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1 OF 3

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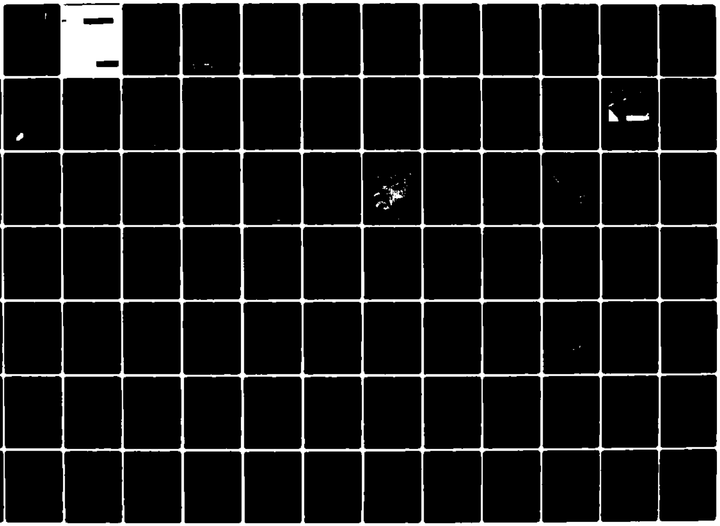

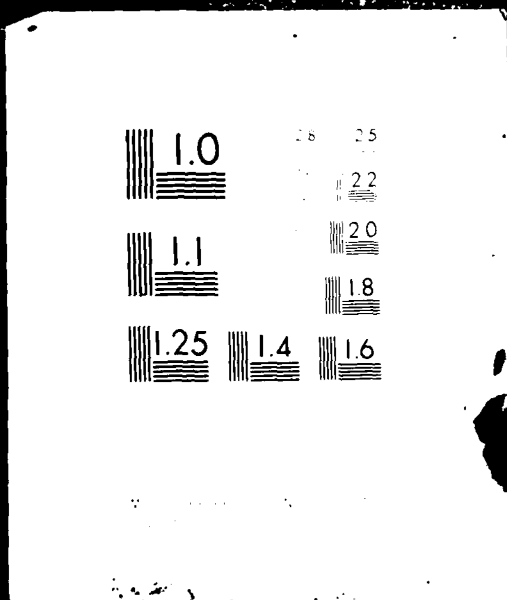

1.0 INTRODUCTION

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MX SITING INVESTIGATION
VOLUME IIC
GEOTECHNICAL REPORT
NELLIS AIR FORCE BASE
BOMBING AND GUNNERY RANGE
(NBGR)

Conducted for:

Department of the Air Force - SAMSO

Contract No.: F04701-74-D-0013

FUGRO NATIONAL, Inc.

Project No.: N-74-066-EG

30 June, 1975

FUGRO NATIONAL, INC.

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The purpose was to collect and analyze geotechnical & related data for the Nellis Bombing and gunnery range, Nevada. The area of study is in Southern Nevada. Included is a review of existing geotechnical information regarding the area.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 FORWARD

This report was prepared for the Department of the Air Force, Space and Missile Systems Organization (SAMSO), in compliance with conditions of the statement of work as part of Contract No. F04701-74-D-0013 and deals with siting of the MX Land Mobile Advanced ICBM system. This contract was authorized under Program Element 63305F as described in the 26 February, 1973 Missile X Program Plan.

This report was prepared for SAMSO by John W. LaViolette, Charles N. Partlow and James R. Miller, with final graphics preparation by Edd V. Joy and James A. Nenneman. Technical review and partial preparation of this report was performed by Kenneth L. Wilson and Robert J. Lynn, Senior Geologists and Kenneth D. Hill, Senior Engineer. TRW Systems personnel monitored the study for SAMSO.

The overall Geotechnical Evaluation Investigation dealt with three separate Department of Defense (DoD) areas (Figure 1); the Nellis Air Force Base Bombing and Gunnery Range (NBGR) is the subject of this report (Volume IIC). Results of the studies for the combined White Sands Missile Range/Fort Bliss Military Reservation (Volume IIA) and for the combined Yuma Proving Grounds/Luke-Williams Bombing and Gunnery Range (Volume IIB) are presented separately.

Results of the NBGR study are presented in a written format and as large (37" x 42") map and overlay graphics. Written

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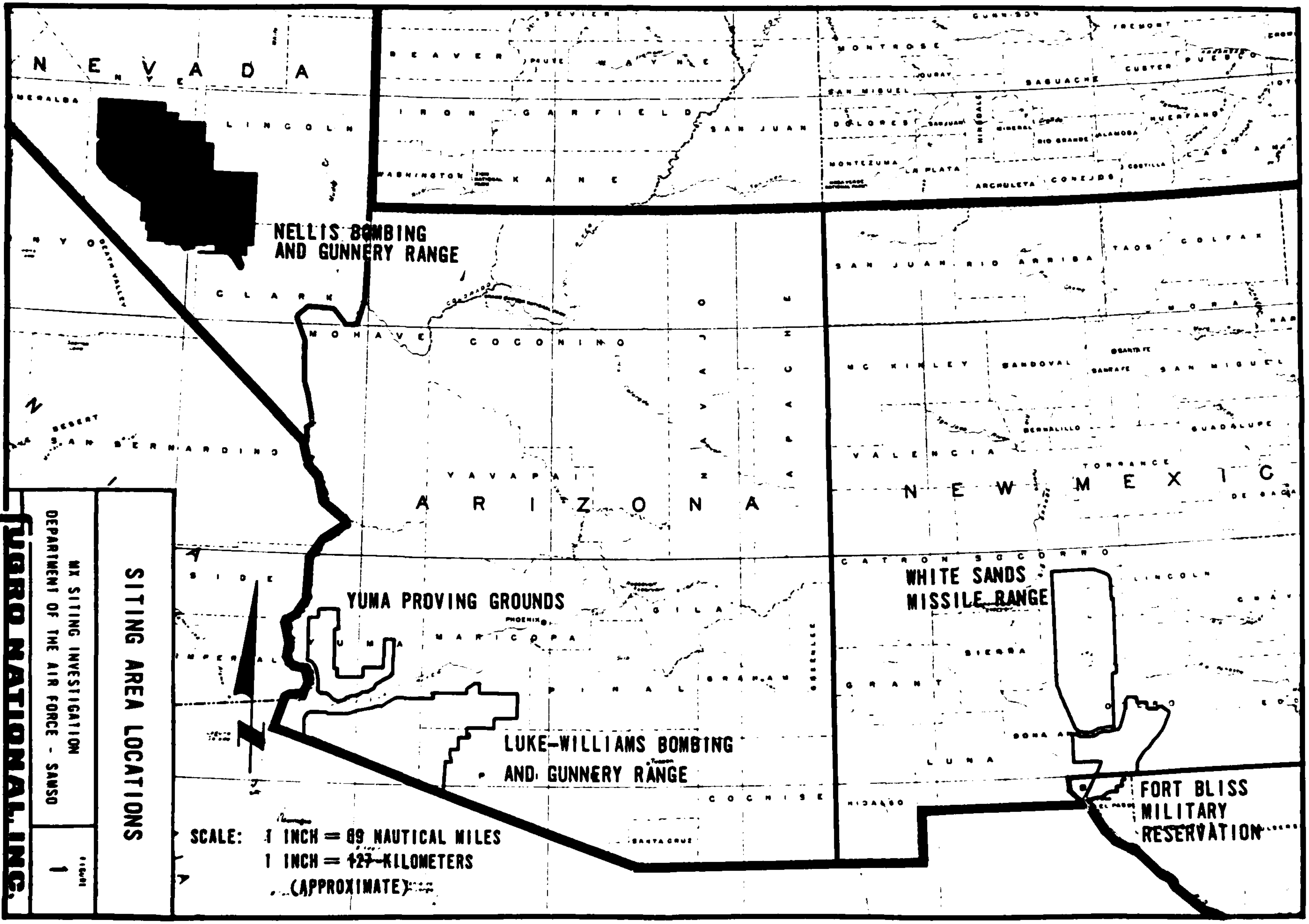

SITING AREA LOCATIONS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 1

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materials for this Geotechnical Evaluation Investigation are presented in four volumes which specifically consist of:

Volume I - Siting Evaluation Report for the three DoD siting areas.

Volume IIC - Geotechnical Report Nellis Air Force Base Bombing and Gunnery Range (NBGR).

Volume III - Recommended Geotechnical Field Investigations for the three DoD siting areas.

Volume IV - Environmental Assessment Report: Geotechnical Field Investigations for the three DoD siting areas.

The purpose of this investigation and the general content of each of the volumes is contained in Section 1.2.

Large map and overlay graphics (with Explanation) were prepared for use with the four volumes cited above. The overlay graphics consist of thirteen base maps, designated N-I through N-XIII (Figure 2), and seven overlays for each map. Titles of the overlays are:

1. Trench
2. Shelter and Pool
3. Hydrology
4. Soils Engineering
5. Geology
6. Topography
7. Ownership and Cultural Features

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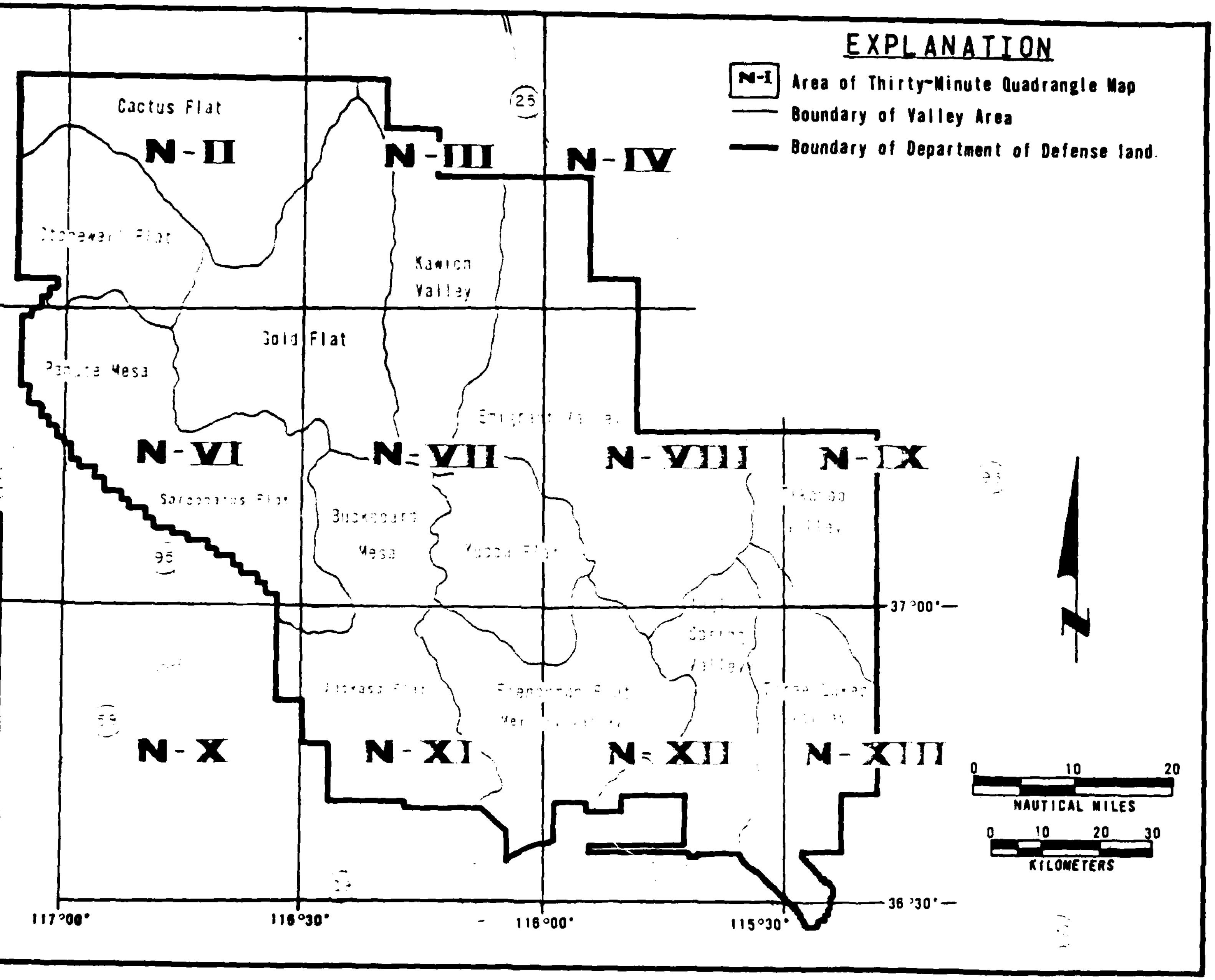

VALLEY AND THIRTY-MINUTE QUADRANGLE LOCATIONS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 2

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The first two overlays show non-specific locations of shelters, pools (aim point system) and trenches (line system). The NBGR graphics have been divided and bound in four individual volumes, which are identified as follows:

Graphics Volume IIC-1 - (Includes N-I; N-II; N-III)

Graphics Volume IIC-2 - (Includes N-IV; N-V; N-VI)

Graphics Volume IIC-3 - (Includes N-VII; N-VIII; N-IX)

Graphics Volume IIC-4 - (Includes N-X; N-XI; N-XII; N-XIII)

1.2 PURPOSE

The purpose of this phase of the study was to:

1. Collect and analyze available geotechnical and related data including:
   a. Geology and Seismology
   b. Topography and Terrain Analyses
   c. Soils and Soils Engineering
   d. Hydrology (surface and groundwater)
   e. Climatology
   f. Ownership and Cultural Features and Land Utilization

   For convenience, data for these categories are hereafter referred to as geotechnical data.
2. Report the results of data collection in a useful and informative format (Volumes IIA, IIB, IIC and overlays).
3. Locate potential sites for shelters, pools and trenches using judgement based upon the results of items 1 and 2 above and criteria developed with SAMSO for

for the non-excluded areas (Volume I).

4. Based on items 1, 2 and 3, determine in general what techniques and methods should be recommended for geotechnical field investigations in specific DoD areas (Volume III).
5. Collect and analyze selected environmental data to provide an environmental assessment of the potential impacts of the recommended geotechnical field investigations (Volume IV).
6. Evaluate and rank the DoD land areas from a geotechnical viewpoint according to their suitability for siting of the MX system (Volume I).

1.3 SCOPE

The scope of the study is presented in Tasks 1 through 10 of the "Program Plan for Geotechnical Services" prepared by Fugro National, Inc. (revised 13 November, 1974) in conjunction with SAMSO/TRW and includes:

1. Collection and analysis of available geotechnical data and selected environmental data (Tasks 1, 2, 3, 7 and 8);
2. Analysis of available aerial photographs (Tasks 2 and 3);
3. Brief ground and aerial reconnaissance of the NBGR area to collect additional data and verify geotechnical conditions determined during the literature research (Task 8);

4. Depiction of the data onto large and small graphics and written description of data within the text and on Data Summary Sheets (Tasks 4, 5, 6, 9 and 10);
5. Identification, evaluation and ranking of potential siting areas for the land mobile system (Task 10).

1.4 STUDY APPROACH AND METHODS

The collection and evaluation of existing geotechnical data from all available sources prior to commencement of field activities was a primary factor controlling the study approach. Data were collected from many agencies, institutions and individuals. Data collection activities included trips to Carson City, Las Vegas, Nellis Air Force Base and Reno, Nevada; Menlo Park and Sacramento, California; Denver, Colorado, and Vicksburg, Mississippi.

Collected geotechnical data were evaluated to determine their specific applicability to siting parameters for the MX land mobile system before inclusion in any of the project reports. General and region-wide analyses, useful in the overall understanding of a siting area, were kept as limited as possible.

The majority of published literature on NBGR pertains to the Nevada Test Site (NTS) which is located in the southcentral portion of NBGR. This work has been primarily surface and subsurface investigations conducted for the testing program of the U. S. Energy Research and Development Administration (ERDA), formerly the U. S. Atomic Energy Commission. Careful analysis of these data and interpretation of aerial photographs has enabled some extrapolation of data to adjacent areas north, east and west of NTS where geotechnical data are less detailed.

Compiled geotechnical data have been depicted primarily on base maps and overlays of the size defined by four fifteen-minute U.S. Geological Survey topographic maps combined into a thirty-minute map (also referred to as a four-quad sheet). Where fifteen-minute maps were not available, reductions or enlargements of other maps were made to obtain the 1:62,500 scale. Although much data were collected, they were not extensively depicted in those areas with surface gradient generally exceeding ten percent (Section 2.1.6) or areas defined by significantly large quantity-distance exclusions (Section 2.1.5). The relative locations of the thirteen four-quad sheets (N-I through N-XIII) are shown on the small report graphics and on the topographic base maps. References in the text to specific overlays are by the title of the overlay followed by the appropriate Drawing number, e.g., (Geology, N-I through N-III).

Data depicted on the overlays were derived from general, regional and site-specific studies. All contacts separating distinct geologic or soils units are shown as solid lines representing data as they were collected from the literature or as interpreted from aerial photographs. Depth contours (Hydrology and Geology overlays) and boundaries of drainage channels susceptible to flooding (Hydrology overlays) are dashed and dot-dashed, respectively, since some interpretation or refinement of the available data was necessary for the placement of the lines.

These lines are queried where continuation of the data could not be made, or where extrapolation was uncertain.

Text discussion in the Geotechnical Report is limited mainly to introductory remarks, regional familiarization, qualifying statements and summary presentation. The text, small graphics and Data Summary Sheets (Section 3.0) supplement the overlays. The Data Summary Sheets aid in the interpretation and qualification of the data displayed on the overlays. In addition, they present data which cannot be easily displayed on the overlays and normally would be incorporated as extensive text.

Important to siting considerations are contiguity of and accessibility between land areas suitable for siting. The Valley Analysis Concept (Section 3.0) has been introduced to enhance data depiction and usability. A Valley (designated by capitalized "V") is a sub-area of the DoD siting area and may be composed of portions of one or more four-quad sheets for which geotechnical data may be compiled. It is bound by one or both of the following:

1. A hydrologic drainage divide (most often the crest of an intervening mountain range), and
2. DoD boundary or any other artificially established boundaries such as public highways, township and range lines, or national monument borders.

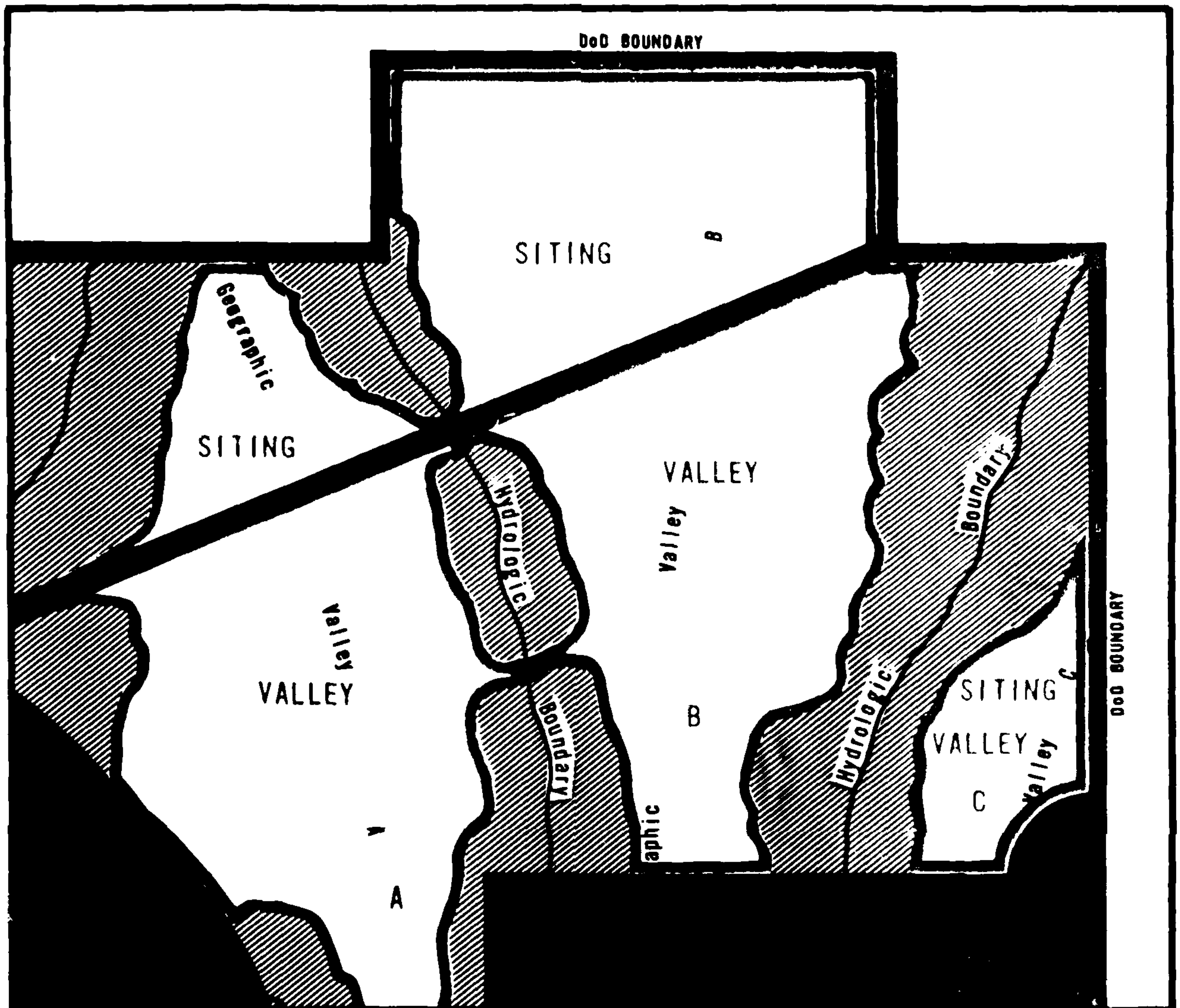
Typically, a Valley includes an alluvial lowland area and the flanks of its bordering mountain ranges. A geographic valley, as designated and named on existing maps, may encompass a portion of, or include the entire alluvial lowland area of a Valley. Most often Valley names correspond with the appropriate geographic valley name.

There are twelve Valleys within NBGR (Figure 2). The location and identification of each Valley and the Valley boundaries are depicted on 1:250,000 scale maps contained within the Valley Analysis (Section 3.0), on the four-quad base map and the small graphics. In NBGR, these include:

1. Stonewall Flat (3.3)
2. Cactus Flat (3.4)
3. Gold Flat (3.5)
4. Kawich Valley (3.6)
5. Emigrant Valley (3.7)
6. Pahute Mesa (Sarcobatus Flat) (3.8)
7. Buckboard Mesa (Jackass Flat) (3.9)
8. Yucca Flat (3.10)
9. Frenchman Flat (Mercury Valley) (3.11)
10. Indian Spring Valley (3.12)
11. Three Lakes Valley (3.13)
12. Tikaboo Valley (3.14)

The area within a designated Valley which is available for siting based only on cultural and quantity-distance exclusions (Section 2.1.5) and general topographic conditions (less than ten percent grade; Section 2.1.6) is referred to as the siting valley. The siting valleys within NBGR are depicted in Figure 7 (Section 2.1.5) and in Sections 3.3 through 3.14.

The relationships among Valleys, geographic valleys and siting valleys are depicted diagrammatically in Figure 3.



EXPLANATION

PRIMARY QUANTITY-DISTANCE EXCLUSION

- Minimum distance from population centers.
- Minimum distance from DoD boundary and/or inhabited buildings
- Minimum distance from traveled public highway
- Excluded areas, e.g. national park, monuments, Indian reservation

SYMBOLS

- Area with greater than ten percent topographic grade
- Valley boundary
- Siting valley boundary

RELATIONSHIPS OF VALLEYS AND SITING VALLEYS TO GEOGRAPHIC VALLEYS

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DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 3

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2.0 REGIONAL ANALYSIS

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 SITING AREA LOCATION AND DESCRIPTION

NBGR is located in south-central Nevada. It lies principally in the southern half of Nye County, and in portions of northwestern Clark County and southwestern Lincoln County.

The Nellis range is an irregularly shaped, somewhat rectangular area of approximately 4529 square nautical miles (nm^2) with a maximum north-south dimension of 87 nautical miles (nm) and a maximum east-west dimension of 79 nm. Surface elevations range from 8202 feet above sea level at Belted Peak to less than 2700 feet in Jackass Flat.

The Nevada Test Site (NTS) within NBGR, comprises approximately 1025 nm^2 of the south-central portion of the range; the Desert National Wildlife Range occupies approximately 1100 nm^2 in the southeast section; the Nevada Wild Horse Range comprises approximately 450 nm^2 of the north-central portion, and the Tonopah Test Range comprises approximately 470 nm^2 of the northwest section (Figure 4).

2.1.2 USES OF LAND AND SURFACE WATER

2.1.2.1 Land

NBGR was established in 1941 and is under the jurisdiction of the U. S. Air Force. It functions primarily as a bombing and gunnery range for training of fighter pilots stationed at Nellis Air Force Base, northeast of Las Vegas. Indian Springs Air Force Auxiliary Field (AFAF) in the Desert Wildlife Range on the east side of NBGR, serves as the base headquarters providing helicopter support for personnel transport and security patrol (Maj. Hosford, oral communication, 1975). NBGR is restricted from public access, except for portions of Kawich Valley and Gold Flat which are used by local ranchers as winter ranges for cattle (Ekren and others, 1971).

NTS was established in 1950 primarily as a proving grounds for nuclear devices. Since then 84 atmospheric tests (pre-1957) and over 360 underground tests (beginning in 1957) have been conducted. The number of tests conducted per year has varied from a high of 41 in 1968 to a low of seven in 1973 (D. G. Jackson, written communication, 1975). Of the nearly 1025 nm^2 comprising NTS, approximately 32 percent is not available for siting because it is used for other purposes. The remaining 68 percent (approximately 700 nm^2) is reserved for use by the Energy Research and Development Administration (ERDA). Of that total, only 30 percent is presently suitable for the testing of underground nuclear devices. The remaining 70 percent has been used for nuclear testing or is considered unsuitable for testing due to unfavorable rock conditions or high relief (Figure 5). The Nuclear Rocket Development Station (approximately 93 nm^2) occupies the southwest corner of NTS and is presently (1975) inactive. ERDA, with headquarters at both Mercury and Las Vegas, Nevada, administers NTS. Access is restricted and rigidly controlled.

Tonopah Test Range at Cactus Flat in the northwestern portion

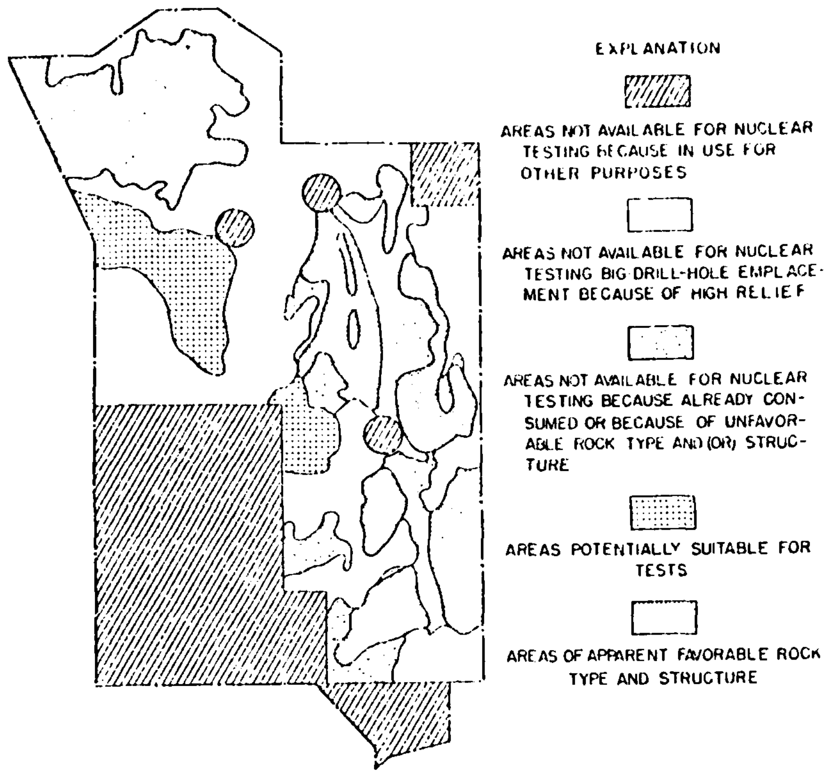

FIGURE 5. Area evaluation for underground nuclear test sites, Nevada Test Site (Houser, 1968).

of NBGR is an active research and development installation, administered by ERDA and Sandia Laboratories (S. A. Moore, oral communication, 1975).

The Desert National Wildlife Range (Figure 4) was set aside in 1936 primarily for management, protection and study of the rare desert bighorn sheep. In addition to over 1000 bighorns, more than 300 species of other birds and animals are protected in the Wildlife Range. The area has about 25,000 visitors annually and limited hunting is allowed to harvest old rams and to provide animal carcasses for study (J. Helvie, oral communication, 1975). This range is part of the National Wildlife Refuge System and is administered by the U. S. Fish and Wildlife Service. Public access to the western portion of the Wildlife Range, within NBGR, is controlled by the U. S. Air Force.

The Nevada Wild Horse Range is administered by the Bureau of Land Management (BLM) and is one of the few areas in the nation set aside for the protection of the North American mustang. At present, the range is entirely within NBGR and it is not open to the general public, although plans are being developed that would open a portion of it for public use (U. S. Department of the Interior, 1972). Controls are not placed on the movement of the wild horses.

Approximately 95 percent of the land surrounding NBGR is owned and administered primarily by the BLM. Several large BLM valleys are contiguous with DoD Valleys. These BLM valleys include: Sarcobatus Flat, Amargosa Desert and Las Vegas Valley south of NBGR; Ralston Valley, Stone Cabin Valley, Reveille Valley and Railroad Valley north of NBGR; and Sand Springs Valley east of NBGR. The remaining five percent of the land is divided between patented and private ownership.

Although gold, silver and mercury have been mined in the past (Ekren and others, 1971; Cornwall, 1972), no mining is presently allowed within the DoD boundaries (Col. Patterson, oral communication, 1975). The major active mining centers are at Goldfield west of NBGR and Beatty to the southwest (U. S. Department of the Interior, 1972).

2.1.2.2 Surface Water

No perennial streams or lakes occur within NBGR. A few perennial springs and seeps do provide enough water to supply isolated water holes in the mountain areas (Colton, 1965; Thordarson and Robinson, 1971; Winograd and others, 1971). Surface water conditions within NBGR are discussed in Section 2.4.

2.1.3 POPULATION AND POPULATION DISTRIBUTION

Approximately 300 government and military personnel are permanent residents of Mercury, Nevada within NTS. A transient population, consisting of about 3500 military and civilian employees, work within the Nevada Test Site, centered principally around Mercury, Nevada and at Indian Springs AFAF. Many employees commute from Nellis Air Force Base or Las Vegas.

Population centers adjacent to NBGR, with their population and distance from the nearest range boundary, are listed in Table 1.

2.1.4 CULTURAL IMPROVEMENTS

Although no public highways pass through NBGR access is provided by improved and unimproved dirt roads extending from 1) U. S. Highway 95 paralleling the southern and western boundary of NBGR; 2) U. S. Highway 6 approximately ten to 15 nm to the north; 3) State Highway 25, zero to 15 nm to the

TABLE 1

Population Centers

Population Center*	Population**	Distance from Range
Greater Las Vegas	162,000	10 nm
Tonopah	1,992	12 nm
Indian Springs	1,167	0 nm
Beatty	775	10 nm
Alamo	338	8 nm
Goldfield	240	7 nm
Hiko	40	16 nm
Warm Springs	35	18 nm
Lathrop Wells	30	2 nm

* Locations shown on Figure 4.

** All population figures are based on the 1970 census (U. S. Census Bureau).

northeast; and 4) U. S. Highway 93, ten to 30 nm to the east (Figure 4). A paved road, Mercury Highway, leads into NTS from Highway 95 and extends north to Yucca Flat. The old State Highway 25 route provides access to Tonopah Test Range and extends east through Kawich and Emigrant Valleys. All access to military facilities and installations on the range is strictly controlled and the entire range is patrolled periodically by helicopter.

The Union Pacific Railroad, extending from Las Vegas northeastward to Salt Lake City, Utah, lies about 21 nm southeast of NBGR.

Major high voltage (greater than 80,000 volts A.C.) electrical transmission lines owned by the Nevada Power Company, enter NBGR at Mercury and Indian Springs (Figure 6). Tonopah and Goldfield both west of NBGR, and the Tonopah Test Range in Stonewall Flat are serviced independently by the Sierra Pacific Power Company. No major gas or oil pipelines are known to pass through or immediately adjacent to NBGR (Lockard, 1970).

Several permanent and semi-permanent instrumentation sites, test sites, target areas, abandoned airstrips and military contaminated areas are scattered throughout NBGR. The locations of these areas and more information about them, are presented on the Ownership and Cultural Features overlays and Data Summary Sheets. Limited by available data, only major known nuclear test events have been designated on these overlays and Data Summary Sheets.

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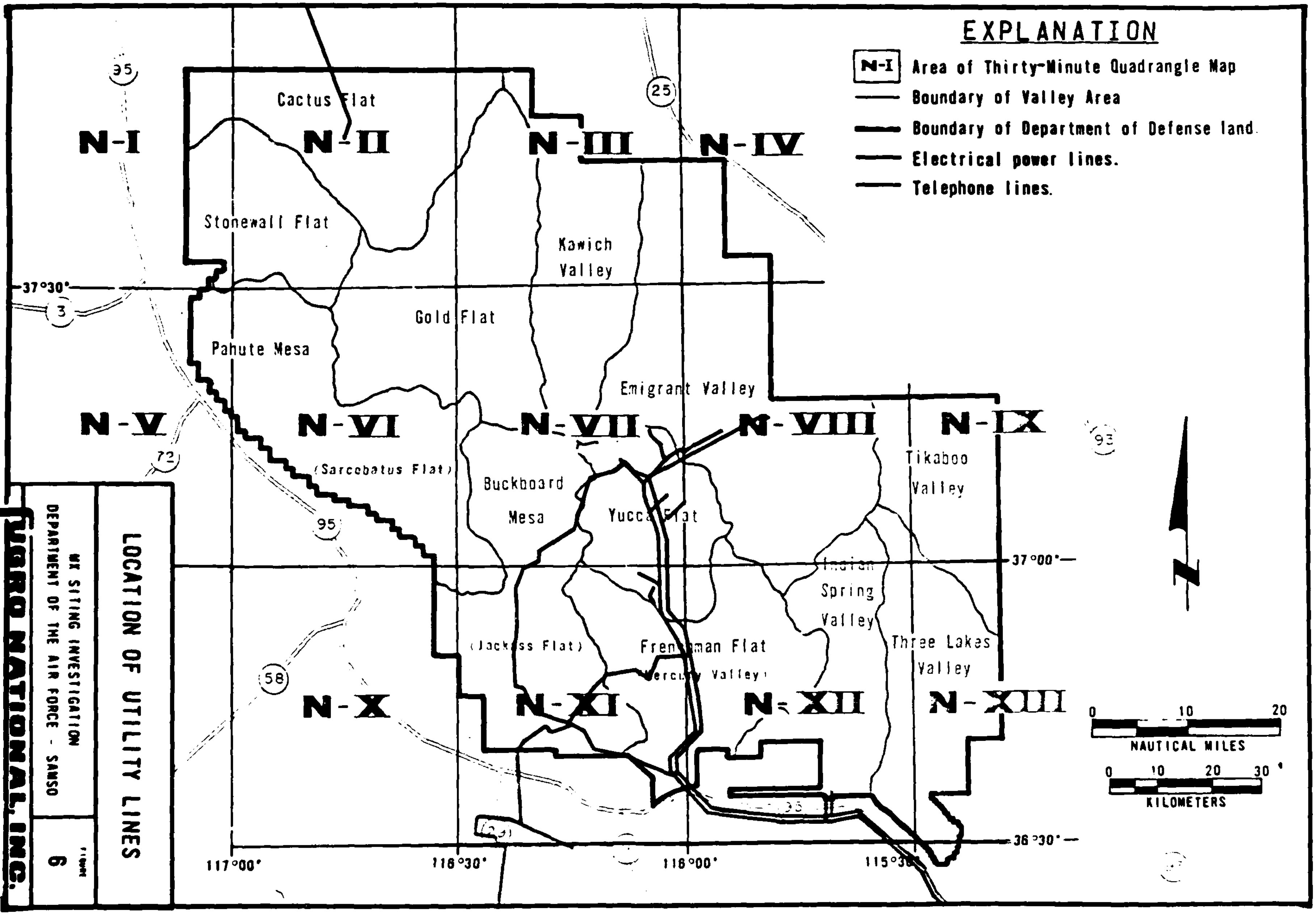

LOCATION OF UTILITY LINES

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FIGURE 6

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2.1.5 CULTURAL AND QUANTITY DISTANCE EXCLUSIONS

The major cultural and quantity-distance exclusions which limit siting areas within NBGR are depicted on the appropriate overlays and include:

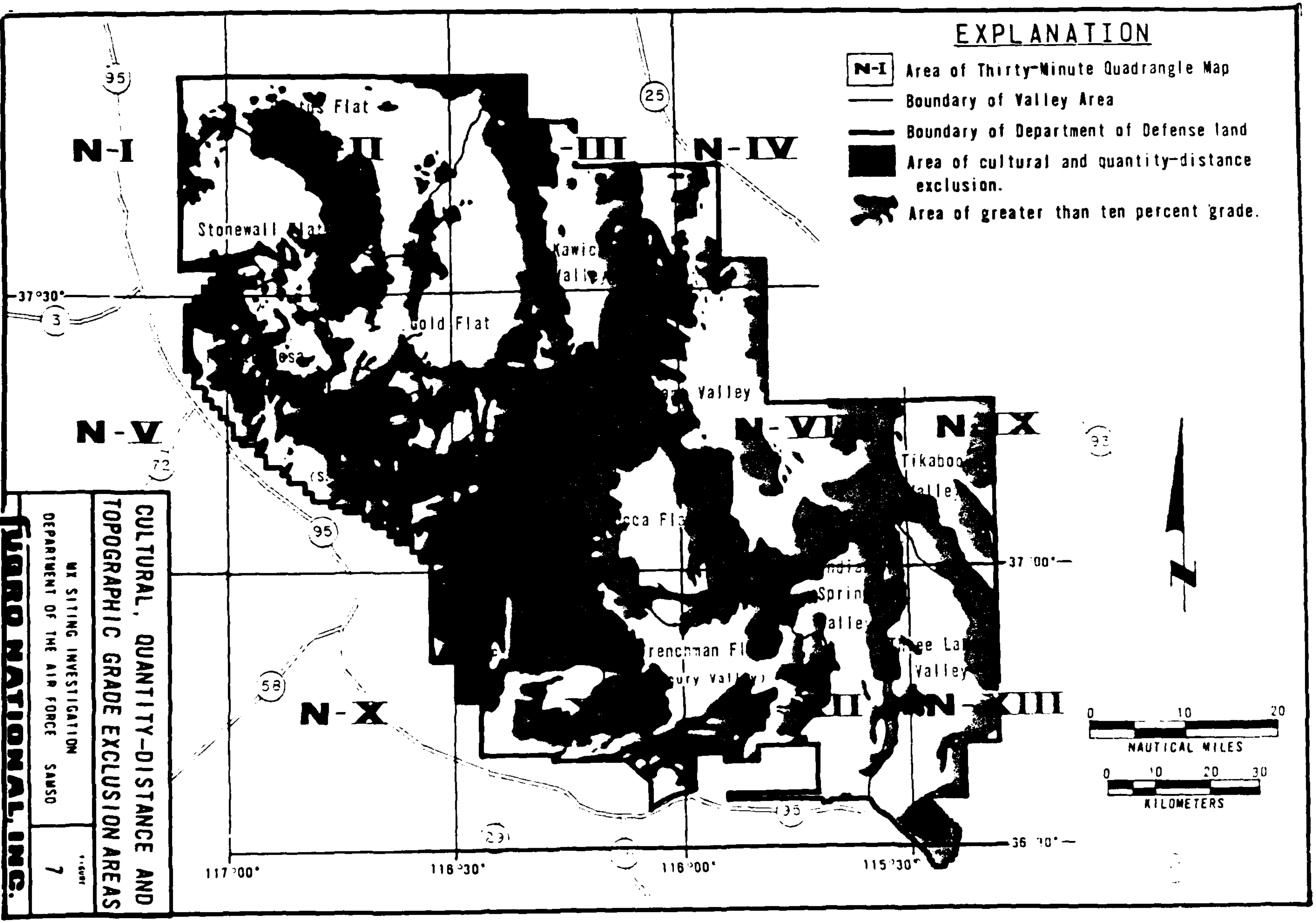
1. An 18 nm arc from Las Vegas, Nevada (Figure 7), and
2. A corridor, 2965 feet wide, inside and parallel to the boundary of NBGR.

