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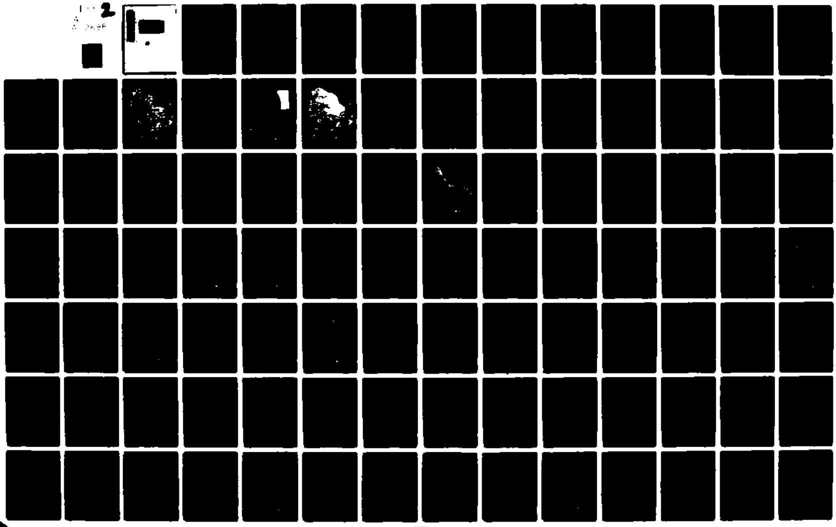

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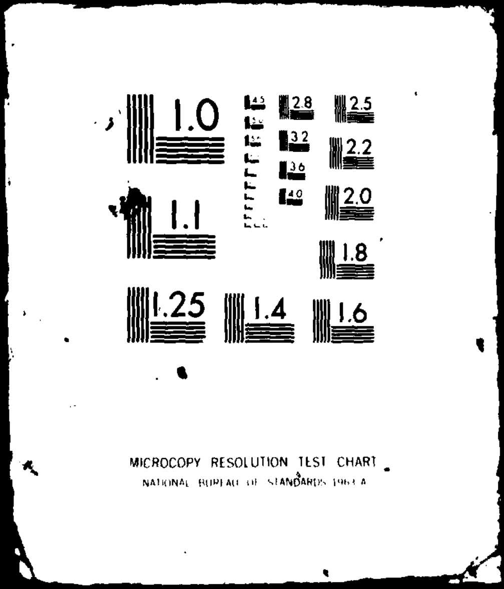

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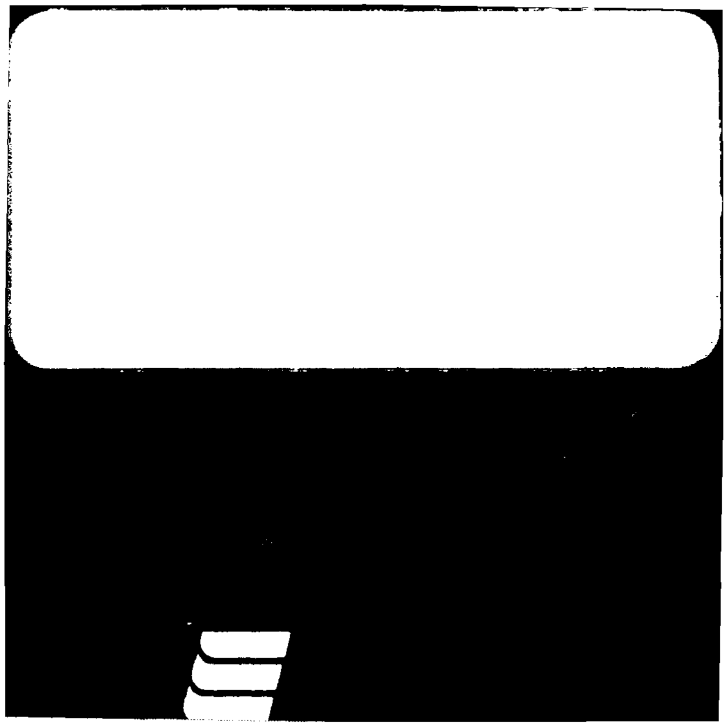

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MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION

DETAILED AGGREGATE RESOURCES STUDY

PAHROC STUDY AREA, NEVADA

Prepared for:

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

Prepared by:

Ertec Western, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

5 June 1981

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Detailed aggregate resources study, Pahroc Area, Nevada. Report contains analysis, evaluation and quantity of aggregate resources found in the Pahroc Valley and the northern portion of Pahranagat Valley. Class RBIa, RBIb and RBII aggregates for Road base, Class CA1, CA2, CB, CC1 and CC2 aggregate for [illegible].

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FOREWORD

This report is one of a series 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. These reports present the results of Detailed Aggregate Resources Studies (DARS) within and adjacent to selected areas in Nevada and Utah that are under consideration for siting the MX missile system.

This volume contains the results of the aggregate resources evaluation for the Pahroc study area. Results of this report are presented as text, appendices, and three drawings. This report has been prepared and submitted on the assumption that the reader is familiar with previous aggregate resources reports.

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EXECUTIVE SUMMARY

This report contains the Detailed Aggregate Resources Study (DARS) evaluation for the Pahroc study area. It is the fourth in a series of reports that contain detailed aggregate information on the location and quality of basin-fill and rock sources of road-base and concrete aggregates. Field reconnaissance, laboratory testing, and existing data from other Ertec Western, Inc. (formerly Fugro National, Inc.) investigations and the Nevada Department of Highways provide the basis for the findings presented in this report.

ROAD-BASE AGGREGATES

Potential road-base aggregate sources were classified as follows:

Class RBIa -	Basin-fill or rock sources containing materials suitable for use as road-base aggregates; based on acceptable laboratory aggregate test results.
Class RBIb -	Basin-fill sources containing materials suitable for use as road-base aggregates; based on correlation with Class RBIa source areas.
Class RBII -	Potential basin-fill sources of materials suitable for use as road-base aggregates; based on photogeologic interpretations, field observations, and limited or inconclusive sieve analysis and/or abrasion data.

Assignment of an aggregate source to one of the above three classes was determined from laboratory test results (gradation, abrasion and, to a lesser extent, soundness) and geomorphological and compositional correlations.

Results of this evaluation are presented on a 1:62,500 scale aggregate resources map (Drawing 2) and are summarized as follows:

Class RBIa Sources:	Four basin-fill sources consisting of good- to high-quality aggregates acceptable for use as road-base construction materials have been located in western Pahroc and northern Pahranagat valleys. All are alluvial fan deposits (Aaf). One crushed-rock source which yielded good- to high-quality aggregates acceptable for use as road-base construction materials has been delineated within the study area. This source is a fairly limited outcrop of calcareous sandstone classified as dolomite rock (Do).
Class RBIb Sources:	Four basin-fill sources within the study area are defined as potential sources of good- to high-quality road-base aggregates. Geomorphological and compositional similarities were used to correlate these units to tested RBIa deposits. Deposits are all alluvial fans and are confined to western Pahroc and northern Pahranagat valleys.
Class RBII Sources:	Several potential basin-fill aggregate sources are located throughout the study area. All of these sources are alluvial fans that have been classified on the basis of limited field and laboratory data.

CONCRETE AGGREGATES

A classification system consisting of five classes was developed for the concrete aggregates evaluation to present potential basin-fill and crushed-rock sources. Although most rock sources will supply coarse concrete aggregates, their delineation was not an objective of this study. Assignment of an aggregate source to one of the five classes was determined from laboratory test results (trial concrete mixes and gradation, abrasion, and soundness of aggregates) and geomorphological and compositional correlations. The emphasis of this study was the evaluation of the concrete-making properties (especially 28-day compressive strengths) of potential aggregates when used in trial concrete mixes.

Class CA1	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths equal to or greater than 6500 psi.
Class CA2	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths less than 6500 psi.
Class CB	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on acceptable laboratory aggregate test results.
Class CC1	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CA1 and CA2 source areas.
Class CC2	Basin-fill sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CB source areas.

The following three trial mixes were used to obtain a range of compressive strength values; however, only Mix 3 results were used to classify sources. In all three trial mixes, fly ash, as a pozzolan, replaced 20 percent of the cement by weight.

- Mix 1 - 7.5 sacks of cement per cubic yard of concrete and 1.5-inches maximum aggregate size;
- Mix 2 - 8.5 sacks of cement per cubic yard of concrete and 1.5-inches maximum aggregate size; and
- Mix 3 - 8.5 sacks of cement per cubic yard of concrete, 0.75-inch maximum aggregate size, and a superplasticizer.

Results of this evaluation are presented on a 1:62,500 scale aggregate resources map (Drawing 3) and summarized as follows:

Class CA1	One basin-fill source in the area contained aggregates that, when used in Mix 3, produced 28-day compressive strengths greater than 6500 psi. This source is an alluvial fan (Aaf) located in northern Pahranagat Valley. High-quality, fine aggregate sources are lacking or of limited extent within the study area.
Class CB Sources:	Three basin-fill sources consisting of good- to high-quality aggregates, potentially acceptable for use as concrete construction materials, were delineated in western Pahroc and northern Pahranagat valleys. All are alluvial fan deposits. The quality of fine aggregates tested within this class ranges from poor to satisfactory.
Class CC1 Sources:	One alluvial fan in the study area is classified as a potential source of concrete aggregates. It is correlated to the Class CA1 source based on geomorphological and compositional similarities.
Class CC2 Sources:	Four alluvial units located along the western side of Pahroc Valley are potential sources of aggregates suitable for use in concrete. They are correlated to Class CB units on the basis of geomorphological and compositional similarities.

CONCLUSIONS

Sufficient quantities of coarse and fine aggregates suitable for use as road-base and/or concrete construction material are available in the Pahroc study area. Laboratory test results indicate that the quality of the coarse aggregates ranges from good to excellent, and the quality of the fine aggregates ranges from poor to satisfactory. Most of the aggregate sources are confined to the west side of Pahroc Valley and the northern end of Pahranagat Valley.

RECOMMENDATIONS

Additional aggregate field investigations and laboratory testing will be required to further refine the physical and chemical characteristics of road-base and concrete aggregate sources as borrow areas prior to the initiation of construction.

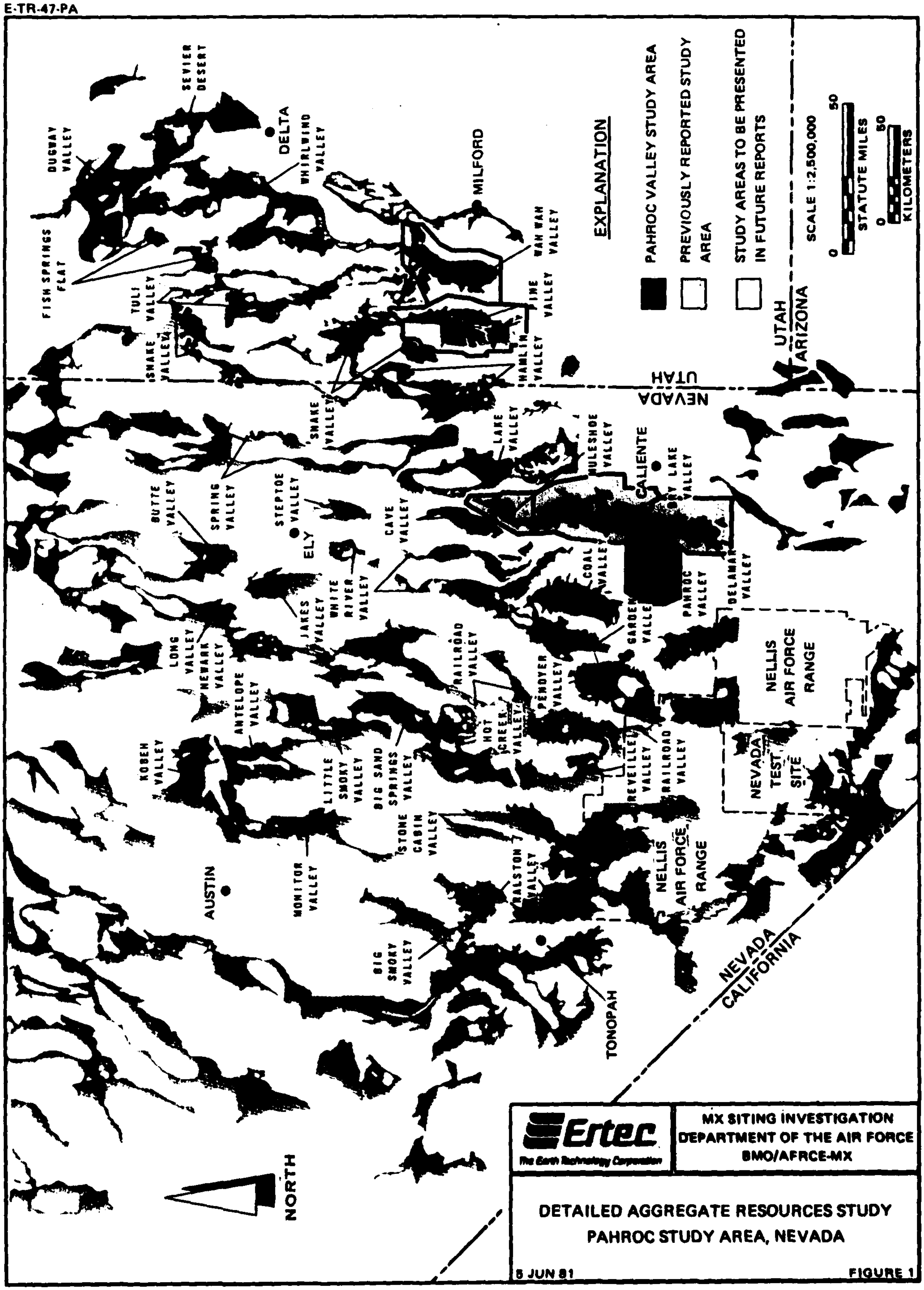
1.0 INTRODUCTION

1.1 STUDY AREA

This report presents the results of the Detailed Aggregate Resources Study (DARS) for the Pahroc study area (Figure 1). The Pahroc study area is located in south-central Lincoln County, Nevada, and includes Pahroc Valley and the extreme northern part of Pahranagat Valley. Pahroc Valley is bounded on the east by the North and South Pahroc ranges and on the west by the Hiko Range. Northern Pahranagat Valley is bounded on the east by the Hiko Range and on the west by the North Pahranagat and Seaman ranges. U.S. Highway 93 passes east-west through the study area, and State Highway 38 passes north-south through Pahranagat Valley. A network of graded roads and four-wheel-drive trails provide additional access to most of the study area. Pahroc and Pahranagat valleys are mainly undeveloped desert rangeland administered by the Bureau of Land Management (BLM). Pahranagat Valley contains some private land along its central axis. The nearest support community is Ash Springs, located approximately 5 miles (8 km) south of the intersection of U.S. Highway 93 and State Highway 38.

