurs during the shaft construction period. The shaft dimensions are stated in the SDRD or other authorized sources as follows:

Finished diameter	-	12 feet
Excavation diameter	-	14 feet (minimum)
Attitude	-	Vertical
Ground Support	-	Unreinforced concrete

The sinking arrangement for the ES-2 shaft is virtually the same as for ES-1, except for the fact that ES-2 is not encumbered by testing considerations. The shaft sinking detail is not repeated here (Section 6.4.1.6). The only testing-related activity planned in ES-2 is shaft wall mapping, but, perched-water testing will be accommodated as needed.

6.5 UNDERGROUND EXCAVATIONS

6.5.1 UPPER DEMONSTRATION BREAKOUT ROOM (UDBR)

This section describes the sizing and layout of the UDBR to accommodate testing and operational requirements. Rock loads, thermal loads, seismic loads, and rock support system section and design are also discussed.

6.5.1.1 Sizing

The size of the UDBR is determined by the Principal Investigators (PIs) to test in a full-sized repository-type opening with a high lithophysae content. The UDBR consists of two sections, which extend approximately 175 feet to the west and 85 feet to the east on both sides of the shaft. Both sections are designed using a common drift width of 25 feet. The design heights are 19 feet and 14 feet, respectively. The longer section of the UDBR is designated for the tests that cannot be influenced by the shaft excavation. Both sections are used to conduct the excavation effects test. The short section can also be used as a refuge chamber when fire doors are sealed.

6.5.1.2 Design Loads

In general, three types of loads are considered during analysis of the underground opening stability at the UDBR level: geostatic loads, seismic loads, and thermal loads. Further discussion of the methods involved in determining the magnitude of design loads is presented in Section 6.5.2.2.

6.5.1.3 Analyses

Although the UDBR is excavated at a different level than the remaining systems of the ESF underground openings, its size and shape is similar to the size and shape of the largest excavations currently considered at the MTL. In general, the type and extent of analyses associated with evaluation of the UDBR stability is similar to those performed for other ESF openings. For a more detailed discussion, refer to Section 6.5.2.3.

6.5.1.4 Ground Support

In general, ground support needs are dictated by the rock mass class encountered at the particular location. In order to provide a uniform approach to the selection of ground support, a rock mass classification system is used. This system is uniform for all underground openings and is capable of accommodating a range of ground conditions anticipated at the ESF. For more details associated with the methodology involved in the development of this system, refer to Section 6.5.2.4.

6.5.2 MAIN TEST LEVEL (MTL)

The development of the MTL layout as an overall system evolved as a result of ESF Interface Control Working Group meetings and considerations of various requirements pertaining to the mission of the ESF in general.

6.5.2.1 Sizing

Size of underground openings and the general form of the MTL layout is based on three major criteria: (1) safety of operation, which dictates the minimum opening dimensions necessary to accommodate mining equipment used in the MTL development and workers' safety; (2) needs associated with testing and site characterization; and (3) consistency with the conceptual design of openings in the repository (MacDougall et al., 1987).

To provide a consistent methodology for the selection of rock support that accommodates a range of rock conditions anticipated underground, the dimensions of underground openings are standardized. The openings range from 16 feet wide by 14 feet high to 25 feet wide by 14 feet high. An arch-shaped roof is used because it is more stable than a flat roof and is consistent with the conceptual design for the repository.

The size of the larger openings is equal to the full-scale openings considered for the future repository. In addition, the pillar sizes (separating various testing areas) are based on testing requirements and the need to protect specific structures vital to operation of the ESF (e.g., shaft stations).

6.5.2.2 Design Loads

In general, three types of loads are considered during underground opening stability analysis at the MTL: geostatic loads, seismic loads, and thermal loads.

Rock properties provided in the RIB indicate that the Topopah Springs (TSw2) tuff can be treated as an elastic medium. Therefore, in the rock mass surrounding the opening, the loads resulting from the modification of the virgin stress field are determined using the theory of elasticity. However, the initial stresses concentrated around the excavation may, in time, undergo redistribution as a result of various phenomena occurring at interfaces between discontinuities and differences in properties of rock materials involved. In order to account for these phenomena, the time-dependent properties of tuff must be considered.

Seismic loads of two different origins are considered: natural seismicity (earthquakes), and underground nuclear explosions (UNEs), which are conducted periodically at the NTS. At the level of the underground facility, it is provisionally assumed that peak accelerations are the same as those at the surface and are equal to 0.5 g.

Further investigations, data collected during site characterization, and the development of a satisfactory model for the surface and downhole data may result in revisions to peak accelerations. The preliminary calculations for seismic-induced stresses in the MTL drifts due to a design basis earthquake are presented in Appendix B.4 (Ehgartner, 1988).

Thermal loads from heating the rock are evaluated using numerical modeling techniques. The results of parameter sensitivity analyses reported by Ehgartner (1987) indicate that changes in rock strength and modulus affect the thermal loads exerted upon the opening and associated safety factors of the drift more than the thermal input variables.

Pillar loads are evaluated (Mrugala, 1988b) using a standard tributary area approach, where they are assumed to be equal to the weight of a rock column extending one half of the entry size on each side of the pillar and up to the surface above the pillar.

6.5.2.3 Analyses

The concern in the design of the underground openings is that they are stable and usable for exploratory activities. For personnel safety, stability implies that no localized rock fall of a size sufficient to cause serious personnel injuries occurs, and no catastrophic failure of the openings that could block personnel access and egress occurs.

Numerical methods provide the means by which the effects of long term, time dependent loading conditions can be investigated. These methods have been employed extensively in recent years to study the effects of static and thermal loads on the stability of underground openings in tuff formations.

The thermal and mechanical effects of underground openings on stability are the focus of 15 reports or studies published to date on this subject (Ehgartner, 1988; Asgian, 1988). These analyses have used a variety of numerical and empirical approaches: finite-element methods, boundary-element methods, and tunnel-indexing methods. Similarly, different constitute models are used: elastic models, ubiquitous-joint models, compliant-joint models, and elastic-plastic models. Other items that vary in the analyses include sizes and shapes of openings, depths, thermal and mechanical properties, and fracture properties in situ conditions.

In general, these analyses point to the conclusion (Ehgartner, 1987; Ehgartner and Kalinski, 1988) that underground openings, as currently designed, are predicted to remain stable. Additional effort is needed in two areas: adaptation of the rock mass classifications to tuff conditions, and verification and validation of the codes used in numerical analysis.

Evaluation of pillar stability is generally associated with the areal extraction ratio, which provides the basis for comparisons of various underground layout concepts. Overall extraction ratio, calculated for the entire ESF, assuming the constant height of 14 feet for all the openings, is compared to several local extraction ratios calculated for the various sections of the ESF (e.g. shaft station areas and other underground section where more testing activities are to be performed). It appears that for the ESF, in its current form, the overall areal extraction ratio is equal to 27 percent, whereas the local extraction ratios range from 25 percent to 32 percent for the four areas of activity considered in these analyses.

Considering the gravity loading, a consistent method for stability assessment of pillars with different dimensions is used in which five commonly-used pillar sizing formulas are employed (Mrugala, 1988b). The recommended factor of safety for each formula assesses the long-term stability of the pillar.

Results of these analyses indicate that scaling rules, which relate the laboratory-determined strength properties of tuff to the strength of the rock mass in situ, need to be established more firmly. These preliminary analyses indicate that pillars of the minimum width of 35 feet to 40 feet appear to have a safety factor sufficient to satisfy long-term stability requirements.

6.5.2.4 Ground Support

Rock mass classifications (Barton et al., 1974; Bieniawski, 1974) provide the basis by which design analyses are translated into the design. The methods were developed through an extensive study of case histories of underground openings in many types of rocks, including tuff. The methods, although developed for a variety of rocks, do not in their current version incorporate the effects of heat in the ground support recommendations.

The preliminary rock mass classification system consistent with the conceptual design for the repository has five ground support categories defined for Yucca Mountain. The categories encompass the full range of conditions reported by Langkopf and Gnirk (1986) and Johnstone et al. (1984) in studies involving empirical rock mass classifications of the Yucca Mountain tuff.

Table 6-1 describes the categories in general geologic terms and presents a summary of the proposed ground support measures for each category. Observations and measurements made during excavation of the ESF ascertain the required ground support at any given location in accordance with predetermined standards.

6.5.3 DEVELOPMENT AND MINING PLANT

The ESF has four major areas of subsurface development: shafts, the UDBR, the MTL, and exploratory drifts. Each construction center is designed both to the individual requirements of the area and as a part of a larger overall system. The total system also conforms to the conceptual design aspects of a repository as known at the time of Title I ESF design.

Shafts are sunk by conventional mechanical excavation methods to avoid the possible alteration of the adjacent rock mass and the hydrological system. The ES-1 shaft is dedicated to testing purposes to support planned site characterization testing in the shaft. Conversely, the ES-2 shaft acts as the production shaft and does not contain planned site characterization tests other than mapping of the freshly excavated shaft wall. Since a considerably higher level of testing activity takes place in ES-1, its associated sinking rate is approximately half that of ES-2. Sinking on both shafts commences at about the same time, with ES-2 reaching the MTL about five months sooner than ES-1.

As ES-1 is sunk, a station is established at the UDBR level, approximately 600 feet from the surface. At this time sinking stops, and development of the UDBR is completed. All planned mining development on this level is done at this time, since future excavation is extremely slow and cumbersome because of the small capacity for handling excavated rock at this level station. Drilling for the excavation effects test is done in the UDBR prior to continued sinking. After the UDBR is completed, ES-1 progresses at it normal sinking pace until the MTL is reached. At that time, excavation of the station takes place, along with preparation of a second excavation effects test, prior to sinking to the final depth.

Table 6-1. Ground support categories

Ground Class NGI* Relative Description	A Very Good	B Good	C Fair	D Poor	E Very Poor
General Ground Condition Relative to Yucca Mountain	Massive, welded tuff; little or no jointing; dry or slightly damp.	Densely welded tuff with one to three joint sets; joints are tight with no alteration.	Densely welded tuff with multiple or random joint sets; little or no joint alteration.	Heavily jointed, welded tuff; typical of conditions at transition within flow units.	Fault zone; crushed tuff in a matrix of low-strength gouge; heavy alteration and possibly minor water.
Ground Support System Recommended for Conceptual Design	Untensioned, friction-type bolts on variable spacing, as needed; typical grid spacing of 6.5 to 10 ft.	Untensioned grouted dowels on a 5- to 6.5-ft grid spacing with wire mesh or chain-link fabric on ribs and crown.	Untensioned grouted dowels on a 5- to 6.5-ft spacing with welded wire mesh and 2 to 3 in. of shotcrete.	Initial support: friction bolts on a 5-ft spacing with 2- to 3-in. fiber-reinforced shotcrete; final support: welded wire mesh, grouted dowels with 3 in. of additional shotcrete.	Light steel ribs or lattice girders placed near face; fiber-reinforced shotcrete 3 to 4 in., followed by welded wire mesh, grouted dowels, and 2 in. of shotcrete.

*Norwegian Geotechnical Institute (Barton et al., 1974).

ES-2 is sunk at a rate greater than ES-1, due to a reduced number of tests. The shaft is furnished, and the loading facilities installed at the ES-2 shaft station. The first priority in MTL development is the excavation of the Demonstration Breakout Room (DBR); therefore, development efforts target this first. During the DBR test work there is no development on the MTL. Since there is a significant amount of time before breakthrough is possible to ES-1, development of the MTL continues by excavating the shaft pillar loop at ES-2, followed by drifting directly to the ES-1 station location. The MTL support area (or core area) can be developed in its entirety before connection between shafts is accomplished, since development support can be totally furnished from ES-2.

It is important that development of the core area not be delayed for various reasons; no full scale testing is allowed on the MTL prior to shaft connection. Space for vital electrical and gathering equipment must be provided prior to excavation for these tests. Any delay in MTL core area development caused by shaft connection restrictions, and consequent possible delay of ES-1, would extend the entire program schedule by the amount of the time lost to the delay.

Once shaft connection is established, permanent data acquisition facilities are installed and tested. The remaining drifting on the MTL is then excavated according to priority needs, with full capabilities of facility support and data retrieval.

Following the development of the MTL, three exploratory drifts are driven to predetermined areas. These drifts are driven in superimposed position to potential repository drifts, but at less than repository size. However, at several locations full repository sized drift openings are developed. The activities are scheduled for completion after MTL test area development is complete.

Coordination of all development sequences in the manner described allows for economical use of planned utilities. Usage is series oriented, thereby decreasing the physical sizes of certain systems such as water supply, mine waste water removal and ventilation. Time phased support assures an efficient, cost-effective development scheme.

6.6 UTILITIES

6.6.1 POWER DISTRIBUTION SYSTEM

The mine power center (Section 3.8.1) is the main subsurface electrical power supply for all MTL underground electrical loads. As the mining and mechanical requirements are determined, the horsepower, kilovolt-amp (kVA), and/or kilowatt (kW) capacity is calculated for the ventilation, waste water, lighting, testing, and IDS loads. The total connected load is utilized in determining the demand factor loading by using the average assumed values of actual run times of all loads divided by the diversity factor of one (1.0). The 1.0 diversity factor allows a certain degree of safety factor to be added to the loading. A cumulative total connected load of 5,284 kVA and a cumulative maximum demand factor load of 2,929 kVA exists for the MTL and bottom-of-shaft underground areas.