In addition, the following minor quantity-distance and cultural features were identified within NBGR, but are not restrictive to siting. They are:

1. Several small buildings whose locations were determined from old topographic maps. Field examination of several of these structures showed them to be abandoned or incorporated into military facilities.
2. Numerous permanent and semi-permanent military instrumentation and monitoring sites which are inhabited on a periodic basis.
3. Facilities at Nevada Test Site and Tonopah Test Range.

2.1.6 GENERAL TOPOGRAPHIC CONDITIONS AND EXCLUSIONS

General topographic conditions for the various landforms present in the siting area are expressed in terms of topographic grade. A principal criterion for exclusion of an area from siting consideration is the area which has a greater than ten percent topographic grade ($5^{\circ}43'$; 528 feet/mile). This condition occurs primarily in areas of exposed rock, areas of shallow rock (Section 2.2.3.2) near the base of mountains



CULTURAL, QUANTITY-DISTANCE AND TOPOGRAPHIC GRADE EXCLUSION AREAS

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FIGURE 7

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and hills, and may also include the topographically higher alluvial fan surfaces (Section 2.2.2). Areas of five to ten percent grade ($2^{\circ}52'$ to $5^{\circ}43'$; 264 to 528 feet/mile) commonly occur near the mountains generally bordering the areas of greater than ten percent grade. Pediments and alluvial fans of various ages comprise the greatest percentage of landforms in the five to ten percent topographic grade range. The zero to five percent topographic grade range (0° to $2^{\circ}52'$; 0 to 265 feet/mile) most commonly occurs in the central portion of the basins. Landforms which predominate in this grade range are playas and alluvial fans; areas of blowing sand and major washes are also present.

The ten percent topographic grade exclusion combined with the cultural and quantity-distance exclusion (Section 2.1.5) accounts for 55 percent (2512 nm^2) of the total area (4529 nm^2) of NBGR and comprises the total area excluded from siting consideration (Figure 7). Of the remaining area, approximately 559 nm^2 is included in the five to ten percent topographic grade range and 1458 nm^2 in the zero to five percent grade range.

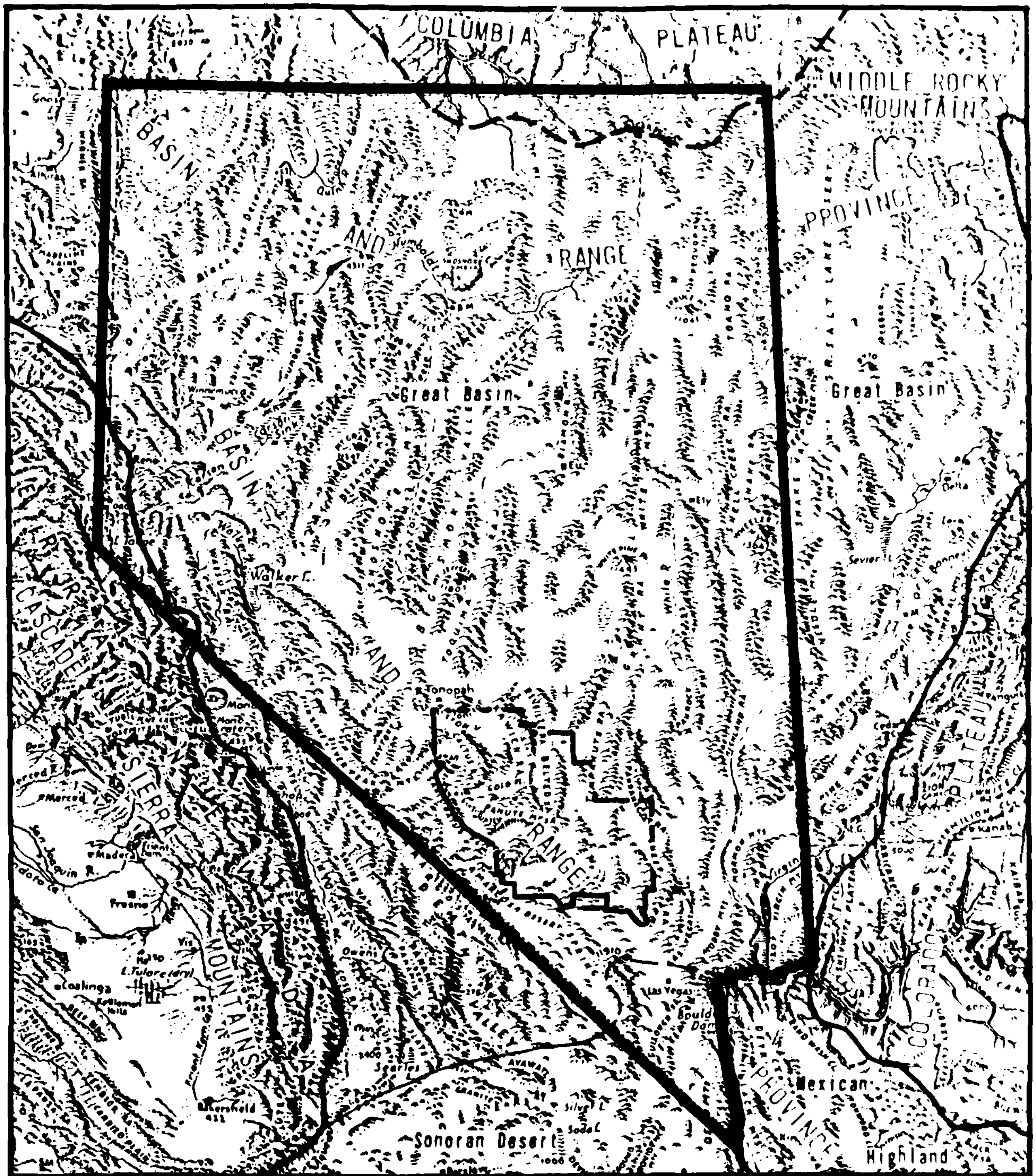
2.2 GEOLOGY

2.2.1 GENERAL

NBGR lies totally within the Great Basin section of the Basin and Range Physiographic Province (Figure 8; Fenneman, 1946). The physiography is controlled by, and therefore strongly reflects, the underlying geologic structure. This area is characterized by a central downdropped basin (graben) commonly flanked on either side by the eroded remnants of uplifted fault blocks (horsts). Typically, closed-basin conditions predominate with primary and secondary drainages terminating at playas in the central portion of the basins.

Closed basins within NBGR include Stonewall Flat, Cactus Flat and Gold Flat in the northwestern portion; Yucca Flat and Frenchman Flat in the south-central portion (within NTS); Kawich Valley and Emigrant Valley north of NTS; and Indian Spring, Three Lakes and Tikaboo Valleys east of NTS (Figure 9; Section 2.2.3.2). These Valleys are characterized by alluvial fans flanking the mountains and coalescing around playa lakes occupying the central portions of the Valleys (Ekren and others, 1971). Stonewall Flat, Cactus Flat and Gold Flat are connected by alluvial passes with less than 10 percent grade.

Pahute Mesa and Buckboard Mesa in the southwest portions of NBGR (Figure 9) have a physiography distinctly different from the other areas and their surface drainage is external from NBGR. Both mesas, which are contiguous, consist of elevated



EXPLANATION

Boundary of Department of Defense land.

Boundary of Physiographic Province. Dashed where approximate.

Section boundary of Physiographic Province. Dashed where approximate.

0 50 100
NAUTICAL MILES

0 50 100
KILOMETER

MODIFIED AFTER: Fenneman, 1946

PHYSIOGRAPHIC DIVISIONS OF NEVADA

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FIGURE 8

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plateaus with relatively flat relief. Surface drainage from Pahute Mesa is southwestward to Sarcobatus Flat outside of NBGR. Buckboard Mesa is drained by Forty-mile Canyon southward through Jackass Flat to the Amargosa Desert, south of NBGR. The predominant rock types on these mesas (Table 2) consist of volcanic flows and tuffs primarily of Tertiary age.

The major mountain ranges in the northwest portion of NBGR include Cactus Range, Stonewall Mountain and Kawich Range. These primarily north-south trending ranges, and the north-northeast trending Belted Range north of NTS, consist predominantly of ash-flow and ash-fall tuffaceous volcanic rocks of Tertiary age with minor outcrops of the underlying limestone, dolomite and quartzite of Mesozoic to Paleozoic age (Table 2).

Within the Desert Wildlife Range the major mountain ranges east of NTS include the Spotted, Pintwater and Desert Ranges. Mesozoic to Paleozoic limestone and dolomite comprise the major portion of these ranges with Tertiary volcanic outcrops occurring in the northern part (Table 2).

Exposed rock in NTS (Table 2) include both sedimentary rock of Paleozoic age and Tertiary volcanic rock. Sedimentary outcrops consist of conglomerate, sandstone, shale, limestone and dolomite, while the volcanic outcrops are composed primarily of rhyolite, dacite, basalt, and tuff (Johnson and Hibbard, 1957). Major highlands include Halfpint Range, Eleana Range, Shoshone Mountain, Specter Range and Massachusetts Mountain.

TABLE 2

Dominant Rock Type in Mountains

Mountain Range	Dominant Rock Type*
In Northwest NBGR	
Goldfield Hills	V Bedrock
Cactus Range	V Bedrock
Stonewall Mountain	V Bedrock
Kawich Range	V Bedrock
Reveille Range	V Bedrock
Belted Range	V Bedrock
In Southwest NBGR	
Pahute Mesa	V Flow Rock
Yucca Mountain	V Bedrock
Timber Mountain	V Bedrock
In Central NBGR (NTS)	
Eleana Range	V and S Bedrock
Shoshone Mountain	V Bedrock
Massachusetts Mountain	V Bedrock
Specter Range	S Bedrock
Halfpint Range	V and S Bedrock
In Southeast NBGR (Desert Wildlife Range)	
Groom Range	M and V Bedrock
Papoose Range	M Bedrock
Spotted Range	S Bedrock
Pintwater Range	S Bedrock
Desert Range	S Bedrock

* V = Volcanic; S = Sedimentary; M = Metamorphic

Basement for the entire area is crystalline metamorphic rock.

2.2.2 GEOMORPHIC SETTING AND SURFICIAL GEOLOGY

2.2.2.1 General

Basin-fill deposits, which are the products of wind, water and gravity erosion of the surrounding mountains, have been accumulating in NBGR for at least the past 30 million years (Appendix B). Intermittent periods of volcanism have contributed interbeds of volcanic rocks to the deposits. Basin-fill deposits present at the surface can be associated with various geomorphic features including, in order of decreasing prominence, alluvial fans and bajadas (A5), pediments (A6), playas (A4), lake terraces (A2), and sand deposits (A3) (Appendix B). These land forms provide the basis for relating the distribution and nature of the surficial deposits and terrain to the suitability for siting the MX system.

Determinations of the physical properties of these deposits are based on data derived from investigations performed primarily by the U. S. Geological Survey (Special Projects Branch, Denver, Colorado) in cooperation with the U. S. Atomic Energy Commission (now U. S. NRC and ERDA); the Nevada Bureau of Mines and Geology; the Department of Conservation and Natural Resources, Nevada. Field investigations included drilling and sampling, surface and subsurface mapping and geophysical (gravity, aeromagnetic, seismic and electrical resistivity) surveys). The majority of these activities have been limited to the area within and immediately adjacent to NTS. Our investigators conducted a brief aerial and ground reconnaissance, and analysis of aerial photographs of NBGR.

2.2.2.1.1 Geologic Relationships Between NBGR and NTS

Detailed studies of basin-fill materials in Yucca Flat and Frenchman Flat in NTS (Wilmarth and others, 1959; Williams, Cole and Moore, 1962; Williams and others, 1963; Hazelwood, 1963; Barnes and others, 1963b; and Carr and others, 1967) allow for a description of basin-fill properties which are probably comparable to other portions of NTS and NBGR, due to similarities in the depositional history (reflecting parallel climatic conditions) and geomorphic development between the areas.

Composition, texture, and other physical properties of the basin-fill deposits will vary throughout the siting area depending mainly upon: 1) distance from the source area, 2) rock types present in the source area, 3) mode of sediment transport and depositional environment, and 4) the amount of compaction of alluvium with depth. Lateral variations of grain size are well documented in both Yucca Flat and Frenchman Flat (Wilmarth and others, 1959; Williams, Cole and Moore, 1962; Williams and others, 1963; Fernald and others, 1968; and Ekren and others, 1971). Generally, particle size distribution grades from an abundance of boulders, cobbles and gravel near the mountain front to clay, silt and fine sand near the central portion of the valley. Variations in grain size with depth do not appear to be as significant. A detailed log of a well in the northern portion of Yucca Flat (located approximately half the distance between the mountain front and playa) indicates that the relative percentages of clay, silt, sand, gravel, cobbles and boulders remain fairly consistent to 550 feet (Williams and others, 1963; Appendix J). Closer to the playa, clay and silt become dominant at least to depths of approximately 200 feet (Johnson and Hibbard, 1957).

Variation in grain-size distribution and in composition of basin-fill materials with differing source rock type was noted by Williams and others (1963). For Yucca Flat they report (although not conclusively) that the coarsest basin-fill deposits occur where limestone, quartzite, and welded volcanic tuff predominate in the adjacent highland areas. However, in areas where only welded and non-welded tuff predominate, gravel, cobble and boulder fractions were noted to be significantly less. Assuming stream energy and the size of contributing drainage basins to be equal throughout, this observation may indicate that areas in the north and east portions of NBGR will have the coarsest basin fill.

The texture of the basin-fill deposits (as expressed in terms of particle size) may change laterally or vertically either gradually or abruptly. For example, a gradational sequence of boulders, cobbles, gravel and sand may be present in one well, while in an adjacent well (at distances less than 2100') abrupt grain size changes (boulders to sand) occur (Wilmarth and others, 1959; Williams and others, 1963) indicating that subsurface correlation of specific basin-fill units over large areal extents may be very difficult.

Caliche, a secondary accumulation of calcium carbonate (Pope, 1971), is present as a competent binding and cementing agent within the basin fill, as massive beds to two feet thick and as scattered veinlets. Preliminary studies by Wilmarth and others (1959) show that the total, relatively high carbonate content of basin-fill materials closely reflects that of adjacent source outcrops. However, caliche to greater or lesser degrees is present throughout NBGR. Seismic refraction lines and selected drill hole sampling in both Yucca and Frenchman Flats show discontinuous and irregular occurrences of caliche to depths of greater than 500 feet (Appendix J; Williams and others, 1963). The coarser grained basin fill (which has a relatively small grain to grain contact area) is better cemented than the clay and silt.

Compaction of basin-fill materials was seen to only increase slightly with depth in both Yucca and Frenchman Flats (Wilmarth and others, 1959; Carr and others, 1967).

2.2.2.1.2 Summary of Geophysical Properties for NTS and NBGR

Because of probable similarities of the physical properties of the basin fill and rock (Section 2.2.2.1.1) similarities may also be expected in the geophysical properties of the basin-fill deposits. Detailed studies (Wilmarth and others, 1959; Hazelwood, 1963; and Carrol and Muller, 1973) show that the compressional wave velocity (p) of basin-fill deposits is highly variable from area to area in Yucca and Frenchman Flats as shown from a sampling of wells (Appendix J). Generally, however, the average seismic velocity will increase with depth as shown in Table 3.

TABLE 3

Average Seismic Velocities of Basin-Fill Deposits

Depth of Basin Fill (feet)	Range of Compressional Wave Velocity (fps)
0 to 300	2000 to 3500
300 to 600	4500 to 5000
Greater than 600	as high as 7000

Source: Hazelwood, 1963

2.2.2.2 Alluvial Fans and Bajadas

Alluvial fans are the predominant geomorphic feature in NBGR, comprising approximately 75 percent (1318 nm^2) of the total area of the siting valleys. They occur along the flanks of all mountain ranges in the area in the form of wedge-shaped deposits which are less than ten feet thick near the mountain fronts and several hundreds of feet thick in the basins. Relationships of three generations (ages) of alluvial fans are shown graphically in Appendix C.

Alluvial fan levels in NBGR are identified as $A5_o$ (older), $A5_i$ (intermediate) and $A5_y$ (younger) to imply relative ages, or $A5_u$ where lithologic correlation and/or relative age assignment could not be made from aerial photographs or the brief field reconnaissance. These relative age assignments are not necessarily intended to imply correlation of units between Valleys, although that may be the case due to similar climatic and geomorphic conditions in adjacent Valleys.

The older and generally topographically higher alluvial fans ($A5_o$) comprise approximately 15 percent of all alluvial fan deposits in NBGR (198 nm^2). These fan units are exposed on the flanks of the Cactus Range, Eleana Range, Belted Range, Spotted Range, and Pintwater Range (Geology, N-II; N-VII; N-VIII; N-IX; N-XI; N-XII; N-XIII) and consist predominantly of poorly sorted, subangular boulder- to sand-size material generally well cemented by caliche (Colton and McKay, 1966; Fernald and others, 1968) and may include fanglomerate (Fernald and others, 1968). This alluvial fan unit is commonly moderately dissected, deeply incised and forms smooth rounded ridges (Table 4). The degree of dissection and depth of incision is greater than that for the intermediate and younger fan units. Most ridges grade upslope nearly to the mountain crest and appear to be eroded remnants of extensive fan aprons which once bordered the mountain front (Fernald and others, 1968).

TABLE 4

Degree of Drainage Dissection and Incision

Degree of Drainage Dissection (No. of streams per nm)		Degree of Drainage Incision (Average in feet)	
Slight	0 - 5	Shallow	0 - 5
Moderate	6 - 10	Moderate	6 - 10
	11 - 15		11 - 15
High	16 - 20	Deep	16 - 20
	> 20		> 20

Intermediate fan levels ($A5_i$) are more extensive throughout NBGR forming approximately 30 percent (395 nm^2) of the alluvial fan deposits. They are present in all siting valleys of NBGR (Geology, N-I through N-XII) and consist predominantly of poorly to moderately sorted cobble- to silt-size material. Desert pavement (a thin residual or lag gravel resulting from removal of the finer particles by wind or water) is well developed on the broad flat interfluvial areas in some Valleys. Where present, the gravel- to cobble-size material has a thin coating of desert varnish (a mineralized patina of iron and manganese oxides) and may form a moderately resistant cap over the finer more easily eroded fan deposits. It forms moderately dissected and incised discontinuous lobate forms extending basinward from the mountain front. Caliche is present in diffuse form as a binding agent in near-surface exposures. Similar fan materials (caliche and alluvial fan deposits) at Yucca Flat are reportedly relatively easily excavated with a hand pick (Wilmarth and others, 1959).

The youngest alluvial fan units ($A5_y$) commonly coalesce to form broad gently sloping bajada surfaces in all Valley areas. These fans comprise nearly 55 percent (725 nm^2) of all exposed alluvial fans in NBGR. They are composed of well to poorly sorted sand and gravel-to boulder-size material grading downslope (basinward) into sand and fine gravel. These fans are typically moderately to slightly dissected and commonly exhibit a shallow depth of incision. In portions of NBGR, entrenchment by streams of this fan to depths of greater than ten feet has been reported (Fernald and others, 1968). In NTS these deposits have an estimated surface size distribution of 75 percent silt, 15 percent sand, five percent gravel, three percent cobbles and two percent boulders (Colton and McKay, 1966). The surface is characterized by poorly developed desert pavement with very little to no desert varnish.

2.2.2.3 Pediments and Pediment Deposits

Pediments as defined for this study are represented by planated rock shelves which may be overlain by a thin mantle (mostly less than ten feet) of sand- to boulder-size residual material (pediment deposits: A6). Pediment surfaces may exhibit varying degrees of dissection with incision generally greater than ten feet and commonly serve as surfaces of sediment transport. Fernald and others (1968) report pediment surfaces in Yucca Flat (Geology, N-VII) to have rounded ridges and deep drainage incision, with ridge crests as much as 80 feet above the present drainages. Pediments were identified in NBGR during a brief field reconnaissance and further delineated in subsequent analysis of aerial photographs. Where present, pediments are commonly highly dissected and extend up to four nm from the mountain front. They are well developed in the eastern portion of the siting area in Indian Spring, and Three Lakes Valleys and Yucca Flat (Geology, N-VII, N-VIII, N-XII and N-XIII) and occupy approximately four percent (83 nm^2) of the total area of the siting valleys. They were noted to be most commonly developed on extrusive volcanic bedrock in Stonewall Flat (Geology, N-I and N-II); and on sedimentary rock, including weakly cemented conglomerate and limestone, and volcanic rock in Kawich Valley (Geology, N-III; Rogers and others, 1967). In some areas, alluvial fan deposits have buried the basinward extension of the pediment. Pediments may exist in other Valleys but are difficult to delineate on aerial photographs due to the similarity of overlying pediment deposits to alluvial fan material, absence of subsurface data, and the lack of ground reconnaissance.

2.2.2.4 Playas

Playas are the lowest areas within active, enclosed basin drainage areas and are generally marked by nearly horizontal, vegetation-free surfaces of fine-grained sediments that may be periodically inundated (Cooke and Warren, 1973).

Playas ($A4_Q$), most often rimmed by mantled playas ($A4m_Q$), are present in the central portion of all the major Valleys within NBGR, except Pahute and Buckboard Mesas where drainage is southward to playa areas outside of NBGR.

The present limits of the playas are well known, topographically and geographically, encompassing approximately four percent (86 nm^2) of surficial basin-fill materials in NBGR. However, fluctuations in climatic and depositional conditions in the geologic past have produced intercalation of other basin-fill material and finer grained playa material, alternating vertically and horizontally in the subsurface (Appendix C). A near-surface example of this intertonguing can be seen in the basin area where thin (generally less than two feet) younger alluvial fan materials overlie the older playa deposits. This condition occurs in Cactus, Stonewall, and Gold Flats, and in Emigrant, Indian Spring and Three Lakes Valleys.

Playa deposits consisting almost entirely of clay and silt, are known to be at least 175 feet thick in Frenchman Playa (Johnson and Hibbard, 1957; Wilmarth and others, 1959) and may be at least that thick in the other Valleys because of similarities in geologic setting. Mantled playa deposits (A4m) consist almost entirely of sand and silt with some gravel averaging four feet thick near the central portions of the Valleys. Mantled deposits in northern NBGR consist of approximately 30 percent silt and 70 percent sand (Colton and Noble, 1967). Field observations confirm that this may be a reasonable size distribution for mantled playa deposits elsewhere in NBGR. Seismic velocities (p-wave) of playa and mantled playa deposits range from 2600 to 5000 feet per second (fps) at NTS (Wilmarth and others, 1959).

Fissures up to 1.2 nm long and 20 feet deep have been reported in Frenchman, Yucca and Groom playas in NBGR (Colton, 1965) and may be present in other playas in NBGR. These fissures are more than 20 feet deep and have been eroded to as wide as 15 feet. Colton (1965) has shown that these fissures may open up within a matter of days and are neither the result of tectonism (faulting or earthquakes) nor subsidence due to groundwater removal (earthcracks). They are the result of shrinkage of clay and clayey silt undergoing mass desiccation over a period of years (Colton, 1965). Colton (1965) reports no evidence for vertical displacement, but horizontal displacements of several feet may be possible. These fissures are, however, limited to the playa areas with no occurrences reported in other basin-fill deposits. They were found to serve as important sources for recharge of basin-fill aquifers (Colton, 1965).

2.2.2.5 Wind Blown Sand

Isolated wind blown sheet sand deposits (A3s) were observed on the east side (windward) of Indian Spring Valley during a brief aerial reconnaissance. Similar areas of sheet sand, denoted primarily by increased occurrences of blade grasses, were also noted in Three Lakes and Tikaboo Valleys. Active sheet sand deposits are present in Yucca Flat. Aerial photographic analysis and the brief aerial field reconnaissance further identified such deposits along the distal portions of playas in many of the Valleys. These deposits comprise less than one percent (two nm^2) of the total area of the siting valleys. Analysis of these deposits in NTS (Colton and McKay, 1966) show that their composition is approximately 30 percent silt and 70 percent sand. Where present, these deposits consist of a blanket of sand a few feet thick with a relatively small areal extent, generally less than one nm^2 in any single occurrence. Well-formed sand dunes or extensive sand dune fields were not noted in NBGR.

2.2.2.6 Stream Channel and Undifferentiated Floodplain Deposits

Stream channel (wash) deposits (Al_Q) totaling approximately seven percent (147nm^2) are present in all Valleys within NBGR. The dominant grain size of these deposits depends on the volume of water discharged by the stream, rates of flow, channel configuration, source material, and rock type and grain size of transported material. Wash deposits are generally less than five feet thick in most Valleys, however, wash deposits 75 feet thick have been reported in Civet Cat Canyon (Buckboard Mesa; Ekren and others, 1971). These deposits in NTS are generally poorly sorted, uncemented and have a general composition of 25 percent silt, 55 percent sand, ten percent gravel, five percent cobbles, and five percent boulders (Colton and Noble, 1967). In general no desert pavement, desert varnish, or soil profiles are developed.

Surfaces of individual washes or streams are characterized by narrow sinuous channels generally less than two feet deep, with deeper incision near the mountain front. These channels may have near vertical bank walls, but more commonly have sides sloping at approximately 45^{o}.

2.2.2.7 Terrace Deposits

Lake terrace deposits (A2) within NBGR are low beach ridges formed parallel to the present playa and represent ancient lake levels. These deposits occur in Stonewall Flat, Gold Flat, Kawich and Emigrant Valleys totaling approximately one percent (17 nm^2) of the total area available for siting. They consist of moderately to well sorted sand, silt and fine gravel and are commonly less than five to ten feet thick, forming low lying, sinuous, and symmetrically rounded ridges. Relief is commonly only five to 15 feet above the valley floor.

2.2.3 ROCK CONDITIONS

2.2.3.1 General

For this study, material considered as rock can be subdivided into three categories; these include bedrock, basement rock and volcanic flow rock (Appendix B). In general, each of these three rock types possess distinctive characteristics of importance for MX siting considerations, such as seismic response, blast effects, or the nature of basin-fill deposits derived from them.

The first, termed bedrock, includes competent volcanic and sedimentary rocks which commonly have seismic velocities (p-wave) of 10,000 to 20,500 fps. These are believed to represent the range of bedrock seismic velocities throughout NBGR (Hazelwood and others, 1963).

The second category of rock is basement rock, which consists of crystalline igneous (granitic) and metamorphic rock (primarily gneiss) with very high seismic velocities (generally greater than 18,000 fps) commonly underlying bedrock and basin-fill materials in the subsurface. Basement rocks, because of their basal stratigraphic position in the geologic record, generally infer great age (e.g., Precambrian through Cretaceous, Appendix B).

The third category, volcanic flow rock, is restricted to extrusive igneous rocks, generally basaltic in composition, which are commonly flat-lying, geologically young (i.e., Quaternary) and overlie or are interbedded with basin-fill material.

Table 5 presents a summary of compressional (p-wave) velocities for the various rock types which are exposed and present within the subsurface beneath NBGR. No data are available for volcanic flow rock.

TABLE 5

Summary of Sonic Velocities for Rock in NTS

Rock Type	Sonic Velocities (feet per second)
Volcanic bedrock	
Bedded tuff	7600
Zeolite tuff	7000 to 8800
Welded tuff	9000 to 12,000
Sedimentary bedrock	
Limestone and dolomite	12,000 to 20,000
Granitic basement rock	15,000 to 18,000

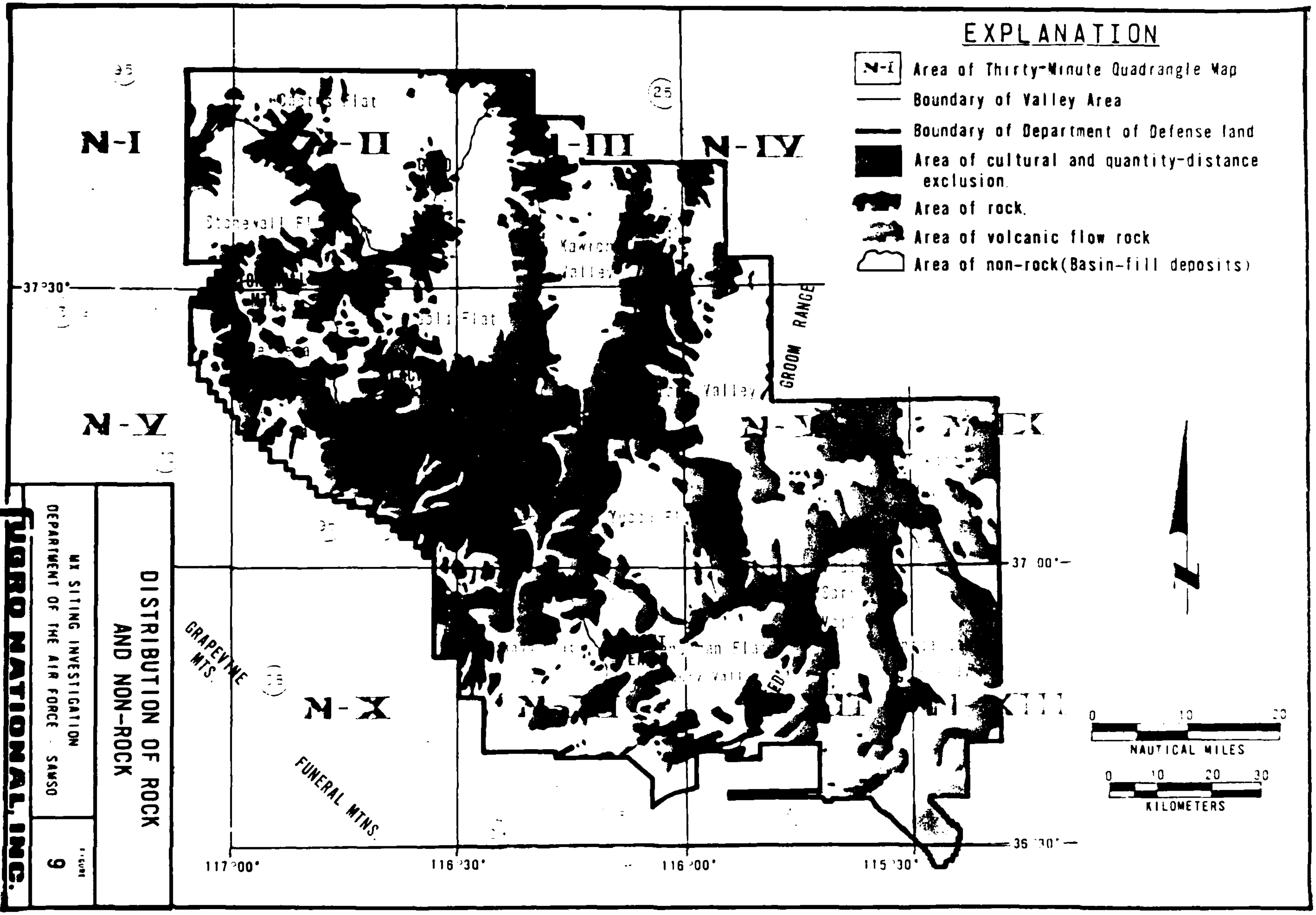
Source: Hazelwood, 1963

2.2.3.2 Exposed Bedrock, Basement Rock and Volcanic Flow Rock

Exposures of sedimentary bedrock units with total stratigraphic thickness exceeding 40,000 feet occur within the mountain areas of NBGR (Figure 9). They are more prevalent in the eastern and northern portions and consist predominantly (in order of decreasing abundance) of limestone, dolomite and quartzite and total approximately 30 percent of the total exposed rock in NBGR.

Tertiary to Quaternary volcanic bedrock with a total composite stratigraphic thickness exceeding 20,000 feet (Ekren and others, 1971), comprise approximately 65 percent of exposed rock in NBGR. They consist predominantly of ash-flow tuffs which are welded to various degrees, rhyolite, quartz-latite and basalt.

DATE: 30 JUNE 1975



DISTRIBUTION OF ROCK AND NON-ROCK

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 9

FUGRO NATIONAL, INC.

Basement rocks consist predominantly of quartz monzonite, granodiorite, granite, gneiss and schist and comprise less than four percent of the total exposed rock in NBGR (Table 2; Figure 9). They occur primarily in the southeastern portion of NBGR.

Volcanic flow rocks have limited areal extent in NBGR with occurrences in Buckboard Mesa, Kawich, Pahute Mesa and Frenchman Flat (Geology, N-III, N-IV, N-IX, N-X) comprising less than one percent of the total exposed rock. Where present they overlie older basin-fill deposits and have a rough surface expression. The presence of such young basalt flows on the surface suggest that similar flows may be present in the subsurface. Occurrences of volcanic flow rock within basin-fill deposits were confirmed in Kawich Valley (Ekren and others, 1971).

In NBGR, approximately 65 percent (2950 nm^2) of the total area consists of rock (Figure 9).

2.2.3.3 Subsurface Rock Conditions

Very limited subsurface data are available for areas outside the limits of NTS. Detailed subsurface studies utilizing drill-hole data and gravity surveys show that depth to rock in Yucca Flat is 2100 feet (Fernald and others, 1968), and as great as 4500 feet in both Gold and Cactus Flat (Ekren and others, 1971). Similar depth ranges may be expected elsewhere in NBGR where similar geologic conditions exist. Based on the presence of an aeromagnetic high in the central portion of Stonewall Flat (Geology, N-I and N-II), it has been suggested that rock must be within 500 feet of the surface (Anderson and others, 1965; Geologic Section Q'-Q''; Appendix I).

