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DATE: January 13, 1989

SUBJECT: MAPPING INFORMATION

Please find enclosed the above-referenced information for your file.

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3.0 ACTIVITY SUMMARIES

In addition to the proposed surfaced-based investigations discussed in this chapter several types of data-gathering activities were initiated prior to the start of site characterization. These ongoing activities were necessary to get an early start on data gathering when the NNWSI Project (now the Yucca Mountain Project) began to focus on tuff at Yucca Mountain as a potential repository host rock. Monitoring equipment for these ongoing studies has already been installed at and near Yucca Mountain, and this equipment will be used during site characterization. The ongoing studies consist primarily of field observations and monitoring and do not require additional site preparation or access. The activities consist of (1) monitoring the hydrologic processes of the unsaturated zone, (2) monitoring the potentiometric (water table) level, (3) monitoring natural infiltration rates in the surficial units of the unsaturated zone, (4) streamflow monitoring, (5) debris flow monitoring, (6) monitoring erosion on hillslopes and in selected stream channels, (7) regional hydrologic studies, (8) ground-water recharge analog studies, (9) seismic network monitoring, (10) biennial geodetic surveys, (11) soil and dust-trap sampling for studying paleoenvironments, (12) sampling and mapping tectonic and paleoclimatic trenches and pits, (13) geologic and geomorphic mapping, (14) meteorological and precipitation monitoring, and (15) surface outcrop sampling for geologic, geomechanical, and geochemical tests. Planned site characterization activities will result in the expansion of several of these activities, with the location of additional new sites being required.

It has been estimated that site characterization activities may disturb approximately 180 ha (440 acres). The extent of this disturbance will vary from minor disturbances associated with off-road use and deployment of monitoring instruments to more major types of disturbance, such as cut-and-fill construction associated with the ESF area. Approximately 18 ha (45 acres) of the estimated total disturbance would be associated with construction of the ESF area, which is not discussed in the SBIP. Actions required as part of, or in support, of, surface-based investigations account for the rest of the proposed disturbance. It should be noted that the major difference in the amount of land projected to be disturbed during site characterization here and in the EA (285 ha) results from the number and approximate locations of proposed field activities being better known now than at the time the EA was published. This has allowed the Project to better use the existing road network in the planning process, thereby greatly reducing the amount of disturbance that was once projected for access road construction.

3.1 SITE PREPARATION

Site Preparation will be required for many of the surface-based site characterization activities. Site preparation is generally defined here as construction-type activities that involve the disruption, removal, and/or relocation of vegetation and surficial materials. This includes cut-and-fill, grading, and excavation operations. Site characterization activities requiring site preparation include construction of the ESF area (which is not considered as a surface-based investigation, and is not discussed herein), drill-pad construction, excavation of trenches and pits, and preparation of bedrock

pavement study areas. Construction of access roads will also be discussed because they are needed to support site characterization activities.

Many surface-based investigations will not require site preparation and will result in minimal or no disturbance. These investigations include meteorological monitoring, radiometric monitoring, geodesy, seismic monitoring, shallow penetrating geophysical surveys, evapotranspiration studies, geologic and surficial deposits mapping, erosion monitoring, precipitation and streamflow monitoring, and unsaturated-zone infiltration monitoring. The types of field activities that are necessary to support these investigations involve:

1. Installation of passive monitoring equipment on the surface or on towers.

2. Installation of survey monuments, small edifices, etc.

3. Use of portable geophysical seismic sources and recorders.

4. Deployment of ground motion detectors or other geophysical instruments.

5. Infrequent off-road vehicular travel.

6. Use of an all-terrain truck-mounted drill rig to drill shallow, <60 m (200 ft) deep boreholes.

The following subsections describe the general categories of field activities that will involve some level of site preparation.

3.1.1 Drilling Preparation

The Yucca Mountain Project has developed a proposed comprehensive drilling program that includes conditionally planned drilling methods and boreholes, which may require some modifications presented herein. Since the drilling of some boreholes is dependent on the results of other investigations, a range for the planned number of holes is presented rather than an absolute number. Conditionally planed drilling activities are discussed in more detail later.

In terms of surface impacts associated with the site preparation required for proposed drilling activities, the drilling of boreholes needs to be separated into two broad groups based on depth and core requirements. Shallow boreholes, typically less than 60 m (200 ft) in depth, that can be drilled using an all-terrain, rubber-wheeled truck-mounted drill rig will not require any surface preparation. Included in such holes would be the unsaturated zone neutron access holes associated with the natural and artificial infiltration investigations, and the seismic shotholes associated with the deep (regional) seismic refraction and reflection surveys. Deeper boreholes, and holes that involve wireline coring techniques that need drilling fluids for circulation, require construction of a drill pad.

Present plans include drilling 53 to 59 deep boreholes, or boreholes requiring construction of a drill pad. Site preparation required for drill-pad construction involves providing an area that is level and cleared of vegetation. The extent of surface disturbance is dependent on the site location and type of drilling, or drill rig used. Disturbance will vary from simply clearing

vegetation and grading level the surface area needed for drilling and support equipment, to cut-and-fill construction necessary to provide a leveled surface area on hill slopes. If drilling fluids are used, a mud pit will be excavated as part of the drill pad, and lined with bentonite (or similar low permeability earthen-type material). A parking and equipment storage area will also be needed as part of the drill pad. The approximate area of surface disturbance associated with drill-pad site preparation is estimated at 1 ha (2.5 acres). If fill dirt is needed to provide a leveled site, it will be excavated from an area adjacent to the drill site, thereby becoming part of the drill pad. Several boreholes will be drilled from the same drill pad. This would include the three UE-25 UZ#9-complex holes and UE-25 VSP#1 hole, USW UZ-2 and UZ-3, USW UZ-11 and UZ-12, and the two unsaturated zone prototype boreholes. Also, the area affected by site preparation for the two multipurpose boreholes is within the pad areas of the exploratory shafts, and is therefore considered part of the disturbed area associated with ESF construction.

Little if any surface preparation will be required for shallow holes drilled with the truck-mounted drill rig. Approximately 266 neutron access holes are proposed. These holes are needed to allow monitoring of infiltration and percolation rates in the surficial materials of the unsaturated zone with a neutron moisture meter. The objective is to monitor infiltration of the existing surficial conditions (i.e., undisturbed vegetation and soils) under natural and artificial precipitation rates. However, minor disturbances will occur as a result of accessing the site of the hole. The amount of disturbance associated with these holes is small compared to the large number of holes because (1) several holes will be located in a small area (e.g., 10 holes per large plot rainfall simulation site, which covers an area of approximately 37 m^2 (440 ft^2)) and (2) the holes will be located no more than 60 m (200 ft) from the nearest existing or proposed road (a compressor, with a 60-m (200-ft) hose, is needed for drilling and will be parked along the nearest road).

In addition to the neutron access holes, seismic shotholes, associated with the proposed deep (or regional) seismic refraction survey (section 3.3.4), will be drilled. These holes will not require site preparation and will range in depth from 15 to 45 m (50 to 150 ft). They will be loaded with explosive charges to serve as the seismic source for the surveys. Prior to detonation, the holes are backfilled with gravel and/or drill cuttings in a manner that reduces the possibility of cratering. Based on the spacing specifications, summarized in Section 3.3.4, 21 to 52 such holes could be drilled. These holes will be located along existing roads as much as possible.

3.1.2 Trenching

Excavation of trenches with bulldozers or backhoes will be needed for tectonic studies of faults and fault zones and for paleohydrology studies. The size and depth of trenches will vary depending on the feature being investigated. Excavated material will be stockpiled adjacent to the trench and will be backfilled into the trench following the completion of investigations. In addition to the planned trenches, smaller soil pits may be needed to support surficial deposits mapping activities.

3.1.3 Artificial Infiltration Study Site Preparation

A minimum amount of site preparation will be required as part of the artificial infiltration ponding studies. Approximately 50 of the unsaturated zone neutron access holes, used originally for monitoring natural infiltration, will serve the dual purpose of monitoring moisture influx under saturated conditions. This artificial infiltration investigation is referred to as ponding studies. Site preparation will involve constructing a low berm of impervious material around one or two neutron access holes, enclosing approximately 10 m^2 (100 ft^2). A dye tracer will be mixed with the ponded water to allow percolation pathways to be mapped. Again, the objective is to determine flow paths of the surficial materials under natural, or nondisturbed, conditions. Therefore, disturbance associated with site preparation (berm construction) will be minimized. The rock mass beneath some highly fractured locations will be excavated to a depth of as much as 7 (25 ft) following ponding, and flow patterns mapped. Up to six such excavations are possible. This disturbance is included in that estimated for trenching.

3.1.4 Bedrock Pavement Study Site Preparation

In this context, the term "pavement" refers to a bedrock surface that has little or no regolith covering. Pavements are uneven natural surfaces and are commonly located on slopes. Surface fracture network studies involve the mapping and measurement of fracture patterns in bedrock. Planned pavement studies will be undertaken only where bedrock is relatively close to the surface. In some instances, clearing of thin layers of surficial material may be required to expose a sufficient amount of bedrock (up to 800 m^2 of cleared area is needed per pavement, depending on the geologic aspects of each pavement location). Where necessary, bedrock will be cleared by spraying the area with compressed air and water. Displaced surface material will collect adjacent to the cleared area. At least two additional bedrock pavement areas will be selected for surface fracture network investigations. Only areas where bedrock is already fairly well-exposed will be selected for study.

3.1.5 Access Road Construction

Two types of access roads exist at or near the site, exclusive of the paved access road and other roads (e.g., haul roads) associated with the ESF: bladed, unimproved dirt or graveled roads, and one-lane dirt tracks or trails. Bladed roads generally are required where the amount of vehicular traffic is significant or where heavy vehicles and equipment must have access, such as the majority of the drill sites. The decision to add road base and/or gravel to the road surface is dependent on the amount of traffic and length of time the road will be used. Primary access roads that will receive daily use will typically be graveled. Shorter roads that connect field sites to the primary access roads will normally not be graveled.

The unimproved road surfaces will average about 7 m (23 ft) in width. However, since drainage ditches, berms, and cut-and-fill slopes are typically associated with construction of these roads, the average width of right-of-way disturbance has been estimated to be approximately 15 m (50 ft). It is anticipated that 20 to 30 miles of these roads will be required to support surface based investigations. These roads will be constructed and maintained in such a manner that runoff from precipitation will be prevented, to the extent

practicable, from ponding or running down the road surface. Cross culverts and water bars will be installed as necessary to control runoff. Road dips, or culverts, will be installed where roads cross natural drainages to minimize potential impacts to natural runoff patterns.

One-lane dirt tracks or trails will be required to access infrequently visited, or short-term, field sites such as trenches, streamflow monitoring stations, bedrock pavement sites, etc. These trails will be bladed or simply consist of vehicle tracks. The need to blade a track to provide access to a field site will be dependent on the terrain. An average disturbance width of 4.5 m (15 ft) is associated with these roads.

With the exception of the borrow area associated with construction of the ESF, excavation of borrow areas for site characterization field activities at, or in the vicinity of, Yucca Mountain is not anticipated at this time. Any road base, gravel, or fill material that may be required for site preparation will be transported to the site from aggregate areas located on the Nevada Test Site (NTS). Such aggregate areas on the NTS are operated by contractors for NTS activities and are independent of Yucca Mountain Project activities.

3.2 PRECIPITATION AND STREAMFLOW MONITORING

The relationship between precipitation and streamflow at the Yucca Mountain site is needed as input into characterization of the unsaturated zone. In order to adequately characterize this relationship, a detailed network of preciptation and streamflow monitoring stations will be established at the site. This activity may also require etablishing additional meteorological stations at the site (in addition to the five existing meteorological towers). The need for additional stations is being determined.

3.2.1 Stream Flow Monitoring

There are plans to install 24 stream gaging stations at selected sites on Yucca Mountain drainages. These stations will be instrumented with continuously recording stream gages which will measure stream flows and allow estimates of runoff to be made. This activity support studies identified in Section 8.3.1.2.1 of the SCP.

3.2.2 Precipitation Monitoring

At the 24 proposed sites of stream flow monitoring identified above, there are also plans to install precipitation gages. In addition to these 24 sites, 4 additional precipitation monitoring sites are planned. This activity supports studies identified in Section 8.3.1.2.1 of the SCP.

3.3 GEOPHYSICAL STUDIES

Geophysical surveys play a major role in providing information on the spatial distribution of bulk properties. Shallow seismic refraction and reflection, and shear wave refraction and reflection, will be used for investigation of faults in the vicinity of Yucca Mountain. Electromagnetic surveys will be performed to investigate the thickness of the volcanic section and fault trends.

3.3.1 Shallow Seismic Reflection

These surveys will be performed using the Mini-Sosie technique, with portable small-scale vibrator sources, and will not necessarily be limited to existing roads. Off-road vehicular travel will be minimized. Shallow reflection will be conducted in short (1 to 5-kilometer; 0.6 to 3.1-mile) traverses. Seven to 15 profiles may be conducted. Initially two preliminary profiles will be run, and a decision to proceed with other profiles will be made based on these results. Potential profile locations include Crater Flat, Rock Valley on the NTS, and in the immediate vicinity of Yucca Mountain. Potential locations of profiles in the immediate vicinity of Yucca Mountain are shown on the maps in Volume 4. All lines will use 9.1-meter (30-foot) source points; common-midpoint data gathers will be stacked every 4.6 meters (15-foot) for 12-fold, or every 9.1 meters for 24-fold, using 12 geophones per group. The penetration of this method can be a few thousand feet depending on seismic propagation conditions. These surveys will be used to delineate subsurface structure and will support activities identified in sections 8.3.1.4.1 and 8.3.1.17.4 of the SCP.

3.3.2 Shallow Seismic Refraction

This type of survey will be performed using portable engineering seismographs and repetitive hammer (sledgehammer) sources. Site preparation is not required; however, these surveys will not necessarily be limited to existing roads. These surveys will be used to delineate shallow subsurface structure, in conjunction with other seismic methods, and will support activities identified in sections 8.3.1.4.2 and 8.3.1.17.4 of the SCP.