1.2 BACKGROUND

Aggregate resources studies for the MX program were introduced in 1977 with the investigation of Department of Defense (DoD) and BLM lands in California, Nevada, Arizona, New Mexico, and Texas (FN-TR-20D). Refinement of the MX siting area added portions of Utah and Nevada that were not evaluated in this



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DETAILED AGGREGATE RESOURCES STUDY
PAHROC STUDY AREA, NEVADA

5 JUN 81

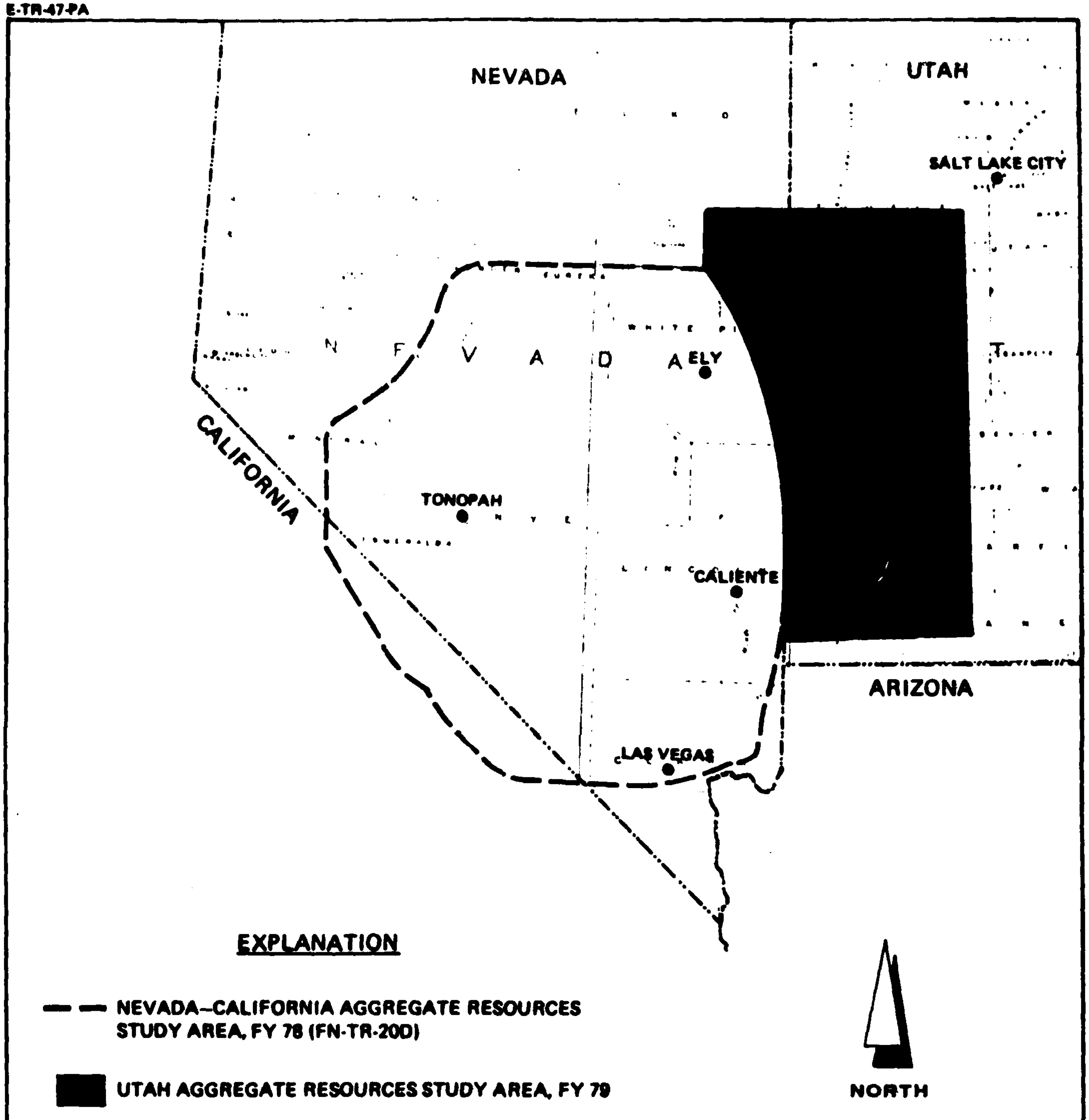
FIGURE 1

initial Aggregate Resources Evaluation Investigation (AREI). This additional area, defined as the Utah-Nevada aggregate resources study area, was examined in the fall of 1979, and a second regional aggregate resources report was submitted on 3 March 1980 (Figure 2).

Both regional aggregate investigations consisted of the compilation and evaluation of existing data with limited field reconnaissance, sample collection, and laboratory aggregate testing. Only general information on the location, quality, and quantity of aggregates was provided.

Subsequent to the regional studies, Valley-Specific Aggregate Resources Studies (VSARS) were started in FY 79. The primary objective of these continuing studies is to provide additional information on potential aggregate sources in specified valleys and in the areas immediately surrounding them. Existing exposures of potential basin-fill and rock aggregate sources are sampled and subjected to a suite of laboratory tests. Results of these tests are used to classify coarse and fine basin-fill and crushed-rock aggregates for suitability as concrete and road-base construction materials.

The aggregate sources presented in the VSARS are to be used as a guide for preliminary construction planning and the selection of areas for more detailed-aggregate evaluations. To date, field investigations have been completed for 16 valley areas with final reports submitted for 11 valley areas (Figure 3).



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UTAH–NEVADA REGIONAL
AGGREGATE STUDIES

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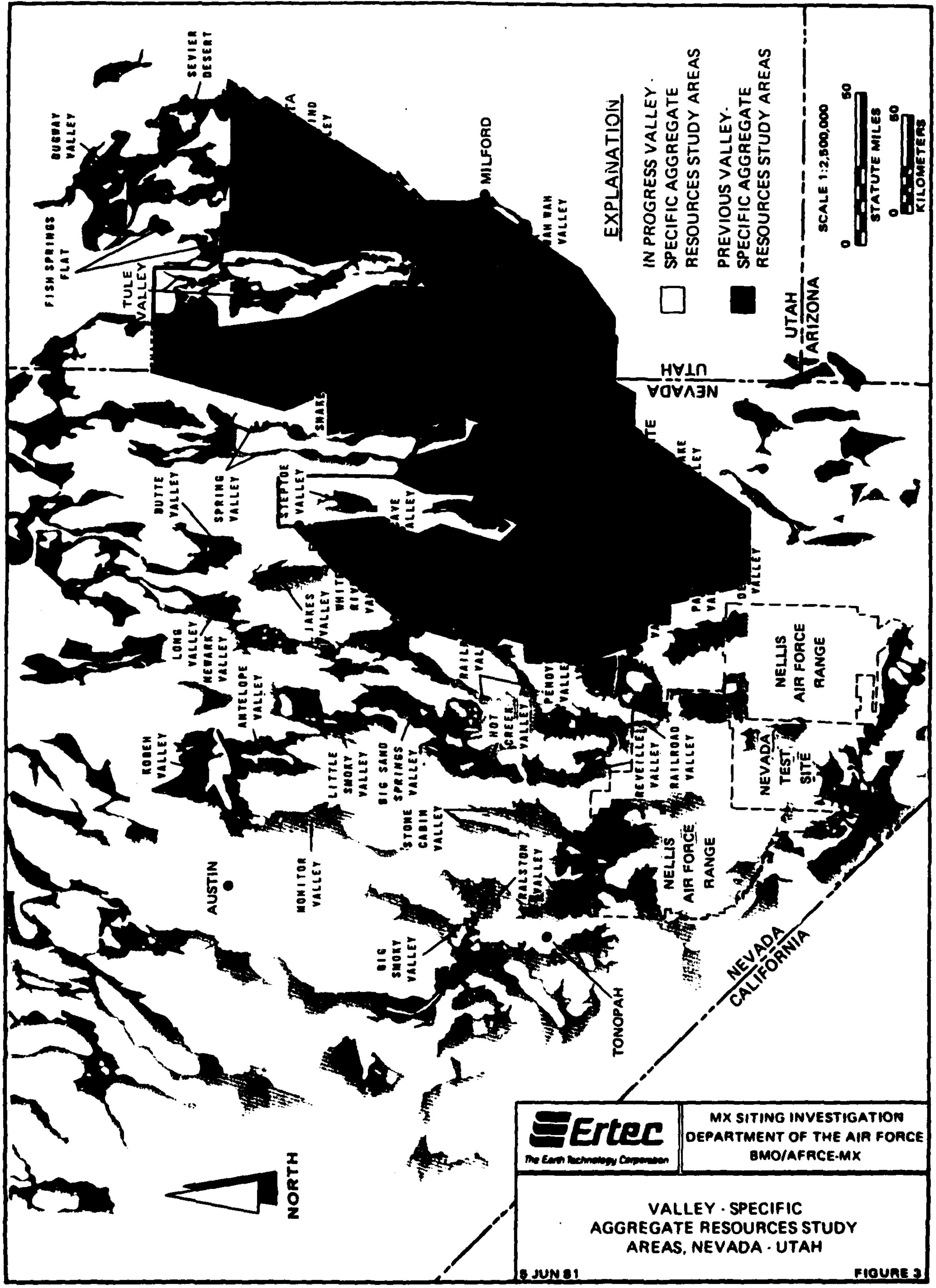
FIGURE 2



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VALLEY - SPECIFIC
AGGREGATE RESOURCES STUDY
AREAS, NEVADA - UTAH

5 JUN 81

FIGURE 3

Field investigations for remaining valleys in the designated deployment area are planned in FY 81 and FY 82.

The DARS were initiated in FY 81 to further analyze and refine potential sources of coarse and fine basin-fill and crushed-rock aggregates identified during the VSARS. These studies consist of both road-base (Section 3.0) and concrete (Section 4.0) aggregate evaluations. The major consideration was to further evaluate basin-fill deposits as potential sources of road-base and concrete aggregates. Limited new data were developed on crushed-rock sources.

1.3 OBJECTIVES

The objectives of the Detailed Aggregate Resources Study are as follows:

Road-Base Aggregates Evaluation

- Refine potential basin-fill and rock sources (initially identified in VSARS) for road-base aggregates; and
- Provide additional laboratory test data on the general quality of basin-fill aggregates for use as road-base material.

Concrete Aggregates Evaluation

- Refine the areal extent of the most acceptable VSARS basin-fill and rock concrete aggregate sources; and
- Provide additional laboratory testing information on the quality and the concrete-making properties of potential coarse and fine basin-fill and crushed-rock aggregates.

1.4 SCOPE

The scope of the two evaluations required office and field studies and included the following:

a. Compilation and analysis of appropriate existing data on the quality and quantity of potential road-base and concrete aggregates. Major sources of data were other Ertec investigations for the siting of the MX system and the Nevada Department of Highways.

b. Initial and final basin-fill deposit differentiation based on geomorphology, grain size, lithology, and aerial photography and topographic map interpretation. Initial and final rock unit divisions based on evaluations of aerial photography and published geologic maps.

c. Staking and permitting on selected BLM lands. Appropriate basin-fill trench locations for samples of road-base and concrete aggregates were determined from items a and b and a brief field reconnaissance.

d. Backhoe excavation of staked and permitted basin-fill locations, sampling when gravel percentage exceeded 30 percent, or when suitable fine aggregates for concrete mixes were present. Selection and sampling of acceptable crushed-rock sources of coarse aggregates for concrete mixes.

e. Valley-wide field reconnaissance utilizing aerial photography and petrographic and grain-size analyses to determine lateral extent and acceptability of basin-fill deposits.

f. Laboratory tests to supplement available existing data for the determination of the suitability of specific basin-fill and rock units as sources of road-base or concrete aggregates. Trial (check) concrete mixes were made to evaluate the basic concrete-making properties of selected concrete aggregate sources as well as engineering properties of hardened concrete.

g. Development and application of road-base and concrete materials classification systems that textually and graphically depict the locations of the most suitable aggregate sources in the study area. The depiction and discussion of areas that are unsuitable or have a low probability for use were not done.

2.0 GEOLOGIC SETTING

2.1 PHYSIOGRAPHY

The Pahroc study area lies within the Basin and Range Physiographic Province. The primary physiographic features of the area are the uplifted mountain ranges and the down-dropped, alluvium-filled basins. These north to north-northeast trending features are controlled by block-faulting and are typical of the Basin and Range province. Elevations of the valley floor in Pahroc Valley range from approximately 4100 to 5000 feet (1250 to 1524 m) and in Pahranagat Valley from 3900 to 4400 feet (1189 to 1341 m).

Mountain ranges flanking Pahroc Valley include the North and South Pahroc ranges and the Hiko Range and in Pahranagat Valley, the Hiko, North Pahrangat, and Seaman ranges. The Pahroc study area adjoins Delamar and Dry Lake valleys to the east. Topographic relief between mountain crests and basin floors varies from 3550 feet (1882 m) in Pahroc Valley to 2300 feet (701 m) in Pahrangat Valley. Both valleys within the study area have open drainage systems.

2.2 LOCATION AND DESCRIPTION OF GEOLOGIC UNITS

Paleozoic and Cenozoic rocks are found predominantly in the mountains within the study area and only infrequently as outliers within the valley fill. The Paleozoic rocks consist of limestone, dolomite, and quartzite with interbedded sandstone and shale. These units are generally exposed along the northern margins of and between the study area valleys; where they are not exposed, they underlie younger geologic units. Cenozoic rocks unconformably overlie Paleozoic rocks and generally consist of undifferentiated volcanic and intravolcanic sedimentary deposits. Unconsolidated Cenozoic deposits lie unconformably above all older units and consist primarily of alluvial, lacustrine, and stream-channel and terrace deposits.