Combining regional gravity studies (Ekren and others, 1971; Miller and others, 1974) and sparse drill-hole data with the NTS data to define a typical valley, it was possible to estimate the 250-foot depth to rock contour for all Valleys except those in the Desert Wildlife Range where no gravity and only limited drill-hole data are available. More detailed delineation of depths to rock greater than 250 feet in NBGR outside of NTS was not possible due to the lack of deep drill-hole information in the central valley areas. Although detailed delineation of rock depth cannot be accomplished at this time, gravity and aeromagnetic data indicate that the central basin fill of all Valleys (except Stonewall Flat), is in excess of 1000 feet thick.

The stratigraphic sequence of rocks encountered in Yucca Flat and Frenchman Flat can be considered typical for most of NBGR because of similar geologic conditions. Beneath the unconsolidated to cemented basin-fill deposits the sequence is generally volcanic tuff (welded and non-welded) ranging in thickness from zero to greater than 300 feet; overlying very hard and fractured pre-Cenozoic limestone, dolomite, argillite and quartzite with buried volcanic flow rocks possibly present beneath the basin-fill deposits and sedimentary bedrock. Neither granitic nor metamorphic basement rocks have been encountered during any subsurface exploration, but are believed to lie at great depths beneath the sedimentary bedrock.

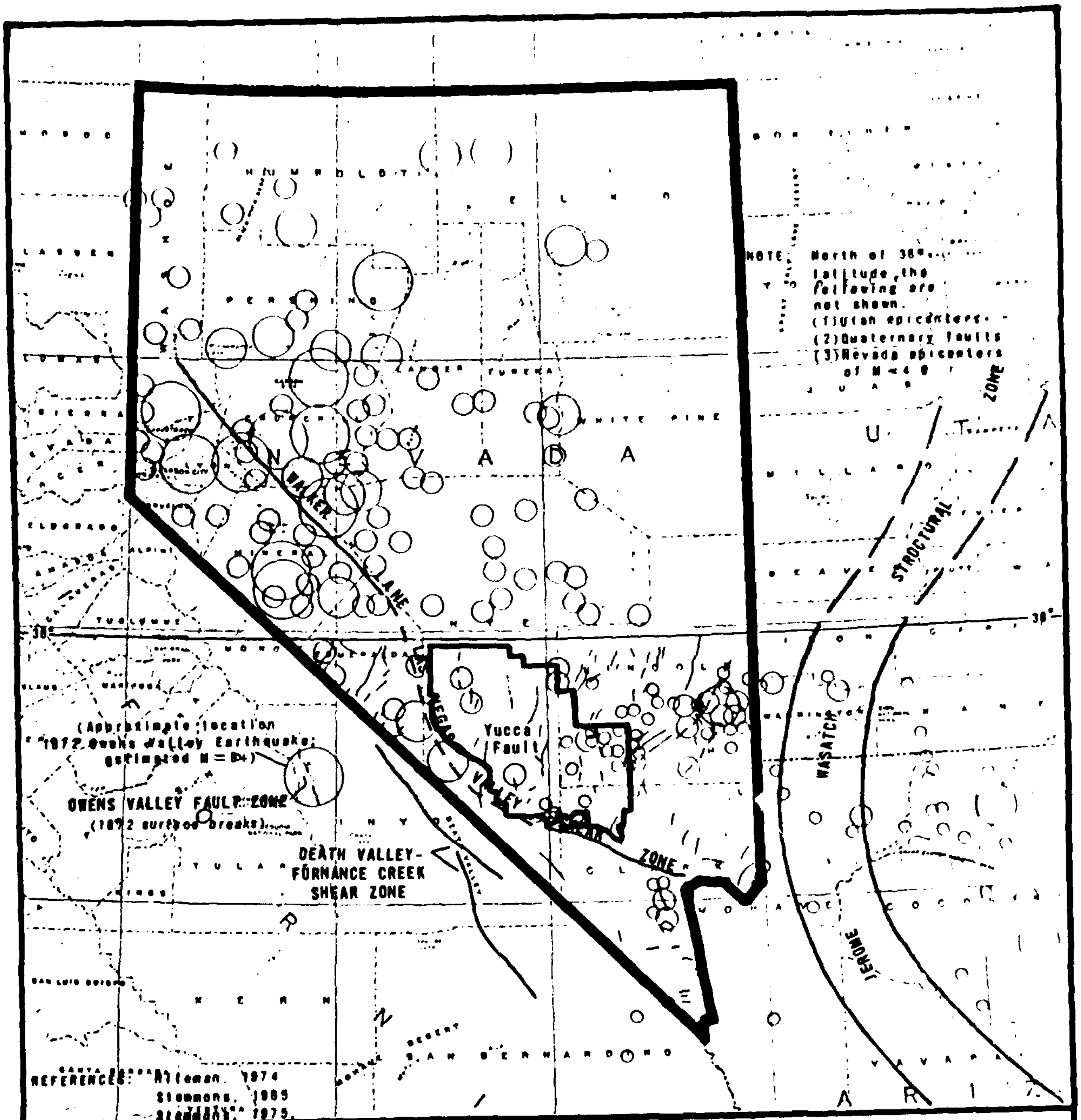
The thickness of the basin-fill deposits and presence of the volcanic tuff bedrock will be highly variable depending upon: 1) the pre-volcanic rock topography, 2) variation in deposition, deformation and erosion of the volcanic rocks, and 3) past volcanic rock erosion and tectonic activity (Williams and others, 1963). Further, the presence of interbedded flows and intrusive dikes within and cutting through basin-fill deposits, and similarities in the physical properties of the non-welded volcanic tuffs to the older basin-fill deposits makes determination of the presence or extent of volcanic bedrock using seismic and gravity data techniques difficult.

2.2.4 SEISMO-TECTONIC SETTING

2.2.4.1 Regional Setting

NBGR lies entirely within the Great Basin portion of the Basin and Range Structural Province. The Great Basin is characterized overall by relatively high levels of seismicity and historic incidences of surface faulting comparable to that found in California (Slemmons, 1967; Gumper and Scholz, 1971). Most of this activity, however, occurs in the northern and central portions of Nevada. The NBGR region is characterized by lower levels of seismicity and less extensive incidences of Quaternary and historic faulting (Figure 10).

Tectonic elements capable of generating earthquakes are known to occur within NBGR, but the majority of these elements occur some distance away from the range boundaries (Figure 10 and Table 6). Tectonic elements considered in this study include:



EXPLANATION

EARTHQUAKE EPICENTERS

M< 4.0 M=4.0-4.9 M=5.0-5.9 M > 6.0

(Epicenters induced by nuclear blasts not shown)

0 50 100 150
NAUTICAL MILES

0 100 200
KILOMETERS

Boundary of Department of Defense land.

Approximate trend of structural element.

Quaternary fault lines

SEISMO-TECTONIC FEATURES

MX SITING INVESTIGATION
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FIGURE
10

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DATE. 30 JUNE 1979

TABLE 6

SEISMO-TECTONIC ELEMENTS

Element and (Structural Province)	Closest Approach to NBGR and Direction	Total Length, Width and Trend	Age of Last (m.y.) Displacement	Age of Last (m.y.) Volcanism	Age of Last (m.y.) Seismicity	Remarks
Walker Lane Las Vegas Valley Shear Zone (Basin and Range)	Intersects Mercury Valley in southern part of NBGR	Approximately 275 nm long, 1 to 5 nm wide (N20°W to N70°W)	Historic on Walker Lane Segment. None in 10 m.y. on Las Vegas Valley segment.	Greater than 2 m.y.	Historic and Instrumental (most epicenters along northern segment of Walker Lane.	Portion of zone which is within and adjacent to NBGR has no Quaternary offsets & only low levels of seismicity.
Death Valley Furnace Creek Shear Zone (Basin and Range)	20 to 80 nm southwest	160 nm long 1 to 10 nm wide (N40°W)	Greater than 2 ~~m.y.~~	None	No historic or instrumental	Total strike-slip offset of approximately 40 nm in Quaternary
Jerome-Wasatch Structural Zone (Basin and Range)	75 to 135 nm east	Over 200 nm long; 25 to 50 nm wide (N30°W to N30°E)	10 m.y.	None	Historic and Instrumental	Zone includes several Quaternary fault traces. Levels of seismicity in Utah segment M=5.6 or larger
Owens Valley Fault (Basin and Range)	60 to 120 nm west	40 nm long 1 to 5 nm wide (N20°W)	1872	None	Historic	1872 Earthquake M = 8+
Northern Nevada Seismic Zone (Basin and Range)	75 to 132 nm northwest depending on location within NBGR	350 nm long 50 to 100 nm wide (N10°E)	Historic or several associated faults.	None	Historic and Instrumental	Historic fault breaks. Several recorded earthquakes M=6.0 to 7.3 (Table 7)

1) the Walker Lane-Las Vegas Valley shear zone which has been projected through the southernmost limits of NBGR (Hinrichs, 1968); 2) the Yucca fault and smaller unnamed faults within and immediately adjacent to NBGR; 3) the Death Valley-Furnace Creek shear zone approximately 20 nm west of NBGR (Stewart, 1966); 4) the Owens Valley fault zone, 60 nm west (Greensfelder, 1973); 5) the Jerome-Wasatch structural zone, 75 nm east; and 6) the northern Nevada seismic zone containing numerous Quaternary faults and exhibiting high levels of seismicity, 75 nm north (Slemmons, 1965). These tectonic elements and pertinent data for each are included in Table 6. The following paragraphs discuss those tectonic elements within or immediately adjacent to NBGR that are important features for estimating seismic risk.

2.2.4.2 Structural Geology

The Walker Lane-Las Vegas Valley shear zone is the largest and most prominent tectonic feature within NBGR. The portion of the Walker Lane-Las Vegas Valley shear zone projected through NBGR has no known evidence of Holocene surface faulting. The Las Vegas Valley portion of this zone has been mapped through Mercury Valley in NTS (Longwell, 1960; Burchfiel, 1965; Stewart, 1966) where it is buried beneath at least 1000 feet of unfaulted basin-fill deposits (Hinrichs, 1968). Winograd and others (1971) suggest that strike-slip movement north of Mercury Valley has probably been taken up by large scale folding of the sedimentary rocks in the Specter Range. Detailed studies show that most of the strike-slip movement on the Las Vegas Valley shear zone probably occurred during the period from ten to 17 million years ago (Fleck, 1970a) with no evidence for younger movement (Liggett and Childs, 1974).

The Walker Lane portion of this zone has been postulated by Shawe (1965) to trend through the central portion of NBGR and to correlate with faults having historic surface rupture in northern Nevada (Figure 10) approximately 75 nm northwest of NBGR. Conversely, Gianella and Callaghan (1934), Nielsen (1965), and Albers (1966) show this portion to stop just west and south of NBGR boundaries. The Walker Lane is a vague and generally concealed zone separating ranges whose trend is mostly northward (northeast of the shear zone) from ranges whose dominant trend is northwestward (southwest of the zone; Figure 10) (Hamilton and Meyers, 1966).

2.2.4.2.1 Faults and Fault Scarps

The most prominent fault in NBGR that displaces Quaternary basin-fill deposits is the 24 nm long Yucca fault which roughly bisects Yucca Flat at NTS (Figure 10). This zone of faulting (Geology, N-VII) is over 3000 feet wide and is characterized by discontinuous fault breaks, numerous lineations, fissures aligned en echelon to the main trace of the fault, and fault scarps with vertical displacement of up to 75 feet in Quaternary deposits. The northern portion of the fault appears to have the largest scarps with unconsolidated basin-fill deposits faulted against compact fanglomerates (Johnson and Hibbard, 1957). Its northern extent is not known but may terminate in bedrock. The southern extension of the fault through Yucca Pass into Frenchman

Flat has been postulated (Johnson and Hibbard, 1957), but not confirmed. Vertical movement of up to three feet along this fault has occurred as of 1969 as a result of underground nuclear explosions (McKeown and Dickey, 1969). Detailed studies of past movements along the Yucca fault as well as analysis of similar faults in Pahute Mesa indicate that the cause of vertical movements may be due to the release of accumulated tectonic strain triggered by underground nuclear explosion (McKeown and Dickey, 1969). Because the fault has offset alluvial materials (Johnson and Hibbard, 1957) and has evidence of accumulating tectonic strain (Snyder, 1973; McKeown and Dickey, 1968) it is considered a capable fault (Appendix D). Conservatively the definition of the U. S. Nuclear Regulatory Commission (formerly the U. S. Atomic Energy Commission) for capable faults was utilized due to the presence of nuclear components within the MX system and the potential for damage to the system by seismic activity or ground rupture.

Normal faults displacing alluvial fan deposits occur along mountain fronts in NBGR (Figure 10) with displacements of up to 1000 feet (Johnson and Hibbard, 1957; Winograd and others, 1971; Ekren and others, 1971). Although no evidence was collected from the literature, or during the brief field examination to substantiate or dispute Quaternary activity along these features, strong linearity and alignment of geomorphic landforms along several of the features (determined from aerial photographic analysis) suggest the age of last displacement may be at least Quaternary. Several investigators have postulated that very recent faulting may be occurring in NTS displacing playa deposits in Frenchman Flat, Yucca Flat and Emigrant Valley (Johnson and Hibbard, 1957; Colton, 1963). Recent studies by Colton (1965) and Winograd and others (1971) show that these features are actually large-scale desiccation features (non-tectonic) which have no associated vertical movement (Section 2.2.2.4).

2.2.4.2.2 Volcanic Activity

Extensive exposures of volcanic rocks are present within NBGR. Most of the volcanic rocks are Middle Tertiary in age with some activity continuing to approximately ten million years ago (Fleck, 1970b). Absolute age dates are not available for the several Quaternary volcanic flows within NBGR.

2.2.4.3 Seismicity

Judgement of the level of seismicity of a region is dependent mainly upon the size of earthquakes that have occurred, their frequency of occurrence, and the resulting intensities of ground shaking. It is well known that various regions of the United States have relatively high levels of seismicity (e.g., coastal California) and others have relatively lower levels as shown in Figure 11.

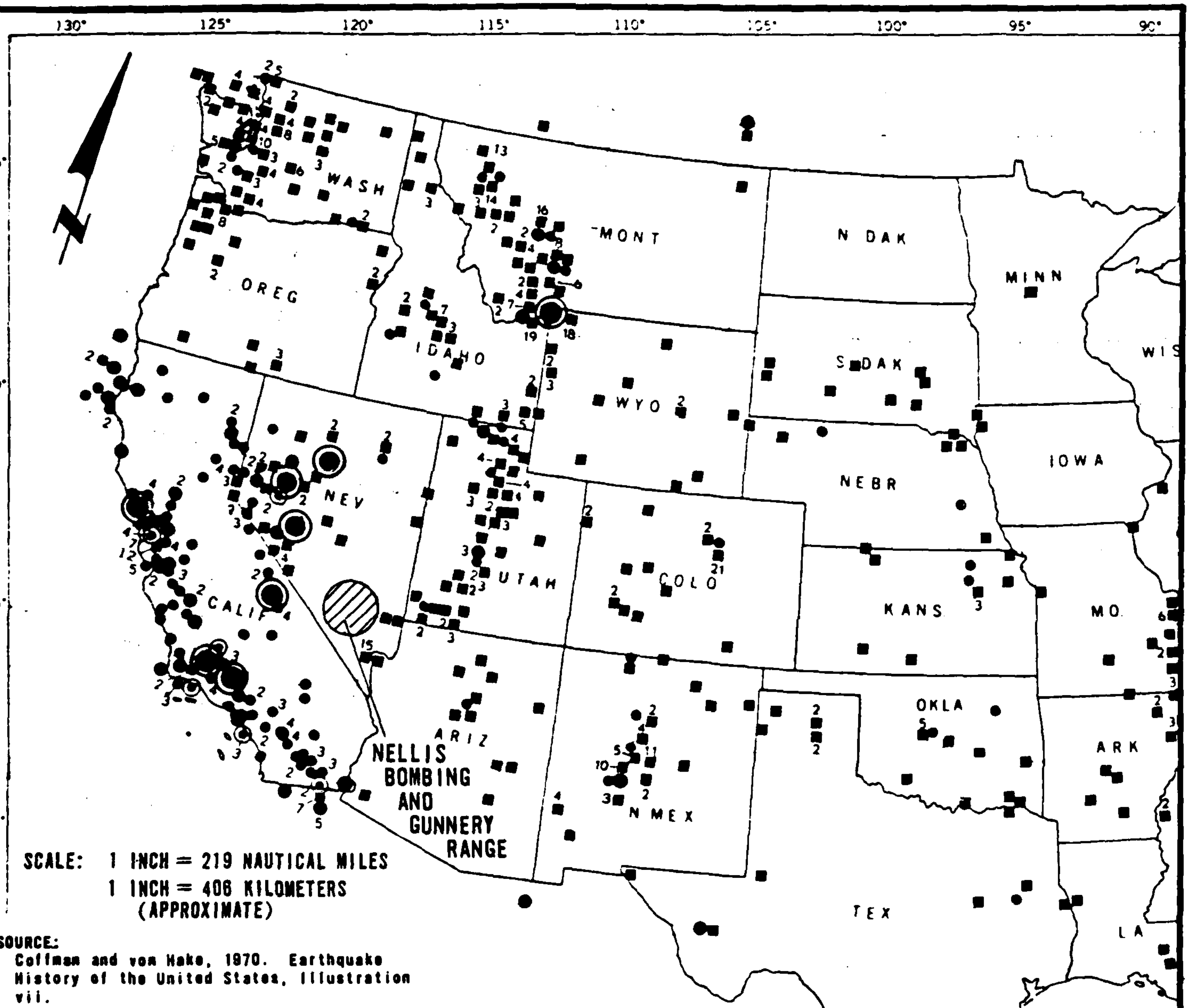
Six seismo-tectonic elements, with associated seismicity from natural causes, may significantly affect NBGR (Table 7). These are the Walker Lane-Las Vegas Valley shear zone, Death Valley-

DATE: 30 JUNE 1975

EXPLANATION*

- ■ INTENSITY V-VII (except California)
- • INTENSITY VII-VIII
- ● INTENSITY VIII-IX
- ◎ INTENSITY IX-X
- ◉ INTENSITY X-XIII

*Earthquakes through 1970 (Modified Mercalli Intensity V and above)



SCALE: 1 INCH = 219 NAUTICAL MILES
1 INCH = 406 KILOMETERS
(APPROXIMATE)

SOURCE:
Coffman and von Hake, 1970. Earthquake History of the United States, Illustration vii.

SEISMIC INTENSITIES IN WESTERN UNITED STATES

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 11

FUGRO NATIONAL, INC.

Furnace Creek fault zone, Jerome-Wasatch structural zone, Owens Valley fault zone, Northern Nevada seismic zone, the Yucca fault, and numerous unnamed faults.

Two important zones of seismicity which may affect NBGR are the distant Owens Valley fault zone and the nearby Death Valley-Furnace Creek fault zone. Levels of seismicity associated with these and other zones are shown in Table 7.

No historic or recorded earthquakes are known to have occurred on the Las Vegas Valley segment of the Walker Lane-Las Vegas Valley shear zone. Liggett and Childs (1974) present evidence based on associated volcanic activity that this zone has not been tectonically active for at least ten million years.

National Earthquake Information Service data (Hileman, 1974) for the period 1927-1973 indicates a maximum recorded event of 6.3 within NBGR. This event represents the Benham underground nuclear test conducted at NTS on 19 December, 1968. Most of the remaining events (M=2.0 to 5.0) within NBGR represent surface and underground nuclear tests. Natural seismicity within NBGR is relatively low (Figure 10).

Williams and others (1973) and Hamilton and others (1971) state that there have been no indications of increased natural seismic activity following large underground nuclear blasts other than in the immediate area of the source. Studies of microearthquake activity following the Benham event (Molnar, 1969) show that the current activity in the NTS portion of NBGR

TABLE 7

LEVELS OF SEISMICITY NBGR

Name of Zone or Feature	Closest Approach to Site (nm)	Earthquakes: Largest Historic (est.)	Earthquakes: Largest Instrumental	Earthquakes: Maximum Credible	Peak Acceleration[1] Values in g: Maximum Credible	Peak Acceleration[1] Values in g: Largest Instrumental	Recurrence (yrs) Interval/Magnitude	Remarks
Walker Lane-Las Vegas Valley Shear Zone	0		7.2			0.5		Most earthquakes on zone occur along northern segment. No earthquakes larger than M=5 known for segment within or adjacent to NBGR.
Death Valley-Furnace Creek Fault Zone	20			8.25[2]	0.32			
Jerome-Wasatch Structural Zone	75		7.1	7.0-8.0[3]	0.05			
Owens Valley Fault	60	8.25		8.25[2]	0.1			
Northern Nevada Seismic Zone	75	7.8	7.3		0.1			
Yucca fault and numerous unnamed faults	0		5.0	6.5[5]	0.7+	0.2		
Underground Nuclear explosions	0		6.3			.5-1.0+[4]		

1. Peak acceleration values derived from Schnabel and Seed, 1973, using closest approach of zone to siting area
2. Greensfelder, 1973
3. Algermissen, 1969
4. Based on observed levels of ground motion from comparable earthquakes and opinion of several investigators (see text)
5. Bonilla, 1967

is lower than that of western Nevada and most other tectonically active regions where microearthquake studies have been made.

The distributions of aftershock epicenters from nuclear explosions at Pahute Mesa suggest that they are related to the buried ring-fracture zone of calderas rather than to the conspicuous Basin and Range-type normal faults exposed at the surface (McKoewn, 1975).

Little is known about pre-instrumental seismicity of Nevada due to sparse settlement and lack of records pertaining to earthquake effects. The largest known historic earthquake to affect the NBGR area was the 1872 Owens Valley earthquake, M=8+ (Figure 10). Table 8 lists pre-instrumental, and recorded earthquakes and their distances from NBGR. Modified Mercalli Intensities (MMI; Appendix D) are the strongest reported and occurred in the area listed. Richter magnitudes and distances from NBGR are estimated for the pre-instrumental events.

2.2.4.4 Seismic Risk

The probability of the occurrence of potentially damaging earthquakes is of major concern in evaluating the seismic risk of a region. Factors that influence the determination of seismic risk are: 1) the size and location of capable faults, 2) the level of seismicity of the region, in particular the seismicity associated with capable faults; and 3) levels and intensities of earthquake-induced vibratory ground motion caused by earthquakes in regions of concern.

TABLE 8

Historical and Instrumental Earthquakes

	Date	Epicentral Area (Approximate)	Magnitude/Maximum Intensity (MM)	Distance from NBGR (Approximate)
HISTORIC (PRE-1927)	1852	Pyramid Lake	?/X	165 nm
	Mar. 15, 1860	Virginia City	VII	150 nm
	May 29, 1868	Virginia City	6 (est.)/VII	150 nm
	Mar. 26, 1872	Owens Valley	8+ (est.)/VIII(?)	60 nm
	1894	Virginia City	?/VIII	150 nm
	Nov. 12, 1872	Austin	6 (est.)	95 nm
	1902	Wonder	Unknown	110 nm
	Feb. 18, 1914	Truckee Meadow	6/VII	165 nm
	Apr. 24, 1914	Reno	6.4/VIII	165 nm
	Oct. 2, 1915	Pleasant Valley	7.8/X	160 nm
	Nov. 10, 1916	Death Valley	6.1/V+	25 nm
INSTRUMENTAL	Dec. 20, 1932	Cedar Mountain	7.2/X	75 nm
	Jan. 25, 1933	Yerington	6.0/VII	120 nm
	Jan. 30, 1934	Excelsior Mtns.	6.3/VIII	65 nm
	Dec. 29, 1948	Verdi	6.0/VII	165 nm
	Jul. 6, 1954	Rainbow Mountain	6.8/IX	130 nm
	Dec. 16, 1954	Fairview Peak	7.3/X	95 nm
	Dec. 16, 1954	Dixie Valley	6.9/X	115 nm
	Jun. 23, 1959	Schurz	6.3/VI	100 nm

Sources: Townley and Allen, 1939; Coffman and von Hake, 1973; Greensfelder, 1973

Low natural seismicity (infrequent occurrences of earthquakes greater than M=4.0) typifies NGBR as compared with areas of higher seismicity to the north, east and west. Studies predicting the susceptibility of an area to relative levels of natural seismic intensity show that NBGR has a maximum expected seismic intensity on the Modified Mercalli Intensity Scale of VI to VIII (Richter, 1959; Algermissen, 1969). This corresponds to the level postulated for the Owens Valley earthquake of 1872.

Intensity of shaking greater than MMI = VIII can be expected locally from underground nuclear blasts. Analysis of all instrumentally recorded seismic events, natural and induced, occurring within NBGR show that the source for the highest intensity of shaking and peak acceleration (Table 7) was the Benham underground test conducted at NTS, which was equivalent to an M = 6.3 natural earthquake and corresponded approximately to MMI = VIII or greater (Appendix D).

2.2.4.4.1 Levels of Vibratory Ground Motion

Maximum credible earthquakes are the largest earthquakes that faults or fault zones are thought capable of producing. Associated maximum credible levels of vibratory ground motion (Table 7) that result have been observed very near to the fault break during major past earthquakes. Examples are those experienced in Lone Pine during the 1872 Owens Valley earthquake (M = 8+), in the Pleasant Valley area in 1915 (M = 7.8), and in the Dixie Valley area in 1954 (M = 6.9).

However, because of the lack of accelerograms stationed near the fault breaks for these events, only estimates of the quantitative levels of vibratory ground motion can be made. The estimates of different investigators show wide discrepancies; it has been estimated that peaks of acceleration ranging from one-half to more than one g (g being the acceleration due to gravity) can be expected.

Maximum credible earthquakes can be estimated for the Death Valley shear zone, the Owens Valley fault and the Jerome-Wasatch zone. Because of their relatively close proximity to NBGR, the Owens Valley fault and the Death Valley shear zone should be considered as sources for generating high levels of vibratory ground motion. The Death Valley-Furnace Creek fault zone is thought capable of generating an 8.25 earthquake (Greensfelder, 1973). Should such an event occur at the closest approach of this zone to NBGR, peak accelerations no greater than 0.32 g can be expected in NBGR (Housner, 1965; Schnabel and Seed, 1973).

The maximum credible earthquake for the Owens Valley fault system is estimated to be magnitude 8.25 (equaling the estimated magnitude of the 1872 event; Greensfelder, 1973). Should such an earthquake occur at the closest approach to NBGR (which is nearly coincident with the epicentral location of the 1872 Owens Valley earthquake), peak accelerations ranging from 0.2 g can be expected (Schnabel and Seed, 1972; Donovan, 1973).

High potential levels of vibratory motion are possible from faults within NBGR as well as from underground nuclear explosions conducted at NTS. Based on length of rupture/magnitude relationships (Bonilla, 1967), the Yucca fault is believed capable of generating a M = 6.5 earthquake. Such an earthquake could produce peak accelerations ranging from 0.4 g to greater than 0.7 g very near or directly above the fault break (Housner, 1965; Donovan, 1973; Schnabel and Seed, 1973; Earthquake Engineering Research Laboratory, California Institute of Technology). Faults of similar length to the Yucca fault are present in the Valleys north and west of Yucca Flat and may be equally as capable of producing large earthquakes with resulting high peak accelerations. Lack of specific geologic and seismic data on these faults prohibits estimation as to their potential seismic risk.

Periodic potentially high levels of ground shaking from underground nuclear explosions can be expected in NBGR. The largest blast recorded was equivalent to an M = 6.3 natural earthquake. Resulting peak accelerations could range from 0.1 g (20 nm from the blast point) to greater than 0.6 g at ground zero (Schnabel and Seed, 1972).

Studies of natural seismicity by Algermissen and Perkins of the U.S.G.S. indicated that the area including NBGR can expect peak accelerations no greater than 0.1 to 0.2 g with a return period of about 500 years (D. Perkins, oral communication, 1975).

2.2.4.4.2 <u>Teleseismic and Distant Earthquake Events</u>
Earthquakes of magnitude 5 to 7 at distances generally exceeding 100 nm and large magnitude (8+) teleseismic events at distances greater than 540 nm (Richter, 1958) may affect the siting area. Of primary concern are the long period waves generated by these distant earthquakes. Resonance may produce oscillation of pools of water (seiches) or damage to long period structures. The most likely source for large magnitude distant earthquakes in the seimically active portions of the western United States (Figure 11) are the northern Nevada seismic zone 100 nm northwest, the San Andreas fault 150 nm to the southwest, the Jerome-Wasatch zone 100 nm to the east, and Aleutian and mid-America oceanic trenches over 1000 nm southwest to northwest.

2.2.4.4.3 <u>Potential Surface Displacement</u>
Surface displacement is most likely to occur along those faults which have displaced Quaternary deposits. Vertical displacement from a maximum credible event on the Yucca fault would probably be about three feet (Bonilla, 1967) with length of rupture between 20 and 50 percent of the total fault length (Albee and Smith, 1966). Other faults (Figure 10) within NBGR may displace Quaternary materials and may have the potential for similar magnitude surface displacements.

2.2.4.4.4 <u>Tectonic Subsidence</u>
Subsidence due to caldera collapse has occurred in the past

in Pahute Mesa (Cornwall, 1972); however, insufficient data are available to determine if active subsidence is occurring. No direct evidence of tectonic subsidence, such as fissures or cracks in basin fill, was noted in the literature, during the brief field reconnaissance or on aerial photographs. Fissures associated with playas are discussed in Section 2.2.2.4.

2.3 SOILS ENGINEERING

2.3.1 GENERAL

The soils engineering data and design evaluation information presented here are derived primarily from aerial photographic interpretation and limited field observations. Geologic units or combinations of similar geologic units identified within NBGR (Geology overlays) are used to roughly classify and define the limits of the various soil map units on the Soils Engineering Overlays (N-I through N-XIII). Specific data on the engineering properties of the soils within NBGR are sparse, but where available the data were incorporated into the classification of the map units. Major sources of data, in addition to aerial photographic interpretation and field observations, included geologic maps (Colton and McKay, 1966; Colton and Noble, 1967; Fernald, Corchary and Williams, 1968; McKay and Sargent, 1970) which related engineering properties to surficial basin-fill units. The data available did not allow an accurate determination of the depths to which the soil classifications are applicable. Therefore, data presented should be considered applicable to the near-surface soils only (to a depth of five feet).

The soil map units (Soils Engineering overlays) may consist of more than one soil type as defined by the Unified Soil Classification System (USCS; Appendix E). Soil classifications assigned to a map unit represent the predominant soil type, but not necessarily the only soil type within that map unit. Soils Engineering Data Summary Sheets (Section 3.0) present both specific engineering and design evaluations using the available data and engineering judgement. Design information should be considered general rather than specific for any map unit and used for concept consideration, but not for specific design.

Data from borings or test pits are presented in Appendix F. The limited amount of subsurface data did not allow for extrapolation of soil properties below a depth of five feet.

NBGR can be divided into two main soil categories for a regional engineering discussion: 1) coarse-grained basin-fill deposits (including alluvial fan, bajada, pediment, lake terrace, stream channel, flood-plain, sheet sand and undifferentiated deposits) which extend from the base of the mountains to the near-level areas of the Valleys; and 2) fine-grained basin-fill deposits (including playas and mantled playas). All major soil types defined by the Unified Soil Classification System are present in NBGR.

Coarse-grained basin-fill deposits generally consist of gravel-, sand- and silt-size material deposited by relatively high energy surface water flow. Sheet sands consist of uniform medium to fine wind-blown sand and are also considered in the discussion to be part of the coarse-grained basin fill. Fine-grained basin-fill deposits consist of clay- and silt-size material, laid down in a low energy environment.

2.3.1.1 Coarse-Grained Basin Fill

Coarse-grained basin fill encompasses 90 percent of the siting valley area in NBGR. Of this total, 78 percent is alluvial fan deposits, 16 percent stream channel, flood-plain and undifferentiated deposits, five percent pediment deposits and less than one percent sheet sand deposits. In general, the coarse-grained basin-fill deposits consist of 40 percent gravel, cobbles and boulders, 40 percent sand, 15 percent silt, and five percent clay. These percentages will vary depending upon nearness to mountains and/or stream channels, relative age of the geomorphic surface, process by which the material was deposited, and the parent material. The small sheet sand areas are a uniform medium to fine-grained sand.

The coarse-grained basin-fill areas are generally considered the most suitable for siting because of the granular nature of the soils and the absence of near-surface groundwater and surface water. The portions of these areas which contain possible design problems are the pediments where rock is encountered within ten feet of the ground surface, areas where caliche is present, and stream channels and flood plains where a high flooding potential exists.

2.3.1.2 Fine-Grained Basin Fill

Playa and mantled playa areas comprise approximately ten percent of the siting valley area. The soils in these areas are heterogeneous mixtures of clay, silt, and sand with clay and silt-size material (finer than the #200 sieve) totaling 90 percent. Mantled playas are designated as playas overlain by a thin (five feet or less) cover of coarse-grained basin fill. While these soils have a well defined surface extent, they may have a greater (presently unknown) areal extent with increasing depth (Section 2.2.2.4).

Fine-grained basin-fill soils are considered to have more design problems than coarse-grained basin fill. These problems include strength dependence upon moisture content and poor drainage.

2.3.2 ROAD CONSTRUCTION

Specific design data for road construction, including California Bearing Ratio values (CBR; American Society for Testing and Materials Designation, D1883), AASHO classifications (Appendix E), and shrink-swell potential are present in the Data Summary Sheets, where available. Since little or no specific data are available for actual design values, the following discussion provides some general information on road design in the two major soil categories based on available soil data and engineering judgement. Trafficability of unimproved terrain is considered in the Terrain Analysis (Section 2.6).

2.3.2.1 Coarse-Grained Basin Fill

Within the coarse-grained basin-fill areas, it is estimated that a CBR value of 10 to 20 is reasonable for the in-situ materials and a CBR value greater than 20 and on the order of 30 is obtained by scarifying and recompacting the surface soils.

Flash flooding (Section 2.4 and Section 2.5) may occur in gullies and intermittent drainages, requiring either periodic road repairs or design of costly road structures across these areas. Maintenance to clear debris deposited by runoff should also be anticipated.

The in-situ CBR value of the sheet sands will be low due to the loose nature of the soil. However, it is estimated that a CBR value on the order of 20 will be obtainable by a moderate amount of scarification and recompaction. Wind erosion and shifting soil occur in these areas and to a lesser extent (i.e., limited amount of movement, fine material only) throughout NBGR. The movement of soil by wind action is not considered to be a major problem, however, some maintenance of road surfaces may be required periodically. Increasing the elevation of the road above the terrain elevation may be considered to reduce the problem of sand build-up on the surface.

2.3.2.2 Fine-Grained Basin Fill

The fine-grained basin fill consists predominantly of silt and clay which have strengths dependent upon moisture content; wet CBR values of less than 15 are estimated for both in-situ and recompacted material. Playa areas will require base course or soil improvement to obtain a normally adequate subgrade strength. A high to extreme flooding potential (Section 2.4.1) also exists within these areaas.

A loss of strength of the playa soils is associated with the addition of moisture and results in consolidation and/or expansion of the near surface soils with the potential for resultant damage to pavement surfaces. Mantled playas will exhibit surface properties similar to alluvial fan areas, however, since they are underlain by playa deposits at a shallow depth, properties and performances will be variable.

2.3.3 EXCAVATIONS

No test data are available upon which to base design evaluations for excavations. Considerations for making excavations involve the following factors:

1. stability of excavation side slopes,
2. presence of free ground water,
3. presence of caliche,
4. presence of unrippable rock (Section 2.2.3), and
5. presence of cobble- and boulder-size material.

Based upon the engineering and geologic classifications of the surficial soil and engineering judgement, the ease of excavation for each soil map unit has been evaluated and is presented in the Data Summary Sheets. The following discussion provides some general information on excavations in the two major soil categories.

2.3.3.1 Coarse-Grained Basin Fill

Most soils in the coarse-grained basin-fill areas can be excavated with conventional equipment at a slope angle of 45 to 60 degrees with the horizontal. In the sheet sand areas flatter side slopes will be required. Caliche and cobbles or boulders are widespread and occur randomly throughout the older alluvial fan areas (Section 2.2.2.1.1) and, where known to be present, it has been noted on the Data Summary Sheets. Blasting of caliche has been required in similar coarse-grained basin-fill areas.

Near-surface rock (less than 25 feet in depth) may occur along the mountain flanks; depth to rock in pediment areas is less than ten feet. In addition, subsurface volcanic flows may be encountered throughout NBGR. Map units with known near-surface rock are indicated on the Data Summary Sheets. With the exception of generalized velocity measurements (Table 3; Section 2.2.2.1.2), little specific information is available on which to base an evaluation of the methods needed to excavate near-surface rock.

The static groundwater table is from 300 feet to greater than 1,000 feet below the ground surface in the coarse-grained basin-fill areas (Section 2.4.2.3) and should not create dewatering problems in excavations. Perched water may occur in NBGR (Section 2.4.2.4), but it is not known to what extent it may be encountered in excavations.

2.3.3.2 Fine-Grained Basin Fill

Due to the high clay content of the playa and mantled playa deposits, excavations may be made near vertical. In addition, caliche and cobbles generally are not present, but may occur randomly. Rock generally is greater than 250 feet below the ground surface in the playa and mantled playa areas, but subsurface volcanic flows may be present (Section 2.2.3.3).