The mine power center transformer kVA ratings are established using the maximum demand factor loading. Refer to technical analysis FS-ST-0052 for the complete load analysis. The rationale for choosing the mine power center configuration, illustrated in FS-GA-0201, is based on the SDRD criteria stating that redundant 4,160-V armored power cables be supplied down each shaft feeding a substation or power center with adequate capacity to supply all construction, operations and testing loads for site characterization and adequate redundancy for acceptable system reliability. This requirement leads to the use of the double-ended or secondary selective unit substation arrangement.

6.6.2 COMMUNICATIONS SYSTEM

The system designed for the subsurface communication and subsurface to surface communication is a dual function dial/page type mine telephone system. It combines the capability of regular rotary dial operated public telephone exchange with a page-all system.

Each station in the system is connected through an interface unit to a separate line of the telephone exchange switchboard. However, up to five parallel extension stations can be connected to the same line. Permanent stations and plug-in type telephone jacks in the MTL utilize this feature. Permanent stations are installed where operational, maintenance or testing personnel are located such as IDS, shop, and shaft stations. Where personnel can be located for performing different temporary work tasks, plug-in telephone jacks are spaced no greater than 200 feet apart. A portable dial/page telephone station can be connected to the jack and removed when the need no longer exists.

Permanent stations are also installed in strategic places important for emergency use. Exact locations of the dial/page stations are determined during Title II design, after the MTL layout is finalized. The mine dial/page phone system is designed as an alternative to the mine page phone system which lacks privacy and multiple conversation capabilities. Advanced features of the system include a separate line for each station so that the number of independent, simultaneous conversations is limited only by the number of stations. Any station inside the subsurface area can call any telephone outside the area as well as any other mine dial/page station within the area.

Automated circuits answer incoming calls and permit the calling party to page desired persons via a self-contained horn-type loudspeaker. This voice page is preceded by a distinctive tone. A calling party may page a person at the location expected without disturbing people at other stations. A dial-access, all-station paging facility is provided for use in reaching people not at their normal location. This facility also reaches those stations using the system for normal conversations. A pushbutton-controlled, all-station page capability goes into operation automatically in the event of a telephone switchboard or connecting cable failure. The stations are equipped with an indicator light emitting bright, repetitive flashes during incoming voice page and waiting-for-an-answer periods. This aids in signaling a call in noisy areas or at stations located in remote areas. The mine dial/page phone system provides the convenience of a telephone station plus additional paging facilities in dusty locations where standard telephone equipment is considered not suitable for the environment.

All these functions take place over a single pair of wires between the station and the interface, which is connected to the telephone switchboard with another corresponding pair of wires. Connection to the surface facilities is made by separate multipair telephone cables running in different shafts, and providing 100 percent redundancy to the subsurface communication system. In addition to the mine dial/page telephone system, the audio alarm communicators of the fire detection and alarm system are utilized as emergency communication speakers for the public address system.

Alternatives for the communications systems were investigated and the following conclusions were reached. Expansions of the DOE/NV telephone system meet the requirements of the users. One multichannel intercom system meets the needs of the users. A closed-circuit television system for hoisting operations improves safety. The communication system is served by the uninterruptible power system. Expansion of the DOE/NV microwave system meets the needs of the users. Dust-proof enclosures must be used for all subsurface communications components.

6.6.3 LIGHTING SYSTEM

As mentioned in Section 3.8.3, the general subsurface MTL mine lighting system consists primarily of incandescent, fluorescent and emergency lighting. Since the desired incandescent lighting illumination level in the drift and test alcove areas is 3.0 fc on a horizontal plane 30 inches above the floor level, a lamp rating of 150 watts at 120 VAC is utilized. The number of fixtures used is based on the largest drift size and length of drift.

An Illumination Engineering Socity and DOE 6430.1a requirement to use fluorescent lighting in shop areas at a recommended illumination level of 50 fc on a horizontal plane 30 inches above the floor level requires the use of 90-watt preheat fixtures. The number of fluorescent fixtures is also based on the drift size per length of drift.

The SDRD also requires that emergency lighting be located underground in each shop area, testing area, power center, shaft stations and access drifts. The unit must be capable of illuminating the aforementioned areas in case of total power loss underground by the use of a battery backup system. The fixture consists of two lamp heads, 30 watts each, with an input voltage rating of 120 VAC and a 12 VDC, 90-minute rated battery.

At present the total connected MTL lighting load is approximately 100 kVA. Refer to technical analysis FS-ST-0052 for a summary of the underground lighting loads and to FS-ST-0047 for a detailed development of each lighting system.

6.6.4 VENTILATION SYSTEM

The ventilation features for both the ES-1 and ES-2 shafts are combination intake and exhaust air systems. Each shaft is essentially split, with a metal duct primarily used as a separate exhaust airway. The main exhaust fan for each shaft is located at the surface, and is provided with a 100 percent backup system to assure continuous ventilation during emergency or scheduled preventive maintenance.

The intake air flows down each shaft into the MTL and exhausts to the surface through the metal ducts. Air distribution into the various MTL development and test areas is controlled by a combination of fans, ducts, regulators and doors. The subsurface openings are subjected to the negative pressure of the ventilation system, generating an optimum airflow design capacity of about 220,000 cfm to 234,000 cfm.

Underground booster fans are needed to attain the airflow capacity as shown in Table 3-1. The total air quantity supports all the phases of development and site characterization scheduled in accordance with the requirements of the SDRD. Monitoring of air quality and quantity and primary fans are provided to indicate normal operating status of the system. Abnormalities activate an alarm or signal so that timely corrective actions can be instituted before serious ventilation problems can occur. Fan noise is controlled by providing appropriate attenuators to limit the sound pressure level below 85 dBA, the American Conference of Government Industrial Hygienists (ACGIH) Threshhold Limit Value (TLV) for an 8-hour exposure.

Fire doors at the shaft station are provided to environmentally isolate the shafts from the MTL in case of an emergency. The use of fire doors will also be a part of the mine evacuation plan, which helps assure that at least one shaft is potentially useful as a fresh air base station. Primary fans are also provided with electrical controls to effect air flow reversal, if needed.

Airborne dust is controlled to concentrations below the TLVs issued by ACGIH. General implementation of dust suppression techniques includes the use of water for drilling, bolting, and handling of excavated rock. Water, biodegradable and nontoxic chemical additives are applied to subsurface roadways. Where the use of water and other wetting agents is not feasible or is limited, appropriate dust collectors are provided.

6.6.5 WATER DISTRIBUTION SYSTEM

The mine supply water system design features all relate to the demand requirements. The water distribution system incorporates a chemical tracer injection system. The mine supply water system demand varies with the fire protection needs and equipment spreads required of various phases of construction, testing, and operation. The equipment spreads are determined from a review of current schedules for construction and testing. By evaluating the water usage for each equipment item and applying the value to the equipment spread, a total water demand for equipment can be determined. The equipment and fire protection demands can be summarized by area, establishing component flow rates. Pipe sizing determinations can then be made utilizing these flow rates, and design velocity limits.

Reliability and safety features of the mine water supply system include distribution looping, pressure regulators, excess floor (line break) valves, relief valves, and water hammer dampening. The mine supply water system piping develops in stages as construction of the ESF progresses.

6.6.6 MINE WASTE WATER COLLECTION SYSTEM

The mine waste water system design must incorporate both collection and transfer features. The sources of mine waste water for collection include water from construction, testing, operation, and fire protection water runoff. Another possible source of mine waste water is naturally occurring ground water inflow. The ground water inflow is estimated for input into the demand summaries, since actual values cannot be calculated. The mine waste water demand is estimated by summarizing the possible sources such as water, for drilling and coring, blast face spray, dust suppression, sprinkler system runoff, and natural inflow of ground water.

These combined flow rates result in a peak demand value used for pump selections, sump design, and pipe sizing. The pumping system consists of various types of drift or shaft bottom pump units feeding into one main mine sump pump unit capable of transferring all mine waste water inflows to the surface. The selection of waste water pumps capable of handling the flow rates, head pressures, and particulates present in mine water is a key issue in establishing a working waste water system. The MTL sump settles out large particulates and includes high pressure pumps to transfer the mine waste water to the surface disposal facility in one lift. No staging at intermediate levels is used.

Many reliability and safety features are utilized in the mine waste water collection and transfer system. The system is fully redundant in that each of the two main sump pumps is capable of transferring the full design peak flow, as is each shaft riser pipe. Vacuum relief devices are utilized for riser pipe protection, and various design methods dampen the effects of water hammer, preventing damage from sudden flow reduction.

The mine waste water system piping develops in stages as construction of the ESF progresses.

6.6.7 COMPRESSED AIR SYSTEM

The compressed air system design features are developed to meet the demand requirements for ESF construction, testing, and operation. The compressed air system demand varies with the equipment spreads required at various phases of development. The equipment spreads are determined from a review of the current schedules for construction and testing. The equipment utilizing compressed air includes such items as pneumatic rock drills, blast face sprays, blowpipes, diaphragm pumps, pneumatic test drill equipment, tuggers, air door cylinders, muckers, and pneumatic wrenches and chipping hammers. By evaluating the compressed air usage for each equipment item and applying the values to the equipment spread, a total compressed air demand can be determined.

The compressed air demands can then be summarized by area and pipe size determinations made. Pipe sizes are determined by utilizing the flow rates and maximum allowable velocities. The total demand value must be corrected for onsite conditions characteristic of the ESF. Corrections for altitude and leakage must be made before compressor selection can occur.

Reliability and safety features of the compressed air system include distribution looping allowing partial shutdown with continued use of compressed air elsewhere; relief valves; aftercoolers to limit the compressed air temperature to safe levels; moisture separators; and air receivers. The compressed air system piping develops in stages as construction of the ESF progresses.

6.6.8 FIRE PROTECTION SYSTEMS

The fire protection system design features are developed by H&N. F&S interfaces with H&N on the fire protection water supply, system monitoring and control, fire doors, fire dampers and portable extinguisher units. Additionally, fire protection emergency procedures and training programs as required are scheduled for implementation during all phases of ESF activity.

Automatic water sprinklers are required for primary fire protection by DOE Order 5480.7, Fire Protection. The requirements pertain to all surface structures. On-off, ordinary hazard, group 2 wet pipe sprinkler systems are provided in surface structures. The hoist house has a freeze-proof preaction system because the building is not heated. The surface data building has a heat detector activated Halon 1301 system that provides the primary protection in the computer area.

6.6.9 ROCK HANDLING SYSTEM

The rock handling system consists of underground transportation with load-haul-dump units, a dump station with a grizzly adjacent to the ES-2 shaft, surge bin, measuring flask and loading chute on the MTL, and the loading pocket cutout immediately below the MTL. At this point, the rock is transferred to the ES-2 hoisting system consisting of the hoist, rock skip and headframe with dump scrolls. On the surface, the skip discharges into an area next to the shaft collar but isolated from the shaft by retaining walls, from where it is transferred to a permanent storage area by haul trucks.

The capacity and/or size of each component of the rock handling system is determined by the maximum anticipated production rate of rock during the development of the underground testing facilities. The highest average production rate assumed is 800 tons per day, with maximum surge up to 1,100 tons per day. The calculated capacity of the skip hoisting system is 240 tons per hour, assuming 2,000 feet per minute maximum hoisting speed and 2.5 minutes duration for a complete hoisting cycle.

Rock is picked up at the face and transported to the ES-2 dump stationed by 5-cubic yard LHD units. Here it is dumped through a grizzly with 12-inch by 12-inch openings, into the surge bin positioned in the loading pocket below. The grizzly is used to limit the size of rock fragments in order to reduce the possibility of clogging openings and gates in the system. The 150-ton capacity surge bin is approximately equal to 30 minutes of hoisting system capacity. This provides adequate and necessary storage to compensate for fluctuations between rock delivery and rock hoisting.

From the surge bin, the rock drops into a measuring flask (measuring pocket) which holds only that volume of rock equal to the capacity of the hoisting skip. This measuring flask automatically prevents overloading the skip. Since the rock excavated from the MTL is from the same rock strata and therefore fairly uniform in density, the measuring flask is the volumetric type. The design allows for the installation of load cells to convert to a gravimetric type measuring flask, if required, for flexibility.

Installed between the surge bin and the measuring flask, is the shut-off gate. This is an undercut arc gate that slices up through muck that is standing at its natural angle of repose when the flask is full. This type of gate does not have to close against a seating surface and is therefore highly clog-resistant. The lower gate, at the bottom of the measuring flask, need not be clog-resistant, since it normally closes only after the rock has been emptied from the measuring flask into the skip. This gate therefore is downward acting and closes against the bottom of the skip loading chute. The openings through the two gates are both 4 feet by 4 feet, which provides choke-free passage of the rock.

The skip is a bottom dump or jeto type for reliability. This type of skip is preferred for hoisting larger volumes in small horizontal areas, since a greater height to width ratio can be used than with an overtipping or kimberly type skip. Scrolls in the headframe engage rollers on the skip, which initiates the skip dumping action as it is being raised into dump position by the mine hoist.

Rock flows down a fixed chute into a dump truck or onto the paved ground level dump area behind the retaining walls, according to program requirements. A front end loader reloads the rock into haul truck(s) for transfer to the permanent surface containment area. The sloped bottoms of the surge bin, measuring flask, chutes, and all other high wear areas are protected by abrasive resistant liners.

