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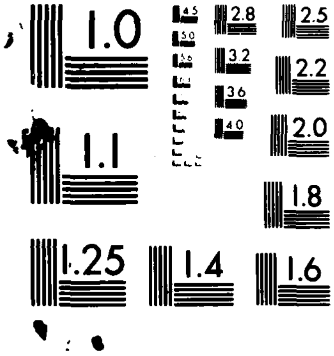

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION

AD A112406

# AGGREGATE RESOURCES STUDIES
# DRY LAKE VALLEY
# MULESHOE VALLEY
# DELAMAR VALLEY
# PAHROC VALLEY
# NEVADA

PREPARED FOR
BALLISTIC MISSILE OFFICE (BMO)
NORTON AIR FORCE BASE, CALIFORNIA

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This report gives information on the above Valleys in location, suitability of basin-fill ~~of~~ rock sources for concrete & road-base construction materials. ~~Three types of aggregate resources are delineated in the four valleys; coarse, fine, and crushed rock aggregate~~

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FN-TR-37-a

# AGGREGATE RESOURCES STUDIES

## DRY LAKE VALLEY
## MULESHOE VALLEY
## DELAMAR VALLEY
## PAHROC VALLEY

## NEVADA

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office (BMO)
Norton Air Force Base, California 92409

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Long Beach, California 90807

6 June 1980

# FOREWORD

This report was prepared for the Department of the Air Force Ballistic Missile Office (BMO) in compliance with Contract No. F04704-80-C-0006, CDRL Item No. 004A2. It presents the results of Valley-Specific Aggregate Resources studies within and adjacent to selected areas in Utah and Nevada that are under consideration for siting the MX system.

This volume contains the results of the aggregate resources studies in Dry Lake, Muleshoe, Delamar, and Pahroc valleys. It is the first of several Valley-Specific Aggregate Resources investigations which will be prepared as separate volumes. Results of this report are presented as text, appendices, and two drawings.

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## EXECUTIVE SUMMARY

This report contains the Valley-Specific Aggregate Resources Study (VSARS) evaluation for Dry Lake, Muleshoe, Delamar, and Pahroc valleys in Nevada. It is the first in a series of reports that contain valley-specific aggregate information on the location and suitability of basin-fill and rock sources for concrete and road-base construction materials. Field reconnaissance and limited laboratory testing, existing data from the State of Nevada Department of Highways, previous regional aggregate investigation, and ongoing Verification studies provide the basis for the findings presented.

A classification system based on aggregate type and potential use was developed to rank the suitability of all basin-fill and rock aggregate sources. Four aggregate types have been designated; coarse, fine, and coarse and fine (multiple) aggregates derived from basin-fill sources and crushed rock aggregates derived from rock sources. Each aggregate type was then classified using the following definitions:

| | |
|---|---|
| Class I | Potentially suitable concrete aggregate and road-base material source. |
| Class II | Possibly unsuitable concrete aggregate/potentially suitable road-base material source. |
| Class III | Unsuitable concrete aggregate or road-base material source. |

Decisions on assigning a particular aggregate source to one of the three classes were determined from Fugro National and existing laboratory aggregate tests performed as part of this study (abrasion resistance, soundness, and alkali reactivity), and to a lesser degree, field visual observations.

Emphasis in this study was placed on the identification of Class I basin-fill, coarse aggregate. These deposits are considered to be the primary sources of concrete and road-base construction materials. Results of the study are presented on a 1:125,000 scale aggregate resources map (Drawing 2) and are summarized as follows:

1. Coarse Aggregate - Three major Class I coarse aggregate basin-fill deposits were located in the four-valley study area.

    a. An extensive alluvial fan complex west of the Bristol, Highland, and Burnt Springs ranges in east-central Dry Lake Valley.

    b. Older lacustrine deposits west of Pahroc Valley (Pahranagat Valley).

    c. Limited alluvial fan deposits bordering the Delamar Mountains in east-central Delamar Valley.

    Potential Class II coarse aggregate sources are widespread and extensive in the study area. Although boundaries of specific deposits could not be delineated, they are typically located within alluvial fans flanking Class I and/or Class II rock sources.

2. Fine Aggregate - Most coarse aggregate basin-fill sources are also potential multiple sources (coarse and fine) that will supply varying quantities of fine aggregate either from

the natural deposit or during processing. However, specific alluvial fan deposits, predominantly comprised of Class I fine aggregate material were identified in northern Muleshoe Valley flanking the Bristol Range and Dutch John Mountain.

3. Crushed Rock - Abundant Class I crushed rock sources surround the study area. Unnamed upper Cambrian and Pennsylvanian and the Highland Peak and Guilmette formations are widespread carbonate rocks (limestone and dolomite) that compose most Class I sources. Individual units or combinations of these units are most extensive in the northern portions of Muleshoe Valley and eastern Dry Lake and Delamar valleys. The useability of any of these rock units as sources of crushed rock aggregate will depend on their location and accessibility within the study area and minability.

Additional aggregate testing and field investigations will be required to further refine the lateral and vertical extents of classification boundaries and define exact physical and chemical characteristics of a particular deposit or rock source within the valley.

# 1.0 INTRODUCTION

## 1.1 STUDY AREA

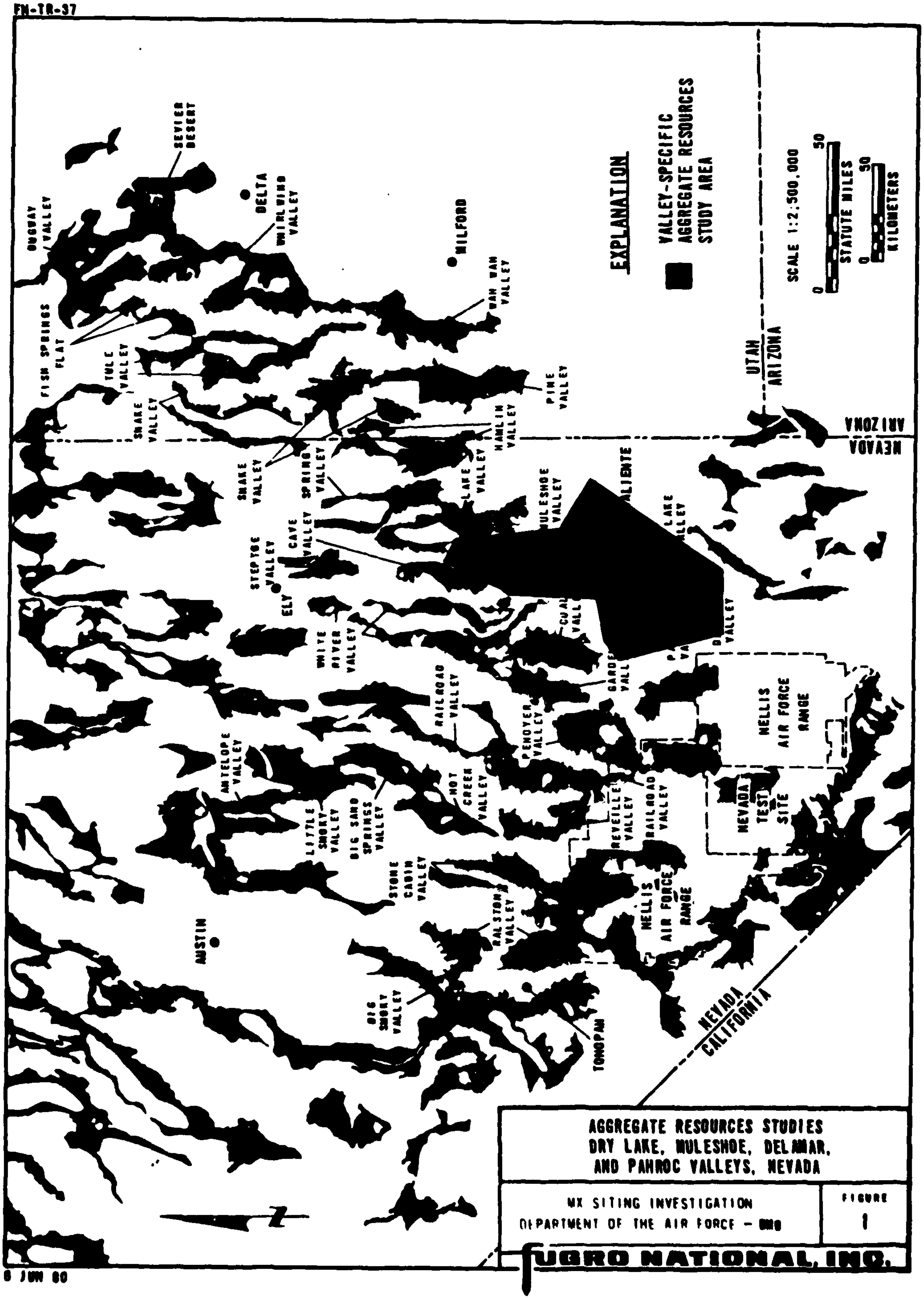
This report presents the results of the Valley-Specific Aggregate Resources Study completed for Dry Lake, Muleshoe, Delamar, and Pahroc valleys (Figure 1). Located in the central portion of Lincoln County, Nevada, the area is elongate in shape with north-south trending alluvial basins flanked by carbonate and volcanic rock mountain ranges. Cave, White River, and Pahranagat valleys border the site on the west and Lake and Pine valleys form the eastern boundary.

U.S. Highway 93 provides access along the eastern boundary and to the central study region. State Highway 38, an improved gravel road, provides access to the western border. A network of unpaved roads and 4-wheel-drive trails crisscross the site area (Drawing 1).

The valleys are mainly comprised of desert rangeland. Several active mining operations are located in the Bristol and Highland ranges. The towns of Pioche and Caliente, Nevada, lie just within the east-central border of the Valley-Specific area and are serviced by the mainline of the Union Pacific Railroad from Salt Lake City, Utah, to Las Vegas, Nevada.

## 1.2 BACKGROUND

The MX aggregate program began in 1977 with the investigation of Department of Defense (DOD) and Bureau of Land Management (BLM) lands in California, Nevada, Arizona, New Mexico, and Texas



**AGGREGATE RESOURCES STUDIES**
**DRY LAKE, MULESHOE, DELAMAR,**
**AND PAHROC VALLEYS, NEVADA**

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE
1

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(FN-TR-20D). Refinement of the MX siting area added portions of Utah and Nevada that were not studied in the initial Aggregate Resources Evaluation Investigation (AREI). This additional area (Figure 2), defined as the Utah Aggregate Resources Study area (UARSA), was evaluated in Fall 1979 and a second general aggregate resources report (FN-TR-34) was submitted on 3 March 1980. Both general aggregate investigations were designed to provide regional information of the general location, quality, and quantity of aggregates that could be used in the construction of the MX system.

Subsequent to the general studies, Valley-Specific Aggregate Resources Studies (VSARS) were developed in FY 79 to provide more detailed information on potential aggregate sources in specified valley areas.

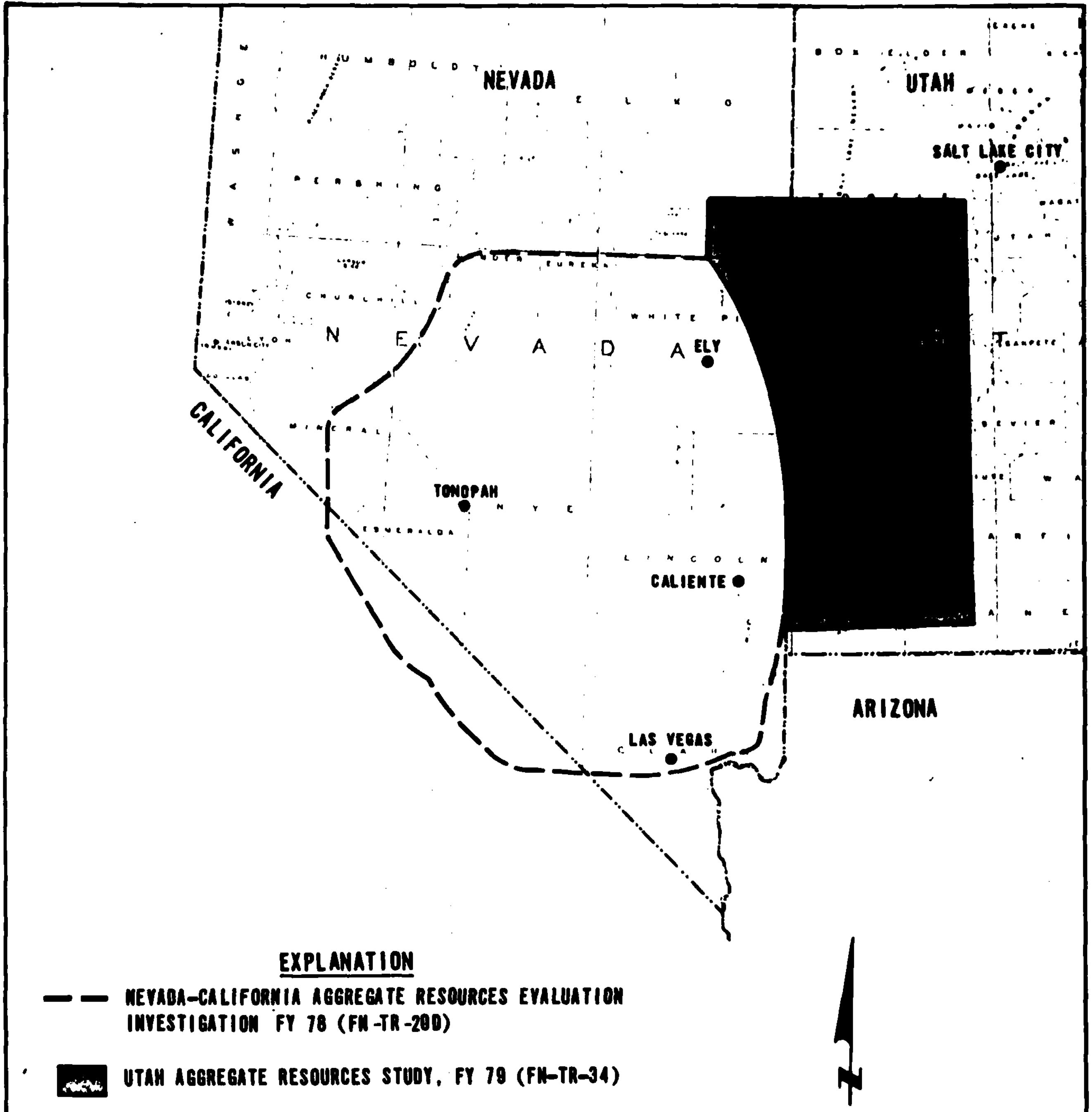
### 1.3 OBJECTIVES

The primary objective of the VSARS program is to classify on a valley basis, basin-fill deposits and rock for suitability as concrete and road base construction materials. The VSARS format is designed to select and present the locations of the most acceptable aggregate sources for preliminary construction planning and follow-on, detailed aggregate investigations.

### 1.4 SCOPE

The scope of this investigation required office and field investigations and included the following:

(1) Collection and analysis of available existing data on the quality and quantity of potential concrete aggregate and road base material sources. American Society



EXPLANATION

NEVADA-CALIFORNIA AGGREGATE RESOURCES EVALUATION INVESTIGATION FY 78 (FN-TR-280)

UTAH AGGREGATE RESOURCES STUDY, FY 79 (FN-TR-34)

SCALE 1: 5,000,000

0 50 100
STATUTE MILES

0 50 100
KILOMETERS

UTAH-NEVADA REGIONAL AGGREGATE STUDIES

MX SITING INVESTIGATION
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FIGURE
2

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6 JUN 80

of Testing and Materials (ASTM) standards and Standard Specifications for Public Works Construction (SSPWC) were used to evaluate quality.

(2) Aerial and ground reconnaissance of all identified potential aggregate sources in the valley area, with more detailed investigation and sample collection of likely basin-fill (coarse and fine aggregates) and rock (crushed rock aggregates) construction material sources.

(3) Laboratory testing to supplement available existing data and to provide detailed information to assist in determining the suitability of specific basin-fill or rock deposits as construction material sources within the valley area.

(4) Development and application of an aggregate classification system (Section 2.5) that emphasizes aggregate type (coarse, fine, or crushed rock) and potential construction use (concrete and/or road base).

# 2.0 STUDY APPROACH

## 2.1 EXISTING DATA

Collection of existing test data from available sources was an important factor in the VSARS program. The principal source of existing data directly pertaining to aggregate construction materials was the State of Nevada Department of Highways (Appendix A). The majority of this information is related to the use of aggregate material for asphaltic concrete, base course in road construction, or ballast material. However, many of the suitability tests for these types of construction materials are similar to those for concrete and were applicable to this investigation (Appendix A).

## 2.2 SUPPLEMENTAL FUGRO NATIONAL DATA

Supplemental Fugro National data were obtain from: (1) field data and supplementary test data compiled during the general aggregate resources study (FN-TR-20D), (2) Dry Lake Valley Verification study (FN-TR-27-DL-I and II), (3) Muleshoe, Delamar, and Pahroc Verification studies (in progress), and (4) the current Valley-Specific Aggregate Resources Study (Appendix A).

Although the primary objective of the initial, general aggregate study was directed toward developing regional evaluations and rankings of all potential aggregate sources, the 20 data points included in the Valley-Specific study area (Drawing 1) also supplied specific aggregate information. These 20 stops contained three 100-pound samples collected for limited laboratory testing (Appendix A).

Verification geologic maps were an initial source of information on the type and extent of basin-fill units within specific valley area. In addition, Verification study data included information from 25 trench locations distributed thoughout the study area (Drawing 1). Depths of the selected trenches ranged from 5 to 18 feet. While the Verification studies are not specifically designed to generate aggregate data, the sampling techniques and testing procedures (Appendix A) are applicable to the aggregate evaluation.

The VSARS program required aerial and ground reconnaissance of the study area to collect additional information to verify conditions determined during the data review. Included in the 63 field station data stops was the collection of 23 samples for laboratory testing. Potential coarse and fine aggregate basin-fill samples were collected by channel sampling stream cuts or occassional man-made exposures. Potential crushed rock aggregate samples were obtained from exposures of fresh or slightly weathered material whenever possible. The weight of the samples collected range between 100 and 150 pounds. Hand samples, which generally did not exceed 5 pounds in weight, were collected for office analyses.

Identification of basin-fill materials in all field studies followed ASTM D2488-69 Description of Soils (Visual-Manual Procedure), and the Unified Soil Classification System (Appendix C). Rock identifications followed procedures described in the

Quarterly of the Colorado School of Mines and Standard Investigative Nomenclature of Constituents of Natural Mineral Aggregates (ASTM C294-69).

## 2.3 DATA ANALYSIS

Geologic and engineering criteria were used in the evaluation of potential aggregate sources within the study area. This was supplemented by laboratory analysis of selected samples during the Valley-Specific aggregate testing program (Table 1). Coarse aggregate is defined as plus 0.185 inch (4.699 mm) fine gravel to boulders basin-fill material. Fine aggregate is defined as minus 0.375 inch (9.52 mm) coarse to fine sand basin-fill material. While all laboratory tests supplied definitive information, the soundness, abrasion, and alkali reactivity results were considered the most critical in determining the use and acceptability of a potential aggregate source.

## 2.4 PRESENTATION OF RESULTS

Results of the study are presented in textual form, tables, two 1:125,000 scale maps, and appendices. Drawing 1 presents the location of the 121 existing test data and supplemental Fugro data sites within the study area. Drawing 2 presents the location of all VSARS laboratory sample sites and all potential basin-fill and rock aggregate sources within the valley area. In addition, these potential aggregate sources are classified according to proposed aggregate use and type (Section 2.5).

| ASTM TEST | SAMPLE TYPE AND NUMBER OF TESTS | | |
|---|---|---|---|
| | COARSE | FINE | ROCK |
| ASTM C-88; SOUNDNESS BY USE OF MAGNESIUM SULFATE | 11 | 10 | 6 |
| ASTM C-131; RESISTANCE TO ABRASION BY USE OF THE LOS ANGELES MACHINE | 12 | | 8 |
| ASTM C-136; SIEVE ANALYSIS | 12 | 10 | |
| ASTM C-289; POTENTIAL REACTIVITY OF AGGREGATES (CHEMICAL METHOD) | 3 | 2 | 3 |
| ASTM C-127 AND C-128; SPECIFIC GRAVITY AND ABSORPTION | 9 | 3 | 5 |

AGGREGATE TESTS
DRY LAKE, MULESHOE, DELAMAR,
AND PAHROC VALLEYS
AGGREGATE RESOURCES STUDIES, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
1

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Geologic unit symbols utilized in Drawing 2 relate to standard geological nomenclature whenever possible. Undifferentiated basin-fill and rock units were established primarily to accomodate accuracy of data and map scale and may contain deposits which could supply significant quantities of high quality materials. A conversion table to relate these geologic symbols to Fugro geologic unit nomenclature is contained in Appendix E.

All contacts which represent distinct boundaries between geologic units are shown as solid lines in Drawing 2. The contacts are dashed where the depicted data were extrapolated beyond the limits of the source data or where accuracy of the data may be questionable. Local small deposits of one geologic unit may be found in close association with a larger deposit of a different geologic unit. Due to the reconnaissance level of the field investigation or scale limitations, these smaller deposits could not be depicted on the aggregate resources map and have been combined with the more prevalent material. Similarly, potential aggregate source classifications are preliminary and may contain lesser amounts of material of another use or type. Therefore, all classification lines are dashed and delimit the best aggregate evaluations possible at this level of investigation. In cases of highly variable rock or basin-fill units and limited aggregate tests, boundaries could not be drawn and information is presented as point data on Drawing 2.

Appendices contain tables summarizing the basic data collected during Fugro National's supplemental field investigations, the results of Fugro National's supplemental testing programs, and existing test data gathered from various outside sources (Appendix A), an explanation of caliche development (Appendix B), the Unified Soil Classification System (Appendix C), photographs of typical aggregate sources within the study area (Appendix D), and a geologic unit cross reference table (Appendix E).

## 2.5 PRELIMINARY CLASSIFICATION OF POTENTIAL AGGREGATE SOURCES

A system was developed to preliminarily classify all potential aggregate sources in the study area. This classification is designed to present the best potential sources of coarse, fine, coarse and fine (multiple source), and crushed rock aggregate types within a Valley-Specific area (Drawing 2) based on potential aggregate use (Table 2). *Concrete aggregate parameters are* the principal consideration in this report as materials suitable for use as concrete aggregate are generally acceptable for use as road-base material. Therefore, the three classifications described below were based primarily on results of the abrasion, soundness, and alkali reactivity tests.

Class I Potentially suitable concrete aggregate and road base material source. Coarse and crushed rock aggregates which either passed abrasion, soundness, and alkali reactivity tests or passed abrasion and soundness tests and were not tested for alkali reactivity; fine aggregates which either passed soundness and alkali reactivity tests or passed soundness tests and were not tested for alkali reactivity.

Class II Possibly unsuitable concrete aggregate/potentially suitable road-base material source. Coarse, fine, and crushed rock aggregates which either failed the soundness and/or alkali reactivity tests or were classified only by field visual observations or other test data.

| AGGREGATE CHARACTERISTIC[1] | | | AGGREGATE USE CLASSIFICATION | | |
|---|---|---|---|---|---|
| | | | CLASS I | CLASS II | CLASS III |
| ABRASION RESISTANCE, PERCENT WEAR[2] | | | < 50 | < 50 | > 50 |
| SOUNDNESS, PERCENT LOSS[3] | COARSE AGGREGATE | Na $SO_4$ | < 12 | > 12 | > 12 |
| | | Mg $SO_4$ | < 18 | > 18 | > 18 |
| | FINE AGGREGATE | Na $SO_4$ | < 10 | > 10 | > 10 |
| | | Mg $SO_4$ | < 15 | > 15 | > 15 |
| POTENTIAL ALKALI REACTIVITY[4] | | | INNOCUOUS TO POTENTIALLY DELETERIOUS | DELETERIOUS | DELETERIOUS |

1. AGGREGATE CHARACTERISTIC BASED ON STANDARD TEST RESULTS
2. ASTM C131 (500 REVOLUTIONS)
3. ASTM C88 (5 CYCLES)
4. ASTM C289

**PRELIMINARY AGGREGATE CLASSIFICATION SYSTEM**
**VALLEY-SPECIFIC AGGREGATE RESOURCES STUDY**

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
2

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Class III Unsuitable concrete aggregate or road base material source. Coarse and crushed rock aggregates which failed abrasion test and were excluded from further testing. Fine, and rarely, coarse aggregates composed of significant amounts of clay- and silt-sized particles.

Sources not specifically identified as Class I, II, or III from the three critical test results or clay- and silt-sized particle content, are designated as Class II sources. All classifications are preliminary with additional field reconnaissance, testing, and case history studies needed to confirm adequacy, delimit areal boundaries, and define exact physical and chemical characteristics.

The following publications/sources were used in defining the three use classifications:

(1) ASTM C33-74A Standard Specifications for Concrete Aggregate,

(2) SSPWC Part II Construction Sections 200-1.1, 1.4, 1.5, and 1.7,

(3) Literature applicable to concrete aggregates,

(4) Industrial producers of concrete aggregates, and

(5) Consultants in the field of concrete aggregates.

# 3.0 GEOLOGIC SETTING

## 3.1 PHYSIOGRAPHY

The study area lies entirely within the Basin and Range physiographic province. Primary physiographic features are controlled by block faulting which has produced the uplifted mountains and down-dropped alluvial filled basins characteristic of this region. Mountain ranges and valley basins generally trend north-south. Elevations within the valley range from about 6400 feet (1950 m) at the northern end of the study area to approximately 4400 feet (1340 m) near the southern terminus. Nine mountain ranges bound the valley basin areas. These are the Schell Creek, North Pahroc, Hiko, and South Pahroc ranges on the west and the Fairview, Bristol, Ely Springs, Highland, Burnt Springs, Chief, and Delamar ranges on the east (Drawing 2). Topographic relief between mountain ridges and basins is generally greatest along the northern and eastern valley margins and ranges from 1000 to 4000 feet (305 to 1220 m). Drainage is essentially closed within Dry Lake and Delamar valleys, whereas, open drainage characterizes Muleshoe and Pahroc valleys.

## 3.2 LOCATION AND DESCRIPTION OF GEOLOGIC UNITS

Paleozoic, Mesozoic, and Cenozoic rocks are found in bedrock highs and mountains within and adjacent to the study area (Drawing 2). Paleozoic sediments consist predominantly of massively to thinly bedded limestones and dolomites with interbedded sandstones, shales, and quartzites. These sediments are located across the entire Valley-Specific area, and where not exposed in bedrock highs, underlie younger geologic units. Unconformably overlying Paleozoic rocks within the site region are Mesozoic deposits consisting predominantly of undifferentiated volcanic and intravolcanic sedimentary rocks principally composed of pyroclastics, mud flows, and breccias of andesitic composition.

Cenozoic rocks uncomformably overlie Paleozoic and Mesozoic units. These rocks consist of Tertiary intrusives, volcanics, and Quaternary alluvial sediments. Tertiary volcanic rocks are composed predominantly of a pyroclastic series of welded and nonwelded vitric and crystalline tuffs that range from mafic to rhyolitic in composition.

Quaternary alluvial deposits lie unconformably above all older units and consist primarily of Late Pliocene and Pleistocene alluvial fan, lacustrine, stream channel, and terrace deposits. These units may reach a combined thickness of many thousands of feet in the valley centers.

These geologic units have been grouped into eight rock and four basin-fill geologic units for use in discussing potential aggregate sources. The grouping of these units was based on similarities in physical and chemical characteristics and map scale limitations. The resulting units simplify discussion and presentation without altering the conclusions of the study.

### 3.2.1 Rock Units

Geologic rock units were grouped into the following eight categories (Drawing 2): quartzite (Qtz), limestone (Ls), dolomite (Do), carbonate rocks undifferentiated (Cau), sedimentary rocks undifferentiated (Su), granitic rocks (Gr), basalt (Vb), and volcanic rocks undifferentiated (Vu). Class II granitic rocks that crop out in the southern portion of the Bristol Range are of limited areal extent and will not be discussed.

#### 3.2.1.1 Quartzite - Qtz

Two lower Paleozoic quartzite deposits, the Prospect Mountain and Eureka quartzites, crop out in the Valley-Specific study area. Major deposits of the Prospect Mountain Quartzite are located along the east-central and southeastern margin of the site area along the west flank of the Highland Range, in the southern end of the Chief Range, and within the west-central portion of the Delamar Mountains (Drawing 2). The formation consists of reddish brown to white, thin to massively bedded, well indurated, fine-grained quartzite with interbeds of less resistant quartzite, micaceous shale, pebble conglomerates, and arkosic sandstone layers. Diabase dikes and sills of basaltic appearance locally intrude the formation.

The Eureka quartzite crops out as small units in the central portion of the study area. It is thin, generally less than 500 feet (150 m) thick, and because of its close association with the Pogonip Group (Cau) is often mapped with this formation. Quartzite units are present at the north end of Burnt Springs and North Pahroc ranges and the south end of the Ely Springs Range. The formation is white or light gray in appearance, vitreous, sugary, fine- to medium-grained, massive orthoquartzite. Interbedded sandstones and dolomitic sandstones occur at the top and bottom of the formation.

#### 3.2.1.2 Limestone - Ls

Limestone is a carbonate rock which is hard, durable, medium-to massively bedded and a major cliff former within the study area. Mapped units represent upper Paleozoic sediments principally of Mississippian, Pennsylvanian, and Permian age. Formations represented include the Pogonip Group, the Joanna, Mercury, and unnamed Pennsylvanian and Permian limestones. The limestones are typically medium to dark gray, fine- to medium-grained, fossiliferous, and sparsely cherty, with well-developed bedding and jointing. This unit is mapped chiefly in the northern portion of the study area, with major deposits occurring in the Grassy and Dutch John mountains, and at the northern end of the North Pahroc Range.

#### 3.2.1.3 Dolomite - Do

Dolomite is a high magnesium carbonate rock that is characteristically dark to medium gray in appearance, medium-grained, sparsely to moderately cherty, hard, with well-developed bedding and jointing. Principal formations that comprise the bulk of this unit are the lower Paleozoic Ely Springs, Laketown, Sevy, and Simonson dolomites. Major deposits are mapped in the Hiko

Range west of Pahroc Valley, within the Schell Range west of Muleshoe Valley, and the Ely Springs Range.

### 3.2.1.4 Carbonate Rocks Undifferentiated - Cau

Materials classified as undifferentiated carbonate rocks include thick, complex sequences of limestone and dolomite with thin interbeds of sandstone, shale, and siltstone. Individual units are not delineated separately due to map scale limitations and the highly interbedded nature of these units. Principal formations in this unit include the Highland Peak, Guilmette, and unnamed Permian and Pennsylvanian deposits. These rocks are typically light to dark gray in appearance, thinly to massively bedded, hard, cherty, fossiliferous, and are durable cliff formers. Undifferentiated carbonate units are the most extensive of the mapped sedimentary rock units within the study area. The Bristol and Highland Ranges along the east-central margins of the site are almost entirely mapped as undifferentiated carbonate rocks.

### 3.2.1.5 Sedimentary Rocks Undifferentiated - Su

Geologic formations mapped as undifferentiated sedimentary rocks include interbedded sandstone, shale, dolomite, limestone, and quartzite that may have been slightly metamorphosed in some areas. These deposits are characterized by poorly indurated material and complex, thin to medium bedding. The highly interbedded nature of these units prevents separation into individual rock types (limestones, dolomites). Undifferentiated sedimentary rocks are not a major unit within the site region and are located primarily in small areas along the west and east margins in the central study area.

#### 3.2.1.6 Basalt - Vb

Tertiary basalt mapped in the study area is characteristically dense, dark gray to black, medium to thick bedded, locally vesicular, and poorly jointed. Occassionally, interbeds of volcanic agglomerate and pumice are present. Basalt is of minor extent and outcrops primarily in and adjacent to the North Pahroc Range.

#### 3.2.1.7 Volcanic Rocks Undifferentiated

Undifferentiated volcanic rocks comprise the most extensive rock unit in the study area. They range from Cretaceous to Pliocene in age and consist predominantly of welded and nonwelded pyroclastics (air falls, ash flows, ignimbrites) of rhyolitic and andesitic composition.

These volcanics also include intravolcanic sedimentary rock consisting primarily of gravel, sand, and silt. Individual rock units have not been delineated because of map scale limitations and complex, but similar composition.

### 3.2.2 Basin-Fill Units

Four basin-fill units are mapped and labelled within the study area (Drawing 2). These consist of alluvial fan (Aaf), older lacustrine (Aol), stream channel and terrace (Aal), and undifferentiated alluvial deposits (Au). Gravel (g) and sand (s) grain-size designations have been assigned basin-fill units in the Verification mapped areas (e.g. Aafg). Recent playa deposits, a fifth basin-fill unit, are also present in Dry Lake and Delamar valleys, but these are labelled as unsuitable aggregate sources and will not be discussed.