The groundwater table is generally 100 feet below the ground surface in these areas (Section 2.4.2.3). Perched water may be encountered and could influence excavation in these areas. Playas and mantled playas are more susceptible to flooding than most other areas of NBGR and special design considerations should be made for this condition. The areas where flooding frequently occurs are noted on the Data Summary Sheets and Hydrology overlays.

2.3.4 FOUNDATIONS AND STRUCTURAL CONSIDERATIONS

2.3.4.1 General

Depending upon the MX siting concept selected, foundation design may or may not be required. If required, important factors to be considered in foundation design include:

1. bearing capacities,
2. settlement and swell potential, and
3. the corrosivity of the soil.

No specific test data are available on which to base recommendations for foundation design, but each map unit is evaluated qualitatively using engineering judgement for relative foundation analysis. The model considered for foundation evaluation was a partially buried reinforced concrete structure with a level floor slab at approximately 24 feet below the existing ground surface (TRW Systems Group, 1975). Although the soil descriptions and properties presented in the Data Summary Sheets are only considered to be applicable to a depth of five feet, the soil properties for the foundation analysis were assumed to extend to the depth of influence of the foundation. The relative shear strength, compressibility, and expansiveness of each soil map unit were considered and are presented in the Data Summary Sheets. General information on foundation design in the two major soil categories using correlation of available soil data and engineering judgement is presented in the following sections.

2.3.4.2 Coarse-Grained Basin Fill

Coarse-grained basin-fill areas are considered satisfactory for the support of near-surface foundations, with moderate bearing values on the order of 2 to 6 kips per square foot considered feasible. The shrink-swell potential of these soils is generally low and provisions in design to account for this condition should be minimal. Alluvial fans are considered to have a moderate compressibility and settlements should be within normal design tolerances. An exception to this may be in areas of recent alluvial deposits, which are porous and potentially collapsible when saturated. The collapsible soil condition has been documented in several arid region studies; however, such collapsible soil areas could not be differentiated within NBGR based upon available information.

2.3.4.3 Fine-Grained Basin Fill

Estimated allowable bearing capacities in the playa and mantled playa areas will be 1 to 3 kips per square foot. Shrink-swell potential will vary from low to high and special design considerations will have to be made for near-surface foundations. Differential settlement is likely due to the variation in the compressibility of the soil in these areas. This will become less of a problem as foundation depths increase.

2.3.4.4 Other Considerations

Other structural design considerations such as lateral pressures on walls and footings, slab support, liquefaction, and soil structure interaction during ground shaking due to earthquakes or blast forces have not been presented. Although some gross estimates could be made regarding these design criteria, the information available in the literature is too sparse for this detailed type of analysis.

2.3.5 SOURCES OF CONSTRUCTION MATERIAL AND SOIL STABILIZATION

2.3.5.1 General

Potential uses of construction material include:

1. sand and fill material,
2. aggregate for base course and concrete,
3. material for rip rap, and
4. material for low permeability pond liners.

Sources of construction materials are located on the Soils Engineering overlays and described in Appendix F (Davis, 1959). Locations of gravel or sandpits shown on U. S. Geological Survey topographic maps are also presented, although no data, other than location, are available. Potential uses of these source materials are listed on the Data Summary Sheets. Available data were used in evaluating each soil map unit for use as a construction or stabilization material. Potential rock and aggregate quarries may be present within the mountain areas.

2.3.5.2 Sand and Fill Material

The suitability of each soil map unit as a source of sand and/or fill material was evaluated, with nonexpansive coarse-grained material containing few fines, considered desirable. In general, the coarse-grained alluvial fan areas (Section 2.2.2.2) and stream channels (Section 2.2.2.6) provide the best source of sand and fill material. Some materials possess desirable properties for concrete sand and/or fill, but are given a poor rating in the Data Summary Sheets because of limited quantity of easily obtainable material. Near-surface rock and near-surface groundwater are considered undesirable properties when identifying easily obtainable sand and fill materials.

2.3.5.3 Aggregate for Base Course, Concrete and Rip Rap

Well graded gravels with some sand, and little or no fines and cobbles, are considered the most desirable source of concrete aggregate and/or road base course. Stream and wash channels (primarily map unit 41) are good sources of aggregate.

Depending upon the intended use of the material, rock may be blasted and crushed to obtain a specific sized aggregate or rip rap; however, the economic considerations of blasting and crushing must be considered. Caliche has been blasted and crushed to obtain road base course (New Mexico State Highway Department, 1972). The quantity, quality and geographic distribution of caliche is unknown. Undesirable conditions for excavating sources of aggregate include near-surface unrippable rock and groundwater, both of which limit the amount of easily obtainable material. In addition, chemical composition data were not available in order to determine potential deleterious effects to concrete and steel.

2.3.5.4 Material for Impermeable Liners

Desirable properties of soil for impermeable liners are low permeability and adequate shear strength to remain stable when saturated. The permeabilities reported in the literature vary for clayey soils by a factor of 100 due to the wide variation in soil type. This factor could be significant when evaluating seepage losses from a pool. Testing will be required to adequately evaluate the material permeability when recompacted. Generally, playas and mantled playas are considered good souces of low permeability material. Since the playas and mantled playas make up ten percent of the siting valleys, the playa material, if satisfactory, may supply a sufficient amount of material for the pool siting concept.

2.3.5.5 Soil Stabilization

Stabilization of the various soils by the addition of cement and chemicals is possible. In general, cement can be mixed with all soils to create a stabilized soil-cement road base or surface, although clay soils are more difficult to mix and require higher percentages of cement. Asphalt can also be combined with granular materials to create a stabilized asphaltic concrete. Polymer compounds are available as a cementing agent for granular materials, but are generally quite costly.

Chemical stabilization with cement or lime can be used to reduce the shrink-swell potential of clays in the playa areas. Cement, lime and long-chain polymers can also be used to reduce the permeability of soils when mixed and recompacted. Testing of the reactions between the particular additive and the specific soil to be stabilized will be necessary for proper design.

2.4 HYDROLOGY

2.4.1 SURFACE HYDROLOGY

2.4.1.1 General Surface Hydrologic Conditions

Nearly all of NBGR lies within the Pacific Southwest Hydrologic Area which includes all of California, northern and central Nevada and portions of Utah and Colorado. The areas southeast of the hydrologic divide, Indian Spring and Three Lakes Valleys, belong to the Lower Colorado Region Hydrologic Basin and include portions of southern Nevada and most of Arizona (Lower Colorado Region State-Federal Interagency, 1971).

Surface drainage within the NBGR portions of both of these hydrologic areas is typical of the Great Basin with drainage into a central playa area. These closed basins are separated by mountain ranges and mesas. Table 9 (Section 2.4.1.3) lists the primary ephemeral drainages, playas, associated hydrologic divides, springs and applicable four-quad areas for each Valley.

Perennial springs have generally been developed (primarily in the Desert National Wildlife Range) to retain water, either by open catchment basins for domestic cattle and wildlife use or through storage in underground tanks. Further development of springs in that portion of NBGR by the Fish and Wildlife Service is being accomplished to support an increasing wildlife population (U. S. Department of the Interior, 1968).

2.4.1.2 Perennial Systems

Perennial systems refer to lakes, rivers and streams which contain water throughout the year. There are no known

Table 9. Surface Hydrologic Summary - NBGR

Valley	Associated Hydrologic Divides	Preliminary Ephemeral Drainages and Playas	Springs	Applicable 4-Quad(s)
1) Stonewall Flat	Cactus Range, Stonewall Mtn., Goldfield Hills	One small unnamed playa	Wildhorse	N-I N-II
2) Cactus Flat	Kawich Range, Cactus Range, Gold Mountain	Breen Creek, Mud Lake, 4 connected playas	Antelope, Cactus, Silverbow	N-II
3) Gold Flat	Gold Mountain, Mount Helen, Kawich Range, Pahute Mesa	Silent Canyon Wash, one large unnamed playa	Corral	N-II
4) Kawich Valley	Kawich Range, Reveille Range, Belted Range	One large playa, two small playas	Cliff, Cedar, Sumner	N-III
5) Pahute Mesa	Buckboard Mesa	No playas. External drainage to Sarcobatus Flat	Monte Cristo	N-VI
6) Buckboard	Pahute Mesa	External drainage through Jackass Flat to Amargosa Desert Forty-mile Wash		N-VII N-XI
7) Yucca Flat	Eleana Range, Halfpint Range, Massachusetts Mountain, Buckboard Mesa	Yucca Lake	Captain Jack, Tippipah, Oak, Whiterock	N-VII
8) Frenchman Flat	Spotted Range, Massachusetts Mountain	Frenchman Lake		N-XI N-XII
9) Emigrant Valley	Groom Range, Belted Range, Spotted Range, Halfpint Range	Papoose Lake, Groom Lake	Johnnie's Water	N-VI
10) Indian Spring Valley	Spotted Range, Pintwater Range	One large central playa	Indian Spring	N-XII
11) Three Lakes Valley	Pintwater Range, Desert Range	Three large playas		N-XIII
12) Tikaboo Valley	Desert Range, Pahranagat Range	No playas within NBGR portion of valley		N-IX

perennial streams or lakes within NBGR. The Colorado River, located approximately 60 nm to the southwest of NBGR is the largest and most prominent perennial system in the eastern Great Basin.

Isolated springs and seeps are located primarily in the mountain areas in and adjacent to NBGR. Several prominent perennial springs near the base of the Spring Mountains (approximately ten nm south of NBGR) periodically flow a few thousand feet to one mile from their orifices before being diverted or seeping into alluvial fans (Winograd and others, 1971) and probably represent an upper limit to perennial flow in NBGR. Most springs in the area are intermittent, with the few perennial springs having flow rates ranging from less than one gallon per minute (gpm) to a maximum of over 400 gpm at Indian Spring (Thordarson and Robinson, 1971). Most spring water not retained in catchments is lost to either evaporation or infiltration (Rush, 1970).

2.4.1.3 Ephemeral Systems

Ephemeral systems include playas and drainage channels (streams and washes) all of which have seasonal or periodic occurrences of water. Playas (totaling less than 90 nm^2) occur throughout NBGR, primarily in the central portions of valleys, in local undrained areas usually in wind deflated portions of the central valley, or occasionally behind resistant lake terrace deposits which border some of the playa areas. The duration of surface water retention in these features depends generally upon the duration and intensity of rainfall in the area and the runoff characteristics of the watershed. Localized areas of standing water, less than one nm^2, were noted during an aerial reconnaissance in January, 1975. These were located primarily on playas in Cactus Flat, Mud Lake, Tikaboo Valley and Three Lakes Valley in the Desert Wildlife Range.

Colton (1965) reports that Yucca playa (Geology, Hydrology, N-VII, N-XI) retained approximately 160 acre-feet of water (0.5 inch deep, covering approximately 3840 acres) for several days following a snow and rainstorm in March, 1963. This occurrence, the likelihood of similar rainstorms (Section 2.5.2.3) and the similarity in climatic and hydrologic conditions elsewhere in NBGR suggest that, in general, surface water may be retained on the playas for short periods of time following periods of extended or intense precipitation.

The primary ephemeral drainages commonly occur in the central portion of the valleys between playas or drain very large watershed areas near the mountains. Table 9 lists recognized primary ephemeral drainages in NBGR, their respective valleys and pertinent four-quad areas. They commonly supply intermittent seasonal (generally late summer and winter) water flow in the area, and may receive channel and flood waters following intense rainstorms.

Generally smaller in size but greater in number are the secondary ephemeral streams which drain smaller drainage basins and are tributary to the primary drainages. Numerous secondary drainages occur throughout NBGR providing periodic flow during

QUALITY OF DATA	DESCRIPTION			
	A. DEPTH TO GROUNDWATER WITHIN BASIN-FILL MATERIAL IN SITING VALLEY (Map area in nm2)			
○	1. 0 to 50 feet			
○	a. 0 to 25 feet			
○	b. 25 to 50 feet			
○	2. 50 to 100 feet			
○	3. Greater than 100 feet			
◒	4. Unknown or not Present	82	100%	Buckboard Me portion, but
	B. AQUIFER CHARACTERISTICS IN VALLEY			
●	1. Type of Aquifer (B=Basin Fill; P=Perched; R=Rock; u=unconfined; c=confined)			Bu
◒	a. Map area and extent	$200nm^2$		(est. for Ja
◒	b. Depth to aquifer (ft.)	300 to 350 (near Lathrop Well		
◒	c. Thickness (ft.)			
◒	d. Composition	Sand, gravel, clay		
◒	e. Porosity (%)			
◒	f. Specific yield (%)			
◒	g. Transmissivity ($ft.^2$/day)			
◒	h. Specific capacity (gpm/ft. of drawdown)			
◒	i. Total pumpage (ac. ft./unit time)			
●	j. Groundwater ownership rights	ERDA		
	C. WATER BUDGET FOR VALLEY			
◒	1. Total Recharge (ac. ft./unit time)	1300/year		
○	2. Total Discharge (ac. ft./unit time)			
	D. ADDITIONAL REMARKS			

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

100% Buckboard Mesa portion unsaturated. Unknown for Jackass Flats portion, but depth believed greater than 200 feet. Data inadequate for contouring.

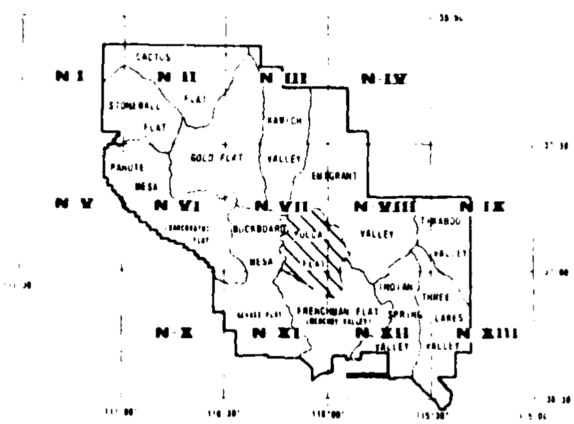
Bu	Rc	
(est. for Jackass Flats portion)	$30nm^2$	
0 (near Lathrop Wells)	750(est.)	3500 t
	100 to 600	
vel, clay	Welded volcanic tuff	Limest
	Highly variable due to local differences in gas bubbles, joints and fractures	
	1 to 5	
	100 to 1000	6 to 6
	2.5 to 56	0.7 to
	5/day (max. in 1967)	

3.9.5 Buckboard Mesa (Jackass Flat)

e for contouring.

	Ru
	3500 to greater than 7500
	Limestone and dolomite fractures
joints and fractures	
	6 to 6.0 x 10^6 (average range)
	0.7 to 30

YUCCA FLAT



VALLEY ANALYSIS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FUGRO NATIONAL, INC.

AD-A113 213 FUGRO NATIONAL INC LONG BEACH CA F/G 8/6

MX SITING INVESTIGATION. VOLUME IIC. GEOTECHNICAL REPORT, NELLI--ETC(U)

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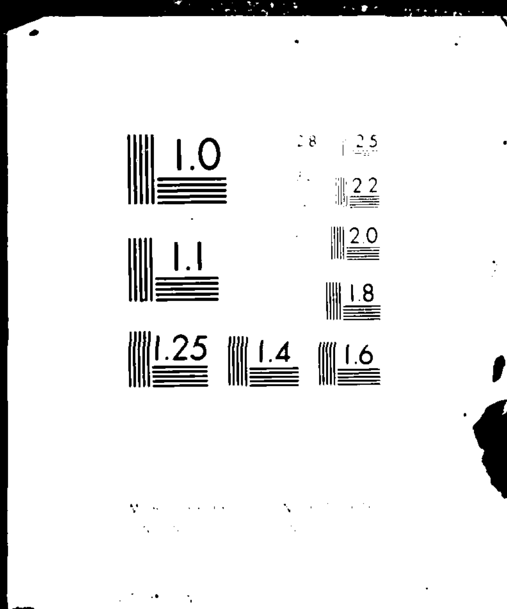
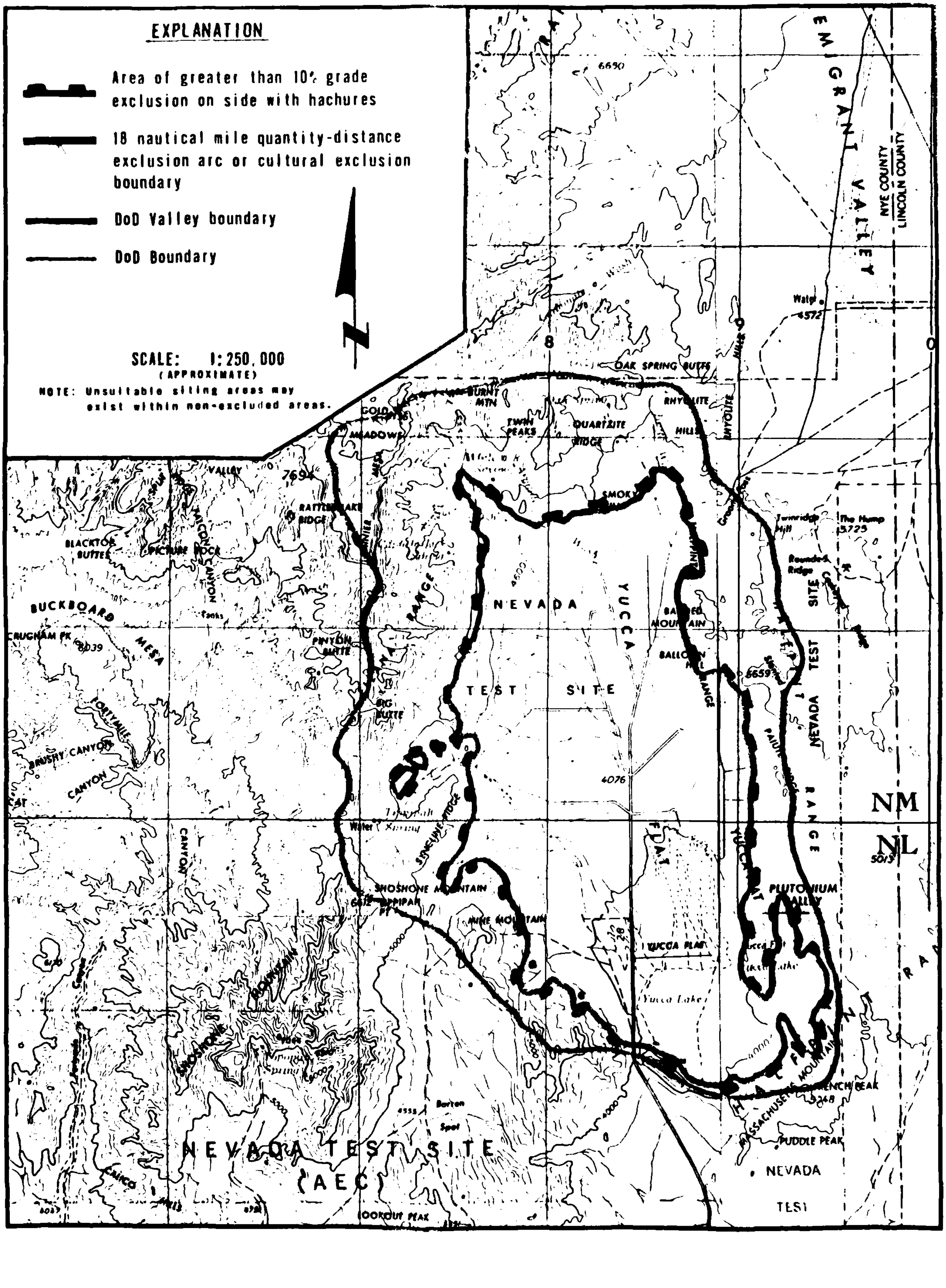



EXPLANATION
Area of greater than 10% grade exclusion on side with hachures
18 nautical mile quantity-distance exclusion arc or cultural exclusion boundary
DoD Valley boundary
DoD Boundary
SCALE: 1:250,000
(APPROXIMATE)
NOTE: Unsuitable siting areas may exist within non-excluded areas.
EMIGRANT VALLEY
NYE COUNTY
LINCOLN COUNTY
OAK SPRING BUTTE
BURNT MTN
TWIN PEAKS
QUARTZITE RIDGE
RHYOLITE HILLS
GOLD MEADOWS
RATTLESNAKE RIDGE
BLACKTOP BUTTES
PICTURE ROCK
BUCKBOARD MESA
PINYON BUTTE
BIG BUTTE
BRUSHY CANYON
FORTYMILE CANYON
NEVADA TEST SITE
YUCCA
BANDED MOUNTAIN
BALLOON
Twinridge Hill
The Hump
5725
Rounded Ridge
NEVADA TEST RANGE
NM
NL
SYNCLINE RIDGE
SHOSHONE MOUNTAIN
MINE MOUNTAIN
YUCCA FLAT
Yucca Lake
PLUTONIUM VALLEY
MASSACHUSETTS MOUNTAIN
FRENCHMAN PEAK
PUDDLE PEAK
SHOSHONE MOUNTAIN
NEVADA TEST SITE
(AEC)
LOOKOUT PEAK
NEVADA
TEST

QUALITY OF DATA	DESCRIPTION		
	A. VALLEY AREA, OWNERSHIP AND LAND UTILIZATION		
●	1. Area of Valley	$232nm^2$	100%
●	a. Area of valley excluded by major cultural or quantity-distance exclusions and 10% grade exclusion	$124nm^2$	53%
●	2. Area of Siting Valley (A.1 minus A.1.a)	$108nm^2$	47%
●	3. Ownership	ERDA, Nevada Test Site	
●	a. Portion of siting valley with direct DoD ownership	None	
●	b. Co-owners or administrators of co-use land/ constraints	None	
●	4. Contiguous BLM or Co-Use Land (area in nm^2)	0	
	a. Relative location in or adjacent to valley	N/A	
	b. Present use	N/A	
	B. CULTURAL AND QUANTITY-DISTANCE EXCLUSIONS		
●	1. Location of 18 nm Arc (population greater than 25,000)	None	
●	2. Location of 3 nm Arc (population greater than 5,000)	None	
●	3. Other	None	
	C. CULTURAL IMPROVEMENTS		
●	1. Roads/Railroads (name)	Mercury Highway	
●	a. Relative location in valley	Central portion of sitin	
●	b. Type and use	Improved; restricted civ	
●	2. Utilities (type)	Underground telephone and	
●	a. Relative location in valley	Subparallel to Mercury H	
●	D. MILITARY/GOVERNMENTAL USE AREAS	Test Areas 1, 2, 3, 4, 7, 15, 16 and 17 of NTS	
●	1. Location and areal extent (nm^2)	Testing has been conduct	
●	2. Present use	Underground testing of n	
●	3. Future use	Underground testing of n	
●	4. Decontamination necessary prior to siting	Siting would be restrict and areas with radioacti	
	E. ADDITIONAL REMARKS		

Quality of Data

- ● Data derived from detailed studies
- ◐ Estimated values
- ○ Insufficient data available

2nm^2	100%	
4nm^2	53%	
8nm^2	47%	
DA, Nevada Test Site		
ne		
ne		
0		
A		
A		
one		
one		
one		
rcury Highway	Unnamed roads and jeep trails	
ntral portion of siting valley, extends north from Mercury	Randomly transect Valley	
nproved; restricted civilian	Unimproved; restri[illegible]ivilian	
nderground telephone and electrical lines		
ubparallel to Mercury Highway		
est Areas 1, 2, 3, 4, 7, 8, 9 and portions of Test Areas 6, 10, 11, 12, 5, 16 and 17 of NTS esting has been conducted throughout entire Valley		
nderground testing of nuclear devices		
nderground testing of nuclear devices		
iting would be restricted in areas with subsidence craters nd areas with radioactive contamination		

QUALITY OF DATA	DESCRIPTION			
	A. TOPOGRAPHIC GRADIENT IN SITING VALLEY			
●	1. Area with Less than 10% Grade	108nm^2	100%	
●	2. Area with 5 to 10% Grade	29nm^2	27%	
●	3. Area with 0 to 5% Grade	79nm^2	73%	
●	4. Location of Alluvial Passes or Valley Boundaries Having Less than 10% Grade	Southern portion of Val Yucca Pass (Mercury Hig		
	B. ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
●	1. Exposed Rock (category/symbol/lithology)	B/I2$_T$/volcanic tuff; B/		
●	a. Location and map area in nm^2	1	1%	Along
●	b. Seismic velocity (p/s in fps)	9000-15,000/4000-8000		
	c. Conditions of volcanic flow	N/A		
●	2. Pediments (rock type)	None known in area less		
●	a. Location and map area in nm^2	0	0	N/A
	b. Exposure condition	N/A		
	c. Distance into siting valley from rock exposures (max./min./avg.) (nm)	N/A		
	C. SUBSURFACE ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
	1. Depth to Rock (map area in nm^2)			
●	a. 0 to 250 feet (excluding pediments)	39	36%	
●	1) Type	B; Dolomite, argillite		
●	2) Seismic velocity (p/s in fps)	23,000-24,000/8000-10,00		
●	b. 250 to 500 feet	21	19%	
●	1) Type	B; Dolomite, argillite		
●	2) Seismic velocity (p/s in fps)	23,000-24,000/8000-10,00		
●	c. 500 to 1000 feet	20	19%	
●	1) Type	B; Dolomite, argillite		
●	2) Seismic velocity (p/s in fps)	23,000-24,000/8000-10,00		
●	d. Greater than 1000 feet	27	25%	
●	1) Type	B; Dolomite, argillite		
●	2) Seismic velocity (p/s in fps)	23,000-24,000/8000-10,00		
●	e. Unknown	0	0	

Quality of Data
- ● Data derived from detailed studies
- ◐ Estimated values
- ○ Insufficient data available

	$108nm^2$	100%	
	$29nm^2$	27%	
	$79nm^2$	73%	
y e	Southern portion of Valley connects with Frenchman Flat by Yucca Pass (Mercury Highway)		
ws) ogy)	B/I2$_T$/volcanic tuff; B/S$_{MP}$/conglomerate, shale and limestone		
	1	1%	Along flanks of Eleana and Halfpint Ranges
	9000-15,000/4000-8000		
	N/A		
	None known in area less than ten percent grade		
	0	0	N/A
	N/A		
	N/A		
LEY ws)			
	39	36%	
	B; Dolomite, argillite		B; Tuff, Welded tuff
	23,000-24,000/8000-10,000		9000-15,000/4000-8000
	21	19%	
	B; Dolomite, argillite		B; Tuff, Welded tuff
	23,000-24,000/8000-10,000		9000-15,000/4000-8000
	20	19%	
	B; Dolomite, argillite		B; Tuff, Welded tuff
	23,000-24,000/8000-10,000		9000-15,000/4000-8000
	27	25%	
	B; Dolomite, argillite		B; Tuff, Welded tuff
	23,000-24,000/8000-10,000		9000-15,000/4000-8000
	0	0	

QUALITY OF DATA	DESCRIPTION		
◒	2. Rock (Section 2.2.3) in Basin-Fill Deposits (map area in nm^2)		
●	a. Type	Tuff, rhyolite	
◒	b. Depth to (ft.)	Variable	
●	c. Thickness (ft.)	270 to 1300	
○	d. Seismic velocity (p/s in fps)	9000-15,000/4000-80	
	D. BASIN-FILL DEPOSITS IN SITING VALLEY		
●	1. Undifferentiated Deposits (A; map area in nm^2)	0	0
	a. Thickness (max./min./avg. in ft.)	N/A	
	b. Lithology	N/A	
	c. Seismic velocity (p/s in fps)	N/A	
●	2. Alluvial Fan Deposits (A_5; map area in nm^2)	84	78%
◒	a. Thickness (max./min./avg. in ft.)	Greater than 500/5/	
●	b. Lithology	5% clay; 15% silt;	
●	c. Seismic velocity (p/s in fps)	/4700	
●	3. Playa Deposits (A_4; map area in nm^2)	5	5%
●	a. Thickness (max./min./avg. in ft.)	200/5/50	
●	b. Lithology	90% clay; 8 % sand	
●	c. Seismic velocity (p/s in fps)	2600/	
●	4. Wind-blown Sand (A_3; map area in nm^2)	1	<1%
●	a. Thickness (max./min./avg. in ft.)	Less than 10/0/	
◒	b. Lithology	Sand, silty sand	
○	c. Seismic velocity (p/s in fps)		
●	5. Pediment Deposits (A_6; map area in nm^2)	0	0
	a. Thickness (max./min./avg. in ft.)	N/A	
	b. Lithology	N/A	
	c. Seismic velocity (p/s in fps)	N/A	
●	6. Stream Channel and Floodplain Deposits (A_1; map area in nm^2)	17	16%
●	a. Thickness (max./min./avg. in ft.)	75/5/	
●	b. Lithology	30% silt; 50% san	
○	c. Seismic velocity (p/s in fps)		

Quality of Data

● Data derived from detailed studies

◒ Estimated values

○ Insufficient data available

osits			See Additional Remarks (a)
	Tuff, rhyolite		
	Variable		
	270 to 1300		
	9000-15,000/4000-8000		
	0	0	
	N/A		
	N/A		
	N/A		
nm2)	84	78%	
	Greater than 500/5/		
	5% clay; 15% silt; 40% sand; 25% granules; 10% cobbles; 5% boulders		
	/4700		
	5	5%	
	200/5/50		
	90% clay; 8 % sand; 2% granules and pebbles		
	2600/		
	1	<1%	
	Less than 10/0/		
	Sand, silty sand		
)	0	0	
	N/A		
	N/A		
	N/A		
	17	16%	
	75/5/		
	30% silt; 50% sand; 20% granules, pebbles and cobbles		

QUALITY OF DATA	DESCRIPTION		
●	7. Terrace Deposits (A_2; map area in nm^2)	0	0
	a. Thickness (max./min./avg. in ft.)	N/A	
	b. Lithology	N/A	
	c. Seismic velocity (p/s in fps)	N/A	
◒	8. General Summary of Relationships	See Additional Remarks	
	E. TECTONIC FRAMEWORK OF SITING VALLEY		
◒	1. Capable or Potentially Capable Fault	Yucca Fault (capable)	
●	a. Total length (nm)	27	
●	b. Relative location	Central portion of Vall	
●	c. Type of faulting, regional and local attitudes (strike and dip)	Dip-slip; strike N5°W t	
●	d. Minimum age of displacement or seismic activity (y.b.p.)	Movement along fault re result of larger underg	
●	2. Volcanism		
●	a. Volcanic flows	No major Quaternary bas	
	1) Location and map area in nm^2	N/A	
	2) Minimum age of volcanic activity (y.b.p.)	N/A	
	F. SEISMICITY OF SITING VALLEY (Regional seismicity discussed in Section 2.2.4 of text)		
○	1. Relative Pre-Instrumental Historic Activity (Section 2.2.4)		
◒	2. Site Area Seismic Activity (instrumental, 1927-1973; Section 2.2.4)		
●	a. Events (epicenters) greater than M=6.0	None	
●	b. Events (epicenters) greater than M=1.0 and less than M=6.0	Numerous events (M=1.0	
○	c. Events less than M=1.0 (includes microearthquakes)		
●	3. Maximum Reported Modified Mercalli Intensity	VII	
◒	4. Source of Possible Ground Acceleration Levels (Section 2.2.4)	Las Vegas Valley Shear Zone	Death Creek
◒	a. Maximum credible level (g)		0.3
◒	b. Most probable level (g)	0.15-0.3	0.1-0
	G. Additional Remarks	(a) Isolated interbedd (b) Thickness of basin limestone, dolomite Caliche beds as muc 200-3500 fps (0-300	

Quality of Data
● Data derived from detailed studies
◒ Estimated values
○ Insufficient data available

0	

ional Remarks (b)

lt (capable)	Carpetbag Fault (capable)
	4300 (feet)
ortion of Valley	Sub-parallels to Yucca Fault, eastern portion of Valley
strike N5°W to N10°E	Dip-slip; strike N40°E
long fault regularly occurs as a larger underground *nuclear explosions*	Activated as a result of Carpetbag *underground* nuclear explosion, 12/17/70

uaternary basalt flows are present at surface

vents (M=1.0 to M=5.0). Associated primarily with nuclear testing.

Valley	Death Valley-Furnace Creek Fault Zone	Jerome-Wasatch Structural Zone	Nuclear Blast (1.2 Megaton)	Yucca Fault
	0.3		1.0+	1.0+
	0.1-0.2	0.05	0.5-1.0+	0.5-1.0+

tern portion of Valley
17/70
.
ins to several hundred feet along the Valley margins. The fill contains tuff, nite fragments in the northern portion and tu f in the ortheastern portion. aterial to a depth of 35 feet. Compressional wav ve ocities (p) range from (greater than 600 feet).

SOILS ENGINEERING PROPERTIES[1]	35	36
Unified soil classification [2]	(GM-SM)	(GM-SM)
AASHO soil classification	(A-1 or A-2)	(A-1 or A-2)
Percent passing #4 sieve		
Percent passing #40 sieve		
Percent passing #200 sieve		
Liquid limit/plasticity index		
Surface consistency		
Dry density (pcf)		110
Permeability (cm/sec)		
In-situ shear strength (psi)		
In-situ angle of internal friction (degrees)		
Cohesion (psi)		
Shrink-swell potential		
Coefficient of compressibility (in^2/lb.)		
In-situ CBR		
Recompacted CBR		
General surface moisture condition		
Compressional wave velocities (fps)		2000 to 3500
Shear wave velocities (fps)		
Deleterious substances	Caliche present in some areas	Caliche may be present
ENGINEERING DESIGN EVALUATIONS[1]		
Suitability as impermeable membrane when recompacted	(Poor)	(Poor)
Suitability as source of sand/fill material	(Fair)/ Good	(Fair)/ Good
Suitability as source of aggregate/base course	(Fair)/ Good	(Fair)/Fair
Near surface foundation design characteristics	(High strength) (Low comp.)	(Mod. strength)
Excavation limitations and slope angle	Sloughing and/or difficult ripping	Sloughing
Additional Remarks	Boulders may be present; (A5O; A5i; A5u)	(A5y)

Explanation

	No literature available and data not extrapolated
(SP-SM)	No literature available and data extrapolated
SP-SM	Data available in literature

(1) Surface soils only, depth of less than 5 feet

(2) Related geologic unit(s) shown in Add: ional Remarks (e.g. Al_Q)

36	37	38	39	41	42
M)	(GM-SM)	(SP-SM)	(GM,GP,SM,SP ML,CL)	(GP,SP,SM,ML)	ML-CL
or A-2)	(A-1 or A-2)	(A-2)	(A-1, A-2, A-4 or A-6)	(A-1, A-2 or A-4)	A-4 or A-6
to 3500					
che may be ent					
)	(Poor)	(Poor)	(Poor)	(Poor)	(Fair)
)/ Good	(Fair)/(Fair)	(Good)/(Good)	(Poor)/(Fair)	(Good)/ Good	N.A./(Poor)
)/Fair	(Fair)/(Fair)	(Poor)/(Fair)	(Poor)/(Fair)	(Fair)/ Good	N.A./(Poor)
strength)	(High strength) (Low comp.)	(Mod. strength) (Mod. comp.)	(Mod. strength) (Mod. expan.)	(Mod. strength) (Mod. comp.)	(Low strength) (High comp.)
hing	Difficult ripping or blasting	Severe sloughing			(slight >60°)
	Depth to rock less than 10 feet (A6)	($A3s_Q$)	(A_Q)	($A1_Q$)	($A4_Q$)

QUALITY OF DATA	DESCRIPTION			
	A. SURFACE WATER IN SITING VALLEY			
●	1. Playas; Intermittent and Perennial Lakes	Yucca Lake (playa)		
○	a. Duration of surface water (wks.)			
●	b. Maximum extent (nm^2)	5		
○	c. Water depth (avg. in ft.)			
●	d. Source of water	Runoff and direct precipi		
●	e. Water quality	Bicarbonate		
●	2. Springs	Captain Jack	Tippipah	C
○	a. Duration of flow (wks.)			
●	b. Estimated maximum flow rate (gpm/season)	0.2/Spring	0.2/Fall	C
●	c. Water quality	Fresh	Fresh	I
●	3. Rivers or Streams	Numerous unnamed streams		
◒	a. Rate (gpm) and duration of flow (wks.)	Ephemeral		
○	b. Water quality			
	B. HYDROLOGIC CHARACTERISTICS OF SITING VALLEY			
●	1. Drainage Channel (PR=Primary; S=Secondary)	Unnamed wash (PR)	Nu	
◒	a. Depth of incision (max./min./avg.; ft.)	40/5/20	10/	
◒	b. Width (max./min./avg.; ft.)	200/25/100	50/	
◒	c. Gradient (ft./mi.)	20 to 120	20	
◒	d. Channel bottom characteristics	Sand and gravel	Pr	
◒	e. Channel cross-section (schematic)			
◒	f. Channel spacing (avg. in ft.)	Main channel	10	
◒	g. Preliminary flood susceptibility rating (Section 2.4.1)	CF_1		
◒	2. Preliminary Flood Susceptibility Rating of Major Landform Surfaces (Section 2.4.1)			
○	a. Undifferentiated deposits			
○	b. Alluvial fans			
◒	c. Playas (active=a; mantled=m)	a: SF_2; m: Unknown	SF_1	
○	d. Pediments			
○	e. Sand dunes			
○	f. Terraces (l=lake; r=river)			
	C. ADDITIONAL REMARKS	(a) Flow rate shown for season shown is tim (b) Water contains prim also have a high co Observations are based		

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

Yucca Lake (playa)

5

Runoff and direct precipitation

Bicarbonate

Captain Jack	Tippipah	Oak	Whiterock	Rainier	Tubb
0.2/Spring	0.2/Fall	0.1/Fall	1/Fall	0.1/Fall	0.1/Fall; see Additional Remarks (a)
Fresh	Fresh	Fresh	Fresh	Fresh	Fresh; see Additional Remarks (b)

Numerous unnamed streams

Ephemeral

Unnamed wash (PR)	Numerous unnamed washes (S)
40/5/20	10/1/5
200/25/100	50/5/15
20 to 120	20 to 120
Sand and gravel	Primarily sand
Main channel	1000
CF_1	

a: SF_2; m: Unknown SF_1

(a) Flow rate shown for all springs may not be maximum flow rate; season shown is time of sampling.
(b) Water contains primarily bicarbonate, sodium and potassium; Oak and Tubb Springs also have a high concentration of calcium.