3.3.3 Deep Seismic Reflection

A proposal to conduct a seismic reflection survey crossing Yucca Mountain and extending across the Furnace Creek Fault and the Walker Lane will be evaluated through prototype testing and peer review.

The prototype test will consist of a field survey of one line to be located either southwest of Beatty or south of Amargosa Valley (Figure 8.3.1.17-13), 15 km (9.3 mi) in length, plus noise tests. The prototype survey will utilize 10 km (6.2-mi) spreads, 24 geophones per group, 50-m (164-ft) group interval, 240 groups per spread, Vibroseis energy source, 100-m (328-ft) vibrator interval, 54,000-kg (120,000 lb) minimum peak vibrator force, and 240 channel floating-point digital recording. This configuration will be varied so as to optimize shallow and midcrustal reflections. Results of the prototype tests and potential application to Project needs will be evaluated by a panel convened for that purpose. This activity supports studies identified in section 8.3.1.17.4.

3.3.4 Regional Seismic Refraction

This proposed activity uses discrete event recorders and explosive sources in accordance with standard practices for geophysical exploration. The receivers will be discrete, portable, battery-powered event recorders which do not require any site preparation and can be readily deployed from a helicopter if necessary. Shot holes will be located along existing highways and roads with shots prepared at predetermined locations approximately every 6 miles along each refraction line. Each shot hole will be drilled about 20 inches in diameter and up to 150 feet deep, and filled with about 2,000 pounds of ammonium nitrate explosive. The uppermost 50 feet of each hole will be tamped with gravel trucked to the location or backfilled with drill cuttings. For larger shots up to about 4,000 pounds of explosive will be used. For these, or more such shot holes will be prepared together. The tendency for surface cratering will vary with the geologic conditions at each shot point, however, each shot will be conservatively designed so as to prevent cratering. Redundant systems (i.e., dual blasting caps) will be used to reduce the possibility of misfire.

Exact locations have not yet been determined, but tentative plans include an east-west profile centered on Yucca Mountain with two, or three cross profiles. This activity supports studies identified in section 8.3.1.8.2 and 8.3.1.17.4 of the SCP.

3.3.5 Regional Magnetotelluric Surveys

Regional magnetotelluric (MT) surveys consist of a number of measurements of the conductivity structure of the earth, made at stations located along a linear profile. The MT method is passive, requiring two perpendicular dipole electrode arrays and a magnetometer on the surface. The dipoles are typically 300 to 3,000 feet long. The magnetometer sensor is a loop of wire 30 to 300 feet in length, buried a few inches beneath the surface with a shovel to decrease interference from wind. Off-road vehicle access is not a requirement for an MT survey.

Proposed MT lines would follow NV route 29 from Lathrop Wells toward the California border and would transect the Amargosa Desert in a north-south direction. The station spacing for MT surveys in Crater Flat and Amargosa Valley would be 3 to 5 miles. Specific station locations have not been identified, and will be determined to some extent in the field by the Principal Investigator during the survey. This activity supports studies identified in sections 8.3.1.8.2 and 8.3.1.17.4 of the SCP.

3.3.6 Other Geophysical Surveys at the Site

Detailed ground geophysical surveys will be performed in the immediate vicinity of Yucca Mountain, where aeromagnetic and other regional surveys indicate the possible existence of anomalous structures. Geophysical measurements such as total natural magnetic intensity, or the magnitude of gravitational acceleration, will be acquired at station locations distributed over, and adjacent to, possible anomalies. Ground magnetic data will be acquired using portable equipment, and will require vehicular access to stations. Small gravity instruments must generally be transported by vehicle, off-road vehicle access is required. Detailed geophysical surveys are presently planned for a

total area of less than 10 square miles. Station spacing will vary according tot he type of survey and the local behavior of the measured geophysical quantity, but generally will range between 200 and 1000 feet. Additional surveys (including seismic, electrical, electromagnetic; airborne or ground-based), not presently planned, may also be required for evaluation of natural resources at the site, or the engineering properties of soil and bedrock at the site of the proposed repository surface facilities. These activities support studies identified in sections 8.3.1.4.1, 8.3.1.8.1, 8.3.1.9.2, 8.3.1.14.2 and 8.3.1.17.4 of the SCP.

3.3.7 Vertical Seismic Profiling Studies

Vertical seismic profiling (VSP) is a seismic exploration method similar to seismic reflection, whereby geophones are placed in boreholes or underground excavations to improve the quality of the acquired seismic image of the subsurface. VSP will be used at Yucca Mountain to image the subsurface where the proposed repository would be located. Subsurface geophones will be installed in the Exploratory Shaft Facility (ESF), in just one of the unsaturated zone drillholes UZ-9, UZ-9a, or UZ-9b, and in the VSP-support drillhole described in section 3.3.2.1. Seismic sources will be deployed on the surface of Yucca Mountain, on and adjacent to existing roads and dirt tracks. Sources will consist of vibrator-trucks. This activity supports studies identified in sections 8.3.1.4.1 and 8.3.1.17.4 of the SCP. The drilling of boreholes supporting this activity is described later in this chapter and in SCP section 8.3.1.2.2.

3.4 EXPLORATORY DRILLING AND DOWNHOLE TESTING

Equipment that may be used at each deep drill site includes a diesel-powered drill rig, pumps for circulating drilling fluid, drilling and coring tools, and an air compressor. Tentative plans call for solid waste generated at drill sites to be hauled to and disposed of at a landfill on the NTS. Water to be used for drilling, dust suppression and compaction, and human consumption will be trucked daily to each site. When drilling fluids are used for circulation during drilling operations, fluids and cuttings, as as air-foam circulation, polymer drilling muds, and bentonite, will be discharged into mud pits. Where possible and necessary, drillholes will be drilled without fluids to minimize the potential of introducing additional liquids to the unsaturated zone. Each deep drillhole will be logged to evaluate the hole conditions during drilling operations.

The exploratory drilling and testing program will include (1) unsaturated zone drilling and testing, (2) water table monitoring and saturated zone testing, (3) water infiltration and recharge studies, (4) in situ stress testing, (5) geological boreholes and geophysical studies, and (6) paleoclimatology investigations. The locations of these proposed boreholes and studies are shown on maps in Volume 4. At many of these sites, such as the infiltration monitoring sites, numerous holes may be drilled as is explained in the following subsections.

3.4.1 Unsaturated Zone Drilling and Testing

Drilling in the unsaturated zone will consist of the unsaturated zone drilling program and the multipurpose borehole activity. In addition to the vertical drilling programs, a horizontal borehole is planned that will consist of drilling laterally into the Topopah Spring welded unit of the unsaturated zone. The location of the hole has been tentatively identified as approximately 600 m (2,000 ft) north-northwest of the repository Conceptual Perimeter Drift Boundary (CPDB) where the Solitario Canyon scarp is exposed. The Solitario Canyon horizontal borehole supports studies identified in section 8.3.1.2.2 of the SCP.

Unconventional dry-drilling methods are required to meet the goals and objectives of drilling in the unsaturated zone. A drilling method is needed that will reach depths of up to 550 m (1,800 ft), using only air as the circulation medium, and will obtain core that is representative of the formation's in situ moisture condition. At least two candidate schemes are under consideration for this planned dry drilling to water table depths: (1) dual tube reverse circulation (DTRC) rotary or down-the-hole hammer technology, and (2) a telescoping ODEX concept similar to that used to drill the existing shallow UZ holes, with the provision for stepdown tool sizes to attain required depths. Feasibility testing of the DTRC rotary method is currently planned for two holes with different diameters, a 17.8-cm (7-inch) hole and a 30.5-cm (12-inch hole. These holes will be located southeast of the ESF area on the NTS. They will be located outside the conceptual controlled area boundary (shown on maps in Volume 4). These holes will be located from the same drill pad.

The unsaturated zone drilling program involves dry drilling and coring of 17 vertical boreholes, within and in he immediate vicinity of the CPDB. Seven of thee boreholes are existing and have been at least partially drilled. This includes a series of holes originally designed to penetrate the unsaturated zone above the conceptual repository horizon, and several deeper holes that penetrate the repository horizon. Site characterization plans call for reentering and deepening of UE-25 UZ#4, UE-25 UZ#5, USW UZ-7, USW UZ-8, and USW UZ-13 to 60 m (200 ft) below the water table. A review of the drilling history of these holes may indicate that it will be difficult to re-enter some of these holes; in that case, new holes will be drilled at the same location. In such a case, the original hole number will be modified with an "a" suffix (e.g., UE-25 UZ#4a).

The balance of the unsaturated zone drilling program consists of drilling 10 additional boreholes to depths that are sufficient to penetrate the water table. Borehole USW UZ-10 will be located near existing holes USW UZ-13 and USW G-3. USW UZ-2 and -3 will be located together near the existing holes USW UZ-6 and -6s on Yucca Crest. The UE-25 UZ#9-complex (9, 9a, and 9b) will be drilled in a closely-spaced pattern on the eastern flank of Yucca Mountain, just outside the CPDB. A fourth hole will be drilled at the same location as the UZ#9-complex, with the purpose of providing a VSP investigation hole. This VSP hole is included in the site vertical borehole investigations, even though it is not necessarily an unsaturated zone investigation hole. USW UZ-14 will be drilled north of the CPDB, near existing hole USW UZ-1. Holes USW UZ-11 and -12 will be located together at the base of the Solitario Canyon fault scarp.

The objective of this activity is to provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Drilling and coring needs to be performed dry so that contamination of samples and disturbance to the in situ hydrologic conditions are avoided, or minimized to the extent practicable. Existing hole USW UZ-1 has been fully instrumented to monitor the hydrologic properties and moisture conditions of the unsaturated zone. The existing UZ holes that will not be deepened will also be instrumented to monitor the hydrologic process of the unsaturated zone. Following the completion of drilling, logging, and pressure testing, the proposed and deepened existing holes will be instrumented in a similar manner for long-term monitoring of the hydrologic process of the unsaturated zone. This monitoring will involve the use of a proposed automated Integration Data Acquisition System (IDAS) that will record and transmit data. The IDAS will require installation of instrument shelters at each drill site. It will also require periodic visits for various reasons, including operation of a diesel generator that will supply power in the absence of power lines to each site. This drilling and testing program supports studies identified in sections 8.3.1.2.2 and 8.3.1.4.3 of the SCP.

Two vertical boreholes will be drilled near the location of each exploratory shaft. These boreholes are designated as multipurpose boreholes and will be drilled to detect and characterize possible perched water, characterize in situ hydrologic conditions, and obtain samples for analysis before constructing the shafts. These holes will be drilled in the same manner as the unsaturated zone boreholes, and support studies identified in section 8.3.1.2.2 of the SCP.

3.4.2 Systematic Drilling Program.

The systematic drilling program consists of drilling 12 boreholes within the CPDB or in its immediate vicinity to collect samples and data on litho-stratigraphy, basic physical properties, fracture characteristics, mineralogy, in situ moisture conditions, and other characteristics of the unsaturated zone. The systematic drilling program is also an important source of samples for geomechanical, geochemical, and geophysical studies. Each borehole will be drilled to approximately 60 m (200 ft) below the water table. These holes will be drilled dry using the same drilling method as will be used for drilling the UZ holes. The exact location of these 12 boreholes will be determined using several criteria, including location of other holes, configuration and areal coverage of the CPDB, and accommodation of basic geostatistical principles. A preliminary configuration of these holes are provided in the maps in Volume 4. This drilling program will also use data from the unsaturated zone and water table boreholes drilled within and near the CPDB. This drilling and testing program supports studies identified in section 8.3.1.4.3 of the SCP.

3.4.3 Natural Infiltration Study Drilling and Testing

A series of shallow holes will be drilled dry to a depth of about 15 m (50 ft) in different hydrogeologic settings at the site to monitor natural infiltration associated with precipitation events (these holes are designated as unsaturated zone neutron holes). In addition to the 74 holes that already exist at the site for these studies, an additional 24 shallow holes are planned during site characterization. Each infiltration-monitoring hole will be drilled without a drill pad, using a portable all-terrain drill rig. All the planned infiltration-monitoring holes and 25 or 26 of the existing holes will also be used for artificial infiltration ponding studies. This activity supports studies identified in section 8.3.1.2.2 of the SCP.

Ponding Studies

At approximately 50 of the unsaturated zone neutron hole locations, a low berm enclosing an area of about 10 m^2 (100 ft^1) will be constructed of impervious material around the monitoring hole. During infiltration testing, a static water level sufficient to cover the surface by 2.5 to 5.0 cm (1 to 2 in) will be maintained in each pond. The duration of testing will vary depending on the length of time required for the site to reach a steady-state percolation rate. This may take a couple of days to a month. The amount of water used will vary from site to site, but will probably not exceed 75,700 liters (20,000 gallons) at any site. This activity supports studies identified in section 8.3.1.2.2 of the SCP.

3.4.5 Artificial Infiltration Drilling and Testing (Rain Fall Simulation Tests)

Infiltration will also be monitored under artificial precipitation rates. Fourteen large-plot rainfall simulation tests and 23 small-plot rainfall simulation tests are planned for this artificial infiltration study. At each of the rainfall simulation test sites, a control plot will be established to monitor natural infiltration during testing. To the extent possible, artificial infiltration sites will be in close proximity to natural infiltration study sites to maximize the use of natural infiltration sites and minimize disturbance. The water used for these tests will be delivered to each site by truck. This activity supports studies identified is section 8.3.1.2.2 of the SCP.

At each of the small-plot rainfall simulation sites, four monitoring holes will be drilled to a depth of about 1.5 m (5 ft). A water distribution system similar to irrigation systems will be installed, and discrete rainfall events will be simulated. Present plans call for four tests at each of the 23 sites; each test will involve distribution of approximately 454 liters (120 gallons) of water over an area of 1 m^2 (9 ft^2).

At each of the large-plot rainfall simulation sites, 10 monitoring holes will be drilled to a depth of 9 to 15 m (30 to 50 ft). Present plans call for five tests at each of the 14 sites. Each test will require the distribution of approximately 11, 360 liters (3,000 gallons) of water over an area of 37 m^2 (400 ft^2). Monitoring of infiltration rates will be accomplished with a portable neutron moisture probe.