### 3.2.2.1 Older Lacustrine Deposits - Aol

Older lacustrine deposits were formed during late Pliocene/early Pleistocene time in response to a much wetter climate. These deposits are located at topographically higher elevations than recent playa deposits in the valley centers and are usually intermixed with or overlain by alluvial fan deposits. They range from coarse gravels to sands, silts, and clays. Classification of these deposits depends primarily on texture and clast composition. They occur principally in portions of Dry Lake Valley and on the flanks of Pahranagat Valley, west of the Pahroc Valley study area (Drawing 2).

### 3.2.2.2 Alluvial Fan Deposits - Aaf

Alluvial fans bordering the mountain fronts and extending out into the valley basins are the most extensive basin-fill deposits within the study area. They are typically heterogeneous to poorly stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay that grade from very coarse-grained near the rock/alluvium contact to fine-grained near the valley centers. Individual fan units contain poorly to well graded, angular to subangular particles and exhibit considerable lateral and vertical textural variation. Composition of the surrounding source rock strongly controls the textural properties of material found in alluvial fan deposits. Fan units formed at the base of carbonate or quartzitic rocks are characteristically coarse grained, whereas fans developed from volcanic sources tend to be finer grained.

Caliche development in soils, a natural process of soil development in arid climates, ranges from none in younger fans to Stage III (Appendix B) in older units.

### 3.2.2.3 Stream Channel and Terrace Deposits - Aal

Stream channel and terrace deposits within the study area are associated with primary and secondary ephemeral streams. Secondary ephemeral streams commonly transect alluvial fan deposits and trend normal to the ranges toward the valley axis. There, they terminate in a central playa area (Dry Lake, Delamar Lake) or a primary drainage system (Muleshoe Valley). Most are too small to be depicted on Drawing 2 and have been grouped with adjacent, more prominent units (i.e., alluvial fan, undifferentiated alluvium). These deposits vary from homogeneous to poorly stratified mixtures of sand, gravel, cobbles, and boulders near mountain fronts to sands, silts, and clays near valley centers.

### 3.2.2.4 Alluvial Deposits Undifferentiated - Au

Undifferentiated alluvial deposits consist of combinations of basin-fill units that were not delineated and mapped during the Verification program. Included in this group are alluvial fans, older lacustrine, stream channel, stream terrace, and pediment deposits. These alluvial deposits are homogeneous to stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay derived from a wide range of rock types. Composition varies according to the characteristics of the individual units and the source rock type. Undifferentiated alluvial deposits are generally located along the inside margins of the valley-specific boundaries around the study region (Drawing 2).

## 4.0 POTENTIAL AGGREGATE SOURCES

Based on the results of field visual observations and aggregate testing, potential basin-fill and rock sources were divided into three basic material types (i.e., coarse, fine, and crushed rock) and classified into one of the three use categories (Section 2.5). Basin-fill deposits tested in the study area may be placed within a multiple type category, (coarse and fine aggregate source). Coarse aggregate is defined as plus 0.185 inch (4.699 mm) fine gravel to boulders and fine aggregate is defined as minus 0.375 inch (9.52 mm) coarse to fine sand.

Classification boundaries (Drawing 2) of basin-fill aggregate sources were generalized and will require additional studies to accurately define their location. Boundaries of identified crushed rock sources are based on the areal map extent of the geologic formations tested (i.e., Eureka Quartzite, Guilmette Formation, Pogonip Group) and not on the aggregate geologic unit (i.e., Cau, Do, Qtz) described in Section 3.2.1.

In the following discussion, the best potential coarse, fine, or crushed rock source within each Class I and Class II category is presented first; followed by successively less probable sources. This ranking of deposits is preliminary and based upon an analysis of Fugro National and exisiting data.

## 4.1 BASIN-FILL SOURCES

### 4.1.1 Coarse Aggregate

#### 4.1.1.1 Potentially Suitable Concrete Aggregate and Road Base Material Sources - Class I

Extensive Class I coarse aggregate sources are located along the east side of Dry Lake Valley in alluvial fan units bordering the Class I crushed rock sources in Bristol, Highland Peak, West, Ely Springs, and Burnt Springs ranges (Drawing 2). The alluvial fan units consist predominantly of moderately to moderately well graded, sandy gravels with subangular to subrounded carbonate and quartzite clasts. Laboratory test data indicate these deposits have acceptable abrasion, soundness, and alkali reactivity values for Class I coarse material (Appendix A). Sieve analysis of these samples suggest that the fan deposits are biased toward the fine end and may lack material in the coarse fraction for crushing. Overburden averages 1 to 3 meters and consists predominantly of caliche cemented gravels (Stage II to III).

Access to these deposits is provided by several unpaved roads that crisscross the area and minability is considered good to excellent. Additional field reconnaissance and testing will be necessary to accurately define the limits of this source.

Class I coarse aggregate deposits are also present in older lacustrine deposits (Aolg) within Pahranagat Valley southwest of Pahroc Valley (Drawing 2). These deposits consist of moderately well-graded, medium dense to dense, stratified sandy gravels composed primarily of carbonate clasts. Coarse fragments are subrounded and sufficient material greater than 3/4-inch exists for crushing. Testing was completed on two samples at widely separated locations and test results are available from three State of Nevada Highway pits. Results were positive, with acceptable losses in the abrasion and soundness tests. Overburden ranged from 1 to 5 meters (averaging 2.5 meters) and consists primarily of sandy material.

Limited coarse alluvial fan deposits (Aafg) in east-central Delamar Valley were also identified as Class I aggregate sources (Drawing 2). The unit consists of moderately well-graded, medium dense, sandy gravels derived primarily from nearby quartzite and carbonate rocks. Seive analysis indicates sufficient quantities of material exist above the 3/4-inch size for crushing. Abrasion and soundness losses were within acceptable limits but testing for alkali reactivity was not made on this sample. Overburden thickness averages less than 1 meter on this deposit.

Additional Class I coarse aggregate sources are present in alluvial fan deposits east of Dutch John Mountain at the north end of the study area. These deposits consist of medium dense, poorly graded sandy gravels with overburden averaging less than 1 meter in thickness. Although boundaries of this unit could not be drawn from the field reconnaissance and limited laboratory testing, field observations suggest that most alluvial fan units bordering Class I rock sources at the northern end of the study area may qualify as Class I aggregate sources.

#### 4.1.1.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

A limited stream channel deposit in Antelope Canyon, just north of Caliente, Nevada, was identified during the investigation as a Class II source of coarse aggregate. This deposit is composed primarily of quartzitic clasts derived from the Prospect Mountain Quartzite (Class II rock source). The deposit consists of medium dense, moderately well-graded, sandy gravel with subangular to subrounded clasts. Test results indicate an acceptable abrasion loss but lack of soundness results require a Class II ranking. A favorable soundness test would qualify this unit as Class I.

Based on field observations, Class II coarse material may be present in alluvial fans near the rock/ alluvium contact of nearly all mountain ranges. Access and mining of these sources should be good to excellent across the study region.

#### 4.1.1.3 Unsuitable Concrete Aggregate or Road Base Material Sources - Class III

No unsuitable coarse aggregate sources were identified in the study area during the Valley-Specific investigation.

### 4.1.2 Fine Aggregate

#### 4.1.2.1 Potentially Suitable Concrete Aggregate and Road-Base Material Sources-Class I

Class I fine aggregate sources are located in alluvial fan deposits bordering the north end of the Bristol Mountain Range and consist of medium dense, moderately well-graded, gravelly sands (Drawing 2). Gravel clasts within the unit are derived predominantly from Class I carbonate rocks. Soundness test results are within Class I standards for fine aggregate (Table 2). Field observations indicate that deleterious substances are minor and the overburden thickness averages between 1 and 2 meters. The untested coarse aggregate content ranges from 20 to 40 percent and based on results of aggregate tests for coarse units in the same general fan complex, may also qualify as a Class I source. Access is provided by several unpaved roads that traverse the alluvial fan complex. Minability is considered good to excellent. Boundaries of Class I fine aggregate sources could not be delineated at this level of investigation and will require additional field studies and testing to define accurately.

Class I fine aggregates sources were also identified in alluvial fan deposits east of Dutch John Mountain in the northern portion of the study area. These deposits are predominantly poorly graded sandy gravels that meet Class I requirements for coarse (Section 4.1.1.1) and fine aggregate sources (multiple source). Boundaries of this unit could not be defined at this level of investigation. Based on field observations, other potential Class I fine aggregate sources may exist in alluvial fan or older lacustrine deposits derived from detritus of identified Class I crushed rock sources.

#### 4.1.2.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Materials Sources - Class II

Class II fine aggregate sources are located in alluvial fan units that receive sediments from the Bristol, Highland, and

Burnt Springs ranges (Drawing 2). These deposits consist of moderately well graded, medium dense, gravelly sands and sandy gravels predominantly of carbonate rock origin. Gravel comprises from 13 to 55 percent of the sieved samples with clasts consisting primarily of limestones and dolomites derived from the nearby mountain ranges. Soundness losses were unacceptable and alkali reactivity tests were not run on these samples.

Abrasion and soundness tests completed for the coarse material from the same alluvial fan complex are well within Class I standards (Table 2). Based on these results, aggregate sources in these areas may provide good multiple sources where gravels comprise a significant percentage of the deposit (Section 4.1.1.1).

An additional Class II fine aggregate source of limited areal extent was noted in a stream channel deposit in Antelope Canyon, just north of Caliente, Nevada. Sand-sized particles comprise up to 45 percent of this sandy gravel multiple source unit whose coarse fraction tested as a Class II coarse aggregate source.

Boundaries of Class II fine aggregate sources could not be delineated on Drawing 2 at this level of investigation and will require additional field reconnaissance and testing to accurately delineate. Additional sources of Class II fine aggregate are probably available in almost all alluvial fan units bordering Class I crushed rock sources.

### 4.1.2.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

Class III fine aggregate sources are located in the valley basins and are comprised predominantly of older lacustrine and recent playa deposits (Drawing 2). These sediments are typically interbedded and stratified moderately dense fine sand, silt, and clay.

## 4.2 CRUSHED ROCK SOURCES

### 4.2.1 Potentially Suitable Concrete Aggregate and Road-Base Material Sources - Class I

Class I crushed rock sources are widely distributed throughout the study area. The most extensive deposits occur in the Bristol, Highland, and Burnt Springs ranges in east-central Dry Lake Valley (Drawing 2) and consist primarily of limestones and dolomites from the Highland Peak formation and unnamed Upper Cambrian limestones and dolomites (Cau). Field observations and limited laboratory testing (Appendix A) of the Highland Peak Formation indicate that splitting characteristics are favorable for crushing and abrasion and soundness losses are moderate to low (Table 2). Alkali reactivity tests have not been completed on this formation. Limestone from this rock unit has been previously quarried at the south end of the Highland Range and used in road construction. This formation also forms the principal Class I material of the Burnt Springs Range and is the major crushed rock source in the central Delamar Mountains.

Unnamed Upper Cambrian limestones and dolomites, although not as extensive as the Highland Peak Formation, are also present as major deposits in the Highland, Burnt Springs, and Ely Spring ranges. Limited field observations suggest that the limestones within this formation are hard, have good splitting characteristics and no observable deleterious properties. Test results show no undesireable aggregate characteristics for a Class I rock unit (Table 2), however, alkali reactivity has not been tested in this source.

Access to deposits in the Bristol and Highland ranges is provided by numerous unpaved roads from Pioche, Nevada to the east and the valley basin to the west. The minability of these deposits is considered fair to very good, depending primarily on the slope of the terrain and the repose of the rock unit. Class I deposits of the Burnt Springs and Ely Springs ranges, because of their close proximity to the valley basin, would provide an excellent, highly accessibly and minable source of Class I crushed rock aggregate for the southcentral portion of the area of investigation.

Unnamed Pennsylvanian limestones (Ls) and the Guilmette Formation (Cau) form large Class I crushed rock sources at the northern end of the study area (Drawing 2). Major deposits of Pennsylvanian limestone occur primarily within the Dutch John and Grassy mountains region, northern North Pahroc Range, and as small units in the Schell Creek Range. Abrasion, soundness, and alkali reactivity test results are all well within Class I requirements. Field observations indicate that the formation is hard to very hard, fine grained, and has slabby splitting characteristics. Existing unpaved roads provide good access to exposures of this formation located near the rock/alluvium contact and the minability of this unit is generally considered good.

The Guilmette Formation forms numerous bedrock highs and low hills in the northern half of the Dry Lake study area. Scattered small knolls composed of rocks primarily from this formation lie within the valley basin parallel to and east of the North Pahroc Range. The Guilmette Formation forms about one-half of the West Range in the east-central portion of the region and portions of the Schell Creek Range and Dutch John Mountain at the northern end of the study area. A small section of this unit is also located in the Hiko Range bordering Pahroc Valley in the southwest portion of the area of investigation. Data from laboratory testing indicates that the limestones display acceptable abrasion and soundness values. Alkali reactivity tests were not run on this unit. Field observations indicate rock jointing is favorable and deleterious materials were generally minor in extent. Access and minability is excellent, especially for those units located within the valley basin.

Class I andesitic volcanic rocks (Vu) were identified at the northern end of the Bristol Range (Drawing 2). While not considered a primary source of Class I crushed rock due to lateral and vertical lithologic variations, acceptable test results indicate that volcanic rocks of this composition could make potentially suitable crushed rock sources in areas where unit boundaries can be defined.

A sandstone member within the Simonson Dolomite (Do) was the only Class I crushed rock aggregate source tested in Pahroc Valley. Although the formation forms major deposits within the Hiko Range in the southwest section of the region and small deposits within the Schell Creek Range at the northern end of the study area, Class I ranking was given only to the sandstone unit. Additional laboratory testing will be necessary to classify the acceptability of the entire formation as a Class I aggregate source. The access and minability of this crushed rock source is considered very good within the Hiko Range.

### 4.2.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

No Class II crushed rock aggregate sources were specifically identified from the laboratory testing program. Extensive rock units indicated on Drawing 2 as Class II crushed rock sources were classified only by field visual observations. The predominant types of rock in this category are undifferentiated volcanics of a highly variable lithologic composition and certain Paleozoic carbonates and sedimentary rocks.

The Prospect Mountain Quartzite (Qtz) was identified as a Class II crushed rock source within the Chief Range at the southern end of Dry Lake Valley and in Delamar Valley within the central portion of the Delamar Range. Field observations indicate that the quartzite is very hard, having slabby splitting characteristics, and no deleterious materials. A Class II ranking was given this formation because direct measurements of aggregate characteristics were not made. However, further examination and laboratory testing may give it a Class I designation.

### 4.2.3 Unsuitable Concrete Aggregate or Road Base Material Sources - Class III

Two crushed rock aggregate sources failed aggregate abrasion tests and were identified as Class III geologic units. The unsuitable sources included an exposure of Eureka Quartzite (Qtz) at the northern end of the Burnt Springs Range and rhyolitic tuffs (Vu) located at the southern end of Delamar Valley (Drawing 2).

## 5.0 CONCLUSIONS

Results of the Valley-Specific aggregate investigation indicate that potentially good to high quality (Classes I and II) basin-fill and crushed rock aggregate sources are present within the Dry Lake, Muleshoe, Delamar, and Pahroc Valley Specific study area to meet construction requirements of the MX system (Drawing 2).

### 5.1 POTENTIAL BASIN-FILL AGGREGATE SOURCES

#### 5.1.1 Coarse Aggregate

Major Class I coarse aggregate deposits listed in order of potential suitability, have been identified within the following areas:

1. Alluvial fan deposits west of the Bristol, Highland, and Burnt Springs ranges in east-central Dry Lake Valley,
2. Older lacustrine sediments west of Pahroc Valley (Pahranagat Valley),and
3. Alluvial fans bordering the Delamar Mountains in east-central Delamar Valley.

Field observations indicate additional sources of Class I coarse aggregate may be available in alluvial fan deposits adjacent to the rock/ alluvium contact of Class I crushed rock sources.

Potential Class II coarse aggregate sources are widespread and extensive in the study area. Although boundaries of specific deposits could not be delineated, they are typically located within alluvial fans flanking Class I and/or Class II rock sources.

### 5.1.2 Fine Aggregate

While most coarse aggregate sources will supply quantities of fine aggregate either from the natural deposits or during processing, several fine aggregate sources were sampled and tested. Class I fine aggregate deposits were identified in alluvial fans bordering Class I rock sources at the north end of the Bristol Range and near Dutch John Mountain (multiple sources). Further field reconnaissance will be required to identify and delineate additional Class I fine aggregate sources, however, based on field observations, potential sources may exist in alluvial fan units derived from Class I rock sources.

Potential Class II fine aggregate sources are widespread and extensive in the study area. Specific deposit boundaries could not be delineated but typically occur basinward of most Class I and Class II coarse aggregate deposits and/or rock exposures.

## 5.2 POTENTIAL CRUSHED ROCK AGGREGATE SOURCES

Class I crushed rock sources exist in most sections of the study area. The most suitable deposits and their corresponding locations are listed below:

1. Unnamed Upper Cambrian and Pennysylvanian carbonates Highland Peak Formation Guilmette Formation - Eastern Dry Lake Valley (Bristol, Highland, Ely Springs, West, and Chief ranges)
2. Highland Peak Formation - Eastern Delamar Valley (Central Delamar Mountains)

3. Unnamed Pennsylvanian limestones - Northern Muleshoe Valley (Schell Creek Range and Dutch John and Grassy mountains)
4. Guilmette Formation - Northwestern Pahroc Valley (Hiko Range)

Class I crushed rock sources, exposed within the Burnt Springs, West and Ely Springs ranges, because of their close proximity to the valley basin and good to excellent minability, could provide crushed rock material for much of the central valley area. Undifferentiated volcanics and limited sedimentary units widely distributed throughout the study area comprise most of the Class II crushed rock sources delineated on Drawing 2.

## 6.0 RECOMMENDATIONS FOR FUTURE STUDIES

Future aggregate studies should include a program to refine the lateral and vertical boundaries of Class I basin-fill, coarse aggregate sources and define their exact physical and chemical characteristics. The following procedures are recommended to achieve these objectives.

1. An examination of stereo aerial photographs of the Class I basin-fill and surrounding areas. Emphasis should be placed on the determination of grain-size and compositional variations within the preliminarily defined Class I source areas and the delineation of any subareas.
2. Field reconnaissance and selection of areas for sampling with standard backhoe equipment.
3. A laboratory aggregate testing program to evaluate the concrete making properties of the Class I basin-fill aggregate sources. This should include a concrete mix design test program and where needed, additional Los Angeles abrasion, soundness, and alkali reactivity tests.

This study would provide information on the relative economic aspects of the various Class I basin-fill sources necessary for developing plant designs and locations, mining methods, and concrete mix designs. It should be initiated immediately to minimize any impact on pre-construction planning considerations.

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# APPENDIX A

## Fugro National Field Station and Supplementary Test Data and Existing Test Data Summary Tables - Dry Lake, Muleshoe, Delamar, and Pahroc Valleys

# EXPLANATION OF FUGRO NATIONAL FIELD STATION AND SUPPLEMENTARY TEST DATA

Fugro National field stations were established at locations throughout the Valley-Specific study area where detailed descriptions of potential basin-fill or rock aggregate sources were recorded (Drawing 1). All field observations and laboratory test data on samples collected at selected stations are presented in Table A-1. Data entries record conditions at specific field station locations that have been generalized in the text and Drawing 2. Detailed explanations for the column headings in Table A-1 are as follows:

| Column Heading | Explanation |
|---|---|
| Map Number | This sequentially arranged numbering system was established to facilitate the labelling of Fugro National field station locations and existing data sites on Drawing 1 and to list the correlating information on Tables A-1 and A-2 in an orderly arrangement. |
| Field Station | Fugro National field station data are comprised of information collected during:<br>o The Valley-Specific Aggregate Resources Study; sequentially numbered field stations were completed by two investigative teams (A and B). The Dry Lake Candidate Deployment Area (DLCDP) designation is obsolete. The presently understood study area consists of Dry Lake, Muleshoe, Delamar, and Pahroc valleys.<br>o The general aggregate investigation in Nevada (NV); R and H indicate ground and aerial reconnaissance stops, respectively.<br>o The Verification study in Dry Lake (DL), Muleshoe (MS), Delamar (DM), and Pahroc |

| Column Heading | Explanation |
|---|---|
| Field Station (cont.) | (P) valleys; trench data (T) were restricted to information below the soil horizon (1 to 2 meters). |
| Location | Lists major physiographic or cultural feature in/or near which field stations or existing data sites are situated. |
| Geologic Unit | Generalized basin-fill or rock geologic units at field station or existing data locations. Thirteen classifications, emphasizing age and lithologic distinctions were developed from existing geologic maps to accomodate map scale of Drawing 2. |
| Material Description | Except in cases where soil or rock samples were classified on laboratory results, the descriptions are based on field visual observations utilizing the Unified Soil Classification System (See Appendix C for detailed USCS information). |
| Field Observations | |
| Boulders and/or Cobbles, Percent | The estimated percentage of boulders and cobbles is based on an appraisal of the entire deposit. Cobbles have an average diameter between 3 and 12 inches (8 and 30 cm); boulders have an average diameter of 12 inches (30 cm) or more. |
| Gravel | Particles that will pass a 3-inch (76 mm) and are retained on No. 4 (4.75 mm) sieve. |
| Sand | Particles passing No. 4 sieve and retained on No. 200 (0.075 mm) sieve. |
| Fines | Silt or clay, soil particles passing No. 200. |
| Plasticity (Index) | Plasticity index is the range of water content, expressed as percentage of the weight of the oven-dried soil, through which the soil is plastic. It is defined as the liquid limit minus the plastic limit. Field classification followed standard descriptions and their ranges are as follows:<br>None - Nonplastic (NP) (PI, 0 - 4)<br>Low - Slightly plastic (PI, 4 - 15)<br>Medium - Medium plastic (PI, 15 - 30)<br>High - Highly plastic (PI, > 31) |

| Column Heading | Explanation |
|---|---|
| Hardness | A field test to identify materials that are soft or poorly bonded by estimating their resistance to impact with a rock hammer; classified as either soft, moderately hard, hard, or very hard. |
| Weathering | Changes in color, texture, strength, chemical composition or other properties of rock outcrops or rock particles due to the action of weather; field classified as either fresh or slight(ly) moderate(ly) or very weathered. |
| Deleterious Materials | Substances potentially detrimental to concrete performance that may be present in aggregate; includes organic impurities, low density material, (ash, vesicules, pumice, cinders), amorphous silica (opal, chert, chalcedony), volcanic glass, caliche coatings, clay coatings, mica, gypsum, pyrite, chlorite, and friable materials, also, aggregate that may react chemically or be affected chemically by other external influences. |
| Laboratory Test Data | |
| Sieve Analysis (ASTM C 136) | The determination of the proportions of particles lying within certain size ranges in granular material by separation on sieves of different size openings; 3-inch, 1 1/2-inch, 3/4-inch, 3/8-inch, No. 4, No. 8, No. 16, No. 30, No. 50, No. 100 and No. 200. |
| No. 8, No. 50 | Asterisked entries used No. 10 and No. 40 sieves, respectively. |
| Abrasion Test (ASTM C 131) | A method for testing abrasion resistance of an aggregate by placing a specified amount in a steel drum ( the Los Angeles testing machine), rotating it 500 times, and determing the material worn away. |
| Soundness Test (ASTM C 88) CA, FA | CA = Coarse Aggregate<br>FA = Fine Agregate<br>The testing of aggregates to determine their resistance to disintegration by saturated solutions of magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate |

| Column Heading | Explanation |
|---|---|
| | information is not available from service records of the material exposed to actual weathering conditions. |
| Specific Gravity and Absorption (ASTM C 127 and 128) | Methods to determine the Bulk Specific Gravity, Bulk SSD Specific Gravity (Saturated - Surface Dry Basis), and Apparent Specific Gravity and Absorption as defined in ASTM E12-70 and ASTM C 125, respectively. |
| Alkali Reactivity (ASTM C 289) | This method covers chemical determination of the potential reactivity of an aggregate with alkalies in portland cement concrete as indicated by the amount of reaction during 24 h at 80 C between 1 N sodium hydroxide solution and aggregate that has been crushed and sieved to pass a No. 50 (300-µm) sieve and be retained on a No. 100 (150-µm) sieve. |
| Aggregate Use | I = Class I; potentially suitable concrete aggregate and road-base material source.<br>II = Class II; possibly unsuitable concrete aggregate/potentially suitable road-base material source.<br>III = Class III; unsuitable concrete aggregate or road base material source.<br>c = coarse aggregate<br>f = fine aggregate<br>f/c = fine and coarse aggregate<br>cr = crushed rock |
| | All sources not specifically identified as Class I, II, or III from the abrasion, soundness, or alkali reactivity tests or the content of clay- and silt-sized particles, are designated as Class II sources. |

| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | | DIST WIT TH |
|---|---|---|---|---|---|---|---|
| | | | | | | BOULDERS AND/OR COBBLES, PERCENT | GRAVEL |
| 1 | DLCDP-A1 | Dry Lake Valley | Qtz | Quartzite | | | |
| 2 | DLCDP-A2 | Dry Lake Valley | Ls | Limestone | | | |
| 3 | DLCDP-A3 | Dry Lake Valley | Aals | Gravelly Sand | SP | T | 35 |
| 4 | DLCDP-A4 | Dry Lake Valley | Su | Sandstone | | | |
| 5 | DLCDP-A5 | Dry Lake Valley | Do | Dolomite | | | |
| 6 | DLCDP-A6 | Schell Creek Mountains | Do | Dolomite | | | |
| 7 | DLCDP-A7 | Silver King Mountains | Aafs | Sandy Gravel | GP | T | [illegible] |
| 8 | DLCDP-A8 | Dry Lake Valley | Vu | Welded Tuff | | | |
| 9 | DLCDP-A9 | Burnt Peak Mountains | Su | Sandstone | | | |
| 10 | DLCDP-A10 | Dry Lake Valley | Qtz | Quartzite | | | |
| 11 | DLCDP-A11 | Dry Lake Valley | Do | Dolomite | | | |
| 12 | DLCDP-A12 | Dry Lake Valley | Aals | Gravelly Sand | SP | T | |
| 13 | DLCDP-A13 | Dry Lake Valley | Vu | Tuff | | | |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AND/OR COBBLES, PERCENT | DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING (A | | | | | | | |
| | GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | N 3 |
| | | | | | Hard | Slight | None | | | | | | | | |
| | | | | | Hard | Slight | <5% Chert | | | | | | | | |
| T | 35 | 60 | 5 | None | | | 5% Caliche Nodules | | | | | | | | |
| | | | | | Very Hard | Slight | Friable | | | | | | | | |
| | | | | | Hard | Slight | <5% Chert, Calcite Veins | | | | | | | | |
| | | | | | Hard | Slight | Calcite Veins | | | | | | | | |
| T | 50 | 45 | 5 | None | | | <5% Caliche Nodules | | | | | | | | |
| | | | | | Hard | Moderate | Pumice | | | | | | | | |
| | | | | | Very Hard | Fresh | None | | | | | | | | |
| | | | | | Hard | Slight | None | | | | | | | | |
| | | | | | Hard | Slight | Calcite Veins | | | | | | | | |
| T | 15 | 80 | 5 | None | | | 15% Volcanic Ash | | | | | | | | |
| | | | | | Soft | Slight | Ash | | | | | | | | |

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## LABORATORY TEST DATA

| SSING (ASTM C 136) | | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | ALK REACT (ASTM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | COARSE AGGREGATE | | | | FINE AGGREGATE | | | | |
| | | | | | | | | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | |
| | | | | | | PERCENT LOSS | | | | | | | | | | |
| NO. 16 | NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | CA | FA | BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | CA |
| | | | | | 22.3 | 1.11 | | 2.80 | 2.82 | 2.85 | 0.57 | | | | | Innocuous |

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|  |  | ALKALI REACTIVITY (ASTM C 289) |  | AGGREGATE USE |
|---|---|---|---|---|
| E | PERCENT ABSORPTION | CA | FA |  |
|  |  |  |  | IIcr |
|  |  |  |  | IIcr |
|  |  |  |  | IIf/c |
|  |  |  |  | IIcr |
|  |  | Innocuous |  | Icr |
|  |  |  |  | IIcr |
|  |  |  |  | IIc/f |
|  |  |  |  | IIcr |
|  |  |  |  | IIcr |
|  |  |  |  | IIcr |
|  |  |  |  | IIcr |
|  |  |  |  | IIf |
|  |  |  |  | IIcr |

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
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FUGRO NATIONAL, INC.

| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | BOULDERS AND/OR COBBLES, PERCENT | DIS MA T |
|---|---|---|---|---|---|---|---|
| | | | | | | | GRAVEL |
| 14 | DLCDP-A14 | Dry Lake Valley | Aafs | Gravelly Sand | SP-SM | | |
| 15 | DLCDP-A15 | Dry Lake Valley | Aafs | Gravelly Sand | SP-SM<br>GP-GM | | |
| 16 | DLCDP-A16 | Dry Lake Valley | Vu | Andesite | | | |
| 17 | DLCDP-A17 | Dry Lake Valley | Aafg | Silty Sandy Gravel | GM | | |
| 18 | DLCDP-A18 | Dry Lake Valley | Aafs | Gravelly Sand | SM | | |
| 19 | DLCDP-A19 | Dry Lake Valley | Aals | Gravelly Sand | SP-SM | | |
| 20 | DLCDP-A20 | Dry Lake Valley | Aafs | Silty Sand | SM | 0 | 10 |
| 21 | DLCDP-A21 | Burnt Spring Range | Aafs | Sandy Gravel | GP-GM | | |
| 22 | DLCDP-A22 | Dry Lake Valley | Vu | Ash Flow | | | |
| 23 | DLCDP-A23 | Burnt Spring Range | Ls | Limestone | | | |
| 24 | DLCDP-A24 | Burnt Spring Range | Ls | Limestone | | | |
| 25 | DLCDP-A25 | Dry Lake Valley | Aals | Sandy Gravel | GP | | |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING (ASTM | | | | | | | | |
| GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | NO. 30 |
| | | | None | | | 10% Caliche Nodules and Friable Mtls. | | | | 100 | 78.8 | 62.7 | 46.7 | 36.2 |
| | | | None | | | 12% Caliche Nodules | 98 | 94.7 | 87.4 | 72.1 | 55.3 | 44.2 | 33.8 | 25.2 |
| | | | | Hard | Slight | Volcanic Glass and Vesicles | | | | | | | | |
| | | | None | | | 20% Caliche and Clay Nodules | 100 | 98.3 | 91.8 | 76.2 | 54.5 | 43.1 | 36.1 | 31.1 |
| | | | None | | | 15% Caliche Nodules | | | | 100 | 81.1 | 70.2 | 60.4 | 51.9 |
| | | | None | | | 5% Caliche Nodules<br>5% Pumice | | | | 100 | 86.9 | 64.8 | 43.4 | 28.5 |
| 10 | 70 | 20 | None | | | None | | | | | | | | |
| | | | None | | | Volcanic Glass, Caliche Coatings | 93.7 | 84.3 | 73.3 | 59.7 | 46.5 | 38.4 | 30.2 | 22.9 |
| | | | | Mod. Hard | Moderate | Volcanic Glass and Pumice | | | | | | | | |
| | | | | Hard | Slight | None | | | | | | | | |
| | | | | Hard | Slight | Calcite Veins | | | | | | | | |
| | | | | | | 10% Intermediate Volcanics | 100 | 99 | 90.2 | 67.6 | 66.5 | | | |

## LABORATORY TEST DATA

| G (ASTM C 136) | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | ALKALI REACTIVIT (ASTM C 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | COARSE AGGREGATE | | | | FINE AGGREGATE | | | | | |
| | | | | | | | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | | |
| NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS CA | FA | BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | CA | |
| 36.2 | 27.1 | 15.9 | 9.7 | | | 12.6 | | | | | 2.63 | 2.68 | 2.77 | 1.96 | | |
| 25.2 | 17.0 | 11.4 | 7.5 | 25.3 | 8.80 | 18.64 | 2.59 | 2.65 | 2.73 | 1.98 | | | | | | |
| | | | | 23.2 | 7.87 | | 2.56 | 2.61 | 2.69 | 1.92 | | | | | Potentially Deleterious | |
| 31.1 | 26.6 | 22.2 | 17.7 | 29.8 | 13.58 | 18.08 | 2.58 | 2.63 | 2.72 | 2.05 | | | | | Innocuous | Inn |
| 51.9 | 42.2 | 33.2 | 25.9 | | | 21.85 | | | | | | | | | | |
| 28.5 | 18.7 | 13.9 | 11.3 | | | 30.13 | | | | | | | 2.69 | 3.9 | | |
| 22.9 | 14.9 | 9.5 | 6.5 | 25.0 | 13.79 | 30.23 | | | | | | | | | | |
| | | | | 26.5 | 2.88 | | | | | | | | | | | |
| | | | | 27.9 | 11.19 | | 2.56 | 2.61 | 2.70 | 1.99 | | | | | Innocuous | |

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| TION | | ALKALI REACTIVITY (ASTM C 289) | | AGGREGATE USE |
|---|---|---|---|---|
| GREGATE | | | | |
| AVITY | PERCENT ABSORPTION | | | |
| APPARENT | | CA | FA | |
| 2.77 | 1.96 | | | IIf |
| | | | | Ic<br>IIf |
| | | Potentially Deleterious | | Icr |
| | | Innocuous | Innocuous | Ic<br>IIf |
| | | | | IIf |
| 2.69 | 3.9 | | | IIf |
| | | | | IIf |
| | | | | Ic<br>IIf |
| | | | | IIcr |
| | | | | Icr |
| | | | | IIcr |
| | | Innocuous | | Ic |

**FUGRO NATIONAL FIELD STATION**
**AND SUPPLEMENTARY TEST DATA**
**DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS**

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
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FUGRO NATIONAL, INC.