The system is designed to minimize spillage of rock from the loading pocket to the shaft bottom by using the clog-resistant surge bin gate and volume limiting loading flask. However, to provide for accidental spills due to human or equipment failure and small amounts of dribble inherent in muck transfer systems, a collection hopper at the shaft bottom is provided immediately above the shaft sump. The hopper contains a spillage collection box of 5-ton capacity, which is periodically hoisted to the MTL level and dumped back into the surge pocket.

The complete rock storage and hoisting facility is provided with a comprehensive system of controls and monitors. The skip loading and hoisting system can be fully automated; however, a loading pocket operator, skip/cage tender, and toplander are included in labor crew estimates. Operators provide primary control and monitoring of the rock handling system.

6.6.10 SANITARY FACILITIES

The sanitary facilities design includes portable toilet unit construction, location determinations, and maintenance operating procedures. Units conform to accepted industry practice for underground operations, and are chosen for consistency in providing a safe and healthy work environment.

6.6.11 LIFE SAFETY SYSTEMS

The required features of the life safety systems were analyzed in a study that outlined the applicable codes, standards and regulations that apply to the ESF. Three alarm warning systems were compared: manual, semiautomatic, and automatic. The automatic system is incorporated in the design (H&N Special Study 6A, Revision 2).

6.6.12 MONITORING AND WARNING SYSTEMS

During Title I, many items of operational monitoring and control were added to the life safety system, including power monitoring; ventilation monitoring and control; hoist operations monitoring; air compressor monitoring; and water system monitoring. Criteria are being developed by F&S and H&N for interfacing with the design at each sensor or actuator.

The automatic alarm system provides flexibility to add or delete monitor and control points as required during the design and development of the monitoring and warning systems. Monitor and control points are controlled by software and can be changed as criteria become better defined or as field operations change.

The life safety monitoring and alarm system allows for the subsurface monitoring of noxious and toxic gases. Gases monitored according to SDRD requirement 1.2.7.7.11 are carbon monoxide, carbon dioxide, nitric oxide, nitrous oxide, hydrogen sulfide, sulfur dioxide, and oxygen. Respective sensor-transmitters are strategically located throughout the drifts and in both shaft collars, and connected to the signal gathering and processing stations. Multiplexed signals from the stations are sent to the computer in the central control room (CCR) for monitoring and alarm. The setpoint limits for alarm are set at the sensor-transmitters in such a way as not to except the ACGIH TLV. The design includes the system of sensor-transmitters, cabling system and interface with H&N at the field data stations.

Environmental monitoring consists of monitoring of temperature, relative humidity and barometric pressure. Temperature and humidity are monitored on the surface, in exhaust ducts of both shafts at the collar level, in both shaft stations at the MTL, at the primary booster fans, in the UDBR, at the skip loader station in ES-2, and at five different locations throughout the MTL drifts. Barometric pressure is monitored on the surface in the intake air flow at ES-2 and in shaft stations at the MTL. Air velocity (and mass air flow as a derivative) is monitored in the intake air of both shaft stations at the MTL and in the exhaust duct at the collar level at both shafts. All of the above-mentioned environmental parameters are monitored continuously by respective sensor-transmitters connected at the data gathering multiplexer stations (designed by H&N) and to the computer in the CCR. A host of other environmental conditions such as dust pollution, noise level, presence of radon daughters in air and gamma radiation background are monitored periodically by portable hand-held sensors and meters in different locations throughout the shafts and mine (FS-GA-0222).

In all subsurface areas used for environmental air handling, the power, control and communication cables are placed in metal cable trays with solid bottoms and solid covers to comply with NFPA-70, NEC Art. 300-22(c). All branch connections to local devices are made of solid or flexible metal conduit.

Power, control and lighting cable trays and IDS instrumentation cable trays run on the opposite sides of the tunnels and drifts. The crossovers between cable trays are made as close to right angles as possible. The cable tray supports are trapeze type hangers attached to the roof or as wall brackets. A minimum distance of 11 feet, 0 inches between the bottom of the tray and the drift floor is provided (FS-GA-0207).

6.6.13 INTEGRATED DATA MANAGEMENT SYSTEM (IDS)

The IDS is designed as a separate subsystem by EG&G/Energy Measurements Division as a subcontractor to Los Alamos National Laboratory, and is not a part of this Title I report.

Approximately 20 experiments in the ESF testing program generate electronic data that is collected, stored, and distributed. A computer-based central data collection utility, the IDS, provides the PIs with a uniform, controlled, and verifiable data acquisition and recording system that functions reliably and efficiently. The IDS automatically acquires, records, and provides copies of certified site characterization data to each participating organization for data management and analysis. At the ESF, the IDS allows the PIs to monitor their tests and review recent data. A description of some of the design aspects of the IDS is contained in Section 3.9.1.

6.7 TESTING

Test constraints are requirements imposed on the ESF design that must be satisfied to ensure that the test can be located properly. Constraints impacting the underground layout can be categorized into three types: sequencing constraints; physical location constraints; and construction and operational constraints.

The zone of influence also becomes an important consideration because of the requirement to separate tests sufficiently so there is no unacceptable test-to-test interference and the requirement to limit, as much as possible, the construction influence to the dedicated testing area.

Selection of specific design features to accommodate the planned testing in the ESF is the result of work performed by the ICWG and incorporated into the SDRD. The test plans are the result of several years of work by the ESF Test Plan Committee, and are documented in the SCP and the associated test study plans. Section 8.4 of the SCP discusses the ESF testing with respect to the facility design. A brief description of each test is provided in Section 3.9.

CHAPTER 7

REPOSITORY LICENSING REQUIREMENTS FOR THE EXPLORATORY SHAFT FACILITY

This Chapter addresses the performance of the ESF as part of the future Yucca Mountain repository. Section 7.1 describes the role of the ESF in the repository and lists the items considered permanent to the repository. Section 7.2 discusses the various repository design and performance requirements applicable to the ESF and the ESF permanent items. Section 7.3 discusses the impacts of the ESF and related characterization activities on repository preclosure (7.3.1) and postclosure performance (7.3.2), the feature of the design approach used to assure that repository requirements are met (7.3.3), and design specific analyses performed as part of Title I design and future Title II analyses plans (7.3.4).

7.1 ESF/REPOSITORY INTERFACES

7.1.1 THE ROLE OF THE ESF FACILITIES IN SUPPORT OF REPOSITORY OPERATIONS

The ESF facilities support the repository in three ways: (1) the shafts and main test level (MTL) drifting supply air to support waste emplacement operations, (2) the exploratory drifting on the MTL accesses waste emplacement areas, and (3) the shafts and drifting support early repository construction. The ESF facilities supporting the repository are ES-1, ES-2, MTL drifting, and lateral exploration drifts.

ES-1 is used in the repository in conjunction with the waste delivery ramp to supply air to support waste emplacement operations.

ES-2 is used in the repository to supply air to the waste emplacement shop and to ventilate the waste emplacement area to the northeast of the central portion of the MTL. This shaft provides a mined material hoisting capability that is sufficient to support early repository construction.

Drifting in the central portion of the MTL routes the downcast air from ES-1 and ES-2 to the repository. The specific drifts to be used for this purpose cannot be identified until the design layout for the MTL central facility is firmly defined.

The three lateral exploration drifts extend from the ESF central experiment facility of the MTL. These drifts intersect the Ghost Dance fault, the Drill Hole Wash structures, and the suspected imbricate fault zone. The drift in a northwesterly direction that intersects the Ghost Dance fault is mined along a repository accessway to waste emplacement drifts. The drift that intersects the Drill Hole Wash structures is constructed on the course for the main repository drift used for removal of the material mined during repository construction and for exhausting of the ventilation air used to support repository construction.

The drift in a southeast direction investigates the existence of the imbricate faults at the repository horizon. This drift is converted to a waste emplacement access drift in the repository.

7.1.2 ESF PERMANENT ITEMS

Permanent items are items or facilities constructed or installed as part of the ESF that are converted for operational use by the repository. The list of facilities and items of the ESF that are candidate permanent items is taken from Appendix E of the Generic Requirements Document. The items are underground openings, shaft liners, operational seals, and ground support.

With one exception, all openings of the ESF used to support repository operations are classified as permanent items. The exception is the portions of the lateral exploration drifts on the MTL that are driven undersized. These drifts sections are not considered as permanent since they are reworked to make them adequate for repository use.

Those openings that are not used directly by the repository are also classified as permanent due to the possible influence that they may have on the stability of the overlaying strata, e.g., the openings with the central facility of the MTL must be considered permanent since they impact the stability of the ES-1 and ES-2 shaft pillar.

Shaft liners for both shafts are permanent items because they are used, as constructed for the ESF, to support the repository. There are no operational seals used in the design of the ESF for Yucca Mountain. All or part of ground support used in the ESF may require modifications to meet repository requirements.

7.2 REPOSITORY LICENSING REQUIREMENTS APPLICABLE TO THE ESF

There are two sets of requirements (as stated in 10 CFR Part 60) imposed on the design of the ESF, because of dual purpose. The ESF is initially intended to satisfy the requirement for in situ testing at the depths at which waste would be emplaced, and therefore must comply with the applicable requirements governing site characterization. Secondly, the two shafts and the underground openings will eventually serve as part of the repository ventilation system, and certain drifts will be converted to serve the repository as waste emplacement access drifts. Therefore, the ESF must comply with applicable repository design criteria and performance requirements. The following is a list of repository licensing requirements that are considered applicable to the design of the ESF. After the 10 CFR Part 60 requirement is cited and quoted, a statement is added describing the basis of applicability to the ESF design.

<u>10 CFR 60.15 Site characterization</u>

<u>(d) The program of site characterization shall be conducted in accordance with the following:</u>
<u>(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 practical.</u>

(2) The number of exploratory boreholes and shafts shall be limited to the extent practical consistent with obtaining the information needed for site characterization.

(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) Subsurface exploratory drilling, excavation, and in situ testing before and during construction shall be planned and coordinated with geologic repository operations area design and construction.

These requirements impose constraints on site characterization and therefore the design of the ESF in order to limit adverse effects on the long-term performance of the repository.

10 CFR 60.111 Performance of the geologic repository operations area through permanent closure

(a) Protection against radiation exposures and releases of radioactive material. The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency.

(b) Retrievability of waste. (1) The geologic repository operations area shall be designed to preserve the option of waste retrieval throughout the period during which wastes are being emplaced and, thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. To satisfy this objective, the geologic repository operations area shall be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, unless a different time period is approved or specified by the Commission. This different time period may be established on a case-by-case basis consistent with the emplacement schedule and the planned performance confirmation program.

(2) This requirement shall not preclude decisions by the Commission to allow backfilling part or all of, or permanent closure of, the geologic repository operations area prior to the end of the period of design for retrievability.

(3) For purposes of this paragraph, a reasonable schedule for retrieval is one that would permit retrieval in about the same time as that devoted to construction of the geologic repository operations area and the emplacement of wastes.

The ESF will be designed to meet these two performance objectives because, following the receipt of a construction authorization, it will be incorporated into the geologic repository operations area. For example, this potential use dictates that the drift stability be designed to meet repository requirements for the operational and retrieval life of the repository.

10 CFR 60.112 Overall system performance objective for the geologic repository after permanent closure

The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that release 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.

The ESF is designed to be conducive to sealing because upon repository closure, the seals in the ESF may be relied upon to meet this performance objective.

10 CFR 60.113 Performance of particular barriers after permanent closure

(a) General provisions. - (1) Engineered barrier system. (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. For disposal in the saturated zone, both the partial and complete filling with groundwater of available void spaces in the underground facility shall be appropriately considered and analyzed among the anticipated processes and events in designing the engineered barrier system.

(ii) In satisfying the preceding requirement, the engineered barrier system shall be designed, assuming anticipated processes and events, so that:

(A) Containment of HLW within the waste packages will be substantially complete for a period to be determined by the Commission taking into account the factor specified in § 60.113(b) provided, that such period shall be not less than 300 years nor more than 1,000 years after permanent closure of the geologic repository; and

(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 1,000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission; provided, that this requirement does not apply to any radionuclide which is released at a rate less than 0.1% of the calculated total release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000 per year of the inventory of radioactive waste, originally emplaced in the underground facility, that remains after 1,000 years of radioactive decay.

The ESF will be designed so it will not create a potential pathway for ground water to contact the waste packages or for radionuclide migration through existing pathways.

(2) Geologic setting. The geologic repository shall be located so that pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years or such other travel time as may be approved or specified by the Commission.

This requirement applies to drifts but not shafts. The path of ground water travel will be measured from the disturbed zone to the accessible environment, and the disturbed zone, by definition in § 60.2, does not surround shafts.

10 CFR 60.131 General design criteria for the geologic repository operations area

[Note: Due to the length of 10 CFR 131(b), only the requirement headings have been quoted. For details, refer to 10 CFR Part 60.]

(b) Structures, systems, and components important to safety--.
(1) Protection against natural phenomena and environmental conditions.....
(2) Protection against dynamic effects of equipment failure and similar events.....
(3) Protection against fires and explosions.....
(4) Emergency capability.....
(5) Utility services.....
(6) Inspection, testing and maintenance.....
(7) Criticality control.....
(8) Instrumentation and control system.....
(9) Compliance with mining regulations.....
(10) Shaft conveyances used in radioactive waste handling.....

Even though no waste will be stored in the ESF, all structures, systems, and components that will be part of the operating repository will be evaluated to determine if any could potentially impact the radiological safety of the public.