3.4.6 Fortymile Wash Recharge Study Drilling and Regional Ground Water Monitoring

As part of the regional ground-water recharge investigations, three holes, each 180 to 240 m (600 to 800 ft) deep, will be drilled in Fortymile Wash to monitor aquifer recharge during precipitation events. The holes will be drilled dry in the same manner as the UZ holes. Spot core will be recovered during drilling. The total depth of each hole will be close to, but not intersect, the water table. After each flooding event in the wash, the holes will be monitored periodically using wireline geophysical tools. In addition, a small berm may be constructed around the collar of each hole. Infiltration from the bermed area will be used to investigate near-surface response, particularly if major flooding does not occur during site characterization. Finally, 10 shallow holes

will be drilled and cased for neutron-moisture logging at key locations across Fortymile Wash to monitor infiltration.

Water samples will be collected from all available sources of ground water and surface water at and near the site, including Amargosa Valley and the Amargosa Desert. Some sampling programs will be conducted in commercial drillholes and wells in the region. Discharge from the hydrologic system will be studied by monitoring evapotranspiration and spring discharge rates. Evapotranspiration monitoring will require surface sampling and shallow drilling to variable depths, generally less than 30 m (100 ft), for the purpose of installing piezometers. These piezometers will be installed in the Amargosa Desert, upgradient from Franklin Lake Plays. These activities support studies identified in section 8.3.1.2.1 of the SCP.

3.4.7 Water Table Monitoring and Sampling

A network consisting of 25 existing geologic, hydrologic, and water table boreholes is being monitored to provide data on the potentiometric surface of the tuffaceous aquifer beneath the Yucca Mountain site and to measure water-level variations over time. In addition to providing water-level data, the holes will be used to collect water samples from the supper part of the saturated zone for chemical and isotopic analyses. Because these holes were drilled with drilling fluids, which may potentially impact the analysis of samples taken from ground water in and surrounding the holes, it will be necessary to first purge the holes of any potentially altered water in order to obtain a representative sample. This will require the removal of any tubing and the installation of a downhole pump for pumping. The pump will have a lift capacity of approximately 75 liters (20 gallons) per minute. Each hole will be pumped until water composition is believed to be representative of that in the formation. This could take up to a week of pumping to achieve. As pumping proceeds, repeated analysis of water samples will be performed to ascertain when sampling will begin.

Water pumped from these holes, as well as water pumped from other holes associated with the different saturated zone investigations, will be discharged into surface drainages only if it is first determined that such discharge will not impact other hydrologic investigations, such as natural infiltration studies or site performance. If it is deemed necessary, discharged water will be piped or trucked away from a particular site. If feasible, water that is to be discharged as a result of saturated zone investigations will be pumped into trucks and used for other Project purposes, such as dust suppression on roads. This activity supports studies identified in sections 8.3.1.2.2 and 8.3.1.2.3 of the SCP.

3.4.8 Water Table Hole Drilling

Eight additional water table boreholes are planed for the exploration and sampling of the water table. Water sampling and analysis similar to that described above will also be conducted at these holes. Six of the eight proposed water table holes will be added to the site potentiometric monitoring network. These consist of USW WT-8 and -9, located west of Yucca Mountain along the Solitario Canyon fault; USW WT-23 and UE-25 WT#24, located north of the CPDB; and UE-25 WT#19 and 20, located south and east of Yucca Mountain. The other two water table holes, USW WT-21 and 22, will be located in Crater Flat

and will be monitored in connection with the regional site potentiometric monitoring program. The drilling methods of these holes will be a combination of the dry methodology used to drill the UZ holes and conventional rotary drilling using air foam as the circulation medium. Water table boreholes WT-8 and -9 will be drilled dry (at least through the unsaturated zone) because core samples obtained from these holes will contribute data to the systematic drilling program. The remaining water table holes will be drilled using conventional methods. These holes support studies identified in sections 8.3.1.2.1, 8.3.1.2.2, and 8.3.1.2.3 of the SCP.

3.4.9 Saturated Zone Drilling and Testing

The proposed saturated zone borehole USW H-7 will be drilled approximately 900 m (3,000 ft) east of, and on the opposite side of, the Solitario Canyon fault from existing hole USW H-6. The drilling method for this hole will be the same as that for WT-8 and WT-9 described in the preceding section. Pump tests will be conducted in H-6 and H-7 to investigate the hydrologic properties of the Solitario Canyon fault zone. For flow testing, a pump with a lift capacity of approximately 1,900 liters (500 gallons) per minute will be installed successively in each of these holes. Thus, each borehole will serve as a pumping and observation well. Pumping will continue for approximately 30 days. It is anticipated that a temporary pipeline will need to be installed to divert discharge away from the sites and away from other hydrologic study areas. This activity supports studies identified in sections 8.3.1.2.3 and 8.3.1.8.3 of the SCP.

A series of single-well and multiple-well pumping tests will be conducted in the existing UE-25 c-hole complex (c#1, c#2, and c#3). These tests will involve the use of both conservative and reactive tracers. Candidate tracers will first be tested in the lab to determine which tracers and what concentrations will best meet the objectives of the tests. Candidate tracers for the conservative tracer tests include benzoic acids, pyridine, sodium chloride, lithium bromide, sodium thiocyanate, fluorescent microspheres (various diameters <2 microns), and fluorocarbons. Candidate reactive tracers include lithium bromide, boron, polystyrene spheres (<1 micron in diameter), and some type of organic tracer to investigate the molecular sieve sorption mechanism. All applicable regulations will be complied with for the use of tracers in flow tests.

About 20 convergent tracer pump tests are planned using various pumping wells, pumping intervals, observation intervals, and tracer injection schemes. This will involve pumping from an isolated interval in one well at the approximate rate of 200 to 750 liters (50 to 200 gallons) per minute until drawndown stabilizes. The tracer will then be released into a second well. Pumping will continue for three to five days until the tracer is recovered. A 30-day pump test is also planned for one of the wells. The test will involve pumping from an isolated interval at the rate of between 400 and 1,500 liters (100 and 400 gallons) per minute. Following these tests, three to five single-well drift-pumpback tests will be performed at the various wells. These tests will be followed by a multiple-well recirculating tracer test that will involve pumping water from an isolated interval in one well into an isolated interval of a second well at the rate of between 200 and 750 liters (50 to 200 gallons) per minute. Tracer will be injected into the recirculating stream and then the pumping stream will be monitored for three to seven days to detect the presence of the tracer. After the tracer is detected, pumped water will not be

reinjected, with pumping to continue until the tracer is recovered. Both conservative and reactive tracer tests will follow the same testing procedures.

Depending on the results of the above tracer tests, either single-well drift-pumpback tracer tests will be conducted at other existing borehole locations throughout the site, or a second complex of pump test boreholes will be drilled at a location southeast of the CPDB in order to conduct multiple-well tracer tests. This second set of pump test boreholes, if drilled, will consist of four holes, tentatively designated as the southern tracer complex. These holes will be drilled and completed in a manner similar to the "c" holes. These activities support studies identified in sections 8.3.1.2.3 and 8.3.1.8.3 of the SCP.

3.4.10 Assessment of Adequate Water Supply

Water needs for the Yucca Mountain Project will be supplied from existing water well UE25 J#13. This well is located on the Nevada Test Site. An assessment of cost, feasibility, and adequacy of this well will be done. The first step in this assessment will involve the compilation and evaluation of all existing data on the well. If existing data is insufficient to adequately assess the potential of this well to meet the water demands expected from the Project, field tests will be performed. The tests would include drawdown and recharge analysis, sand content monitoring, and water quality analysis. This activity supports studies identified in section 8.3.1.16.2 of the SCP.

3.4.11 Exploratory Geologic Coreholes

Two deep (approximately 5000 ft) coreholes are planned for the core area, north of Yucca Mountain in Yucca Wash and in Drill Hole Wash (USW G-5 and USW G-6). An additional deep corehole is planned immediately south of Yucca Mountain, on the NTS (UE-25 G#7). Location of these holes plus existing geologic coreholes are shown in Figure 3-4. These holes will require construction of drill pads and access roads. They will be fully cored using H-series or larger wireline coring equipment. Mud or air foam will be used as the circulating medium. The uppermost 1,000 to 2,000 feet of each hole may be reamed to a diameter of 6.25 to 12 inches using rotary drilling equipment and air foam circulation, if necessary to set steel casing for hole stability and circulation control. A fourth G-hole (tentatively designated as UE-25 G#8) will be drilled east of Yucca Mountain near Fortymile Wash to study the effects of groundwater flow on mineralization in the Topopah Spring member of the Paintbrush tuff. The proposed drilling method for this hole is dual-wall reverse circulation. These drilling and sampling activities will support studies identified in sections 8.3.1.3.2, 8.3.1.4.1, 8.3.1.4.2, 8.3.1.15.1, and 8.3.1.15.2 of the SCP.

3.4.12 In Situ Stress Drilling and Testing

In situ stress will be measured by the hydrofracturing method at two as yet undetermined locations. One location will be in the vicinity of Yucca Mountain at an existing borehole location. The second location will be east of the site on the NTS. An additional borehole will be required for this site. Hydrofracturing requires isolating a select interval of boreholes and injecting water into that interval until the surrounding walls fail and resultant stress measurements are obtained. This activity is expected to improve the understanding of previous stress measurements performed at Yucca Mountain.

YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

PROPOSED ACTIVITY LOCATIONS

2 0 2
MILES

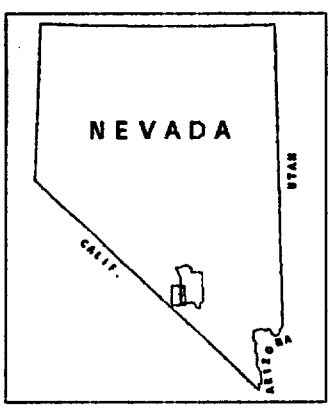
2 0 2
KILOMETERS

LEGEND

- UNSATURATED ZONE NEUTRON HOLES AND ARTIFICIAL RAINFALL SIMULATION SITES (<100 FT. DEEP)
- UNSATURATED ZONE, SYSTEMATIC DRILLING, AND MULTI-PURPOSE BOREHOLES
- COREHOLES (GEOLOGIC, VOLCANIC, CALCITE-SILICA, AND REPOSITORY SURFACE FACILITY
- WATER TABLE, SATURATED ZONE, AND RECHARGE BOREHOLES
- TRENCHES, PITS, AND PAVEMENTS
- EXPLORATORY SHAFTS
- METEORDLOGICAL AND STREAMFLOW MONITORING SITES
- MEDIUM DUTY ROADS
- LIGHT DUTY ROADS
- UNIMPROVED ROADS
- TRAILS
- RAILROADS
- POWERLINES
- SHALLOW SEISMIC REFLECTION LINES
- CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1956 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAP
7/1986 AND 9/1987 1:24,000 UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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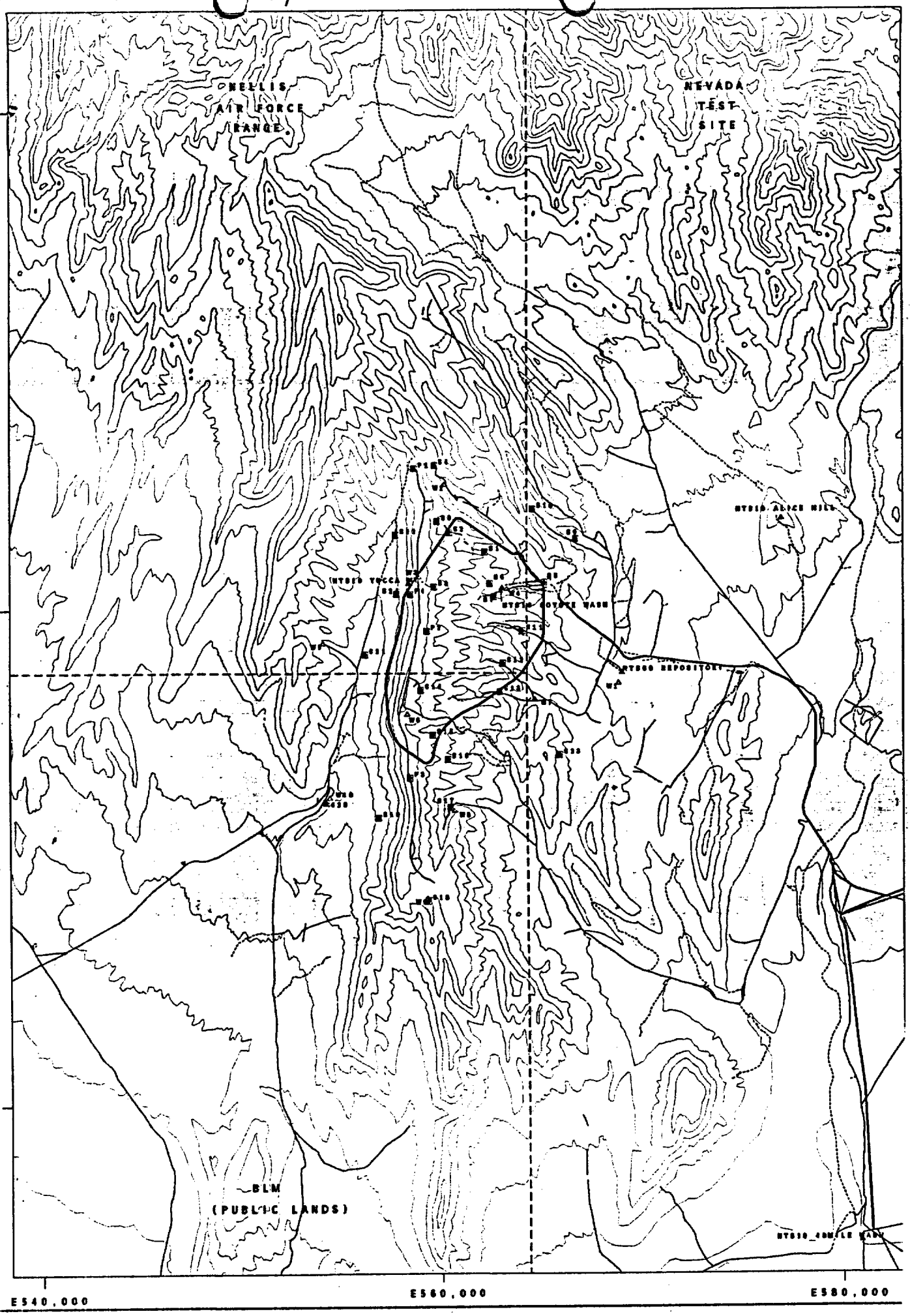
Map #3 YMP-89-C 1



YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

SITE METEOROLOGICAL AND PRECIPITATION/ STREAMFLOW MONITORING NETWORKS

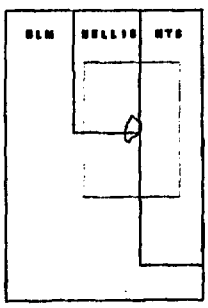
1 0 1
MILES
1 0 1
KILOMETERS

LEGEND

- STREAMFLOW AND PRECIPITATION MONITORING SITES - PROPOSED
- METEOROLOGICAL MONITORING TOWERS EXISTING
- METEOROLOGICAL MONITORING SITES PROPOSED
- LIGHT DUTY ROADS
- UNIMPROVED ROADS
- TRAILS
- CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - 1:100,000 USGS MAP
1956 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAPS
7/1986 AND 9/1987 1:24,000 UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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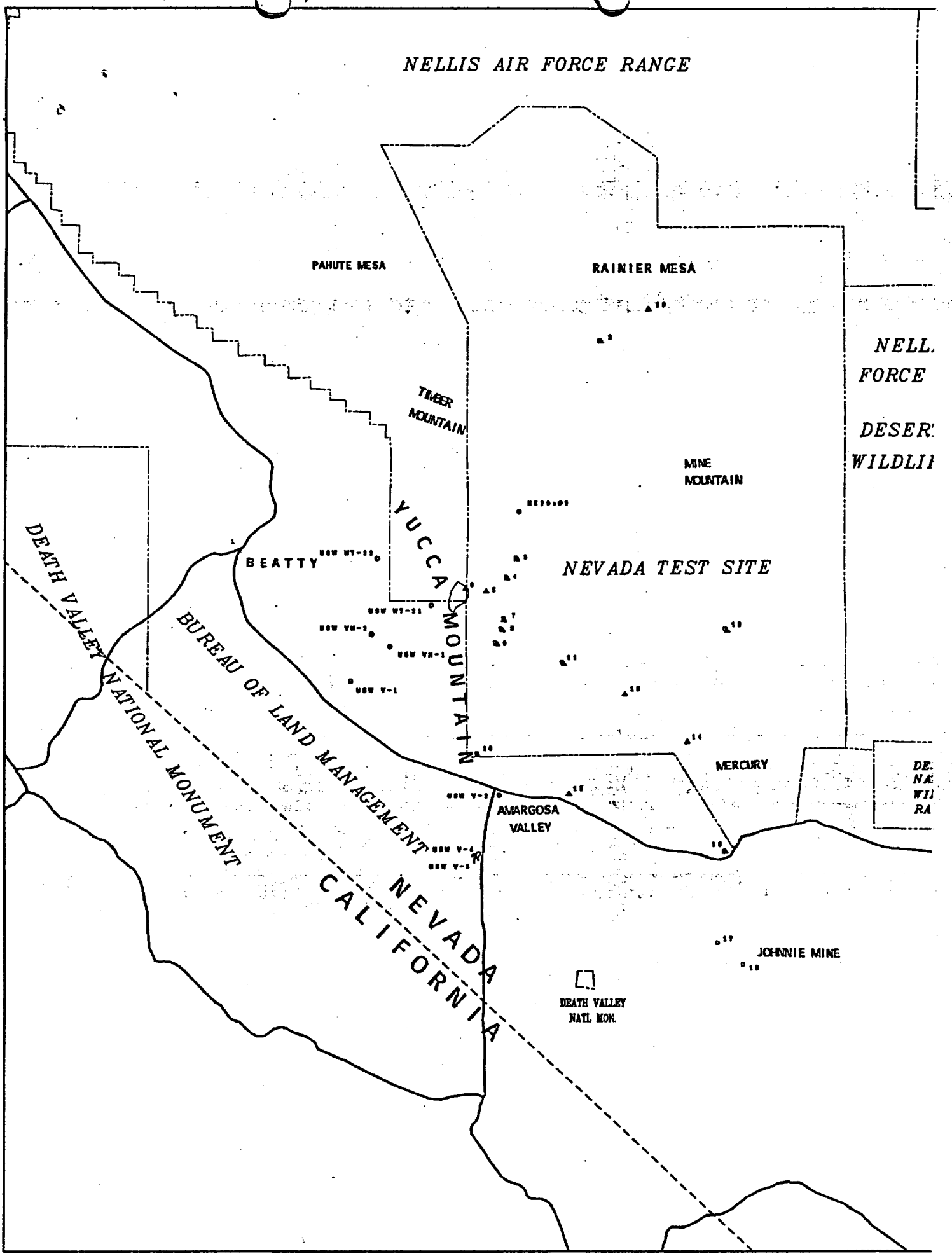
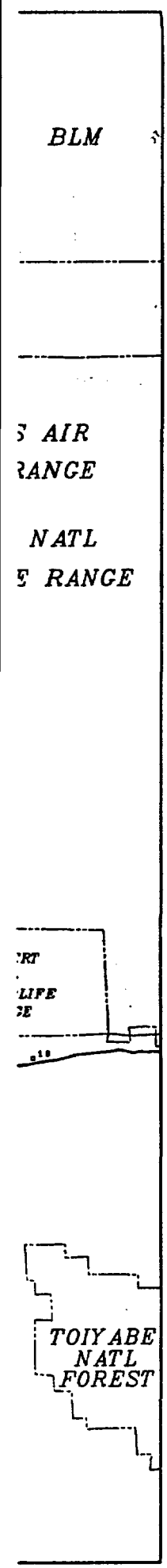
Map #4 YMP-89-014





YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

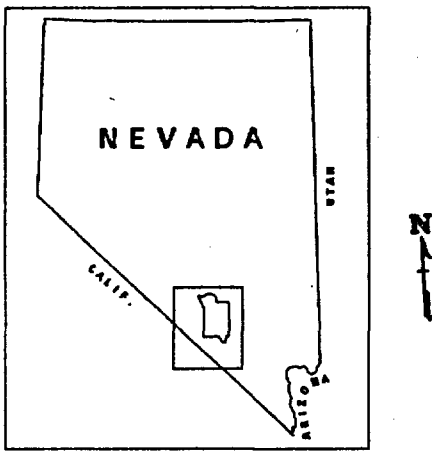
REGIONAL INVESTIGATIONS

LEGEND

- ▲ EXISTING PRECIPITATION MONITORING STATIONS
- ▫ EXISTING STREAMFLOW MONITORING STATIONS
- ● EXISTING HOLES
- ○ PROPOSED HOLES
- ? USW V-3 & V-4 APPROXIMATE LOCATIONS
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- STATE BOUNDARY
- ADMINISTRATIVE BOUNDARY
- CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

ROADS AND ADMINISTRATIVE BOUNDARIES FROM
1:2,000,000 SCALE USGS NATIONAL MAP ATLAS
DIGITAL LINE GRAPH (DLG) DATA
MAP COMPILED IN DECEMBER 1988



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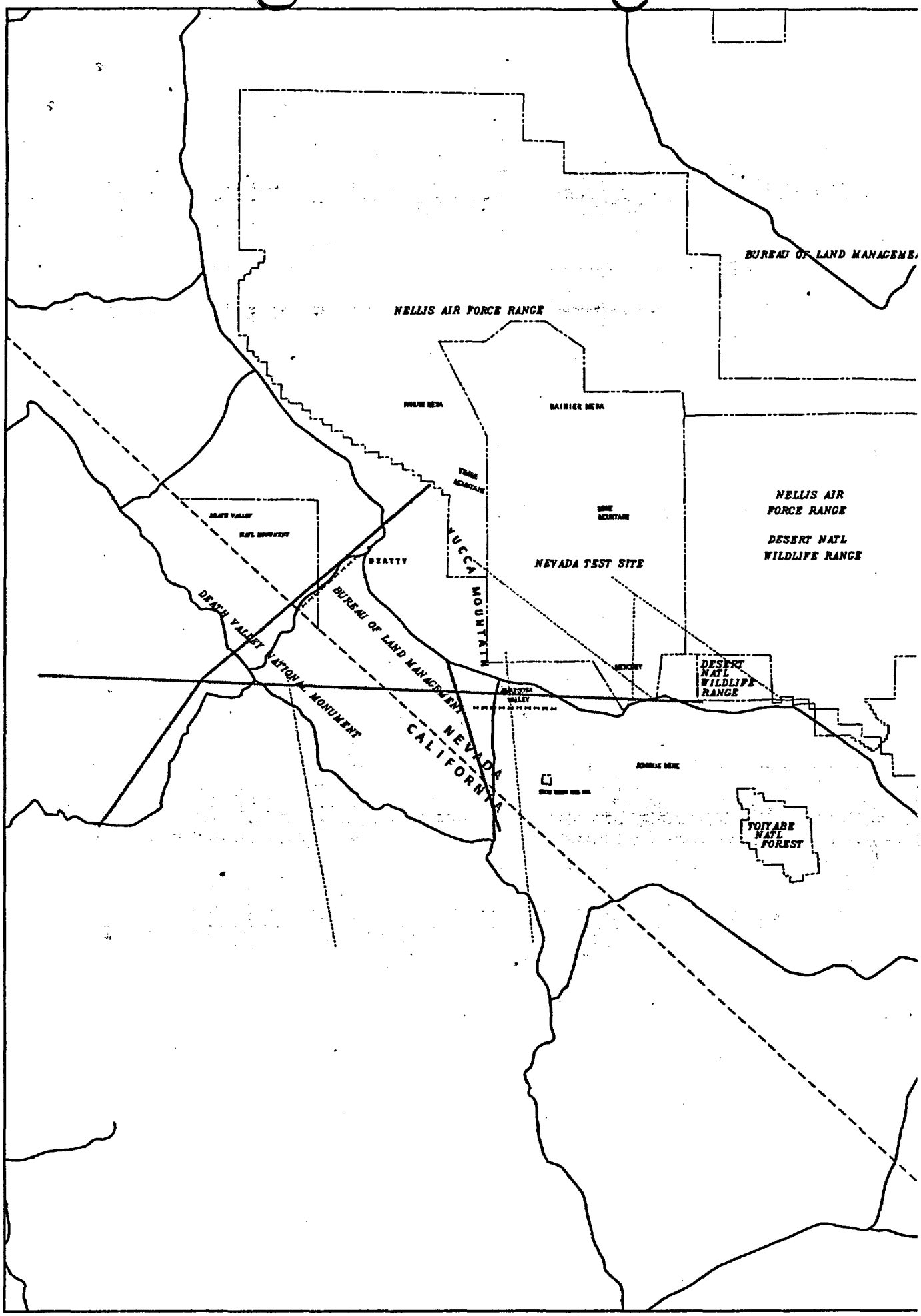
ap #5 VMP-89-015



Depending on the results of tests at these two locations, additional existing boreholes, which would no longer be used for other studies, would be selected for testing. An many as 20 existing boreholes could be selected for in situ stress testing. This activity supports studies identified in section 8.3.1.15.2 of the SCP.

3.4.13 Volcanic Exploratory Drillholes

Four exploratory holes are planned to investigate magnetic anomalies in southern Crater Flat and the Amargosa Desert. They will be drilled using conventional rotary drilling methods, with air foam as circulation medium, to a depth of roughly 1,000 feet. These holes will be drilled over magnetic anomalies which may be igneous intrusions or buried volcanics. Each hole will be drilled until igneous rock is reached, or until sufficient depth is reached depending on surface and downhole geophysical measurements. continuous core will be acquired using conventional or wireline coring equipment with drilling mud as circulating medium. This activity supports studies identified in section 8.3.1.8.1 of the SCP.

3.4.14 Playa Coring Study Drilling and Sampling

Perennial lake systems throughout the Great Basin will be sampled by means of backhoe trenching (to depths of up to about 12 ft.), truck-mounted auger drill, drive-tube sampler, or other portable drill (to depths of about 100 ft). Vehicle access to each sampling location will be required to transport the drilling/sampling equipment. The purpose of the activity is to study the recent (500,000 year) variation in lake size, hydraulics, temperature, and chemical composition over time, through the analysis of sediments. Core samples will be taken from various locations throughout Nevada, for assay and dating of the organic material, fossils, and minerals recovered from lacustrine, playa, and marsh sediments. This activity will support studies identified in section 8.3.1.5.1 of the SCP.

3.4.15 Calcite-Silica Deposits Coring

In order to recover calcite and opaline silica deposits below the depth of Trench 14 several holes may be drilled in the vicinity of Trench 14 on the Nevada Test Site, for investigation of the subsurface character of the Bow Ridge Fault. A drill pad (UE 25 ph #1) will be constructed on the western slope of Exile Hill, with a short access road. A series of shallow (generally less than 50 feet deep) coreholes will be drilled along a profile across the surface indications of the fault zone. If the vertical holes do not intersect the deposit one or more deeper (200 to 500 ft) coreholes may be drilled at a steep angle to intersect the fault zone at depth. Air foam and drilling mud will be used as circulation media. This activity supports studies identified in section 8.3.1.5.2 of the SCP.

3.4.16 Repository Surface Facilities Drilling

A program of drilling is planned for the purposed site of the conceptual repository surface facilities in Midway Valley that will augment existing, pre-site characterization investigations. The purpose of these drill holes is to make geophysical measurements of dynamic soil properties to support

repository surface facility design. This activity supports investigations described in SCP Section 8.3.2.14.2.

3.5 TRENCHING

Several trenches and test pits at and near Yucca Mountain have been excavated for geologic, tectonic, and paleoclimatic studies. Many of these trenches are sampled and mapped on an ongoing basis. It may be necessary during site characterization to enlarge and deepen some of these existing trenches (e.g., Trench 14 on the west slope of Fran Ridge) to collect additional data and to prevent trench degradation.