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| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | BOULDERS AND/OR COBBLES, PERCENT | GRAVEL |
|---|---|---|---|---|---|---|---|
| 26 | DLCDP-A26 | Dry Lake Valley | Vu | Welded Tuff | | | |
| 27 | DLCDP-A27 | Dry Lake Valley | Vu | Rhyolite | | | |
| 28 | DLCDP-A28 | Dry Lake Valley | Aafs | Gravelly Sand | SP | T | 35 |
| 29 | DLCDP-A29 | Highland Range | Ls | Limestone | | | |
| 30 | DLCDP-A30 | Dry Lake Valley | Aol | Sandy Gravel | GP | | |
| 31 | DLCDP-A31 | Dry Lake Valley | Aaf | Gravelly Sand | SP | 10 | 45 |
| 32 | DLCDP-A32 | Pahranagat Valley | Aol | Gravelly Sand | SP | | |
| 33 | DLCDP-A33 | Pahranagat Valley | Aol | Sandy Gravel | GP | | |
| 34 | DLCDP-A34 | Pahroc Valley | Vu | Rhyolite | | | |
| 35 | DLCDP-A35 | Pahroc Valley | Su | Sandstone | | | |
| 36 | DLCDP-A36 | Pahroc Valley | Ls | Limestone | | | |
| 37 | DLCDP-A37 | Pahroc Valley | Aafs | Sandy Gravel | GP | 5 | 7 |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AND/OR COBBLES, PERCENT | DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING ( | | | | | | | |
| | GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | N 3 |
| | | | | | Hard | Slight | Volcanic Glass and Pumice | | | | | | | | |
| | | | | | Mod. Hard | Slight | Volcanic Glass and Pumice | | | | | | | | |
| T | 35 | 60 | 5 | None | | | Volcanic Glass, Ash, Caliche Nodules | | | | | | | | |
| | | | | | Hard | Slight | None | | | | | | | | |
| | | | | None | | | <5% Chert, Caliche Coatings | 90.3 | 72.6 | 51.7 | 35.9 | 25.7 | | | |
| 0 | 45 | 55 | T | None | | | 5% Chert, Caliche, Volcanic Glass | | | | | | | | |
| | | | | None | | | Caliche Coatings and Low Density Mtls. | 100 | 97.8 | 90.0 | 78.7 | 59.8 | 44.7 | 30.9 | 2 |
| | | | | None | | | 10% Intermediate Volcanics, Chert, Caliche | 80.5 | 58.4 | 38.4 | 25.0 | 16.5 | | | |
| | | | | | Mod. Hard | Moderate | Volcanic Glass, Pumice, Mica | | | | | | | | |
| | | | | | Hard | Slight | None | | | | | | | | |
| | | | | | Hard | Slight | <5% Chert | | | | | | | | |
| 5 | 70 | 30 | 0 | None | | | <5% Chert | | | | | | | | |

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## LABORATORY TEST DATA

| PASSING (ASTM C 136) | | | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | RE (AS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | COARSE AGGREGATE | | | | FINE AGGREGATE | | | | |
| | | | | | | | | | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | |
| . | NO. 16 | NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS CA | PERCENT LOSS FA | BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | CA |
| | | | | | | 27.3 | 1.91 | | | | | | | | | | |
| | | | | | | 24.3 | 4.14 | | 2.68 | 2.70 | 2.74 | 0.71 | | | | | |
| .7 | 30.9 | 20.9 | 12.4 | 7.5 | 4.6 | 34.7 | 18.15 | 35.30 | 2.45 | 2.53 | 2.66 | 3.31 | | | | | Potenti<br>Deleteri |
| | | | | | | 23.9 | 3.86 | | 2.54 | 2.58 | 2.66 | 1.81 | | | | | |
| | | | | | | 35.5 | 3.64 | | 2.63 | 2.65 | 2.69 | 0.81 | | | | | |

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| TION | | | | | |
|---|---|---|---|---|---|
| GREGATE | | | ALKALI REACTIVITY (ASTM C 289) | | AGGREGATE USE |
| RAVITY | | PERCENT ABSORPTION | | | |
| | APPARENT | | CA | FA | |
| | | | | | IIcr |
| | | | | | IIcr |
| | | | | | IIf/c |
| | | | | | Icr |
| | | | | | Ic<br>IIf |
| | | | | | IIf/c |
| | | | Potentially Deleterious | Deleterious | IIf/c |
| | | | | | Ic |
| | | | | | IIcr |
| | | | | | Icr |
| | | | | | IIcr |
| | | | | | IIc/f |

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

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FUGRO NATIONAL, INC.

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| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | BOULDERS AND/OR COBBLES, PERCENT | DIST MATE THA |
|---|---|---|---|---|---|---|---|
| | | | | | | | GRAVEL |
| 38 | DLCDP-A38 | Dry Lake Valley | Do | Dolomite | | | |
| 39 | DLCDP-A39 | Dry Lake Valley | Vu | Andesite | | | |
| 40 | DLCDP-A40 | Dry Lake Valley | Qtz | Quartzite | | | |
| 41 | DLCDP-A41 | Dry Lake Valley | Aol | Gravelly Sand | SP | T | 25 |
| 42 | DLCDP-A42 | Dry Lake Valley | Aafs | Gravelly Sand | SP | 0 | 30 |
| 43 | DLCDP-A43 | Dry Lake Valley | Aafg | Sandy Gravel | GP | | |
| 44 | DLCDP-A44 | Dry Lake Valley | Aafs | Silty Sandy Gravel | GM | | |
| 45 | DLCDP-A45 | Antelope Canyon | Aal | Gravelly Sand | SP | T | 45 |
| 46 | DLCDP-A46 | Antelope Canyon | Qtz | Quartzite | | | |
| 47 | DLCDP-A47 | Muleshoe Valley | Ls | Limestone | | | |
| 48 | DLCDP-A48 | Antelope Canyon | Aal | Sandy Gravel | GP | | |
| 49 | DLCDP-A49 | Dutch John Mountains | Aaf | Silty Gravel | GM | | |
| 50 | DLCDP-A50 | Bristol Pass | Aaf | Gravelly Sand | SP | T | 40 |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING (ASTI | | | | | | | |
| GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | NO. 30 |
| | | | | Hard | Slight | Calcite Veins | | | | | | | | |
| | | | | Hard | Slight | Volcanic Glass, Pumice, Vesicles | | | | | | | | |
| | | | | Very Hard | Fresh | None | | | | | | | | |
| 25 | 75 | 0 | None | | | Chert, Volcanic Glass, Caliche Coatings | | | | | | | | |
| 30 | 70 | T | None | | | Volcanic Glass, Caliche Coatings | | | | | | | | |
| | | | None | | | Volcanic Glass, Caliche Coatings | 79.6 | 59.3 | 46.2 | 39.0 | 34.4 | | | |
| | | | None | | | 15% Ash Fragments and Clay Lumps | 94.7 | 93.2 | 81.7 | 63.9 | 45.8 | 36.1 | 29.1 | 24.8 |
| 45 | 55 | T | None | | | Low Density Material | | | | | | | | |
| | | | | Very Hard | Slight | None | | | | | | | | |
| | | | | Hard | Slight | Calcite Veins | | | | | | | | |
| | | | None | | | Caliche Coatings, Volcanic Ash | 97.8 | 83.7 | 70.0 | 60.8 | 52.5 | 45.4 | 35.1 | 23. |
| | | | None | | | 10% Chert, Caliche Coatings | | 100 | 96.4 | 73.7 | 38.2 | 28.2 | 23.5 | 21. |
| 40 | 60 | T | None | | | Chert, Pumice | | | | | | | | |

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## LABORATORY TEST DATA

| (ASTM C 136) | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | ALKALI REACTIVITY (ASTM C 289) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | COARSE AGGREGATE | | | | FINE AGGREGATE | | | | | |
| | | | | | | | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | | |
| NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS CA | PERCENT LOSS FA | BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | CA | F |
| | | | | 64.9 | | | | | | | | | | | | |
| | | | | 20.4 | 11.97 | | 2.54 | 2.59 | 2.67 | 1.96 | | | | | | |
| 24.8 | 21.6 | 18.8 | 15.8 | 27.8 | 8.26 | 18.16 | | | | | | | | | | |
| 23.1 | 12.0 | 6.9 | 4.7 | 22.7 | | 20.33 | | | | | | | | | | |
| 21.1 | 20.3 | 19.6 | 17.6 | 25.6 | 5.10 | 8.00 | 2.63 | 2.67 | 2.75 | 1.56 | 2.56 | 2.61 | 2.68 | 1.79 | | |
| | | | | 27.5 | 5.30 | | 2.60 | 2.65 | 2.73 | 1.84 | | | | | | |

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| ON | | ALKALI REACTIVITY (ASTM C 289) | | AGGREGATE USE |
|---|---|---|---|---|
| EGATE | | | | |
| VITY | PERCENT ABSORPTION | | | |
| PPAR-ENT | | CA | FA | |
| | | | | IIcr |
| | | | | IIcr |
| | | | | IIcr |
| | | | | IIf |
| | | | | IIf/c |
| | | | | Ic |
| | | | | Ic<br>IIf |
| | | | | IIf/c |
| | | | | IIcr |
| | | | | IIcr |
| | | | | IIc/f |
| 2.68 | 1.79 | | | Ic/f |
| | | | | Ic<br>IIf |

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
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FUGRO NATIONAL, INC.

4

| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | BOULDERS AND/OR COBBLES, PERCENT | GRAVEL |
|---|---|---|---|---|---|---|---|
| 51 | DLCDP-A51 | Delamar Valley | Ls | Limestone | | | |
| 52 | DLCDP-A52 | Delamar Valley | Vu | Ignimbrite | | | |
| 53 | DLCDP-A53 | Delamar Valley | Vu | Rhyolite | | | |
| 54 | DLCDP-A54 | Delamar Valley | Vu | Andesite | | | |
| 55 | DLCDP-A55 | Delamar Valley | Vu | Rhyolitic Tuff | | | |
| 56 | DLCDP-B1 | Muleshoe Valley | Ls | Limestone | | | |
| 57 | DLCDP-B2 | Sidehill Valley | Ls | Limestone | | | |
| 58 | DLCDP-B3 | Steward Spring | Ls | Limestone | | | |
| 59 | DLCDP-B4 | Muleshoe Valley | Ls | Limestone | | | |
| 60 | DLCDP-B5 | Muleshoe Valley | Vu | Andesite | | | |
| 61 | DLCDP-B6 | Muleshoe Valley | Vu | Welded Tuff | | | |
| 62 | DLCDP-B7 | Miller Summit | Vu | Welded Ash Flow | | | |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING (AST | | | | | | | |
| PERCENT | GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | NO. 30 |
| | | | | | Hard | Slight | <5% Chert | | | | | | | | |
| | | | | | Hard | Slight | Volcanic Glass, Low Density Materials | | | | | | | | |
| | | | | | Hard | Slight | Volcanic Glass, Low Density Materials | | | | | | | | |
| | | | | | Hard | Slight | Volcanic Glass | | | | | | | | |
| | | | | | Mod. Hard | Moderate | Volcanic Glass, Pumice, Vesicles | | | | | | | | |
| | | | | | Hard | Slight | None | | | | | | | | |
| | | | | | Very Hard | Fresh | None | | | | | | | | |
| | | | | | Very Hard | Fresh | Chert | | | | | | | | |
| | | | | | Hard | Slight | Chert | | | | | | | | |
| | | | | | Very Hard | Slight | •Volcanic Glass | | | | | | | | |
| | | | | | Hard | Slight | Volcanic Glass, Pumice | | | | | | | | |
| | | | | | Hard | Slight | Volcanic Glass | | | | | | | | |

| O.<br>6 | NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS | | BULK | BULK SSD | APPARENT | PERCE ABSORP | BULK | BULK SSD | APPARENT | PERCE ABSORP | CA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | CA | FA | | | | | | | | | |
| | | | | | 62.5 | | | | | | | | | | | Potentially Deleterious |
| | | | | | 35.2 | 5.61 | | 2.67 | 2.68 | 2.70 | 0.47 | | | | | |

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| ABSORPTION | ALKALI REACTIVITY (ASTM C 289) | | AGGREGATE USE |
|---|---|---|---|
| | CA | FA | |
| | | | IIcr |
| | | | IIcr |
| | | | IIcr |
| | | | IIcr |
| | Potentially Deleterious | | IIcr |
| | | | Icr |
| | | | IIcr |
| | | | IIcr |
| | | | IIcr |
| | | | IIcr |
| | | | IIcr |
| | | | IIcr |

**FUGRO NATIONAL FIELD STATION**
**AND SUPPLEMENTARY TEST DATA**
**DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS**

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
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**FUGRO NATIONAL, INC.**

| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | BOULDERS AND/OR COBBLES, PERCENT | |
|---|---|---|---|---|---|---|---|
| 63 | DLCDP-B8 | Miller Summit | Ls | Limestone | | | |
| 64 | NV-R-27 | Chief Range | Au | Silty Sand | SP-SM | | 5 |
| 65 | NV-R-28 | Chief Range | Au | Gravelly Sand | SP | | 35 |
| 66 | NV-R-30 | Pioche Hills | Aaf | Sandy Gravel | GP-GC | | 60 |
| 67 | NV-R-31 | Lake Valley | Aaf | Clayey Sanduff | SC-SM | | 5 |
| 68 | NV-R-32 | Lake Valley | Vu | Rhyolite | | | |
| 69 | NV-R-33 | Grassy Mountain | Aaf | Sandy Gravel | GP | | |
| 70 | NV-R-85 | Hiko Range | Cau | Limestone | | | |
| 71 | NV-R-86 | Pahranagat Valley | Au | Silty Sand | SM | | 20 |
| 72 | NV-R-87 | Pahranagat Valley | Aal | Silty Sand | SM | | [illegible] |
| 73 | NV-R-88 | Pahranagat Valley | Au | Silty Sandf | SP/SW | | [illegible] |
| 74 | NV-R-89 | Pahranagat Valley | Aaf | Silty Sand | SP-SM | | 10 |
| 75 | NV-R-90 | Pahranagat Valley | Vu | Silicic Tuff | | | |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AND/OR COBBLES, PERCENT | DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING (A | | | | | | | |
| | GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | N 3 |
| | | | | | Very Hard | Slight | Chert | | | | | | | | |
| | 5 | 80 | 15 | Low | | | 95% Glassy Volcanics | | | | | | | | |
| | 35 | 50 | 15 | None | | | 40% Glassy Volcanics | | | | | | | | |
| | 60 | 35 | 5 | Low | | | Chert, Caliche, Clay | | | | | | | | |
| | 5 | 60 | 35 | Low | | | 80% Glassy Volcanics | | | | | | | | |
| | | | | | | | Glassy | | | | | | | | |
| | | | | | | | Chert, Caliche | 100 | 92.7 | 80.5 | 62.3 | 49.2 | 42.0 | 37.3 | 30 |
| | | | | | | | Chert | | | | | | | | |
| | 20 | 65 | 15 | None | | | 5% Glassy Volcanics, Caliche Coatings | | | | | | | | |
| | 25 | 60 | 15 | None | | | 95% Glassy Volcanics | | | | | | | | |
| | 5 | 90 | 5 | None | | | 85% Glassy Volcanics | | | | | | | | |
| | 10 | 80 | 10 | Mod. | | | 100% Glassy Volcanics | | | | | | | | |
| | | | | | | | Glassy | | | | | | | | |

## LABORATORY TEST DATA

| ASSING (ASTM C 136) | | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | AL REACT (ASTM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | COARSE AGGREGATE | | | | FINE AGGREGATE | | | | |
| | | | | | | | | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | |
| NO. 16 | NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS | | BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | CA |
| | | | | | | CA | FA | | | | | | | | | |
| 37.3 | 30.5 | | | 6.8 | 26.0 | 5.3 | | | | | | | | | | |

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| GATE | | | | |
|---|---|---|---|---|
| TY | PERCENT ABSORPTION | ALKALI REACTIVITY (ASTM C 289) | | AGGREGATE USE |
| PAR- NT | | CA | FA | |
| | | | | IIcr |
| | | | | IIf |
| | | | | IIf/c |
| | | | | IIc/f |
| | | | | IIf |
| | | | | IIcr |
| | | | | Ic<br>IIf |
| | | | | IIcr |
| | | | | IIf |
| | | | | IIf |
| | | | | IIf |
| | | | | IIf |
| | | | | IIcr |

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
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FUGRO NATIONAL, INC.

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| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | BOULDERS AND/OR COBBLES, PERCENT | GRAVEL |
|---|---|---|---|---|---|---|---|
| 76 | NV-H-9 | Chief Mountains | Qtz | Quartzite | | | |
| 77 | NV-H-10 | Bristol Range | Cau | Limestone | | | |
| 78 | NV-H-11 | Bristol Range | Cau | Limestone | | | |
| 79 | NV-H-15 | Bristol Range | Cau | Limestone | | | |
| 80 | NV-H-16 | Grassy Mountain | Cau | Limestone | | | |
| 81 | NV-H-17 | Dutch John Mountain | Cau | Limestone | | | |
| 82 | NV-LN-1 | Pahranagat Valley | Au | Gravelly Sand | SP | | |
| 83 | NV-LN-3 | Delamar Mountains | Su | Sandy Gravel | GP | | |
| 84 | DL-T-1 | Coyote Wash | Aals | Silty Sand | SP-SM | | |
| 85 | DL-T-2 | Dry Lake Valley | Aals | Silty Sand | SP-SM | | |
| 86 | DL-T-3 | Dry Lake Valley | Aafs | Gravelly Sand | SP | | |
| 87 | DL-T-4 | Dry Lake Valley | Aafs | Silty Sand | SP-SM | | |
| 88 | DL-T-5 | Dry Lake Valley | Aafs | Gravelly Sand | SP | | |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ERCENT | DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING (AS | | | | | | | |
| | GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | NO. 3 |
| | | | | | | | None | | | | | | | | |
| | | | | | | | Dolomitic | | | | | | | | |
| | | | | | | | Dolomitic | | | | | | | | |
| | | | | | | | Chert | | | | | | | | |
| | | | | | | | 1 to 2% Chert | | | | | | | | |
| | | | | | | | 1 to 2% Chert | | | | | | | | |
| | | | | | | | | 100 | 96.9 | 91.2 | 80.2 | 62 | 45.8 | 30.4 | |
| | | | | | | | | 100 | 99.1 | 89.2 | 63.1 | 45.5 | 35.4 | 32.2 | |
| | | | | | | | | | 100 | 96.3 | 88 | 79.3 | 68.7* | | 33* |
| | | | | | | | | | | 94.2 | 82.8 | 70.6 | 60.8* | | 43.4 |
| | | | | | | | | | 100 | 95 | 82 | 76 | 70* | | 44* |
| | | | | | | | | | 100 | 94.5 | 90.3 | 82 | 72* | | 45.3 |
| | | | | | | | | | 100 | 90 | 79 | 61 | 40* | | 20* |

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## LABORATORY TEST DATA

| (ASTM C 136) | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | ALKALI REACTIVITY (ASTM C 289) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | COARSE AGGREGATE | | | | FINE AGGREGATE | | | | | |
| | | | | | | | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | | |
| NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS | | BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | CA | FA |
| | | | | | CA | FA | | | | | | | | | | |
| | 9.3 | 5.6 | 3.7 | 22.0 | 6.42 | 6.38 | | 2.43 | | | | 2.53 | | | | |
| | 2.5 | 1.1 | 0.7 | 19.6 | 2.41 | 2.70 | | | | | | | | | | |
| 33* | | 14.7 | 10.7 | | | | | | | | | 2.62 | | | | |
| 43.4* | | 20.2 | 13.2 | | | | | | | | | 2.67 | | | | |
| 44* | | 7 | 3 | | | | | | | | | | | | | |
| 45.3* | | 22.7 | 16.7 | | | | | | | | | 2.66 | | | | |
| 20* | | 10 | 8 | | | | | | | | | 2.64 | | | | |

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| ION | | | | | |
|---|---|---|---|---|---|
| REGATE | | | ALKALI REACTIVITY (ASTM C 289) | | AGGREGATE USE |
| AVITY | | PERCENT ABSORPTION | | | |
| | APPARENT | | CA | FA | |
| | | | | | IIcr |
| | | | | | IIcr |
| | | | | | IIcr |
| | | | | | IIcr |
| | | | | | IIcr |
| | | | | | IIcr |
| 3 | | | | | If/c |
| | | | | | Ic/f |
| 2 | | | | | IIf |
| 7 | | | | | IIf/c |
| | | | | | IIf |
| 6 | | | | | IIf |
| 4 | | | | | IIf/c |

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
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FUGRO NATIONAL, INC.

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| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | BOULDERS AND/OR COBBLES, PERCENT | DIST MAT TH<br>GRAVEL |
|---|---|---|---|---|---|---|---|
| 89 | DL-T-6 | Dry Lake Valley | Aals | Silty Sand | SM | | |
| 90 | DL-T-7 | Dry Lake Valley | Aals | Silty Sand | SP-SM | | |
| 91 | DL-T-8 | Dry Lake Valley | Aafs | Silty Sand | SM | | |
| 92 | MS-T-1 | Muleshoe Valley | Aafs | Sandy Silt | ML | | T |
| 93 | MS-T-2 | Muleshoe Valley | Aals | Silty Sand | SM | | 0 |
| 94 | MS-T-3 | Muleshoe Valley | Aals | Sandy Silt | ML | | T |
| 95 | MS-T-4 | Muleshoe Valley | Aafs | Gravelly Sand | SM | | 30 |
| 96 | MS-T-5 | Muleshoe Valley | Aafs | Gravelly Sand | SP-SM | | 18 |
| 97 | MS-T-6 | Muleshoe Valley | Aals | Silty Sand | SM | | 20 |
| 98 | P-T-2 | Pahroc Valley | Aafs | Silty Sand | SM | | 5 |
| 99 | P-T-4 | Pahroc Valley | Aafs | Gravelly Sand | SM | | 20 |
| 100 | P-T-6 | Pahroc Valley | Aafs | Gravelly Sand | SP-SM | | 25 |
| 101 | DM-T-2 | Delamar Valley | Aafs | Sandy Gravel | GP | | 70 |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AND/OR COBBLES, PERCENT | DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING ( | | | | | | | |
| | GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | |
| | | | | | | | | | | 100 | 98 | 96.5 | 92* | | 7 |
| | | | | | | | | | | 99 | 93.5 | 85 | 70.5* | | 3 |
| | | | | | | | | | 100 | 87.3 | 75.3 | 65 | 57* | | 4 |
| | T | 25 | 75 | | | | | | | | | | | | |
| | 0 | 65 | 35 | | | | | | | | | | | | |
| | T | 40 | 60 | | | | | | | | | | | | |
| | 30 | 55 | 15 | | | | | | | | | | | | |
| | 18 | 70 | 12 | | | | | | | | | | | | |
| | 20 | 60 | 20 | | | | | | | | | | | | |
| | 5 | 75 | 20 | | | | | | | | | | | | |
| | 20 | 60 | 20 | | | | | | | | | | | | |
| | 25 | 70 | 5 | | | | | | | | | | | | |
| | 70 | 25 | 5 | | | | | | | | | | | | |

2

LABORATORY TEST DATA

| ING (ASTM C 136) | | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | ALKAL REACTIV (ASTM C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | COARSE AGGREGATE | | | | FINE AGGREGATE | | | | | |
| | | | | | | | | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | | |
| 0. 6 | NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS | | BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | CA | |
| | | | | | | CA | FA | | | | | | | | | | |
| | 72.5* | | 44 | 33 | | | | | | | | | | 2.66 | | | |
| | 39* | | 13 | 9 | | | | | | | | | | 2.61 | | | |
| | 48.3* | | 35.7 | 25.7 | | | | | | | | | | 2.66 | | | |

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|---|---|---|---|---|
| TY | PERCENT ABSORPTION | ALKALI REACTIVITY (ASTM C 289) |  | AGGREGATE USE |
| AR- T |  | CA | FA |  |
| 6 |  |  |  | IIf |
| 61 |  |  |  | IIf |
| 66 |  |  |  | IIf/c |
|  |  |  |  | IIIf |
|  |  |  |  | IIIf |
|  |  |  |  | IIIf |
|  |  |  |  | IIf/c |
|  |  |  |  | IIf |
|  |  |  |  | IIf |
|  |  |  |  | IIf |
|  |  |  |  | IIf |
|  |  |  |  | IIf |
|  |  |  |  | IIc/f |

**FUGRO NATIONAL FIELD STATION**
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MX SITING INVESTIGATION
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FUGRO NATIONAL, INC.

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| MAP NUMBER | FIELD STATION | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | BOULDERS AND/OR COBBLES, PERCENT | GRAVEL |
|---|---|---|---|---|---|---|---|
| 102 | DM-T-3 | Delamar Valley | Aafs | Silty Sand | SP-SM | | 20 |
| 103 | DM-T-4 | Delamar Valley | Aafs | Gravelly Sand | SM | | 25 |
| 104 | DM-T-5 | Delamar Valley | Aafs | Silty Sand | SM | | 10 |
| 105 | DM-T-6 | Delamar Valley | Aafs | Gravelly Sand | SM | | 20 |
| 106 | DM-T-7 | Delamar Valley | Aolf | Sandy Silt | ML | | 0 |
| 107 | DM-T-8 | Delamar Valley | Aafs | Silty Sand | SM | | 5 |
| 108 | DM-T-10 | Delamar Valley | Aafs | Silty Gravel | GM | | 40 |

| FIELD OBSERVATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PERCENT | DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT | | | PLASTICITY | HARDNESS | WEATHERING | DELETERIOUS MATERIALS | SIEVE ANALYSIS, PERCENT PASSING (A | | | | | | | |
| | GRAVEL | SAND | FINES | | | | | 3" | 1½" | ¾" | ⅜" | NO. 4 | NO. 8 | NO. 16 | N 3 |
| | 20 | 70 | 10 | | | | | | | | | | | | |
| | 25 | 60 | 15 | | | | | | | | | | | | |
| | 10 | 80 | 10 | | | | | | | | | | | | |
| | 20 | 65 | 15 | | | | | | | | | | | | |
| | 0 | 50 | 50 | | | | | | | | | | | | |
| | 5 | 80 | 15 | | | | | | | | | | | | |
| | 40 | 40 | 20 | | | | | | | | | | | | |

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## LABORATORY TEST DATA

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ING (ASTM C 136) | | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | ALKAL REACTIV (ASTM C | |
| | | | | | | | | COARSE AGGREGATE | | | | FINE AGGREGATE | | | | | |
| | | | | | | | | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | | |
| NO. 16 | NO. 30 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS | | BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | CA | |
| | | | | | | CA | FA | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

DRY LA

DEPART

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| ABSORPTION | ALKALI REACTIVITY (ASTM C 289) | | AGGREGATE USE |
|---|---|---|---|
| | CA | FA | |
| | | | IIf |
| | | | IIf |
| | | | IIf |
| | | | IIf |
| | | | IIIf |
| | | | IIf |
| | | | IIc/f |

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

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FUGRO NATIONAL, INC.

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# EXPLANATION OF EXISTING DATA

Existing data pertaining to aggregates were extracted from the State of Nevada Department of Highways. These reports are compilations of avaiable site data from existing files and records and are intended to accurately locate, investigate, and catalog materials needed for highway construction. Explanations for column headings which appear in Table A-2, that have not been previously discussed in Table A-1, are given below:

| Column Heading | Explanation |
|---|---|
| Site Number | State of Nevada Department of Highways pit or site number. Locations correspond to map numbers listed on this table and placed on Drawing 1. |
| Soundness Test | The testing of aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions. |

| MAP NUMBER | SITE NUMBER | DATA SOURCE | LOCATION | GEOLOGIC UNIT | MATERIAL DESCRIPTION | USCS SYMBOL | >6" | 3- |
|---|---|---|---|---|---|---|---|---|
| 109 | LN15-1 | Nevada Dept. of Highways | Pahranagat Valley | Au | Silty Gravel | GP-GM | 5 | 1 |
| 110 | LN15-2 | Nevada Dept. of Highways | Pahranagat Valley | Au | Silty Gravel | GM-GC | 3 | |
| 111 | LN15-3 | Nevada Dept. of Highways | Pahranagat Valley | Au | Silty Gravel | GP-GM | 4 | |
| 112 | LN15-4 | Nevada Dept. of Highways | Pahranagat Valley | Aol | Silty Gravel | GM-GC | 4 | |
| 113 | LN15-7 | Nevada Dept. of Highways | Pahranagat Valley | Au | Silty Gravel | GP-GM | 4 | |
| 114 | LN15-8 | Nevada Dept. of Highways | Pahranagat Valley | Aol | Silty Gravel | GP-GM | 9 | |
| 115 | LN15-12 | Nevada Dept. of Highways | Pahranagat Valley | Aol | Silty Gravel | GM | 1 | |
| 116 | LNRS-3 | Nevada Dept. of Highways | Dry Lake Valley | Aolf | Silty Gravel | GP-GM | 0 | |
| 117 | LN24-2 | Nevada Dept. of Highways | Delamar Mountains | Au | Clayey Gravel | GC | 4 | |
| 118 | LN02-5 | Nevada Dept. of Highways | Pahranagat Valley | Aaf | Sandy Gravel | GP | | 1 |
| 119 | LN02-7 | Nevada Dept. of Highways | Pahranagat Valley | Au | Silty Gravel | GM | | 1 |
| 120 | LN02-8 | Nevada Dept. of Highways | Pahranagat Valley | Au | Sandy Gravel | GP | | |
| 121 | LN02-9 | Nevada Dept. of Highways | Pahranagat Valley | Au | Gravelly Sand | SP-SM | | |

AD-A112 406 FUGRO NATIONAL INC LONG BEACH CA F/G 8/7
MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION. AGGREGATE RES--ETC(U)
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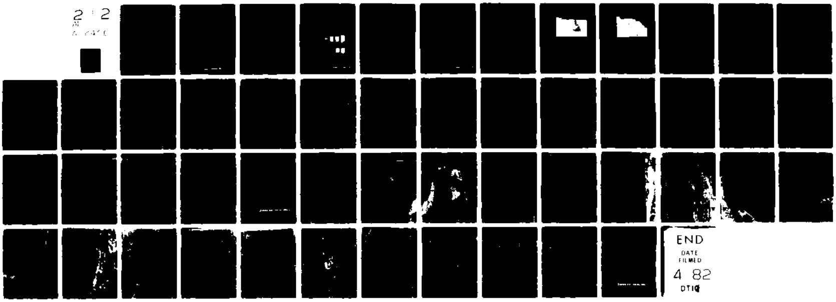
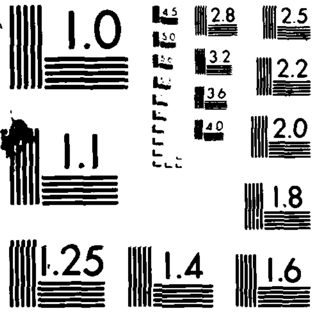




1.0
4.5
5.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

| SIEVE ANALYSIS | | | | | | | | | | | | | | ABRASION TEST (ASTM C 131) | SOUNDNESS TEST (ASTM C 88) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-6" | 1½" | 1" | ¾" | ½" | ¼" | ⅜" | NO. 4 | NO. 10 | NO. 16 | NO. 40 | NO. 50 | NO. 100 | NO. 200 | PERCENT WEAR | PERCENT LOSS | | SPE |
| | | | | | | | | | | | | | | | CA | FA | BUL |
| 10 | | | 26 | | | 49 | | | | | | | 4-13 | 23.1 | | | |
| 4 | | | 19 | | | 35 | | | | | | | 5-26 | 25.4 | | | |
| 5 | | | 28 | | | 48 | | | | | | | 2-20 | 25.4 | | | |
| 4 | | | 16 | | | 31 | | | | | | | 5-11 | 28.3 | | | |
| 4 | | | 12 | | | 24 | | | | | | | 4-12 | 36.9 | | | |
| 9 | | | 30 | | | 45 | | | | | | | 5-12 | 25.5 | | | |
| 1 | | | 6 | | | 10 | | | | | | | 5-16 | 35 | | | |
| 1 | | | 11 | | | 29 | | | | | | | 7-22 | 25 | | | |
| 6 | | | 18 | | | 26 | | | | | | | 1-68 | 34.8 | | | |
| 100 | 92 | 84 | 77 | 62 | | | 48 | 68 | 49 | 20 | 15 | 9 | 6 | 22 | 6.42 | 6.38 | |
| 100 | 81 | 61 | 48 | 31 | | 21 | 16 | 15 | 13 | 9 | 5 | 4 | 3 | 23 | | 2.97 | 2. |
| | | 100 | 100 | 89 | | 81 | 65 | 50 | 41 | 22 | 17 | 11 | 7 | 28.7 | | | |
| | | | 100 | 85 | | 74 | 62 | 48 | 38 | 20 | 16 | 11 | 7 | 31.2 | | | |

| SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128) | | | | | | | | PLASTICITY INDEX (ASTM D 423 AND D 424) | ALKALI REACTIVITY (ASTM C 289) | |
|---|---|---|---|---|---|---|---|---|---|---|
| COARSE AGGREGATE | | | | FINE AGGREGATE | | | | | | |
| SPECIFIC GRAVITY | | | PERCENT ABSORPTION | SPECIFIC GRAVITY | | | PERCENT ABSORPTION | | | |
| BULK | BULK SSD | APPARENT | | BULK | BULK SSD | APPARENT | | | CA | FA |
| | | 2.65 | | | | | | NP | | |
| | | 2.56 | | | | | | NP-16 | | |
| | | 2.65 | | | | | | NP | | |
| | | 2.58 | | | | | | NP-9 | | |
| | | 2.51 | | | | | | NP | | |
| | | 2.68 | | | | | | NP | | |
| | | | | | | | | NP | | |
| | | 2.52 | | | | | | NP | | |
| | | 2.52 | | | | | | NP-17 | | |
| | | 2.53 | | | | | | | | |
| 2.76 | 2.78 | 2.81 | 0.65 | | | | | | | |
| | | 2.56 | | | | | | NP | | |
| | | 2.59 | | | | | | NP | | |

**EXISTING TEST DATA**
DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
A-2
PAGE 1 OF 1

FUGRO NATIONAL, INC.