Observations are based on interpretation of topographic maps and aerial photographs.

QUALITY OF DATA	DESCRIPTION			
	A. DEPTH TO GROUNDWATER WITHIN BASIN-FILL MATERIAL IN SITING VALLEY (Map area in nm^2)			
●	1. 0 to 50 feet	0	0	
●	a. 0 to 25 feet	0	0	
●	b. 25 to 50 feet	0	0	
●	2. 50 to 100 feet	0	0	
●	3. Greater than 100 feet	7	6%	Greate
●	4. Unknown or not Present	101	94%	Unsatu
	B. AQUIFER CHARACTERISTICS IN VALLEY			
●	1. Type of Aquifer (B=Basin Fill; P=Perched; R=Rock; u=unconfined; c=confined)			Bu
◒	a. Map area and extent	$230nm^2$		
●	b. Depth to aquifer (ft.)	1600 to 1800		
◒	c. Thickness (ft.)	200 to 300 (saturated z		
●	d. Composition	Sand and gravel containi zeolite and montmorillon		
◒	e. Porosity (%)	5 to 10		
○	f. Specific yield (%)			
◒	g. Transmissivity (ft^2/day)	See Additional Remarks (		
◒	h. Specific capacity (gpm/ft. of drawdown)	1.2-1.9		
○	i. Total pumpage (ac. ft./unit time)			
●	j. Groundwater ownership rights	ERDA		
	C. WATER BUDGET FOR VALLEY			
◒	1. Total Recharge (ac. ft./unit time)	400/year		
◒	2. Total Discharge (ac. ft./unit time)	See Additional Remarks (		
	D. ADDITIONAL REMARKS	(a) Approximate (b) Transmissibility va similar deposits in (c) Downward leakage to (d) Estimated transmiss (Winograd and other		

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

0	
0	
0	
0	
6%	Greater than 1700 feet in local areas
94%	Unsaturated

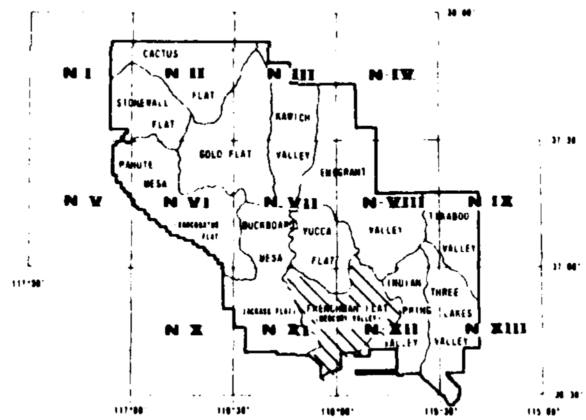
Bu	Rc	Ru
800	650 to 1700	Greater than 1500 (south end of Yucca L
0 (saturated zone)		Greater than 100
ravel containing abundant d montmorillonite clay	Volcanic tuff	Fractured limestone and dolomite
		See Additional Remarks (d)
onal Remarks (a)	See Additional Remarks (b)	0.4 to 530
	0.30-0.60	
onal Remarks (c)		

ximate
missibility values of 700 to 3400 gpd/ft. obtained in
ar deposits in Frenchman Flat.
ard leakage to the underlying carbonate rock.
ated transmissibility of 6000 to 900,000 gpd/ft.
grad and others, 1971)

Ru
han 1500 (south end of Yucca Lake)
han 100
limestone and dolomite
tional Remarks (d)
30

FRENCHMAN FLAT

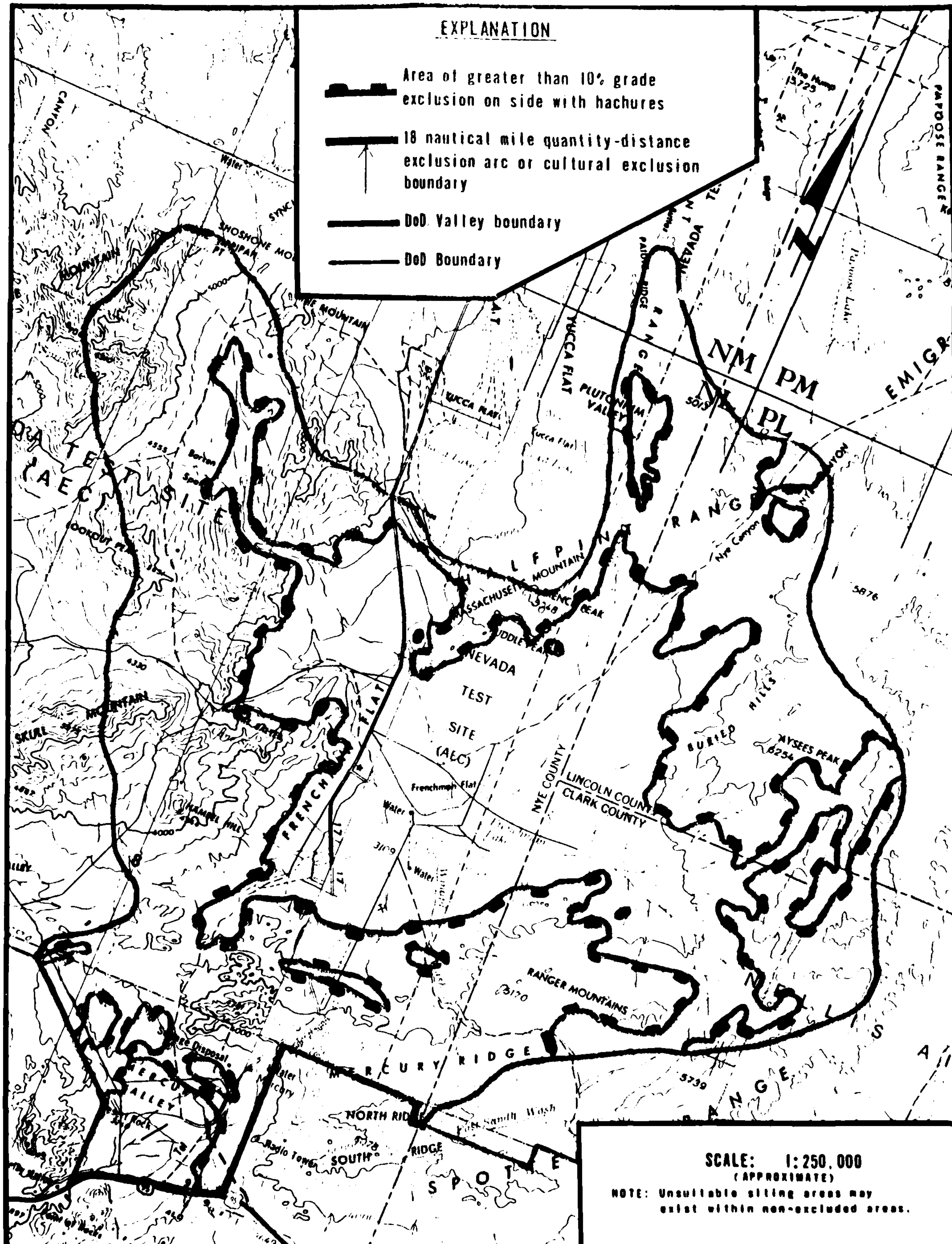
(MERCURY VALLEY)



VALLEY ANALYSIS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FUGRO NATIONAL, INC.


EXPLANATION
Area of greater than 10% grade exclusion on side with hachures
18 nautical mile quantity-distance exclusion arc or cultural exclusion boundary
DoD Valley boundary
DoD Boundary
NEVADA TEST SITE (AEC)
YUCCA FLAT
FRENCHMAN FLAT
MERCURY RIDGE
RANGER MOUNTAINS
NYE COUNTY
LINCOLN COUNTY
CLARK COUNTY
SCALE: 1:250,000
(APPROXIMATE)
NOTE: Unsuitable siting areas may exist within non-excluded areas.

QUALITY OF DATA	DESCRIPTION			
	A. VALLEY AREA, OWNERSHIP AND LAND UTILIZATION			
●	1. Area of Valley	399nm^2	100%	
●	a. Area of valley excluded by major cultural or quantity-distance exclusions and 10% grade exclusion	272nm^2	68%	
●	2. Area of Siting Valley (A.1 minus A.1.a)	127nm^2	32%	
●	3. Ownership	ERDA, Nevada Test Site		
●	a. Portion of siting valley with direct DoD ownership	None		
●	b. Co-owners or administrators of co-use land/ constraints	None		
●	4. Contiguous BLM or Co-Use Land (area in nm^2)	0		
	a. Relative location in or adjacent to valley	N/A		
	b. Present use	N/A		
	B. CULTURAL AND QUANTITY-DISTANCE EXCLUSIONS			
●	1. Location of 18 nm Arc (population greater than 25,000)	None		
●	2. Location of 3 nm Arc (population greater than 5,000)	None		
●	3. Other	None		
	C. CULTURAL IMPROVEMENTS			
●	1. Roads/Railroads (name)	Mercury Highway		
●	a. Relative location in valley	Extends from Mercury north		
●	b. Type and use	Improved; restricted civil		
●	2. Utilities (type)	Underground telephone and		
●	a. Relative location in valley	Subparallel to Mercury Hig		
●	D. MILITARY/GOVERNMENTAL USE AREAS	Test Area 5 and portions o		
●	1. Location and areal extent (nm^2)	and 28 of NTS Primarily on east side of		
●	2. Present use	Underground testing of nuc		
●	3. Future use	Underground testing of nuc		
●	4. Decontamination necessary prior to siting	Siting would be restricte craters and areas with ra		
	E. ADDITIONAL REMARKS			

Quality of Data

● Data derived from detailed studies

◒ Estimated values

○ Insufficient data available

$399nm^2$	100%	
$272nm^2$	68%	
$127nm^2$	32%	
ERDA, Nevada Test Site		
None		
None		
0		
N/A		
N/A		
None		
None		
None		
Mercury Highway		Unnamed roads and jeep trails
Extends from Mercury north to Yucca Lake		Randomly transect Valley
Improved; restricted civilian		Unimproved; restricted civilian
Underground telephone and electrical lines		
Subparallel to Mercury Highway		
Test Area 5 and portions of Test Areas 6, 11, 14, 16, 26, 27 and 28 of NTS Primarily on east side of playa, $127nm^2$		
Underground testing of nuclear devices		
Underground testing of nuclear devices		
Siting would be restricted in areas with subsidence craters and areas with radioactive contamination		

QUALITY OF DATA	DESCRIPTION			
	A. TOPOGRAPHIC GRADIENT IN SITING VALLEY			
●	1. Area with Less than 10% Grade	$127nm^2$	100%	
●	2. Area with 5 to 10% Grade	$50nm^2$	39%	
●	3. Area with 0 to 5% Grade	$77nm^2$	61%	
●	4. Location of Alluvial Passes or Valley Boundaries Having Less than 10% Grade	Northern portion of Val (Mercury Highway)		
	B. ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
●	1. Exposed Rock (category/symbol/lithology)	B/I_{2T}/welded tuff; B/S		
●	a. Location and map area in nm^2	6	5%	Along f
○	b. Seismic velocity (p/s in fps)			
	c. Conditions of volcanic flow	N/A		
◒	2. Pediments (rock type)	None		
◒	a. Location and map area in nm^2	0	0	N/A
	b. Exposure condition	N/A		
	c. Distance into siting valley from rock exposures (max./min./avg.) (nm)	N/A		
	C. SUBSURFACE ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
	1. Depth to Rock (map area in nm^2)			
◒	a. 0 to 250 feet (excluding pediments)	89	70%	
◒	1) Type	B; tuff, sandstone, si		
○	2) Seismic velocity (p/s in fps)			
◒	b. 250 to 500 feet	10	8%	
◒	1) Type	B; tuff, sandstone, si		
○	2) Seismic velocity (p/s in fps)			
◒	c. 500 to 1000 feet	6	5%	
◒	1) Type	B; tuff, sandstone, si		
○	2) Seismic velocity (p/s in fps)			
◒	d. Greater than 1000 feet	16	12%	
◒	1) Type	B; tuff, sandstone, si		
○	2) Seismic velocity (p/s in fps)			
○	e. Unknown	0	0	

Quality of Data

● Data derived from detailed studies
◒ Estimated values
○ Insufficient data available

$127nm^2$	100%	
$50nm^2$	39%	
$77nm^2$	61%	
Northern portion of Valley connects with Yucca Flat by Yucca Pass (Mercury Highway)		
B/I_{2T}/welded tuff; B/S_{MP}/ sedimentary conglomerate, shale and limestone		
6	5%	Along flanks of Specter Range, Skull Mountain and Massachusetts Mtn.
N/A		
None		
0	0	N/A
N/A		
N/A		
89	70%	
B; tuff, sandstone, siltstone (northwest portion)		
10	8%	
B; tuff, sandstone, siltstone (northwest portion)		
6	5%	
B; tuff, sandstone, siltstone (northwest portion)		
16	12%	
B; tuff, sandstone, siltstone (northwest portion)		
0	0	

QUALITY OF DATA	DESCRIPTION			
◐	2. Rock (Section 2.2.3) in Basin-Fill Deposits (map area in nm^2)			Basa bene
○	a. Type			
○	b. Depth to (ft.)			
○	c. Thickness (ft.)			
○	d. Seismic velocity (p/s in fps)			
	D. BASIN-FILL DEPOSITS IN SITING VALLEY			
●	1. Undifferentiated Deposits (A; map area in nm^2)	0	0	
	a. Thickness (max./min./avg. in ft.)	N/A		
	b. Lithology	N/A		
	c. Seismic velocity (p/s in fps)	N/A		
●	2. Alluvial Fan Deposits (A_5; map area in nm^2)	97	76%	
◐	a. Thickness (max./min./avg. in ft.)	Greater than 500 in		
◐	b. Lithology	Sand, gravel, cobble		
●	c. Seismic velocity (p/s in fps)	4700-7500/		
●	3. Playa Deposits (A_4; map area in nm^2)	6	5%	
◐	a. Thickness (max./min./avg. in ft.)	400/ /175		
◐	b. Lithology	Clay, silt, fine san		
●	c. Seismic velocity (p/s in fps)	2600/		
●	4. Wind-blown Sand (A_3; map area in nm^2)	0	0	
	a. Thickness (max./min./avg. in ft.)	N/A		
	b. Lithology	N/A		
	c. Seismic velocity (p/s in fps)	N/A		
◐	5. Pediment Deposits (A_6; map area in nm^2)	0	0	
	a. Thickness (max./min./avg. in ft.)	N/A		
	b. Lithology	N/A		
	c. Seismic velocity (p/s in fps)	N/A		
●	6. Stream Channel and Floodplain Deposits (A_1; map area in nm^2)	18	14%	
◐	a. Thickness (max./min./avg. in ft.)	100/0/50		
◐	b. Lithology	Sand, gravel, silt		
○	c. Seismic velocity (p/s in fps)			

Quality of Data

● Data derived from detailed studies

◐ imated values

○ sufficient data available

		Basalt flows may be present beneath surface
0	0	
N/A		
N/A		
N/A		
97	76%	
Greater than 500 in central portion of valley/ /		
Sand, gravel, cobbles		
4700-7500/		
6	5%	
400/ /175		
Clay, silt, fine sand		
2600/		
0	0	
N/A		
N/A		
N/A		
0	0	
N/A		
N/A		
N/A		
18	14%	
100/0/50		
Sand, gravel, silt		

QUALITY OF DATA	DESCRIPTION		
●	7. Terrace Deposits (A_2; map area in nm^2)	0	0
	a. Thickness (max./min./avg. in ft.)	N/A	
	b. Lithology	N/A	
	c. Seismic velocity (p/s in fps)	N/A	
○	8. General Summary of Relationships	Basin-fill deposits g central portion of si	
	E. TECTONIC FRAMEWORK OF SITING VALLEY		
◒	1. Capable or Potentially Capable Fault	Unnamed fault extendi	
◒	a. Total length (nm)	15	
●	b. Relative location	Southern portion of V	
●	c. Type of faulting, regional and local attitudes (strike and dip)	Dip-slip; strike N70°	
○	d. Minimum age of displacement or seismic activity (y.b.p.)		
●	2. Volcanism		
●	a. Volcanic flows	Tertiary basalt flows	
●	1) Location and map area in nm^2	West side of Valley,	
○	2) Minimum age of volcanic activity (y.b.p.)		
	F. SEISMICITY OF SITING VALLEY (Regional seismicity discussed in Section 2.2.4 of text)		
○	1. Relative Pre-Instrumental Historic Activity (Section 2.2.4)		
◒	2. Site Area Seismic Activity (instrumental, 1927-1973; Section 2.2.4)		
●	a. Events (epicenters) greater than M=6.0	None	
●	b. Events (epicenters) greater than M=1.0 and less than M=6.0	More than 30 events l	
○	c. Events less than M=1.0 (includes microearthquakes)		
●	3. Maximum Reported Modified Mercalli Intensity	VII	
◒	4. Source of Possible Ground Acceleration Levels (Section 2.2.4)	Las Vegas Valley Shear Zone	Dea Cre
◒	a. Maximum credible level (g)		0.3
◒	b. Most probable level (g)	0.2-0.6	0.1
	G. Additional Remarks		

Quality of Data

● Data derived from detailed studies

◒ Estimated values

○ Insufficient data available

	0	0			
	N/A				
	N/A				
	N/A				
	Basin-fill deposits greater than 1500 feet thick in central portion of siting Valley.				
	Unnamed fault extending from Frenchman Flat to Rock Valley (potentially capable)				
	15				
	Southern portion of Valley				
udes	Dip-slip; strike N70°E				
ivity					
	Tertiary basalt flows				
	West side of Valley, near Cane Spring Wash ; 3				
icity vity					
l,					
	None				
less	More than 30 events less than M=4.0. Associated primarily with nuclear testing.				
hquakes)					
nsity	VII				
Levels	Las Vegas Valley Shear Zone	Death Valley-Furnace Creek Shear Zone	Jerome-Wasatch Structural Zone	Nuclear Blast (1,2 Megaton)	Yucca Fault
		0.35			
	0.2-0.6	).15-0.3	0.05	0.2-0,6	0.2-0,6

SOILS ENGINEERING PROPERTIES[1]	35	36
Unified soil classification[2]	(GM-SM)	(GM-SM)
AASHO soil classification	(A-1 or A-2)	(A-1 or A-2)
Percent passing #4 sieve		
Percent passing #40 sieve		
Percent passing #200 sieve		
Liquid limit/plasticity index		
Surface consistency		
Dry density (pcf)		110
Permeability (cm/sec)		
In-situ shear strength (psi)		
In-situ angle of internal friction (degrees)		
Cohesion (psi)		
Shrink-swell potential		
Coefficient of compressibility (in^2/lb.)		
In-situ CBR		
Recompacted CBR		
General surface moisture condition		
Compressional wave velocities (fps)		2000 to 3500
Shear wave velocities (fps)		
Deleterious substances	Caliche present in some areas	Caliche may be present
ENGINEERING DESIGN EVALUATIONS[1]		
Suitability as impermeable membrane when recompacted	(Poor)	(Poor)
Suitability as source of sand/fill material	(Fair)/ Good	(Fair)/ Good
Suitability as source of aggregate/base course	(Fair)/ Good	(Fair)/ Fair
Near surface foundation design characteristics	(High strength) (Low comp.)	(Mod. strength)
Excavation limitations and slope angle	Sloughing and/or difficult ripping	Sloughing
Additional Remarks	Boulders may be present; (A5o; A5i; A5u)	(A5y)

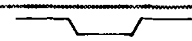
Explanation

(blank box)	No literature available and data not extrapolated
(SP-SM)	No literature available and data extrapolated
SP-SM	Data available in literature

(1) Surface soils only, depth of less than 5 feet

(2) Related geologic unit(s) shown in Additional Remarks (e.g. Alo)

	MAP UNIT NUMBER				
	36	37	39	41	42
	(GM-SM)	(GM-SM)	(GM,GP,SM,SP ML,CL)	(GP,SP,SM,ML)	ML-CL
	(A-1 or A-2)	(A-1 or A-2)	(A-1,A-2, A-4 or A-6)	(A-1,A-2 or A-4)	A-4 or A-6
	110				
	2000 to 3500				
esent eas	Caliche may be present				
	(Poor)	(Poor)	(Poor)	(Poor)	(Fair)
od	(Fair)/ Good	(Fair)/(Fair)	(Poor)/(Fair)	(Good)/ Good	N.A./(Poor)
od	(Fair)/ Fair	(Fair)/(Fair)	(Poor)/(Fair)	(Fair)/ Good	N.A./(Poor)
ngth))	(Mod. strength)	(High strength) (Low comp.)	(Mod. strength) (Mod. expan.)	(Mod. strength) (Mod. comp.)	(Low strength) (High comp.)
nd/or ipping	Sloughing	Difficult ripping or blasting			(>60°)
y be A5u)	(A5y)	Depth to rock less than 10 feet; (A6)	(A_Q)	($A1_Q$)	($A4_Q$)

QUALITY OF DATA	DESCRIPTION	
	A. SURFACE WATER IN SITING VALLEY	
●	1. Playas; Intermittent and Perennial Lakes	Unnamed playa in central
○	a. Duration of surface water (wks.)	
●	b. Maximum extent (nm^2)	6
○	c. Water depth (avg. in ft.)	
◒	d. Source of water	Runoff and direct precip
○	e. Water quality	
●	2. Springs	Cane
○	a. Duration of flow (wks.)	
◒	b. Estimated maximum flow rate (gpm/season)	2/Fall; see Additional Re
◒	c. Water quality	Fresh; see Additional Rem
●	3. Rivers or Streams	Numerous unnamed streams
◒	a. Rate (gpm) and duration of flow (wks.)	Ephemeral
○	b. Water quality	
	B. HYDROLOGIC CHARACTERISTICS OF SITING VALLEY	
◒	1. Drainage Channel (PR=Primary; S=Secondary)	Cane Spring Wash (PR)
◒	a. Depth of incision (max./min./avg.; ft.)	40/5/20
◒	b. Width (max./min./avg.; ft.)	400/50/200
◒	c. Gradient (ft./mi.)	20 to 120
◒	d. Channel bottom characteristics	Sand and gravel
◒	e. Channel cross-section (schematic)	
◒	f. Channel spacing (avg. in ft.)	Main channel
◒	g. **Preliminary** flood susceptibility rating (Section 2.4.1)	CF_1
◒	2. Preliminary Flood Susceptibility Rating of Major Landform Surfaces (Section 2.4.1)	
○	a. Undifferentiated deposits	
○	b. Alluvial fans	
◒	c. Playas (active=a; mantled=m)	a: SF_2; m: Unknown to
○	d. Pediments	
○	e. Sand dunes	
○	f. Terraces (l=lake; r=river)	
	C. ADDITIONAL REMARKS	(a) Flow rate shown may season shown is time (b) Water contains prima Observations are based o

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

3.11.4 Frenchman Flat (Mercury Valley)

Unnamed playa in central portion of Valley

6

Runoff and direct precipitation

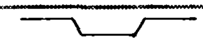
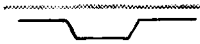
Cane

2/Fall, see Additional Remarks (a)

Fresh, see Additional Remarks (b)

Numerous unnamed streams

Ephemeral

Cane Spring Wash (PR)	Barren Wash (PR)	Numerous unnamed washes (S)
40/5/20	40/5/20	10/1/5
400/50/200	300/50/150	50/5/15
20 to 120	20 to 120	20 to 120
Sand and gravel	Sand and gravel	Primarily sand
		
Main channel	Main channel	1000
CF_1	CF_1	

a: SF_2; m: Unknown to SF_1

(a) Flow rate shown may not be maximum flow rate; season shown is time of sampling.
(b) Water contains primarily bicarbonate, sodium, calcium, sulfate and potassium.

Observations are based on interpretation of topographic maps and aerial photographs.

QUALITY OF DATA	DESCRIPTION			
	A. DEPTH TO GROUNDWATER WITHIN BASIN-FILL MATERIAL IN SITING VALLEY (Map area in nm^2)			
◒	1. 0 to 50 feet	0	0	
◒	a. 0 to 25 feet	0	0	
◒	b. 25 to 50 feet	0	0	
◒	2. 50 to 100 feet	0	0	
●	3. Greater than 100 feet	25	20%	Probably gr
◒	4. Unknown or not Present	102	80%	Unsaturated
	B. AQUIFER CHARACTERISTICS IN VALLEY			
●	1. Type of Aquifer (B=Basin Fill; P=Perched; R=Rock; u=unconfined; c=confined)		Bu	
◒	a. Map area and extent	$340nm^2$ (est.)		
◒	b. Depth to aquifer (ft.)	600 to 1100		
○	c. Thickness (ft.)	150 to 500		
◒	d. Composition	Sand, gravel, clay		
◒	e. Porosity (%)	5 to 10		
○	f. Specific yield (%)			
◒	g. Transmissivity (ft^2/day)	See Additional Remarks (a)		
◒	h. Specific capacity (gpm/ft. of drawdown)	1.12 to 1.4		
○	i. Total pumpage (ac. ft./unit time)			
●	j. Groundwater ownership rights	ERDA		
	C. WATER BUDGET FOR VALLEY			
◒	1. Total Recharge (ac. ft./unit time)	100/year		
◒	2. Total Discharge (ac. ft./unit time)			See Ad
	D. ADDITIONAL REMARKS	(a) Transmissibility values (b) Transmissibility values (c) Downward leakage to the aquifers is less than 10		

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

Probably greater than 700 feet

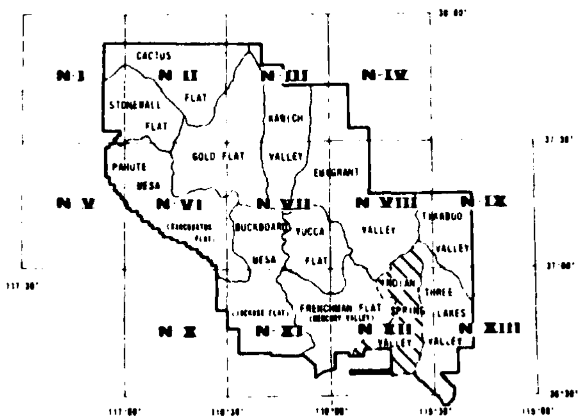
Unsaturated

Bu	Rc	Ru
	600 to 700	800 to greater than 2000
		100 to greater than 750
clay	Volcanic tuff	Fractured limestone and dolomite
l Remarks (a)	See Additional Remarks (b)	6 to 6.0 x 10^6 (average range)
		0.7 to 30

See Additional Remarks (c)

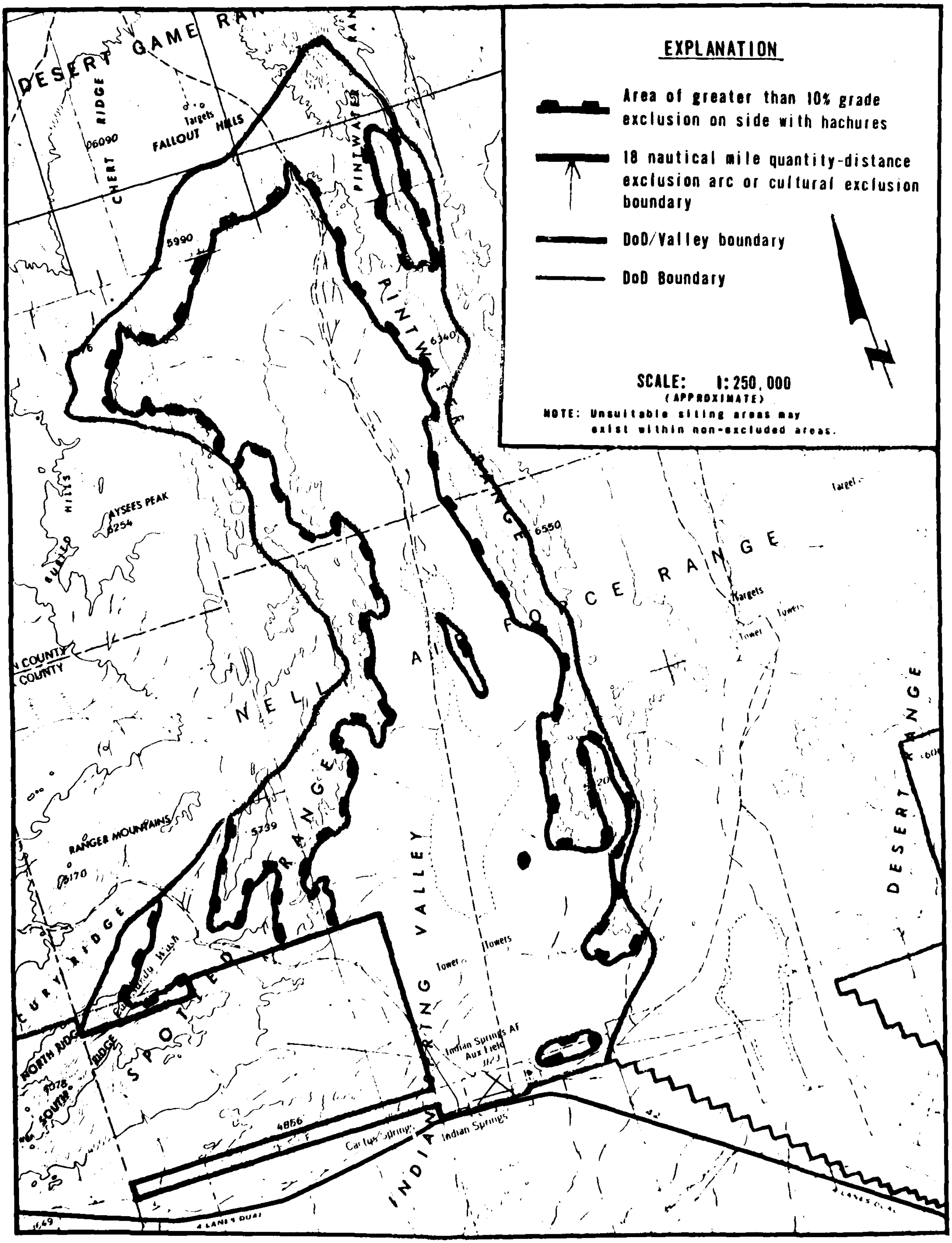
sibility values of 700 to 3400 gpd/ft.
sibility values of 440-880 gpd/ft.
leakage to the underlying carbonate rock
is less than 100 ac. ft./year

INDIAN SPRING VALLEY



VALLEY ANALYSIS	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	

FUGRO NATIONAL, INC.



EXPLANATION
Area of greater than 10% grade exclusion on side with hachures
18 nautical mile quantity-distance exclusion arc or cultural exclusion boundary
DoD/Valley boundary
DoD Boundary
SCALE: 1:250,000
(APPROXIMATE)
NOTE: Unsuitable siting areas may exist within non-excluded areas.
DESERT GAME RANGE
CHERT RIDGE
FALLOUT HILLS
Targets
PINTWATER RANGE
NELLIS AIR FORCE RANGE
AYSEES PEAK
6254
BURIED HILLS
RANGER MOUNTAINS
SPOTTED RANGE
INDIAN SPRING VALLEY
DESERT RANGE
NORTH RIDGE
SOUTH RIDGE
Indian Springs AF Aux Field
Indian Springs
Cactus Springs
Tower
Towers
Targets
Target
5990
6340
6550
5739
6170
6090
4856
4 LANES DUAL

QUALITY OF DATA	DESCRIPTION		
	A. VALLEY AREA, OWNERSHIP AND LAND UTILIZATION		
●	1. Area of Valley	271nm^2	100%
●	a. Area of valley excluded by major cultural or quantity-distance exclusions and 10% grade exclusion	133nm^2	49%
●	2. Area of Siting Valley (A.1 minus A.1.a)	138nm^2	51%
●	3. Ownership	DoD, U.S. Air Force, Nelli	
●	a. Portion of siting valley with direct DoD ownership	138nm^2	100%
●	b. Co-owners or administrators of co-use land/ constraints	Entire Valley (Desert Natio supervised by U.S. Fish and	
◓	4. Contiguous BLM or Co-Use Land (area in nm^2)	500	BLM (Las Vegas Val
●	a. Relative location in or adjacent to valley	Adjacent to Valley south	
◓	b. Present use	Limited agriculture	
	B. CULTURAL AND QUANTITY-DISTANCE EXCLUSIONS		
●	1. Location of 18 nm Arc (population greater than 25,000)	None	
●	2. Location of 3 nm Arc (population greater than 5,000)	None	
●	3. Other	None	
	C. CULTURAL IMPROVEMENTS		
●	1. Roads/Railroads (name)	Highway 95	
●	a. Relative location in valley	Passes east-west through	
●	b. Type and use	Improved; public road	
●	2. Utilities (type)	Telephone and electrical	
●	a. Relative location in valley	South end of siting valle	
●	D. MILITARY/GOVERNMENTAL USE AREAS	Individual unnamed target	
●	1. Location and areal extent (nm^2)	Located throughout Valley	
●	2. Present use	Target practice	
●	3. Future use	Target practice	
●	4. Decontamination necessary prior to siting	Removal of unexploded 20	
	E. ADDITIONAL REMARKS		

Quality of Data

● Data derived from detailed studies

◓ Estimated values

○ Insufficient data available

	$271nm^2$	100%	
	$133nm^2$	49%	
	$138nm^2$	51%	
	DoD, U.S. Air Force, Nellis AFB		
	$138nm^2$	100%	
	Entire Valley (Desert National Wildlife Range) supervised by U.S. Fish and Wildlife Service		
	500	BLM (Las Vegas Valley)	
	Adjacent to Valley south of DoD boundary		
	Limited agriculture		
er	None		
	None		
	None		
	Highway 95	Unnamed roads and jeep trails	
	Passes east-west through town of Indian Springs	Randomly transect Valley	
	Improved; public road	Unimproved; restricted civilian	
	Telephone and electrical lines service Indian Springs AFAF		
	South end of siting valley		
	Individual unnamed targets		
	Located throughout Valley		
	Target practice		
	Target practice		
ig	Removal of unexploded 20 to 50 mm shells and 25 lb. bombs		

QUALITY OF DATA	DESCRIPTION			
	A. TOPOGRAPHIC GRADIENT IN SITING VALLEY			
●	1. Area with Less than 10% Grade	138nm^2	100%	
●	2. Area with 5 to 10% Grade	43nm^2	31%	
●	3. Area with 0 to 5% Grade	95nm^2	69%	
●	4. Location of Alluvial Passes or Valley Boundaries Having Less than 10% Grade	Southern portion of Vall		
	B. ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
●	1. Exposed Rock (category/symbol/lithology)	B/S_{MP}/limestone, dolomit		
●	a. Location and map area in nm^2	15	11%	Locate
○	b. Seismic velocity (p/s in fps)			
	c. Conditions of volcanic flow	N/A		
◒	2. Pediments (rock type)	B; dolomite, limestone,		
◒	a. Location and map area in nm^2	10	7%	On east
○	b. Exposure condition			
◒	c. Distance into siting valley from rock exposures (max./min./avg.) (nm)	1.5/0.25/1.0		
	C. SUBSURFACE ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
	1. Depth to Rock (map area in nm^2)			
○	a. 0 to 250 feet (excluding pediments)			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	b. 250 to 500 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	c. 500 to 1000 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	d. Greater than 1000 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	e. Unknown	113	82%	

Quality of Data

● Data derived from detailed studies

◒ Estimated values

○ Insufficient data available

2	100%	
2	31%	
2	69%	

ern portion of Valley connects with Three Lakes Valley across alluvial pass.