10 CFR 60.133 Additional design criteria for the underground facility

(a) General criteria for the underground facility. (1) The orientation, geometry, layout, and depth of the underground facility, and the design of any engineered barriers that are part of the underground facility shall contribute to the containment and isolation of radionuclides.

Since the ESF will become part of the underground facility, it will be designed with respect to repository orientation, geometry, layout, and depth, which all contribute to waste isolation.

(2) The underground facility shall be designed so that the effects of credible disruptive events during the period of operations, such as flooding, fires and explosions, will not spread through the facility.

The facilities of the ESF are designed so that disruptive events such as flooding, fires, and explosions will not spread to the features of the repository that provide for personnel safety. This requirement applies during the operational life of the repository and impacts such items as the ventilation system, the water drainage patterns, and construction materials.

<u>(b) Flexibility of design. The underground facility shall be designed with sufficient flexibility to allow adjustments where necessary to accommodate specific site conditions identified through in situ monitoring, testing, or excavation.</u>

The ESF, specifically the layout of the underground openings, is integrated with the repository in a manner that allows changes in the design of testing areas or the repository layout because of specific site conditions that are identified during site characterization.

<u>(c) Retrieval of waste. The underground facility shall be designed to permit retrieval of waste in accordance with the performance objectives of § 60.111.</u>

Certain ESF drifts are to be converted to serve the repository as waste emplacement room access drifts, and are also used for waste retrieval if required. The design of these drifts must be in accordance with repository criteria concerning retrieval.

<u>(d) Control of water and gas. The design of the underground facility shall provide for control of water or gas intrusion.</u>

The ESF will be part of the underground facility; therefore water and, if necessary, gas intrusion will be controlled in a manner that does not adversely affect repository performance, testing and worker safety.

<u>(e) Underground openings. (1) Openings in the underground facility shall be designed so that operations can be carried out safely and the retrievability option maintained.</u>

<u>(2) Openings in the underground facility shall be designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock.</u>

Underground openings of the ESF that become a part of the repository are designed to the same criteria that governs the design of the repository drifts in terms of operational safety and control of potential deleterious rock movement or fracturing and stability for 100 years.

<u>(f) Rock excavation. The design of the underground facility shall incorporate excavation methods that will limit the potential for creating a preferential pathway for ground water to contact the waste packages or radionuclide migration to the accessible environment.</u>

The excavation methods planned for ESF construction will incorporate means to minimize the damage to the surrounding rock mass. (See 10 CFR 60.113(a)(1).

(h) Engineered barriers. Engineered barriers shall be designed to assist the geologic setting in meeting the performance objectives for the period following permanent closure.

Components of the ESF that may serve as engineered barriers will be designed to assist the geologic setting in meeting the postclosure performance objectives.

(i) Thermal loads. The underground facility shall be designed so that the performance objectives will be met taking into account the predicted thermal and thermomechanical response of the host rock, and surrounding strata, groundwater system.

The design of shafts and openings of the ESF that become an integral part of the repository will consider the impact of the thermal pulse and thermomechanical response of the host rock.

10 CFR 60.134 Design for seals for shafts and boreholes

(a) General design criterion. Seals for shafts and boreholes shall be designed so that following permanent closure they do not become pathways that compromise the geologic repository's ability to meet the performance objectives or [sic] the period following permanent closure.
(b) Selection of materials and placement methods. Material and placement methods for seals shall be selected to reduce, to the extent practicable:

(1) The potential for creating a preferential pathway for groundwater to contact the waste packages or

(2) for radionuclide migration through existing pathways.

The exploratory shafts and all boreholes in the ESF will be designed with the capability of being sealed according to these two requirements.

10 CFR 60.137 General requirements for performance confirmation

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.

The ESF must be designed to permit implementation of a performance confirmation program, because the ESF will eventually become part of the geologic repository operations area and because performance confirmation is required to commence during site characterization.

10 CFR 60.140 General requirements

(a) The performance confirmation program shall provide data which indicates, where practicable, whether:

(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limit assumed in the licensing review; and

(2) Natural and engineered systems and components required for repository operation, or which are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated.

(b) The program shall have been started during site characterization and it will continue until permanent closure.

(c) The program shall include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to accomplish the objective as stated above.

(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.

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization construction, and operational activities.

(3) It monitors and analyses changes from the baseline condition of parameters that could affect the performance of a geologic repository.

(4) It provides an established plan for feedback and analysis of data, and implementation of appropriate action.

The ESF design accommodates the testing and monitoring required in a way that does not adversely affect the ability of the natural and engineered elements of the geologic repository to meet the performance objectives.

10 CFR 60.141 Confirmation of geotechnical and design parameters

(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters are confirmed and to ensure that appropriate action is taken to inform the Commission of changes needed in design to accommodate actual field conditions encountered.
(b) Subsurface conditions shall be monitored and evaluated against design assumptions.
(c) As a minimum, measurements shall be made of rock stress and strain, rate and location of water inflow into subsurface areas, changes in groundwater conditions, rock pore water pressures including those along fractures and joints, and the thermal and thermomechanical response of the rock mass as a result of development and operations of the geologic repository.

(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurement and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences and the recommended changes reported to the Commission.
(e) In situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure to ensure that the performance of the natural and engineering feature are within design limits.

The ESF must be designed to allow for a testing and monitoring program to confirm geotechnical and design parameters. This is required because the ESF will be part of the repository.

10 CFR 60.142 Design testing

(a) During the early or developmental stages of construction, a program for in situ testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.
(b) The testing shall be initiated as early as is practicable.
(c) A backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.
(d) Test sections shall be established to test the effectiveness of borehole and shaft seals before full-scale operation proceeds to seal borehole and shafts.

The ESF will be designed to accommodate required design testing. This provision requires this testing to be initiated as early as practicable.

10 CFR 60.151 Applicability [of quality assurance].

The quality assurance program applies to all systems, structures and components important to safety, to design and characterization of barriers important to waste isolation and to activities related thereto. These activities include: site characterization, facility and equipment construction, facility operation, performance confirmation, permanent closure, and decontamination and dismantling of surface facilities.

A quality assurance program based on the criteria of Appendix B of 10 CFR Part 50 has been applied to the design of the ESF. The criteria applied to the ESF design included:

1. Structures, systems or components important to safety.
2. Engineered barriers important to waste isolation.
3. Any activity related to (1) or (2).
4. Any activity (i.e., quality activity) that would adversely affect a natural barrier that is important to waste isolation (see NUREG-1318).

10 CFR 60.152 Implementation [of a quality assurance program].

DOE shall implement a quality assurance program based on the criteria of Appendix B of 10 CFR Part 50 as applicable, and appropriately supplemented by additional criteria as required by § 60.151.

Items important to safety and engineered barriers important to waste isolation must be designed, procured, and constructed in accordance with 10 CFR Part 50, Appendix B as described in this provision. Activities related to these items and barriers, along with quality activities must be performed according to established procedures that conform to 10 CFR Part 50, Appendix B.

7.3 APPROACH TO SATISFYING REQUIREMENTS

This section describes the approach taken to assess the performance of the ESF as part of the repository and to demonstrate compliance of the ESF with the repository requirements.

Sections 7.3.1 and 7.3.2 address potential impacts of site characterization activities on preclosure and postclosure performance objectives of the repository. Both sections are structured to discuss the performance objectives and the approach used to assess potential performance impacts; information (primarily analyses results) pertinent to the evaluation; and the evaluation and conclusions. Section 7.3.3 discusses the approach taken during Title I design of the ESF to assure that the ESF meets repository requirements, and that the potential impacts of the ESF on repository performance are minimized. Section 7.3.4 presents preliminary results of design specific analyses (based on 50 percent Title I design) and the plans for future analyses to be done as part of the Title II design. These analyses treat the ESF as part of the repository and are done to evaluate long term performance objectives, therefore they differ from the design analyses presented in Section 6.4, which are concerned with the ESF prior to its conversion for repository use.

7.3.1 PERFORMANCE OF THE ESF DURING PRECLOSURE PERFORMANCE ACTIVITIES

This section discusses the preclosure objectives of the repository and the approach to assessing potential performance impacts from site characterization activities. The material presented in this section is summarized from Section 8.4.4 of the Site Characterization Plan (SCP). The reader is referred to this section of the SCP if additional details related to the potential impacts of site characterization on repository preclosure performance are required.

7.3.1.1 Preclosure Performance Objectives and Approach to Assessing Site Characterization Impacts

Two repository preclosure performance objectives are defined in 10 CFR Part 60: (a) Protection against radiation exposures and releases of radioactive material (10 CFR 60.111a), and (b) Retrievability of Waste (10 CFR 60.111b). As part of the repository during preclosure activities, the ESF should be capable of meeting these same performance objectives.

The site characterization activities of concern in this section broadly fall into two categories: surface-based investigations, consisting essentially of shallow and deep boreholes and trenches; and subsurface based investigations of the ESF. The ESF includes two shafts, the Upper Demonstration Breakout Room, drifts within the dedicated test area, and drifts to Drill Hole Wash, Ghost Dance fault, and the imbricate fault zone. The shallow boreholes and trenches are generally not within the eventual area of surface operations of the repository. They have very low potential for impacting repository construction, and their locations are known. The repository designers consider the possible effects of these activities, and if any adverse effects are identified they can be mitigated in the design. The layout of the deep boreholes considers the site characterization-related design requirements in 10 CFR 60.15(d) to limit the number of boreholes to the extent practicable, to locate boreholes to the extent practicable in planned repository pillars, and to coordinate subsurface drilling, excavation and testing with repository design. The deep boreholes are expected to have a very low potential for impacting repository operation. The zone of influence of the deep boreholes is not expected to impact the repository drifts. The locations and presence of the deep boreholes and any identified potential impacts are considered and are expected to be mitigated in the repository design.

Potential subsurface-based investigation related effects that impact the repository operations in a manner that affect compliance with the preclosure performance objective have also been considered. The zones of influence were evaluated for the ESF-related tests to assess the potential for test-to-test interferences. These analyses show that the zones of influence, particularly the stress-related influence, for the ESF tests are generally contained within the dedicated test area or are accommodated by slight design modifications. There is thus no expectation that the ESF tests themselves would impact the ability of the repository to meet the preclosure performance objectives. Two aspects of the ESF that have a somewhat greater potential of impacting the compliance of the repository with the preclosure performance objectives are: structural failure of either of the two shafts or the drifts that comprise the facility, and potential surface flooding.

Failures in the shaft liner, wall rock, or drift ground support systems may be initiated by disruptive events. Examples of potential disruptive events include seismic pulses, thermal loading, equipment colliding into drift walls, and corrosion or deterioration of ground support.

7.3.1.2 Potential Impacts of Preclosure Activities on Repository Performance Objectives

Radiation Safety

Because no radioactive waste is handled or transported in the exploratory shafts, a concrete liner or drift collapse is not likely to lead to any radiological release. Where waste is transported through the access drifts in the event of retrieval, the waste is located in a container surrounded by a transfer cask. The cask is designed to meet radiation shielding requirements and maintain its structural integrity during a drift collapse with no release of radioactivity.

A potentially adverse consequence due to a structural failure is caused by the dust generated by the concrete liner or rock (and shotcrete). Excessive dust may plug the HEPA filters and make radiation detectors inoperable in the event of concurrent radiological releases. The potential impacts of dust generation on the performance of HEPA filters and radiation detectors are studied as part of repository design activities.

Retrieval

During retrieval, specific drifts may be used for transportation of waste. Waste is neither transported nor retrieved through the ESF shafts. Structural failure in any of the access drifts is accommodated either by cleanup or by seeking alternate transportation routes using existing adjacent or newly mined drifts.

Because the retrieval operations rely on approximately 60 percent of the total airflow that passes through the two converted exploratory shafts (SNL, 1987), retrieval is affected by loss of one or both of the shafts. However, the waste ramp still provides intake air for retrieval operations and maintains a negative pressure head relative to the mining area of the repository. This assures a leakage flow from the mining to the retrieval areas of the repository. Retrieval is slowed depending on the severity of the shaft damage and the time required to reopen the shaft or construct a new shaft. However, sufficient lag time exists to allow consideration of several options, including repair of the shaft, rerouting ventilation from alternate repository intakes, or constructing a new access for air entry.

Surface Flooding

The repository facilities, including the two exploratory shafts, are designed to withstand the effects of flooding. The shaft collars are located above the height of the probable maximum flood, and the ground surface around the shaft surface facilities is graded with flood protection as a requirement. Additionally, any water entering the shafts is collected in a sump below repository level and any water entering the ESF drains to a low point in the ESF, then is pumped to the surface.

The above assessments show that the site characterization related activities have little or no potential to impact the preclosure performance objectives of the repository.

7.3.2 POTENTIAL IMPACTS OF SITE CHARACTERIZATION ON POSTCLOSURE REPOSITORY PERFORMANCE OBJECTIVES

The material presented in this section is summarized from Section 8.4.3 of the SCP. The reader is referred to this section of the SCP if additional details related to the potential impacts of site characterization on repository postclosure performance are required.

7.3.2.1 Approach to Assess the Potential Impacts of Site Characterization Activities on the Repository System

The approach taken to evaluate potential impacts of site characterization activities on postclosure performance is to determine how each category of activity in both the surface-based testing and ESF testing programs affects the thermal, mechanical, geochemical, and hydrological conditions of the site, and then determine the potential impacts on the performance objectives from these modified conditions.