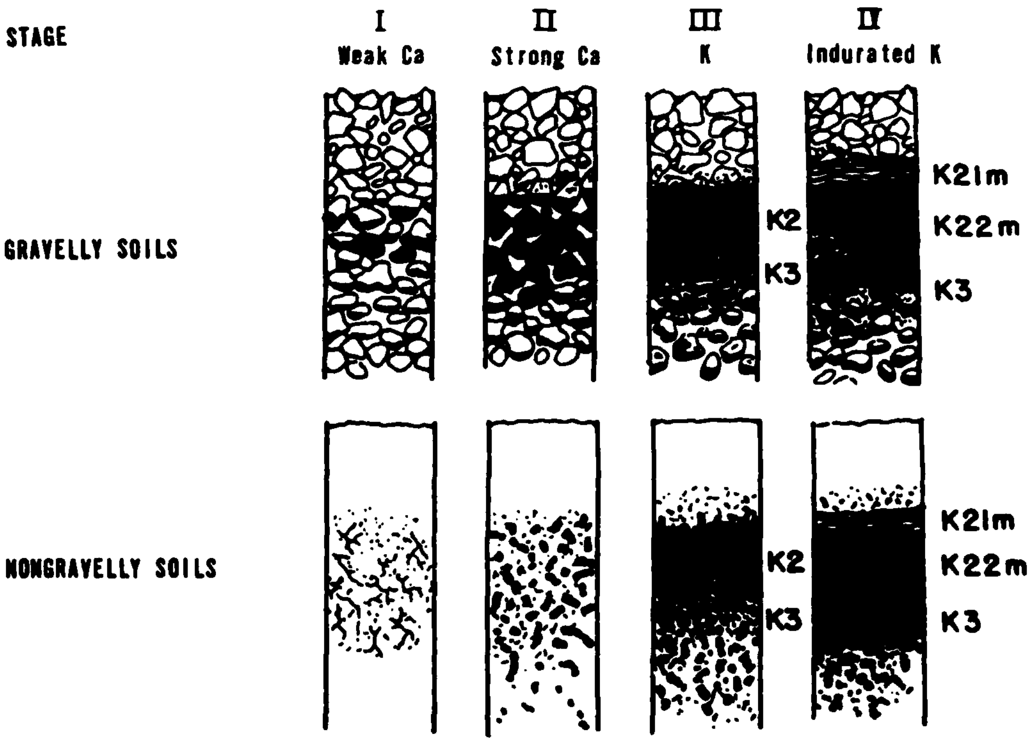
3

# APPENDIX B

## Summary of Caliche Development

## DIAGNOSTIC CARBONATE MORPHOLOGY

| STAGE | GRAVELLY SOILS | NONGRAVELLY SOILS |
|---|---|---|
| I | Thin, discontinuous pebble coatings | Few filaments or faint coatings |
| II | Continuous pebble coatings, some interpebble fillings | Few to abundant nodules, flakes, filaments |
| III | Many interpebble fillings | Many nodules and internodular fillings |
| IV | Laminar horizon overlying plugged horizon | Laminar horizon overlying plugged horizon |



Stages of development of a caliche profile with time. Stage I represents incipient carbonate accumulation, followed by continuous build-up of carbonate until, in Stage IV, the soil is completely plugged.

Reference: Gile, L.H. Peterson, F.F., and Grossman, R.B., 1965, The K horizon: A master horizon of carbonate accumulation: Soil Science, v. 99, p. 74-82.

SUMMARY OF CALICHE DEVELOPMENT

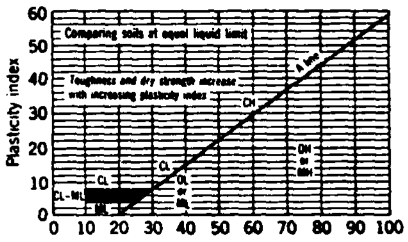
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE
B-1

FUGRO NATIONAL, INC.

# APPENDIX C

## Unified Soil Classification System

| Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights) | | | | | Group Symbols[a] | Typical Names | Information Required for Describing Soils | Laboratory Classification Criteria | |
|---|---|---|---|---|---|---|---|---|---|
| Coarse-grained soils More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye) | 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) | Clean gravels (little or no fines) | Wide range in grain size and substantial amounts of all intermediate particle sizes | | *GW* | Well graded gravels, gravel-sand mixtures, little or no fines | Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses<br>For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics<br>Example:<br>*Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*) | Use grain size curve in identifying the fractions as given under field identification<br>Determine percentages of gravel and sand from grain size curve<br>Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows:<br>Less than 5% *GW, GP, SW, SP*<br>More than 12% *GM, GC, SM, SC*<br>5% to 12% *Borderline* cases requiring use of dual symbols | $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4<br>$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 |
| | | | Predominantly one size or a range of sizes with some intermediate sizes missing | | *GP* | Poorly graded gravels, gravel-sand mixtures, little or no fines | | | Not meeting all gradation requirements for *GW* |
| | | Gravels with fines (appreciable amount of fines) | Nonplastic fines (for identification procedures see *ML* below) | | *GM* | Silty gravels, poorly graded gravel-sand-silt mixtures | | | Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols |
| | | | Plastic fines (for identification procedures, see *CL* below) | | *GC* | Clayey gravels, poorly graded gravel-sand-clay mixtures | | | Atterberg limits above "A" line, with *PI* greater than 7 |
| | Sands More than half of coarse fraction is smaller than No. 4 sieve size | Clean sands (little or no fines) | Wide range in grain sizes and substantial amounts of all intermediate particle sizes | | *SW* | Well graded sands, gravelly sands, little or no fines | | | $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6<br>$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 |
| | | | Predominantly one size or a range of sizes with some intermediate sizes missing | | *SP* | Poorly graded sands, gravelly sands, little or no fines | | | Not meeting all gradation requirements for *SW* |
| | | Sands with fines (appreciable amount of fines) | Nonplastic fines (for identification procedures, see *ML* below) | | *SM* | Silty sands, poorly graded sand-silt mixtures | | | Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols |
| | | | Plastic fines (for identification procedures, see *CL* below) | | *SC* | Clayey sands, poorly graded sand-clay mixtures | | | Atterberg limits below "A" line with *PI* greater than 7 |
| | Identification Procedures on Fraction Smaller than No. 40 Sieve Size | | | | | | | | |
| | | Dry Strength (crushing characteristics) | Dilatancy (reaction to shaking) | Toughness (consistency near plastic limit) | | | | | |
| Fine-grained soils More than half of material is *smaller* than No. 200 sieve size | Silts and clays liquid limit less than 50 | None to slight | Quick to slow | None | *ML* | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity | Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses<br>For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions<br>Example:<br>*Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*) | |  <br>Plasticity chart for laboratory classification of fine grained soils |
| | | Medium to high | None to very slow | Medium | *CL* | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays | | | |
| | | Slight to medium | Slow | Slight | *OL* | Organic silts and organic silt-clays of low plasticity | | | |
| | Silts and clays liquid limit greater than 50 | Slight to medium | Slow to none | Slight to medium | *MH* | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts | | | |
| | | High to very high | None | High | *CH* | Inorganic clays of high plasticity, fat clays | | | |
| | | Medium to high | None to very slow | Slight to medium | *OH* | Organic clays of medium to high plasticity | | | |
| Highly Organic Soils | | Readily identified by colour, odour, spongy feel and frequently by fibrous texture | | | *Pt* | Peat and other highly organic soils | | | |

From Wagner, 1957.

[a] *Boundary classifications*. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW–GC*, well graded gravel-sand mixture with clay binder.

[b] All sieve sizes on this chart are U.S. standard.

### *Field Identification Procedure for Fine Grained Soils or Fractions*

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

*Dilatancy* (Reaction to shaking):

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

*Dry Strength* (Crushing characteristics):

After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, *adding water if necessary*. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. *The dry strength increases with increasing plasticity.*

High dry strength is characteristic for clays of the CH group. A typical *inorganic silt possesses only very slight dry strength*. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

*Toughness* (Consistency near plastic limit):

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

## UNIFIED SOIL CLASSIFICATION SYSTEM

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
C-1

FUGRO NATIONAL, INC.

# APPENDIX D

## Dry Lake, Muleshoe, Delamar, and Pahroc Valleys Study Area Photographs

Older Lacustrine Deposit (Aolg), widely scattered within Pahranagat Valley, southwest of the Pahroc Valley area; Class I, coarse aggregate source (Field Station 30).

DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE
D-1

FUGRO NATIONAL, INC.

Sandstone member of the Simonson Dolomite (Do) located within Pahroc Valley in the southwastern portion of the study area; Class I, crushed rock aggregate source (Field Station 35).

DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE
D-2

FUGRO NATIONAL, INC.

# APPENDIX E

## Fugro National Geologic Unit Cross Reference

| UARSA POTENTIAL AGGREGATE SOURCE SYMBOLS | FUGRO NATIONAL GENERAL GEOLOGIC UNIT EXPLANATION | |
|---|---|---|
| | | **ROCK** |
| | | Shown in regions where rock is exposed. The areally predominant (greater than 70 percent) rock type is indicated. In those areas where two rock types occur, the predominant rock type is shown followed by the subordinate rock type (e.g., $S_1/_{gr}$, $I_4$). Rock may be subdivided into bedrock (B). |
| | I | IGNEOUS (UNDIFFERENTIATED) - Rocks formed by solidification of a molten or partially molten mass. |
| Gr | $I_1$ | Intrusive (Plutonic) - Rocks formed by solidification of molten material beneath the surface (e.g., granite, granodiorite, diorite, gabbro). |
| Vu | $I_2$ | Extrusive (intermediate and acidic) - Volcanic rocks of intermediate and acidic composition formed by solidification of molten material at or near the surface (e.g., rhyolite, latite, dacite, andesite). |
| Vb | $I_3$ | Extrusive (basic) - Volcanic rocks of basic composition generally formed by solidification of molten material at or near the surface (e.g., basalt). |
| Vu | $I_4$ | Extrusive (pyroclastic) - Rocks formed by accumulation of volcanic ejecta (e.g., ash, tuff, welded tuff, agglomerate). |
| Su | S | SEDIMENTARY (UNDIFFERENTIATED) - Rocks formed by accumulation of clastic solids, organic solids and/or chemically precipitated minerals. |
| Su, QTz | $S_1$ | Arenaceous and/or Siliceous Rocks - Composed of sand size particles (e.g., sandstone, orthoquartzite) or of cryptocrystalline silica (e.g., opal, chert). |
| Ls, Do, Cau | $S_2$ | Carbonate Rocks - Composed predominantly of calcium carbonate detritus or chemical precipitates (e.g., limestone, dolomite, chalk). |
| | $S_3$ | Argillaceous Rocks - Composed of clay and silt sized particles (e.g., siltstone, shale, claystone). |
| | $S_4$ | Evaporite Rocks - Precipitated from solution as a result of evaporation (e.g., halite, gypsum, anhydrite, sylvite). |
| Su | $S_5$ | Coarse Clastic Rocks - Composed of gravel-sized or larger clasts (e.g., conglomerate, breccia). |
| Mu | M | METAMORPHIC (UNDIFFERENTIATED) - Rocks formed through recrystallization in the solid state of preexisting rocks by heat and pressure. |
| Mu | $M_1$ | Coarse grained - Rocks formed by higher-grade regional metamorphism, either banded or granular (e.g., gneiss, granulite, amphibolite). |
| Mu | $M_2$ | Fine grained (schistose) - Rocks formed by lower grade regional metamorphism (e.g., schist, slate, phyllite). |
| Mu | $M_3$ | Nonfoliated - Rocks formed chiefly by contact metamorphism (e.g., hornfels, marble). |
| QTz | $M_4$ | Metaquartzite - Rocks formed by metamorphism of highly siliceous rocks. |
| | | **BASIN-FILL** |
| | A | BASIN-FILL DEPOSITS - Fine- to coarse-grained materials deposited principally by wind, water or gravity. |
| Aal | $A_1$ | Younger Fluvial Deposits - Major modern stream channel and flood plain deposits. |
| Au, Aal | $A_2$ | Older Fluvial Deposits - Older incised stream channel and flood-plain deposits in elevated terraces bordering major modern drainages. |
| Au | $A_3$ | Eolian Deposits - Wind-blown deposits of sand occurring as either thin sheets ($A_{3s}$) or dunes ($A_{3d}$). |
| Aol | $A_4$ | Playa and Lacustrine Deposits - Deposits occurring in modern, active playas ($A_4$) or in either inactive playas or older lake beds and abandoned shorelines associated with extinct lakes ($A_{4i}$). |
| Aaf | $A_5$ | Alluvial Fan Deposits - Alluvial deposits consisting of debris flow and water laid alluvium near mountain fronts, grading into predominantly water laid alluvium deposited in shifting distributary channels near the basin center. Younger ($A_{5y}$), intermediate ($A_5$) and older ($A_{5o}$) alluvial fans are differentiated by surface soil development, terrain conditions and present depositional environment. |
| Au | $A_3/A_5$ | Mixed non-rock units. Most areally extensive unit is listed first. |
| Aaf | $A_{5o}$ ($A_5$) | Parenthetic unit underlies thin veneer of overlying mapped unit. |

FUGRO NATIONAL GEOLOGIC UNIT CROSS REFERENCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO

FIGURE
E-1

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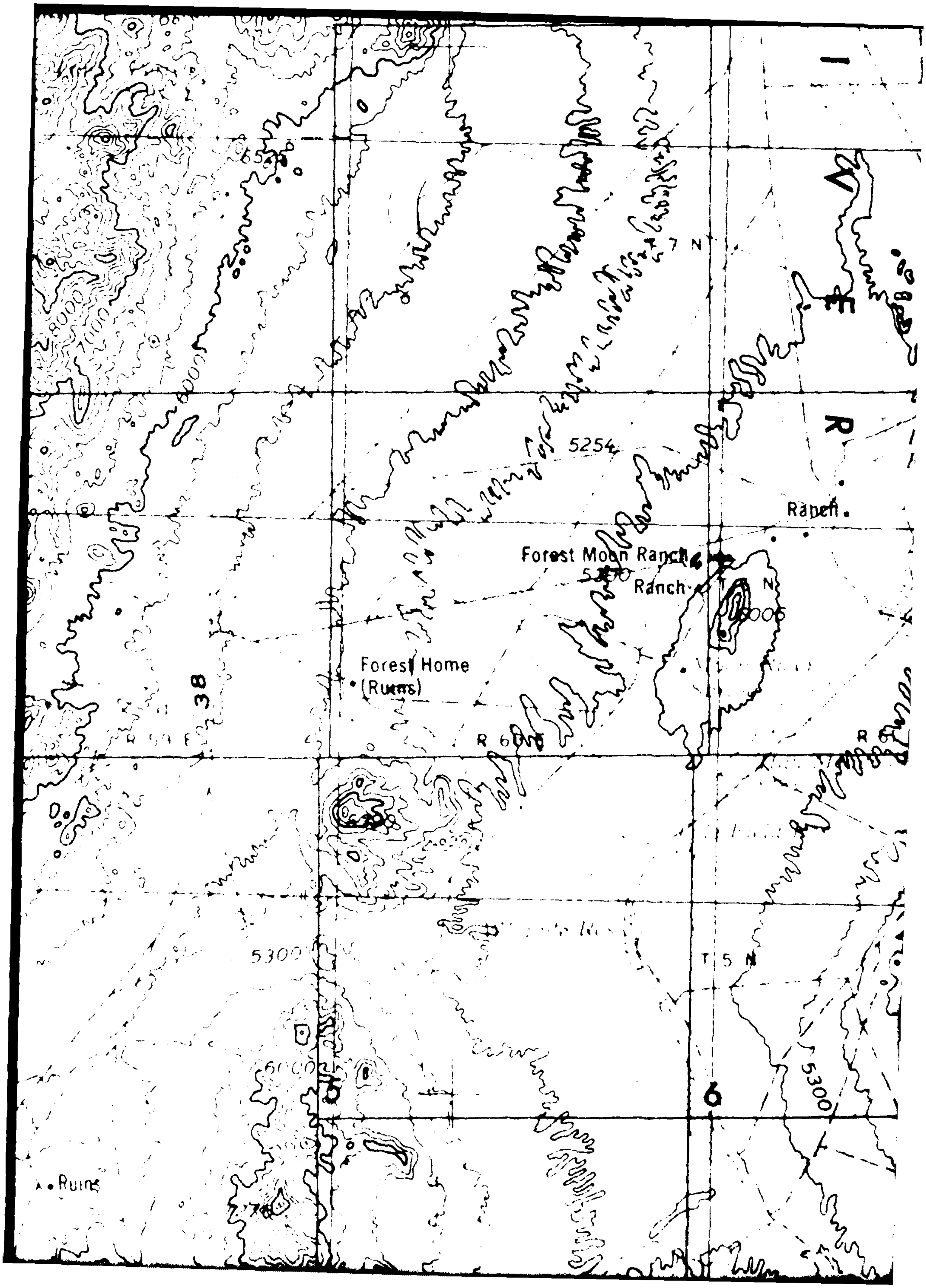
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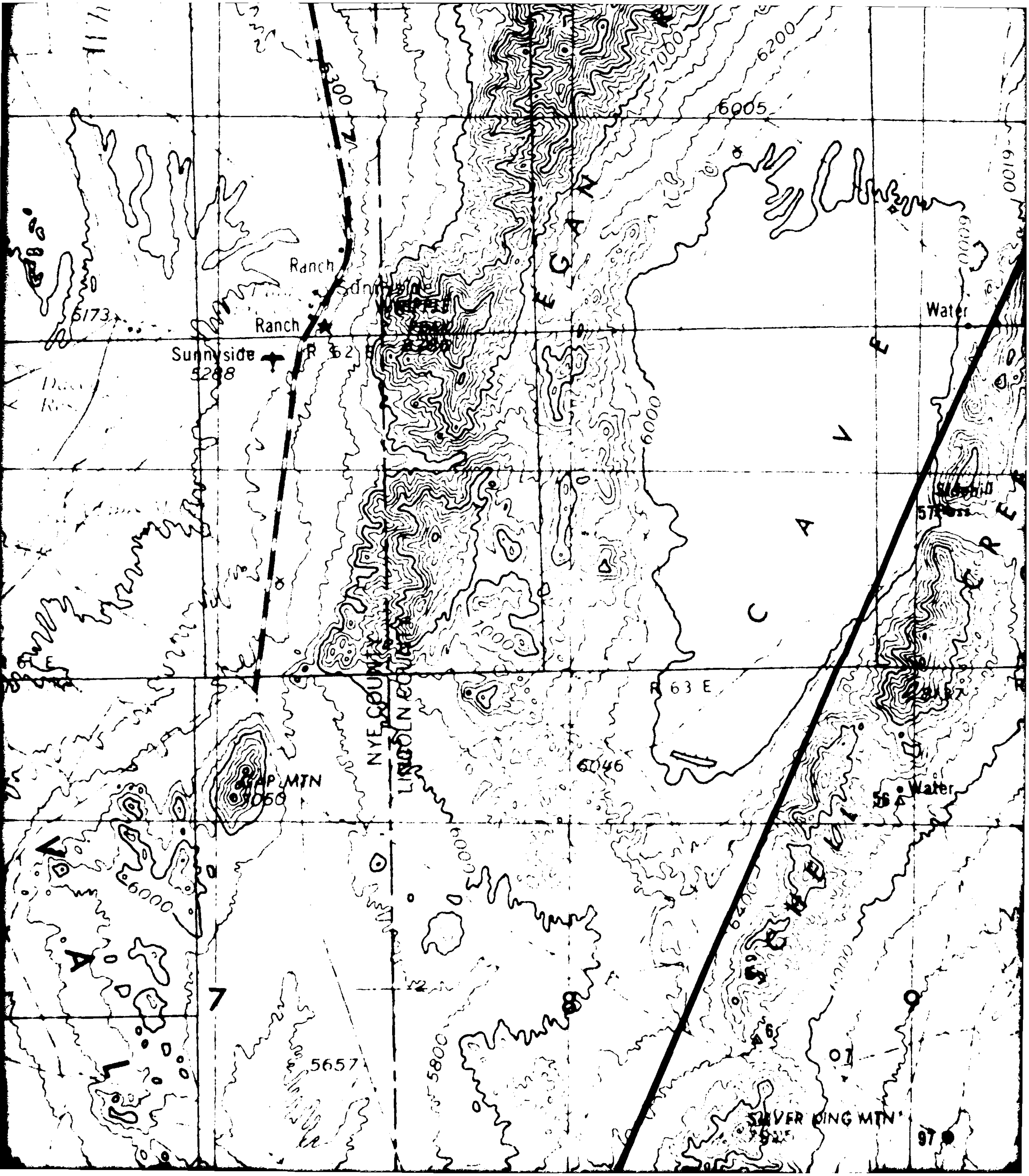
Ruins



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Water
C A V E
R 63 E
NYE COUNTY
LINCOLN COUNTY
GAP MTN
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S C H E L L
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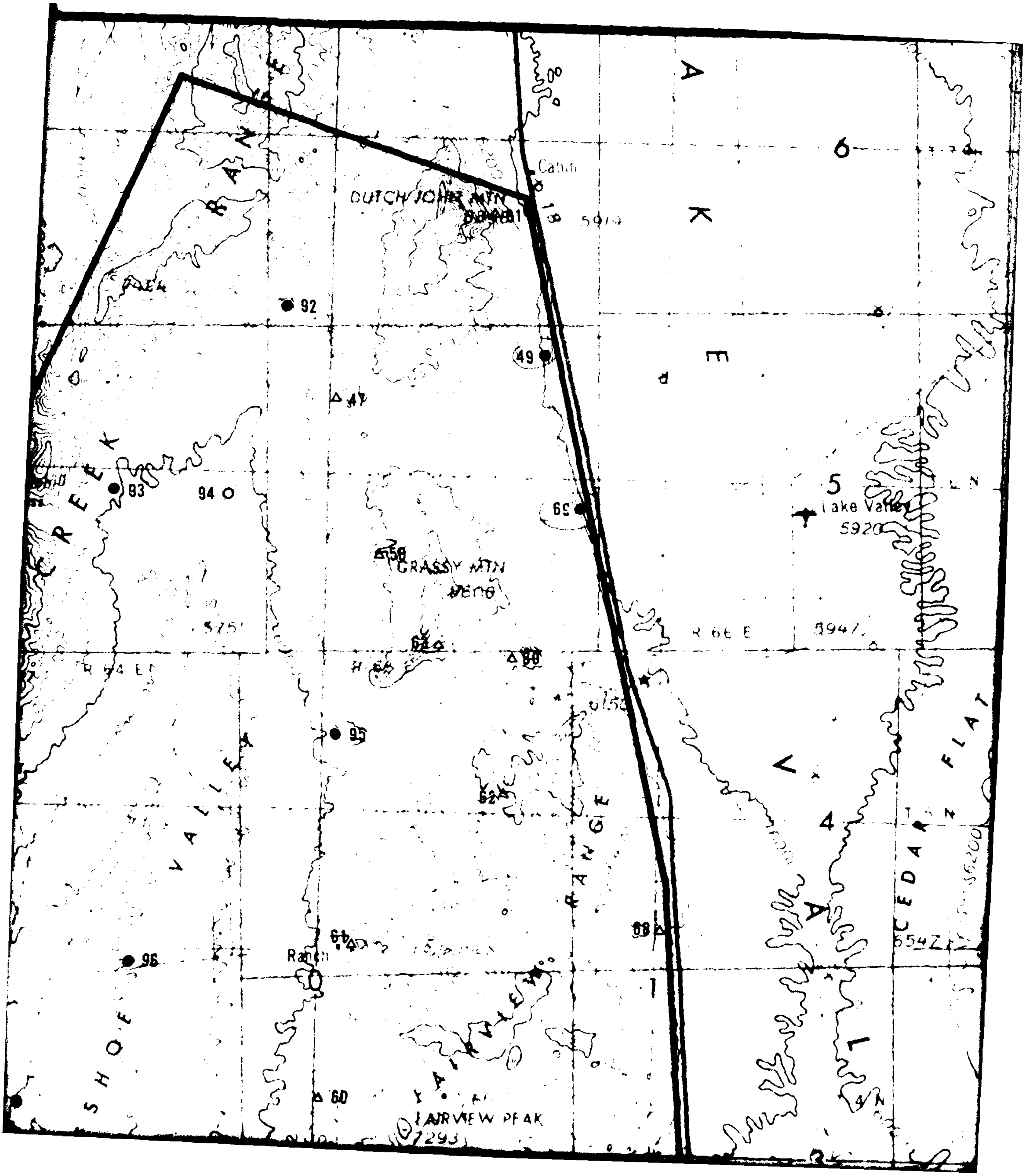DUTCH JOHN MTN
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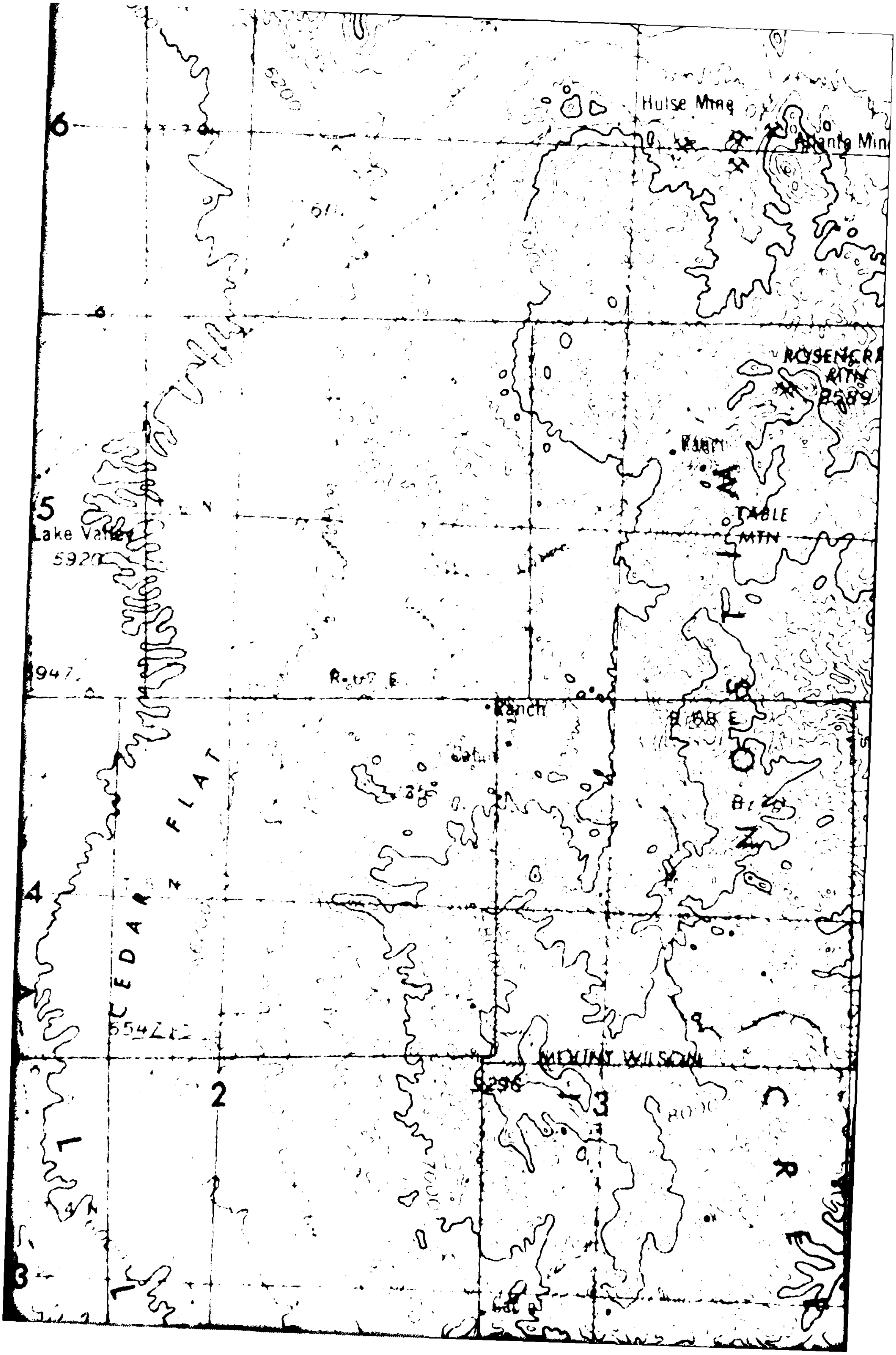
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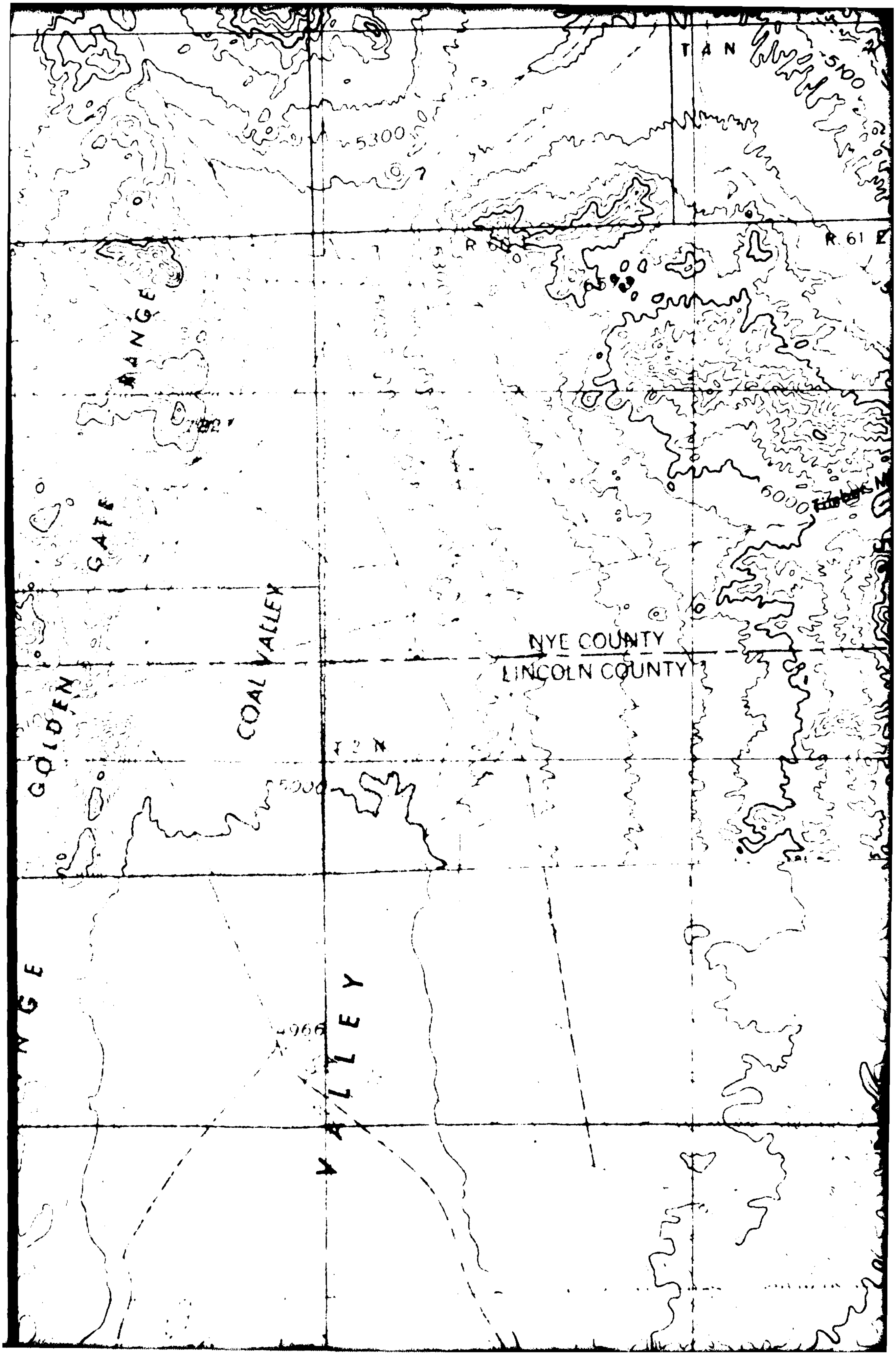