/limestone, dolomite, quartzite

	11%	Located along flanks of Spotted and Pintwater Ranges

lomite, limestone, quartzite

	7%	On eastern flank of Spotted Range, western and southern flanks of Pintwater Ranges

.25/1.0

	82%	

QUALITY OF DATA	DESCRIPTION		
◓	2. Rock (Section 2.2.3) in Basin-Fill Deposits (map area in nm^2)		
○	a. Type		
○	b. Depth to (ft.)		
○	c. Thickness (ft.)		
○	d. Seismic velocity (p/s in fps)		
	D. BASIN-FILL DEPOSITS IN SITING VALLEY		
◓	1. Undifferentiated Deposits (A; map area in nm^2)	1	<1%
○	a. Thickness (max./min./avg. in ft.)		
○	b. Lithology		
○	c. Seismic velocity (p/s in fps)		
●	2. Alluvial Fan Deposits (A_5; map area in nm^2)	73	53%
○	a. Thickness (max./min./avg. in ft.)		
◓	b. Lithology	Gravel, sand, si	
○	c. Seismic velocity (p/s in fps)		
●	3. Playa Deposits (A_4; map area in nm^2)	12	9%
◓	a. Thickness (max./min./avg. in ft.)	50/1/	
◓	b. Lithology	Clay, silt, fine	
○	c. Seismic velocity (p/s in fps)		
●	4. Wind-blown Sand (A_3; map area in nm^2)	1	<1%
○	a. Thickness (max./min./avg. in ft.)		
◓	b. Lithology	Silty sand	
○	c. Seismic velocity (p/s in fps)		
◓	5. Pediment Deposits (A_6; map area in nm^2)	10	7%
◓	a. Thickness (max./min./avg. in ft.)	10/	
◓	b. Lithology	Sand, gravel, m	
○	c. Seismic velocity (p/s in fps)		
●	6. Stream Channel and Floodplain Deposits (A_1; map area in nm^2)	11	8%
◓	a. Thickness (max./min./avg. in ft.)	/1/5	
◓	b. Lithology	Sand and gravel	
○	c. Seismic velocity (p/s in fps)		

Quality of Data

● Data derived from detailed studies

◓ Estimated values

○ Insufficient data available

N			
Deposits			Basalt flows may be present beneath the surface
area	1	<1%	
a in nm2)	73	53%	
	Gravel, sand, silt, clay		
m2)	12	9%	Mantled playa deposits ($A4_{QM}$) | 15 | 11%
	50/1/		5/1/
	Clay, silt, fine sand		Fine sand, silty sand
nm2)	1	<1%	
	Silty sand		
n nm2)	10	7%	
	10/		
	Sand, gravel, may be calichified		
osits	11	8%	
	/1/5		
	Sand and gravel		

QUALITY OF DATA	DESCRIPTION		
●	7. Terrace Deposits (A_2; map area in nm^2)	0	0
	a. Thickness (max./min./avg. in ft.)	N/A	
	b. Lithology	N/A	
	c. Seismic velocity (p/s in fps)	N/A	
◒	8. General Summary of Relationships	At least 700 feet of b	
	E. TECTONIC FRAMEWORK OF SITING VALLEY		
◒	1. Capable or Potentially Capable Fault	Unnamed fault on west	
◒	a. Total length (nm)	5	
◒	b. Relative location	East side of Valley	
●	c. Type of faulting, regional and local attitudes (strike and dip)	Dip-slip; strike N5°W	
○	d. Minimum age of displacement or seismic activity (y.b.p.)		
●	2. Volcanism		
●	a. Volcanic flows	No major Quaternary ba	
	1) Location and map area in nm^2	N/A	
	2) Minimum age of volcanic activity (y.b.p.)	N/A	
	F. SEISMICITY OF SITING VALLEY (Regional seismicity discussed in Section 2.2.4 of text)		
○	1. Relative Pre-Instrumental Historic Activity (Section 2.2.4)		
◒	2. Site Area Seismic Activity (instrumental, 1927-1973; Section 2.2.4)		
●	a. Events (epicenters) greater than M=6.0	None	
●	b. Events (epicenters) greater than M=1.0 and less than M=6.0	One event less than M=	
○	c. Events less than M=1.0 (includes microearthquakes)		
◒	3. Maximum Reported Modified Mercalli Intensity	VII	
◒	4. Source of Possible Ground Acceleration Levels (Section 2.2.4)	Las Vegas Valley Shear Zone	Deat Cree
◒	a. Maximum credible level (g)		0.25
◒	b. Most probable level (g)	0.15-0.6	0.1-
	G. Additional Remarks		

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

0	0	

N/A

N/A

N/A

At least 700 feet of basin-fill materials is known in central portion of Valley

Unnamed fault on west side of Pintwater Range (potentially capable)

5

East side of Valley

Dip-slip; strike N5°W

No major Quaternary basalt flows are present at surface

N/A

N/A

None

One event less than M=4.0

VII

Las Vegas Valley Shear Zone	Death Valley-Furnace Creek Shear Zone	Jerome-Wasatch Structural Zone	Nuclear Blast (1.2 Megaton)	Yucca Fault
	0.25			
0.15-0.6	0.1-0.2	0.05	0.1-0.4	0.1-0.4

SOILS ENGINEERING PROPERTIES[1]	35	36
Unified soil classification[2]	(GM-SM)	(GM-SM)
AASHO soil classification	(A-1 or A-2)	(A-1 or A-2)
Percent passing #4 sieve		
Percent passing #40 sieve		
Percent passing #200 sieve		
Liquid limit/plasticity index		
Surface consistency		
Dry density (pcf)		110
Permeability (cm/sec)		
In-situ shear strength (psi)		
In-situ angle of internal friction (degrees)		
Cohesion (psi)		
Shrink-swell potential		
Coefficient of compressibility (in^2/lb.)		
In-situ CBR		
Recompacted CBR		
General surface moisture condition		
Compressional wave velocities (fps)		2000 to 3500
Shear wave velocities (fps)		
Deleterious substances	Caliche present in some areas	Caliche may be present
ENGINEERING DESIGN EVALUATIONS[1]		
Suitability as impermeable membrane when recompacted	(Poor)	(Poor)
Suitability as source of sand/fill material	(Fair)/ Good	(Fair)/ Good
Suitability as source of aggregate/base course	(Fair)/ Good	(Fair)/ Fair
Near surface foundation design characteristics	(High strength) (Low comp.)	(Mod. strength)
Excavation limitations and slope angle	Sloughing and/or difficult ripping	Sloughing
Additional Remarks	Boulders may be present; (A5o; A5i; A5u)	(A5y)

Explanation

(blank box)	No literature available and data not extrapolated
(SP-SM)	No literature available and data extrapolated
SP-SM	Data available in literature

(1) Surface soils only, depth of less than 5 feet
(2) Related geologic unit(s) shown in Additional Remarks (e.g. Al_Q)

36	37	38	39	41	42
(GM-SM)	(GM-SM)	(SP-SM)	(GM,GP,SM,SP ML,CL)	(GP,SP,SM,ML)	ML-CL
(A-1 or A-2)	(A-1 or A-2)	(A-2)	(A-1,A-2,A-4 or A-6)	(A-1,A-2 or A-4)	A-4 or A-6
110					
2000 to 3500					
Caliche may be present				(Poor)	(Fair)
(Poor)	(Poor)	(Poor)	(Poor)	(Poor)	(Fair)
(Fair)/ Good	(Fair)/(Fair)	(Good)/(Good)	(Poor)/(Fair)	(Good)/ Good	N.A./(Poor)
(Fair)/ Fair	(Fair)/Fair)	(Poor)/(Fair)	(Poor)/(Fair)	(Fair)/ Good	N.A./(Poor)
(Mod. strength)	(High strength) (Low comp.)	(Mod. strength) (Mod. comp.)	(Mod. strength) (Mod. expan.)	(Mod. strength) (Mod. comp.)	(Low strength) (High comp.)
Sloughing	Difficult ripping or blasting	Severe sloughing			(>60°)
(A5y)	Depth to rock less than 10 feet; (A6)	(A3s$_Q$)	(A$_Q$)	(A1$_Q$)	(A4$_Q$)

SOILS ENGINEERING
3.12.3 Indian Spring Valley

1	42	43
,ML)	ML-CL	(GM,SM,ML,CL)
or A-4)	A-4 or A-6	(A-2,A-4 or A-6)
	(Fair)	(Fair)
	(Fair)	(Fair)
Good	N.A./(Poor)	N.A./(Fair)
Good	N.A./(Poor)	N.A./(Poor)
rength)	(Low strength)	(Low strength)
p.)	(High comp.)	(Mod. comp.)
	($>60^{\circ}$)	($>60^{\circ}$)
	($A4_Q$)	$A4m_Q$)

QUALITY OF DATA	DESCRIPTION	
	A. SURFACE WATER IN SITING VALLEY	
●	1. Playas; Intermittent and Perennial Lakes	Unnamed playa in cent
○	a. Duration of surface water (wks.)	
●	b. Maximum extent (nm^2)	12
○	c. Water depth (avg. in ft.)	
●	d. Source of water	Runoff and direct pre
○	e. Water quality	
●	2. Springs	Indian; see Additional
◒	a. Duration of flow (wks.)	Perennial
◒	b. Estimated maximum flow rate (gpm/season)	430/Summer
◒	c. Water quality	Fresh; see Additional
●	3. Rivers or Streams	Several unnamed strea
◒	a. Rate (gpm) and duration of flow (wks.)	Ephemeral
○	b. Water quality	
	B. HYDROLOGIC CHARACTERISTICS OF SITING VALLEY	
●	1. Drainage Channel (PR=Primary; S=Secondary)	Unnamed wash (PR)
◒	a. Depth of incision (max./min./avg.; ft.)	40/5/20
◒	b. Width (max./min./avg.; ft.)	200/5/100
◒	c. Gradient (ft./mi.)	20 to 120
◒	d. Channel bottom characteristics	Sand and gravel
◒	e. Channel cross-section (schematic)	
◒	f. Channel spacing (avg. in ft.)	Main channel
◒	g. Preliminary flood susceptibility rating (Section 2.4.1)	CF_1
◒	2. Preliminary Flood Susceptibility Rating of Major Landform Surfaces (Section 2.4.1)	
○	a. Undifferentiated deposits	
○	b. Alluvial fans	
◒	c. Playas (active=a; mantled=m)	a: SF_2; m: Unknown
○	d. Pediments	
○	e. Sand dunes	
○	f. Terraces (l=lake; r=river)	
	C. ADDITIONAL REMARKS	(a) Indian Spring is supplies water t (b) Water contains p Observations are base topographic maps and

Quality of Data

● Data derived from detailed studies

◒ Estimated values

○ Insufficient data available

Unnamed playa in central portion of Valley

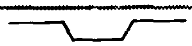
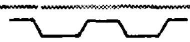
12

Runoff and direct precipitation

Indian; see Additional Remarks (a)	Tin	Sand	Quartz
Perennial			
430/Summer			
Fresh; see Additional Remarks (b)			

Several unnamed streams

Ephemeral

Unnamed wash (PR)	Numerous unnamed washes (S)
40/5/20	10/1/5
200/5/100	50/5/15
20 to 120	20 to 120
Sand and gravel	Primarily sand
	
Main channel	1000
CF_1	

of

a: SF_2; m: Unknown to SF_1

(a) Indian Spring is located 1.5nm south of DoD boundary and supplies water to Indian Springs AFAF.
(b) Water contains primarily bicarbonate, sodium, calcium and magnesium.

Observations are based on a brief aerial reconnaissance and interpretation of topographic maps and aerial photographs.

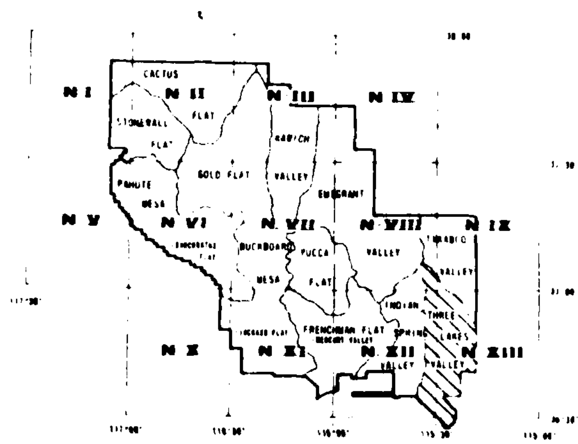
B. AQUIFER CHARACTERISTICS IN VALLEY	
1. Type of Aquifer (B=Basin Fill; P=Perched; R=Rock; u=unconfined; c=confined)	Bu
a. Map area and extent	490nm^2 (est.)
b. Depth to aquifer (ft.)	650 (est.)
c. Thickness (ft.)	
d. Composition	
e. Porosity (%)	5 to 10
f. Specific yield (%)	
g. Transmissivity (ft.^{2}/day)	
h. Specific capacity (gpm/ft. of drawdown)	
i. Total pumpage (ac. ft./unit time)	
j. Groundwater ownership rights	NBGR and U.S. Fish and Wildlife Service

100%	Unknown. Estimated depth of 50 feet at Indian Springs and greater than 650 feet in central portion of Valley. Data inadequate for contours.

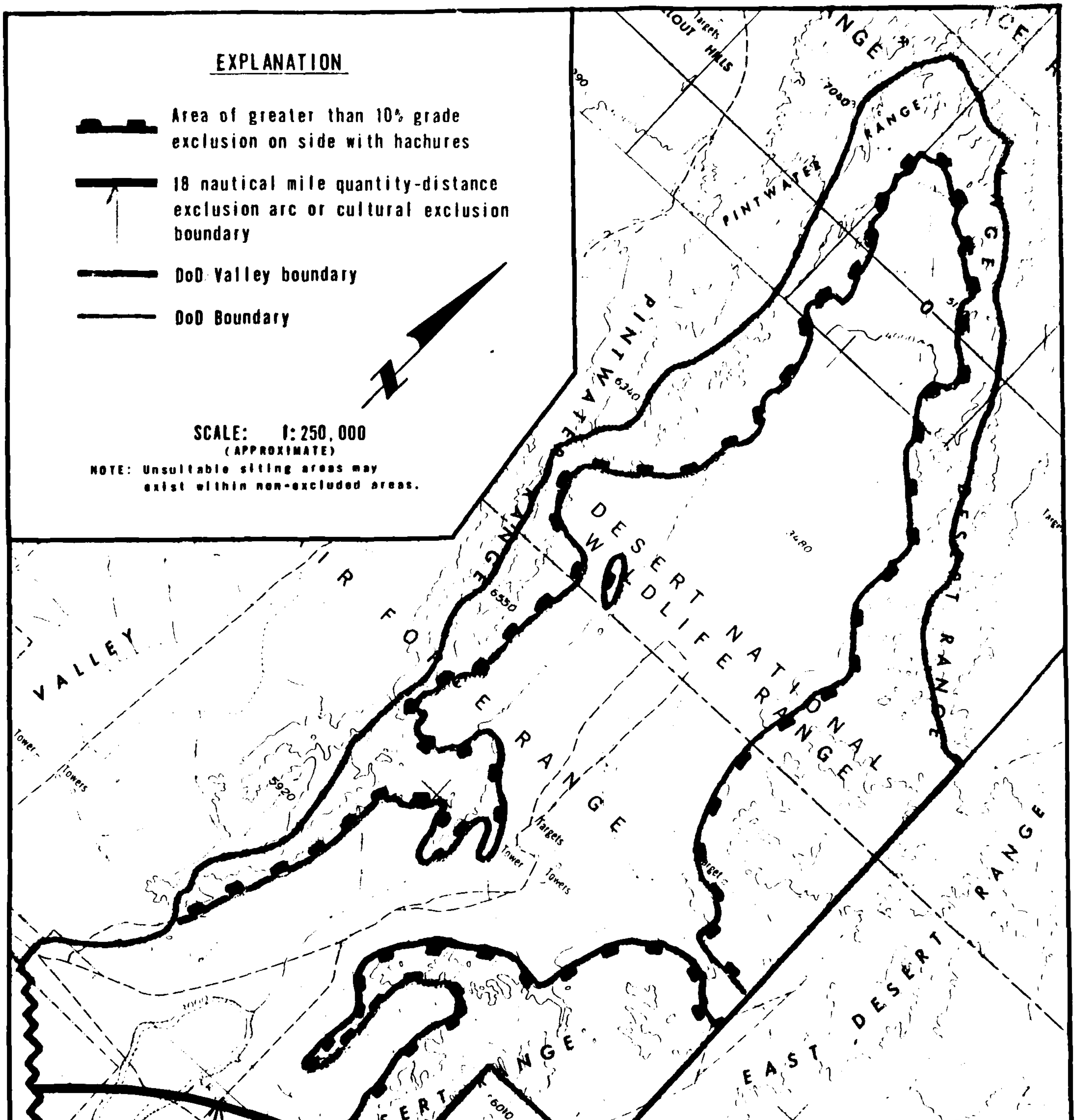
Bu	Ru
est.)	
st.)	Greater than 1000(est.)
	Greater than 1100
	Primarily carbonate rocks
	5 to 10
	See Additional Remarks (a)
	4.8-6.0
d U.S. Fis[illegible] and e Service	
/year	

ffective transmissibilities of two wells in Valley
ow 10,000 to 20,000 gpd/ft.

THREE LAKES
VALLEY



VALLEY ANALYSIS	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	
FUGRO NATIONAL, INC.	



EXPLANATION
Area of greater than 10% grade exclusion on side with hachures
18 nautical mile quantity-distance exclusion arc or cultural exclusion boundary
DoD Valley boundary
DoD Boundary
SCALE: 1:250,000
(APPROXIMATE)
NOTE: Unsuitable siting areas may exist within non-excluded areas.
VALLEY
PINTWATER RANGE
DESERT NATIONAL WILDLIFE RANGE
DESERT RANGE
EAST DESERT RANGE
FROM LAS VEGAS
Targets
Tower
Towers
5920
6350
6010

OWNE

QUALITY OF DATA	DESCRIPTION		
	A. VALLEY AREA, OWNERSHIP AND LAND UTILIZATION		
●	1. Area of Valley	336nm^2	100%
●	a. Area of valley excluded by major cultural or quantity-distance exclusions and 10% grade exclusion	172nm^2	51%
●	2. Area of Siting Valley (A.1 minus A.1.a)	164nm^2	49%
●	3. Ownership	DoD, U.S. Air Force, Nell	
●	a. Portion of siting valley with direct DoD ownership	164nm^2	100%
●	b. Co-owners or administrators of co-use land/ constraints	Entire Valley (Desert Nat supervised by U.S. Fish a	
◐	4. Contiguous BLM or Co-Use Land (area in nm^2)	500	BLM (Las Vegas W
●	a. Relative location in or adjacent to valley	Adjacent to Valley south	
◐	b. Present use	Limited agriculture	
	B. CULTURAL AND QUANTITY-DISTANCE EXCLUSIONS		
●	1. Location of 18 nm Arc (population greater than 25,000)	Southern portion of Valle	
●	2. Location of 3 nm Arc (population greater than 5,000)	None	
●	3. Other	None	
	C. CULTURAL IMPROVEMENTS		
◐	1. Roads/Railroads (name)	Unnamed roads and jeep tr	
◐	a. Relative location in valley	Randomly transect Valley	
●	b. Type and use	Unimproved; military and	
●	2. Utilities (type)	None	
	a. Relative location in valley	N/A	
●	**D. MILITARY/GOVERNMENTAL USE AREAS**	Individual unnamed targe	
●	1. Location and areal extent (nm^2)	Located throughout Valle	
●	2. Present use	Target practice	
●	3. Future use	Target practice	
●	4. Decontamination necessary prior to siting	Removal of unexploded 20	
	E. ADDITIONAL REMARKS		

Quality of Data

- ● Data derived from detailed studies
- ◐ Estimated values
- ○ Insufficient data available

OWNERSHIP AND CULTURAL FEATURES
3.13.1 Three Lakes Valley

	$336nm^2$	100%	
	$172nm^2$	51%	
	$164nm^2$	49%	
	DoD, U.S. Air Force, Nellis AFB		
	$164nm^2$	100%	
	Entire Valley (Desert National Wildlife Range) supervised by U.S. Fish and Wildlife Service		
	500	BLM (Las Vegas Valley)	
	Adjacent to Valley south of DoD boundary		
	Limited agriculture		
	Southern portion of Valley from Las Vegas, Nevada		
	None		
	None		
	Unnamed roads and jeep trails		
	Randomly transect Valley		
	Unimproved; military and restricted civilian		
	None		
	N/A		
	Individual unnamed targets		
	Located throughout Valley		
	Target practice		
	Target practice		
g	Removal of unexploded 20 to 55 mm shells and 25 lb. bombs		

QUALITY OF DATA	DESCRIPTION			
	A. TOPOGRAPHIC GRADIENT IN SITING VALLEY			
●	1. Area with Less than 10% Grade	$164nm^2$	100%	
●	2. Area with 5 to 10% Grade	$46nm^2$	28%	
●	3. Area with 0 to 5% Grade	$118nm^2$	72%	
●	4. Location of Alluvial Passes or Valley Boundaries Having Less than 10% Grade	Southern portion of Vall		
	B. ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
●	1. Exposed Rock (category/symbol/lithology)	B/S_{MP}/limestone, dolomit		
●	a. Location and map area in nm^2	13	8%	Along
○	b. Seismic velocity (p/s in fps)			
	c. Conditions of volcanic flow	N/A		
◒	2. Pediments (rock type)	B; limestone, dolomite,		
◒	a. Location and map area in nm^2	10	6%	On eas
○	b. Exposure condition			
◒	c. Distance into siting valley from rock exposures (max./min./avg.) (nm)	3.0/0.5/1.5		
	C. SUBSURFACE ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
	1. Depth to Rock (map area in nm^2)			
○	a. 0 to 250 feet (excluding pediments)			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	b. 250 to 500 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	c. 500 to 1000 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	d. Greater than 1000 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	e. Unknown	141	86%	

Quality of Data

- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

$164nm^2$	100%	
$46nm^2$	28%	
$118nm^2$	72%	

Southern portion of Valley connects with Indian Springs Valley

B/S_{MP}/limestone, dolomite, quartzite

13	8%	Along flanks of Pintwater and Desert Ranges

N/A

B; limestone, dolomite, quartzite

10	6%	On eastern flank of Pintwater Range

3.0/0.5/1.5

141	86%	

QUALITY OF DATA	DESCRIPTION			
◒	2. Rock (Section 2.2.3) in Basin-Fill Deposits (map area in nm^2)			Ba
○	a. Type			
○	b. Depth to (ft.)			
○	c. Thickness (ft.)			
○	d. Seismic velocity (p/s in fps)			
	D. BASIN-FILL DEPOSITS IN SITING VALLEY			
◒	1. Undifferentiated Deposits (A; map area in nm^2)	2	1%	
○	a. Thickness (max./min./avg. in ft.)			
○	b. Lithology			
○	c. Seismic velocity (p/s in fps)			
●	2. Alluvial Fan Deposits (A_5; map area in nm^2)	96	59%	
◒	a. Thickness (max./min./avg. in ft.)	Approximately 200/		
◒	b. Lithology	Poorly sorted, het		
○	c. Seismic velocity (p/s in fps)			
●	3. Playa Deposits (A_4; map area in nm^2)	17	10%	
◒	a. Thickness (max./min./avg. in ft.)	200/50/		
◒	b. Lithology	Silt, clay and fin		
○	c. Seismic velocity (p/s in fps)			
●	4. Wind-blown Sand (A_3; map area in nm^2)	0	0	
	a. Thickness (max./min./avg. in ft.)	N/A		
	b. Lithology	N/A		
	c. Seismic velocity (p/s in fps)	N/A		
◒	5. Pediment Deposits (A_6; map area in nm^2)	10	6%	
◒	a. Thickness (max./min./avg. in ft.)	10/0/5		
◒	b. Lithology	Sand, gravel, loca		
○	c. Seismic velocity (p/s in fps)			
●	6. Stream Channel and Floodplain Deposits (A_1; map area in nm^2)	19	12%	
◒	a. Thickness (max./min./avg. in ft.)	Approximately 25 f		
◒	b. Lithology	Gravel and sand, w		
○	c. Seismic velocity (p/s in fps)			

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

Basalt flows may be present beneath the surface

2 | 1%

96 | 59%

Approximately 200/ /

Poorly sorted, heterogeneous mixtures of boulders, gravel, sand, silt, and clay

17 | 10%

200/50/

Silt, clay and fine-grained sand

Mantled playa deposits (A4m) | 7 | 4%

Gravel, sand, silt [illegible] lay

0 | 0

N/A

N/A

N/A

10 | 6%

10/0/5

Sand, gravel, locally cemented with caliche

19 | 12%

Approximately 25 feet/ /

Gravel and sand, well sorted

QUALITY OF DATA	DESCRIPTION		
●	7. Terrace Deposits (A_2; map area in nm^2)	0	0
	a. Thickness (max./min./avg. in ft.)	N/A	
	b. Lithology	N/A	
	c. Seismic velocity (p/s in fps)	N/A	
◒	8. General Summary of Relationships	At least 300 feet of b	
	E. TECTONIC FRAMEWORK OF SITING VALLEY		
◒	1. Capable or Potentially Capable Fault	Unnamed fault bounding	
◒	a. Total length (nm)	13	
●	b. Relative location	Northern end of Valley	
●	c. Type of faulting, regional and local attitudes (strike and dip)	Dip-slip; strike N20°W	
○	d. Minimum age of displacement or seismic activity (y.b.p.)		
●	2. Volcanism		
●	a. Volcanic flows	No major Quaternary ba	
	1) Location and map area in nm^2	N/A	
	2) Minimum age of volcanic activity (y.b.p.)	N/A	
	F. SEISMICITY OF SITING VALLEY (Regional seismicity discussed in Section 2.2.4 of text)		
○	1. Relative Pre-Instrumental Historic Activity (Section 2.2.4)		
◒	2. Site Area Seismic Activity (instrumental, 1927-1973; Section 2.2.4)		
●	a. Events (epicenters) greater than M=6.0	None	
●	b. Events (epicenters) greater than M=1.0 and less than M=6.0	Four events less than	
○	c. Events less than M=1.0 (includes microearthquakes)		
◒	3. Maximum Reported Modified Mercalli Intensity	VI	
◒	4. Source of Possible Ground Acceleration Levels (Section 2.2.4)	Las Vegas Valley Shear Zone	Dea Cre
◒	a. Maximum credible level (g)		0.3
◒	b. Most probable level (g)	0.2-0.6	0.1
	G. Additional Remarks		

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

	0	0			
	N/A				
	N/A				
	N/A				
	At least 300 feet of basin-fill materials known to exist in central portion of Valley				
	Unnamed fault bounding east side of Pintwater Range (potentially capable)				
	13				
	Northern end of Valley				
	Dip-slip; strike N20°W				
	No major Quaternary basalt flows are present at surface				
	N/A				
	N/A				
	None				
	Four events less than M=4.0				
)					
	VI				
s	Las Vegas Valley Shear Zone	Death Valley-Furnace Creek Fault Zone	Jerome-Wasatch Structural Zone	Nuclear Blast (1.2 Megaton)	Yucca Fault
		0.3			
	0.2-0.6	0.1-0.2	0.05	0.1-0.3	0.1-0.3

SOILS ENGINEERING PROPERTIES (1)	35	36
Unified soil classification (2)	(GM-SM)	(GM-SM)
AASHO soil classification	(A-1 or A-2)	(A-1 or A-2)
Percent passing #4 sieve		
Percent passing #40 sieve		
Percent passing #200 sieve		
Liquid limit/plasticity index		
Surface consistency		
Dry density (pcf)		110
Permeability (cm/sec)		
In-situ shear strength (psi)		
In-situ angle of internal friction (degrees)		
Cohesion (psi)		
Shrink-swell potential		
Coefficient of compressibility (in^2/lb.)		
In-situ CBR		
Recompacted CBR		
General surface moisture condition		
Compressional wave velocities (fps)		2000 to 3500
Shear wave velocities (fps)		
Deleterious substances	Caliche present in some areas	Caliche may be present
ENGINEERING DESIGN EVALUATIONS (1)		
Suitability as impermeable membrane when recompacted	(Poor)	Poor
Suitability as source of sand/fill material	(Fair)/ Good	(Fair)/ Good
Suitability as source of aggregate/base course	(Fair)/ Good	(Fair)/ Fair
Near surface foundation design characteristics	(High strength) (Low comp.)	(Mod. strength)
Excavation limitations and slope angle	Sloughing and/or difficult ripping	Sloughing
Additional Remarks	Boulders may be present; (A5o; A5i; A5u)	(A5y)

Explanation

[ ]	No literature available and data not extrapolated
(SP-SM)	No literature available and data extrapolated
SP-SM	Data available in literature

(1) Surface soils only, depth of less than 5 feet

(2) Related geologic unit(s) shown in Additional Remarks (e.g. Al_Q)

	36	37	41	42	43
	(GM-SM)	(GM-SM)	(GP,SP,SM,ML)	ML-CL	(GM,SM,ML,CL)
	(A-1 or A-2)	(A-1 or A-2)	(A-1,A-2 or A-4)	A-4 or A-6	(A-2,A-4 or A-6)
	110				
	2000 to 3500				
t	Caliche may be present				
	Poor	(Poor)	(Poor)	(Fair)	(Fair)
	(Fair)/ Good	(Fair)/(Fair)	(Good)/ Good	N.A./(Poor)	N.A./(Poor)
	(Fair)/ Fair	(Fair)/(Fair)	(Fair)/(Good)	N.A./(Poor)	N.A./(Poor)
)	(Mod. strength)	(High strength) (Low comp.)	(Mod. strength) (Mod. comp.)	(Low strength) (High comp.)	(Low strength) (Mod. comp.)
/or ing	Sloughing	Difficult ripping or blasting		($>60^{o}$)	($>60^{o}$)
e)	(A5y)	Depth to rock less than 10 feet; (A6)	($A1_Q$)	($A4_Q$)	($A4m_Q$)

QUALITY OF DATA	DESCRIPTION			
	A. DEPTH TO GROUNDWATER WITHIN BASIN-FILL MATERIAL IN SITING VALLEY (Map area in nm^2)			
○	1. 0 to 50 feet			
○	a. 0 to 25 feet			
○	b. 25 to 50 feet			
○	2. 50 to 100 feet			
○	3. Greater than 100 feet			
◒	4. Unknown or not Present	164	100%	Unkno porti
	B. AQUIFER CHARACTERISTICS IN VALLEY			
●	1. Type of Aquifer (B=Basin Fill; P=Perched; R=Rock; u=unconfined; c=confined)			Bu
◒	a. Map area and extent	450 nm^2 (est.)		
◒	b. Depth to aquifer (ft.)	100 to 300		
○	c. Thickness (ft.)			
◒	d. Composition			
○	e. Porosity (%)			
◒	f. Specific yield (%)	5 to 10		
○	g. Transmissivity (ft.^{2}/day)			
○	h. Specific capacity (gpm/ft. of drawdown)			
○	i. Total pumpage (ac. ft./unit time)			
●	j. Groundwater ownership rights	NBGR/U.S. Fish and Wil		
	C. WATER BUDGET FOR VALLEY			
◒	1. Total Recharge (ac. ft./unit time)	8,000/year		
○	2. Total Discharge (ac. ft./unit time)			
	D. ADDITIONAL REMARKS			

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

164	100%	Unknown. Estimated depth between 100 and 300 feet in central portion of Valley. Data inadequate for contouring.

Bu	Rc
450 nm^2 (est.)	
100 to 300	200 to 1200
	Primarily carbonate rocks
5 to 10	5 to 10
NBGR/U.S. Fish and Wildlife Service	
8,000/year	1,900/year

QUALITY OF DATA	DESCRIPTION		
	A. SURFACE WATER IN SITING VALLEY	Unnamed playas in north portion of Valley	
●	1. Playas; Intermittent and Perennial Lakes		
○	a. Duration of surface water (wks.)		
●	b. Maximum extent (nm^2)	9	
○	c. Water depth (avg. in ft.)		
●	d. Source of water	Runoff and direct precipi	
○	e. Water quality		
◒	2. Springs	None	
	a. Duration of flow (wks.)	N/A	
	b. Estimated maximum flow rate (gpm/season)	N/A	
	c. Water quality	N/A	
●	3. Rivers or Streams	Several unnamed streams	
◒	a. Rate (gpm) and duration of flow (wks.)	Ephemeral	
○	b. Water quality		
	B. HYDROLOGIC CHARACTERISTICS OF SITING VALLEY		
●	1. Drainage Channel (PR=Primary; S=Secondary)	Unnamed wash (PR)	Num
◒	a. Depth of incision (max./min./avg.; ft.)	40/5/20	10/1
◒	b. Width (max./min./avg.; ft.)	200/5/100	50/5
◒	c. Gradient (ft./mi.)	20 to 120	20
◒	d. Channel bottom characteristics	Sand and gravel	Pri
◒	e. Channel cross-section (schematic)		
◒	f. Channel spacing (avg. in ft.)	Main channel	100
◒	g. Preliminary flood susceptibility rating (Section 2.4.1)	CF_1	
◒	2. Preliminary Flood Susceptibility Rating of Major Landform Surfaces (Section 2.4.1)		
○	a. Undifferentiated deposits		
○	b. Alluvial fans		
◒	c. Playas (active=a; mantled=m)	a: SF_2; m: Unknown to	
○	d. Pediments		
○	e. Sand dunes		
○	f. Terraces (l=lake; r=river)		
	C. ADDITIONAL REMARKS	Observations are based o topographic maps and aer	

Quality of Data

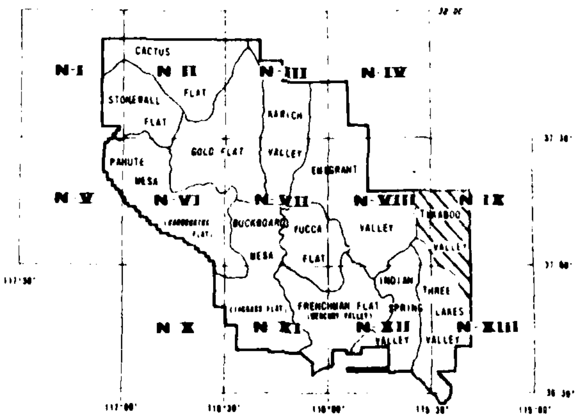
● Data derived from detailed studies

◒ Estimated values

○ Insufficient data available

	Unnamed playas in north portion of Valley	Unnamed playas in central portion of Valley	Unnamed playas in south portion of Valley
	9	1	7
	Runoff and direct precipitation		
	None		
	N/A		
	N/A		
	N/A		
	Several unnamed streams		
	Ephemeral		
	Unnamed wash (PR)	Numerous unnamed washes (S)	
	40/5/20	10/1/5	
	200/5/100	50/5/15	
	20 to 120	20 to 120	
	Sand and gravel	Primarily sand	
	Main channel	1000	
	CF_1		
of			
	a: SF_2; m: Unknown to SF_1		
	Observations are based on a brief aerial reconnaissance and interpretation of topographic maps and aerial photographs.		

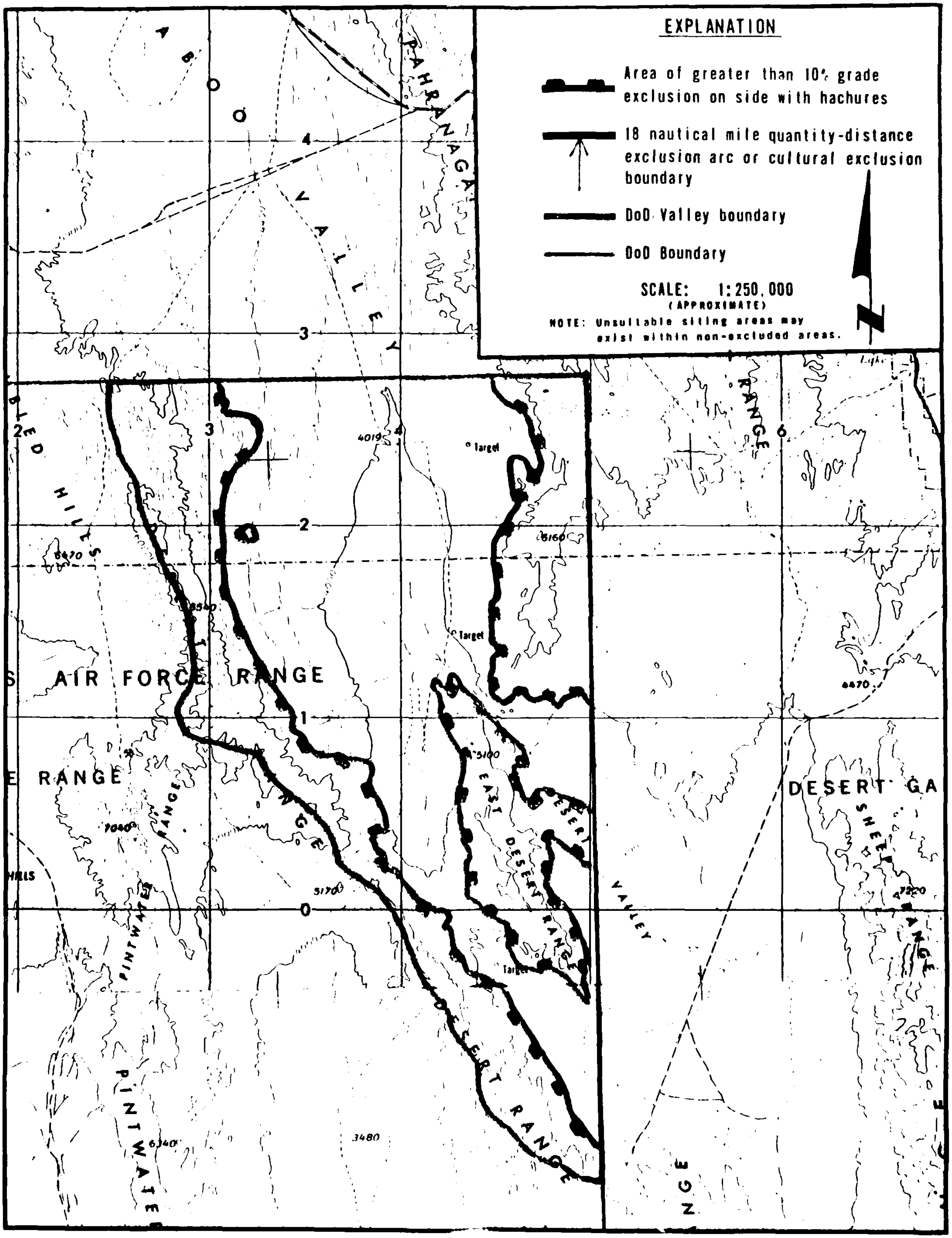
TIKABOO VALLEY



VALLEY ANALYSIS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE   SAMSO

FUGRO NATIONAL, INC.