Specific Paleozoic and Cenozoic geologic units have been grouped into two rock and one basin-fill categories for use in discussing potential sources of aggregates. The grouping of the units was based on similarities in physical and chemical characteristics and map-scale limitations. The resulting categories simplify discussion and presentation without altering the conclusions of the study.

2.2.1 Rock Units

Dolomite rocks (Do) and carbonate rocks undifferentiated (Cau) are the primary potential sources of crushed-rock aggregates in the study area valleys. While all other rock units may locally supply aggregates, insufficient test data prohibit their consideration as major aggregate sources, and they will not be discussed in this report.

Materials classified as dolomite (Do) include the limited occurrence of an intraformational calcareous sandstone at the top of the Middle Devonian Simonson Dolomite. It crops out in Pahroc Valley on the east side of the Hiko Range. This rock is typically hard, medium-grained, and slightly weathered with well-developed jointing.

Materials classified as undifferentiated carbonate rocks (Cau) include thick, complex sequences of limestone and dolomite with occasional interbeds of sandstone or quartzite and intraformational conglomerate. The formation in this unit is the Upper Devonian Guilmette Formation. It crops out in the North Pahranagat Range and to a limited extent in the Hiko Range. These rocks are typically light- to dark-grey in color, thin- to very thick-bedded, durable, locally sandy or conglomeratic, fossiliferous, and resistant cliff-formers.

2.2.2 Basin-fill Units

The basin-fill geologic units within the study area that are potential sources of coarse and fine aggregates are alluvial fans deposits (Aaf). All other basin-fill units may locally supply aggregates but are not considered major sources and will not be discussed in this report.

Alluvial fans are the most extensive potential sources of basin-fill aggregates within the study area. They occur on the east flanks of the Hiko Range north of U.S. Highway 93, west of the North Pahroc Range, and east of the North Pahranagat Range. Alluvial fan deposits are typically heterogeneous to poorly stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay. The units are predominantly sandy gravel.

Most alluvial fan deposits have developed soil horizons consisting of silty, clayey sand, 1 to 2 feet (0.3 to 0.6 m) in thickness, overlying a zone of carbonate accumulation (caliche). The caliche horizon generally ranges in thickness from 1 to 1.5 feet (0.3 to 0.5 m) and exhibits Stage I to III development with Stage II being most common (Appendix F).

3.0 ROAD-BASE AGGREGATES EVALUATION

3.1 STUDY APPROACH

The primary objective of the road-base aggregate study was to evaluate the suitability of basin-fill and rock aggregates for use as road base. Two important considerations were applied to basin-fill aggregate sources identified as potentially suitable in VSARS, refinement of source boundaries, and additional laboratory tests to further evaluate physical and chemical characteristics. Sources of crushed-rock aggregates were refined using only existing data, published geologic maps, and limited photogeologic interpretations. Information on potential rock sources for use as road-base aggregates was not specifically collected for this evaluation. Only existing VSARS data and data developed from the concrete aggregates evaluation (Section 4.0) were assessed.

The study approach for the road-base aggregates evaluation required a review of an in-progress Ertec Verification (E-TR-27-PA-I and II) report for Pahroc Valley and previous aggregate reports (FN-TR-20D and FN-TR-37-a) for Pahroc and Pahranagat valleys. This data base helped define the scope of the road-base materials investigation which included office and field photogeologic and topographic interpretations, field reconnaissance, and collection and laboratory testing of basin-fill samples.

3.1.1 Requirements for Road-Base Aggregates

For the purpose of this report, road-base aggregates are defined using the Nevada Department of Highways (1976) classification of

Type I Class A aggregate base. The requirements for aggregates suitable for such a base are as follows:

Gradation:

Sieve Size	Percent Passing by Weight
1.5 inches	100
1.0 inch	80-100
No. 4	30- 65
No. 16	15- 40
No. 200	2- 12

Fractured Faces	35 percent, minimum
Plasticity Index	3-15 percent
Liquid Limit	35 maximum
Resistance (R value)	70 minimum
Percent Wear (500 Rev.)	45 percent, maximum

During the road-base aggregate studies, gradation and percent wear were the two primary criteria used to evaluate potential source areas. Magnesium sulfate ($MgSO_4$) soundness tests were performed on selected coarse aggregate samples to gain additional information related to the effects of weathering on aggregates. Soundness losses exceeding 18 percent were considered potentially unacceptable (American Society of Testing and Materials, 1978). The remaining requirements were not evaluated during this study.

3.1.2 Data Acquisition and Analysis

Office studies for the road-base aggregates evaluation required preliminary basin-fill and rock unit differentiation based on photogeologic interpretations and published topographic and geologic maps. All available data on basin-fill, grain-size gradations were compiled to estimate gravel content for the defined basin-fill units.

The field program involved backhoe excavation of 10 trenches selected during office studies and initial field reconnaissance. Trenches were excavated and sampled in groups of two or three, 0.1 to 0.2 mile (0.2 to 0.3 km) apart, to characterize individual basin-fill units. Completion depths ranged from 12 to 15 feet (3.7 to 4.6 m) and, where collected, representative samples averaged 100 pounds (45 kg) per trench.

Due to gradation variability in basin-fill deposits, field limits of 30 percent or more gravel and 20 percent or less silt and clay were established as basic aggregate grain-size distribution requirements. Gravel is defined as coarse aggregates which pass the 3.0-inch (75-mm) sieve and are predominantly retained on a No. 4 (4.75-mm) sieve. Aggregates larger than 3.0 inches (cobbles and boulders) were generally present in the materials investigated but were not included in the laboratory samples because of sample-size limitations. Silt and clay particles are defined as material passing through a No. 200 sieve (0.0029-inch [0.075-mm]).

Field studies also included six petrographic and grain-size data field stops and valley-wide photogeologic field reconnaissance. These analyses were performed to supplement and confirm office studies and to provide a data base for lithologic and gradation correlations of basin-fill units.

Laboratory testing that included three sieve analyses, one abrasion test, and one $MgSO_4$ soundness test was performed to broaden the existing data base during the road-base aggregates evaluation. Confirmation test data (gradation, abrasion, and soundness tests) from the concrete aggregates evaluation (Section 4.0) were also used to supplement test data for the road-base aggregates evaluation.

The scope of the study did not allow sample collection and laboratory testing of all potential road-base aggregate sources. Existing data and field petrographic and grain-size analyses were used to correlate lithologic and gradation properties to basin-fill units which were not sampled. An important element of this correlation procedure was the use of aerial photography to help delineate the lateral extent of basin-fill deposits. Photogeologic and field observations ascertained geomorphological and topographical relationships of basin-fill units and the source rock lithology and distribution of predominantly gravelly materials.

3.1.3 Presentation of Results

Results of the road-base aggregates evaluation are presented in the form of text, figures, 1:62,500 scale drawings, and appendices. Drawing 1 shows the locations of all the data points used in the Detailed Aggregate Resources Study. The data points are grouped by study type and assigned categorized map numbers. VSARS data points are designated by map numbers 1 to 199 and correspond to map numbers in the appendix table of the Pahroc area VSARS report (FN-TR-37-a). DARS data points are assigned map number groups 200 to 299 for trench locations and 300 to 399 for petrographic and grain-size data stop locations. Verification data points are assigned the map number group 400 to 599. Appendix Table G-1 converts map number to Pahroc Verification Report (E-TR-27-PA-I and II) activity type and number for direct reference.

Drawing 2 presents the locations of all potential road-base aggregate sources, DARS trenches, select VSARS data stops, and field petrographic and grain-size data stops in the study area. Geologic unit symbols used in Drawing 2 relate to standard geologic nomenclature whenever possible. A conversion table relating these symbols to the geologic unit nomenclature used in other Ertec reports is contained in Appendix Table F-3.

A solid contact line separates basin-fill and rock units in Drawing 2 to differentiate these two basic material types. All rock contacts are from published data or limited air-photo interpretation and are dashed. Basin-fill contacts are derived from photogeological mapping with limited field reconnaissance and are also dashed.

Classifications of potential sources of basin-fill and crushed-rock road-base aggregates are distinguished by different patterns. Patterns for basin-fill and rock sources of the same classification are similar, with the basin-fill pattern emphasized by a dark background tone.

The appendices contain tables that summarize the basic field data collected during the course of the study and the subsequent laboratory test procedures and results. Appendices A and B include DARS trench data and petrographic and grain-size analysis data, respectively. Appendix C contains representative trench logs. Appendix Table D-1 presents a laboratory testing flow diagram for the road-base aggregates evaluation. Appendix F includes three tables describing soil classification, caliche development, and geologic unit cross reference.

3.1.4 Classification of Road-Base Aggregates

A classification system was designed to present the most likely locations of potential sources of basin-fill and crushed-rock road-base aggregates. It was developed from an evaluation as well as from an extrapolation of all available data.

This classification system is primarily based on laboratory test results (gradation and abrasion and, to a lesser extent, soundness) and geomorphological and compositional correlations. The classification is presented in hierarchy form; classification of the highest potential source areas is described first and classification of the lowest potential source areas is described last.

Class	Explanation
RBIa	Basin-fill or rock sources containing materials suitable for use as road-base aggregates; based on acceptable laboratory aggregate test results.

Class RBIa includes those source areas where the potential for suitable road-base aggregates is the highest. Each delineated area has been sampled and tested. In order to assign Class RBIa to a basin-fill deposit, the source must satisfy the overall requirements outlined in Section 3.1.1.

Class	Explanation
RBIb	Basin-fill sources containing materials suitable for use as road-base aggregates; based on correlation with Class RBIa source areas.

Class RBIb basin-fill deposits are correlated to tested RBIa deposits on the basis of limited laboratory sieve analysis data and field observations. Field observations included petrographic and grain-size analyses which provided data on lithology of adjacent source rock and general amounts and lithologies of gravel present in the basin-fill units. Photogeologic interpretations were also used to correlate Class RBIb deposits to RBIa deposits. Specific geomorphological parameters included surface texture, drainage patterns, relative relief, and topographic profiles.

Class	Explanation
RBII	Potential basin-fill sources of materials suitable for use as road-base aggregates; based on photogeologic interpretations, field observations, and limited or inconclusive sieve analysis and/or abrasion data.

Class RBII includes poorly defined, basin-fill aggregate sources. Field observations and inconclusive field and laboratory data indicate these deposits may be potentially acceptable for use as road-base aggregate sources.

All classifications are based on limited data. Additional field reconnaissance, testing, and case history studies are needed to confirm adequacy, delimit exact areal boundaries, and refine chemical and physical characteristics.

3.2 SOURCES OF ROAD-BASE AGGREGATES

The potential basin-fill and rock units defined for use as road-base aggregates in the Pahroc study area include alluvial fan deposits (Aaf) and a dolomite rock unit (Do).

3.2.1 Basin-Fill Sources

All three classes of road-base aggregates, RBIa, RBIb, and RBII, are present in the basin-fill units of Pahroc or northern Pahranagat Valley (Drawing 2).

3.2.1.1 Class RBIa

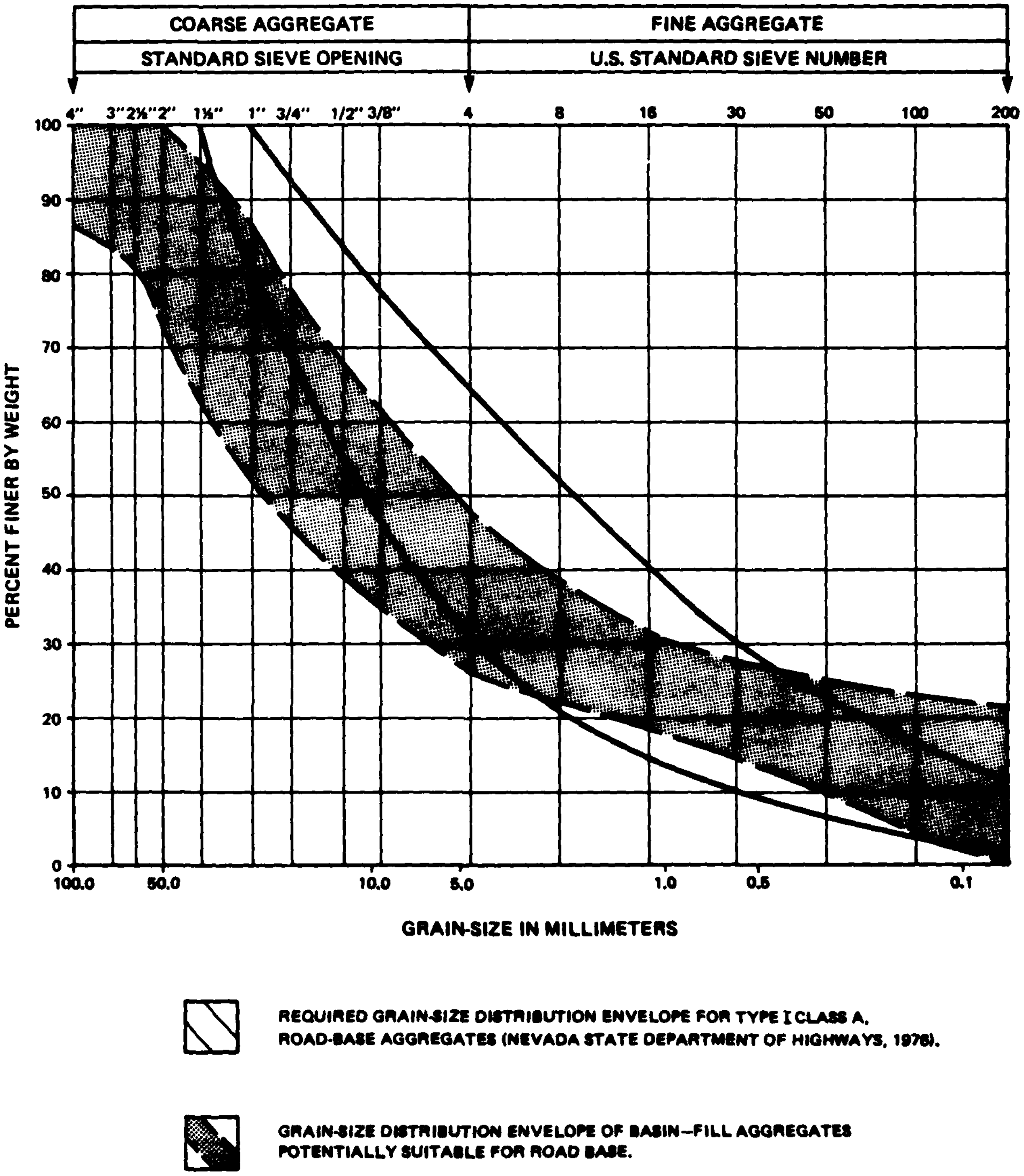
Class RBIa sources within the study area are located along the east side of the Hiko Range in Pahroc Valley and on the east side of the North Pahranagat Range in northern Pahranagat Valley. There are four Class RBIa basin-fill deposits composed of alluvial fan units (Aaf) within the study area.