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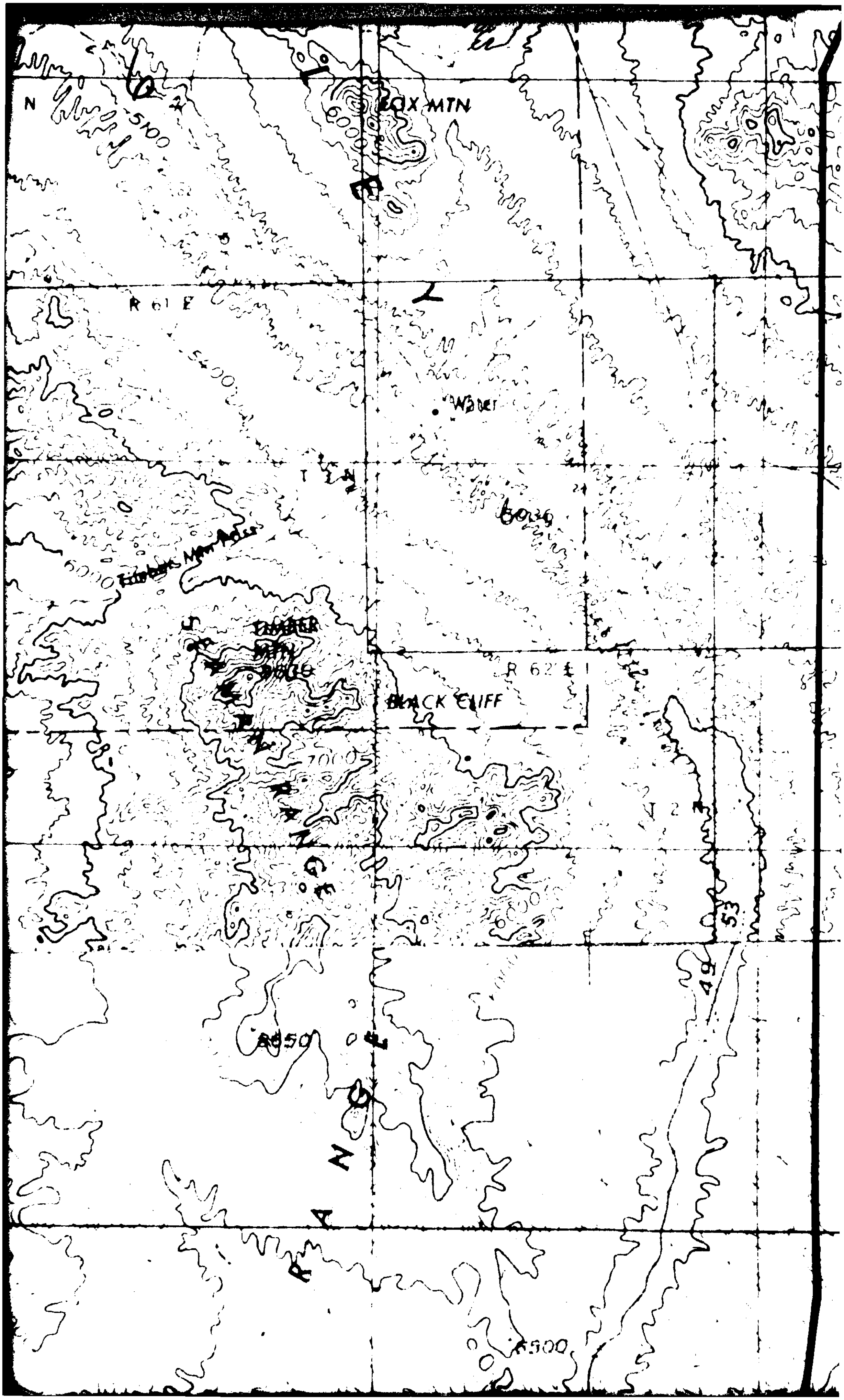
VALLEY



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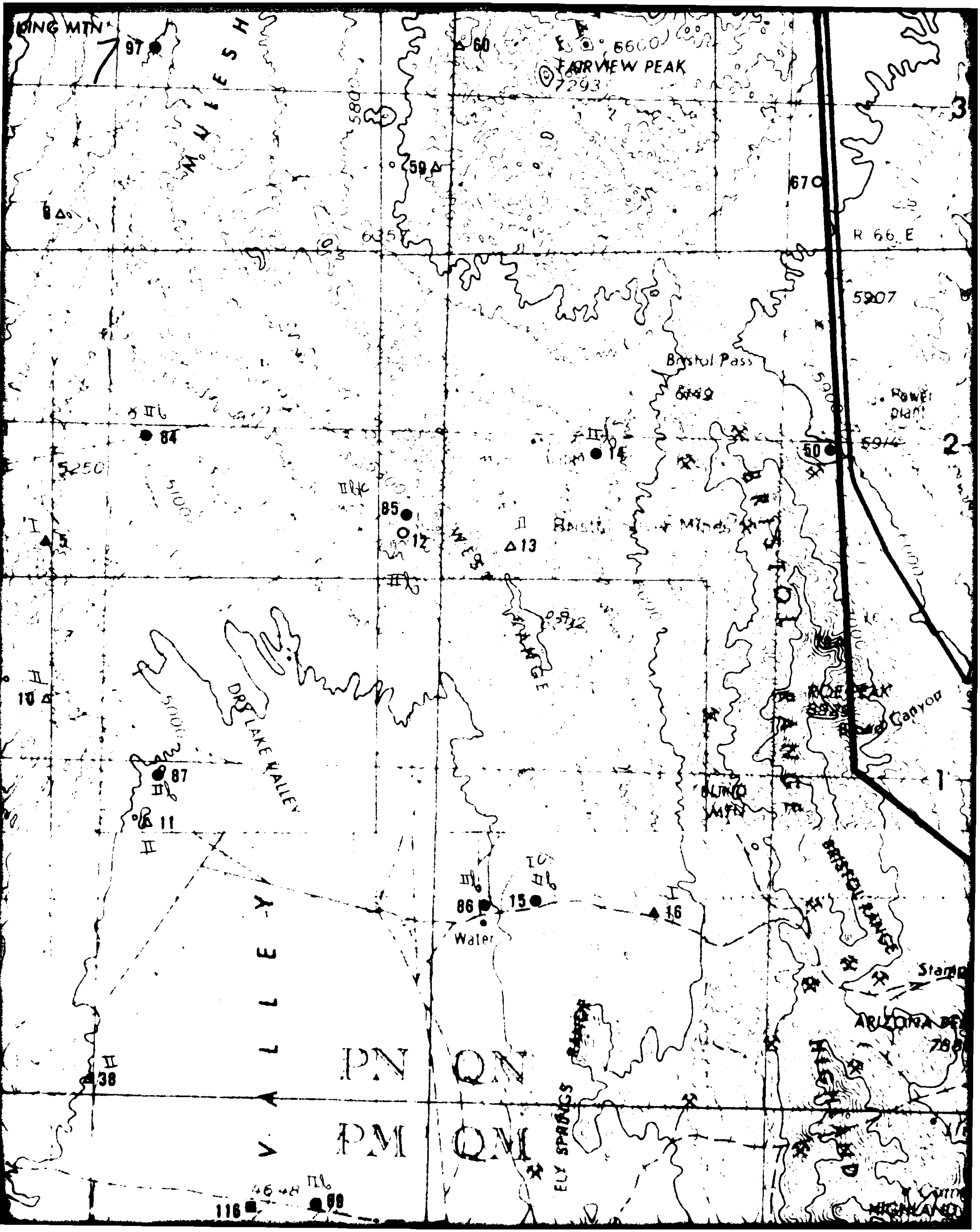

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Power plant
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5250
5100
14
II b
85
12
13
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DRY LAKE VALLEY
5000
87
II b
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BLIND MTN
BRISTOL RANGE
Boyd Canyon
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ARIZONA PEAK
Stamp
VALLEY
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QN
PM
QM
ELY SPRINGS
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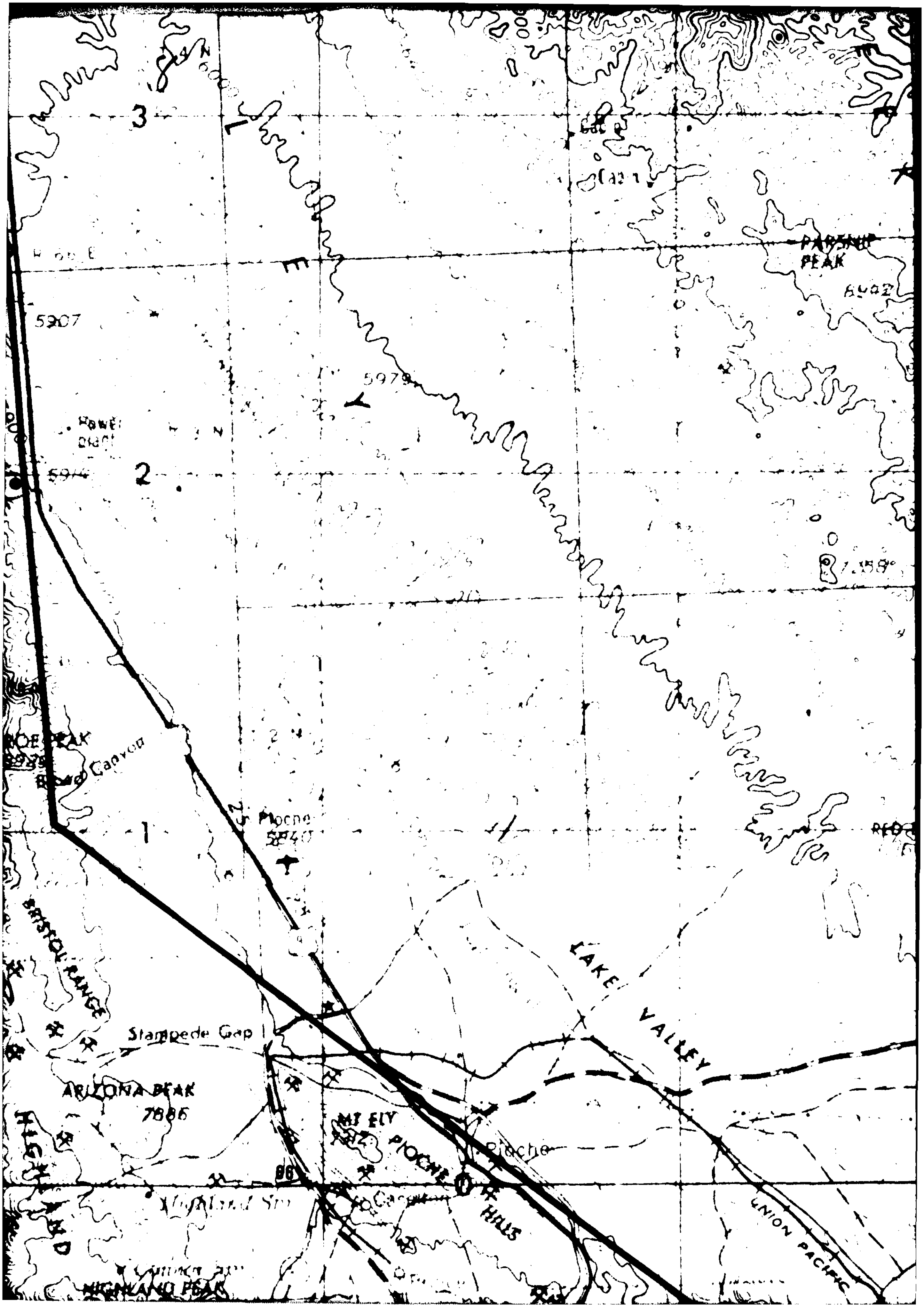
4648
HIGHLAND

3
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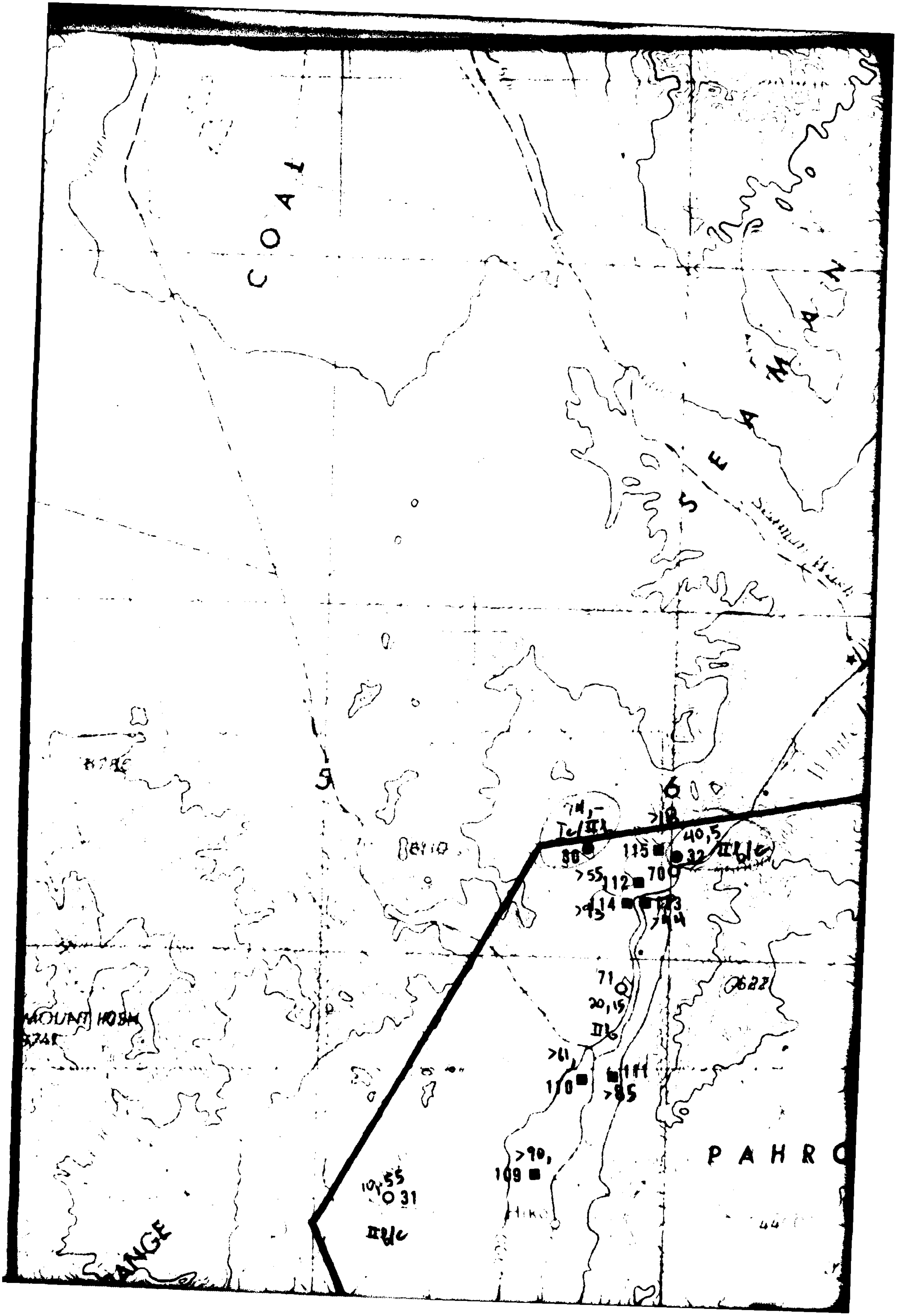
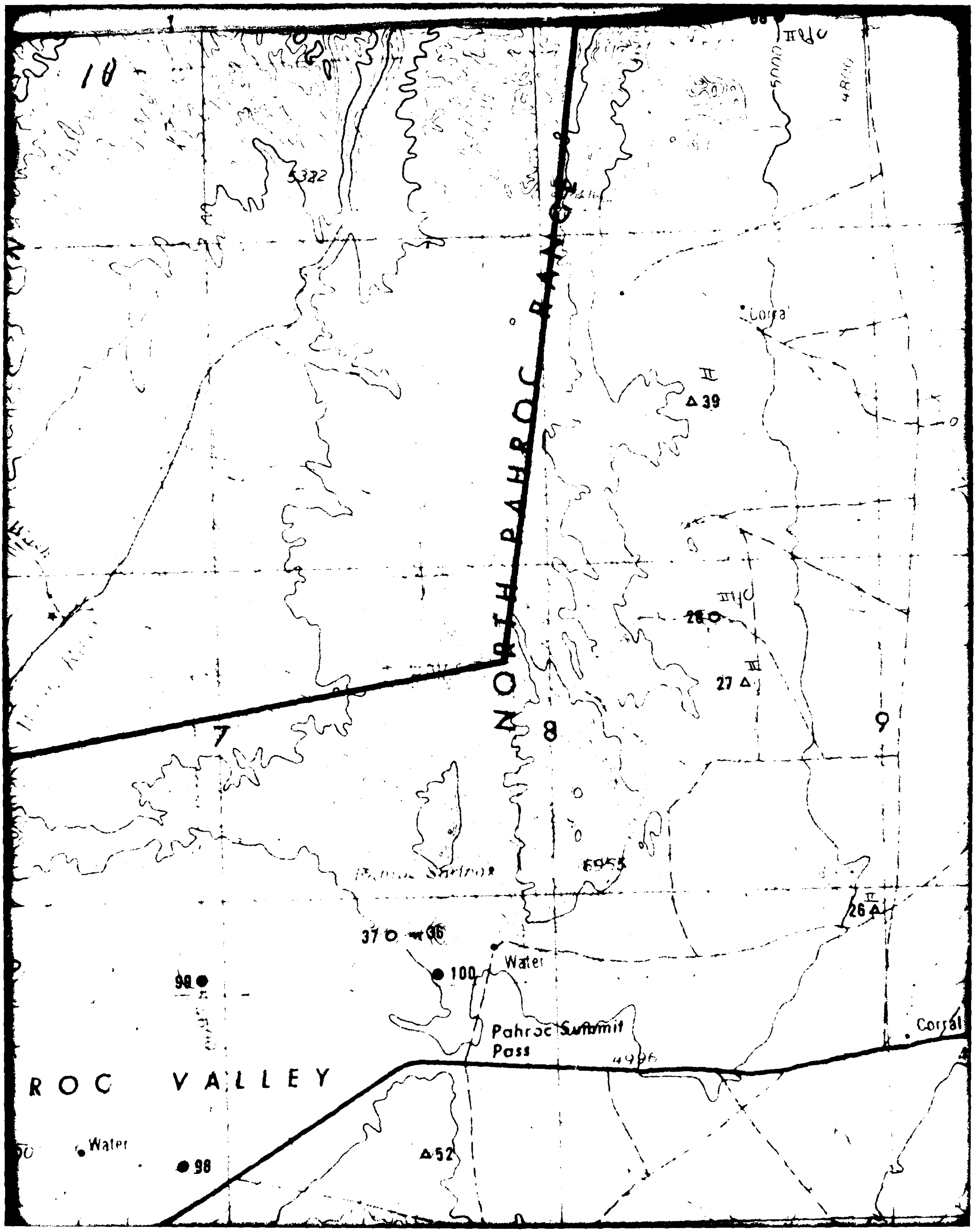
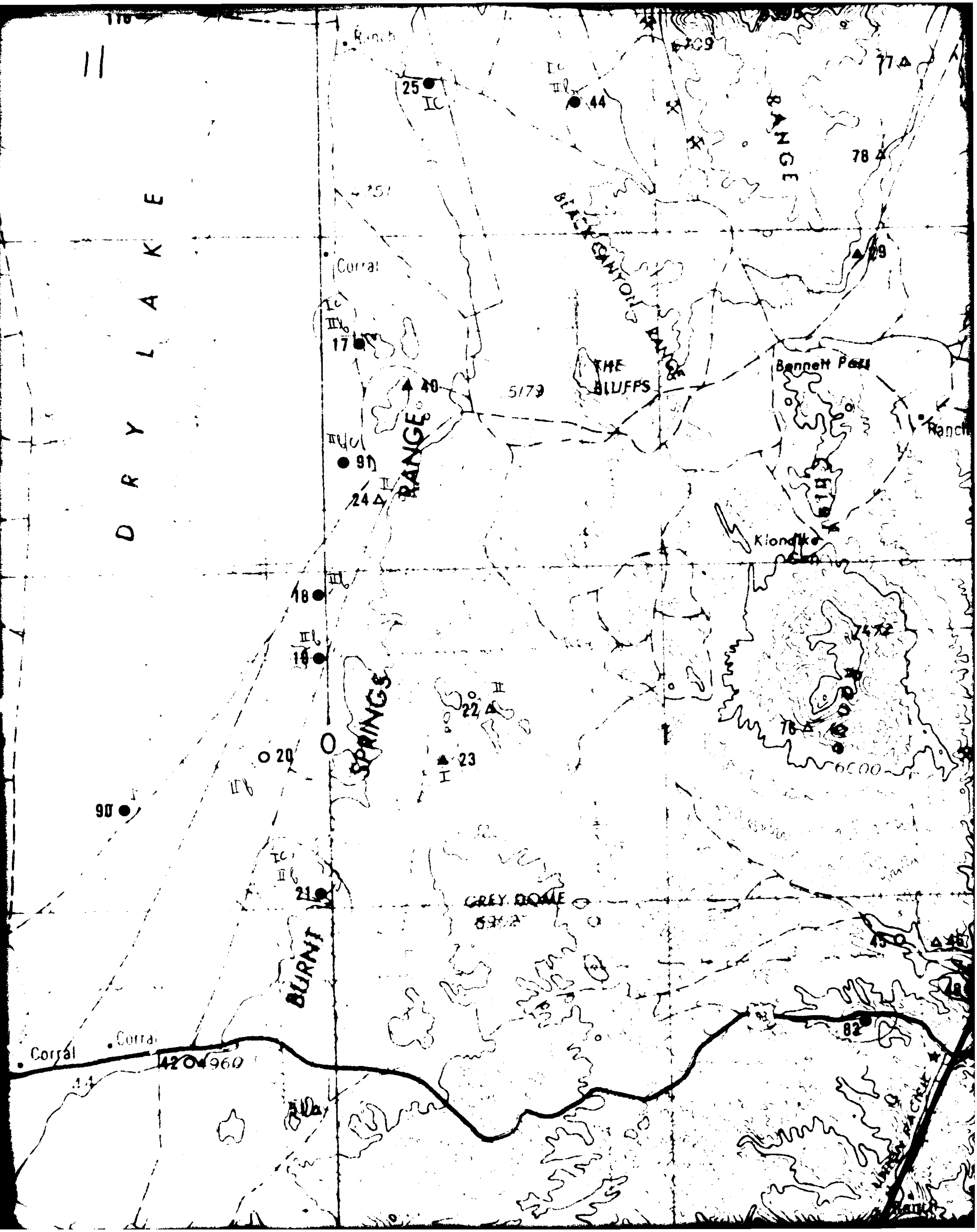
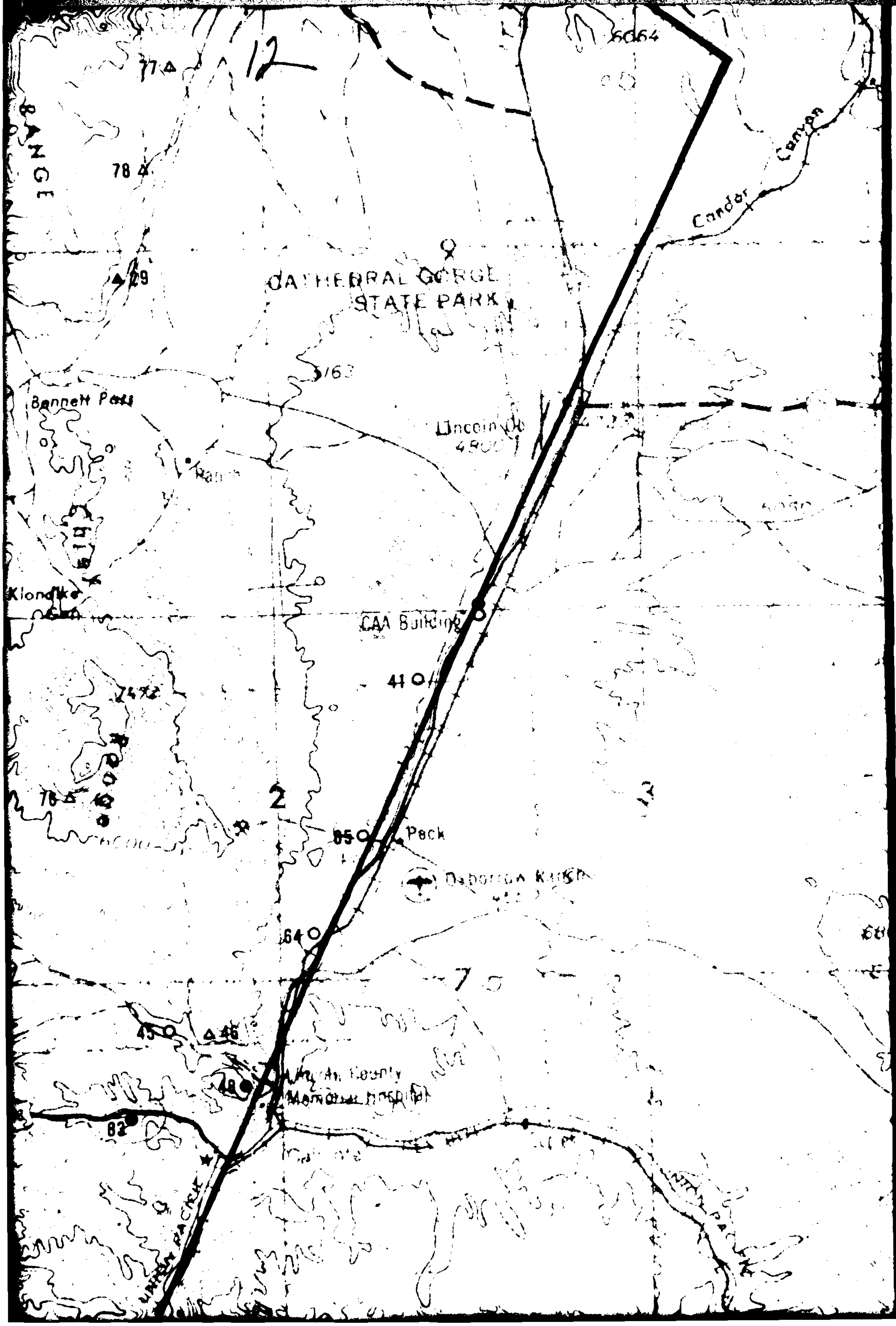
5979
Power plant
PARSNIP PEAK
6842
NOE PEAK
Pioche
5840
BRISTOL RANGE
Stampede Gap
ARIZONA PEAK
7886
HIGHLAND
HIGHLAND PEAK
Highland Spr
MT ELY
PIOCHE HILLS
Pioche
LAKE VALLEY
UNION PACIFIC

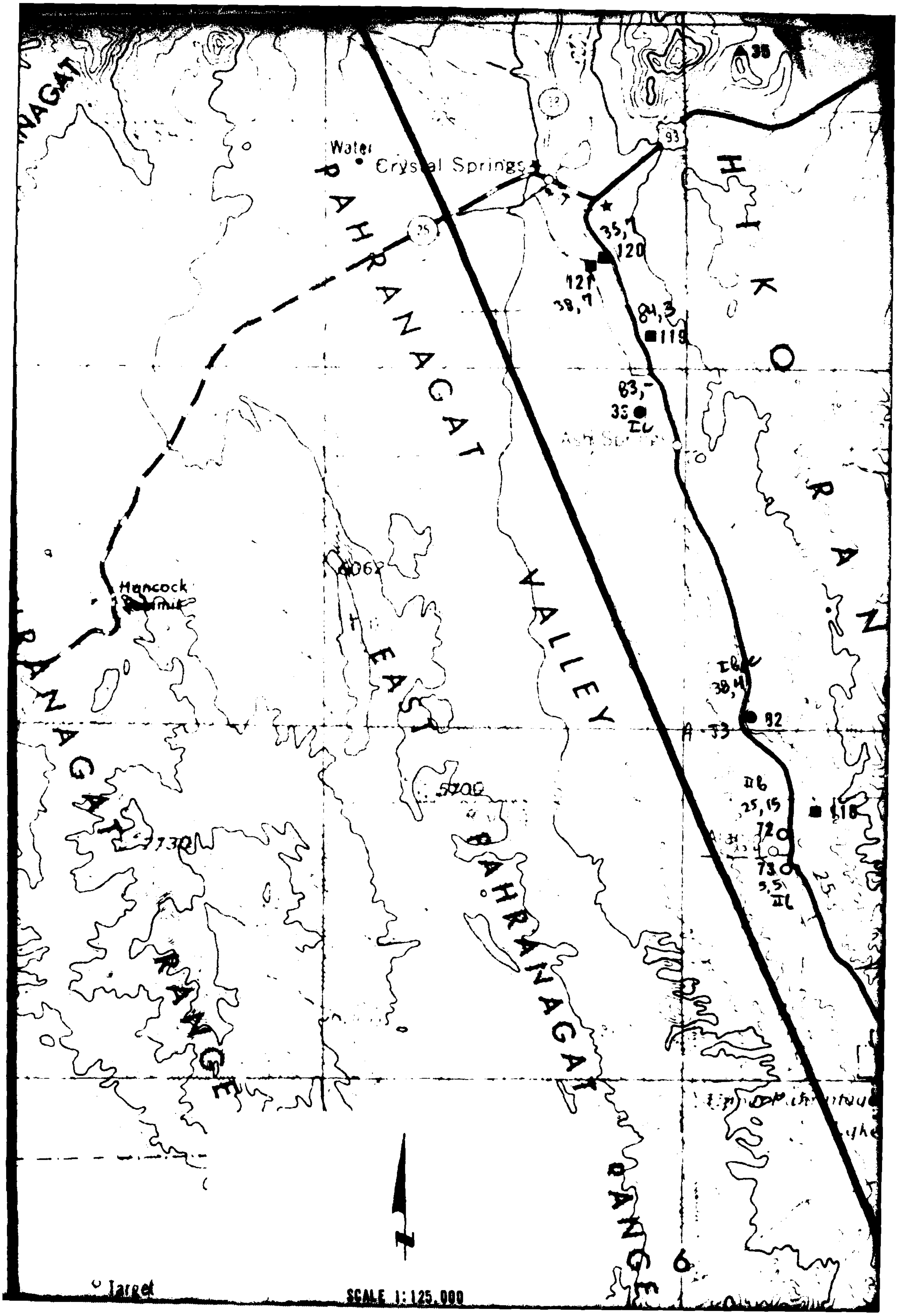

COAL
SEAMAN
5
6
8785
8110
MOUNT HOSH
8741
7622
PAHR
RANGE
74, –
Tc/III
80
>18
40,5
III b/c
115
32
>55
112
70
>43
114
113
>44
71
20,15
III b
>61
110
111
>85
>90,
109
10,55
31
III b/c