EXPLANATION
Area of greater than 10% grade exclusion on side with hachures
18 nautical mile quantity-distance exclusion arc or cultural exclusion boundary
DoD Valley boundary
DoD Boundary
SCALE: 1:250,000
(APPROXIMATE)
NOTE: Unsuitable siting areas may exist within non-excluded areas.
AIR FORCE RANGE
PAHRANAGAT
DESERT VALLEY
EAST DESERT RANGE
DESERT RANGE
PINTWATER RANGE
SHEEP RANGE
DESERT GA
Target
4019
5160
8540
5100
7040
5170
3480
6340
4470
7220

QUALITY OF DATA	DESCRIPTION		
	A. VALLEY AREA, OWNERSHIP AND LAND UTILIZATION		
●	1. Area of Valley	189nm^2	100%
●	a. Area of valley excluded by major cultural or quantity-distance exclusions and 10% grade exclusion	96nm^2	51%
●	2. Area of Siting Valley (A.1 minus A.1.a)	93nm^2	49%
●	3. Ownership	DoD, U.S. Air Force,	
●	a. Portion of siting valley with direct DoD ownership	93nm^2	100%
●	b. Co-owners or administrators of co-use land/ constraints	Entire Valley (Desert supervised by U.S. Fi	
◒	4. Contiguous BLM or Co-Use Land (area in nm^2)	200	BLM (Sand Sp
●	a. Relative location in or adjacent to valley	Adjacent to Valley no DoD boundary	
◒	b. Present use	Limited agriculture	
	B. CULTURAL AND QUANTITY-DISTANCE EXCLUSIONS		
●	1. Location of 18 nm Arc (population greater than 25,000)	None	
●	2. Location of 3 nm Arc (population greater than 5,000)	None	
●	3. Other	None	
	C. CULTURAL IMPROVEMENTS		
◒	1. Roads/Railroads (name)	Unnamed roads and jee	
◒	a. Relative location in valley	Randomly transect Val	
●	b. Type and use	Unimproved; military	
●	2. Utilities (type)	None	
	a. Relative location in valley	N/A	
●	**D. MILITARY/GOVERNMENTAL USE AREAS**	Individual unnamed ta	
●	1. Location and areal extent (nm^2)	Located throughout Va	
●	2. Present use	Target practice	
●	3. Future use	Target practice	
●	4. Decontamination necessary prior to siting	Removal of unexploded	
	E. ADDITIONAL REMARKS		

Quality of Data

● Data derived from detailed studies

◒ Estimated values

○ Insufficient data available

OWNERSHIP AND CULTURAL FEATURES
3.14.1 Tikaboo Valley

$189nm^2$	100%		
$96nm^2$	51%		
$93nm^2$	49%		
DoD, U.S. Air Force, Nellis AFB			
$93nm^2$	100%		
Entire Valley (Desert National Wildlife Range) supervised by U.S. Fish and Wildlife Service			
200	BLM (Sand Spring Valley)	250	BLM (Garden Valley)
Adjacent to Valley northwest of DoD boundary		Adjacent to Valley northeast of DoD boundary	
Limited agriculture		Limited agriculture	
None			
None			
None			
Unnamed roads and jeep trails			
Randomly transect Valley			
Unimproved; military and restricted civilian			
None			
N/A			
Individual unnamed targets Located throughout Valley			
Target practice			
Target practice			
Removal of unexploded 20 to 50 mm shells and 25 lb. bombs			

QUALITY OF DATA	DESCRIPTION			
	A. TOPOGRAPHIC GRADIENT IN SITING VALLEY			
●	1. Area with Less than 10% Grade	$93nm^2$	100%	
●	2. Area with 5 to 10% Grade	$20nm^2$	22%	
●	3. Area with 0 to 5% Grade	$73nm^2$	78%	
●	4. Location of Alluvial Passes or Valley Boundaries Having Less than 10% Grade	None		
	B. ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
●	1. Exposed Rock (category/symbol/lithology)	$B/S2_{MP}$/limestone and d		
●	a. Location and map area in nm^2	4	4%	Along
○	b. Seismic velocity (p/s in fps)			
	c. Conditions of volcanic flow	N/A		
◒	2. Pediments (rock type)	B; Dolomite, limestone,		
◒	a. Location and map area in nm^2	5	5%	East
○	b. Exposure condition			
◒	c. Distance into siting valley from rock exposures (max./min./avg.) (nm)	6.0/0.5/2		
	C. SUBSURFACE ROCK CONDITIONS IN SITING VALLEY (BR=Basement, B=Bedrock, VF=Volcanic Flows)			
	1. Depth to Rock (map area in nm^2)			
○	a. 0 to 250 feet (excluding pediments)			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	b. 250 to 500 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	c. 500 to 1000 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	d. Greater than 1000 feet			
○	1) Type			
○	2) Seismic velocity (p/s in fps)			
○	e. Unknown	84	91%	

Quality of Data

● Data derived from detailed studies

◒ Estimated values

○ Insufficient data available

N			
Y			
	$93nm^2$	100%	
	$20nm^2$	22%	
	$73nm^2$	78%	
alley Grade	None		
Flows)			
hology)	$B/S2_{MP}$/limestone and dolomite; $B/S2_T$/limestone; $I2_T$/welded tuff		
	4	4%	Along flanks of Desert Range
	N/A		
	B; Dolomite, limestone, quartzite		
	5	5%	Eastern flank of Desert Range
ck	6.0/0.5/2		
VALLEY Flows)			
	84	91%	

QUALITY OF DATA	DESCRIPTION			
◒	2. Rock (Section 2.2.3) in Basin-Fill Deposits (map area in nm^2)			Bas ben
○	a. Type			
○	b. Depth to (ft.)			
○	c. Thickness (ft.)			
○	d. Seismic velocity (p/s in fps)			
	D. BASIN-FILL DEPOSITS IN SITING VALLEY			
●	1. Undifferentiated Deposits (A; map area in nm^2)	0	0	
	a. Thickness (max./min./avg. in ft.)	N/A		
	b. Lithology	N/A		
	c. Seismic velocity (p/s in fps)	N/A		
●	2. Alluvial Fan Deposits (A_5; map area in nm^2)	76	82%	
○	a. Thickness (max./min./avg. in ft.)			
◒	b. Lithology	Sand, gravel		
○	c. Seismic velocity (p/s in fps)			
●	3. Playa Deposits (A_4; map area in nm^2)	4	4%	
○	a. Thickness (max./min./avg. in ft.)			
◒	b. Lithology	Clay, silt		
○	c. Seismic velocity (p/s in fps)			
●	4. Wind-blown Sand (A_3; map area in nm^2)	0	0	
	a. Thickness (max./min./avg. in ft.)	N/A		
	b. Lithology	N/A		
	c. Seismic velocity (p/s in fps)	N/A		
◒	5. Pediment Deposits (A_6; map area in nm^2)	5	5%	
◒	a. Thickness (max./min./avg. in ft.)	10/0/5		
◒	b. Lithology	Sand, gravel		
○	c. Seismic velocity (p/s in fps)			
●	6. Stream Channel and Floodplain Deposits (A_1; map area in nm^2)	4	5%	
○	a. Thickness (max./min./avg. in ft.)			
◒	b. Lithology	Sand		
○	c. Seismic velocity (p/s in fps)			

Quality of Data

- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

		Basalt flows may be present beneath the surface
0	0	
N/A		
N/A		
N/A		
76	82%	
Sand, gravel		
4	4%	
Clay, silt		
0	0	
N/A		
N/A		
N/A		
5	5%	
10/0/5		
Sand, gravel		
4	5%	
Sand		

QUALITY OF DATA	DESCRIPTION		
●	7. Terrace Deposits (A_2; map area in nm^2)	0	0
	a. Thickness (max./min./avg. in ft.)	N/A	
	b. Lithology	N/A	
	c. Seismic velocity (p/s in fps)	N/A	
◒	8. General Summary of Relationships	Single water well in n	
	E. TECTONIC FRAMEWORK OF SITING VALLEY		
◒	1. Capable or Potentially Capable Fault	Unnamed fault bounding	
◒	a. Total length (nm)	17	
●	b. Relative location	Northwest corner of Va	
●	c. Type of faulting, regional and local attitudes (strike and dip)	Dip-slip; strike N30°	
○	d. Minimum age of displacement or seismic activity (y.b.p.)		
●	2. Volcanism		
●	a. Volcanic flows	No major Quaternary b	
	1) Location and map area in nm^2	N/A	
	2) Minimum age of volcanic activity (y.b.p.)	N/A	
	F. SEISMICITY OF SITING VALLEY (Regional seismicity discussed in Section 2.2.4 of text)		
○	1. Relative Pre-Instrumental Historic Activity (Section 2.2.4)		
◒	2. Site Area Seismic Activity (instrumental, 1927-1973; Section 2.2.4)		
●	a. Events (epicenters) greater than M=6.0	None	
●	b. Events (epicenters) greater than M=1.0 and less than M=6.0	Four events less than	
○	c. Events less than M=1.0 (includes microearthquakes)		
◒	3. Maximum Reported Modified Mercalli Intensity	VI	
◒	4. Source of Possible Ground Acceleration Levels (Section 2.2.4)	Las Vegas Valley Shear Zone	De Cr
◒	a. Maximum credible level (g)		0.
◒	b. Most probable level (g)	0.1-0.2	0.
	G. Additional Remarks		

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

0

water well in northern portion of Valley penetrated 500 feet of basin-fill materials

d fault bounding Desert Range on the east (potentially capable)

est corner of Valley

ip; strike N30°W

or Quaternary basalt flows are present at surface

events less than M=4.0

gas Valley Zone	Death Valley-Furnace Creek Fault Zone	Jerome-Wasatch Structural Zone	Nuclear Blast (1.2 Megaton)	Yucca Fault
	0.2			
.2	0.1	0.05	0.1-0.2	0.1-0.15

SOILS ENGINEERING PROPERTIES (1)	35	36
Unified soil classification (2)	(GM-SM)	(GM-SM)
AASHO soil classification	(A-1 or A-2)	(A-1 or A-2)
Percent passing #4 sieve		
Percent passing #40 sieve		
Percent passing #200 sieve		
Liquid limit/plasticity index		
Surface consistency		
Dry density (pcf)		110
Permeability (cm/sec)		
In-situ shear strength (psi)		
In-situ angle of internal friction (degrees)		
Cohesion (psi)		
Shrink-swell potential		
Coefficient of compressibility (in^2/lb.)		
In-situ CBR		
Recompacted CBR		
General surface moisture condition		
Compressional wave velocities (fps)		2000 to 3500
Shear wave velocities (fps)		
Deleterious substances	Caliche present in some areas	Caliche may be present
ENGINEERING DESIGN EVALUATIONS (1)		
Suitability as impermeable membrane when recompacted	(Poor)	(Poor)
Suitability as source of sand/fill material	(Fair)/ Good	(Fair)/(Good
Suitability as source of aggregate/base course	(Fair)/ Good	(Fair)/(Fair
Near surface foundation design characteristics	(High strength) (Low comp.)	(Mod. strength)
Excavation limitations and slope angle	Sloughing and/or difficult ripping	Sloughing
Additional Remarks	Boulders may be present; (A5o; A5i; A5u)	(A5y)

Explanation

(blank box)	No literature available and data not extrapolated
(SP-SM)	No literature available and data extrapolated
SP-SM	Data available in literature

(1) Surface soils only, depth of less than 5 feet

(2) Related geologic unit(s) shown in Additional Remarks (e.g. Al$_Q$)

	36	37	39	41	42
	(GM-SM)	(GM-SM)	(GM,GP,SM,SP, ML,CL)	(GP,SP,SM,ML)	ML-CL
2)	(A-1 or A-2)	(A-1 or A-2)	(A-1,A-2,A-4 or A-6)	(A-1,A-2 or A-4)	A-4 or A-6
	110				
	2000 to 3500				
esent eas	Caliche may be present				
	(Poor)	(Poor)	(Poor)	(Poor)	(Fair)
od	(Fair)/(Good	(Fair)/(Fair)	(Poor)/(Fair)	(Good)/(Good)	N.A./(Poor)
od	(Fair)/(Fair	(Fair)/(Fair)	(Poor)/(Fair)	(Fair)/(Good)	N.A./(Poor)
ngth))	(Mod. strength)	(High strength) (Low comp.)	(Mod. strength) (Mod. expan.)	(Mod. strength) (Mod. comp.)	(Low strength) (High comp.)
nd/or ripping	Sloughing	Difficult ripping or blasting		60^{o}	($>60^{o}$)
y be A5u)	(A5y)	Depth to rock less than 10 feet; (A6)	(A_Q)	($A1_Q$)	($A4_Q$)

QUALITY OF DATA	DESCRIPTION	
	A. SURFACE WATER IN SITING VALLEY	
●	1. Playas; Intermittent and Perennial Lakes	Unnamed playa in cent
○	a. Duration of surface water (wks.)	
●	b. Maximum extent (nm^2)	4
○	c. Water depth (avg. in ft.)	
●	d. Source of water	Runoff and direct pre
○	e. Water quality	
◒	2. Springs	None
	a. Duration of flow (wks.)	N/A
	b. Estimated maximum flow rate (gpm/season)	N/A
	c. Water quality	N/A
◒	3. Rivers or Streams	Numerous unnamed stre
◒	a. Rate (gpm) and duration of flow (wks.)	Ephemeral
○	b. Water quality	
	B. HYDROLOGIC CHARACTERISTICS OF SITING VALLEY	
◒	1. Drainage Channel (PR=Primary; S=Secondary)	Unnamed wash (PR)
◒	a. Depth of incision (max./min./avg.; ft.)	40/5/20
◒	b. Width (max./min./avg.; ft.)	300/50/100
◒	c. Gradient (ft./mi.)	20 to 120
◒	d. Channel bottom characteristics	Sand and gravel
◒	e. Channel cross-section (schematic)	
◒	f. Channel spacing (avg. in ft.)	Main channel
◒	g. Preliminary flood susceptibility rating (Section 2.4.1)	CF_1
◒	2. Preliminary Flood Susceptibility Rating of Major Landform Surfaces (Section 2.4.1)	
○	a. Undifferentiated deposits	
○	b. Alluvial fans	
◒	c. Playas (active=a; mantled=m)	a: SF_2; m: Unknown
○	d. Pediments	
○	e. Sand dunes	
○	f. Terraces (l=lake; r=river)	
	C. ADDITIONAL REMARKS	Observations are bas topographic maps and

Quality of Data
- ● Data derived from detailed studies
- ◒ Estimated values
- ○ Insufficient data available

Unnamed playa in central portion of Valley

4

Runoff and direct precipitation

None

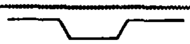
N/A

N/A

N/A

Numerous unnamed streams

Ephemeral

Unnamed wash (PR)	Numerous unnamed washes (S)
40/5/20	10/1/5
300/50/100	50/5/15
20 to 120	20 to 120
Sand and gravel	Primarily gravel
	
Main channel	1000
CF_1	

of

a: SF_2; m: Unknown to SF_1

Observations are based on a brief aerial reconnaissance and interpretation of topographic maps and aerial photographs.

QUALITY OF DATA	DESCRIPTION			
	A. DEPTH TO GROUNDWATER WITHIN BASIN-FILL MATERIAL IN SITING VALLEY (Map area in nm^2)			
○	1. 0 to 50 feet			
○	a. 0 to 25 feet			
○	b. 25 to 50 feet			
○	2. 50 to 100 feet			
○	3. Greater than 100 feet			
◐	4. Unknown or not Present	93	100%	Unkn port
	B. AQUIFER CHARACTERISTICS IN VALLEY			
◐	1. Type of Aquifer (B=Basin Fill; P=Perched; R=Rock; u=unconfined; c=confined)	Bu		
◐	a. Map area and extent	$285nm^2$ (est.)		
○	b. Depth to aquifer (ft.)			
○	c. Thickness (ft.)			
○	d. Composition			
○	e. Porosity (%)			
○	f. Specific yield (%)			
○	g. Transmissivity ($ft.^2$/day)			
○	h. Specific capacity (gpm/ft. of drawdown)			
○	i. Total pumpage (ac. ft./unit time)			
●	j. Groundwater ownership rights	NBGR/U.S. Fish and Wil		
	C. WATER BUDGET FOR VALLEY			
◐	1. Total Recharge (ac. ft./unit time)	3,400/year		
○	2. Total Discharge (ac. ft./unit time)			
	D. ADDITIONAL REMARKS			

Quality of Data

- ● Data derived from detailed studies
- ◐ Estimated values
- ○ Insufficient data available

	93	100%	Unknown. Estimated depth greater than 500 feet in central portion of Valley. Data inadequate for contouring.

hed;

Bu

285nm^2 (est.)

NBGR/U.S. Fish and Wildlife Service

3,400/year

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Shelter concept; Pool concept; Trench concept; MX siting investigation; Nevada; New Mexico; Arizona; DoD lands; Land Mobile Missile (over)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The report presents the results of a review of existing geotechnical information regarding NBGR. The available information is presented in Data Summary Sheets and on maps and overlays at a scale of 1:62,500. Subjects covered are soils engineering, surface and groundwater hydrology, topography and geology, and cultural and ownership features. The study is for MX siting considerations.

19. Key words continued

Quantity distance exclusions
Geotechnical siting
Groundwater
Soils Engineering
Geology
Environmental assessment
Siting area

APPENDIX A

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ADDENDUM TO BIBLIOGRAPHY

SOURCES OF PERSONAL COMMUMINCATION

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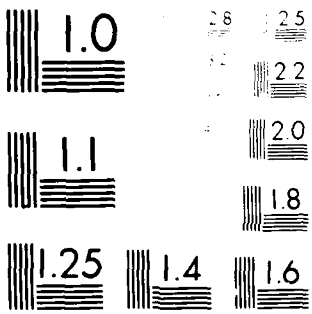
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Jackson, David G., Director, Office of Information Services, Energy Research and Development Administration, Las Vegas, Nevada.

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Quiring, Ralph, Meteorologist, Air Resources Laboratory, ESSA, Las Vegas, Nevada.

APPENDIX B

GEOLOGIC TIME SCALE

GEOLOGIC UNIT SYMBOL EXPLANATION

GEOLOGIC TIME SCALE

ERA	PERIOD	EPOCH	BEGINNING OF INTERVAL*
CENOZOIC	QUATERNARY	HOLOCENE (Recent)	10,000
		PLEISTOCENE	2 my
	TERTIARY	PLIOCENE	5 my
		MIOCENE	23 my
		OLIGOCENE	36 my
		EOCENE	53 my
		PALEOCENE	65 my
MESOZOIC	CRETACEOUS		135 my
	JURASSIC		190 my
	TRIASSIC		230 my
PALEOZOIC	PERMIAN		280 my
	PENNSYLVANIAN		320 my
	MISSISSIPPIAN		345 my
	DEVONIAN		395 my
	SILURIAN		435 my
	ORDOVICIAN		500 my
	CAMBRIAN		570 my
PRECAMBRIAN			

*IN YEARS BEFORE PRESENT: my = MILLION YEARS

MODIFIED AFTER BERGGREN, 1972; NEWMANN, 1970

GEOLOGIC UNIT SYMBOL EXPLANATION

ROCK

Shown in regions where rock is exposed; the areally predominant (greater than 70 percent) rock type is indicated. Rock may be subdivided into bedrock [B], basement rock [BR] or surface volcanic flows [VF].

I IGNEOUS (UNDIFFERENTIATED). Rocks formed by solidification of a molten or partially molten mass [B, BR, or VF].

- I_1 Intrusive. Typically crystalline, formed by the solidification of molten material below the surface (i.e., granite, syenite, diorite). [BR].
- I_2 Extrusive (undifferentiated). Formed by solidification of molten material at or near the surface [BR].
- I_3 Extrusive (flows). True extrusive rocks formed by solidification of molten material on the surface (basalt, dacite, etc.). [VF]. Pattern denotes young basaltic flows which overlie basin fill materials.
- I_4 Extrusive (volcaniclastics). Formed by welding or cementation of deposits of volcanic ejecta (i.e., tuff, agglomerate). [B or VF].

S SEDIMENTARY (UNDIFFERENTIATED). Coarse- to fine-grained materials that exhibit some degree of cementation and were deposited by water, wind, gravity, or evaporation [B].

- S_1 Sandstone. Composed predominantly of sand size particles.
- S_2 Limestone and Dolomite. Composed predominantly of carbonate material.
- S_3 Shale. Composed predominantly of clay and silt size particles (i.e., shale, siltstone).
- S_4 Evaporites. Composed of salt materials which result from precipitation (i.e., gypsum, anhydrite, halite).
- S_5 Clastics. Composed of particles which range from silt- to boulder-size particles. May be angular or rounded (i.e., conglomerate, breccia).

M METAMORPHIC (UNDIFFERENTIATED). Rocks formed through alteration of igneous or sedimentary rock material by pressure, heat, or chemical changes below the weathered zone (i.e., gneiss, schist, slate, marble, quartzite). [B or BR].

C ROCK COMPLEXES. Indicated where no areally predominant (greater than 70 percent) rock type occurs [B, BR, or VF].

GEOLOGIC UNIT SYMBOL EXPLANATION

BASIN-FILL DEPOSITS

A SURFICIAL DEPOSITS (UNDIFFERENTIATED). Fine- to coarse-materials deposited principally by wind, water or gravity.

A_1 Stream Channel and Floodplain Deposits. Sand- to boulder-size fragments. Admixture of silt and clay, deposited principally by water.

A_2 Terrace Deposits. Clay, silt, sand and gravel materials. Principally stream or lake deposits.

A_3 Wind-Blown Sand. Principally sand size particles deposited by wind, in sheets (A_{3s}) or dunes (A_{3d}). May be active or inactive.

A_4 Playa Deposits. Principally clay and silt size particles, may have admixtures of sand and gravel. Principally deposited in thin laminae by water and evaporation. Inactive playa deposits (A_{4m}) may be mantled by a thin cover of alluvial or wind-blown material.

A_5 Alluvial Fan Deposits. Subrounded to angular silt- to boulder-sized particles. Deposited principally by water and gravity in areas below mountain fronts. Coarse grained facies (A_{5c}) have greater than 70 percent of their outcrop area covered by gravel. Coalescing alluvial fans form bajadas. Where geologic ages Q, QT or T have not been assigned, fan deposits are either undifferentiated (u) or relative ages are indicated by o - oldest, i - intermediate or y - youngest.

A_6 Pediments and Pediment Deposits (Undifferentiated). Planated bedrock shelf generally overlain by thin mantle (up to 10 feet) of sand- to boulder-size residual or alluvial material. May be a surface of transport.

GEOLOGIC AGES OF UNITS

Q Quaternary (<2 m.y.)

QT Quaternary or Tertiary (<65 m.y.)

T Tertiary (2 - 65 m.y.)

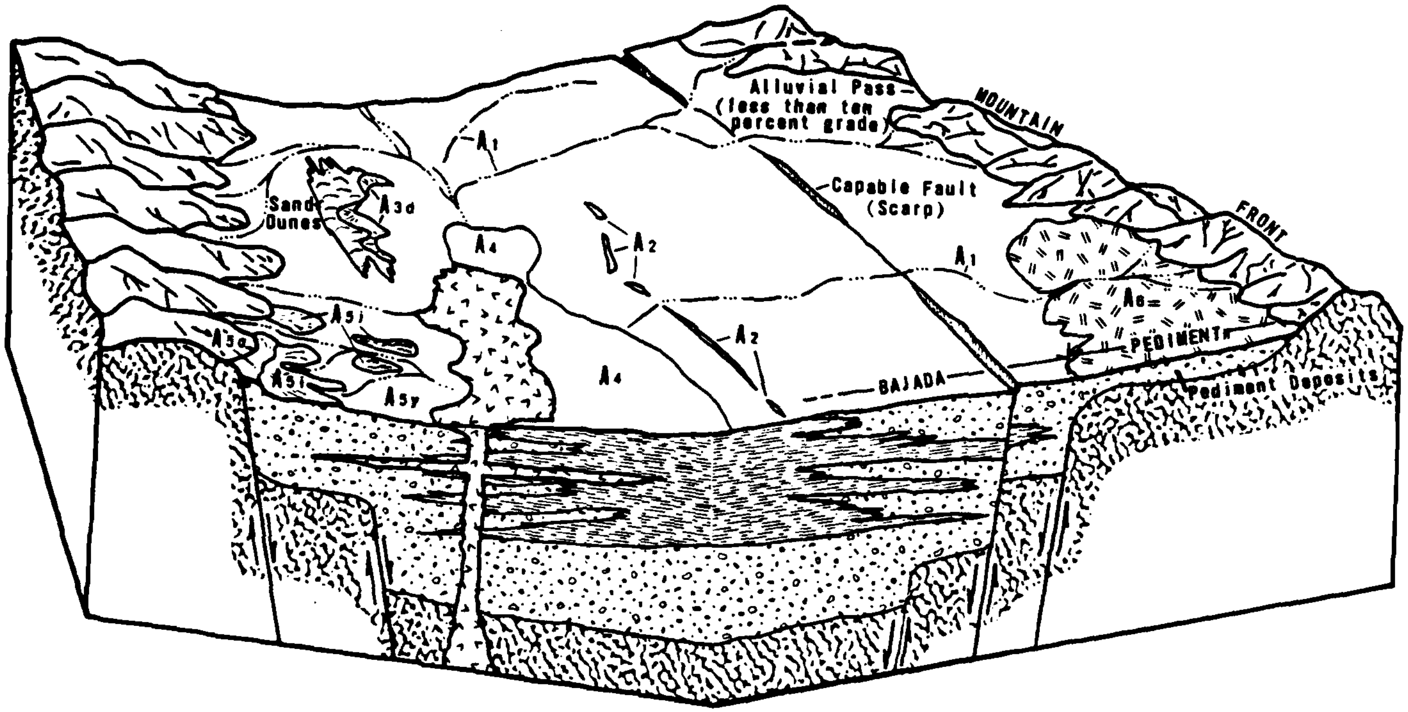
MP Mesozoic or Paleozoic (65 - 570 m.y.)

P€ Precambrian (>570 m.y.)

APPENDIX C

GEOMORPHIC AND GEOLOGIC FEATURES

DATE: 30 JUNE 1975



EXPLANATION

BASIN-FILL DEPOSITS

COARSE-GRAINED: Gravel, sand and silt; grain size commonly decreases basinward. Deposits include:

- A_1-Stream and undifferentiated floodplain
- A_2-Terrace
- A_{3d}-Sand (dunes)
- A_5-Alluvial fan: o=older, i=intermediate, y=younger
- A_6-Pediment

FINE-GRAINED: Clay and silt; deposited in Pleistocene lake; A_4-Playa.

ROCK

ROCK

VOLCANIC FLOW ROCK

PEDIMENT

GEOMORPHIC AND GEOLOGIC FEATURES

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE C-1

FUGRO NATIONAL, INC.

APPENDIX D

MODIFIED MERCALLI INTENSITY SCALE

NRC CRITERIA DEFINING A CAPABLE FAULT

MODIFIED MERCALLI INTENSITY SCALE OF 1931

As abridged and used by the National earthquake
Information Center of the U.S. Department of Commerce

I. Not felt except by a very few under specially favorable circumstances. (I Rossi-Forel Scale)

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to III Rossi-Forel Scale)

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor-cars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale)

IV. During the day, felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motor-cars rocked noticeably. (IV to V Rossi-Forel Scale)

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale)

VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale)

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly-built or badly designed structures; some chimneys broken. Noticed by persons driving motor-cars. (VIII Rossi-Forel Scale)

VIII. Damage slight in specially designed structures; considerable in ordinary, substantial buildings, with partial collapse; great in poorly-built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor-cars disturbed. (VIII+ to IX Rossi-Forel Scale)

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale)

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with their foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale)

XI. Few, if any, masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.

NRC CRITERIA DEFINING A CAPABLE FAULT

A "capable fault" is a fault which has exhibited one or more of the following characteristics:

1) movement at or near the ground surface at least once within the past 35,000 years, or recurring movement within the past 500,000 years;

2) macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault;

3) structural relationship to a capable fault, according to (1) or (2), such that movement on one could be reasonably expected to be accompanied by movement on the other.

Source: U. S. Atomic Energy Commission, 1973, Reactor Site Criteria: Title 10 - Rules and Regulations, pt. 100, p. 237-238.

APPENDIX E

UNIFIED SOIL CLASSIFICATION SYSTEM

AASHO SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION SYSTEM

<table>
<tr><th colspan="3">Major Divisions</th><th>Group Symbols</th><th>Typical Names</th><th colspan="3">Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights)</th><th>Information Required for Describing Soils</th></tr>
<tr><td>1</td><td colspan="2">2</td><td>3</td><td>4</td><td colspan="3">5</td><td>6</td></tr>
<tr><td rowspan="8">Coarse-grained Soils
More than half of material is <u>larger</u> than No. 200 sieve size.
The No. 200 sieve size is about the smallest particle visible to the naked eye.</td><td rowspan="4">Gravels
More than half of coarse fraction is larger than No. 4 sieve size.
(For visual classification, the ¼-in. size may be used as equivalent to the No. 4 sieve size)</td><td rowspan="2">Clean Gravels (Little or no fines)</td><td>GW</td><td>Well-graded gravels, gravel-sand mixtures, little or no fines.</td><td colspan="3">Wide range in grain sizes and substantial amounts of all intermediate particle sizes.</td><td rowspan="2">For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.</td></tr>
<tr><td>GP</td><td>Poorly-graded gravels, gravel-sand mixtures, little or no fines.</td><td colspan="3">Predominantly one size or a range of sizes with some intermediate sizes missing.</td></tr>
<tr><td rowspan="2">Gravels with Fines (Appreciable amount of fines)</td><td>GM</td><td>Silty gravels, gravel-sand-silt mixtures.</td><td colspan="3">Nonplastic fines or fines with low plasticity. (for identification procedures see ML below)</td><td rowspan="6">Give typical name; indicate approximate percentages of sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.

Example:
<u>Silty sand</u>, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand, (SM).</td></tr>
<tr><td>GC</td><td>Clayey gravels, gravel-sand-clay mixtures.</td><td colspan="3">Plastic fines (for identification procedures see CL below).</td></tr>
<tr><td rowspan="4">Sands
More than half of coarse fraction is smaller than No. 4 sieve size.</td><td rowspan="2">Clean Sands (Little or no fines)</td><td>SW</td><td>Well-graded sands, gravelly sands, little or no fines.</td><td colspan="3">Wide range in grain sizes and substantial amounts of all intermediate particle sizes.</td></tr>
<tr><td>SP</td><td>Poorly-graded sands, gravelly sands, little or no fines.</td><td colspan="3">Predominantly one size or a range of sizes with some intermediate sizes missing.</td></tr>
<tr><td rowspan="2">Sands with Fines (Appreciable amount of fines)</td><td>SM</td><td>Silty sands, sand-silt mixtures.</td><td colspan="3">Nonplastic fines or fines with low plasticity. (for identification procedures see ML below)</td></tr>
<tr><td>SC</td><td>Clayey sands, sand-clay mixtures.</td><td colspan="3">Plastic fines (for identification procedures see CL below).</td></tr>
<tr><td rowspan="8">Fine-grained Soils
More than half of material is <u>smaller</u> than No. 200 sieve size.</td><td colspan="2" rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td colspan="3">Identification Procedures on Fraction Smaller than No. 40 Sieve Size</td><td rowspan="2"></td></tr>
<tr><td>Dry Strength (Crushing characteristics)</td><td>Dilatancy (Reaction to shaking)</td><td>Toughness (Consistency near PL)</td></tr>
<tr><td colspan="2" rowspan="3">Silts and Clays
Liquid limit less than 50</td><td>ML</td><td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.</td><td>None to slight</td><td>Quick to slow</td><td>None</td><td rowspan="6">Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses.

For undisturbed soils and information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.

Example:
<u>Clayey silt</u>, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).</td></tr>
<tr><td>CL</td><td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.</td><td>Medium to high</td><td>None to very slow</td><td>Medium</td></tr>
<tr><td>OL</td><td>Organic silts and organic silty clays of low plasticity.</td><td>Slight to medium</td><td>Slow</td><td>Slight</td></tr>
<tr><td colspan="2" rowspan="3">Silts and Clays
Liquid limit greater than 50</td><td>MH</td><td>Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.</td><td>Slight to medium</td><td>Slow to none</td><td>Slight to medium</td></tr>
<tr><td>CH</td><td>Inorganic clays of high plasticity, fat clays.</td><td>High to very high</td><td>None</td><td>High</td></tr>
<tr><td>OH</td><td>Organic clays of medium to high plasticity, organic silts.</td><td>Medium to high</td><td>None to very slow</td><td>Slight to medium</td></tr>
<tr><td colspan="3">Highly Organic Soils</td><td>Pt</td><td>Peat and other highly organic soils.</td><td colspan="3">Readily identified by color, odor, spongy feel and frequently by fibrous texture.</td></tr>
</table>

AASHO SOIL CLASSIFICATION SYSTEM

General classification	*Granular materials (35% or less passing No. 200)*							*Silt-clay materials (more than 35% passing No. 200)*			
	A-1			*A-2*							*A-7*
Group classification	*A-1-a*	*A-1-b*	*A-3*	*A-2-4*	*A-2-5*	*A-2-6*	*A-2-7*	*A-4*	*A-5*	*A-6*	*A-7-5*, *A-7-6*
Sieve analysis, % passing:											
No. 10	50 max	....	....	....	....	....	....	....	....	....	
No. 40	30 max	50 max	51 min	....	....	......	....	....	....	....	
No. 200	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing No. 40:											
Liquid limit	......		....	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min†
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good						Fair to poor				

* After AASHO [1].

† Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

APPENDIX F

SPECIFIC SOIL TEST DATA

SPECIFIC SOILS ENGINEERING TEST DATA
(for locations see Soil Engineering Overlays N-I through N-XIII)

Number	Depth (ft.)	Method of Exploration	Remarks
60 (a)	600	Seismic o Refraction Electrical Borings	Testing conducted on alluvium in Yucca Flat Compressional Wave Velocity o Surface to approximately 250 to 300 ft. 2,000 to 3,500 fps o Approximately 250 to 300 ft. to approximately 550 to 600 ft. 4,500 to 5,000 fps o Greater than 600 ft. Velocities approach 7,000 fps Range of Average Electrical Resistivities o Less than 450 ft., 300-1,000 ohm-meters o Greater than 450 ft., 100-300 ohm-meters o Playa Silts, 20-50 ohm-meters
61 (b)	1-1500	Borings	U.S.G.S. Investigations in Yucca Flat

Densities (g/cc)

	Min.	Max.	Av.
o Alluvium	1.3	2.31	1.94
o Sand	1.4	1.8	1.6
o Gravel	1.4	2.2	1.89

U.S.G.S. Investigations in Yucca Flat

Physical Properties	High	Low	Mean
o Porosity (percent)	41.9	16.2	30.8
o Grain Density (g/cc)	2.70	2.31	2.57
o Dry Bulk Density (g/cc)	2.23	1.43	1.76
o Sample State Bulk Density (g/cc)	2.27	1.61	1.93
o Saturated Bulk Density (g/cc)	2.39	1.81	2.17
o Magnetic Susceptibility (10^{-6} cgs units)	1,089	96.2	?20.5

FUGRO NATIONAL, INC.

SPECIFIC SOILS ENGINEERING TEST DATA

(for locations see Soil Engineering Overlays N-I through N-XIII)

Number	Depth (ft.)	Method of Exploration	Remarks
62 (c)	1-500	Seismic Borings	Density (g/cc) o 0.5 to 2 ft. 1.46 o 2 to 16 ft. 1.65 o Caliche 2.0 to 2.05 Vertical Compression Wave Velocities (fps)
63 (d)	unknown	unknown	Gravel pit indicated; no data available.
64 (d)	unknown	unknown	Gravel pit indicated; no data available.
65 (d)	unknown	unknown	Gravel pit indicated; no data available.
66 (e)	unknown	unknown	Gravel pit indicated; no data available.
67 (e)	unknown	unknown	Sand pit indicated; no data available.
68 (e)	unknown	unknown	Sand pit indicated; no data available.
69 (f)	unknown	unknown	Gravel pit indicated; no data available.