Excavation of several new trenches is planned during site characterization to support tectonic and paleohydrologic investigations. The need for 27 new trenches has been identified to date; 26 for tectonic investigations and 1 near existing Trench 14 for paleoclimatic investigations. Approximate locations are known only for the paleoclimatic trench (designated as 14B) and the Bare Mountain fault trenches (BM1 and BM2). Field reconnaissance will be required to provide approximate locations for the others. As a result, only trenches with known approximate location coordinates are shown on maps. However, the fault zones or general area of the planned trenches are known.

3.5.1 Regional and Site Quaternary Faults Trenching

Trenching activities (both new excavation and rework) are planned for the following fault zones and individual faults in the Yucca Mountain area; Bow Ridge Fault, Windy Wash Fault zone, Ghost Dance Fault zone, and Solitario Canyon Fault. A total of eight trenches have been proposed for investigation of these fault zone. In addition to the trenching of faults in the Yucca Mountain area, additional trenches will be excavated across the following regional fault systems: the Bare Mountain Fault Zone (two trenches), the Rock Valley Fault System (two trenches), and the Stagecoach Road Fault zone. Exact locations and size of trenches is dependent on field reconnaissance. These activities support studies identified in section 8.3.1.17.4 of the SCP.

3.5.2 Exploratory Trenching in Midway Valley

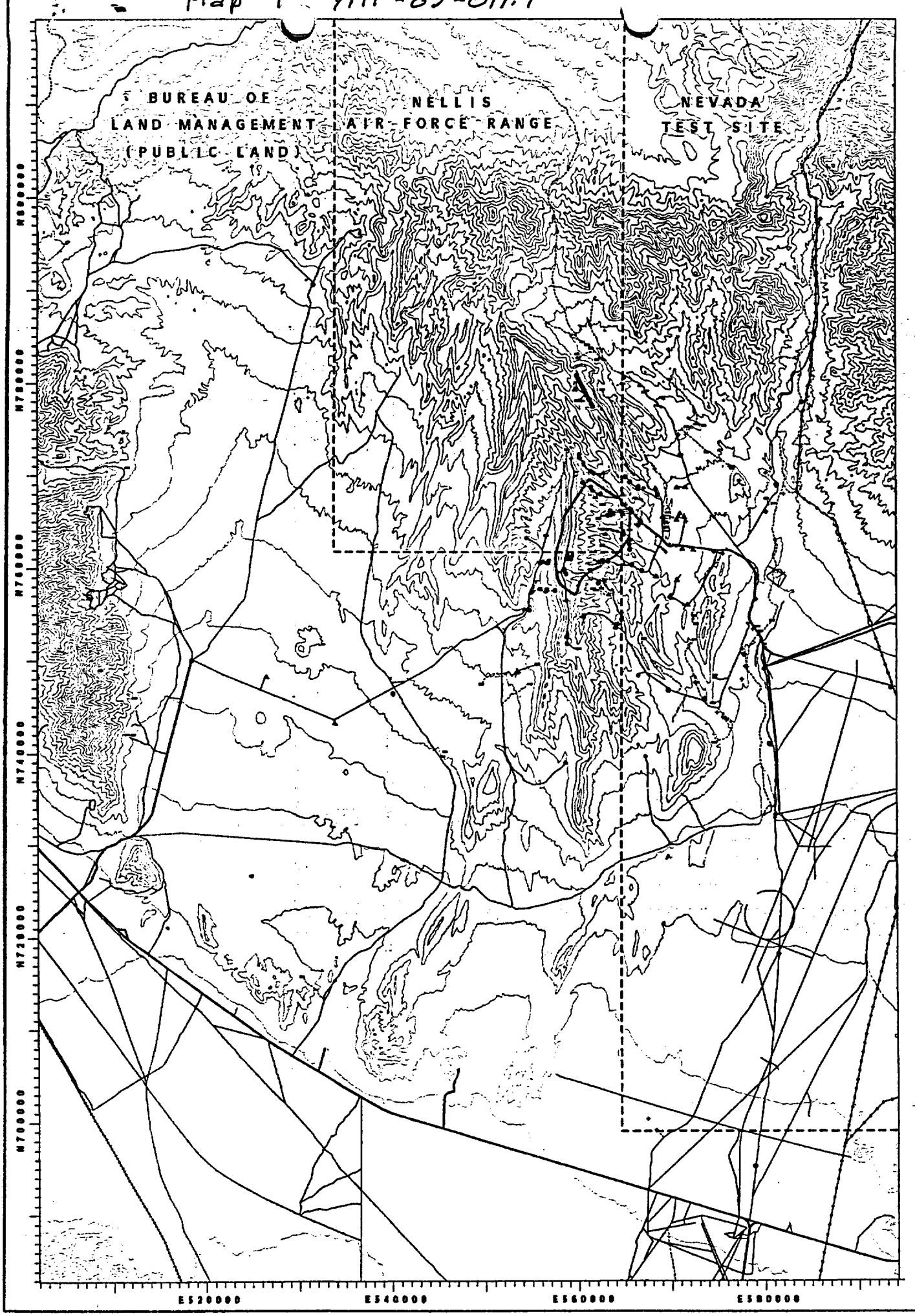
There are plans to excavate a series of up to 12 trenches at the potential site of the conceptual repository surface facilities. Four large trenches (approximately 4 m wide by 20 m deep and up to 300 m in length) will be excavated across the site or a ring around the perimeter of the site. The depth of the trench will need to be such that it exposes at least 100,000 year old material. The walls of the trench will be logged. More detailed investigations will be conducted in areas where faulting is suspected or cannot be disproved. This may involve excavating up to 8 additional smaller (3 m x 3 m x 16 m) trenches. These activities will support studies identified in section 8.3.1.17.4 of the SCP.

3.5.3 Paleohydrology Trenching

Existing Trench 14 across the Bow Ridge Fault on the western slope of Exile hill will be deepened and widened to further investigate the calcite and opaline

silica deposits detected in this trench. In addition to reworking Trench 14, an additional trench (tentatively designated 14B) will be excavated nearby to compliment investigations at Trench 14. These activities will support studies identified in Section 8.3.1.5.2 of the SCP.

Map #1 YMP-89-011.1



YUCCA MOUNTAIN PROJECT

SURFACE BASED INVESTIGATIONS PLAN

EXISTING ACTIVITIES MAP

2 0 2
MILES

2 0 2
KILOMETERS

LEGEND

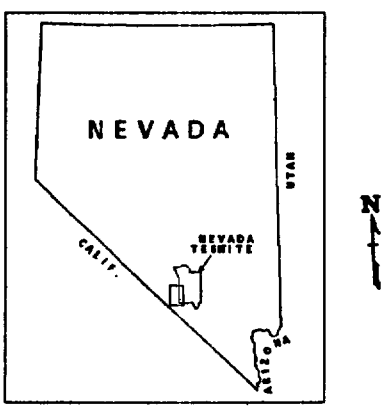
- UNSATURATED ZONE NEUTRON HOLES AND OTHER MISC. SHALLOW UNSATURATED ZONE HOLES (<100 FT. DEEP)
- UNSATURATED ZONE BOREHOLES
- COREHOLES (GEOLOGIC, VOLCANIC, EXPLORATORY, AND REPOSITORY SURFACE FACILITY
- WATER TABLE AND SATURATED ZONE BOREHOLES, AND POTENTIAL WATER SUPPLY WELLS
- SEISMIC SHOTHOLES
- TRENCHES, PITS AND BEDROCK PAVEMENTS
- METEOROLOGICAL AND STREAMFLOW MONITORING SITES

✓ MEDIUM DUTY ROADS
✓ LIGHT DUTY ROADS
✓ UNIMPROVED ROADS
✓ TRAILS
✓ RAILROADS
✓ POWERLINES

) CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1986 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAP
7/1986 AND 9/1987 1:24,000 UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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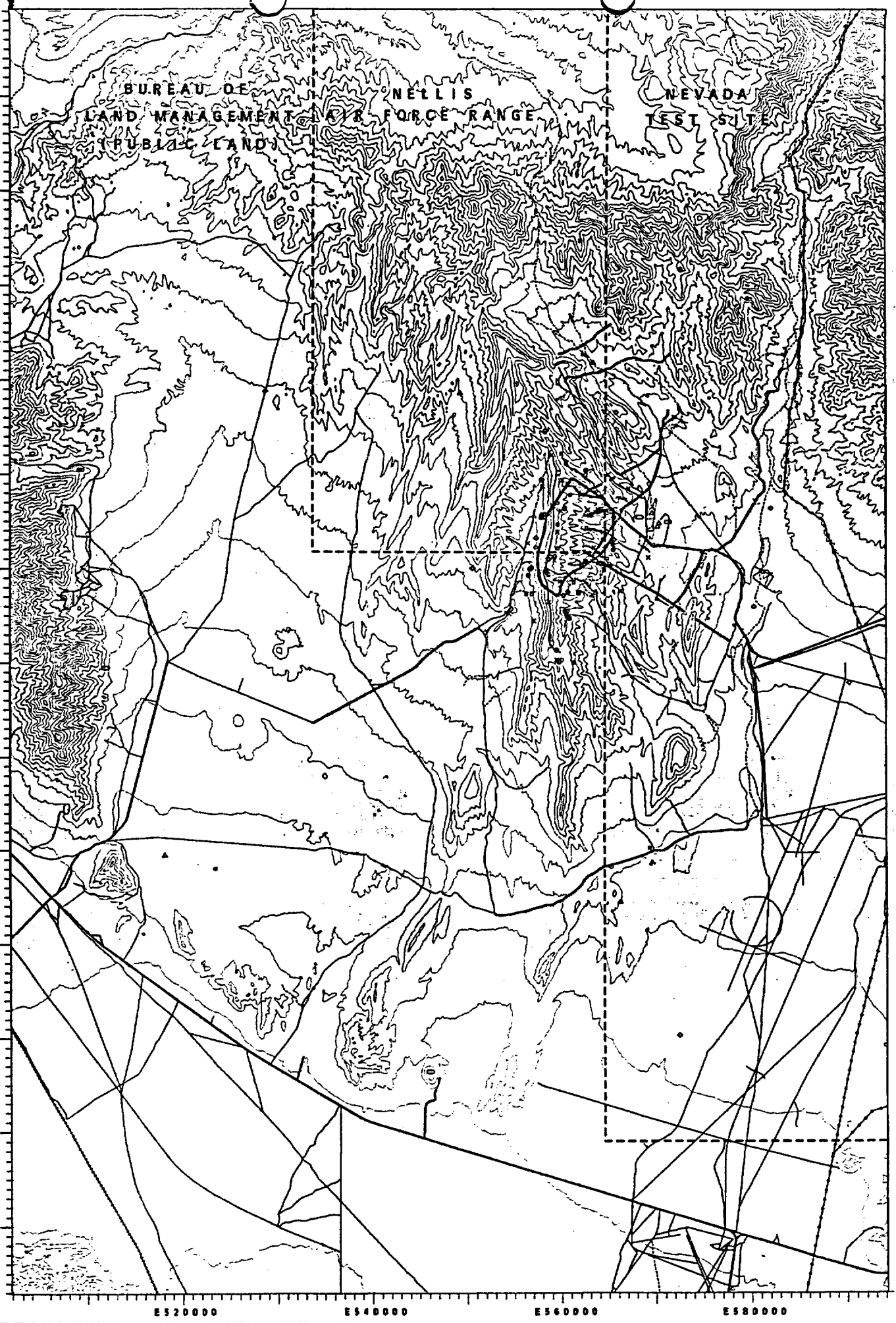
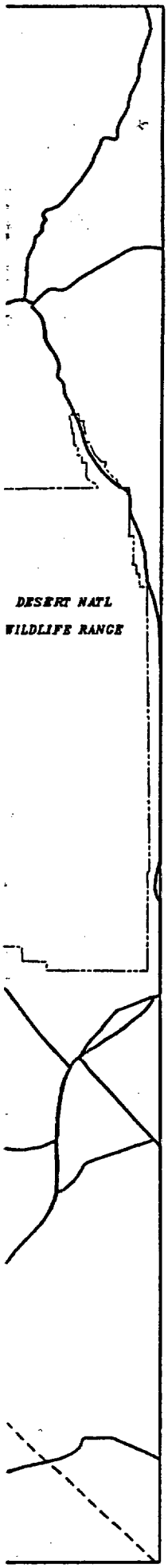
M #2 VMP-89-012.1





YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

PROPOSED REGIONAL SURVEY LINES

MILES

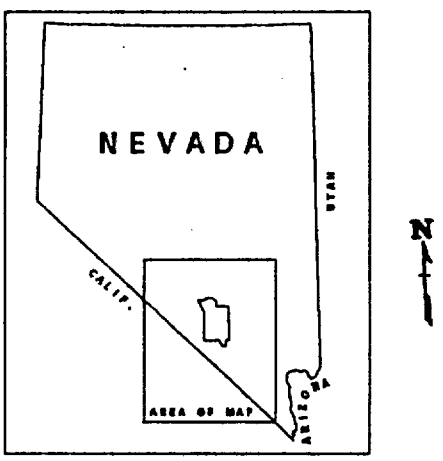
KILOMETERS

LEGEND

- PROPOSED REGIONAL SEISMIC REFRACTION SURVEY LINES
- PROPOSED REGIONAL SEISMIC REFLECTION SURVEY LINES
- PROPOSED MAGNETOTELLURIC SURVEY LINES
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- STATE BOUNDARY
- ADMINISTRATIVE BOUNDARY

SOURCES:

ROADS AND ADMINISTRATIVE BOUNDARIES FROM
1:2,000,000 SCALE NATIONAL MAP ATLAS
DIGITAL LINE GRAPH (DLG) DATA
MAP COMPILED IN DECEMBER 1988