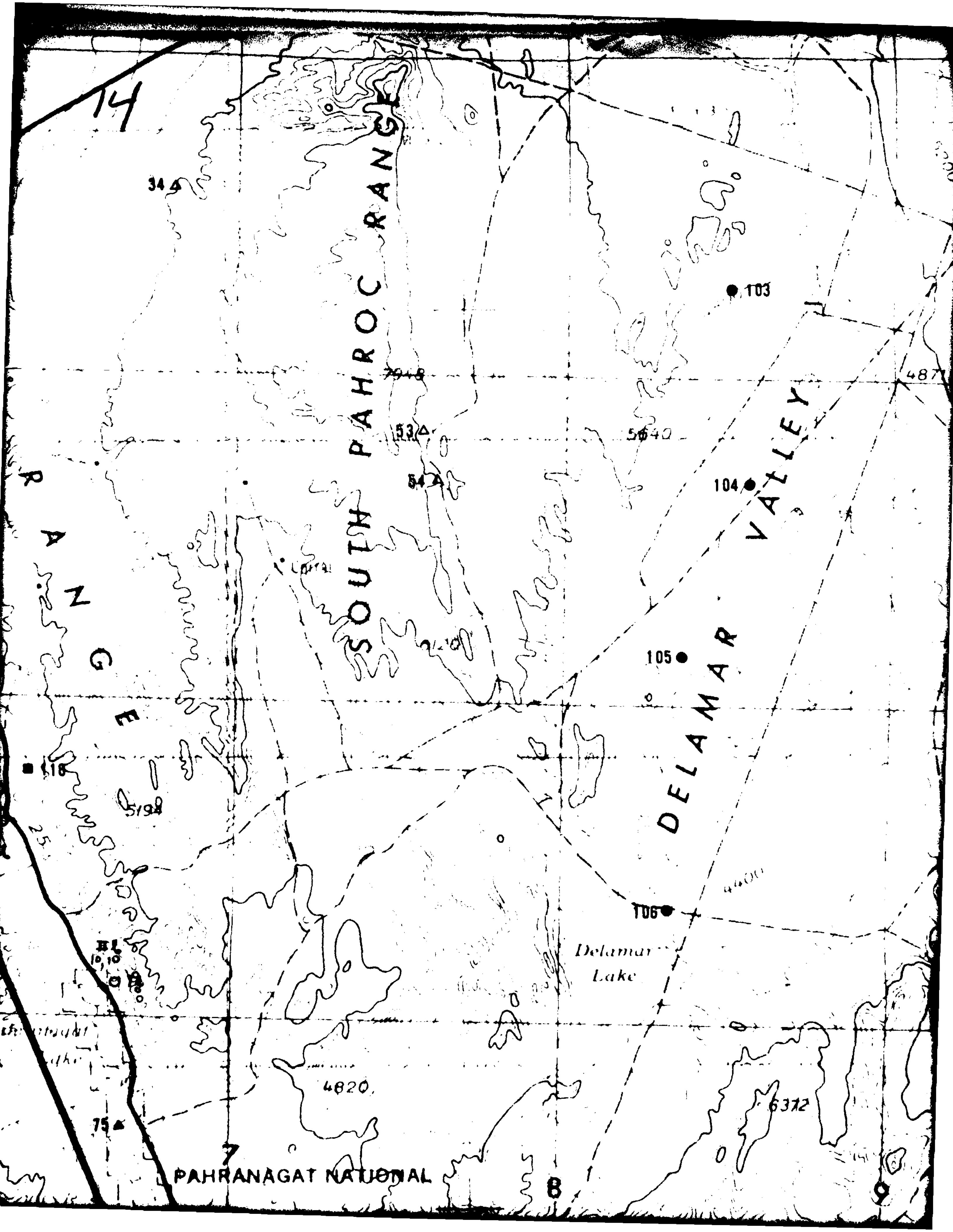

10
5382
NORTH PAHROC RANGE
5000
4800
Corral
39
28
27
7
8
9
6955
37
36
100
Water
99
Pahroc Summit Pass
4996
Corral
26
ROC VALLEY
Water
98
52


11
DRY LAKE
Ranch
Corral
25
IC
44
IIb
RANGE
77
78
BLACK CANYON RANGE
29
17
IIIb
40
5179
THE BLUFFS
Bennett Pass
Ranch
91
IIIa
24
II
RANGE
Klondike
18
IIIb
19
IIb
SPRINGS
22
23
I
20
90
2472
76
6000
21
IIb
BURNT
GREY DOME
45
46
82
Corral
Corral
4960
Ranch

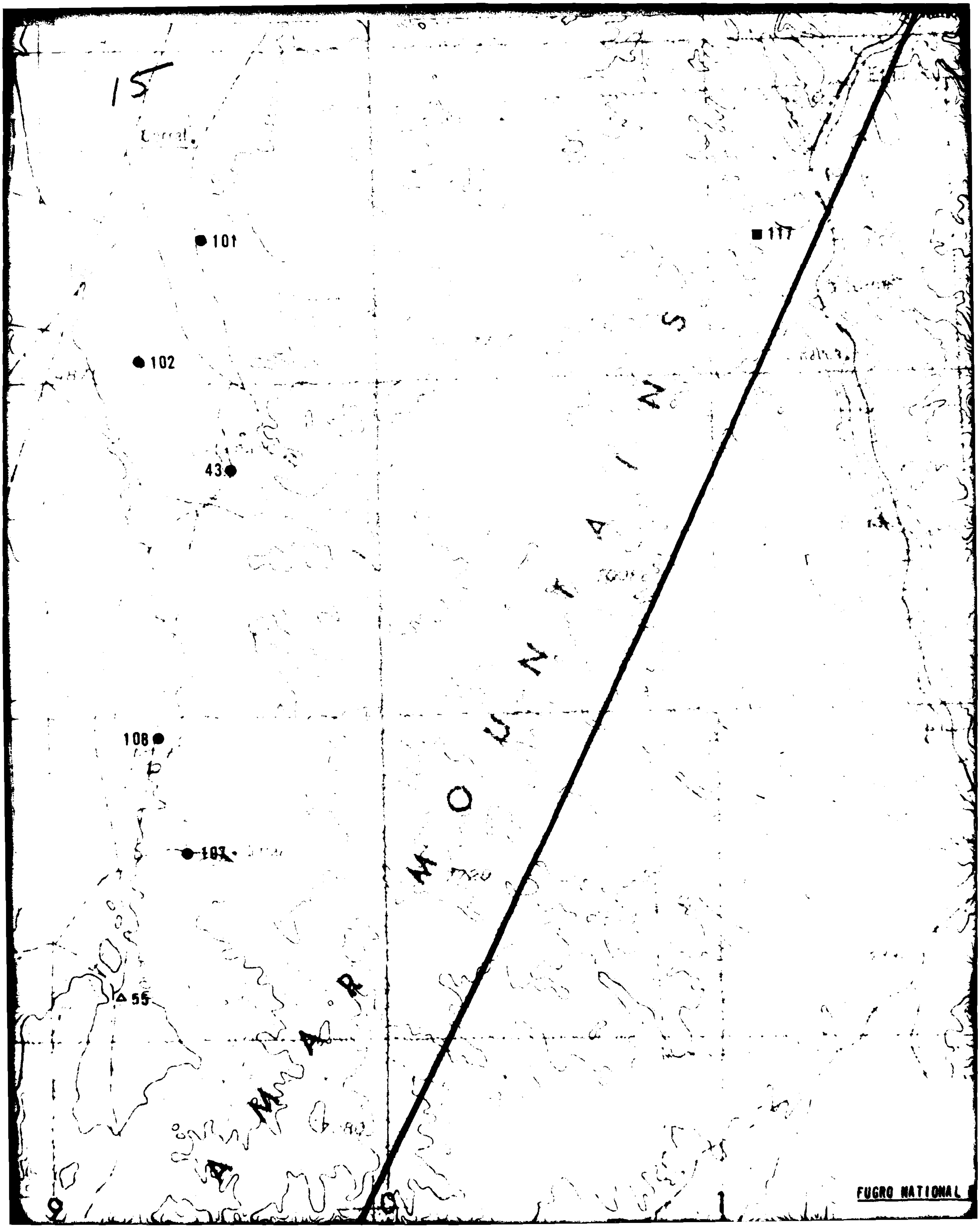


12
6064
77
RANGE
78
Condor Canyon
29
CATHEDRAL GORGE
STATE PARK
5763
Bennett Pass
Lincoln
4800
Ranch
Klondike
Gap
CAA Building
41
7492
76
2
13
85
Pack
64
7
68
45
46
48
Lincoln County
Memorial Hospital
82
Caliente
UNION PACIFIC


PAHRANAGAT
38
93
Water
Crystal Springs
25
35,7
120
121
38,7
84,3
119
83,-
33
IL
Ash Springs
HIKO RANGE
PAHRANAGAT VALLEY
Hancock Summit
6062
EAST PAHRANAGAT RANGE
PAHRANAGAT RANGE
7730
5700
IL
38,M
92
33
II6
25,15
116
72
73
5,5
IL
25
6
Target
SCALE 1:125,000


14
SOUTH PAHROC RANGE
34
103
7948
53
5640
54
104
RANGE
Corral
DELAMAR VALLEY
4871
105
116
5198
25
106
4600
Delamar Lake
4820
6312
75
7
PAHRANAGAT NATIONAL
8
9

15

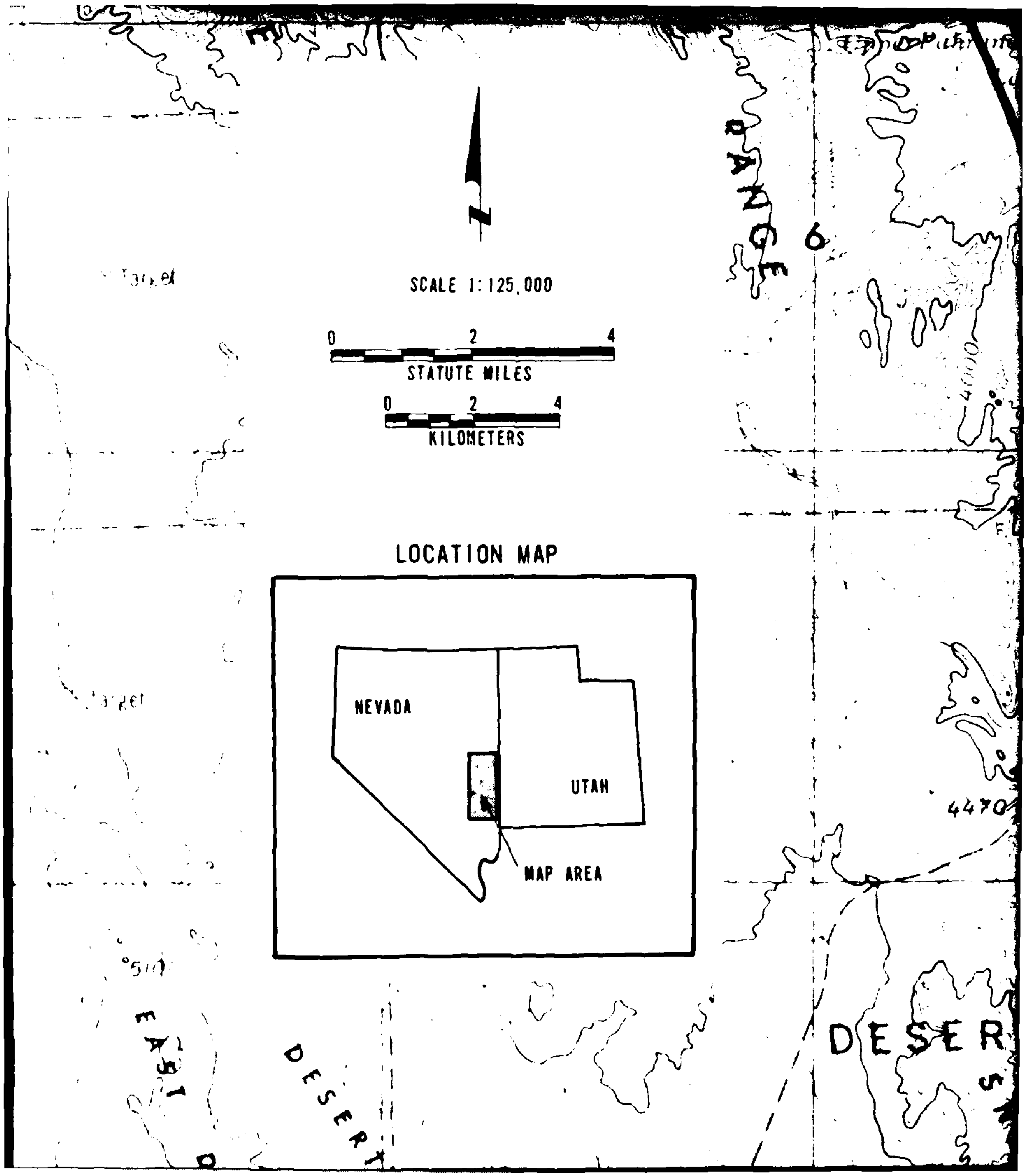


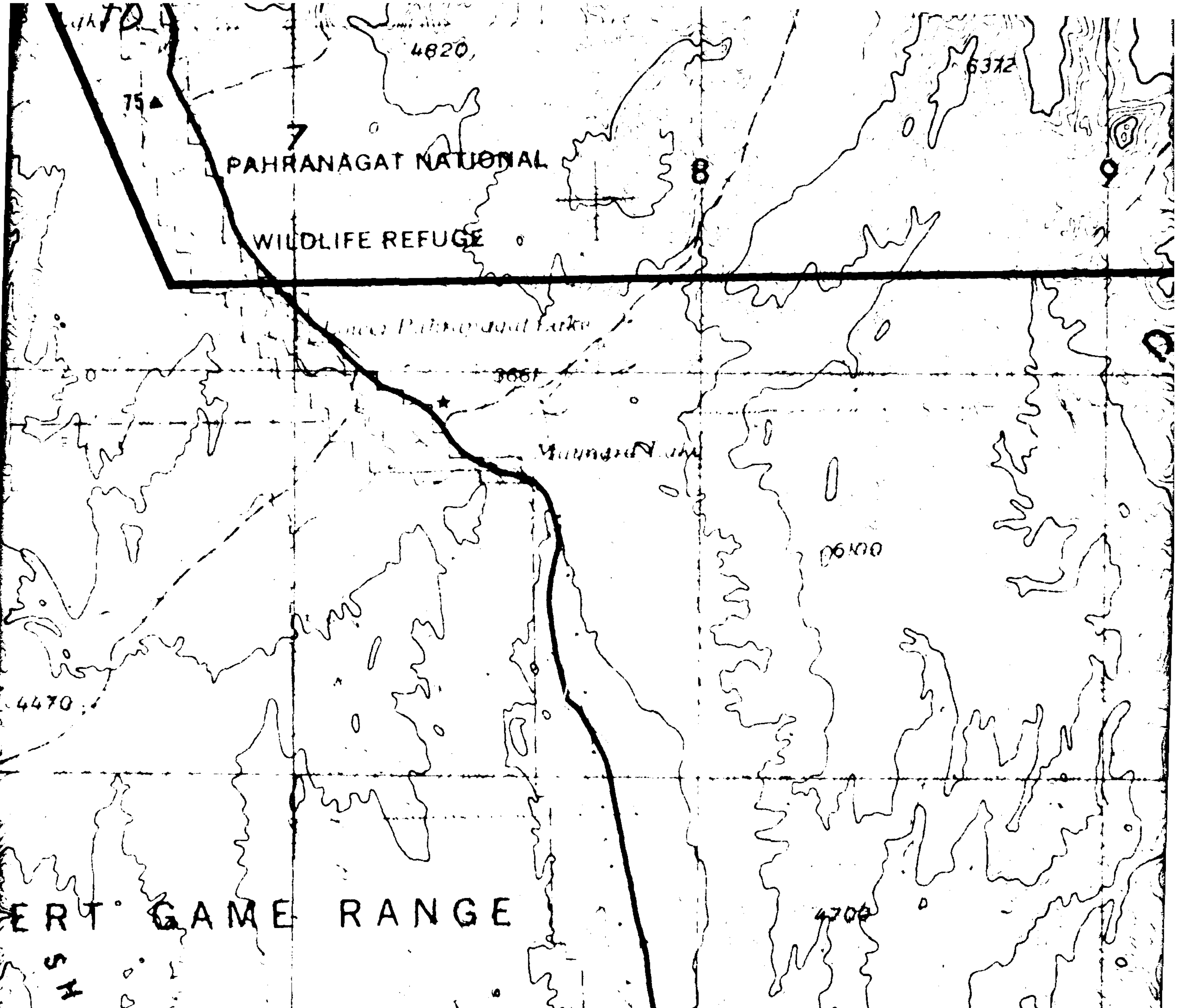
FUGRO NATIONAL

16

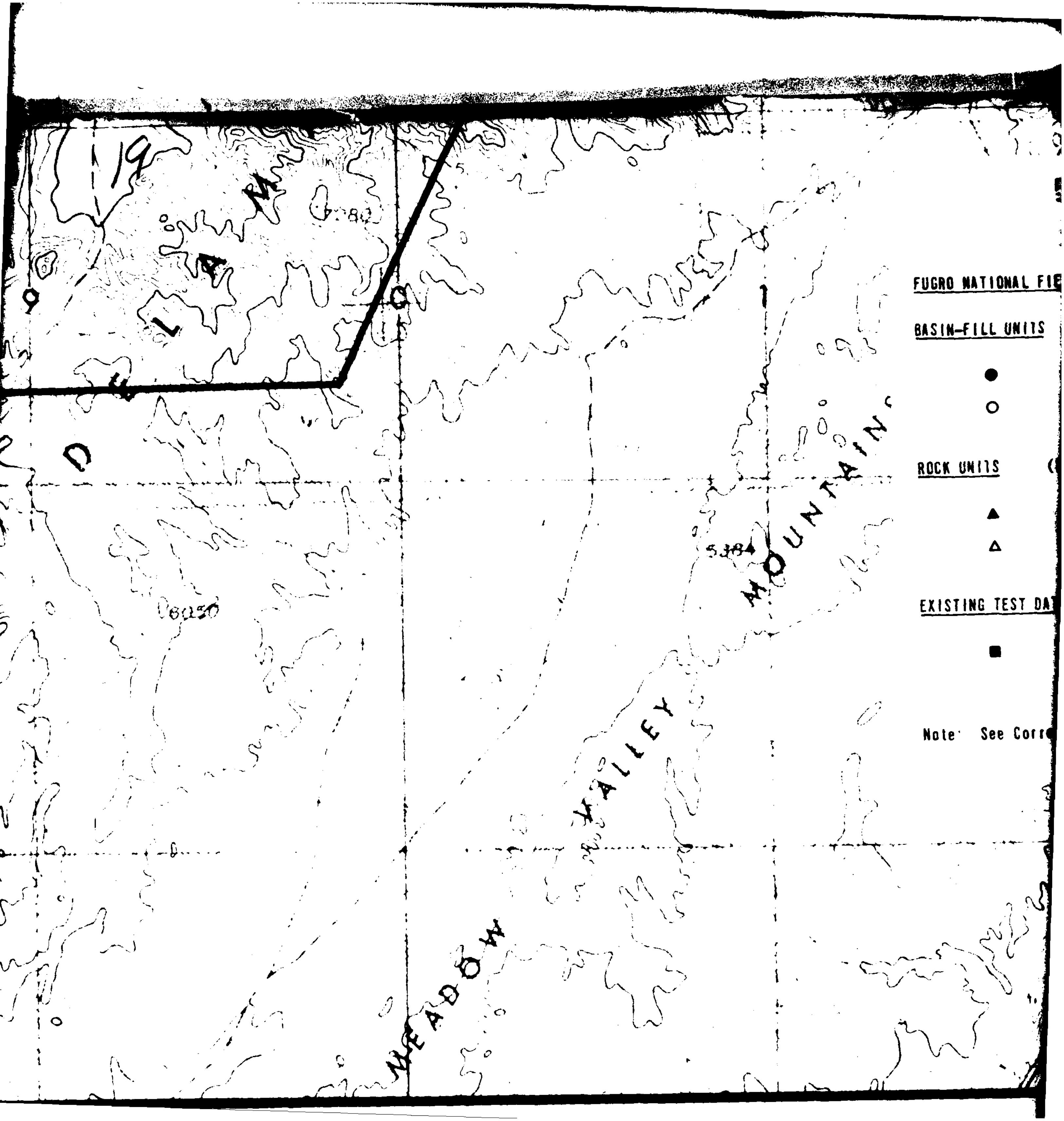
EXPLANATION

**FUGRO NATIONAL FIELD STATIONS**

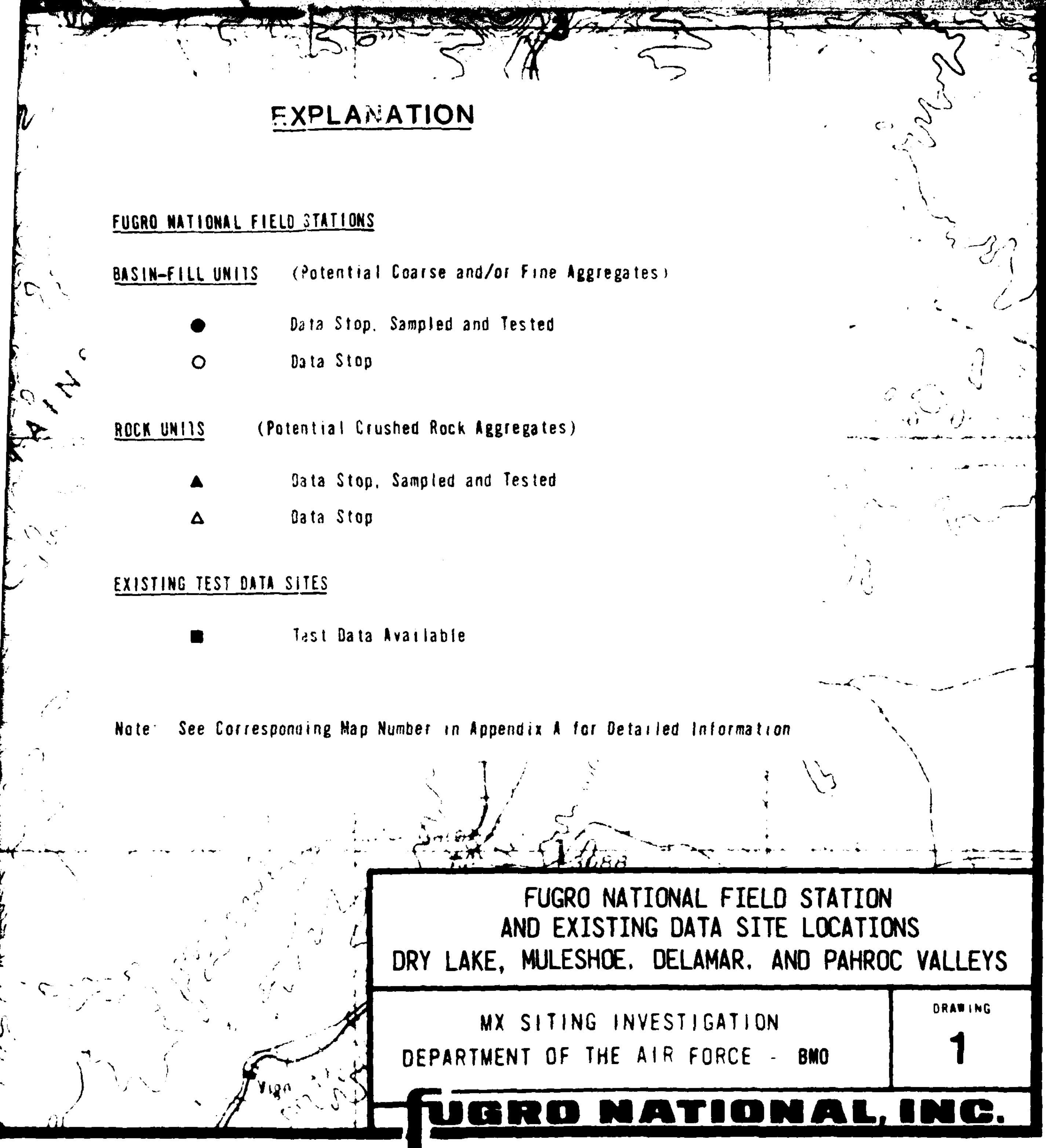

SCALE 1:125,000
0
2
4
STATUTE MILES
0
2
4
KILOMETERS
LOCATION MAP
NEVADA
UTAH
MAP AREA
RANGE 6
DESERT
EAST
DESERT
4470
Target
Target



4820
6372
75
7
8
9
PAHRANAGAT NATIONAL
WILDLIFE REFUGE
Lower Pahranagat Lake
3661
Maynard Lake
6100
4470
4700
ERT GAME RANGE
SHE


19
D E L A M
MEADOW VALLEY MOUNTAINS
7280
6050
5384
FUGRO NATIONAL FIE
BASIN-FILL UNITS
●
○
ROCK UNITS
▲
△
EXISTING TEST DA
■
Note: See Corr

20



# EXPLANATION

FUGRO NATIONAL FIELD STATIONS

BASIN-FILL UNITS (Potential Coarse and/or Fine Aggregates)

| | |
|---|---|
| ● | Data Stop, Sampled and Tested |
| ○ | Data Stop |

ROCK UNITS (Potential Crushed Rock Aggregates)

| | |
|---|---|
| ▲ | Data Stop, Sampled and Tested |
| △ | Data Stop |

EXISTING TEST DATA SITES

| | |
|---|---|
| ■ | Test Data Available |

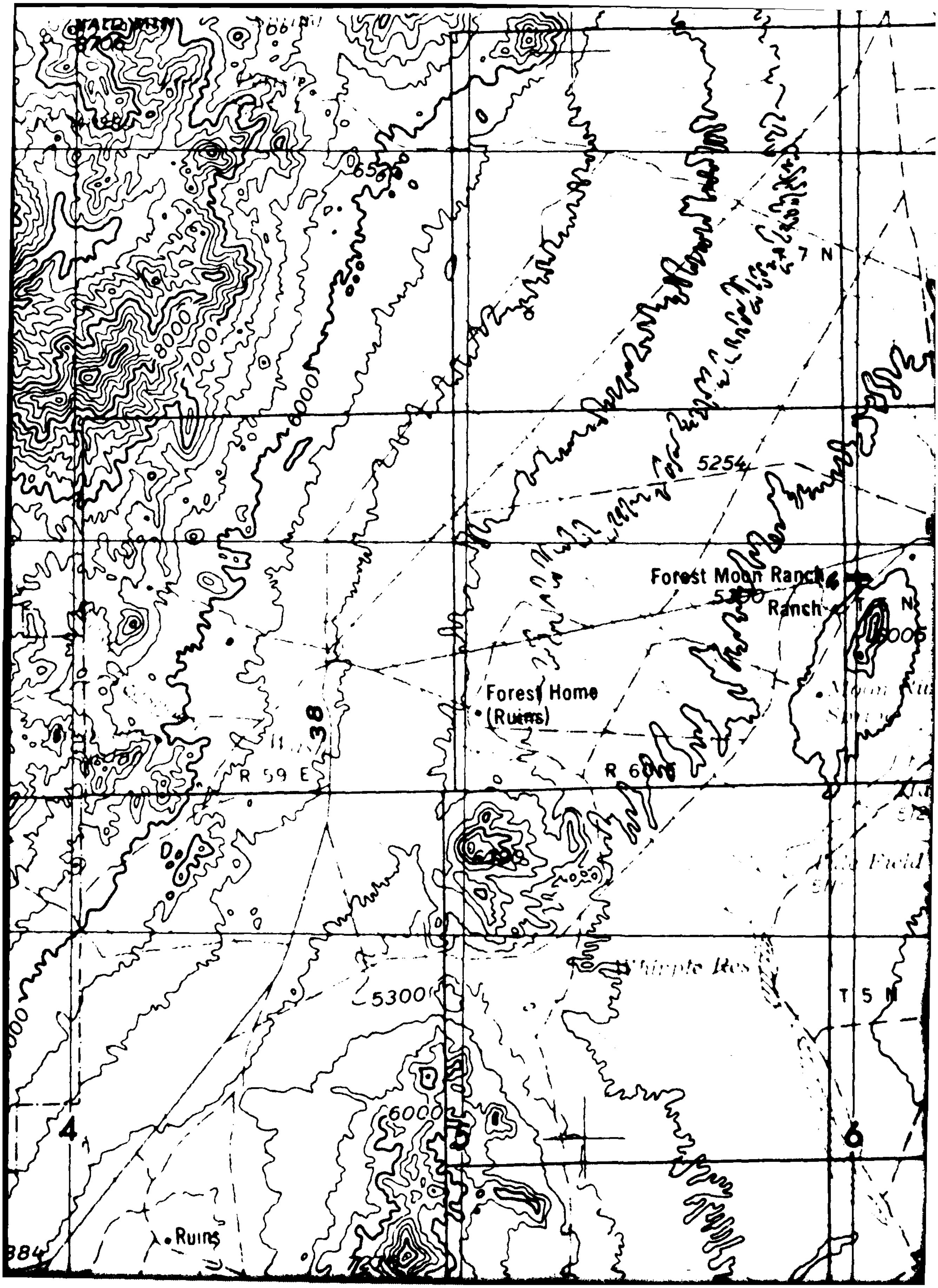
Note: See Corresponding Map Number in Appendix A for Detailed Information

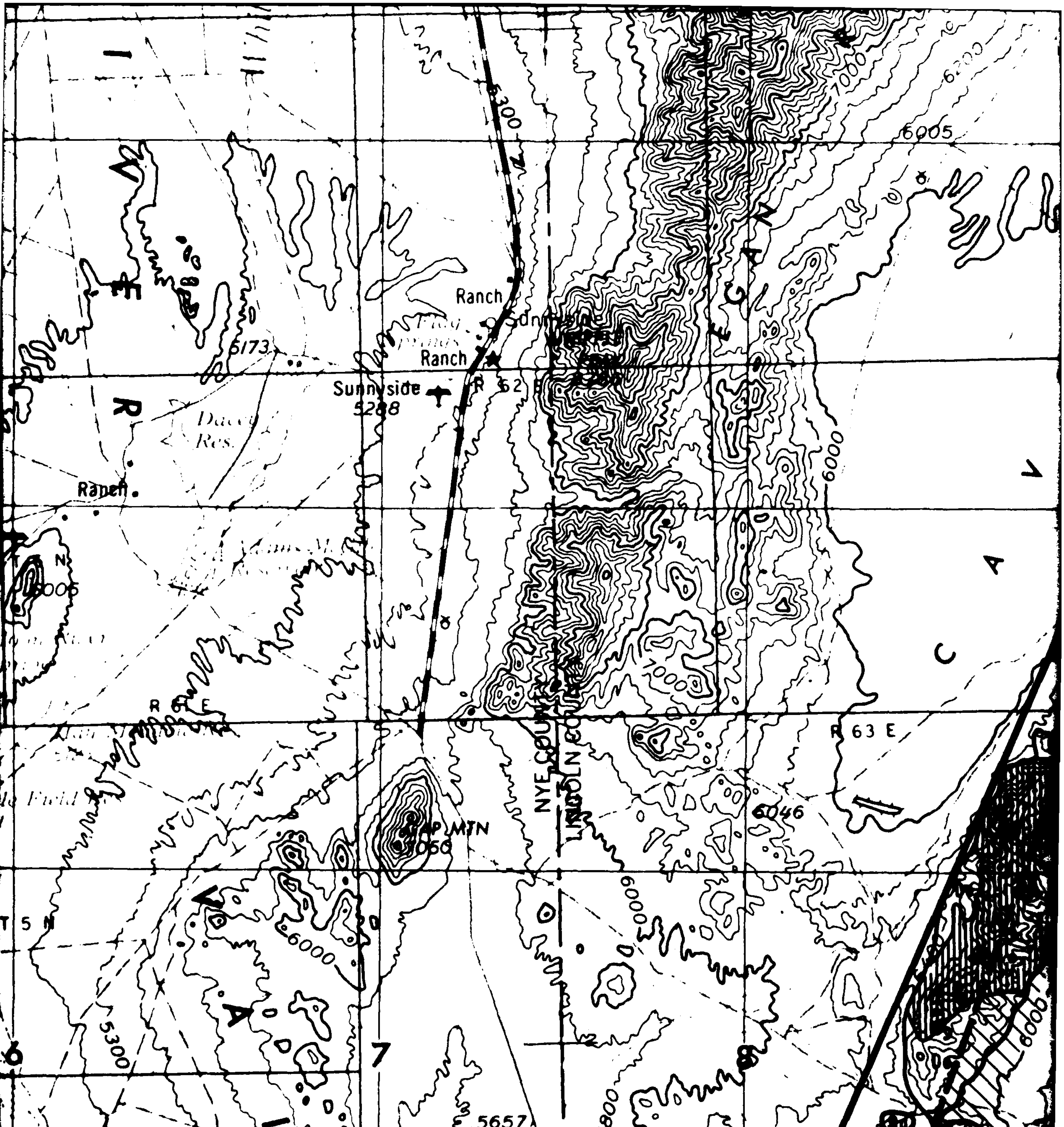
## FUGRO NATIONAL FIELD STATION
## AND EXISTING DATA SITE LOCATIONS
## DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