In Pahroc Valley, the Class RBIa deposit consists of well-graded, subangular to subrounded sandy gravel. The gravel content of the deposit ranges from 43 to 56 percent. The sand content is about 45 percent. The silt and clay content of the deposit (below the overburden layer) is one percent or less. These deposits commonly consist of 72 to 78 percent carbonate clasts, seven to 22 percent quartzite clasts, and two percent or less volcanic clasts.

In northern Pahranagat Valley, three Class RBIa deposits consist of poorly to well-graded, subangular to subrounded sandy gravel and gravelly sand. The gravel content of the deposits range from a low of 40 percent to a high of 75 percent. Sand content ranges from 20 to 40 percent. The silt and clay content of the deposits (below the overburden layer) ranges from four to 11 percent. These deposits commonly consist of 72 to 90 percent carbonate clasts, generally less than 22 percent quartzite clasts, and less than three percent volcanic clasts. The northernmost Class RBIa deposit in Pahranagat Valley differs from the other Class RBIa deposits in that it contains a higher percentage of volcanic clasts.

The gradation of Class RBIa deposits approximates the grain-size distribution requirements stated in Section 3.1.1 (Figure 4). There is generally a deficiency of coarse and fine gravel passing the 1.5-inch to No. 4 sieves and a slight excess of fine sand passing the No. 50 to No. 200 sieves. Sufficient oversize material is available for crushing to provide additional aggregates of all sizes. Processing of most RBIa deposits will be necessary to conform to the design gradation requirements.

It has been observed that variations in grain-size gradations occur within a deposit depending on sample location. In general, gradations within a deposit are finer near the valley axis and coarser near mountain fronts. Due to access restrictions, samples were generally collected at distal and medial locations within each deposit.



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GRAIN-SIZE DISTRIBUTION ENVELOPES
ROAD-BASE AGGREGATES, CLASS RBIa
PAHROC STUDY AREA, NEVADA

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FIGURE 4

Laboratory abrasion tests performed on samples from all Class RBIa deposits show a fairly narrow range from 24 to 35.5 percent wear. Laboratory $MgSO_4$ soundness test results on coarse aggregates from Pahranagat Valley range from 4.1 to 18.2 percent loss. One $MgSO_4$ soundness test result on coarse aggregates from Pahroc Valley yielded a 13 percent loss. $MgSO_4$ soundness test results on fine aggregates from both valleys ranged from 17.4 to 35.3 percent loss. A $NaSO_4$ soundness test performed on a fine aggregates sample from Pahranagat Valley yielded a loss of 2.8 percent. Abrasion test results are within acceptable values. Coarse aggregates generally have acceptable $MgSO_4$ soundness test results, but fine aggregates do not.

Class RBIa deposits have areal extents ranging from approximately 0.25 to 3.1 mi^2 (0.65 to 8.0 km^2). The thickness of these deposits is estimated to be at least 25 feet (7.6 m). Generally, 70 to 85 percent of the material in these deposits will be suitable for use as road-base aggregates.

3.2.1.2 Class RBIb

Class RBIb basin-fill sources consist of alluvial deposits that have been correlated to Class RBIa units and, therefore, are considered to contain material acceptable for use as road-base aggregates. Class RBIb basin-fill sources are located on the east side of the Hiko Range in Pahroc Valley and on the east side of the North Pahranagat Range in northern Pahranagat Valley. There are four Class RBIb basin-fill deposits composed of alluvial fan units (Aaf) within the study area.

Since Class RBIb basin-fill deposits are correlated to Class RBIa deposits, they possess the same general characteristics as the RBIa deposits, well-graded, subangular to subrounded sandy gravel and gravelly sand composed of predominantly carbonate clasts with secondary quartzite and volcanic clasts.

Although variations in grain-size gradations will occur, depending on sample location within the deposit and the proximity of the deposit to its source area, Class RBIb deposits are interpreted to have gradation distributions similar to RBIa deposits.

The Class RBIb deposits range in surface area from approximately 0.1 to 3.4 mi^2 (0.3 to 8.8 km^2). The thickness of these deposits is estimated to be at least 25 feet (7.6 m). Generally, from 70 to 85 percent of the material in these deposits will be suitable for use as road-base aggregates.

3.2.1.3 Class RBII

Sources of Class RBII basin-fill aggregates are alluvial fan deposits (Aaf) that are potentially acceptable for use as road base. These deposits have been classified on the basis of limited field and laboratory data collected during this and other Ertec studies.

Class RBII deposits are located in Pahroc Valley east of the Hiko Range and west of the North Pahroc Range. All of the Class RBII deposits are alluvial fan units (Aaf).

Limited laboratory and field data used to define the Class RBII deposits on the east side of the Hiko Range (west side of Pahroc

Valley) indicate that they are compositionally similar to RBIa and RBIb deposits, consisting of sandy gravel and gravelly sand composed predominantly of carbonate clasts. Class RBII deposits west of the North Pahroc Range (east side of Pahroc Valley) consist of gravelly sand composed predominantly of carbonate clasts. Gravel content varies from 10 to 50 percent. There may be considerable variations from this general description within individual deposits. Although no DARS gradation data exist for Class RBII deposits in the study area, it is assumed that variations in gradation are generally similar to those of Class RBIa deposits. The areal extent of all Class RBII deposits ranges from approximately 0.3 to 7.0 mi^2 (0.8 to 20.5 km^2).

3.2.2 Rock Sources

The study approach used to evaluate road-base aggregates emphasized the analysis of basin-fill deposits and dictated that only previously tested, crushed-rock sources be discussed and classified. As a consequence, other rock units potentially suitable as sources of crushed-rock road-base aggregates are not included or described in this study.

The source of crushed rock for use as road-base aggregates is an intraformational calcareous sandstone assigned to the dolomite rocks (Do) geologic unit. This Class RBIa source is located on the west side of Pahroc Valley, east of the Hiko Range.

Laboratory abrasion and MgSO4 soundness test results are 35.5 percent wear and 3.6 percent loss, respectively. These test results are well within acceptable ranges for road-base aggregates.

4.0 CONCRETE AGGREGATES EVALUATION

4.1 STUDY APPROACH

The purpose of the concrete aggregates evaluation is to determine the suitability of aggregates within the Pahroc study area for use in concrete. To accomplish this, two objectives have been established:

- o Evaluate the basic physical and chemical characteristics of the aggregates; and
- o Determine the concrete-making properties of the aggregates.

The study approach required to achieve these objectives included a review of in-progress Ertec Verification (E-TR-27-PA-I and II) and previous Ertec aggregate reports (FN-TR-20D and FN-TR-37-a). This data base helped define the scope of the concrete aggregates investigation and included office and field photogeologic and topographic interpretations, field reconnaissance, and collection and laboratory testing of basin-fill and rock samples.

4.1.1 Requirements for Concrete Aggregates

The following requirements for aggregates and concrete (made using these aggregates) were established using criteria from the American Society of Testing and Materials (1979), the "Concrete Manual" prepared by the United States Department of the Interior (1975), and from Milos Polivka (1981, personal communication).

1. Aggregates

   - o Gradation - The aggregate gradation specifications used by the American Society of Testing and Materials (1979, C 33) were selected to evaluate the samples tested. These grading specifications follow.

Coarse Aggregates

Sieve Size	Percent Passing by Weight	Sieve Size	Percent Passing by Weight
2 inches	100	1 inch	100
1.5 inches	95-100	0.75 inch	90-100
1 inch	---	0.5 inch	---
0.75 inch	35-70	0.375 inch	20-55
0.50 inch	---	No.4	0-10
0.375 inch	10-30	No.8	0-5
No.4	0-5		

Fine Aggregates

Sieve Size	Percent Passing by Weight
0.375 inch	100
No.4	95-100
No.8	80-100
No.16	50-85
No.30	25-60
No.50	10-30
No.100	2-10
No.200	

- Abrasion - Los Angeles Machine abrasion losses for coarse aggregates are not to exceed 50 percent.

- Soundness - Five-cycle magnesium sulfate ($MgSO_4$) soundness losses are not to exceed 18 percent and 15 percent for coarse and fine aggregates, respectively. Although not a requirement for the evaluation, five-cycle sodium sulfate ($NaSO_4$) soundness tests are performed on samples that failed $MgSO_4$ testing. Resultant losses are not to exceed 12 percent and 10 percent for coarse and fine aggregates, respectively.

- Reactivity - Aggregates are to be nonreactive to alkali-silica and alkali-carbonate rock tests. Results are incomplete and will be submitted as an addendum to this report.

2. Concrete

- Compressive Strength - The primary concrete requirement is a 28-day compressive strength equal to or greater than 6500 psi.

- o Static Modulus of Elasticity - Values of 3 to 6 million psi at 28 days required.
- o Splitting Tensile Strength - Ten percent or less of the compressive strength value at 28 days required.
- o Ultimate Drying Shrinkage - Values of 0.03 to 0.10 percent (300 to 1000 millionths) required.

4.1.2 Data Acquisition and Analysis

4.1.2.1 Office Studies

Office studies for the concrete aggregates evaluation required preliminary basin-fill and rock-unit differentation based upon photogeologic interpretations and published topographic and geologic maps. All available data on basin-fill, grain-size gradations were compiled to estimate gravel content for the defined basin-fill units. All available test data on the aggregate properties of basin-fill and rock units were compiled to select sample locations in units previously tested and found preliminarily acceptable for use as sources of concrete aggregates.

4.1.2.2 Field Studies

The field program involved backhoe excavation of five trenches selected during office studies and initial field reconnaissance. The trenches were excavated to obtain samples of coarse and fine aggregates (gravel and sand).

Due to gradation variability in basin-fill deposits, field limits of 30 percent or more gravel and 15 percent or less silt and clay were established as basic aggregate grain-size distribution requirements. Gravel is defined as coarse aggregates which pass the 3.0-inch (75-mm) sieve and are predominantly retained on a No. 4 (4.75-mm) sieve. Silt and clay particles are defined as material passing through a No. 200 sieve (0.0029-inch [0.075-mm]).

The five trenches excavated to collect basin-fill samples for concrete aggregates evaluation were each located 150 feet apart (46 m) to characterize an individual basin-fill unit. Trenches were excavated to depths ranging from 12 to 15 feet (3.7 to 4.6 m). Bulk representative samples averaged 400 pounds (182 kg) per trench.

Field studies also included six petrographic and grain-size data field stops and valley-wide photogeologic field reconnaissance. These analyses were performed to supplement and confirm the office studies and to provide a broader data base for lithologic and gradation correlations of basin-fill units.

4.1.2.3 Laboratory Testing

The laboratory aggregate testing program was performed in two phases. The first phase consisted of standard tests for determining the basic properties of the aggregates and included the following:

- o Unit Weights and Voids in Aggregates;
- o Standard Specifications for Concrete Aggregates;
- o Soundness of Aggregates, Magnesium Sulfate ($MgSO_4$) and Sodium Sulfate ($NaSO_4$);
- o Sieve Analysis by Washing, less than No. 200 fraction;
- o Fineness Modulus;
- o Specific Gravity and Absorption, Coarse and Fine Aggregates;

- Resistance to Abrasion, Los Angeles Machine;
- Sieve Analysis, Coarse and Fine Aggregates; and
- Petrographic Examination of Aggregates for Concrete.

Generally, these tests were performed on aggregates from a location adjacent to a source previously tested and identified as the most promising in the VSARS program. This repetitive testing was done to confirm the suitability of aggregates for concrete (see Section 4.1.1, Requirements for Concrete Aggregates). Table 1 lists the number of tests completed in the Pahroc study area.

The second phase of the testing consisted of an evaluation of the concrete-making properties of the aggregates when used in the following three trial (check) concrete mixes.

Mix 1 - 7.5 sacks (94 pounds per sack) of cement per cubic yard of concrete with 1.5-inches maximum aggregate size.

Mix 2 - 8.5 sacks (94 pounds per sack) of cement per cubic yard of concrete with 1.5-inches maximum aggregate size.

Mix 3 - 8.5 sacks (94 pounds per sack) of cement per cubic yard of concrete with 0.75-inch maximum aggregate size and a superplasticizer.

In the trial mix, fly ash, as a pozzolan, replaced 20 percent of the cement by weight. All concrete trial mix design criteria are presented in Table 2. Samples were collected for one basin-fill (coarse and fine aggregates) trial mix. Material greater than 1.5 inches was crushed to conform to gradation requirements. If necessary, coarse and fine aggregates were processed to conform to gradation requirements.