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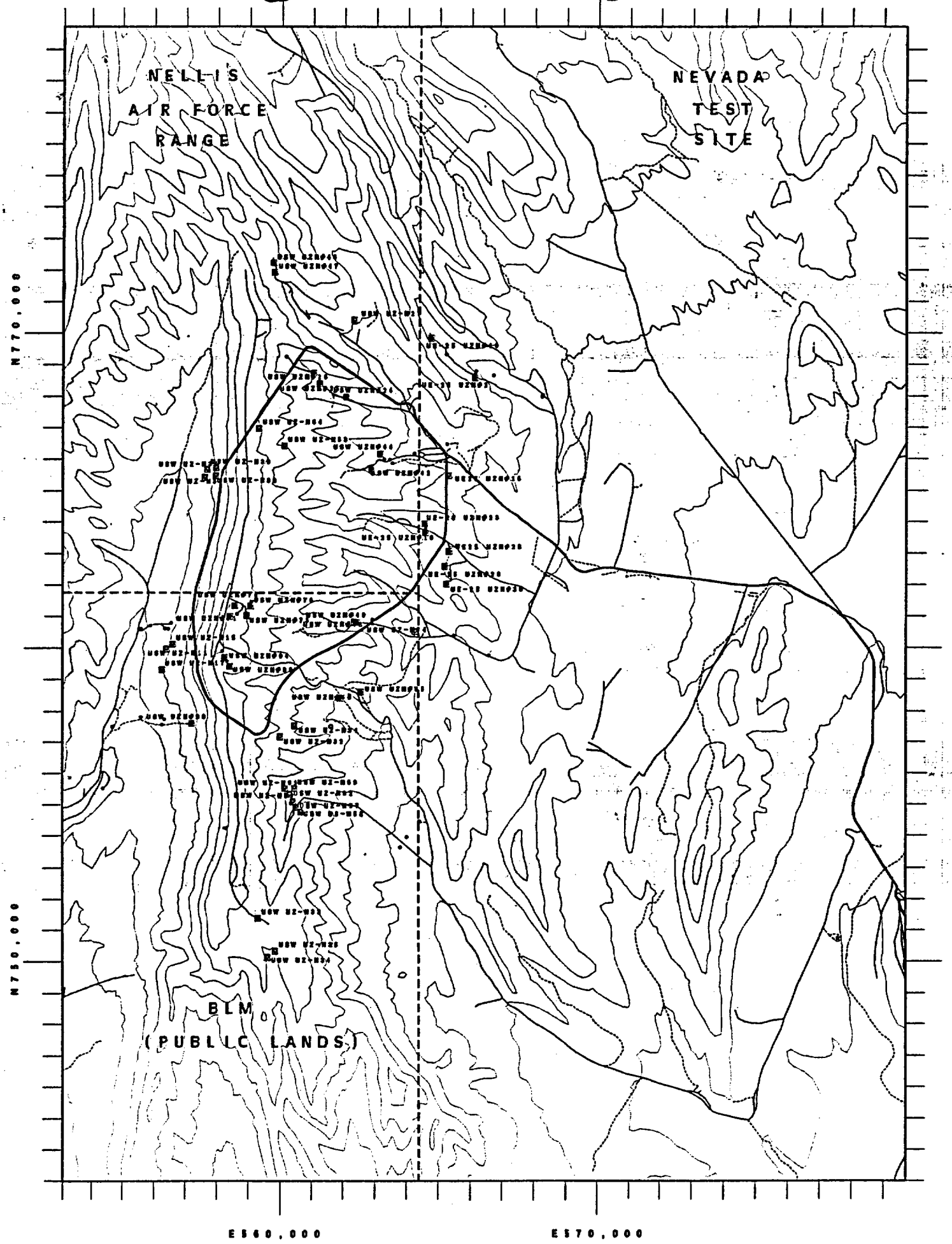
M #6 YMP-89-016


NELLIS
AIR FORCE
RANGE
NEVADA
TEST
SITE
BLM
(PUBLIC LANDS)
N770,000
N750,000
E560,000
E570,000

YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

NATURAL INFILTRATION MONITORING, AND PROPOSED ARTIFICIAL INFILTRATION PONDING STUDIES

1 0 1
MILES

1 0 1
KILOMETERS

LEGEND

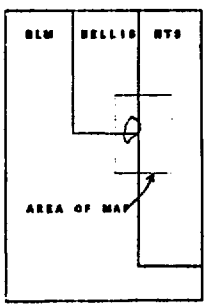
- NATURAL INFILTRATION MONITORING (UNSATURATED ZONE NEUTRON ACCESS HOLE) - EXISTING
- NATURAL INFILTRATION MONITORING (UNSATURATED ZONE NEUTRON ACCESS HOLE) - PROPOSED
- PROPOSED ARTIFICIAL INFILTRATION PONDING STUDY AT EXISTING UNSATURATED ZONE NEUTRON ACCESS HOLE LOCATION
- PROPOSED ARTIFICIAL INFILTRATION PONDING STUDY AT PROPOSED UNSATURATED ZONE NEUTRON ACCESS HOLE LOCATION

LIGHT DUTY ROADS
UNIMPROVED ROADS
TRAILS

CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1956 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAPS
7/1986 AND 9/1987 1:24,000 UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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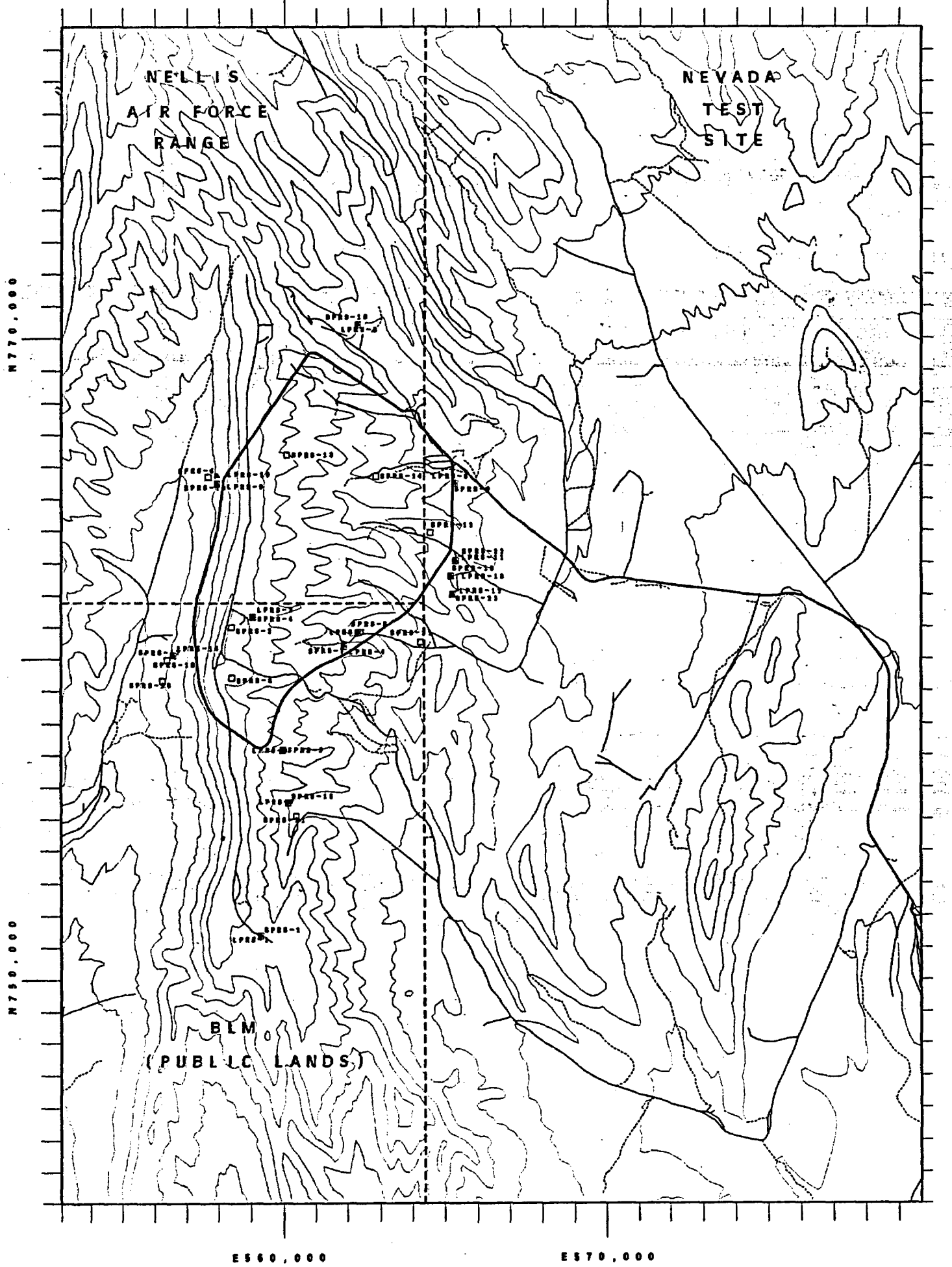
Map #7 YMP-8 017.1



YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

PROPOSED RAINFALL SIMULATION STUDY SITES

1 0 1
MILES

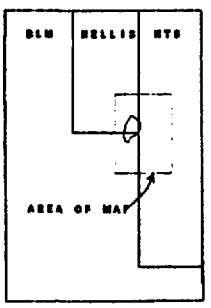
1 0 1
KILOMETERS

LEGEND

- ▲ LARGE-PLOT RAINFALL SIMULATION STUDY SITE - PROPOSED (10 HOLES PER SITE)
- ◻ SMALL-PLOT RAINFALL SIMULATION STUDY SITE - PROPOSED (4 HOLES PER SITE)
- LIGHT DUTY ROADS
- UNIMPROVED ROADS
- TRAILS
- CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1956 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAPS
7/1986 AND 9/1987 1:24,000 UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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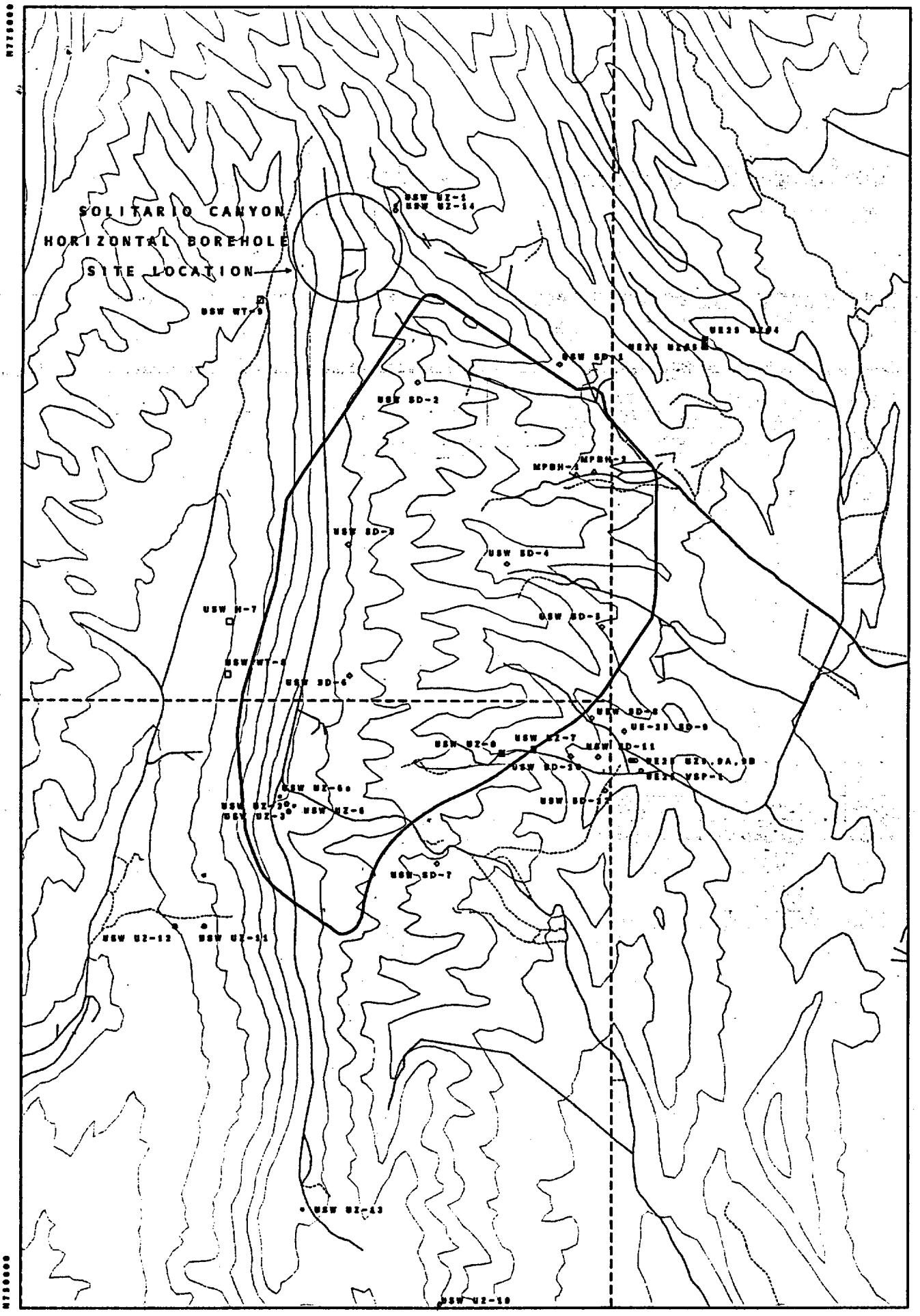
EG&G YMP-89-17.1

Map #8 YMP-89-018



YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

INTEGRATED, UNSATURATED ZONE AND SYSTEMATIC DRILLING PROGRAM BOREHOLES

.50 0 .50
MILES

250 0 250
METERS

LEGEND

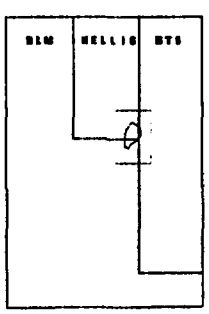
- UNSATURATED ZONE BOREHOLE - EXISTING
- UNSATURATED ZONE BOREHOLES AND VERTICAL SEISMIC PROFILE (VSP) BOREHOLE - PROPOSED
- MULTI-PURPOSE BOREHOLE - PROPOSED
- SYSTEMATIC DRILLING (SD) PROGRAM BOREHOLE - PROPOSED
- WATER TABLE AND SATURATED ZONE BOREHOLES, WHICH CONTRIBUTES DATA TO SD PROGRAM
- EXISTING UNSATURATED ZONE BOREHOLES THAT WILL BE REDRILLED TO DEPTH OF WATER TABLE