Vertical Compression Wave Velocities (fps) for 62 (c):

	Mean	Min.	Max.
o 0-15	2,690	1,430	3,030
o 15-40	3,050	1,630	3,380
o 40-100	3,240	1,960	12,500
o 100-150	4,000	2,750	5,820
o 150-300	4,300	3,790	5,560
o 300-350	4,710	4,170	8,060
o 350-460	5,220	3,590	8,060
o 460-500		4,500	13,350

SPECIFIC SOILS ENGINEERING TEST DATA

(for locations see Soil Engineering Overlays N-I through N-XIII)

Number	Depth (ft.)	Method of Exploration	Remarks
70 (g)	unknown	unknown	Gravel pit indicated; no data available.
71 (g)	unknown	unknown	Gravel pit indicated; no data available.
72 (g)	unknown	unknown	Gravel pit indicated; no data available.
73 (g)	unknown	unknown	Gravel pit indicated; no data available.
74 (g)	unknown	unknown	Gravel pit indicated; no data available.
75 (g)	unknown	unknown	Gravel pit indicated; no data available.
76 (h)	unknown	unknown	Gravel pit indicated; no data available.
77 (h)	unknown	unknown	Gravel pit indicated; no data available.
78 (h)	unknown	unknown	Gravel pit indicated; no data available.
79 (h)	unknown	unknown	Gravel pit indicated; no data available.
80 (i)	unknown	unknown	Gravel pit indicated; no data available.
81 (i)	unknown	unknown	Gravel pit indicated; no data available.
82 (j)	unknown	unknown	Gravel pit indicated; no data available.
83 (k)	unknown	unknown	Gravel pit indicated; no data available.
84 (k)	unknown	unknown	Gravel pit indicated; no data available.

SPECIFIC SOILS ENGINEERING TEST DATA

(for locations see Soil Engineering Overlays N-I through N-XIII)

Number	Depth (ft.)	Method of Exploration	Remarks
85 (1)	3	sample only	Source of sand for previous construction; minimun of 10,000 yd^3 of available sand.
86 (1)	0	visual	Outcrop of rock; rock comprised of quartz, feldspar, hornblende, and augite; appears strongly jointed; minimum of 50,000 yd^3 or rock.
87 (1)	3	sample only	Dry wash; sand, gravel and boulders.
88 (1)	0	sample only	Stream channel; sand and gravel bars present.
89 (1)	6 to 10	sample only	Sand and gravel; 2 to 3 ft. of overburden; 50,000 yd^3 of coarse material.

(a) Hazelwood, R. M., et al., 1963
(b) Williams, W. P., et al., 1963
(c) Wilmarth, V. R., et al., 1960
(d) McKay, E. J., and Williams, W. P., 1964
(e) Hinrichs, E. N., 1968
(f) Sargent, K. A. and Stewart, 1971
(g) Poole, F. G., 1965
(h) Colton, R. B., and McKay, E. J., 1966
(i) Gibbons, A. R., et al., 1963
(j) Barnes, H., et al., 1963
(k) Orkild, 1963
(l) Davis, 1959

APPENDIX G

WELL AND WATER QUALITY DATA

LOCATION OF WATER WELLS AND OTHER BORINGS
NOT SHOWN ON FOUR-QUAD OVERLAYS

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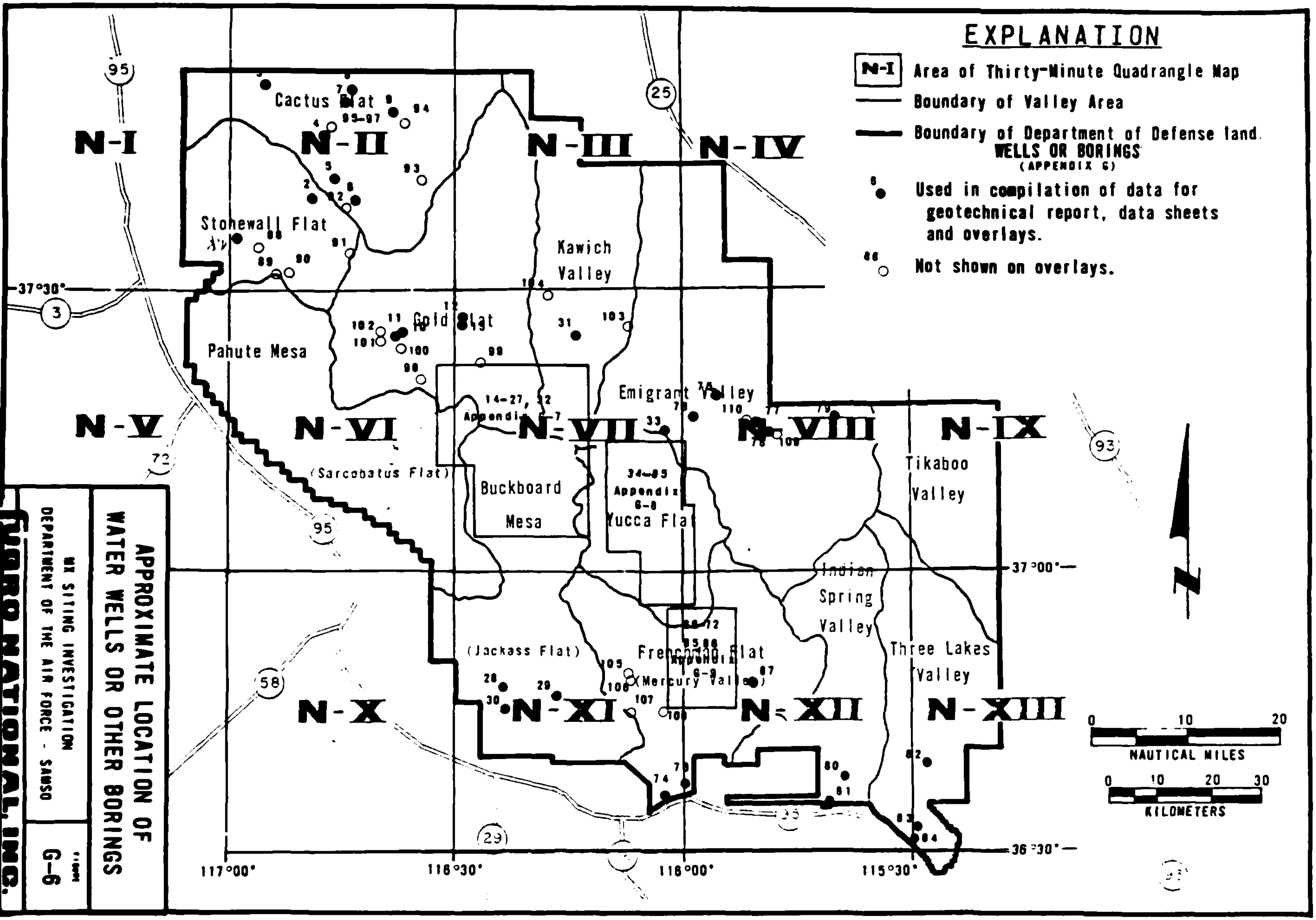


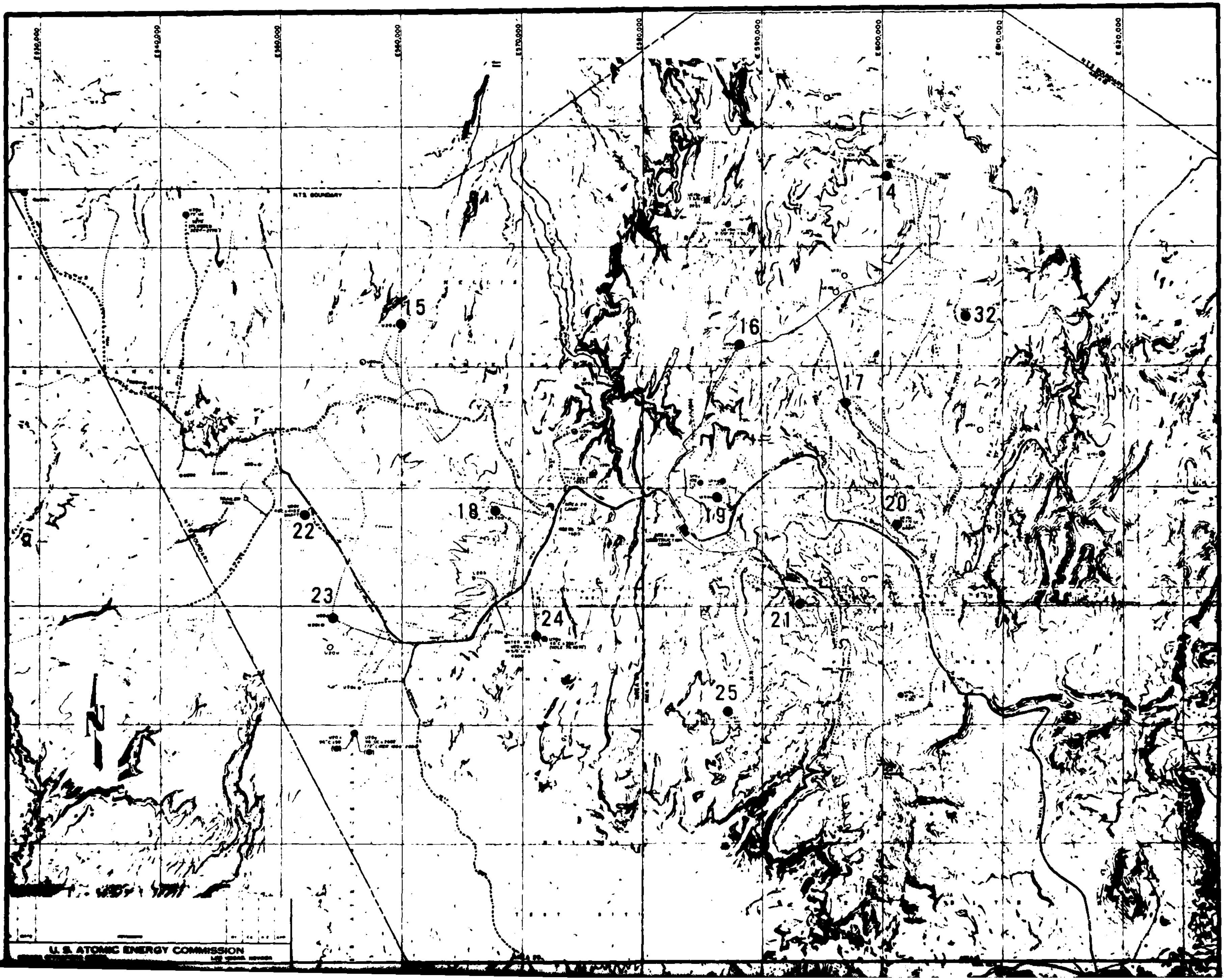
APPROXIMATE LOCATION OF WATER WELLS OR OTHER BORINGS

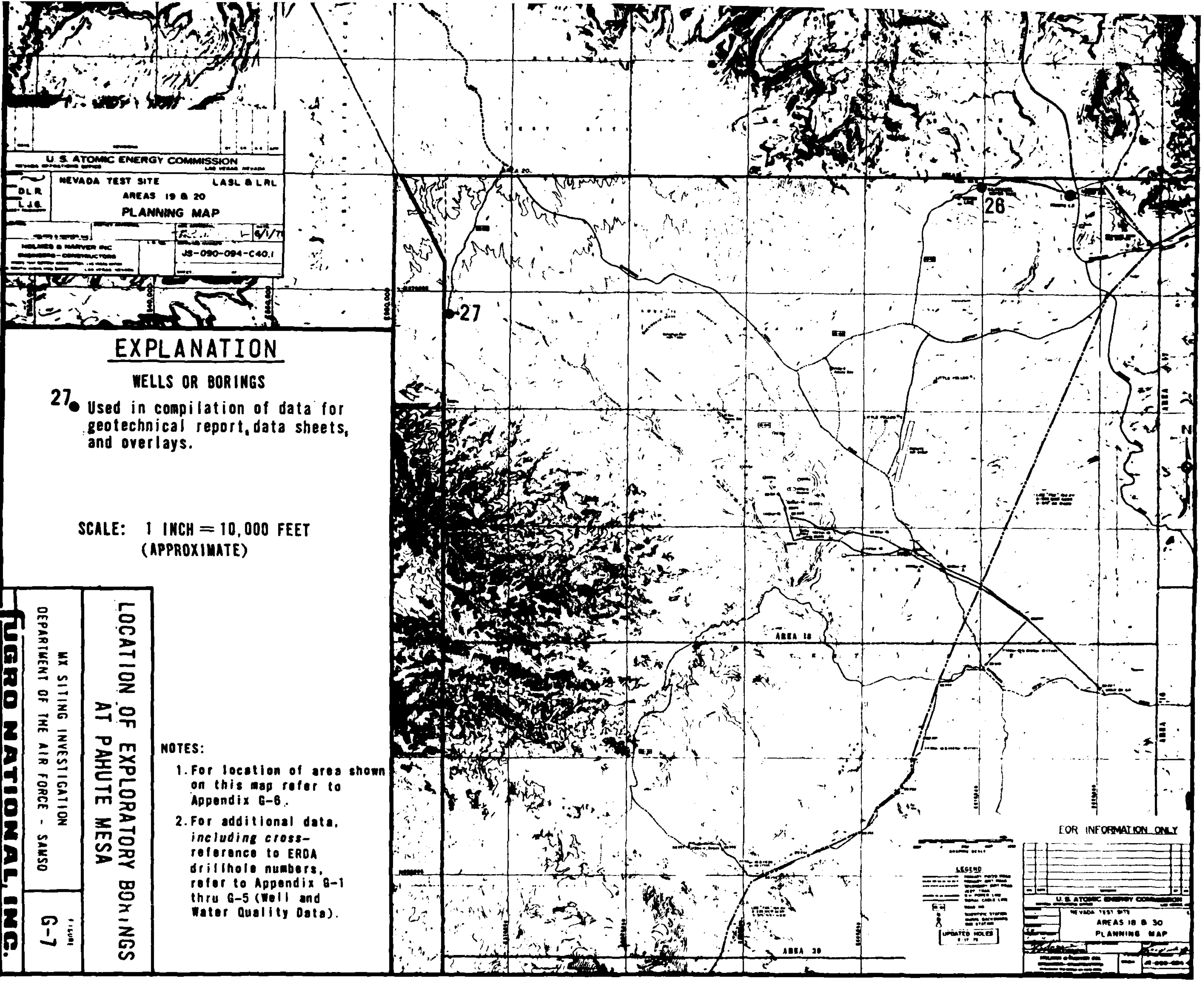
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE G-6

FUGRO NATIONAL, INC.

DATE: 30 JUNE 1975





EXPLANATION

WELLS OR BORINGS

27● Used in compilation of data for geotechnical report, data sheets, and overlays.

SCALE: 1 INCH = 10,000 FEET
(APPROXIMATE)

NOTES:

1. For location of area shown on this map refer to Appendix G-6.
2. For additional data, *including cross-reference to ERDA drillhole numbers,* refer to Appendix G-1 thru G-5 (Well and Water Quality Data).

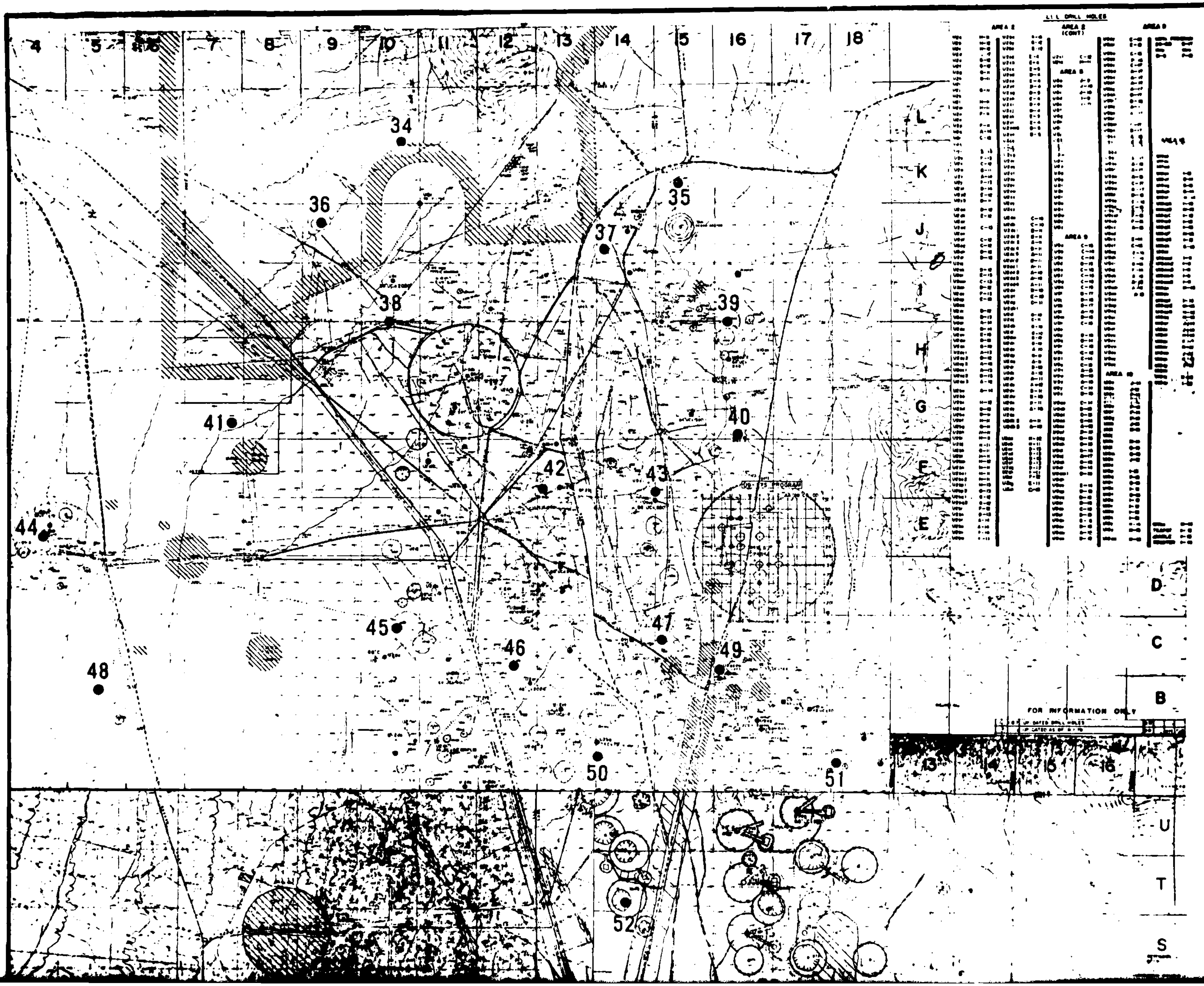
LOCATION OF EXPLORATORY BORINGS AT PAHUTE MESA

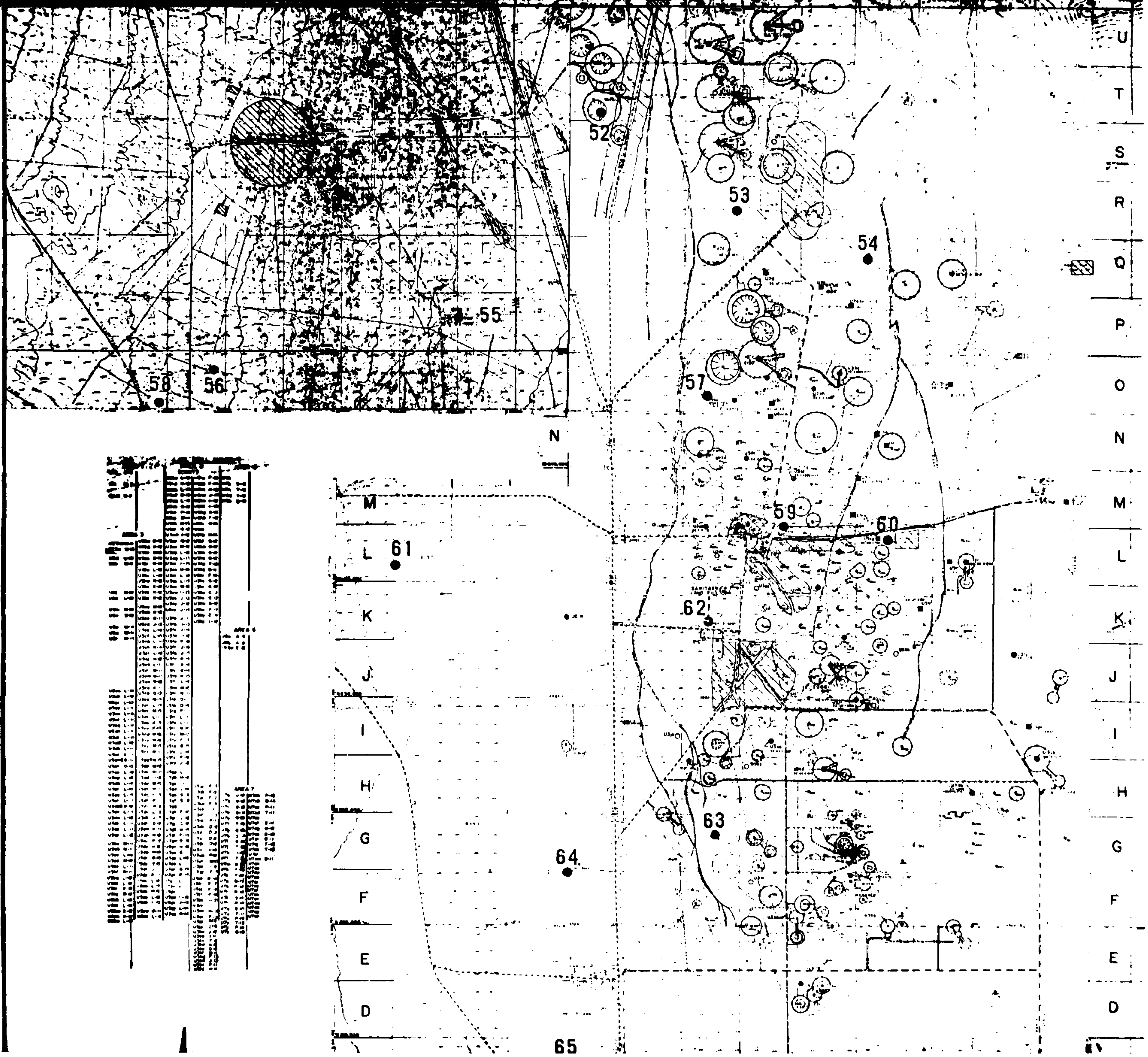
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE G-7

FUGRO NATIONAL, INC.

DATE: 30 JUNE 1975

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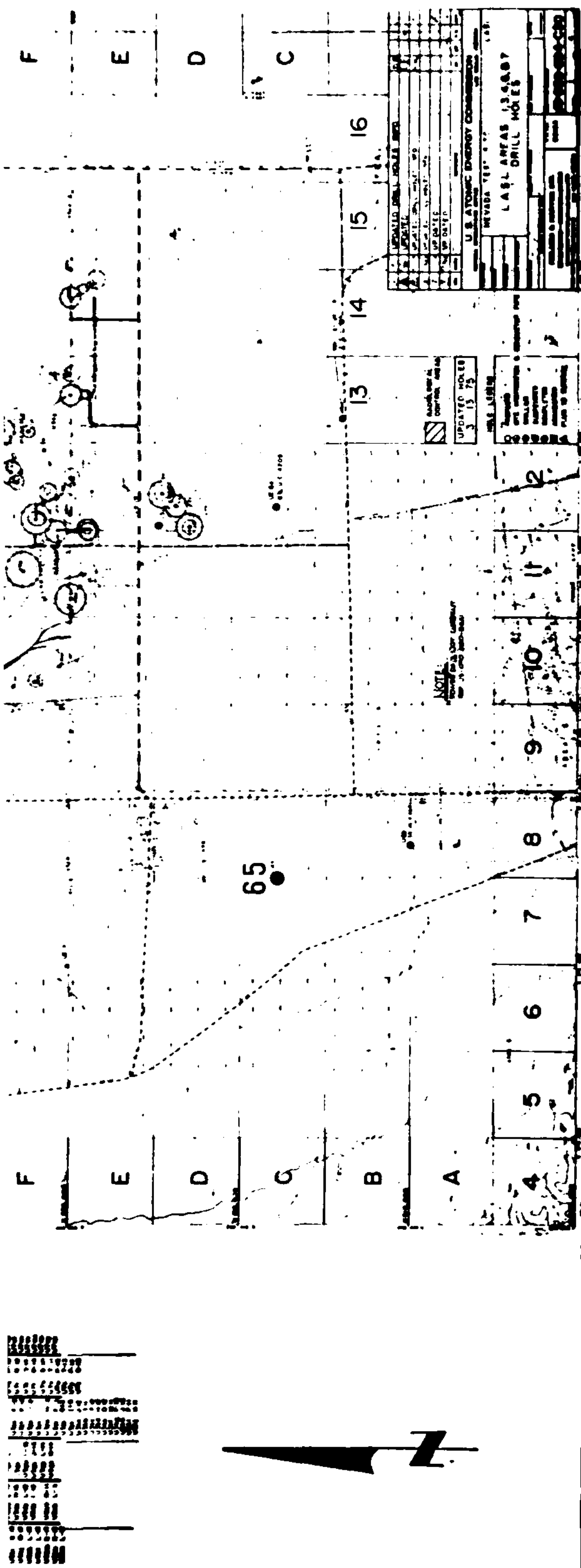


EXPLANATION

WELLS OR BORINGS

65 ● Used in compilation of data for geotechnical report, data sheets, and overlays.

SCALE: 1 INCH = 5000 FEET
(APPROXIMATE)

NOTES:

1. For location of area shown on this map refer to Appendix G-6
2. For additional data, including cross-reference to ERDA drillhole numbers, refer to Appendix G-1 thru G-5(Well and Water Quality Data).

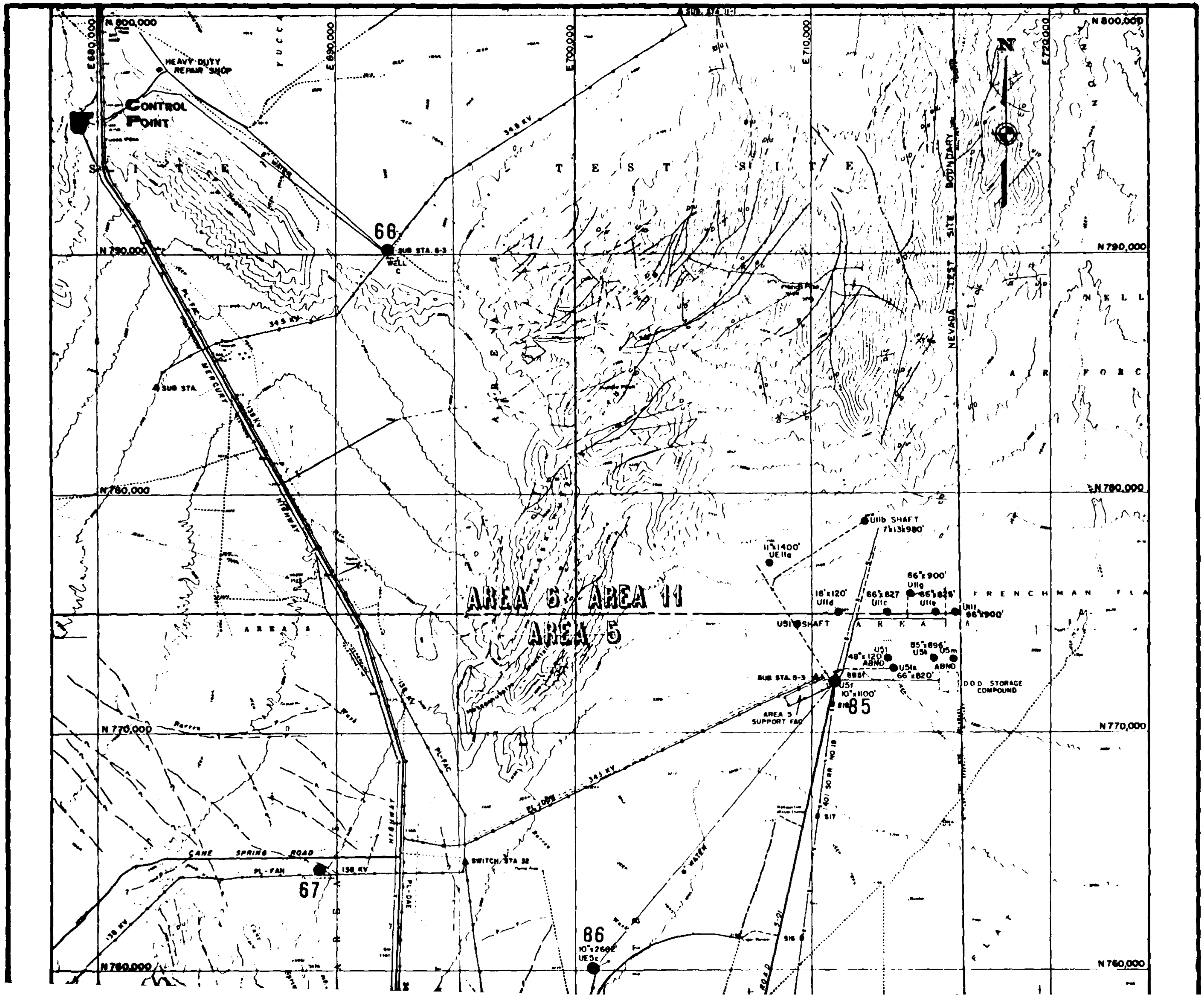
LOCATION OF EXPLORATORY BORINGS
AT YUCCA FLAT

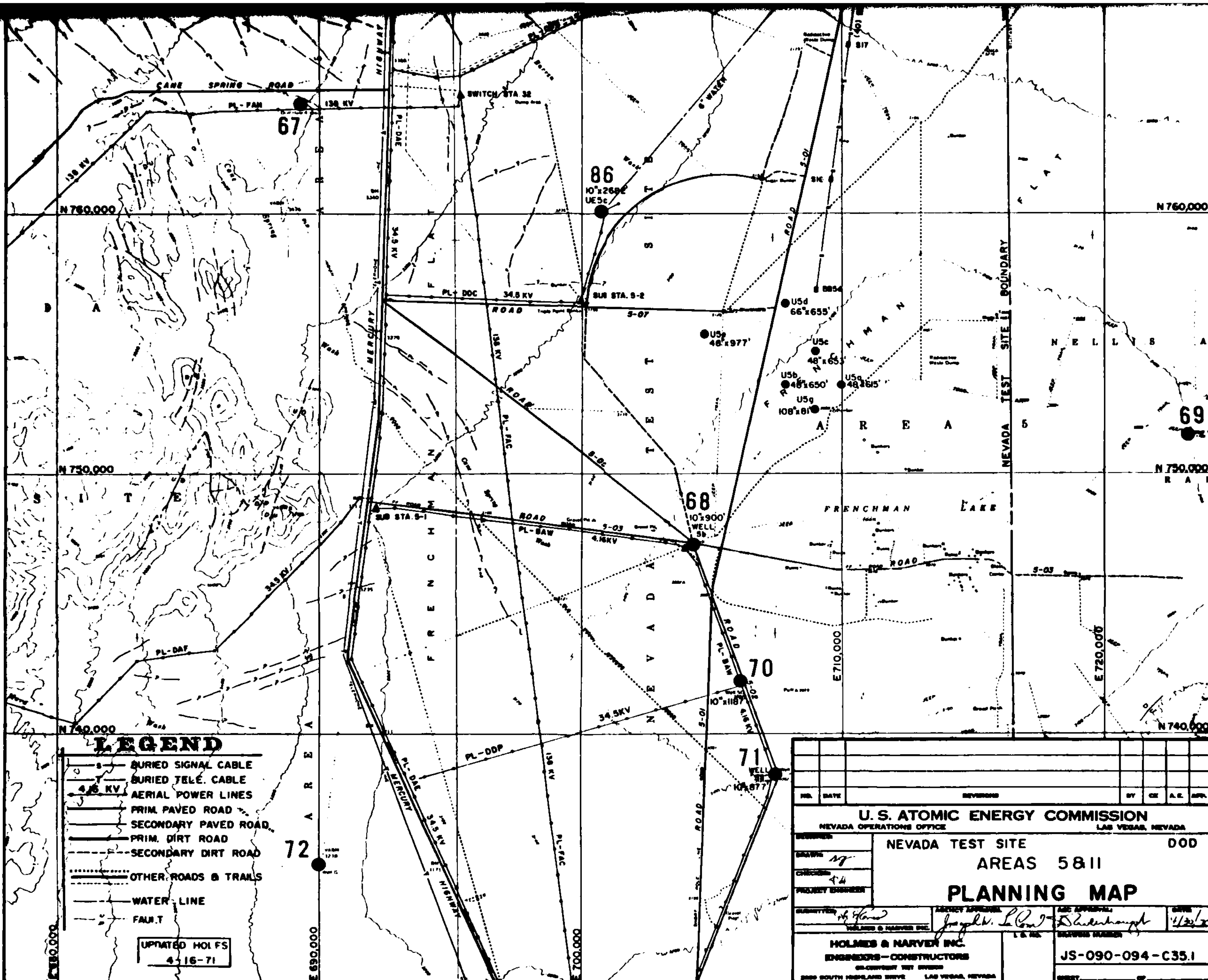
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
G-8

FUGRO NATIONAL, INC.

DATE: 30 JUNE 1975





EXPLANATION

WELLS OR BORINGS

71 ● Used in compilation of data for geotechnical report, data sheets, and overlays.

LOCATION OF EX
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FUGRO NA

EXPLANATION

WELLS OR BORINGS

71 ● Used in compilation of data for geotechnical report, data sheets, and overlays.

SCALE: 1 INCH = 5000 FEET
(APPROXIMATE)

NOTES:

1. For location of area shown on this map refer to Appendix G-6.
2. For additional data, including cross-reference to ERDA drillhole numbers, refer to Appendix G-1 thru G-5 (Well and Water Quality Data).

LOCATION OF EXPLORATORY BORINGS AT FRENCHMAN FLAT

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE G-9

FUGRO NATIONAL, INC.

LOCATION OF WATER WELLS AND OTHER BORINGS
NOT SHOWN ON FOUR-QUAD OVERLAYS

	LOCATION			Remarks
	Latitude-Longitude	Valley	4-Quad	
88	37° 35' 40" 116° 55' 30"	Stonewall Flat	N-II	No data
89	37° 32' 40" 116° 53' 20"	Stonewall Flat	N-II	Bedrock area
90	37° 32' 40" 116° 51' 10"	Stonewall Flat	N-II	Bedrock area
91	37° 34' 50" 116° 44' 10"	Stonewall Flat	N-II	Bedrock area
92	37° 40' 20" 116° 42' 50"	Cactus Flat	N-II	Bedrock area
93	37° 42' 20" 116° 33' 20"	Cactus Flat	N-II	No data
94	37° 43' 00" 116° 35' 30"	Cactus Flat	N-II	No data
95	37° 47' 10" 116° 45' 10"	Cactus Flat	N-II	Sandia 1 Limited data
96	37° 47' 10" 116° 45' 30"	Cactus Flat	N-II	Sandia 2 Limited data
97	37° 47' 30" 116° 45' 30"	Cactus Flat	N-II	Sandia 4 Limited data
98	37° 18' 01" 116° 32' 03"	Gold Flat	N-VI	Bedrock area
99	37° 18' 07" 116° 24' 30"	Gold Flat	N-VII	Bedrock area
100	37° 20' 42" 116° 34' 05"	Gold Flat	N-VI	Bedrock area
101	37° 25' 50" 116° 36' 50"	Gold Flat	N-VI	No data
102	37° 25' 50" 116° 36' 50"	Gold Flat	N-VI	Limited data
103	37° 25' 38" 116° 12' 36"	Kawich Valley	N-VII	Bedrock area
104	37° 26' 50" 116° 28' 20"	Kawich Valley	N-VII	Bedrock area
105	36° 49' 35" 116° 06' 53"	Frenchman Flat	N-XI	Bedrock area
106	36° 49' 19" 116° 06' 41"	Frenchman Flat	N-XI	Bedrock area

LOCATION OF WATER WELLS AND OTHER BORINGS
NOT SHOWN ON FOUR-QUAD OVERLAYS

Number	LOCATION			Remarks
	Latitude-Longitude	Valley	4-Quad	
107	36° 45' 34" 116° 06' 59"	Frenchman Flat	N-XI	Bedrock area
108	36° 45' 39" 116° 02' 44"	Frenchman Flat	N-XI	Bedrock area
109	37° 14' 39" 115° 48' 00"	Emigrant Valley	N-VIII	Limited data
110	37° 15' 40" 115° 50' 20"	Emigrant Valley	N-VIII	Limited data

APPENDIX H

CLIMATOLOGICAL DATA SUMMARY SHEETS

APPENDIX I

GEOLOGIC SECTIONS

ABBREVIATIONS

S.E.	Surface Elevation
T.D.	Total Depth

APPENDIX J

LITHOLOGIC LOG, NEVADA TEST SITE

SONIC LOG DATA, YUCCA FLAT

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