	ASTM STANDARD TEST	AGGREGATE AND CONCRETE TEST DESCRIPTIONS[1]	TOTAL NUMBER OF TESTS*			
			BASIN-FILL		ROCK	
			CA	FA	ROCK	FA
AGGREGATES	C29	UNIT WEIGHT AND VOIDS IN AGGREGATE	1		–	
	C33	STANDARD SPECIFICATIONS FOR CONCRETE AGGREGATE	1		–	
	C88	SOUNDNESS OF AGGREGATE; Mg SO_4/NaSO_4	1/–	1/1	–	–
	C117	SIEVE ANALYSIS BY WASHING, < # 200 FRACTION	2		–	–
	C125	FINENESS MODULUS	–	1	–	–
	C127	SPECIFIC GRAVITY/ABSORPTION, COARSE AGGREGATE	6/2	–/–	–	–
	C128	SPECIFIC GRAVITY/ABSORPTION, FINE AGGREGATE	–/–	3/1	–	–
	C131	RESISTANCE TO ABRASION, LOS ANGELES MACHINE	1	–	–	–
	C136	SIEVE ANALYSIS, COARSE AND FINE AGGREGATE	7	6	–	–
	C295	PETROGRAPHIC EXAM. OF AGGREGATES FOR CONCRETE	1	1	–	–
CONCRETE	C39	COMPRESSIVE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS	24		–	
	C138	UNIT WEIGHT, YIELD, AIR CONTENT OF CONCRETE	3		–	
	C143	SLUMP OF PORTLAND CEMENT CONCRETE	4		–	
	C157	LENGTH CHANGE OF HARDENED CEMENT MORTAR AND CONCRETE	30		–	
	C173	AIR CONTENT OF CONCRETE, VOLUMETRIC METHOD	3		–	
	C192	MAKING AND CURING CONCRETE SPECIMENS	3		–	
	C227	POTENTIAL ALKALI-SILICA REACTIVITY, MORTAR-BAR METHOD	–	–	–	–
	C469	STATIC MODULUS OF ELASTICITY, POISSONS RATIO OF CONCRETE IN COMPRESSION	24		–	
	C496	SPLITTING TENSILE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS	6		–	
	C684	MAKING AND TESTING ACCELERATED CURE CONCRETE COMPRESSION TEST SPECIMENS	6		–	
	222-1-77[2]	SELECTING PROPORTIONS FOR NORMAL AND HEAVY WEIGHT CONCRETE	3		–	
	PROP.[3]	POTENTIAL ALKALI-CARBONATE ROCK REACTIVITY, LENGTH CHANGE METHOD	–		–	
	C39-56[4]	COEFFICIENT OF LINEAR THERMAL EXPANSION OF CONCRETE	6 (IP)		–	

1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (1978)
2. AMERICAN CONCRETE INSTITUTE (1977)
3. MIELENZ (1980) PROPOSED ASTM STANDARD TEST
4. UNITED STATES ARMY CORPS OF ENGINEERS (1977)

(IP) - TEST IN PROGRESS

* BASIN-FILL SOURCES SUPPLIED BOTH COARSE AND FINE AGGREGATES FOR CONCRETE MIX. LEDGE ROCK SOURCES SUPPLIED COARSE AGGREGATES; LOCAL SAND SOURCES (GENERALLY COLLECTED WITHIN A FEW MILES OF CORRESPONDING LEDGE ROCK SOURCES) SUPPLIED FINE AGGREGATES FOR CONCRETE MIX.

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AGGREGATE AND TRIAL MIX TESTS
CONCRETE AGGREGATES EVALUATION
PAHROC STUDY AREA, NEVADA

5 JUN 81

TABLE 1

CONCRETE CONSTITUENTS AND PROPERTIES	CONCRETE TRIAL MIX DESIGN CRITERIA					
	MIX 1 7.5/1.5 IN.[1]		MIX 2 8.5/1.5 IN.[1]		MIX 3 8.5/0.75 IN.; SUPER.[1]	
	VOLUME	WEIGHT	VOLUME	WEIGHT	VOLUME	WEIGHT
CEMENT, NEVADA TYPE II (LOW ALKALI; FT^3, LBS)	2.87	564	3.25	639	3.25	639
FLY ASH, WESTERN (REPLACES 20% OF CEMENT BY WEIGHT; FT^3, LBS)	0.99	141	1.12	160	1.12	160
SUPERPLASTICIZER (WRDA 19; OZ/CWT)[2]	—	—	—	—	15	—
WATER REDUCER (WRDA 79; OZ/CWT)	5	—	5	—	5	—
AIR ENTRAINMENT ADMIXTURE (DARAVAIR: OZ/CWT [FT^3])	1.2 [1.08]	—	3.75 [1.08]	—	3.0 [1.08]	—
SLUMP, MAXIMUM (INCHES)	3 - 4		3 - 4		0 - 1[3]	
AIR CONTENT, RANGE (PERCENT)	4 - 6		4 - 6		4 - 6	
WATER/CEMENT RATIO (BY WEIGHT)	0.36		0.32		0.33	
CEMENT FACTOR (SCY)[4]	7.5		8.5		8.5	

1. SACKS OF CEMENT PER CYD / MAXIMUM AGGREGATE SIZE
2. OZ/CWT = OUNCES/100 POUNDS OF CEMENT AND FLY ASH
3. SLUMP BEFORE ADDITION OF SUPERPLASTICIZER
4. SCY = SACKS OF CEMENT/CUBIC YARD OF CONCRETE

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CONCRETE TRIAL MIX DESIGN CRITERIA
PAHROC STUDY AREA, NEVADA

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TABLE 2

The following tests were performed to evaluate fresh and hardened properties of concrete made from the Pahroc study area aggregates:

Fresh Properties

- Unit Weight, Yield and Air Content of Concrete;
- Slump of Portland Cement Concrete;
- Air Content of Concrete, Volumetric Method;
- Making and Curing Concrete Specimens;
- Making and Testing Accelerated Cure Concrete Compression Test Specimens; and
- Selecting Proportions for Normal and Heavyweight Concrete.

Hardened Properties

- Compressive Strength of Cylindrical Concrete Specimens;
- Length Change of Hardened Cement Mortar and Concrete;
- Potential Alkali-Silica Reactivity, Mortar-Bar Method;
- Static Modulus of Elasticity of Concrete in Compression;
- Splitting Tensile Strength of Cylindrical Concrete Specimens;
- Potential Alkali-Carbonate Rock Reactivity, Length Change Method; and
- Coefficient of Linear Thermal Expansion of Concrete.

The results of all tests summarized in Table 1 are important to the concrete aggregates evaluation, but hardened concrete properties are considered the most significant (see Section 4.1.1, Requirements for Concrete Aggregates). Although the primary requirement for concrete is a 28-day compressive strength of 6500 psi, one-day (accelerated), seven-day, and 90-day tests were done to determine the range of compressive strength values.

In order to compare different aggregate sources, 28-day compressive strengths of Mix 3 were always used.

Occasionally, fresh concrete properties varied from design concrete specifications and may have affected hardened concrete test results. If known or significant, the causative factor and its effect on test results are mentioned in the discussions on sources of concrete aggregates (Section 4.2.1).

The scope of the study did not allow sample collection and laboratory testing of all potential basin-fill and rock concrete aggregate sources. Existing data and field petrographic and grain-size analyses were used to correlate lithologic and gradation properties to basin-fill units which were not sampled. An important element of this correlation procedure was the use of aerial photography to help delineate the lateral extent of basin-fill deposits. Photogeologic field observations ascertained geomorphological and topographical relationships of basin-fill units and the source rock lithology and distribution of predominantly gravelly materials.

Limited laboratory and field data prevented most correlations of data from tested to untested rock units. Potential aggregate sources were confined to the limits of tested or correlated outcrops as determined from existing data, limited photogeological interpretation, and field reconnaissance.

4.1.3 Presentation of Results

Results of the concrete aggregates evaluation are presented in the form of text, tables, figures, 1:62,500 scale drawings, and appendices. Drawing 1 is a location map showing the position in the study area of all data points used in the Detailed Aggregate Resources Study. All data points are grouped by study type and assigned categorized map numbers (see Section 3.1.3).

Drawing 3 presents the locations of the potential concrete aggregate sources, DARS trenches, select VSARS data stops, and field petrographic and grain-size data stops in the study area. Geologic unit symbols used in Drawing 3 relate to standard geologic nomenclature whenever possible. A conversion table relating these symbols to the geologic unit nomenclature used in other Ertec reports is contained in Appendix Table F-3.

A solid contact line separates basin-fill and rock units in Drawing 3 to differentiate these two basic material types. All rock contacts are taken from published data or limited air-photo interpretation and are dashed. Basin-fill contacts are derived from photogeological mapping with limited field reconnaissance and are also dashed.

Classifications of potential basin-fill and rock concrete aggregate sources are distinguished by different patterns. Patterns for basin-fill and rock sources of the same classification are similar, with the basin-fill pattern emphasized by a dark background tone.

The appendices contain tables that summarize the basic field data collected during the course of the study and the subsequent laboratory test procedures and results. Appendices A and B contain DARS trench data and petrographic and grain-size data, respectively. Appendix C contains representative trench logs. Appendix Table D-2 presents a laboratory testing flow diagram for the concrete aggregates evaluation. Appendix E presents the chemical analyses of cement, fly ash, and water used in making the concrete trial mixes. Appendix F includes three tables describing soil classification, caliche development, and geologic unit cross reference.

4.1.4 Classification of Concrete Aggregates

A classification system was designed to present the most likely basin-fill and crushed-rock concrete aggregate sources. It was developed from an evaluation as well as from an extrapolation of all available data. Data include laboratory test results (compressive strength of concrete and grain-size, abrasion, and soundness of aggregates) and geomorphological and compositional correlations.

The classification system groups potential aggregate sources into three categories:

1. Aggregate sources which were used in concrete mixes - Class CA1 and Class CA2;
2. Aggregate sources which were subjected to basic aggregate tests - Class CB; and
3. Untested aggregate sources which were correlated to Classes CA1, CA2, or CB - Class CC1 and Class CC2.

The classification is presented in hierarchy form; classification of the highest potential source areas is described first, and classification of the lowest potential source areas is described last.

Class	Explanation
CA1	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths equal to or greater than 6500 psi using Mix 3 (Section 4.1.2).
CA2	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths less than 6500 psi using Mix 3 (Section 4.1.2).

Classes CA1 and CA2 describe those specific sources where basin-fill or crushed-rock aggregates have been collected and used in making trial mix batches of concrete. Following appropriate ASTM standards, concrete cylinders containing the collected aggregates were made, cured, and tested for various hardened concrete properties. The class is divided into two categories by 28-day compressive strength test results.

Generally, aggregates from each potential source area have been tested previously during the VSARS program. Confirmation testing that included gradation, abrasion, and soundness tests was performed when applicable to ensure the continued acceptability of a sample for use in concrete. Abrasion and $MgSO_4$ soundness values do not exceed coarse aggregate requirements specified in Section 4.1.1. Tested samples of fine aggregate used in the concrete trial mix consistently have $MgSO_4$ soundness losses exceeding the required 15 percent maximum; however, $NaSO_4$ soundness losses generally do not exceed 10 percent.

Class	Explanation
CB	Basin-fill or rock sources containing aggregates potentially suitable

for use in concrete; based on acceptable laboratory aggregate test results.

The Class CB describes those source areas that have been sampled and tested only for grain-size gradation, abrasion, and $MgSO_4$ soundness. Trial concrete mixes were not made. Gradation, abrasion, and soundness values specified in Section 4.1.1 were used to assign this classification to an aggregate source.

Class	Explanation
CC1	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CA1 or CA2 areas.
CC2	Basin-fill sources of aggregates potentially suitable for use in concrete; based on correlation with Class CB areas.

Untested Class CC deposits are correlated to tested Class CA or CB deposits on the basis of field observations and limited field and laboratory test results. Class CC basin-fill deposits consist of units of the same apparent relative age as Class CA and CB deposits. Class CC1 rock deposits are additional nearby outcrops of the same unit as Class CA deposits.

Field observations and petrographic and grain-size analyses provided correlative data on lithology of adjacent source rock and lithology and general amounts of gravel present in the basin-fill units. Photogeologic interpretations were also used to correlate Class CC basin-fill deposits to Class CA or CB basin-fill deposits. Specific geomorphological parameters correlated during the procedure included surface texture, drainage patterns, relative relief, and topographic profiles.

All classifications are based on limited data. Additional field reconnaissance, testing, and case history studies are needed to confirm adequacy, delimit exact areal boundaries, and refine chemical and physical properties.

4.2 SOURCES OF CONCRETE AGGREGATES

4.2.1 Basin-Fill Sources

Basin-fill sources of concrete aggregates are grouped into four classes, CA1, CB, CC1, and CC2. Deposits defined on the basis of laboratory test data are included in Class CA1 and Class CB. Untested basin-fill deposits correlated to deposits with test data are included in Classes CC1 and CC2.

4.2.1.1 Class CA1

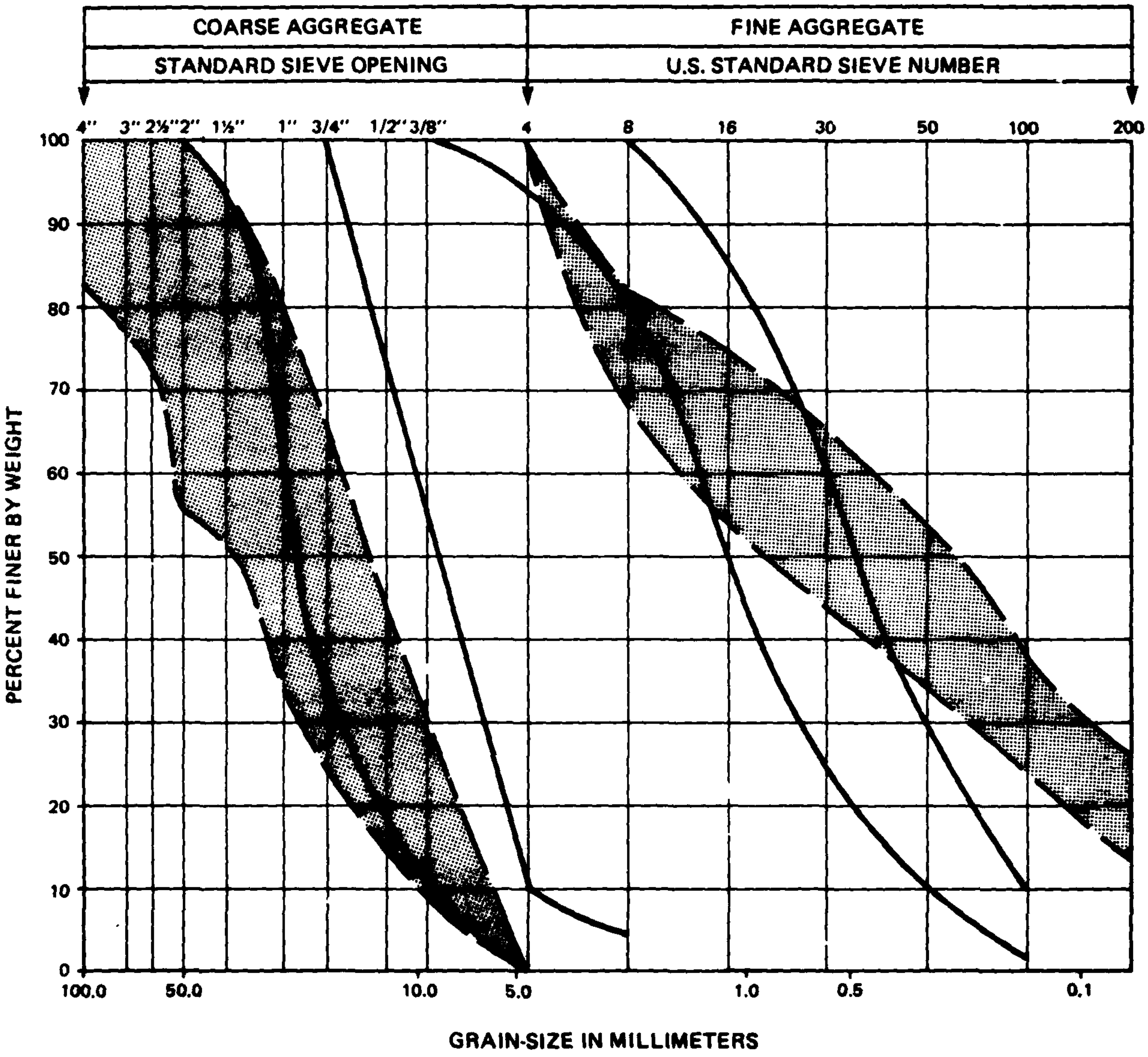
There is one Class CA1 basin-fill source identified within the study area. It is located on the western side of northern Pahranagat Valley adjacent to the North Pahranagat Range (Drawing 3).