- LIGHT DUTY ROADS
- UNIMPROVED ROADS
- TRAILS

CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1958 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAPS
7/1986 AND 9/1987 1:24,000 UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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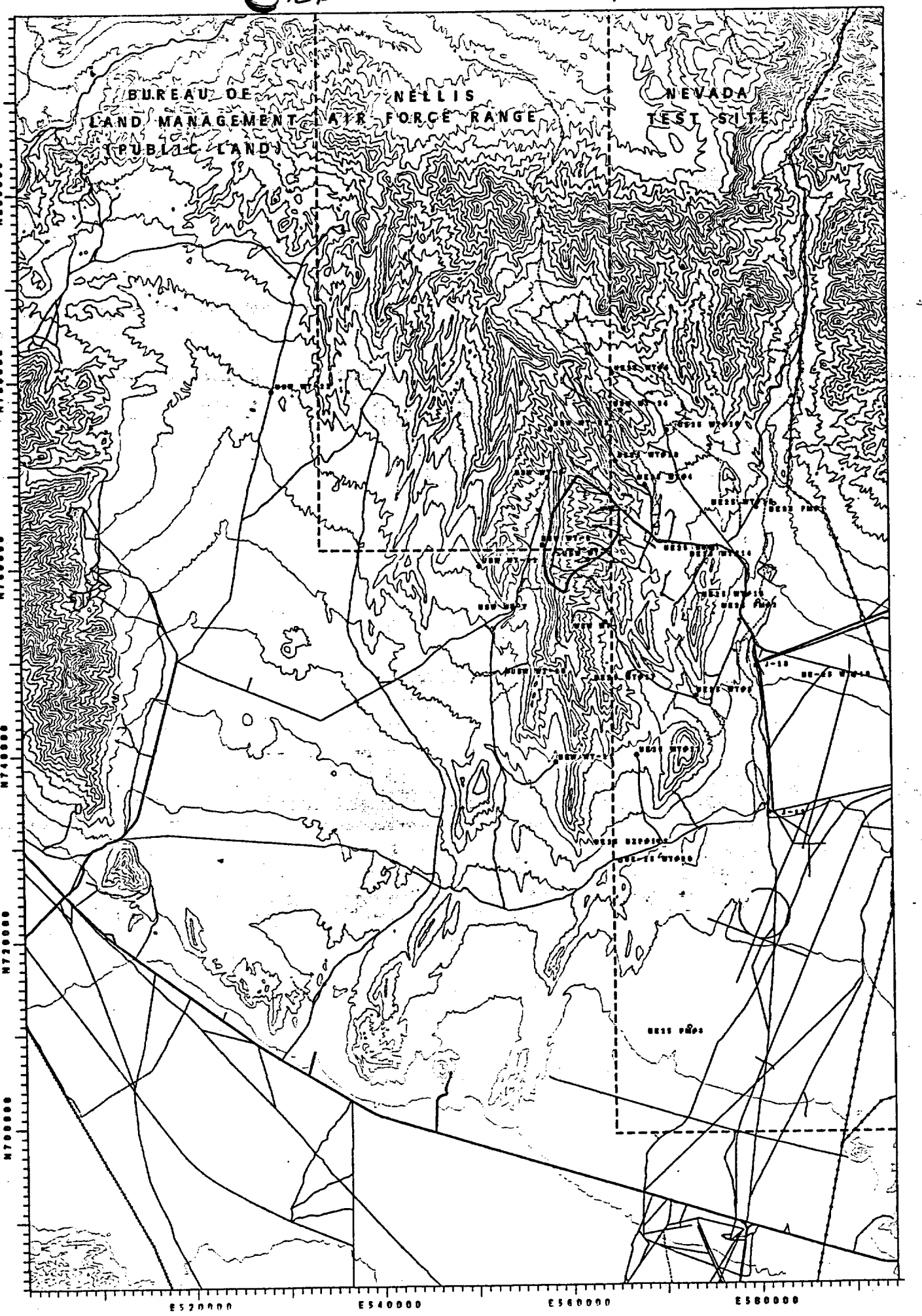
EG&G YMP-89-018.1

Map #9 YMP-89-011



YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

WATER TABLE BOREHOLES AND FORTYMILE WASH RECHARGE INVESTIGATION BOREHOLES

2 0 2
MILES

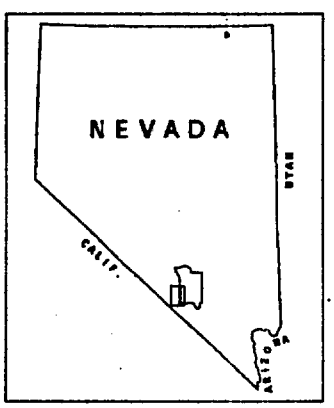
2 0 2
KILOMETERS

LEGEND

- WATER TABLE HOLES - EXISTING
- WATER TABLE HOLES - PROPOSED
- FORTYMILE WASH RECHARGE INVESTIGATION BOREHOLES - PROPOSED
- UNSATURATED ZONE PROTOTYPE HOLES PROPOSED
- NATURAL INFILTRATION MONITORING (UNSATURATED ZONE NEUTRON ACCESS HOLES) - EXISTING
- POTENTIAL WATER SUPPLY WELLS EXISTING
- MEDIUM DUTY ROADS
- LIGHT DUTY ROADS
- UNIMPROVED ROADS
- TRAILS
- RAILROADS
- POWERLINES
- CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1956 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAP
7/1986 AND 9/1987 1:24,000 UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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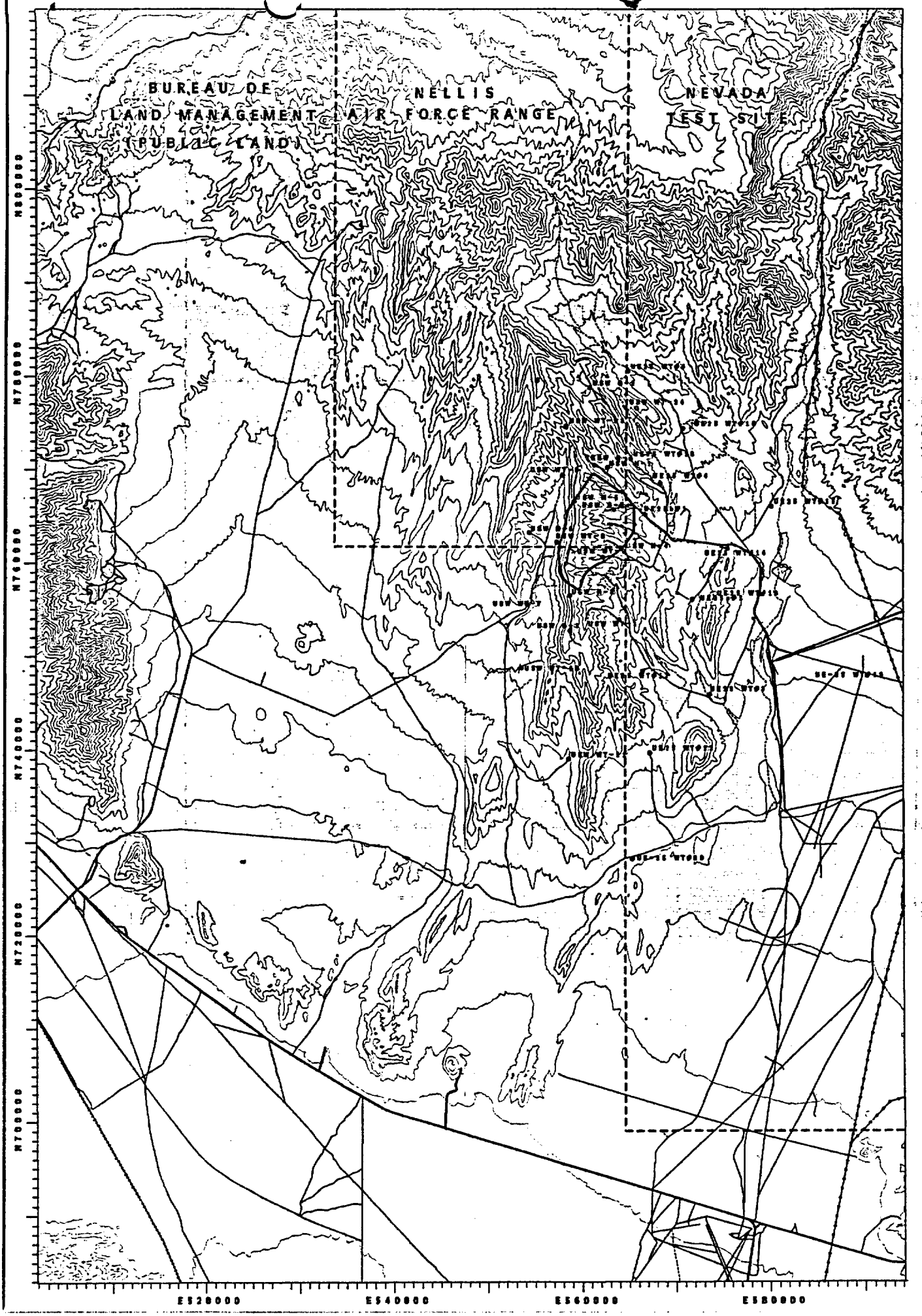
EG&G YMP-89-019.1

Map #10 YMP-89-020



YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

SITE POTENTIOMETRIC-LEVEL MONITORING NETWORK

2 0 2
MILES

2 0 2
KILOMETERS

LEGEND

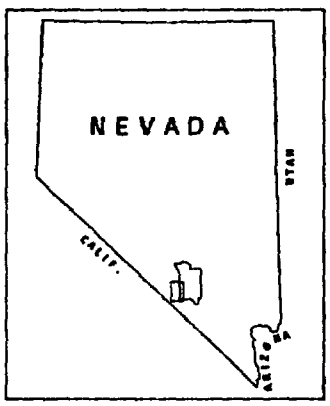
- EXISTING HOLES
- PROPOSED HOLES

- MEDIUM DUTY ROADS
- LIGHT DUTY ROADS
- UNIMPROVED ROADS
- TRAILS
- RAILROADS
- POWERLINES

- CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1956 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAP
7/1986 AND 9/1987 1:24,000
UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE
COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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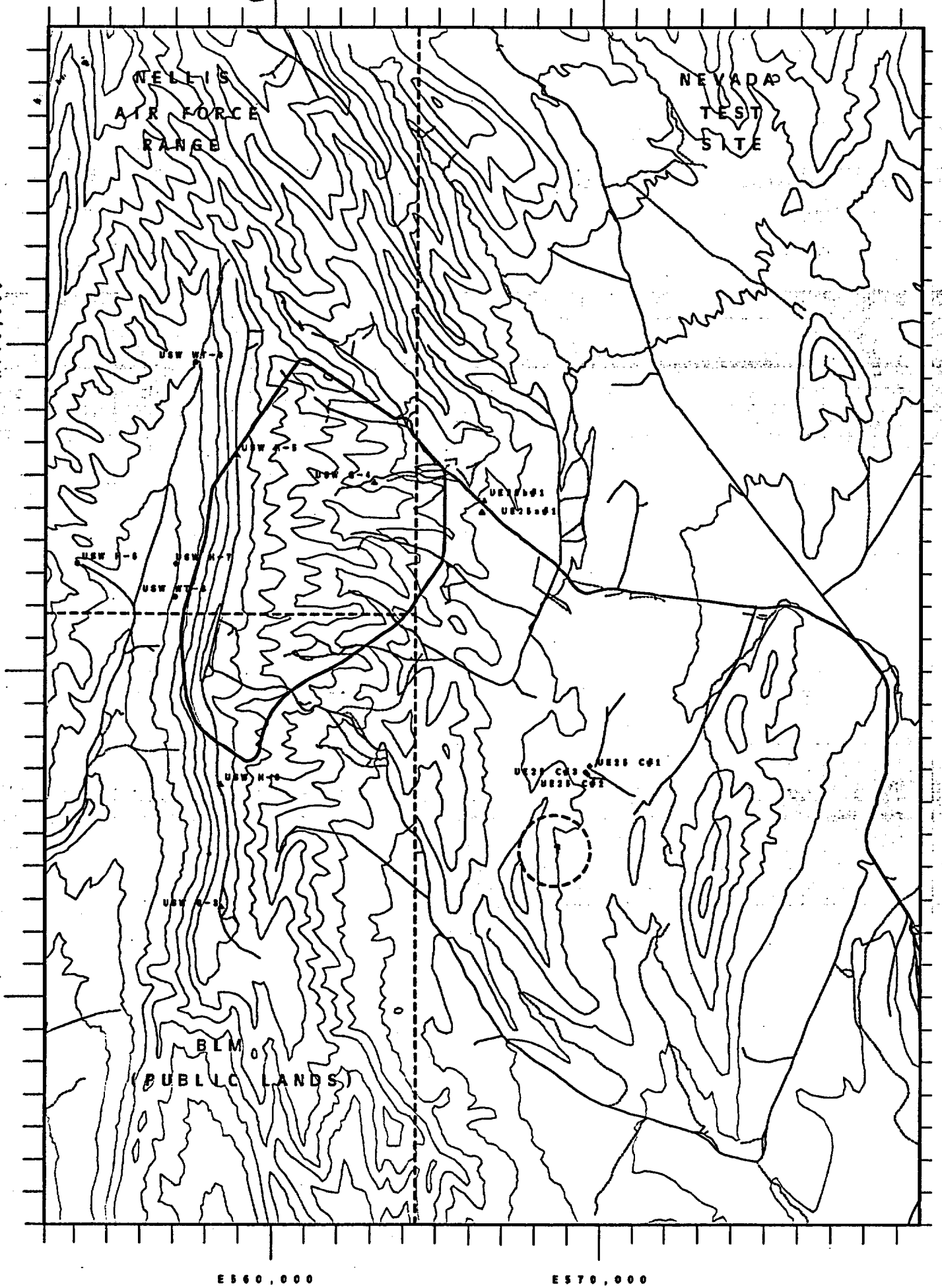
YMP-89-20.1