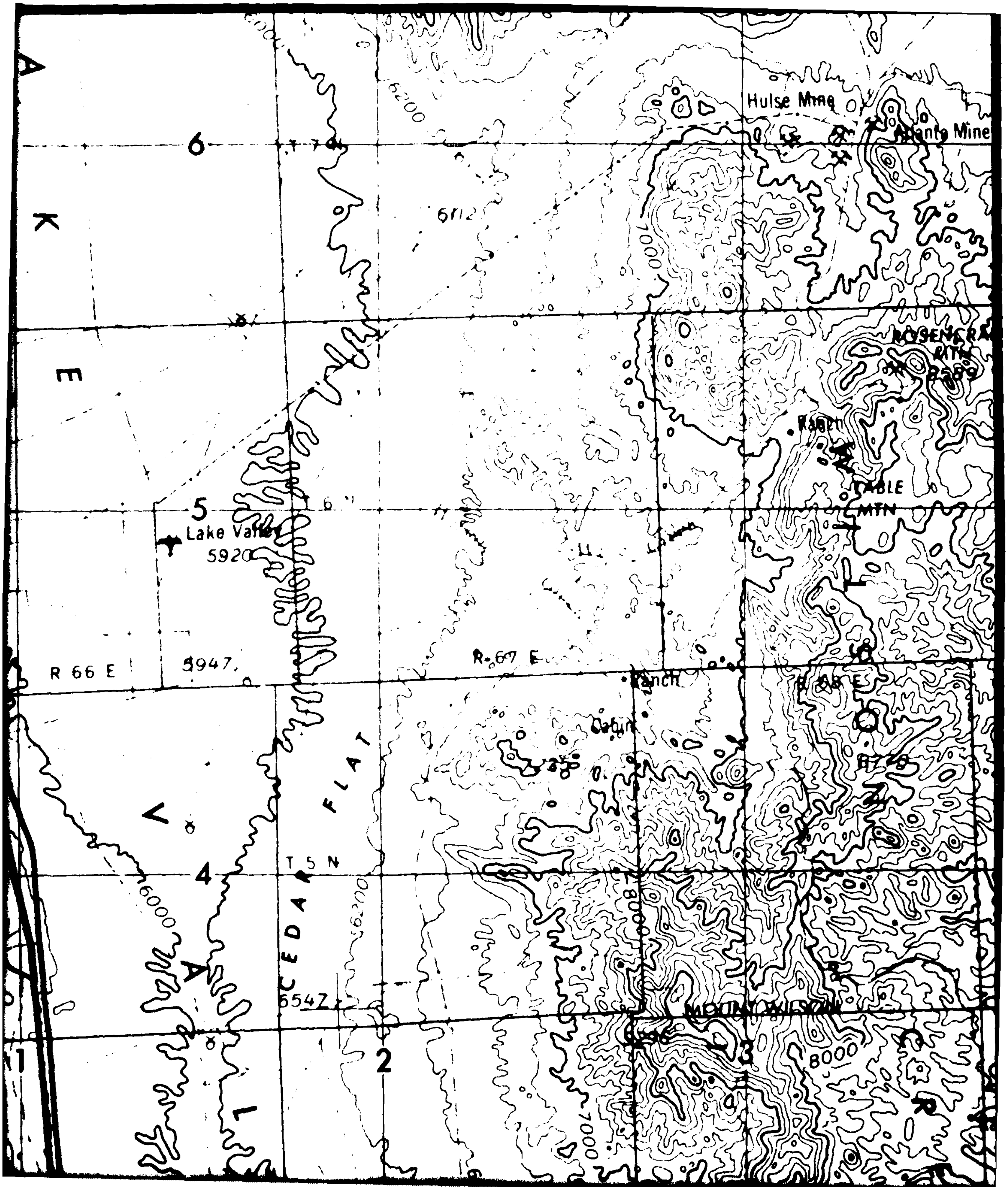
DRAWING
1

**FUGRO NATIONAL, INC.**

8706
8000
7000
6000
5254
7 N
Forest Moon Ranch
5300
Ranch
T 6 N
6005
Forest Home
(Ruins)
38
R 59 E
R 60 E
Field
Whipple Res
5300
T 5 N
6000
4
5
6
Ruins
384
000

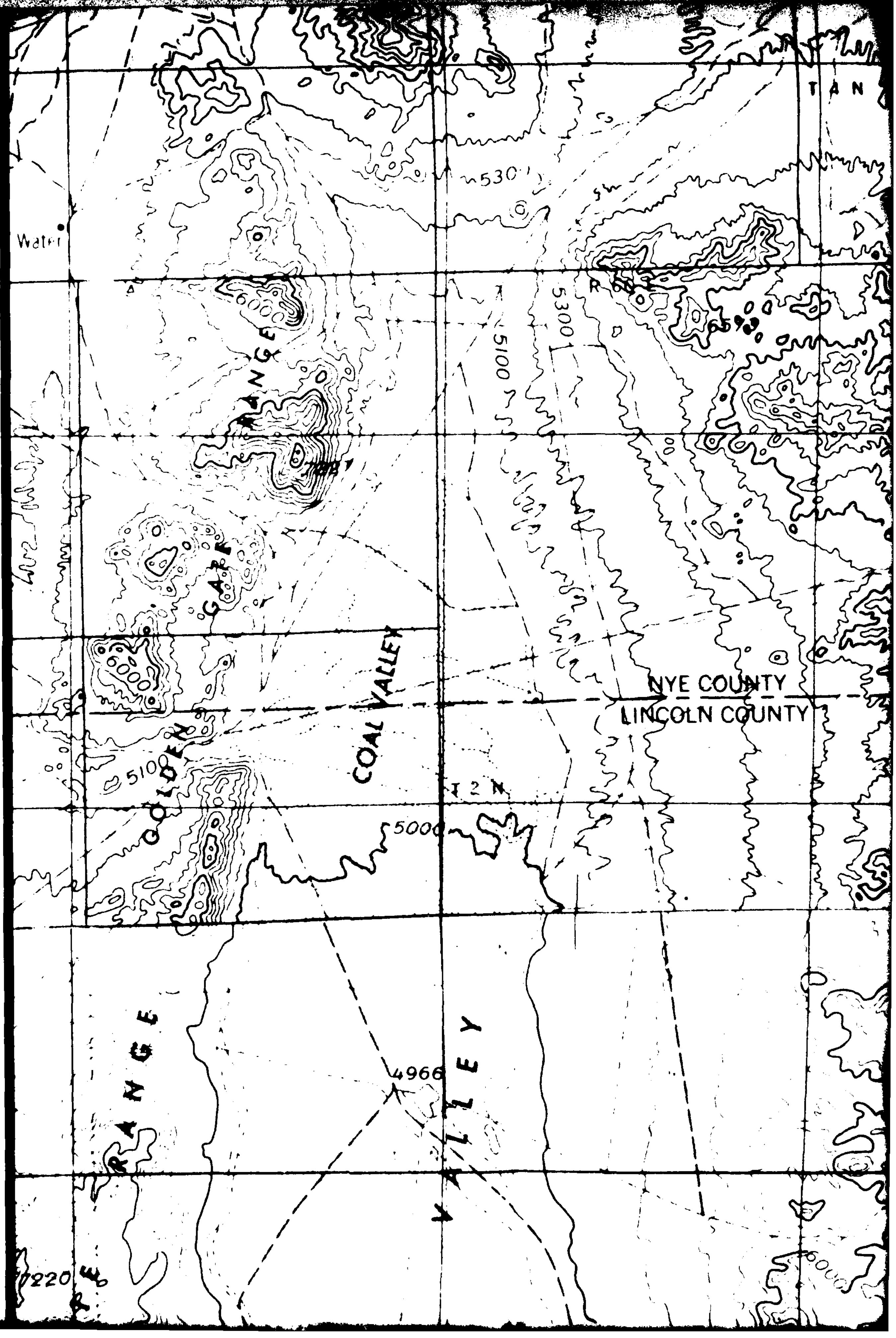

I
V
E
R
5300
Ranch
Sunnyside
Ranch
R 62 E
Sunnyside
5288
5173
Dacey
Res.
Ranch
T 6 N
6005
R 61 E
Field
7000
6200
6005
E
G
A
N
6000
V
A
C
R 63 E
CAP MTN
7050
NYE COUNTY
LINCOLN COUNTY
6046
T 5 N
6000
V
A
L
5300
6
7
8
5657
5800
6000


Cabin
18
59/9
K
6100
6000
6200
Water
Aaf
Vu
Ls
Aafs
Su
Vu
Aafs
Aafs
Aaf
R 64 E
751
6000
Vu
Aafs
Aafs
Aaf
6400
Ranch
Vu
Aals
Aafg
5600
8000
R
VALLEY

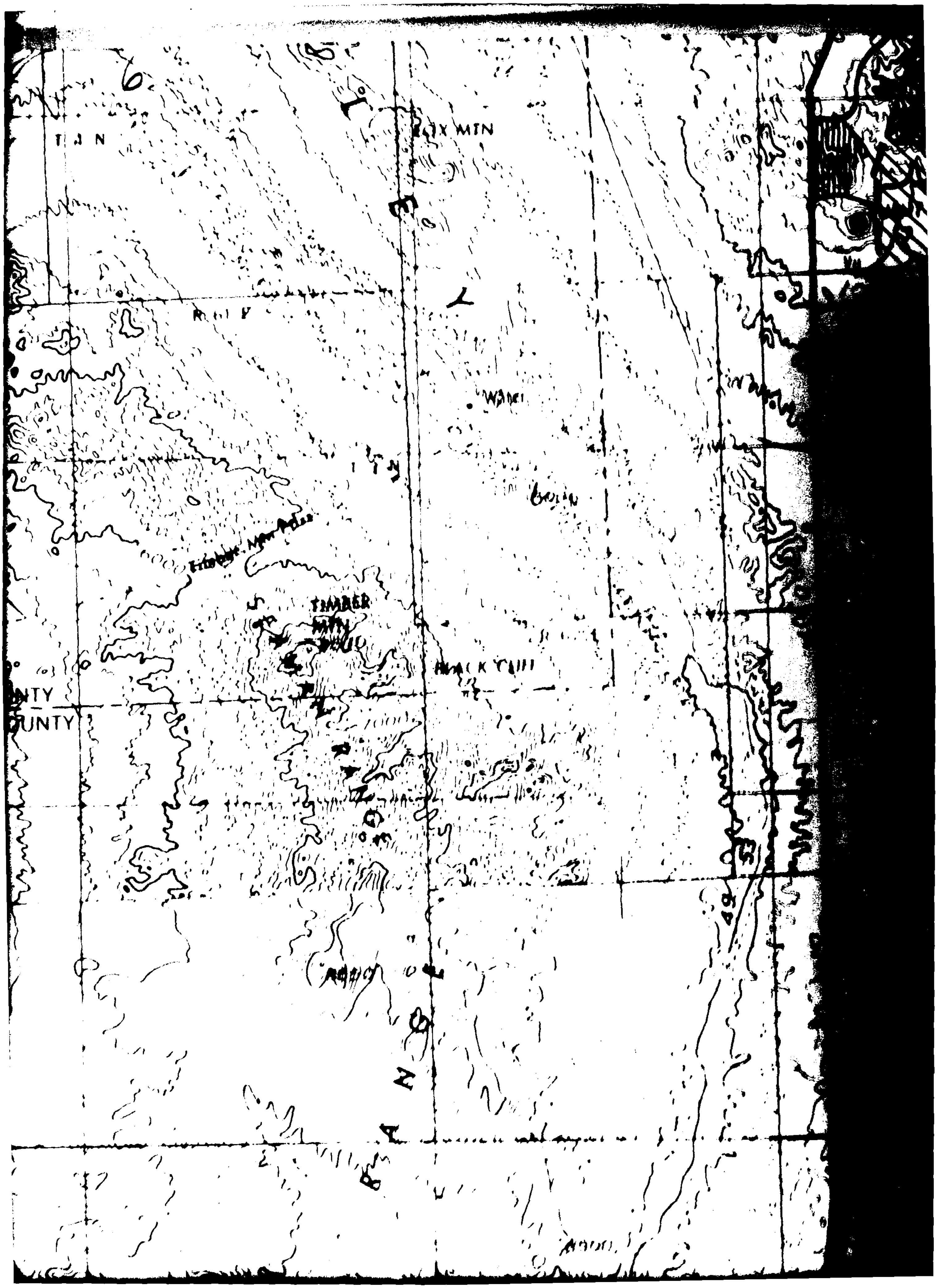


A
K
E
V
A
L
L
6
5
4
2
3
Hulse Mine
Atlanta Mine
6112
6200
ROSENCRA
PKPK
8589
Ranch
TABLE
MTN
Lake Valley
5920
5947
R 66 E
R 67 E
R 68 E
Ranch
Cabin
CEDAR
FLAT
T 5 N
6000
6200
6547
MOUNT WILSON
8000
7000

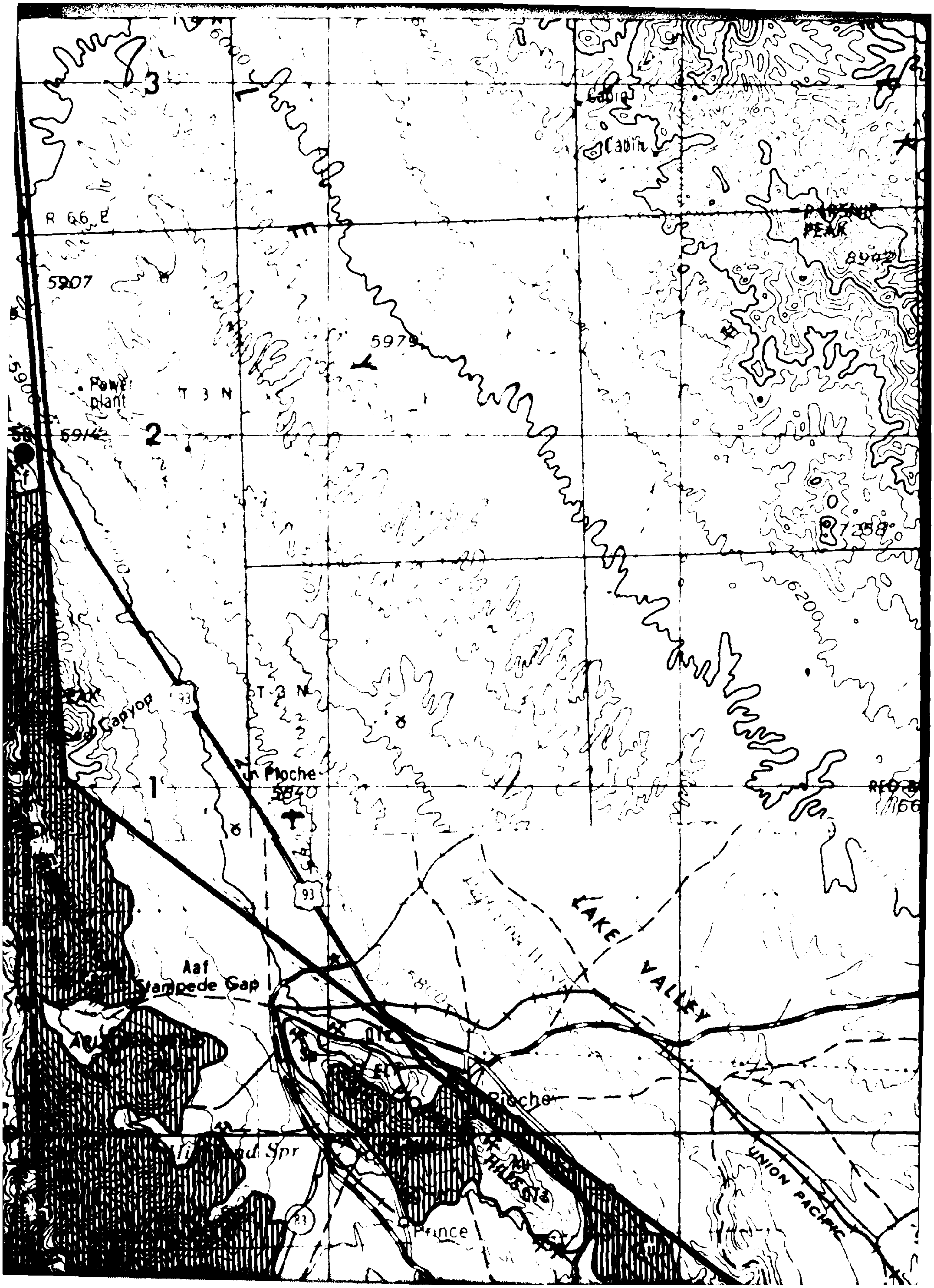
5

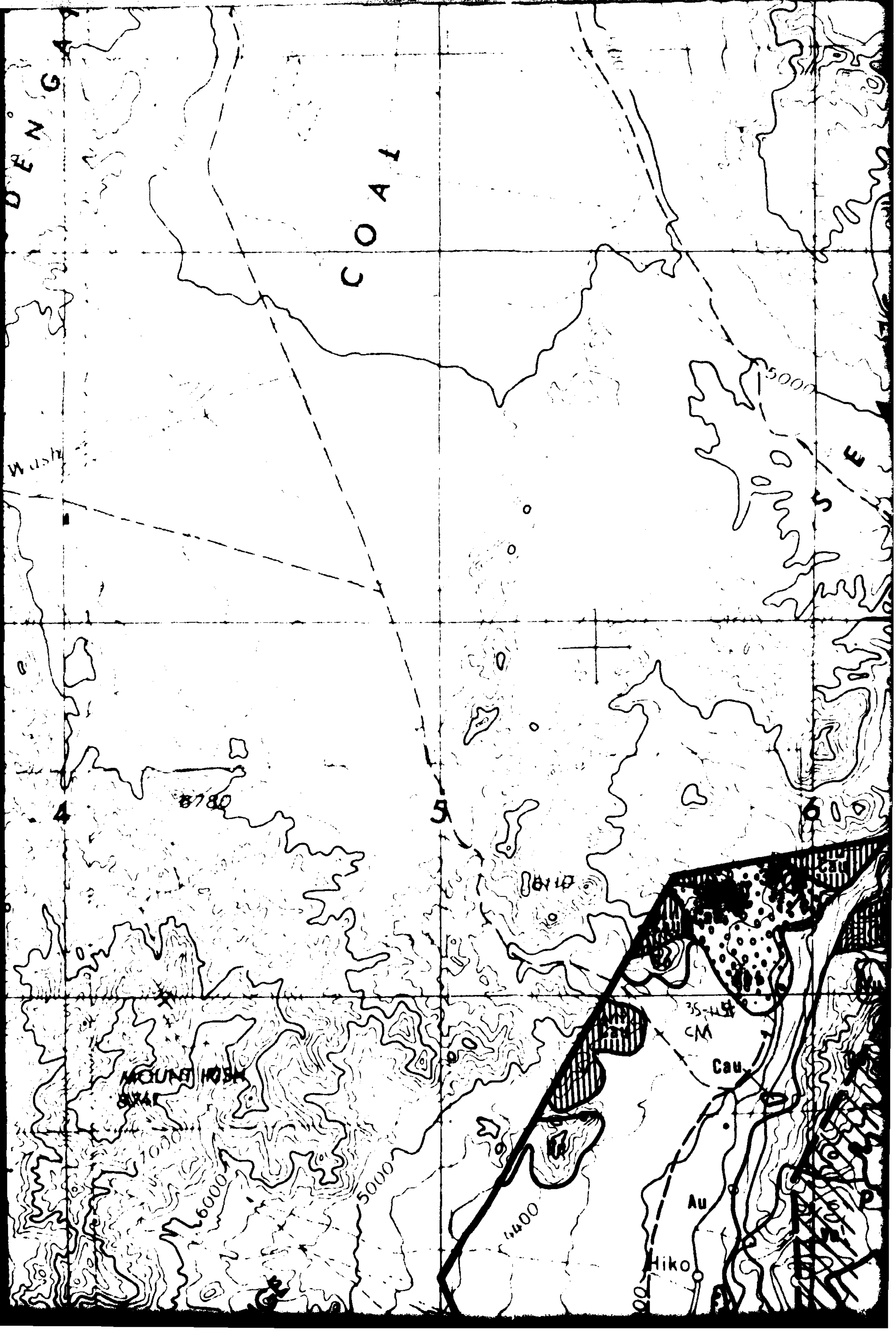


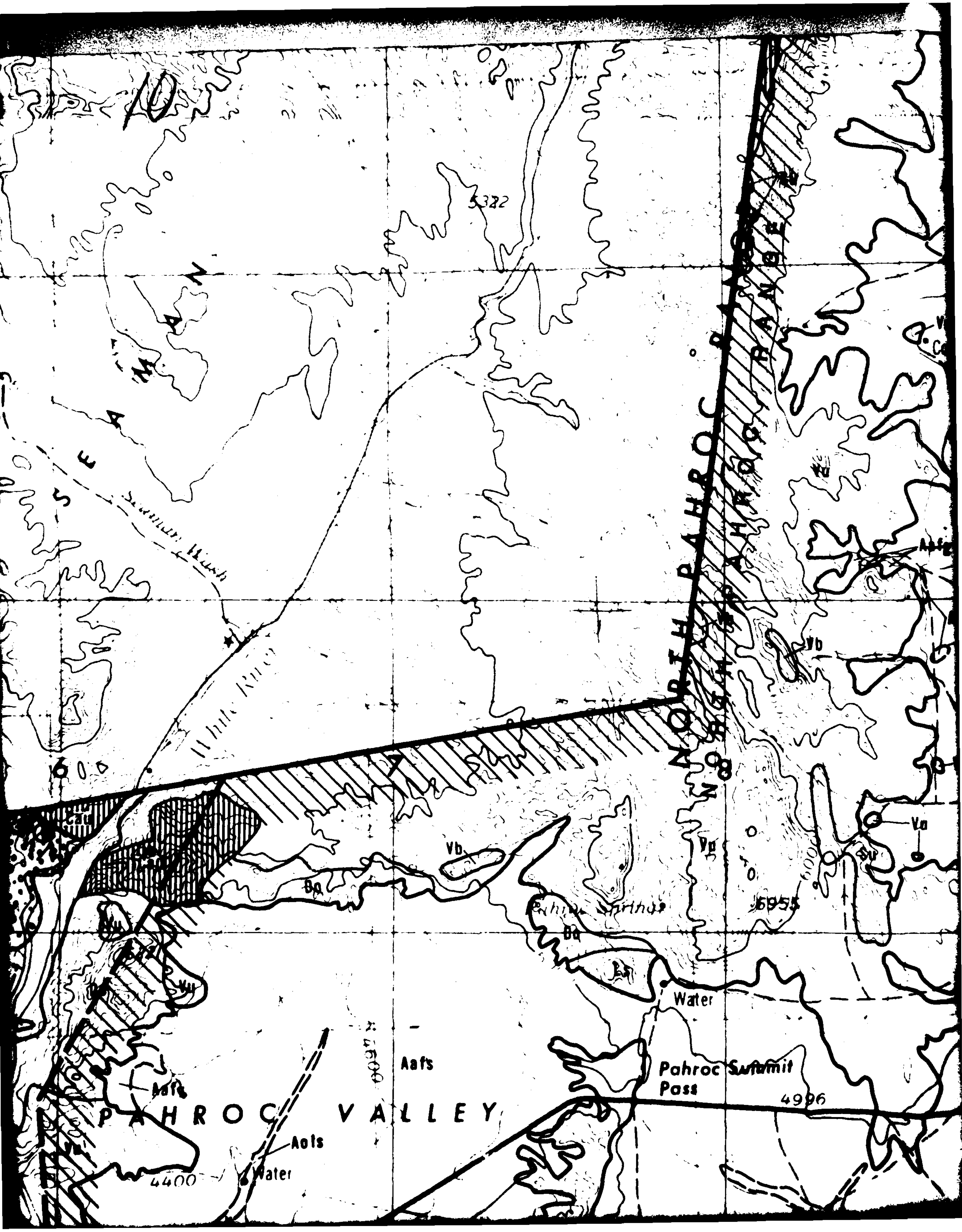
TAN
5300
Water
R
6000
RANGE
5100
5300
6597
7287
GAP
GOLDEN
6000
COAL VALLEY
NYE COUNTY
LINCOLN COUNTY
5100
T 2 N
5000
RANGE
VALLEY
4966
7220
6000

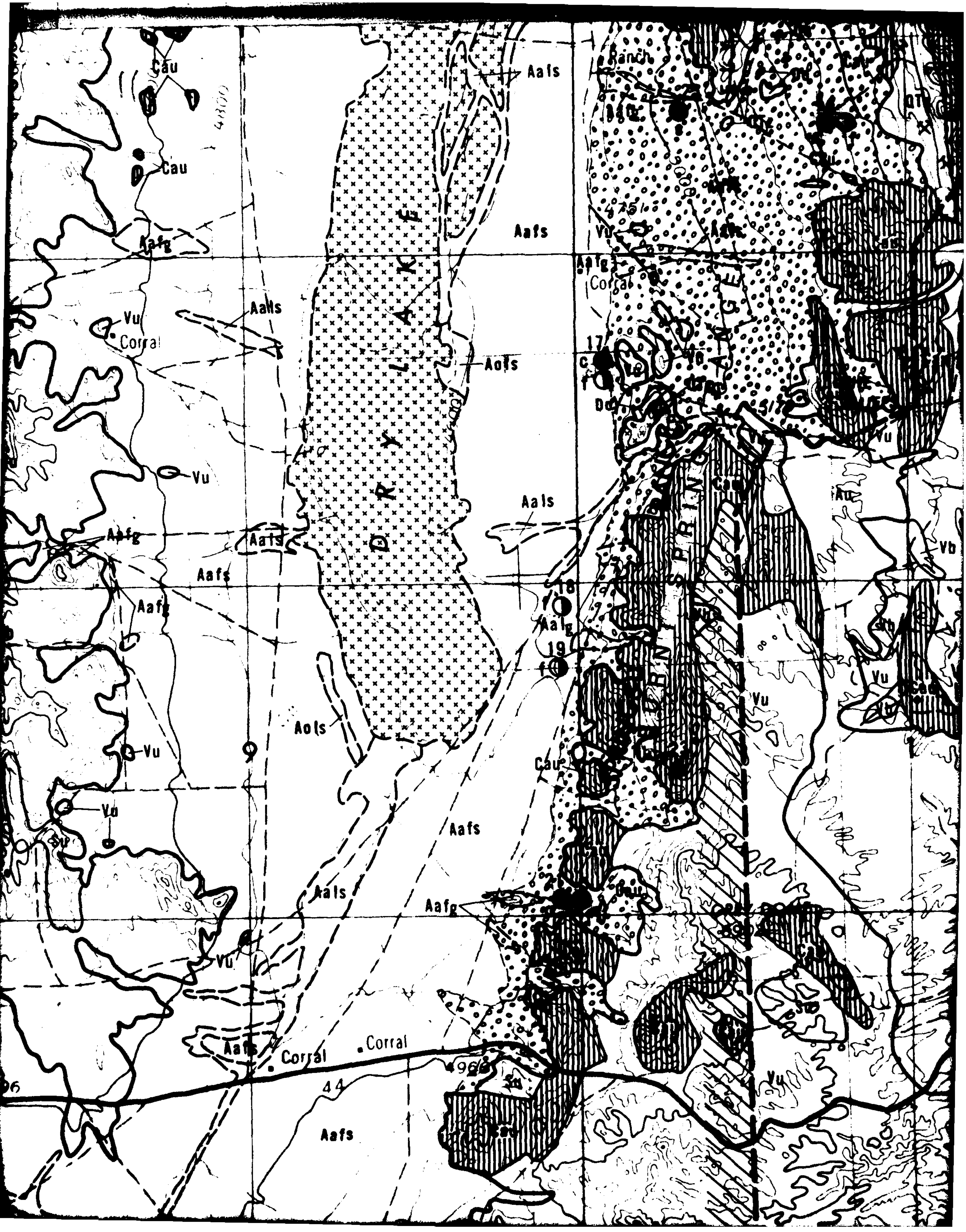

T 1 N
FOX MTN
TIMBER
MTN
BLACK CLIFF
NTY
OUNTY
UNTY
R A N G E

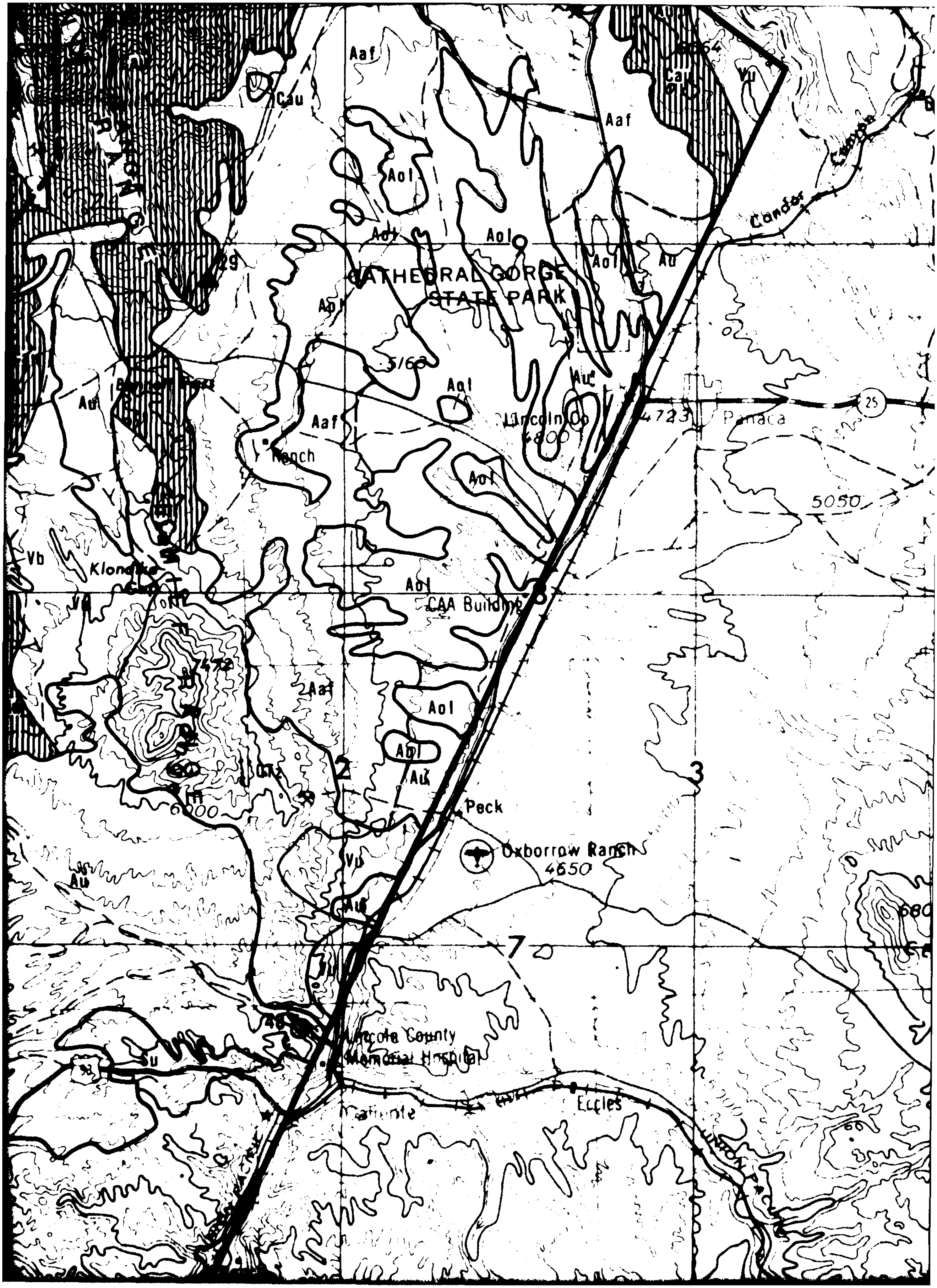
WHITING MESA
FAIRVIEW PEAK
Aafs
Vu
Do
QTz
5250
5400
5500
5000
Su
DRY LAKE VALLEY
Cabin
Bristol
14
58
5907
5914
Aaf
R 66 E
5900
PN
PM
4648
Aols
Water
Vu
Do

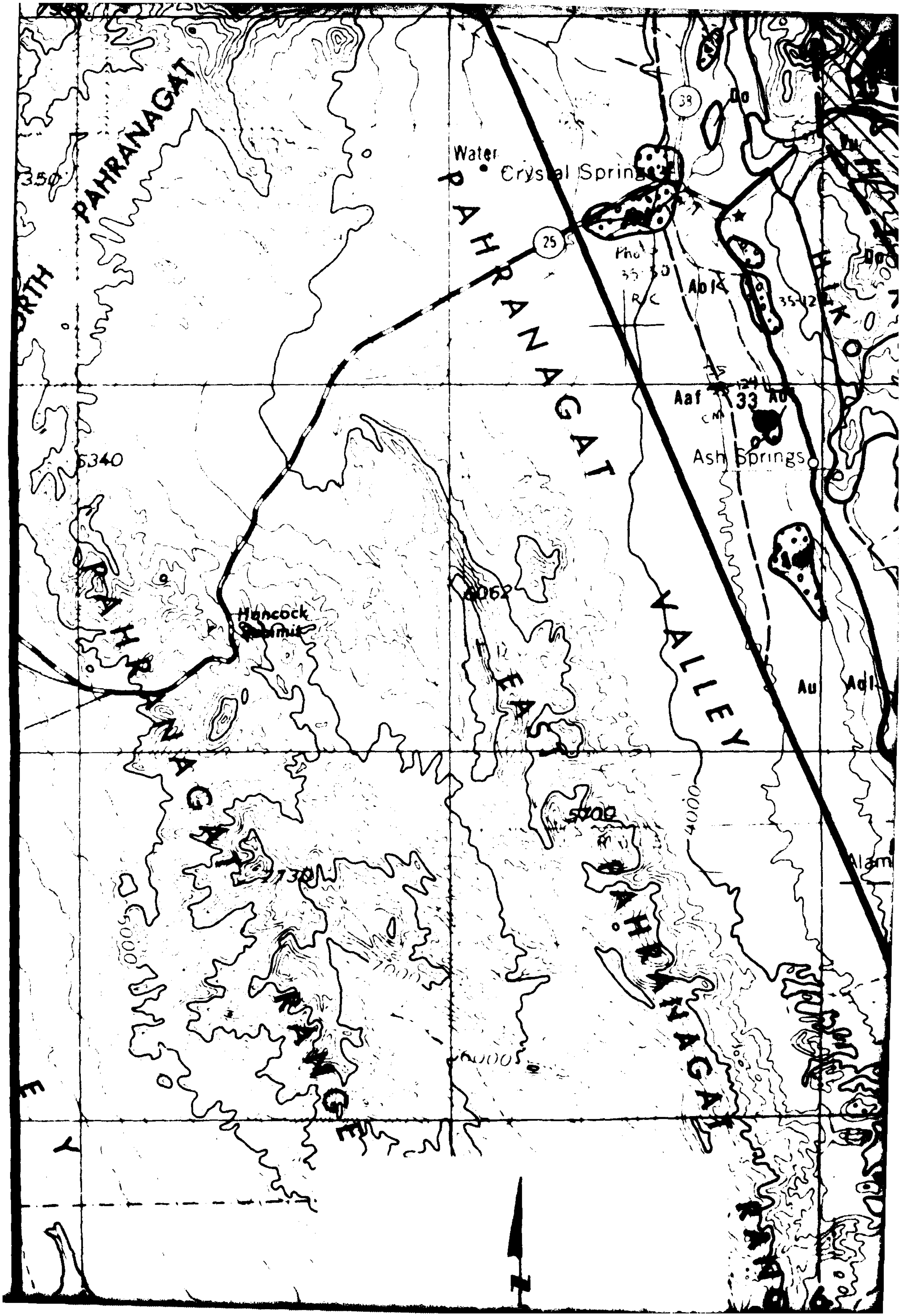

3
Cabin
Cabin
R 66 E
PARSNIP PEAK
8942
5907
5979
Power plant
T 3 N
5914
2
7258
6200
T 3 N
Canyon
93
Pioche
5840
1
93
LAKE VALLEY
Aaf
Stampede Gap
Pioche
UNION PACIFIC
93
Prince