1. The Class CA1 basin-fill source is an alluvial fan deposit consisting mainly of poorly graded sandy gravel. The gravel ranges from 51 to 74 percent of the deposit (excluding cobbles and boulders), and the sand ranges from 24 to 39 percent. Cobbles and boulders comprise about 10 percent of the total material within the deposit. Silt and clay comprise from three to 11 percent of the deposit.

The gravel clasts sampled are approximately equidimensional to thick-tabular in shape. Approximately 83 percent of the gravel clasts are of satisfactory physical quality; 14 percent are porous, weak, and internally fractured and are of fair quality; and three percent are soft or highly porous and are of poor quality. The collected gravel sample is composed of 86 percent limestone and dolomitic limestone, nine percent quartzite, and five percent coating material, weathered rhyolite, and chert. About 37 percent of the gravel clasts are partially or completely coated by calcareous material. The dolomite and dolomitic limestone clasts may be susceptible to a deleterious degree to the alkali-carbonate reaction. The rhyolite and chert clasts may be susceptible to a deleterious degree to the alkali-silica reaction.

The sand particles sampled are typically subrounded to angular and are generally similar in composition and quality to the gravel clasts within the deposit. The sand contains approximately 71 percent satisfactory material, 16 percent fair-quality material, and 13 percent poor-quality material. The sand is considered to be susceptible to a deleterious degree to both alkali-carbonate and alkali-silica reactions.

Grain-size gradations of the Class CA1 deposit only partially meet design gradation requirements (Figure 5). The percentages of coarse to medium gravel passing the 2-inch to 0.375-inch sieves is generally deficient. There is an abundance of oversize material that can be processed to provide additional aggregates of all sizes. The percentages of fine aggregates do not conform to design gradation requirements. There is a deficiency of sand passing the No. 8 sieve and an excess of fine sand passing the No. 30 to No. 100 sieve sizes. Processing of the deposit will be necessary to conform to the design gradation requirements. Variations in grain-size gradations will



▨ REQUIRED GRAIN-SIZE DISTRIBUTION ENVELOPES FOR COARSE AND FINE AGGREGATES USED IN CONCRETE (AMERICAN SOCIETY FOR TESTING AND MATERIALS, 1978, C 33; THE RECOMMENDED GRADATIONS FOR AGGREGATES WITH 1.5 AND 0.75 INCH MAXIMUM SIZE ARE COMBINED INTO ONE ENVELOPE).

▨ GRAIN-SIZE DISTRIBUTION ENVELOPES OF BASIN–FILL COARSE AND FINE AGGREGATES POTENTIALLY SUITABLE FOR CONCRETE.

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GRAIN-SIZE DISTRIBUTION ENVELOPES
CONCRETE AGGREGATES, PA-A- (6-10)
PAHROC STUDY AREA, NEVADA

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FIGURE 5

occur within the deposit depending on proximity to the source area. In general, this source is relatively finer grained near the valley axis and coarser grained adjacent to the mountain fronts.

A coarse aggregate sample from the Class CA1 deposit was subjected to laboratory abrasion and $MgSO_4$ soundness tests and yielded results of 24.5 percent wear and 3.7 percent loss, respectively. These values for abrasion and soundness are well within acceptable ranges for coarse aggregates for concrete-construction-material use. The fine aggregates sample from this deposit was subjected to both $MgSO_4$ and $NaSO_4$ soundness tests. The sample failed the $MgSO_4$ soundness test with a 17.4 percent loss, but passed the $NaSO_4$ soundness test with a 2.8 percent loss.

Concrete (Mix 3) made using the aggregates from this Class CA1 deposit had a 28-day compressive strength of 7365 psi and a 90-day compressive strength of 8860 psi. Concrete trial Mixes 1 and 2 yielded 28-day compressive strengths of 6065 and 4630 psi, respectively (Table 3). The air content of Mix 2 (11.5 percent) was much higher than the maximum air content as specified by the mix design (6.0 percent) and probably caused a lowering of the compressive strengths of this mix. Fresh concrete properties and hardened concrete test results (chord modulus of elasticity, splitting tensile strength, drying shrinkage) are also included in Table 3. Test results for hardened concrete are generally within or exceed the requirements mentioned in

AGGREGATE SOURCE[1]	FIELD STATION	CONCRETE MIX DESIGN CRITERIA[2] SACKS OF CEMENT/CYD / MAX. AGG. SIZE	FRESH CONCRETE PROPERTIES					
			SLUMP[3] (IN.)	AIR CONTENT (%)	UNIT WEIGHT (PCF)	WATER/ CEMENT RATIO	CEMENT FACTOR (SCY)	ASTM STANDARD TEST
BASIN–FILL	PA-A- (6-10)	MIX 1 7.5/1.5 IN.	3.75	1.5	149.2	0.36	7.69	COMPRESSIVE STRENGTH, AS (PSI)
								CHORD MODULUS OF ELASTICITY, (PSI x 10^6)
								SPLITTING TENSILE STRENGTH, (PSI)
								DRYING SHRINKAGE, ASTM (PERCENT)
	PA-A- (6-10)	MIX 2 8.5/1.5 IN.	4.0	11.5	141.8	0.32	8.28	COMPRESSIVE STRENGTH, AS (PSI)
								CHORD MODULUS OF ELASTICITY, (PSI x 10^6)
								SPLITTING TENSILE STRENGTH, (PSI)
								DRYING SHRINKAGE, AST (PERCENT)
	PA-A- (6-10)	MIX 3 8.5/0.75 IN., SUPER-PLASTICIZER	1 BEF. 6 AFT.	6.3	143.4	0.30	8.55	COMPRESSIVE STRENGTH, A (PSI)
								CHORD MODULUS OF ELASTICIT (PSI x 10^6)
								SPLITTING TENSILE STRENGTH (PSI)
								DRYING SHRINKAGE, AST (PERCENT)

1. BASIN-FILL SOURCES SUPPLIED BOTH COARSE AND FINE AGGREGATES FOR CONCRETE MIX. LEDGE-ROCK SOURCES SUPPLIED COARSE AGGREGATES; LOCAL SAND SOURCES (GENERALLY COLLECTED WITHIN A FEW MILES OF CORRESPONDING LEDGE-ROCK SOURCES) SUPPLIED FINE AGGREGATES FOR CONCRETE MIX.
2. ASTM AND ACI SPECIFICATIONS AND PROCEDURES WERE FOLLOWED IN THE MIX DESIGN AND BATCHING OF THE CONCRETE TRIAL MIXES. THE CONCRETE MIXES CONSISTED OF COARSE AND FINE AGGREGATES, LOW ALKALI CEMENT, FLY ASH (20% BY WEIGHT REPLACEMENT OF CEMENT), SUPERPLASTICIZER, AIR-ENTRAINING ADMIXTURE, AND WATER REDUCER.
3. BEF. – SLUMP BEFORE ADDITION OF SUPERPLASTICIZER.
   AFT. – SLUMP AFTER ADDITION OF SUPERPLASTICIZER.
4. COMPRESSIVE AND TENSILE STR CYLINDERS. DRYING SHRINKAG MENS; TIMETABLE INCLUDES A

HARDENED CONCRETE TEST RESULTS

ASTM STANDARD TEST [4]	TIMETABLE				
	1 DAY (ACCELERATED)	7 DAYS	28 DAYS	90 DAYS	
MPRESSIVE STRENGTH, ASTM C 39 (PSI)	2795	4660	6065	6875	
MODULUS OF ELASTICITY, ASTM C 469 (PSI x 10^6)	3.20	4.84	5.21	5.98	
TING TENSILE STRENGTH, ASTM C 496 (PSI)	—	—	490	—	
DRYING SHRINKAGE, ASTM C 157 (PERCENT)	7 DAYS	14 DAYS	21 DAYS	28 DAYS	35 DAYS
	0.00	0.018	0.029	0.033	0.034
OMPRESSIVE STRENGTH, ASTM C 39 (PSI)	2090	3920	4630	5560	
D MODULUS OF ELASTICITY, ASTM C 469 (PSI x 10^6)	2.18	4.26	4.44	5.04	
TTING TENSILE STRENGTH, ASTM C 496 (PSI)	—	—	510	—	
DRYING SHRINKAGE, ASTM C 157 (PERCENT)	7 DAYS	14 DAYS	21 DAYS	28 DAYS	35 DAYS
	0.00	0.014	0.025	0.030	0.032
COMPRESSIVE STRENGTH, ASTM C 39 (PSI)	3300	5750	7365	8860	
D MODULUS OF ELASTICITY, ASTM C 469 (PSI x 10^6)	3.54	4.45	4.92	5.18	
TTING TENSILE STRENGTH, ASTM C 496 (PSI)	—	—	615	—	
DRYING SHRINKAGE, ASTM C 157 (PERCENT)	7 DAYS	14 DAYS	21 DAYS	28 DAYS	35 DAYS
	0.00	0.019	0.031	0.037	0.039

MPRESSIVE AND TENSILE STRENGTH VALUES ARE AVERAGES OBTAINED FROM TWO TESTED LINDERS. DRYING SHRINKAGE VALUES ARE AVERAGES OBTAINED FROM TWO TESTED SPECI- NS; TIMETABLE INCLUDES A SEVEN DAY MOIST CURE.

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CONCRETE TRIAL MIX TEST RESULTS
PA-A-(6-10)
PAHROC STUDY AREA, NEVADA

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2

Section 4.1.1 except initial drying shrinkage values and Mix 2 tensile strength.

The areal extent of the Class CA1 deposit is approximately 3.1 mi^2 (8.0 km^2). It is estimated that the material sampled from this deposit extends to a depth of at least 25 feet (7.6 m). It is also estimated that this deposit has a yield of 65 to 80 percent after handling, poor-quality constituents, and silt and clay losses.

4.2.1.2 Class CB

Class CB basin-fill aggregate sources are alluvial fan deposits that have been sampled and laboratory tested and are considered to be potential concrete aggregate sources. Class CB aggregates have not been used in trial concrete mixes. Test results show that these deposits contain at least 30 percent gravel clasts of all sizes (3-inches to No. 4 sieve size), have less than 50 percent abrasion wear, and, where applicable, have less than 18 percent loss when subjected to a $MgSO_4$ soundness test.

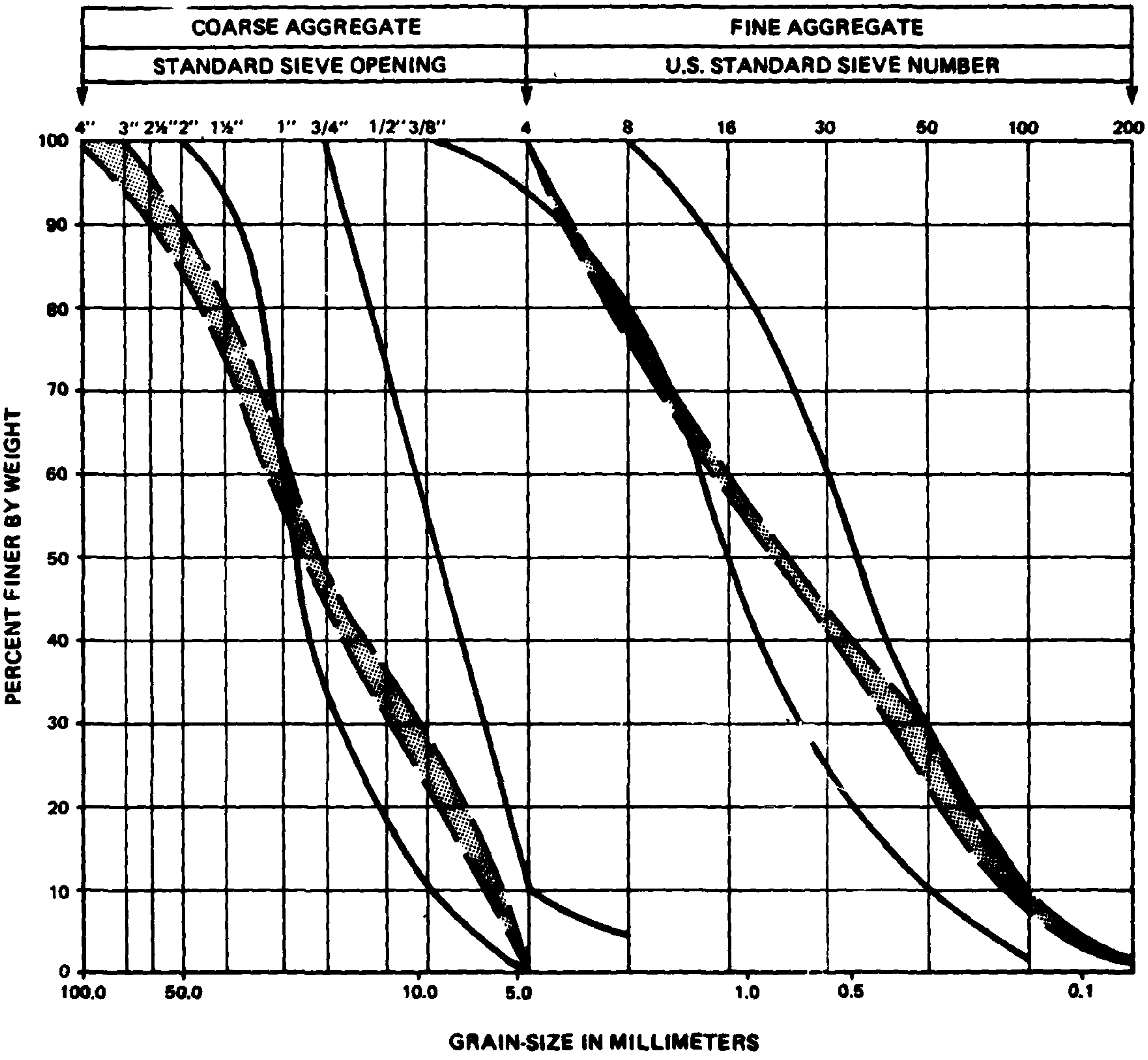
Class CB deposits are located along the west sides of both Pahroc and northern Pahranagat valleys. There are three Class CB sources within the study area and all are alluvial fan (Aaf) deposits.