The site characterization activities consist of surface-based activities and subsurface-based activities. The activities are grouped into five types: surface-related activities (e.g., pavements, trenches, ponding tests, road construction, dust control, drill-pad construction); drilling activities (e.g., boreholes); exploratory shaft construction; underground construction of drifts and testing alcoves; and testing activities in the ESF.

These site characterization activities affect the chemical, hydrological, and thermomechanical conditions of the site in a similar manner because the penetrations and use of fluids and materials are similar. The disturbances to the site conditions are evaluated with respect to the performance requirements to judge whether the disturbances are significant. Disturbances are judged to be significant only when they are of such magnitude that they could potentially affect the capability of the site to meet the regulatory requirements of 10 CFR Part 60.

The unsaturated zone at Yucca Mountain is the primary repository-system element that the DOE expects to rely on in demonstrating the waste-isolation capabilities of the site. In general, the primary manner by which site characterization activities affect postclosure performance is alteration of the hydrologic or geochemical environment at Yucca Mountain. Because many of the site characterization activities involve excavations in the unsaturated zone, the general conclusions about the effect of such excavations are summarized below.

Water flow occurs predominantly in the unsaturated rock matrix. Neither large aperture fractures nor the excavations are expected to be conduits for water flow in the unsaturated zone under existing conditions. Fractures and excavations, however, must be examined as potential pathways for gas-phase movement, including water vapor.

Excavations are backfilled with material that is similar to the tuff rock. The properties of this backfill are such that under expected conditions it is also unsaturated. This backfill inhibits gas-phase flow and flow of surface water that has access to these excavations. Further, water entering the backfill is expected to be imbibed into the rock matrix.

If fluids are introduced into excavations during site characterization operations, these fluids are expected to be dispersed into the available rock matrix pore space within short distances from the excavations. Although localized flow in fractures could result, the flow is expected to be imbibed and dispersed within the rock matrix.

Data from site characterization activities are required in order to show whether the above hypotheses are valid descriptions of conditions and processes at the site. The large uncertainties in the preliminary assessments of site performance cannot be quantified without data from site characterization activities.

These interpretations of current data are based primarily on physical concepts of unsaturated flow in a porous, fractured rock such as the rock at the repository horizon at the Yucca Mountain site. These interpretations are continuously re-evaluated during site characterization as alternative models for unsaturated flow at Yucca Mountain are refined.

7.3.2.2 Design Features That May Contribute to Performance

The following items are design features or considerations related to site characterization activities that contribute to performance or aid in mitigating potential deleterious impacts to performance from site characterization activities.

The ESF is designed to maintain a lateral separation distance from potential waste emplacement panels. The core area for testing within the ESF is separated by a minimum distance of 30 m. Because unsaturated flow within the repository horizon is hypothesized to be primarily vertical, this separation distance aids in preventing the ESF from becoming a preferential pathway for radionuclide transport from waste emplacement. It also prevents water used in testing activities from reaching emplaced waste containers.

The ESF is designed to drain water used in ESF construction and testing toward ES-1. This design feature inhibits water from the ESF from moving into waste emplacement panels.

The exploratory shafts have been located and collared in bedrock, where flooding potential is small, to mitigate the potential of having the shafts serve as preferential pathways for water from the surface.

Borehole drilling is coordinated with repository design to locate boreholes, to the extent practical, in pillars. This allows a stand-off distance from waste canisters and aids in preventing the boreholes from becoming preferential pathways. In addition, statistical methods are used in planning the boreholes in order to limit their number.

The ESF is designed with sufficient flexibility to locate in situ tests where they have a high likelihood of success.

The amount of water introduced to the site is controlled. The water usage is limited to the extent practicable and is tagged with tracers to allow detection. Many of the boreholes are drilled dry to prevent water intrusion to the rock mass. Strict water controls are used during drill-and-blast operations.

The openings in the ESF incorporate excavation methods that limit the disturbance of the surrounding rock mass. In effect, smooth-wall blasting is used.

The ESF is ventilated. Ventilation removes a substantial amount of water. Within a few years, the volume of water removed is comparable to the volume of water added to the rock during ESF construction testing.

Boreholes and the exploratory shafts are sealed to aid in preventing them from serving as preferential pathways for flooding events, increased percolation, or transport of radionuclides, or for gas-phase transport.

Surface activities such as the construction of spoils piles are designed to avoid the creation of surface-water impoundments.

7.3.3 APPROACH TO ASSURE THAT THE ESF MEETS REPOSITORY REQUIREMENTS

7.3.3.1 General Approach to Assure That The ESF Meets Repository Requirements

All steps in the development of the ESF i.e., planning, development of design requirements, design, performance evaluation, and supporting analysis have considered the ESF (due to its physical connections to the repository, its function in supporting repository operations, and its location within the repository boundary) to be an integral part of the repository. This approach assures that the requirements imposed on the repository for assurance of public safety and waste isolation are also considered in the design of the ESF.

7.3.3.2 Design Approach to Ensure That the ESF Facilities Exhibit a 100-year Maintainable Life

The permanent features of the ESF are designed to have the same maintainable life as the repository. Compliance with this requirement is predicated on following a design philosophy that includes the following: use of a common design methodology for the ESF and the repository; use of certified and verified codes; use of common sizes for underground openings; application of common design loads to both the ESF and the repository; identical site parameters used for the designs; degree of conservatism in the design of the ESF is greater than the conservatism used for the design of the repository; construction techniques are controlled more precisely; and construction materials and fluids are controlled more stringently.

The designs of the ESF and the repository are based on a common documented design approach. For the shafts, this approach is presented in SAND88-7050 (in preparation) titled "Shaft Design Criteria and Methodology Guide." A similar document is planned for the drifts, but it is not complete. However, the methods used are defined and agreed to by the ESF and repository designer in time to be used in the analysis supporting the Title II design of the ESF.

The computer codes used to perform the analysis for the repository and the ESF shafts and underground opening are certified and verified. Certification and verification will be completed prior to completion of Title II design.

The drift sizes in the ESF are in all cases equal to or smaller than the drifts planned for the repository. The shafts of the ESF are smaller than the shafts used in the repository.

The design loads applied to the ESF with respect to the repository are geostatic and thermal loads. The geostatic loads applied to the ESF and the repository are the same except for adjustments made to account for differences in overburden. Thermal loads applied to the ESF and repository result from the same source term. The loads are different because of the location of the facilities with respect to the thermal source temporally delays the impact of thermal loading on the ESF.

The parameters needed to perform the analysis of the ESF and the repository come from the same data base. An additional degree of conservatism is used in the design of the ESF due to the quality of the data available at the time of ESF design.

To ensure that the methods used in construction of the ESF do not jeopardize the repository, conservative techniques are used. For example, the amount of overbreak allowed in the construction of the ESF is less than what may be allowed in the repository.

Construction materials and fluids are stringently controlled to assure that the repository is not jeopardized. As experience is gained in the ESF, it may be possible to relax these controls.

7.3.4 DESIGN SPECIFIC ANALYSES

This section discusses the analyses performed during the Title I design of the ESF to assess its performance as part of the repository and analyses planned for Title II design. Analyses presented in Section 6.4 are based solely on the design as it functions prior to repository construction and waste emplacement. Four analyses reports are discussed below. Draft versions of the reports are located in Appendix B - Technical Analyses.

Synopses of 14 past analyses are presented in Appendix B.1. The analyses assess the preclosure stability of the conceptual design of shafts and ramps in the Topopah Spring and Calico Hills formations; however, the results support the feasibility of constructing and maintaining a safe ESF.

Three-dimensional thermoelastic far-field analyses of the ESF were performed to determine the expected thermal loads imposed on the ESF shafts and underground drifts. The preliminary results are presented in Appendix B.2.

The preliminary results of a sensitivity study of the thermal far-field loads imposed on the ESF excavations are presented in Appendix B.3. The analyses report a range of expected temperatures, strains, and stresses for several locations along ES-1.

Seismic loads induced on the underground drifts are calculated in Appendix B.4 based on the Nevada Nuclear Waste Storage Investigations Working Group Report Exploratory Shaft Seismic Design Basis. Appendix A-3 of the Working Group Report recommends the seismic induced strains to be imposed on the ESF shafts.

Future work done as part of Title II design includes finalizing the above reports and applying the loads established above (thermal and seismic) in addition to the in situ loads (see RIB) to the Title II design of the ESF shafts and evaluating the stability of the Title II excavations. Separate reports are planned for the shaft and drift evaluations.

CHAPTER 8

CLOSURE AND DECOMMISSIONING

8.1 INTRODUCTION

Closure and decommissioning of the ESF takes place under one of the following scenarios: 1) Yucca Mountain is not selected as the repository site and the repository is not constructed, or 2) Yucca Mountain is selected as the repository site and the repository is constructed. The describes, in general terms, the closure and decommissioning activities that take place for these two cases.

8.2 YUCCA MOUNTAIN NOT SELECTED

If Yucca Mountain is not selected for the repository site, the ESF is recommended for closure and decommissioning. The subsurface closure activities begin with the withdrawal of all testing and drilling equipment. Some items that may be left in place include rock bolts, wire mesh, concrete foundations, concrete roadways, concrete embeds, and concrete and shotcrete drift liners.

The subsurface drifts and shafts are then backfilled to minimize subsidence effects on the surface from the previous underground activities and to protect and preserve adjacent stratigraphic features. Backfilling begins at the most remote location of the drifts that are farthest from the shaft station area. Previously excavated and stored mined material from the surface rock pile is pneumatically stowed in these areas. Backfilling the drift areas using the pneumatic stowing system enables all void area to be filled to approximately 65 percent of the original in situ rock density.

The pneumatic stowing operation continues working back to the shaft station area until the subsurface drift area has been completely backfilled, including the pump, substation and station areas. The procedure is also followed at the Upper Demonstration Breakout Room (UDBR).

At the completion of the subsurface backfilling, the pneumatic stowing equipment is dismantled and hoisted to the surface, where it is reassembled to continue placing crushed rock in the shaft station and sump areas to about 15 feet above the roof of the shaft station.

The next activity is to construct a lower plug and chemical seal ring at elevation 3,108 feet in ES-1, and 3,115 feet in ES-2. The purpose of this plug is to seal off the backfilled areas and support the loads imposed by the shaft backfill materials.

Rockbolts and wire mesh installed in the shafts during construction are removed, and a key way is cut into the shaft walls. The bottom concrete plug is then placed. This plug extends approximately 10 feet up from the top of the backfilled rock.

Part of this bottom plug is a 36-inch thick polymer seal. Movement of the bottom plug/seal is prevented by keying into the shaft walls, by the frictional forces acting along the length of the plug, and by the in situ creep pressures of the formation.

After the bottom concrete plug is in place, the backfilling operation continues until the backfill material is within approximately 16 feet of the surface. The backfill operation is then discontinued and the pneumatic stowing equipment removed from the shaft collar area. The headframe foundation, structural steel supports and shaft collars are then removed and a final concrete plug is constructed. The plug is approximately 10 feet thick. The concrete plug is designed to withstand the remaining overburden and any planned future activity that would be conducted above the plug. This final cap also prevents the seepage of ground water or rain water into the abandoned, backfilled shaft. The remaining approximately 6 feet above the plug are backfilled with soil material and topsoil.

8.2.1 SURFACE RESTORATION

When the shaft backfilling operations are complete, all remaining equipment in the shaft collar areas and the hoists and associated outfitting are disassembled and removed from the site.

The salvage operations for buildings, trailers, and equipment are then initiated. Appropriate items are separated, stockpiled in a protective manner, and prepared for offsite salvage. All buildings and trailers are emptied of their contents, disconnected from the service and anchor connections, disassembled, and removed from the site and salvaged. The balance of the surface facilities, including the substation and power poles, drainage control structures, concrete structures and all utilities, are disassembled and removed from the site for salvage or disposal. All unsalveagable items are disposed of in an appropriate offsite landfill.

During the decommissioning phase, the operator consults with the governing agency to determine the requirement for abandonment of all surface drillholes. The surface drillholes may be sealed and capped, plugged back, or turned over to the land owner as is. The site is then graded and contoured using stockpiled topsoil and reclaimed using appropriate reclamation techniques.

8.3 YUCCA MOUNTAIN SELECTED

This section describes the relationship between the ESF and the repository during the repository Phase I construction, preclosure, and postclosure activities should the Yucca Mountain site be selected for the underground nuclear waste repository.

8.3.1 PHASE I REPOSITORY CONSTRUCTION

Maintenance of the ESF between the end of the currently planned testing activities and the start of the Phase I repository construction includes shaft and drift maintenance, additional construction, equipment maintenance, and decommissioning of completed ESF test equipment. The ESF is maintained in a state of readiness to allow flexibility if new ESF tests or additional drift development is required. Requalification, repair, or replacement of the ESF hoists, headframes, utilities, equipment, and support facilities is not required to support the Phase I repository construction because of this ESF maintenance approach.

During the initial Phase I repository construction period, ES-1 and ES-2 provide the ventilation intake and exhaust. In addition, ES-1 provides access for men and materials, utilities, and supplies and ES-2 is used for muck hoisting.

The three ESF exploratory drifts are the starting points for drift development to access the repository men-and-materials shaft and the exhaust shaft underground areas. Shop areas are also started from the exploratory drifts.