Map# VMP-89-021.1



YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

SOLITARIO CANYON FAULT HYDRAULIC CONDUCTIVITY INVESTIGATION SITES, AND PROPOSED SATURATED ZONE PUMP TEST LOCATIONS

1 0 1
MILES

1 0 1
KILOMETERS

LEGEND

- EXISTING DRILLHOLE/OBSERVATION WELL
- PROPOSED DRILLHOLE/OBSERVATION WELL
- PROPOSED DRILLHOLE/ PRIMARY PUMP TEST HOLE
- C-HOLE COMPLEX - EXISTING
- POTENTIAL LOCATIONS FOR TESTING WITH CONSERVATIVE TRACERS THROUGHOUT THE SITE, EXISTING HOLES (DEPENDENT ON C-HOLE COMPLEX TESTS)
- ? SOUTHERN TRACER COMPLEX (4 PROPOSED HOLES - LOCATIONS NOT SPECIFIED)

LIGHT DUTY ROADS
UNIMPROVED ROADS
TRAILS

CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1956 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAPS
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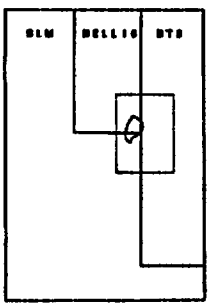
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988



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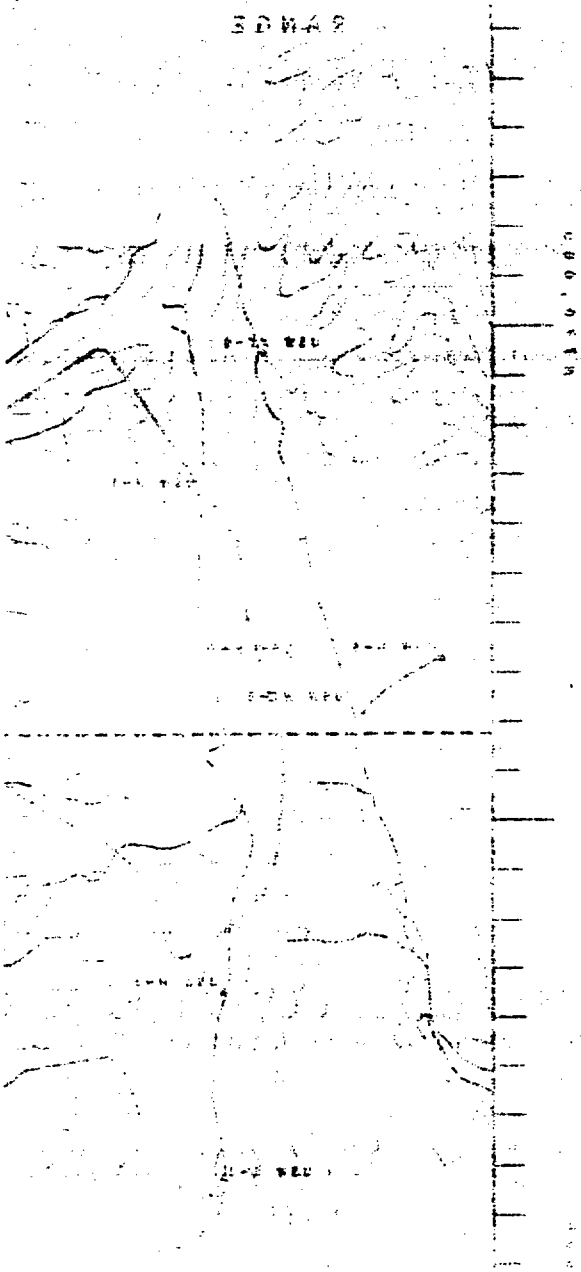
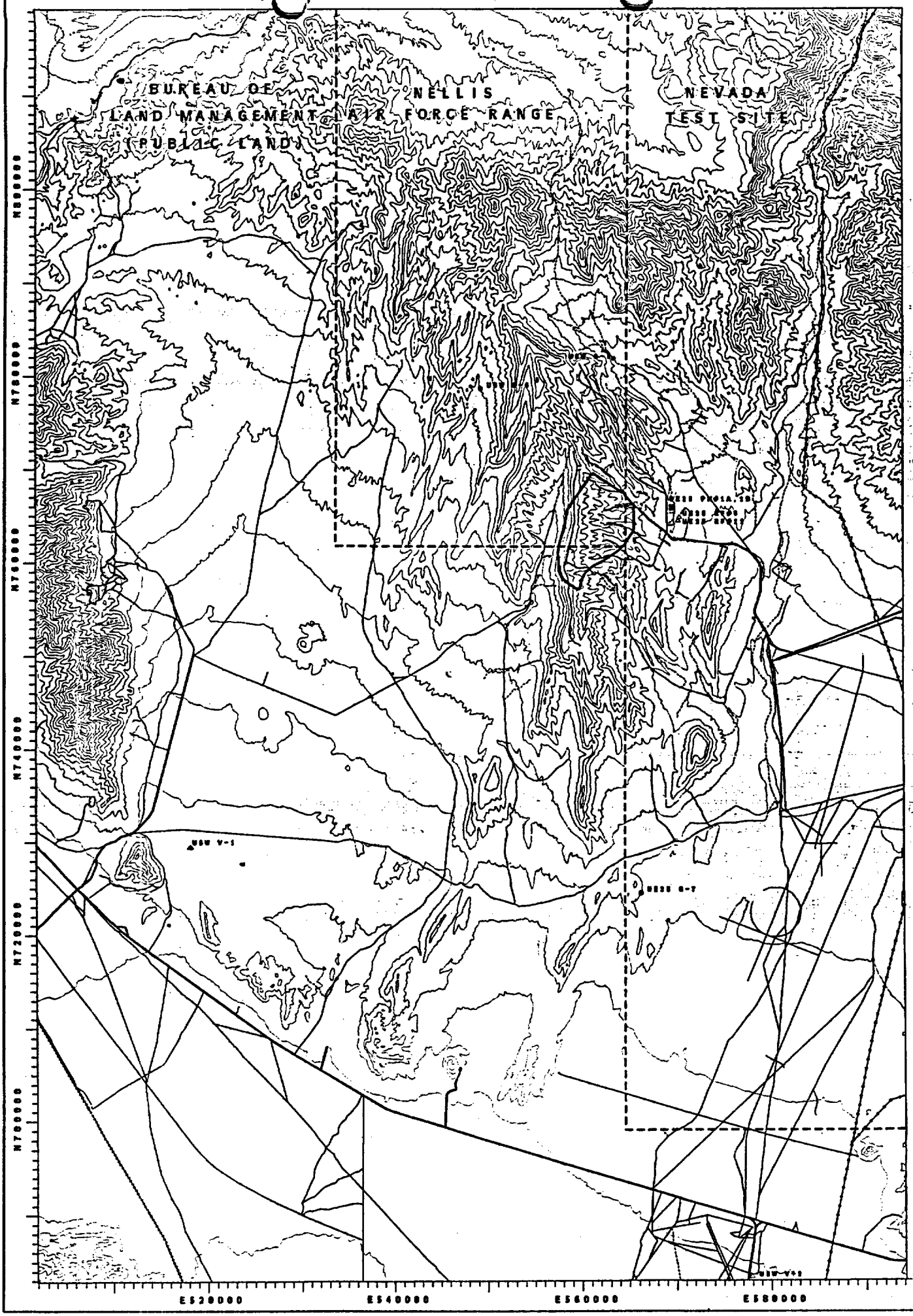
YMP-89-021.1



Map #12 - YMP-89-12.1



YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

PROPOSED COREHOLES, INCLUDING GEOLOGIC VOLCANISM, CALCITE-SICLICA, AND REPOSITORY SURFACE FACILITY HOLES

2 0 2
MILES

2 0 2
KILOMETERS

LEGEND

- GEOLOGIC COREHOLE - PROPOSED
- VOLCANISM COREHOLE - PROPOSED
- CALCITE-SILICA COREHOLE - PROPOSED
- REPOSITORY SURFACE FACILITY COREHOLE - PROPOSED

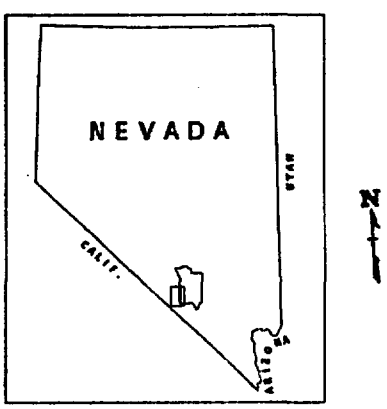
- MEDIUM DUTY ROADS
- LIGHT DUTY ROADS
- UNIMPROVED ROADS
- TRAILS
- RAILROADS
- POWERLINES

CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

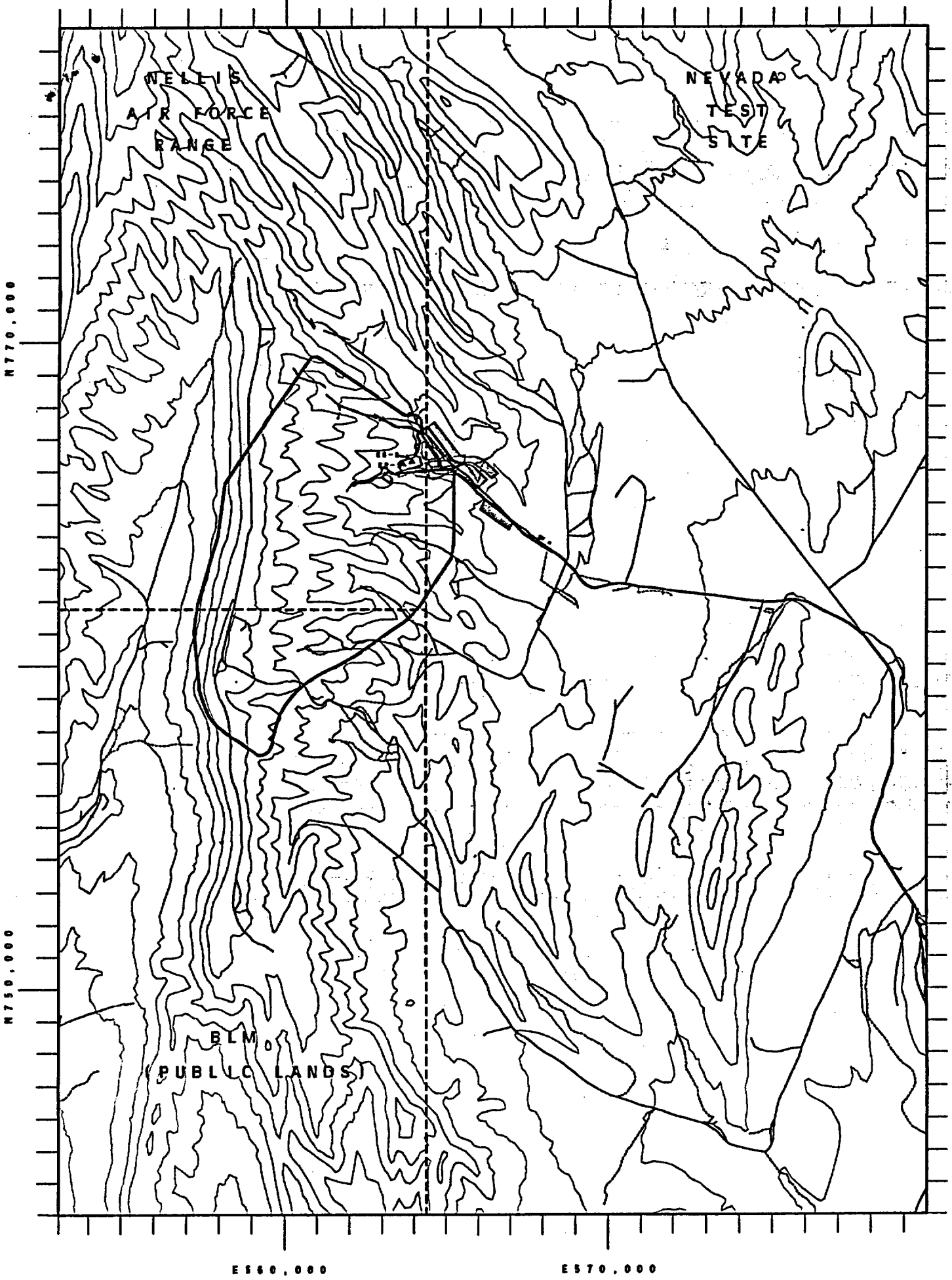
50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1956 1:24,000 USGS TOPOGRAPHIC MAPS
1976 1:24,000 USGS ORTHOPHOTO MAPS
1983 1:100,000 USGS TOPOGRAPHIC MAP
7/1986 AND 9/1987 1:24,000 UNCONTROLLED AERIAL PHOTOGRAPHY
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE

MAP COMPILED IN DECEMBER 1988



EG&G YMP-89-022.1

Map #13 YMP-89-03.1



YUCCA MOUNTAIN PROJECT

SURFACE-BASED INVESTIGATIONS PLAN

PROPOSED EXPLORATORY SHAFT SUPPORT FACILITIES

1 0 1
MILES

1 0 1
KILOMETERS

LEGEND

▲ PROPOSED EXPLORATORY SHAFTS

LIGHT DUTY ROADS
UNIMPROVED ROADS
TRAILS

CONCEPTUAL PERIMETER DRIFT BOUNDARY

SOURCES:

50 M ELEVATION CONTOURS - USGS 1:100,000 MAP
1958 1:24,000 USGS TOPOGRAPHIC MAPS
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1983 1:100,000 USGS TOPOGRAPHIC MAPS
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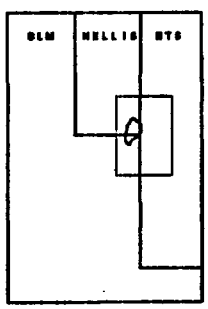
GRID TICKS BASED ON NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE
MAP COMPILED IN DECEMBER 1988
ESF SOURCE: HOLMES & NARVER DRAWING #JS-025-ESF-C3.B



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