Class CB basin-fill deposits generally consist of poorly to well-graded, subangular to subrounded sandy gravel. The gravel content of most Class CB deposits ranges from 40 to 74 percent and the silt content ranges from one to five percent. The deposits are primarily composed of limestone and dolomite, quartzite, and volcanic clasts, with minor caliche and chalcedony.

The gradation of one Class CB deposit approximates the grain-size distribution requirements stated in Section 4.1.1 (Figure 6). The percentages of coarse gravels passing the 2- and 1-inch sieves are deficient. Sufficient oversize material is available for crushing to provide additional aggregates of all sizes. Based on limited data, the percentages of 1-inch to No. 4 coarse aggregates conform to design gradation requirements. Although the percentages of fine aggregates conform closely to these requirements, there is a slight deficiency of coarse sand passing the No. 8 sieve. Variations in grain-size gradations will occur within the deposit depending on proximity to the source area. In general, this source is relatively finer grained near the valley axis and coarser grained adjacent to the mountain fronts.

Laboratory abrasion tests performed on samples from all Class CB deposits resulted in fairly low wear values, ranging from 24.3 to 34.7 percent. Laboratory $MgSO_4$ soundness test results on coarse aggregate samples ranged from 4.1 to 18.2 percent loss and on fine aggregate samples from 28.2 to 35.3 percent loss. $MgSO_4$ soundness test results on coarse aggregates were within and exceeded ASTM standards and DARS requirements. $MgSO_4$ soundness test results on fine aggregates exceeded requirements.

The areal extent of Class CB deposits ranges from 0.25 to 2.8 mi^2 (0.65 to 7.2 km^2). It is estimated that the material



▨ REQUIRED GRAIN-SIZE DISTRIBUTION ENVELOPES FOR COARSE AND FINE AGGREGATES USED IN CONCRETE (AMERICAN SOCIETY FOR TESTING AND MATERIALS, 1978, C 33; THE RECOMMENDED GRADATIONS FOR AGGREGATES WITH 1.5 AND 0.75 INCH MAXIMUM SIZE ARE *COMBINED INTO ONE ENVELOPE*).

▨ GRAIN-SIZE DISTRIBUTION ENVELOPES OF BASIN–FILL COARSE AND FINE AGGREGATES POTENTIALLY SUITABLE FOR CONCRETE.

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FIGURE 6

sampled from these deposits extends to a depth of at least 25 feet (7.6 m) and will have a yield of from 70 to 90 percent.

4.2.1.3 Class CC1

A Class CC1 source within the study area is located in Pahranagat Valley east of the North Pahranagat Range. This alluvial deposit has been correlated to the adjacent Class CA1 concrete aggregate source on the basis of geomorphological and compositional similarities.

The Class CC1 deposit is therefore considered to be a potential source of concrete aggregates consisting of poorly graded, equidimensional to thick-tabular sandy gravel of generally satisfactory physical quality. The lithology of the gravel is predominantly dolomite and limestone with small amounts of caliche and chert. The areal extent of the Class CC1 deposit is approximately 2 mi^2 (5.2 km^2).

4.2.1.4 Class CC2

Class CC2 basin-fill aggregate sources are alluvial deposits that have been correlated to Class CB concrete aggregate sources on the basis of geomorphological and compositional similarities. Class CC2 deposits are therefore assumed to contain material similar in size and composition to Class CB deposits. These four deposits are located along the west side of Pahroc Valley adjacent to the Hiko Range. The areal extent of individual Class CC2 deposits ranges from 0.1 to 3.4 mi^2 (0.3 to 8.8 km^2).

4.2.2 Rock Sources

Rock concrete aggregate sources are grouped into two classes. Rock defined on the basis of laboratory test data is included in Class CB. Class CC1 contains rocks correlated to tested rock units.

4.2.2.1 Class CB

Class CB crushed-rock sources are rock units that have been sampled and laboratory tested and, on the basis of the test results, are considered to be potential sources of concrete aggregates. Class CB rocks have not been used in concrete trial mixes.

The Class CB rock source within the study area is located in Pahroc Valley on the east side of the Hiko Range, north of U.S. Highway 93, and is an intraformational calcareous sandstone of the dolomite rock unit (Do). The sampled interval consists of a limited outcrop of hard, medium-grained, slightly weathered calcareous sandstone.

A laboratory abrasion test performed on this rock yielded a result of 35.5 percent wear. When subjected to a MgSO4 soundness test, the crushed rock exhibited a 3.6 percent loss. These results are well below the maximum allowable abrasion wear of 50 percent and soundness loss of 18 percent for coarse aggregate used as concrete construction material.

4.2.2.4 Class CC1

Class CC1 potential concrete aggregate sources are untested rock outcrops of the undifferentiated carbonate rock unit (Cau).

Published geologic maps were used to delineate these outcrops. These sources are part of the same geologic unit as the Class CA1 and CA2 sources in Dry Lake Valley (E-TR-47-DL) and have essentially the same lithologies, limestone, dolomitic limestone, and dolomite.

5.0 CONCLUSIONS

Results of the Detailed Aggregate Resources Study indicate that there are sufficient quantities of aggregates available in the Pahroc study area for the construction of the MX missile system.

Good- to high-quality basin-fill and crushed-rock coarse aggregates are present in northern Pahranagat and western Pahroc valleys. Good- to high-quality crushed-rock coarse aggregates are present in the Hiko and North Pahranagat ranges. Sufficient quantities of poor- to satisfactory-quality, fine aggregates are present in basin-fill deposits in the two valleys. After shelter layouts are finalized, potential borrow areas can be delineated based on the results of this study.

Although most rock will supply acceptable coarse aggregates, limited sources are delineated in this study. Sufficient quantities of basin-fill aggregates within the area will probably make processing of crushed-rock aggregates unnecessary.

As discussed in the report, field studies placed an arbitrary cut-off limit of a minimum of 30 percent gravel for the source to be considered for road-base or concrete aggregates. Nevertheless, basin-fill deposits with less than 30 percent gravel are also probably potentially suitable for use as aggregates. However, yield from such sources will be low, and extensive processing and/or blending will be required to satisfy the gradation requirements.

5.1 ROAD-BASE AGGREGATES

5.1.1 Class RBIa Sources

Four basin-fill deposits consisting of good- to high-quality coarse aggregates acceptable for road base have been located within the study area. They are all alluvial fan units (Aaf) confined to northern Pahranagat and western Pahroc valleys. Their total areal extent is approximately 8.1 mi^2 (21 km^2).

Gradation results indicate that, where sampled, the deposits approximate ASTM standards and DARS requirements. The deposits generally are deficient in coarse and fine gravel, passing the 1.5-inch to No. 4 sieves, and are excessive in fine sand, passing the No.50 to No. 200 sieves. Sufficient oversized material is available for crushing to provide additional aggregates of all sizes.

Abrasion results on tested samples are within ASTM standards and DARS requirements. $MgSO_4$ soundness results generally are high, just within or exceeding ASTM standards and DARS requirements; where tested, $NaSO_4$ soundness results are within ASTM standards and DARS requirements.

One good- to high-quality coarse aggregate crushed-rock source acceptable for use as road-base aggregates has been delineated within the study area. This source is a limited outcrop of intraformational calcareous sandstone assigned to the dolomite rock unit (Do). Samples from this rock source yielded test results for abrasion and soundness well within acceptable ranges as specified by ASTM standards and DARS requirements.

5.1.2 Class RBIb Sources

Four basin-fill deposits within the study area are defined as potential sources of good- to high-quality aggregates for use as road-base construction material. Geomorphological and compositional similarities were used to correlate these units to tested RBIa deposits. The units are all alluvial fan units (Aaf) confined to northern Pahranagat and western Pahroc valleys. Their total areal extent is approximately 7.4 mi^2 (19.2 m^2).

5.1.3 Class RBII Sources

Several potential road-base aggregate sources defined by limited field and laboratory data are present in various locations throughout the study area. All deposits are alluvial fans, consist predominantly of sandy gravel or gravelly sand, and are compositionally similar to Class RBIa and RBIb deposits. These deposits have a total areal extent of approximately 10.5 mi^2 (27.2 km^2).

5.2 CONCRETE AGGREGATES

5.2.1 Class CA1 Sources

One basin-fill deposit consisting of good- to high-quality aggregates that produced concrete with 28-day compressive strengths equal to or greater than 6500 psi has been delineated within the study area. Chord modulus of elasticity, splitting tensile strength, and drying shrinkage results generally conform to the standard concrete requirements, although minor deviations do occur.

Gradation results indicate that, where sampled, the deposit approximates ASTM standards and DARS requirements. Typically, percentages of fine gravel conform to gradation specifications, but there is a lack of coarse to medium gravel passing the 2-inch to 0.375-inch sieves. The fine aggregate samples generally contain a deficiency of sand passing the No. 8 sieve and an excess of fine sand passing the No. 30 to No. 100 sieve sizes. Processing of basin-fill deposits can be used to bring gradations within design requirements. Crushing of oversize materials will produce additional aggregates of all sizes. In addition, variations in grain-size gradation will occur within the deposit depending on proximity to the source area. Aggregates are relatively finer grained near the valley axis and coarser grained near the mountain fronts.

Abrasion and soundness tests performed on coarse aggregates from the Class CA1 deposit are also within specified ASTM and DARS requirements. The fine aggregates within these deposits are generally of lower quality (high $MgSO_4$ soundness losses), but results are inconclusive regarding their use as concrete-construction material. The Class CA1 basin-fill deposit is an alluvial fan unit (Aaf) located in northern Pahranagat Valley. It has a total areal extent of approximately 3.1 mi^2 (6 km^2).

5.2.2 Class CB Sources

Three basin-fill deposits consisting of good- to high-quality coarse aggregates potentially acceptable for use as concrete construction material were delineated within the study area.

These deposits are all alluvial fan units (Aaf) and are confined to northern Paharanagat and western Pahroc valley. Their total areal extent is approximately 5 mi^2 (13 km^2). No concrete trial mixes were made, but abrasion test results on samples from these deposits were well within acceptable ranges as specified by ASTM standards and DARS requirements. $MgSO_4$ soundness test results on coarse aggregates were within and exceeded ASTM standards and DARS requirements. $MgSO_4$ soundness test results on fine aggregates exceeded requirements. The gradation of the Class CB deposit approximates the design grain-size distribution requirements, although, the percentages of coarse gravels passing the 2- and 1-inch sieves are deficient.

5.2.3 Class CC1 Sources

One basin-fill alluvial fan deposit (Aaf) in the study area is classified as a potential source of concrete aggregates. The unit was correlated to the Class CA1 source based on geomorphological and compositional similarities. The deposit has a total areal extent of approximately 2 mi^2 (5 km^2).

5.2.4 Class CC2 Sources

Several alluvial fan units (Aaf) located along the west side of Pahroc Valley are classified as potential sources of concrete aggregates. Units were correlated to Class CB sources on the basis of geomorphological and compositional similarities. They have an areal extent of approximately 5.4 mi^2 (14 km^2).

6.0 RECOMMENDATIONS FOR FUTURE STUDIES

The conclusions of this Detailed Aggregate Resources Study of the Pahroc study area, as enumerated in Section 5.0, are based on limited field and laboratory test results. However, the results presented in this report provide sufficient data for selecting potential borrow areas. After selection of the borrow areas, more extensive studies are required to further determine the characteristics of the aggregates.

6.1 SOURCES OF ROAD-BASE AGGREGATES

It is recommended that additional field exploration (backhoe or drilling) and detailed laboratory testing be performed. The laboratory tests should consist of sieve analysis, resistance to abrasion, CBR, and other appropriate tests as deemed necessary by the designers.

6.2 SOURCES OF CONCRETE AGGREGATES

It is recommended that additional field investigations (backhoe or drilling) and detailed laboratory testing be performed. The aggregate samples should be subjected to the following tests:

- Sieve Analysis;
- Resistance to Abrasion;
- Soundness;
- Specific Gravity and Absorption; and
- Petrographic Examination of Aggregates for Concrete.

In addition, the following detailed tests using concrete made from these aggregates should be performed:

- Compressive Strength;
- Splitting Tensile Strength;
- Flexural Strength;
- Shrinkage;

- Thermal Expansion;
- Modulus of Elasticity;
- Potential Alkali-Silica Reactivity;
- Potential Alkali-Carbonate Rock Reactivity; and
- Resistance of Concrete to Rapid Freezing and Thawing.

In addition, it is recommended that concrete trial mixes with different size aggregates and admixtures be made in order to assess the variation in compressive strength, durability, shrinkage, and thermal properties of concrete.

In-progress Verification studies (E-TR-27-PA-I and II) performed in Pahroc Valley indicate that potential for sulfate attack of soils on concrete is "negligible." However, it is recommended that additional studies be made to further evaluate the potential for sulfate attack of soils on concrete and to determine the type of cement to be used in concrete.