When the repository men-and-materials shaft and tuff ramp are completed and become operational, ES-1 and ES-2 are converted to provide intake air to the repository development and emplacement ventilation systems. Conversion of ES-1 and ES-2 includes removal, salvage, or disposal of test equipment utilities, shaft furnishings, hoists and headframes, and selected surface support facilities. Modifications and installations required for ES-1 and ES-2 include ventilation intake structures and shaft inspection/maintenance hoisting and conveyance systems.

8.3.2 PRECLOSURE

The repository preclosure period begins after completion of the repository Phase I construction and continues through the repository operational phase, caretaker phase, and closure and decommissioning phase. During the repository preclosure period, ES-1 and ES-2 continue to provide intake air to the repository waste emplacement ventilation system.

The anticipated maintenance program consists of inspection of ESF shafts and drifts at regular predetermined intervals and performance of any maintenance, such as repair of minor drift "skin surface" scaling and cleanup. This maintenance is coordinated and scheduled with the repository maintenance programs and is consistent in scope and frequency.

Because the ESF is part of the repository, ESF closure and decommissioning activities are consistent with the overall repository closure and decommissioning program. Closure and decommissioning of the ESF includes final stripping of utilities and furnishings; removal of shaft liners; installation of seals; backfilling of drifts and shafts; removal of remaining ESF surface buildings; equipment and utilities; and the restoration of the site.

8.3.3 POSTCLOSURE

The repository postclosure period begins after completion of the repository closure and decommissioning activities (10 CFR 960.2). Because the ESF remains part of the repository, the postclosure performance of the ESF is consistent with the postclosure performance of the overall repository.

CHAPTER 9

ADVANCE PROCUREMENT ITEMS

9.1 LIST OF ITEMS

The equipment and systems listed below require more than three (3) months for manufacture and delivery after receipt of a purchase order. The assumption is made that rental or used equipment is not available for lease.

Mining and Drilling Equipment

Diamond Core Drill LY-44 or equal
Ingersol-Rand (CMM-2) or equal drill carrier
5, 3½, and 1 cubic yard capacity LHDs
Mine Service Vehicles
Blast drill jumbos

Ventilation Equipment

250 and 350 HP axial vane fans
Mobile dust collection units

Electrical Equipment

Underground Transformers and panels
4,160 V armored shaft power conductor
Hoist power control systems
69 kV - 4.16 kV Transformer
69 kV Bypass Switch
69 kV Oil Circuit Breakers
69 kV Isolator Switches
1,400 kW Emergency Generators 4,160 V
4,160 V Generator Switchgear
5 kV Pad Mounted Disconnect Switches
4,160 V Switchgear
1,500 kVA Transformer
750 kVA Transformer
500 kVA Transformer
300 kVA Transformer
112.5 kVA Transformer
4/0 ACSR Wire
5 kV 3/C Armored Cable for Down Hole
5 kV 3/C Shielded Cable for Feeders
600 V #500 MCM Cable
600 V #350 MCM Cable
600 V #250 MCM Cable
#500 MCM Bare Grounding Cable
#4/0 Bare Grounding Cable
Fiber Optics Cable for Data Cable System
Cable Trays
480 V Power Distribution Panels
Batteries for Backup Power

Shaft Equipment

Cages, Buckets and rope attachments
Skip loader and spill pocket equipment

Hoists and Headframes

Refurbishment of hoists
Headframes

Mechanical Systems

1,500 cfm capacity air compressors

Architectural Systems

80 feet by 96 feet Hoist House (Pre-Engineered Building)
60 feet by 50 feet IDS Surface Data Building (Pre-Engineered)
60 feet by 60 feet Change House (Pre-Engineered Building)
20 feet by 24 feet Pump House (Pre-Engineered Building)
50 feet by 100 feet Warehouse (Pre-Engineered Building)
24 feet by 56 feet Double-Wide Trailers.

Civil Systems

8,000 Gallon Septic Tank
150,000 Gallon Water Tank
10,000 Gallon Water Tank
12 inch Steel Water Line
Chlorination System (Package Unit)
6 inch Steel Sewer Pipe
6 inch Steel Water Pipe
4 inch Steel Water Pipe
Precast Manholes
Precast Concrete Vaults
36 inch Diameter Culverts
36 inch Diameter Culverts End Sections
Oil Water Separator
Underground Fuel Tanks

Communications Systems

Alarm Systems
Silencers

9.2 ACQUISITION STRATEGY

Each Yucca Mountain Project procurement, regardless of estimated cost, is planned and documented to assure a systematic approach.

Upon receipt of a purchasing requisition by the Reynolds Electrical & Engineering Company, Inc. (REECo) Procurement Department, the requisition is stamped and screened by the Procurement Requisitioning Supervisor for a project stamp on the face of the requisition, the proper signature and date is provided in spaces on the purchase requisition and the Quality Assurance (QA) level, or a waiver that one is not required, noted on the requisition. The procurement strategy follows the requirements of the QA Plan.

The Requisitioning Supervisor then initials all purchasing requisitions, indicating the above review has been completed and assigns a requisition number.

Every purchase requisition folder has a purchase order history form included. All correspondence, telephone calls, review or other procurement actions are logged by Procurement Department personnel directly involved in the action.

Project documents generated by REECo, other Project participants and Nevada Test Site (NTS) support contractors have controlled distribution. The check sheet is a part of every Project purchase order, and includes the Chief Purchasing Agent's review of each Project purchase order upon receipt for completeness. The check sheet also indicates by the buyer's signature that the solicitation process is complete, including a memorandum to the file for QA Level I and II purchases. The Purchasing Agent (PA) then initials, indicating that the supplied evaluation for QA Levels I and II has been accomplished and that the purchase order has been reviewed. The Procurement Department Senior Auditor and the REECo QA representative review the check sheet for completeness. The PA assigns the requisition to a buyer and enters it into the Procurement Tracking System.

For QA Levels I and II, the Chief Purchasing Agent documents the review with a memorandum to the file. All buyers performing QA Level I or II Project activities are certified to perform their specific duties.

After the review of all requisition documents for completeness and accuracy, the buyer transfers all technical and quality requirements from the requisition to the solicitation document. The buyer then issues the solicitation to vendors capable of providing the item or service.

For QA Levels I and II, the Certified Buyer reviews all solicitation documents for the adequate transfer of the provisions from the requisition documents and includes the following, as necessary:

(1) A statement of the scope of work to be performed by the supplier.

(2) Identification of test, inspection, and acceptance requirements of the purchaser for monitoring and evaluating the work to be performed by the supplier.

(3) Requirement that the supplier, and all lower-tier suppliers, have a documented QA program that implements applicable regulations as required by the requisitioner.

(4) Access to the suppliers and all lower-tier supplier's facilities and QA records for inspection by the purchaser.

(5) Identification of all documentation required from the supplier and all lower-tier suppliers to include the time submittal is required, and the minimum retention of such documents.

(6) Identification of procedures for reporting and approving disposition of nonconformance.

(7) Identification of the technical and quality requirements required for ordering spare and replacement parts or assemblies.

(8) Identification through a manufacturer's published application catalog or through prior approval of acceptable equivalent items. The solicitation document is then reviewed and initialed by the PA, and that review is documented by a memorandum to the file.

All solicitations for QA Level I and II suppliers is established and maintained in the Procurement Department. Evaluation of suppliers for Quality Assurance Level I and II procurements must be coordinated through the Procurement Department. For the evaluation of suppliers, REECo Procurement organizes a team that includes representatives from the REECo QA and procurement organizations, the originating organization, the Yucca Mountain Project Office, and other technical and departmental representatives. This team does a complete in-plant inspection of the supplier's facility and any other lower-tier facility involved in this procurement action. The quality program requirements are the criteria for the the quality portion of the evaluation.

After completion of each vendor evaluation survey and submission of related reports to the Procurement Department, the committee then meets, and reviews and evaluates the reports; documents their conclusions; and recommends appropriate action.

All data of the evaluation of a supplier is retained in the purchase order file of record, in the vendor's Quality and Performance Data File in the Procurement Department. Any amendments to the solicitation requirements are approved by the requisitioner and the REECo QA organization and documented in the procurement file.

After receipt of bids, the buyer reviews and prepares all documents for award to the selected qualified, responsive, responsible bidder whose bid is most advantageous to the government. The PAs review each procurement package prior to award for completeness of quality and technical requirements.

For QA Levels I and II, bid evaluations are performed by the REECo Procurement and QA organizations and a representative from the originating organization as a minimum. The bid is evaluated for technical and quality requirements; suppliers personnel and production capabilities; suppliers' past performance; and alternatives and exceptions. Unacceptable conditions resulting from the bid evaluation are resolved, or commitments to resolve such conditions shall be obtained by the buyer prior to award of the contract.

All changes to procurement documents are subject to the same degree of control as utilized in the preparation of the original documents.

Changes that are made as a result of the bid evaluation or precontract negotiations are incorporated into the procurement documents, and reviewed and approved by the same organizations that approved the original action. The results of all bid evaluations, precontract negotiations, and the resulting changes are documented by the buyer in a memorandum to the file.

After PAs approve the procurement package, all Project QA Levels I and II are forwarded to the cognizant technical representative and to the Project QA organization for approval prior to award.

After award by appropriate Procurement Department personnel, a copy of the final contractual document is forwarded to the Project QA organization for QA Level I procurements.

The Procurement Department forwards a copy of the purchase order to the location where acceptance occurs. These documents are necessary to determine the conformance of the items or services to the purchase order requirements.

All changes, acceptance reports, nonconformance reports, and corrective actions required are coordinated with the originating organization and REECo QA, and documented in the file of record in accordance with established REECo Procurement Department procedures.

For QA Levels I and II, all contract-required documents generated by the supplier are transmitted by memorandum to the requesting department by the buyer.

Items or services are accepted in accordance with requirements established in the procurement documents and the approved procedures of the organization originating the procurement action. All QA Level I and II procurements have a technical inspection performed on each procurement. The expediter notifies the originating organization that the item has been delivered and held at point of delivery until acceptance by the originating organization. Copies of all acceptance reports are maintained in the file of record.

The procurement quality control representative has the responsibility to ensure that all conditions that adversely affect quality are identified, the cause determined, and corrective action taken, and that all such conditions are documented and reported to the appropriate levels of management. Copies of any corrective action are forwarded to the Project Office through REECo QA.

The procurement file of record and any other REECo-controlled quality activity is maintained and controlled in accordance with the REECo Quality Assurance Program Plan for the Yucca Mountain Project and the Quality Assurance Records Management Handbook.

CHAPTER 10

TITLE II DESIGN

10.1 MANAGEMENT

The Yucca Mountain Project Office is the organization in the U.S. Department of Energy/Nevada Operations Office that is responsible for the management of the Exploratory Shaft Facility (ESF) Title II design. The Project Office is assisted in this management function by the Technical & Management Support Services (T&MSS) contractor Management and Integration group and Quality Assurance group. The Management and Integration group coordinates the activities associated with engineering analysis, technical assessment, project studies, project participant integration and project task management. The Quality Assurance group is an autonomous organization, reporting directly to the Project Office, whose responsibility is the overall project quality as it relates to facility licensability. The plans for Title II design are undergoing revision per discussions with the Nuclear Regulatory Commission. The plans presented here predate those discussions.

Development of the ESF design and test program design is divided into three areas. Each area is the responsibility of a separate organization. Each organization having a design responsibility reports directly to the Project Office. The three design areas are surface facilities, underground facilities and underground testing. Surface facility design is the responsibility of Holmes & Narver, Inc. (H&N) an Architect/Engineering (A/E) firm experienced in nuclear industry-related civil-structural work. Underground facility design is the responsibility of Fenix & Scisson, Inc. (F&S) an A/E firm experienced in nuclear industry-related work in underground design and development. Los Alamos National Laboratory (Los Alamos) has the lead responsibility to provide all ESF design, construction, and operational support inputs for testing to the Project Office. The test design and facility development is produced through the cooperative efforts of the participants delegated the responsibility for conducting the individual tests. The ESF surface and underground testing for Title II design is based on characterization testing identified in the statutory Site Characterization Plan (SCP), approved Title I design, and the design-related comments; and the design-related requirements and guidance documents of the project as interpreted by the design basis documents of the responsible individual design participant.

In addition, Reynolds Electrical and Engineering Company, Inc. (REECo), the designated construction organization reporting directly to the Project Office, participates in a design oversight capacity during the Title II design process to ensure constructibility and worker health and safety for all personnel.

10.2 PARTICIPANTS

The organizations involved in the ESF Title II design are as follows:

YUCCA MOUNTAIN PROJECT OFFICE

The Project Office is responsible for the management, direction, and coordination of the overall ESF Title II design effort.

TECHNICAL & MANAGEMENT SUPPORT SERVICES CONTRACTOR

The T&MSS contractor is responsible for supporting the Project Office in the management and integration of the ESF. Duties include project coordination; technical review/analysis of project reports; and regulatory, institutional, quality assurance, socioeconomic, transportation, and environmental studies.

Mac Technical Services, Inc. (MACTEC)

MACTEC provides quality assurance support to the Project Office.

HOLMES & NARVER, INC.

H&N is responsible for the Title II engineering and design for the ESF surface facilities and utilities; subsurface utilities related to testing; communications; data facilities; and life safety systems. The H&N Title II ESF design responsibilities include the main pad, auxiliary pads, roads, site drainage, surface power system, surface water system, sewage system, surface mine waste water system, communication system, surface structures, subsurface data building, life safety system, uninterruptible power systems for the surface and underground testing, and provisions for the Integrated Data Systems (IDS) design.