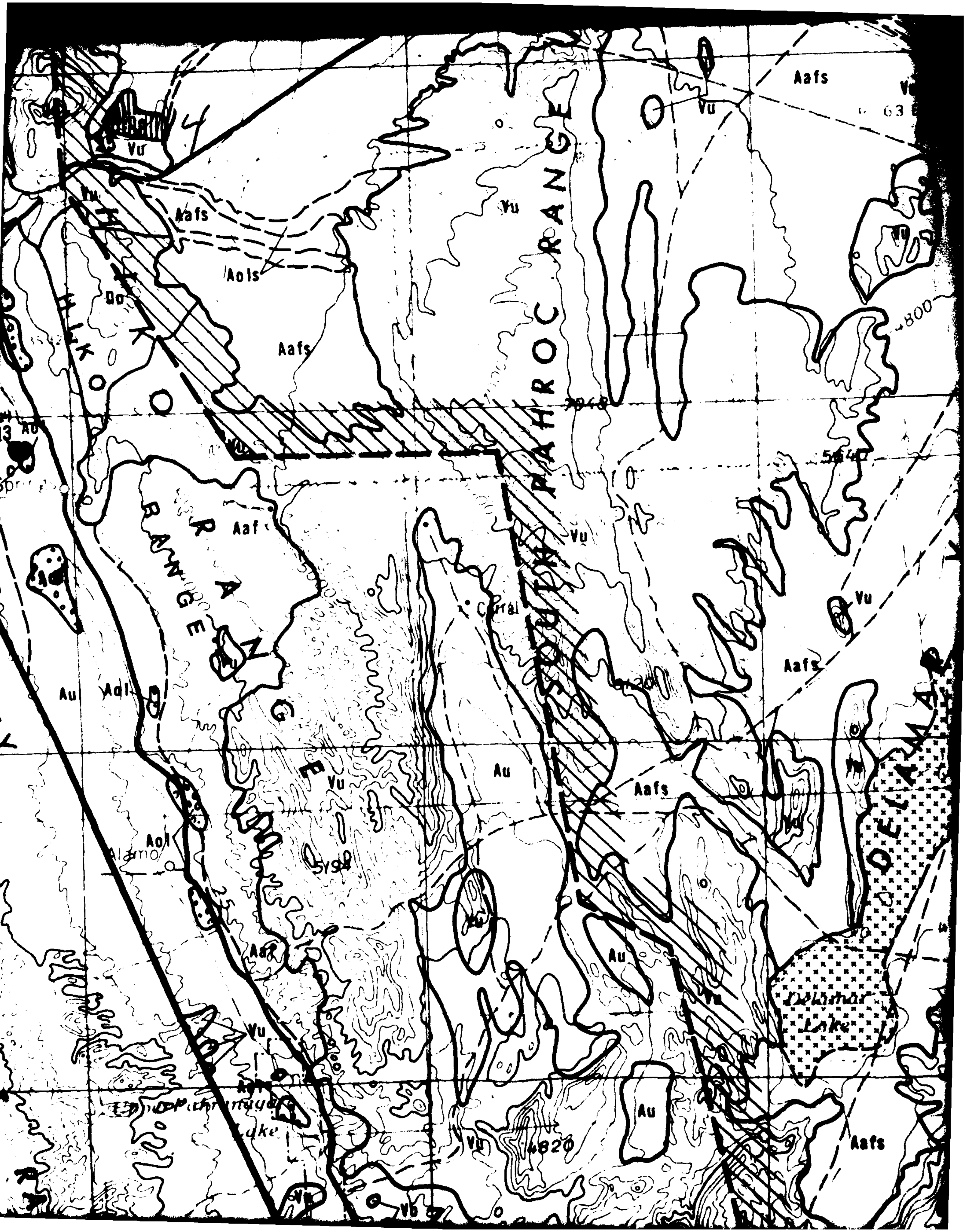

DENGA
COAL
SE
Wash
4
5
6
8780
8410
MOUNT HOSH
8341
7000
6000
5000
5000
6400
Cau
Cau.
CM
35-45
Au
Hiko
P

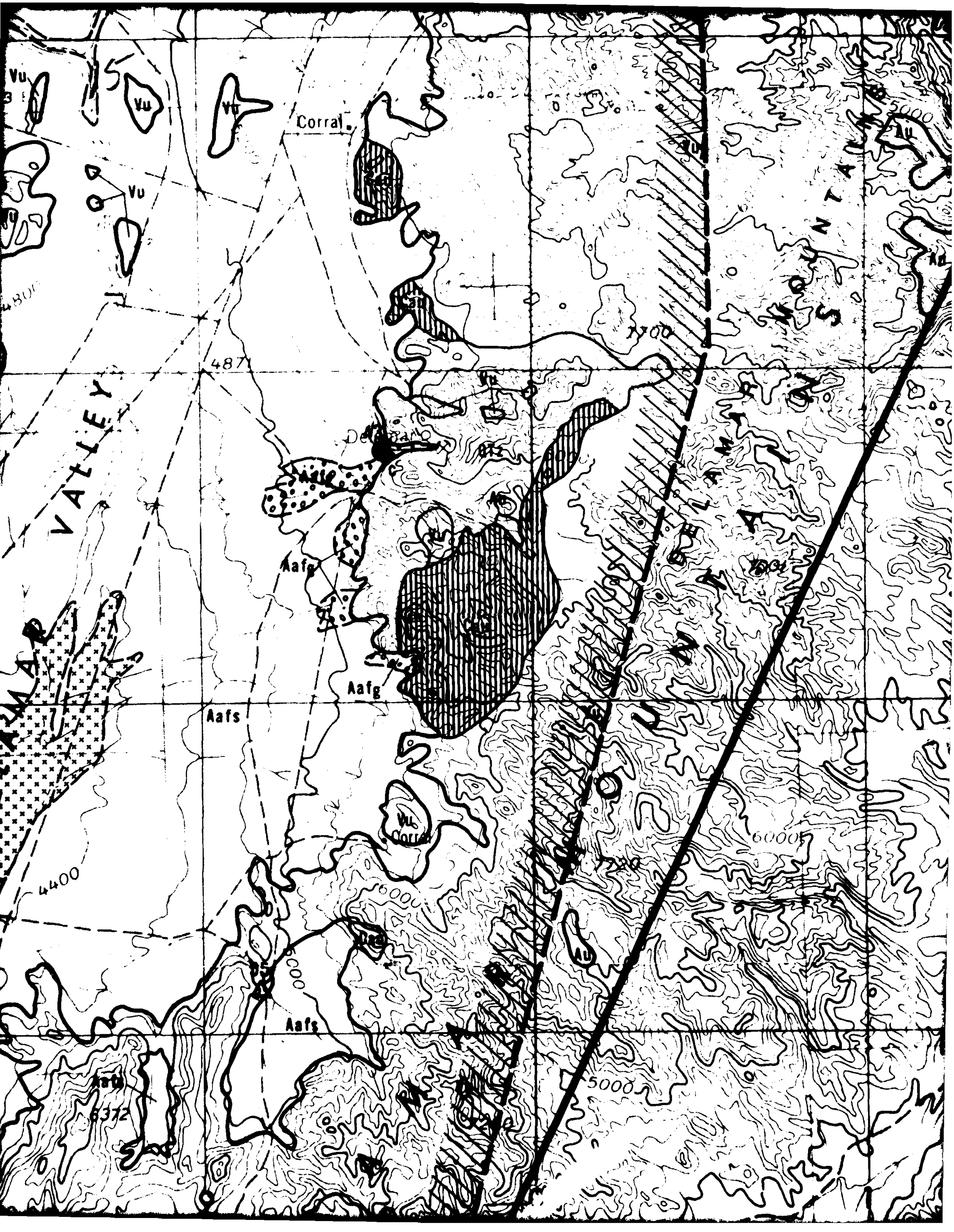

10
SEAMAN
Seaman Wash
5322
White River
NORTH PAHROC RANGE
NORTH PAHROC RANGE
Vu
Vb
Vu
Vb
Cau
Ba
Ba
Vu
Vu
Vu
Pahroc Springs
6955
6000
Vu
Vu
Water
Pahroc Summit Pass
4996
4600
Aafs
Aafs
PAHROC VALLEY
Aols
Water
4400

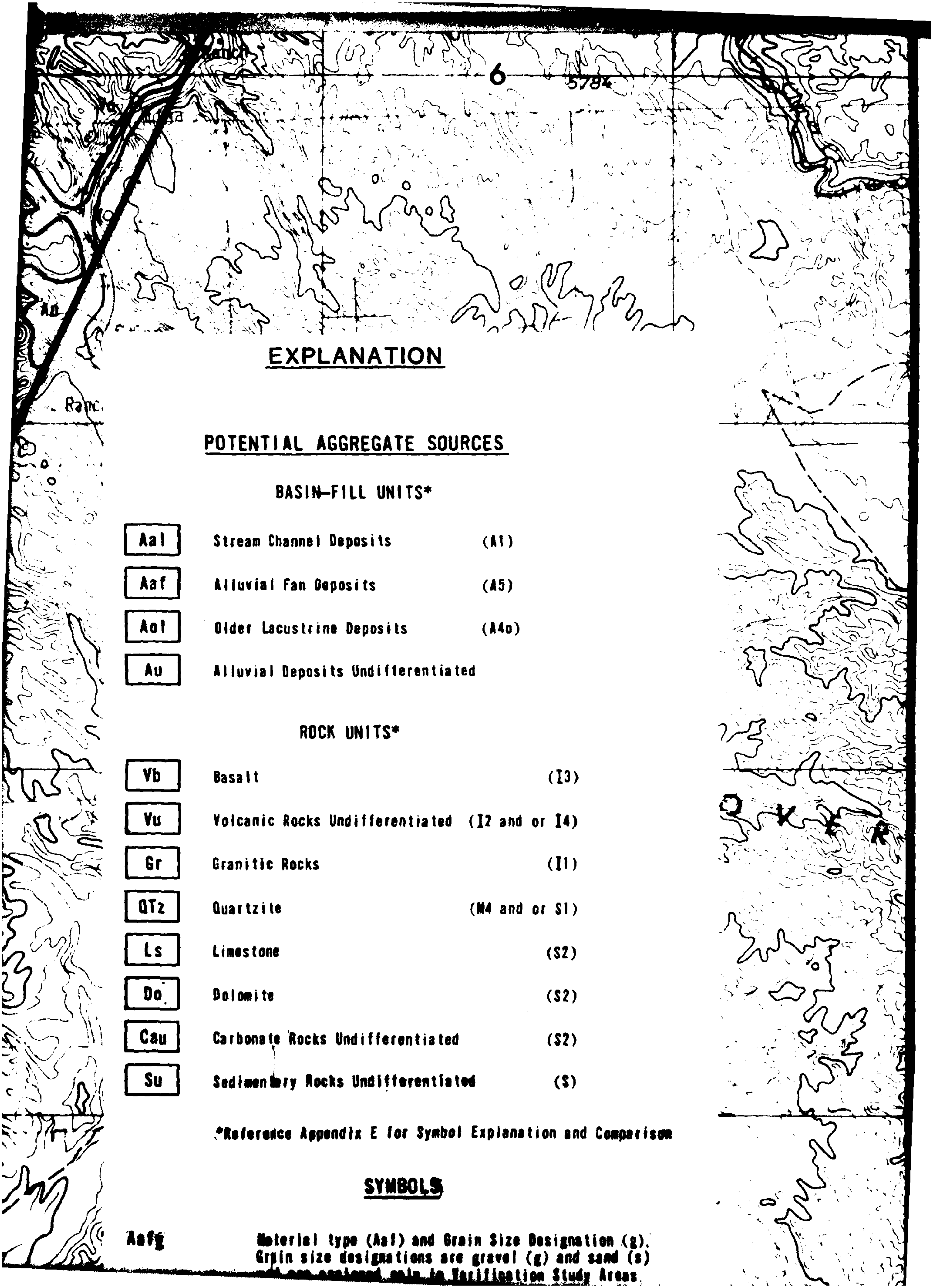

Cau
Cau
4800
Aafg
Aals
Vu
Corral
Vu
Aafg
Aafs
Aafs
Aafg
Vu
Vu
9
Aals
Vu
Aafs
Corral
Corral
96
44
966
Aafs
Aafs
DRY LAKE
Aols
Aols
Aafs
Aals
Ranch
Vu
Aafg
Corral
17
18
19
Aalg
Cau
Aafg
Vu
Vu
Vb
Vu
Vu


Aaf
Cau
Vu
Aol
Au
CATHEDRAL GORGE
STATE PARK
Condor Canyon
29
5/63
25
Panaca
4723
Lincoln Co
4800
Ranch
5050
Vb
Klondike
CAA Building
8
7472
2
3
Peck
Oxborrow Ranch
4650
6000
7
Lincoln County
Memorial Hospital
93
Su
Caliente
Eccles
680


NORTH PAHRANAGAT
350
Water
Crystal Springs
38
25
Do
PAHRANAGAT VALLEY
Pho
Adl
Aaf
33
Au
Ash Springs
HIKO
5340
PAHRANAGAT RANGE
Hancock Summit
6062
EAST
5700
PAHRANAGAT
7730
4000
7000
5000
Alam
Y
N


Aafs
Vu
63
Vu
Aafs
Aols
Do
HIKO
PAHROC RANGE
Aafs
Vu
Vu
4800
13 Au
Spring
Aaf
RANGE
5640
SOUTH PAHROC
Vu
Corral
Vu
Aafs
Au
Adl
Au
Aafs
Vu
DELAMAR
Aol
Alamo
5794
Vu
Au
Vu
Aaf
Delamar Lake
Vu
Upper Pahranagat Lake
Au
Vu
4820
Aafs
Vb
Vb
Y


Vu
Vu
Vu
Vu
Corral
4800
487
VALLEY
AR
Aafg
Aafg
Aafg
Aafs
Aafs
4400
6372
DELAMAR
MOUNTAINS
MOUNTAINS
7700
7700
6000
6000
5000
5000
Au
Au
Au
Au
Corral
Vu



# EXPLANATION

## POTENTIAL AGGREGATE SOURCES

### BASIN-FILL UNITS*

| | | |
|---|---|---|
| Aal | Stream Channel Deposits | (A1) |
| Aaf | Alluvial Fan Deposits | (A5) |
| Aol | Older Lacustrine Deposits | (A4o) |
| Au | Alluvial Deposits Undifferentiated | |

### ROCK UNITS*

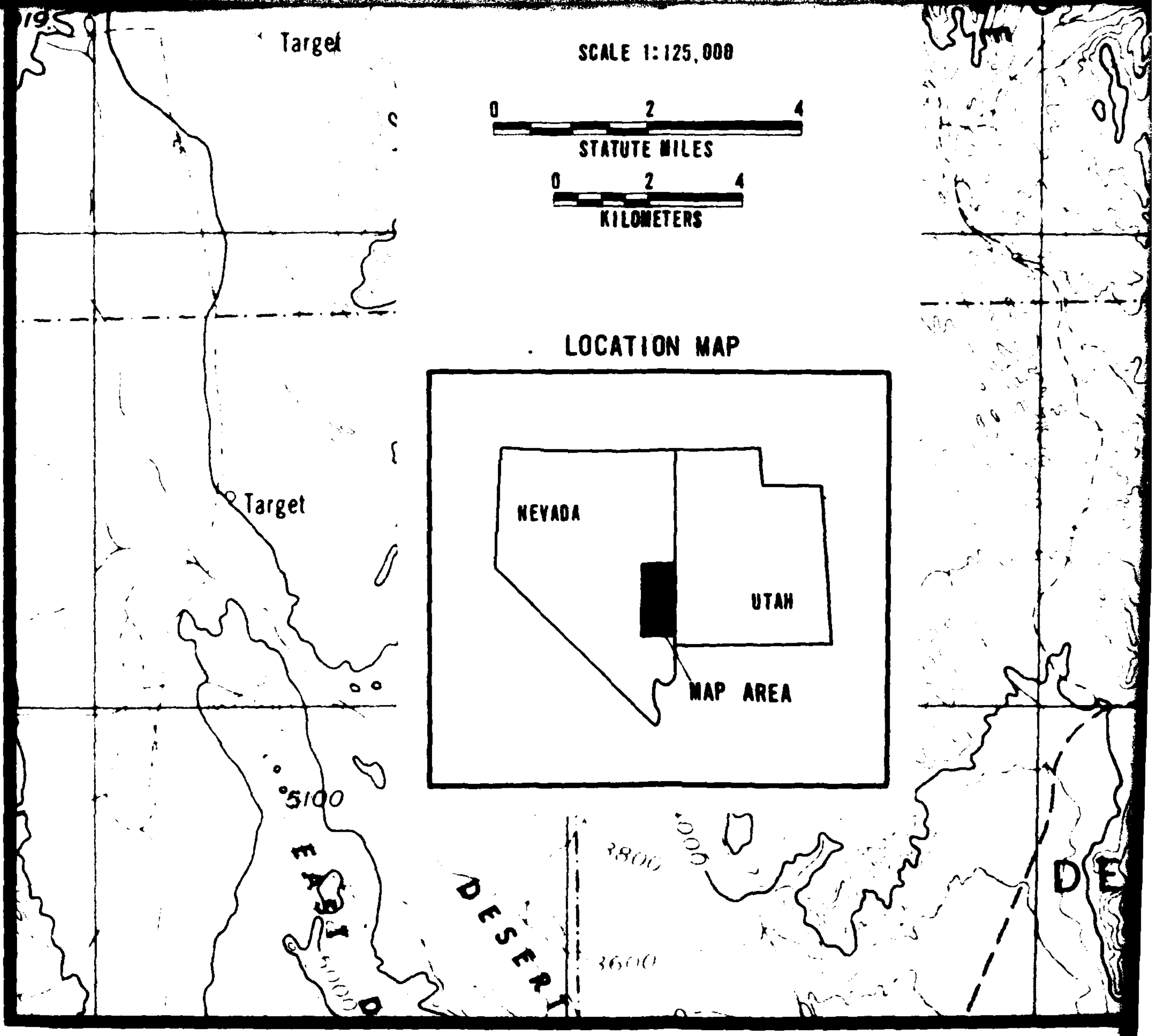
| | | |
|---|---|---|
| Vb | Basalt | (I3) |
| Vu | Volcanic Rocks Undifferentiated | (I2 and or I4) |
| Gr | Granitic Rocks | (I1) |
| QTz | Quartzite | (M4 and or S1) |
| Ls | Limestone | (S2) |
| Do | Dolomite | (S2) |
| Cau | Carbonate Rocks Undifferentiated | (S2) |
| Su | Sedimentary Rocks Undifferentiated | (S) |

*Reference Appendix E for Symbol Explanation and Comparison

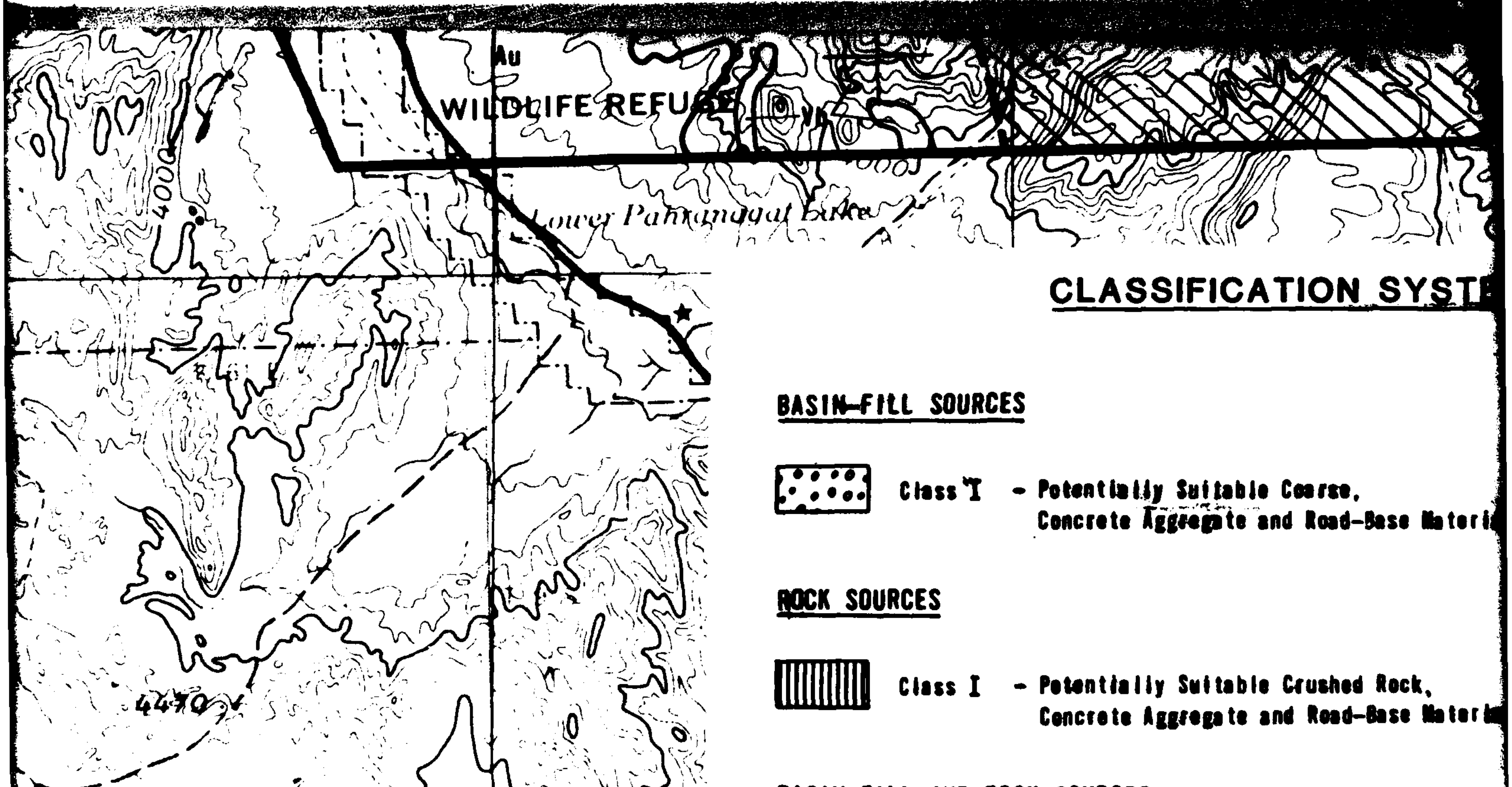
## SYMBOLS

| | |
|---|---|
| Aafg | Material type (Aaf) and Grain Size Designation (g). Grain size designations are gravel (g) and sand (s) and are assigned only in Verification Study Areas. |

17


19
Target
SCALE 1:125,000
0 2 4
STATUTE MILES
0 2 4
KILOMETERS
LOCATION MAP
NEVADA
UTAH
MAP AREA
Target
5100
EAST D
DESERT
3800
3600
DE

6 JUN 80



## CLASSIFICATION SYST

**BASIN-FILL SOURCES**

● Class I - Potentially Suitable Coarse,
Concrete Aggregate and Road-Base Materi

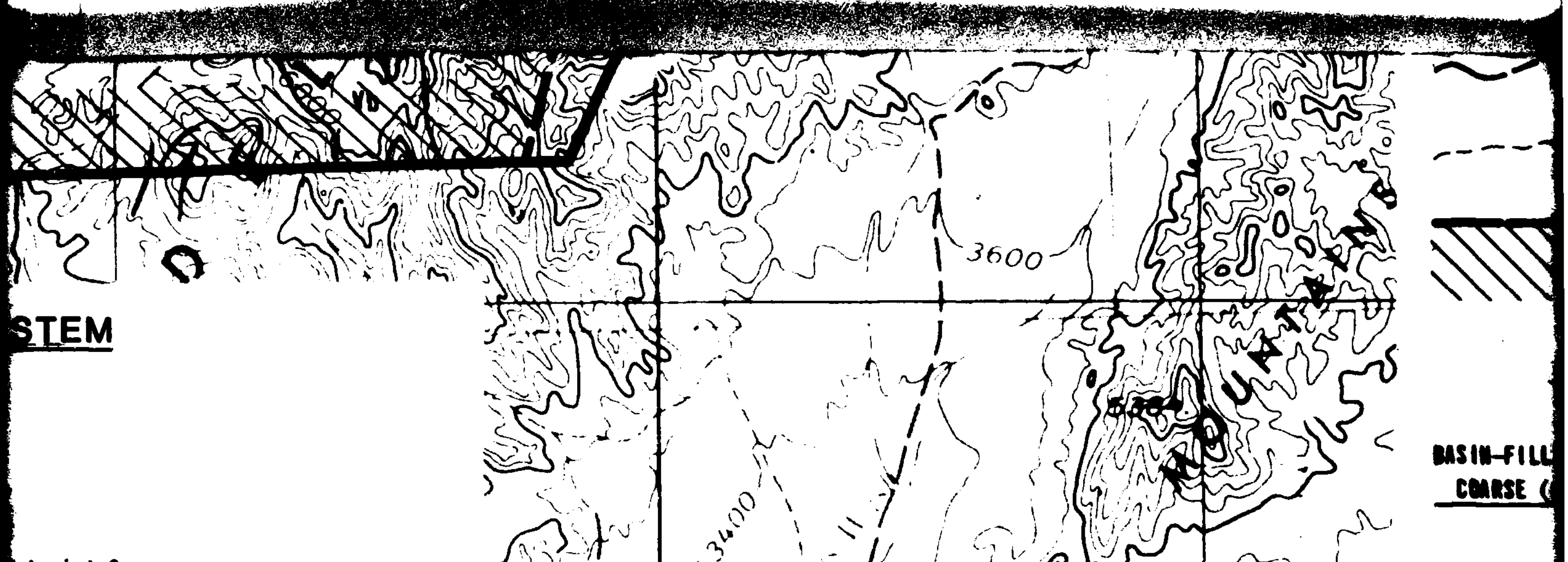
**ROCK SOURCES**

▥ Class I - Potentially Suitable Crushed Rock,
Concrete Aggregate and Road-Base Mater

**BASIN-FILL AND ROCK SOURCES**

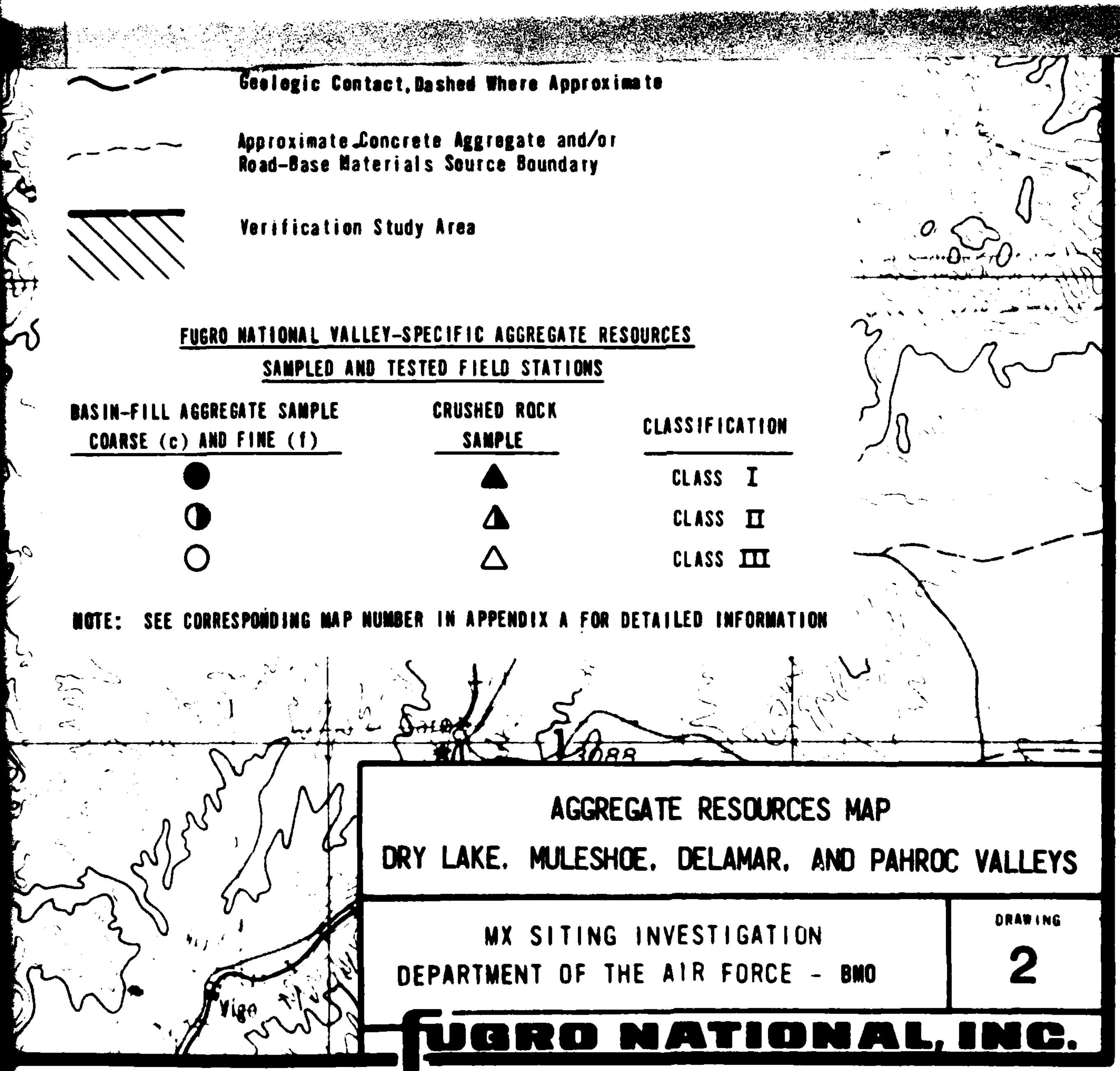
☐ Class II - Possibly Unsuitable Coarse, Fine and/or
Potentially Suitable Road-Base Material

⁙ Class III - Unsuitable Coarse, Fine and/or Crushed
Concrete Aggregate or Road-Base Materia



STEM
terial Source
terials Source
d/or Crushed Rock Concrete Aggregate/
rial Source
hed Rock
terial Source
BASIN-FILL
COARSE (
NOTE: SE
MEADOW
VALLEY
MOUNTAINS
D
3600
3400
4000
3000

20



Geologic Contact, Dashed Where Approximate

Approximate Concrete Aggregate and/or Road-Base Materials Source Boundary

Verification Study Area

**FUGRO NATIONAL VALLEY-SPECIFIC AGGREGATE RESOURCES SAMPLED AND TESTED FIELD STATIONS**

| BASIN-FILL AGGREGATE SAMPLE COARSE (c) AND FINE (f) | CRUSHED ROCK SAMPLE | CLASSIFICATION |
|---|---|---|
| ● | ▲ | CLASS I |
| ◐ | ◭ | CLASS II |
| ○ | △ | CLASS III |

NOTE: SEE CORRESPONDING MAP NUMBER IN APPENDIX A FOR DETAILED INFORMATION

## AGGREGATE RESOURCES MAP
## DRY LAKE, MULESHOE, DELAMAR, AND PAHROC VALLEYS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

DRAWING
2

FUGRO NATIONAL, INC.