FENIX & SCISSON, INC.

F&S is responsible for the Title II engineering and design for the ESF underground facilities and utilities, and the surface hoisting systems. The F&S Title II ESF design responsibilities include the ESF shaft collars, shaft excavation and lining, hoists and headframes, subsurface excavations, shaft internals and conveyances, and in-shaft and underground utilities. Systems that comprise the underground utilities are the underground ventilation system, underground water system, underground mine waste water system, compressed air supply and related underground distribution, subsurface power system, and portions of the underground instrumentation and communication systems.

LOS ALAMOS NATIONAL LABORATORY

Los Alamos manages and integrates the testing design requirements, plans, and definitive design criteria on testing for the ESF Title II as developed by the Project Principal Investigators. Los Alamos provides technical assistance to coordinate the underground testing requirements and data acquisition portions of the ESF Title II design effort with H&N and F&S. Los Alamos integrates support test requirements with REECo, and designs, installs, operates, and maintains the IDS. In addition, Los Alamos is in charge of the testing for the chlorine-36 test, diffusion, geochemistry, volcanism, mineralogy, and petrology.

SANDIA NATIONAL LABORATORIES (SNL)

SNL is responsible for ensuring that the ESF is compatible with the planned repository. SNL is also in charge of the shaft convergence tests, the demonstration breakout room, sequential drift mining, the heated block test, the canister scale heater experiment, the plate loading tests, the small scale heater slot strength test, development of the prototype boring machine, thermal stress measurements, and performance assessment.

UNITED STATES GEOLOGICAL SURVEY (USGS)

The USGS is in charge of shaft wall mapping, photography and hand specimen sampling, rock matrix tests, hydrologic properties test, intact fractures test, infiltration test, permeability testing, radial boreholes, hydrochemistry tests, excavation effects tests, perched-water tests, overcore stress tests, seismicity, and climatology.

LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL)

LLNL is in charge of the waste package environment test.

REYNOLDS ELECTRICAL & ENGINEERING COMPANY, INC.

REECo is the construction manager for the ESF and provides technical advice on drilling and the constructibility of the ESF. In addition, REECo assists in the development, implementation, and control of a personnel health and safety program for the ESF.

10.3 DESCRIPTION OF TITLE II DESIGN QA PROGRAM

The ESF Title II design phase QA program is governed by the Yucca Mountain Project Quality Assurance Plan, as is the Title I design phase. The grading by QA levels continues, with QA Level I items and activities requiring the highest degree of quality because of their relationship to the radiological health and safety of the public in the preclosure and postclosure phases of the repository. QA Level II is assigned to items and activities associated with public and worker nonradiological health and safety. QA Level III items and activities are those having no major function in the characterization of the site, but which require good professional and industrial practice for their intended use.

A methodology is being developed and installed to support the identification of items and activities, items important to safety, items important to waste isolation, quality activities and the assignment of quality assurance levels. This methodology is consistent with NRC NUREG-1318, "Technical Position on Items and Activities in the High Level Waste Geologic Repository Program Subject to Quality Assurance Requirements."

The Title II design phase has a QA Level I classification because it involves the preparation of detailed design documents for engineered items important to radiological safety and/or waste isolation. The design output of this phase is drawings, specifications and analyses that are used for the construction of the ESF.

Items and activities continue to be assigned individual QA levels, which take precedence over the assignment given to the Title II design phase because it is recognized that many items and activities are not essential to radiological safety or waste isolation. However, it is the responsibility of the Yucca Mountain Project to identify those items and activities and justify through the methodology established by the Project the decisions made in assigning QA levels to all items and activities.

10.4 MANAGEMENT OVERSIGHT AUDIT

In the process of performing ESF Title I design, the documentation and traceability of interface requirements and other design information was based on existing QA requirements. ESF design decisions for Title II will be as rigorous as those required for a licensable activity. A Project Office selected readiness assessment review board and team provide the Project with an independent evaluation of the management and quality assurance activities necessary, and provide insight into the risks associated with alternate courses of action.

A checklist is prepared by identifying a list of quality assurance and management areas that need development and implementation prior to the design being released for construction. Of particular importance prior to and during Title II design are: (1) organization; (2) quality assurance program; (3) design control; (4) instructions, procedures, plans and drawings; (5) document control; (6) corrective action; (7) quality assurance records; (8) audits; (9) logic and schedules; and (10) testing support. Checklist questions are developed within each topic. The answers provide the status and the problems associated with each topic.

The evaluation results are identified as one of following: (1) organization, (2) procedure availability, (3) QA assignment, (4) design input documents, (5) design control, (6) planning/design logic, and (7) other concerns.

The conclusions and recommendations made by the review team are considered as prerequisites, and implemented, as appropriate, across the project. These prerequisites are then added to the ESF schedule.

10.5 BASIS FOR DESIGN FOR TITLE II

Documents that serve as the basis for design for the Title II ESF Design are the following:

10 CFR Part 60 Disposal of High Level Radioactive Wastes in Geologic Repositories.
OGR/B-2, Generic Requirements for a Mined Geologic Disposal System.
Yucca Mountain Mined Geologic Repository System Design - Appendix E Requirements
Yucca Mountain Mined Geologic Repository System Design Requirements
ESF Subsystems Design Requirements Document (SDRD)
NNWSI Project Reference Information Base
DOE Order DOE 6430.1A, 12/25/87, Draft General Design Criteria

DOE Order 5480.4, Environmental Protection, Safety, and Health Protection
Site Characterization Plan
NNWSI/88-9, Quality Assurance Plan
Approved Engineering Change Requests
ESF Interface Control Documents
ESF Title I 100 Percent Technical Assessment Review Review Record Memorandum
F&S Scope of Work for Title II
F&S Basis for Design for Title II
F&S ESF Title I Design Drawings and Outline Specifications
H&N Title II Design Basis Document
H&N Title II Scope & Planning Basis Document
H&N ESF Title I Design Drawings and Outline Specifications

The ESF SDRD (NVO-309) provides functional requirements and performance criteria for the ESF. The most stringent of the applicable regulations, codes and standards furnish other basic design criteria. The criteria derived from these sources are considered authorized basic design criteria.

Other information may be provided as design input by the Yucca Mountain Project Office in the form of letters and verbal instructions. In all cases, such design input must be reviewed and accepted by the A/E, and must be approved by the Project Office prior to inclusion in the basis for design.

A substantial quantity of design criteria exists as a result of ESF planning activities, correspondence, meetings and special studies. Those criteria, which further defines the ESF or performance requirements, are included in the basis for design. Upon approval of the documents, the criteria become authorized basic design criteria.

The A/Es are responsible for performing engineering design and analyses, and developing plans, schedules, specifications, drawings, and cost estimates for ESF construction activities. Because of interfaces with other ESF project participants, the precise scope of engineering is detailed in the scope and planning documents.

CHAPTER 11

CONSTRUCTION

11.1 MANAGEMENT PLAN

The management for the construction, inspection, and acceptance testing of the ESF system is divided into four vertically integrated levels of authority. From the top down these levels of authority are the U.S. Department of Energy/ Nevada Operations Office (DOE/NV), the Yucca Mountain Project Office, the Exploratory Shaft Facility (ESF) site office, and the ESF site contractors. A total of ten organizations are involved.

The Nevada Operations Office is the overall DOE authority in Nevada and the ESF project parent organization, containing the Project Office as one of its several organizational groups.

The Project Office, which has ESF construction management responsibility, has three divisions: regulatory and site evaluation, engineering and development, and project and operations control. Each division has its own support staff. In addition, the Western Division of the Mine Safety and Health Administration (MSHA) provides technical support to the Engineering and Development division.

The ESF Management Plan (ESFMP) provides guidance and the overall management philosophy that governs all activities at the ESF. The ESFMP is subordinate to the Project Plan and the Project Management Plan. The requirements specified in these higher-tiered documents are tailored to specifically apply to the management of the ESF. Other plans at the same hierarchical level are specified in the ESFMP to provide specific management guidance in technical areas such as configuration management and systems engineering management.

The ESFMP requires the development of specific ESF-related procedures to control activities such as field changes, Title III design, work authorization, inspection and acceptance, quality, testing support, site security, and access and visitor control. The ESFMP establishes the site management organizational structure, defines responsibilities and authorities, and provides guidance for the management of work to be performed at the ESF. This guidance includes quality management, work breakdown structure, logic diagrams and schedules, milestones, performance criteria, functional support requirements, performance measurement, planning and control systems, information and reporting requirements, and the application of the requirements from other plans to the ESF activities.

11.2 PARTICIPANTS

The organizations involved in the construction of the ESF Title II are as follows:

YUCCA MOUNTAIN PROJECT OFFICE

The Project Office is responsible for management, direction, and coordination of the overall ESF construction, inspection, and acceptance testing effort.

TECHNICAL & MANAGEMENT SUPPORT SERVICES (T&MSS) CONTRACTOR

The T&MSS supports the Project Office in the management and integration of ESF construction, operations, and testing. Duties include project management and integration; technical review/analysis of project construction and operations progress and results; evaluation of project reports; and ongoing regulatory, institutional, quality assurance, socioeconomic, transportation, and environmental studies.

MAC TECHNICAL SERVICES, INC. (MACTEC)

MACTEC provides quality assurance support to the Project Office.

HOLMES & NARVER, INC. (H&N)

H&N is responsible for surveying and inspection of their design for surface facilities and utilities; subsurface utilities related to testing; communications; data facilities; and life safety systems. Specific H&N technical support responsibilities include the main pad, auxiliary pads, roads, site drainage, surface power system, surface water system, sewage system, surface mine waste water system, communication system, surface structures, subsurface data building, life safety system, uninterruptible power systems for the surface and underground testing, and provisions for the integrated data systems design. Additionally, H&N provides support for the ESF onsite surface facilities, systems inspections, field surveying, and materials testing.

FENIX & SCISSON, INC. (F&S)

F&S is responsible for the engineering and design related technical support on the ESF underground facilities and utilities, and the surface hoisting systems. Specific F&S technical support responsibilities include the ESF shaft collars, shaft excavation and lining, hoists and headframes, subsurface excavations, shaft internals and conveyances, and in-shaft and underground utilities. Systems that comprise the underground utilities are the underground ventilation system, underground water system, underground mine waste water system, compressed air supply and related underground distribution, subsurface power system, and portions of the underground instrumentation and communication systems. Additionally, F&S provides underground facilities and systems inspection support at the ESF site.

LOS ALAMOS NATIONAL LABORATORY (LOS ALAMOS)

Los Alamos manages and integrates the efforts of the PIs and the resulting overall site characterization testing program at the ESF site. Los Alamos provides management and is responsible for collecting, controlling, translating, quality, maintenance, archiving, and safe-guarding of all test data reported through the electronic data reporting network at the ESF site.

Los Alamos provides technical assistance to coordinate the underground testing and data acquisition portions of the ESF operations efforts. In addition, Los Alamos is in charge of the testing for the chlorine-36 test, diffusion, Integrated Data System, geochemistry, volcanism, mineralogy, and petrology.

SANDIA NATIONAL LABORATORIES (SNL)

SNL is responsible for ensuring that the ESF is compatible with the planned repository. SNL is in charge of the shaft convergence tests, the demonstration breakout room, sequential drift mining, the heated block test, the canister scale heater experiment, the plate loading tests, the small scale heater slot strength test, development of the prototype boring machine, thermal stress measurements, and performance assessment.

UNITED STATES GEOLOGICAL SURVEY (USGS)

The USGS is in charge of the shaft wall mapping, photography and hand specimen sampling, rock matrix tests, hydrologic properties, intact fractures test, infiltration test, permeability testing, radial boreholes, hydrochemistry tests, excavation effects tests, perched-water tests, overcore stress tests, seismicity, and climatology.

LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL)

LLNL is in charge of the waste package environment test.

REYNOLDS ELECTRICAL & ENGINEERING COMPANY, INC. (REECO)

REECo is the construction manager for the ESF. REECo responsibilities include overall ESF site construction, management and integration of the subcontractor tasks and work packages, management and integration of ESF site operations, operational test support, and construction/operations related quality control. REECo administers the personnel health and safety program for the ESF site.

11.3 QA PROGRAM FOR CONSTRUCTION AND INSPECTION OF THE ESF

The ESF Title III phase follows the requirements of the Yucca Mountain Project Quality Assurance Plan with emphasis on the QA criteria associated with inspection of construction. Administrative procedures involve procurement, control of processes (blasting, welding, etc.), and inspection. These requirements are imposed upon the Architect/ Engineers (A/Es) and construction contractors who develop and issue quality control operating procedures for inspections and construction operations including welding, stress relieving, warehousing and testing.

The QA Levels are applied with ESF Quality Level Assignments made during the Title II phase. The performance of a construction or inspection operation is governed by the QA classifications assigned to an item and include all phases of construction from qualification of personnel to inspection documentation.

Also during Title III, technical compliance, inspection and testing includes an integrated approach to activities performed by the various project participants. REECo performs technical compliance activities (as specified in the approved for construction or issued for construction plans and drawings) as necessary to ensure REECo management that the construction is in accordance with those drawings and specifications as per DOE Order 4700.1, Part C, subsection 3c(3)(f)4. The A/Es perform and/or witness inspection and testing activities that attest to the fact that implies construction is per the drawings and specification, and that the constructed system, structure, or component will function in operation as intended. T&MSS assures that REECo and the A/Es document the inspections, testing, and verification activities.

During Title III, the role of QA emphasizes achievement of actual quality in the construction process, in addition to the meeting of programmatic requirements such as record keeping. The Quality Assurance program concentrates on the actions and processes that directly affect quality of construction by specifying training of all personnel whose workmanship capabilities contribute to the construction of the ESF, and its eventual operation.

11.4 CONSTRUCTION PACKAGES

The majority of the construction is completed by REECo as the constructor using direct hire labor. The only work to be subcontracted by REECo is the sinking of the ES-1 and ES-2 shafts and the construction of the 150,000-gallon and 10,000-gallon water tanks. The possibility of REECo sinking the two shafts using direct hire labor is being evaluated now.

Major construction activities include mobilizing and demobilizing all construction aids as required to construct the facilities. This activity includes surface and underground mobile equipment and materials. It also includes temporary construction power, water, sanitary facilities and field construction offices; constructing all site access roads and pads; procuring and installing all permanent site power, water, sewer, communications, mine waste water, and instrumentation facilities; procuring and constructing all pre-engineered metal buildings, field office trailers, and associated mechanical and electrical components; and excavating, lining and equipping the ES-1 and ES-2 shafts. This work includes procurement and installation of headframes, hoisting systems and shaft conveyances; procurement and construction support to in-shaft testing as required during excavation of the ES-1 and ES-2 shafts; procurement of associated equipment and materials; and construction of all underground drifts and alcoves as necessary to support in situ testing of the ESF.

11.5 READINESS REVIEWS

The readiness review process is conducted and documented in accordance with the Administrative Procedure 5.13Q. The Yucca Mountain Project Office and DOE Headquarters have agreed to hold readiness reviews before the start of site preparation, the start of multipurpose borehole testing, and the start of the shafts.

The Project is currently completing detailed planning and scheduling activities that include the identification of the prerequisites to be accomplished in order to assure timely and successful readiness reviews.

The readiness review for the start of site preparation is the precursor to ESF site construction activities. The readiness review for the start of multi-purpose borehole testing determines the presence of and volume of perched water, rock mass properties, and monitors changes to the baselines. If changes in the baseline occur, it assesses the impact on the shaft data obtained. The readiness review for the start of shafts is the precursor for both the continuation of the ESF construction activities initiated during site preparation and the initiation of site characterization activities of testing and mapping performed during the shaft sinking operations.

11.6 TESTING DURING CONSTRUCTION

Many tests are performed during the construction of the ESF. These include mapping, fracture mineralogy, seismic tomography, radial boreholes, perched water (if encountered), shaft convergence, demonstration breakout rooms, excavation effects, intact fracture (coring), chlorine-36 sampling, matrix hydrologic properties sampling, laboratory mechanical properties sampling, hydrochemistry sampling, and shaft and borehole seals.

Tests that require construction constraint or hold points at the MTL are mapping, DBR, sequential drift mining, heated room, perched water (if encountered), matrix hydrologic properties sampling, and laboratory mechanical properties sampling.

In addition to actual hold points for construction, nearly all tests require coordination for such activities as drilling of instrumentation and other holes, installing cable/data wiring and the protection of instruments from damage.

Coordination between test planning and construction planning is an ongoing effort as the test plans and procedures are developed. Some experience is being gained from prototype testing, but many construction hold points are not determined until actual observations of exposed rock are available in the ESF.

CHAPTER 12

OPERATIONS AND TESTING

12.1 OPERATIONS

Reynolds Electrical & Engineering Company, Inc. (REECo) provides the operation and maintenance support to the Exploratory Shaft Facility (ESF) during construction and testing. This support includes:

1. Providing labor, equipment and material to maintain sites, roads and grounds.
2. Providing labor, equipment and material to maintain all utility systems including power, water, sewer mine waste water and communications.
3. Providing labor, equipment and material to maintain buildings and field office trailers.
4. Providing mechanical services to maintain all mobile equipment assigned to the project.
5. Supplying equipment and material necessary to maintain project components stored at the Nevada Test Site (NTS) and onsite.
6. Supplying material and equipment necessary to maintain all underground service systems including the hoisting systems, ventilation, compressed air, water, and waste water systems, power, warning and monitoring system and communication systems.
7. Supplying material and equipment to maintain the conveyances, muck transfer and hoisting systems of the shifts.
8. Supplying labor, equipment and materials as required to support testing during the operations phase.
9. Providing warehousing services for equipment and materials during and after construction.
10. Providing communications systems to and from the ESF, including telephone service center charge.
11. Providing supervisory and administrative support as required during the construction and operations phase.
12. Supplying bus transportation services to the facility from outlying areas.
13. Providing safety and MSHA training to all personnel involved.

The management of the facility and the relationship and responsibilities of the Yucca Mountain Project Office and the project participants is defined in the ESF Management Plan (draft in review process). These relationships and responsibilities are shown in Figures 12-1 and 12-2.

12.2 LONG TERM TESTING

The Title I design of the ESF is designed with sufficient flexibility to provide space for the conduct of performance confirmation tests. The performance confirmation tests are defined in 10 CFR Part 60 as a "program of tests, experiments, and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objectives for period after permanent closure will be met." Details of such tests are not available at this time. However, it is anticipated that the site characterization tests, for which the ESF is being designed, such as seal tests, room heater experiment, and engineered barrier field system tests, may become performance confirmation tests.

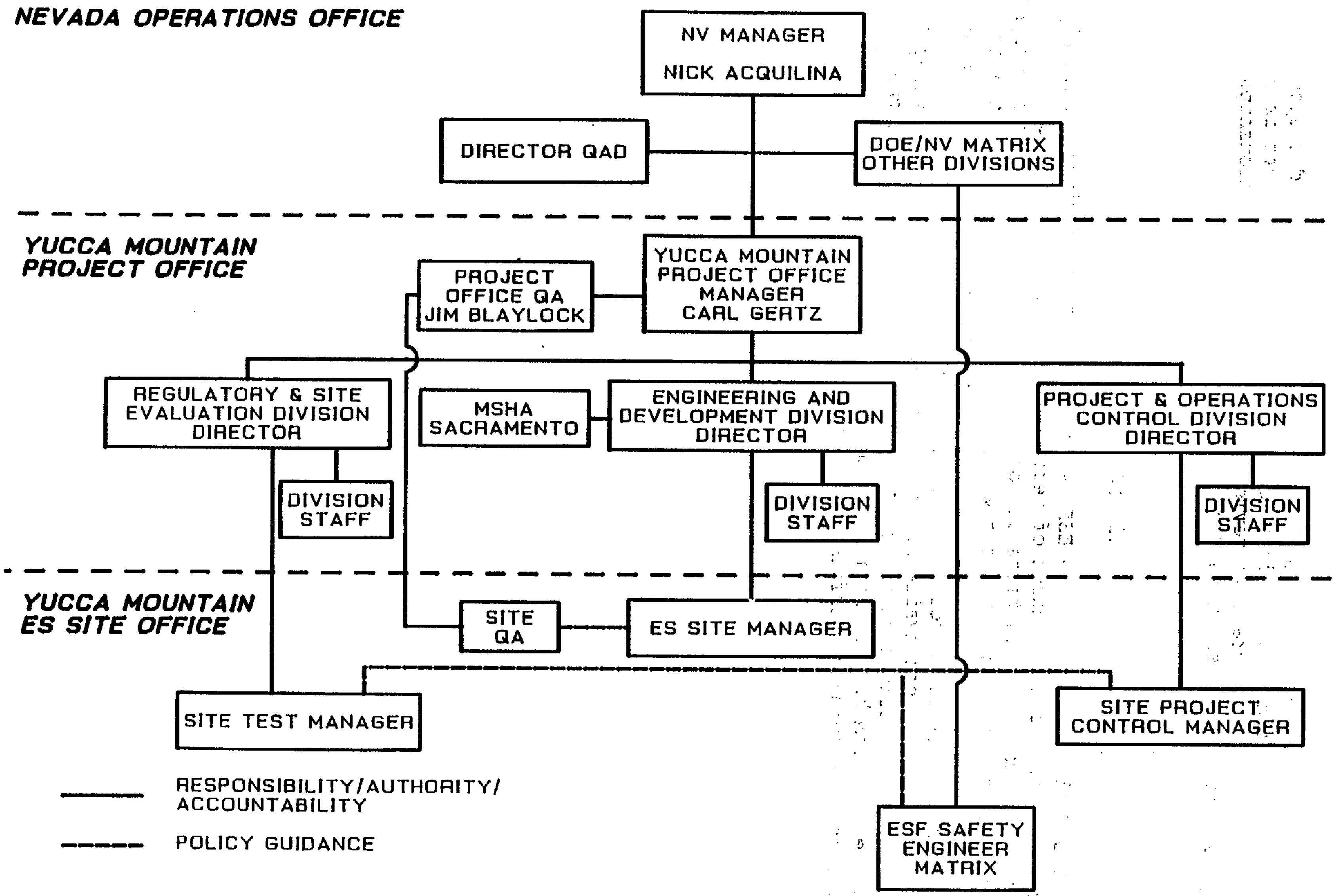


Figure 12-1. ES related organization.

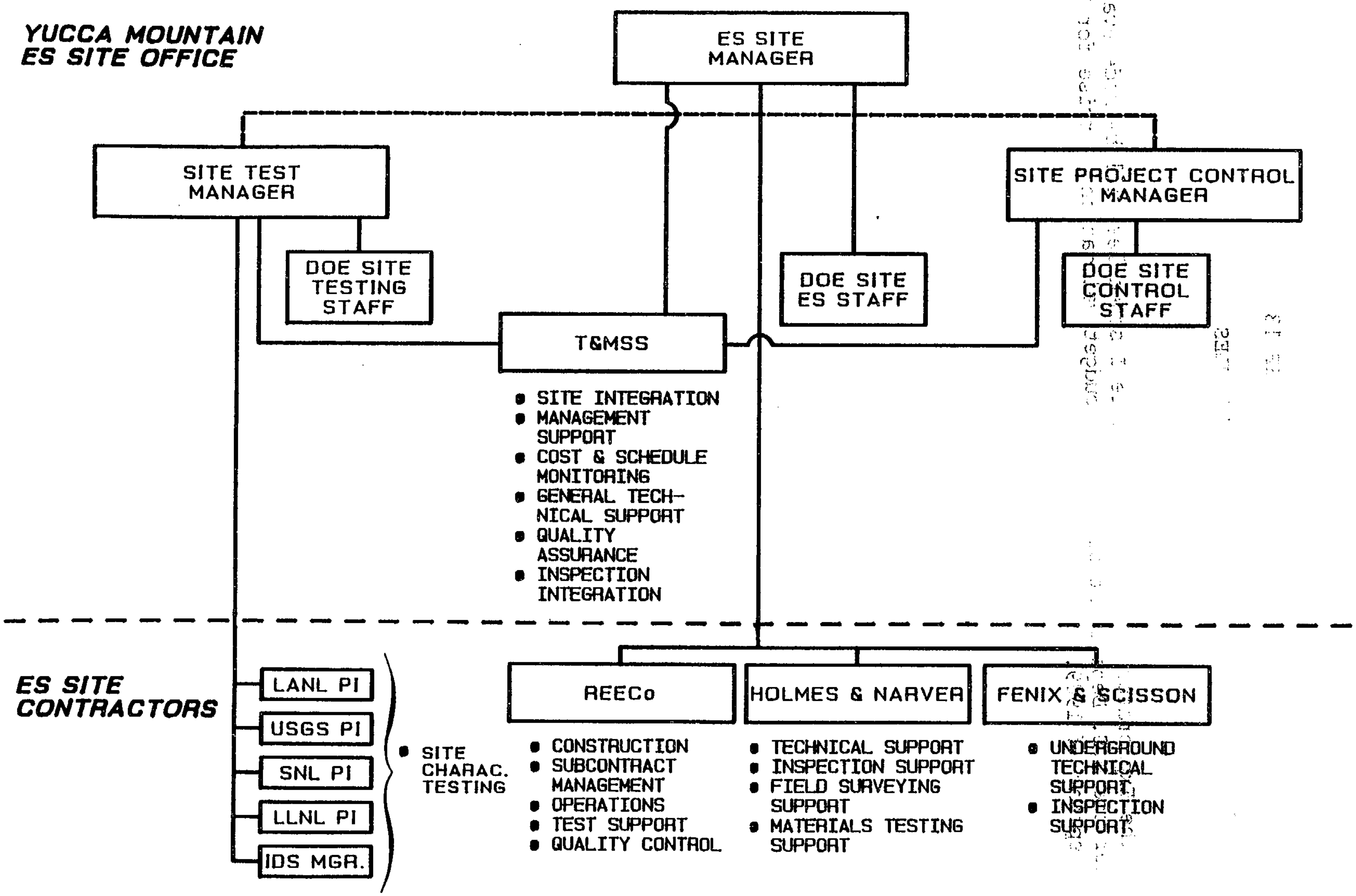


Figure 12-2. ES site organization.

CHAPTER 13

SCHEDULES

The Exploratory Shaft Facility Title I schedules will be made available after the U.S. Department of Energy's budget validation exercise for Title I in the spring of 1989.

CHAPTER 14

COST ESTIMATES

The Exploratory Shaft Facility Title I cost estimates will be made available after the U.S. Department of Energy's budget validation exercise for Title I in the spring of 1989.