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APPENDIX A

SUMMARY OF FIELD AND LABORATORY TEST DATA

FIELD AND LABORATORY TEST DATA

Field observations and laboratory test data on samples collected at selected stations are presented in Table A-1. Field stations were established at various locations throughout the study area where detailed descriptions of potential basin-fill, fine aggregate, and crushed-rock sources were recorded. Detailed explanations for the column headings of Table A-1 are as follows:

COLUMN HEADING	EXPLANATION
MAP NUMBER	Map numbers are sequentially arranged identifiers of field stations occupied during the course of the aggregate study.
FIELD STATION	These designations are internal DARS identifiers of all field stations. Each one consists of a two-letter valley abbreviation followed by the letter A (aggregate trench).
LOCATION	The location column lists the geographic portion of the valley in which the field station is located (e.g., NE-northeast).
GEOLOGIC UNIT	The geologic unit listed is a term used to differentiate basin-fill deposits based on geomorphology. A geologic unit cross reference, outlining all units used, is included as Table F-3.
MATERIAL DESCRIPTION	Material descriptions are based on either field or laboratory USCS classifications using appropriate ASTM standards for basin-fill deposits. Coarse and fine aggregate gradations used in concrete trial mix designs are included at the end of each concrete aggregate trench group.
USCS SYMBOL	Appropriate field or laboratory ASTM standards are used to classify sampled material. The Unified Soil Classification System is used in this study. Table F-1 contains detailed information on the USCS.

FIELD OBSERVATIONS

Boulders and/or Cobbles	The estimated occurrence of boulders and cobbles is based on an appraisal of the entire deposit. Cobbles have an intermediate diameter of 3 to 12 inches (8 to 30 cm); boulders have an intermediate diameter of 12 inches (30 cm) or more. Because of sample-size limitations, boulders were not generally sampled. Cobbles were representatively sampled for concrete aggregate evaluations but only generally sampled for road-base aggregate evaluations. Field observations of boulders and cobbles are important considerations for in-situ gradations only. Number percentages are equated to the following equivalent dry weight terms: Rare - 1 - 4 percent Few - 5 - 20 percent Some - > 20 percent
Gravel	Coarse aggregate particles that pass a 3-inch (76-mm) sieve but are predominantly retained on a No. 4 (4.75 mm) sieve.
Sand	Fine aggregate particles that almost entirely pass a No. 4 sieve but are predominantly retained on a No. 200 (0.075 mm) sieve.
Fines	Soil particles that pass a No. 200 sieve (silt and clay).
Overburden Thickness (Feet)	Surficial soil overlying a usable aggregate deposit. Material generally consists of silt and sand with low concentrations of gravel. Numbers presented indicate thickness of deposit in feet.
Total Trench Depth (Feet)	Depth, in feet, of trench excavation used to collect aggregate samples. Depth followed by the letter R indicates that depth below which soil strength exceeded excavation capability. The common conditions for refusal (R) are calcium carbonate accumulation (caliche) and/or presence of oversized material.

Deleterious Materials (Material/Depth/Stage)

Deleterious materials are substances that are potentially detrimental to concrete in service. Substances that may be present include: organic impurities, low density materials (ash, vesicles, pumice, cinders), amorphous silica (opal, chert, chalcedony), volcanic glass, caliche and clay coatings, mica, gypsum, pyrite, chlorite, friable materials, and aggregates that may react chemically or be affected chemically by other external influences. The most common deleterious material is calcium carbonate accumulation (caliche). When it is abundant, the interval(s) at which it occurs and the stage of development (Table F-2) are listed. Caliche can occur disseminated throughout a deposit, as lenses, and as discrete layers. The depth space is left blank when caliche is present throughout the deposit.

Plasticity (Index)

Plasticity index (PI) is the range of water content, expressed as a percentage of the weight of the oven-dried soil (less than No. 40 sieve material), through which a soil behaves plastically . It is defined as the liquid limit minus the plastic limit. Field terms used to approximate plasticity index range include the following.

Plasticity	PI	Wet Consistency
Slight	(4-15)	Slightly sticky; after pressure, soil adheres to both thumb and finger but comes off cleanly. Does not appreciably stretch.
Medium	(15-30)	Sticky; after pressure, soil adheres to both thumb and finger and tends to stretch somewhat before pulling apart from either digit.
High	(>30)	Very sticky; after pressure, soil adheres strongly to both digits and is markedly stretched when digits are separated.

Hardness

Hardness determination is a field test used to identify materials that are soft or poorly bonded by estimating their resistance to crushing by impact with a

	rock hammer. Classification terms used include:
Soft	Hammer point indents deeply with firm blow.
Moderately Hard	Hammer point indents only shallowly with firm blow.
Hard	Hammer breaks hand-held sample with one firm blow.
Very Hard	Hammer breaks intact sample with many blows.
<u>Weathering</u>	Weathering is defined as any changes in color, texture, strength, chemical composition, or other properties of rock due to the effects of various atmospheric conditions. Field terms used to classify degree of weathering include: fresh, slight(ly), moderate(ly), or very weathered.

LABORATORY TEST DATA

<u>Sieve Analysis (ASTM C 136)</u>	A sieve analysis is the determination of the proportions of particles existing within certain size ranges in granular material by separation on sieves of different size openings, expressed as a weight percent of the total sample. Numbers presented represent the percent of the sample passing through the stated sieve size. Sieve sizes include: 3-inch (75-mm), 2 1/2-inch (63-mm), 2-inch (50-mm), 1 1/2-inch (38.1-mm), 1-inch (25-mm), 3/4-inch (19-mm), 1/2-inch (12.5-mm), 3/8-inch (9.5-mm), No. 4 (4.75-mm), No. 8 (2.36-mm) No. 16 (1.18-mm) No. 30 (0.6-mm), No. 50 (0.3-mm), No. 100 (0.15-mm), No. 200 (0.075-mm).
<u>Specific Gravity and Absorption (ASTM C 127 and 128)</u>	In general, specific gravity is defined as the ratio of the weight in air of a unit volume of material to the weight in air of an equal volume of water. Absorption is the process by which a liquid is drawn into and tends to fill permeable pores in a porous solid body, also, the increase in weight of a porous

	solid body resulting from the penetration of a liquid into its permeable pores. Specific definitions of bulk, bulk saturate-surface-dry (SSD), and apparent specific gravity, as well as absorption are contained in ASTM-E 12-70 and C 125, respectively.
Fineness Modulus	Fineness modulus is an empirical factor obtained by adding the total percentages of a sample of aggregate, retained on each of a specified series of sieves, and dividing the sum by 100.
Unit Weight	Unit weight is the weight of a unit volume of dry, rodded aggregate, commonly expressed as pounds per cubic foot (pcf).
Abrasion Test (ASTM C 131)	The abrasion test is a method for testing resistance to wearing away by rubbing and friction, by placing a specified quantity of aggregates in a steel drum (the Los Angeles testing machine), rotating the drum 500 times, and determining the percent of material worn away.
Soundness Test (ASTM C 88)	Soundness tests are used to determine resistance to large or permanent volume changes of aggregates by placing samples in saturated solutions of magnesium or sodium sulfate. The test furnishes information useful in studying resistance to weathering action, particularly when adequate service records of the material tested are not available. For concrete aggregate tests, magnesium sulfate soundness tests are run first. If the material fails this test, sodium sulfate soundness tests are performed.
Petrographic Examination (ASTM C 295)	A petrographic examination is a procedure used to identify the physical and chemical properties of aggregates that have a bearing on the quality of the material in consideration of its intended use. Typical properties analyzed include: description and classification of constituents, relative amounts of constituents, particle coatings, rock type, particle condition

and particle shape, texture and structure, color, mineral composition and heterogeneities, and presence of constituents known to cause deleterious chemical reactions in concrete.

Alkali Reactivity

Alkali-Silica ASTM C 227	A potential alkali-silica reactivity test evaluates the susceptibility of cement-aggregate combinations to expansive reactions involving the alkalies sodium and potassium by measurement of the increase (or decrease) in length of mortar bars containing the combination during storage under prescribed conditions of test.
Alkali-Carbonate ASTM Proposed Standard	A potential alkali-carbonate reactivity test evaluates the susceptibility of cement-aggregate combinations to expansive reactions involving the carbonates of dolomite (in certain calcitic dolomites and dolomitic limestones) by measurement of the increase (or decrease) in length of concrete specimens (prisms) containing the combination during storage under prescribed conditions of test. This test is a proposed ASTM standard and has not been formally approved by the American Society of Testing and Materials.

AGGREGATE USE CLASSIFICATION

Road Base Aggregate	RBIa	Basin-fill or rock sources containing materials suitable for use as road-base aggregates; based on acceptable laboratory aggregate test results.
	RBIb	Basin-fill sources containing materials suitable for use as road-base aggregates; based on correlation with Class RBIa areas.
	RB II	Potential basin-fill sources of materials suitable for use as road-base aggregates; based on photogeologic interpretations, field observations, and limited or inconclusive sieve analysis and/or abrasion data.

Concrete Aggregate	CA1	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths equal to or greater than 6500 psi.
	CA2	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths less than 6500 psi.
	CB	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on acceptable laboratory aggregate test results.
	CC1	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CA1 or CA2 source areas.
	CC2	Basin-fill sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CB source areas.
	FA	Basin-fill sources containing fine aggregates used with crushed-rock samples for certain concrete trial mixes.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES	DISTRIBUTION OF MATERIAL FINER THAN COBBLES (PERCENT)		
							GRAVEL	SAND	FINES
201	PA-A-1	Pahroc Valley, W	Aaf	Sandy Gravel	GW	Some/ Rare			
202	PA-A-2	Pahroc Valley, W	Aaf	Sandy Gravel	GW	-/Few			
203	PA-A-3	Pahroc Valley, W	Aaf	Sandy Gravel	GP-GM				
	PA-A-(1,2)			Sandy Gravel	GW-GM				
204	PA-A-4	Pahroc Valley, NW	Aaf	Sandy Gravel	GM	-/Rare	50	35	15
205	PA-A-5	Pahroc Valley, NW	Aaf	Sandy Gravel	GM	-/Few	50	35	15
206	PA-A-6	Pahranagat Valley	Aaf	Sandy Gravel	GW-GM	Some/ Rare			
207	PA-A-7	Pahranagat Valley	Aaf	Sandy Gravel	GW-GM	-/Some			
208	PA-A-8	Pahranagat Valley	Aaf	Sandy Gravel	GW	-/Some			
209	PA-A-9	Pahranagat Valley	Aaf	Sandy Gravel	GP	Rare/ Some			
210	PA-A-10	Pahranagat Valley	Aaf	Sandy Gravel	GP-GM	Some/ Few			
	PA-A-(6, 7,8,9,10)			1.5in-0.75in					
	PA-A-(6, 7,8,9,10)			0.75in-No.4					

FIELD OBSERVATIONS												
OVERBURDEN THICKNESS (FEET)	TOTAL TRENCH DEPTH (FEET; R= REFUSAL DEPTH)	DELETERIOUS MATERIALS (MATERIAL/DEPTHS/ STAGE)	PLASTICITY	HARDNESS	WEATHERING	SIEVE ANALYSIS,					
						3 IN.	2½ IN.	2 IN.	1½ IN.	1 IN.	¾ IN.
1.5	8.5(R)	Caliche/3-4/II	Slight			96.9	95.3	94.1	89.3	78.7	70.4
1.5	12.0	Caliche/1.5-2.5, 9-10/II	Slight			100	93.5	92.5	87.3	76.5	70.1
1.0	4.0(R)	Caliche/1-1.5,4/II									
						100	94.1	91.5	85.6	78.3	71.6
1.0	10.0(R)	Caliche/1-2,10/II									
2.0	6.5(R)	Caliche/2-6.5/II									
1.0	13.2	Caliche Rare/-/II	Slight			100	96.5	94.6	93.2	85.0	80.0
1.0	12.8	Caliche Rare/-/I	Slight			100	98.5	95.5	92.3	85.7	79.0
1.5	12.8	Caliche Rare/-/I,II	Slight					100	96.7	87.2	78.3
1.0	13.0	Chert, Caliche/-/I	Slight			85.9	85.9	82.8	78.5	67.8	61.5
0.5	13.5	Chert;Phyllite	Slight			83.5	81.4	67.0	64.7	52.0	44.7
									100	55.3	1.1
											100

2

LABORATORY TEST DATA

LYSIS, ASTM C 136 (PERCENT PASSING)										SPECIFIC GRAVITY AND ABSORPTION, ASTM C 127 AND C 128								F M (P
										COARSE AGGREGATE				FINE AGGREGATE				
										SPECIFIC GRAVITY			ABSORP. (PERCENT)	SPECIFIC GRAVITY			ABSORP. (PERCENT)	
¾ IN.	½ IN.	⅜ IN.	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		
0.4	62.2	55.7	43.7	33.9	25.6	18.3	9.7	3.6	0.5									
0.1	62.3	56.8	45.9	36.3	27.7	19.4	13.7	4.5	1.0									
71.6	64.5	59.6	49.6	40.0	30.9	22.7	14.2	8.3	5.3									
80.0	71.0	64.4	49.1	39.0	31.3	25.9	19.8	14.6	10.2									
79.0	69.5	60.0	42.6	34.6	30.0	26.7	21.8	16.4	11.3									
78.3	64.5	54.3	36.2	25.2	19.2	16.0	12.5	9.1	4.4									
61.5	50.7	43.2	30.9	23.4	18.7	15.7	11.5	7.3	4.3									
44.7	37.2	33.3	26.5	23.1	20.2	17.7	14.3	10.4	6.1									
1.1										2.64	2.66	2.69	0.67					
100	72	50	3							2.61	2.66	2.73	1.7					

3

FINENESS MODULUS (PERCENT)	UNIT WEIGHT (PCF)	ABRASION TEST ASTM C 131 (PERCENT WEAR)	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS)				PETROGRAPHIC EXAMINATION ASTM C 295	ALKALI REACTIVITY		AGGREGATE USE CLASSIFICATION
			COARSE AGGREGATE		FINE AGGREGATE			SILICA METHOD, ASTM C 227 (LENGTH CHANGE, PERCENT)	CARBONATE METHOD, PROP. ASTM (LENGTH CHANGE, PERCENT)	
			$MgSO_4$	$NaSO_4$	$MgSO_4$	$NaSO_4$				
										RBIa,C
										RBIa,C
										RBIa,C
		35.5	13.0		28.2					
										RBIb,C
										RBIb,
										RBIa,
										RBIa,
										RBIa,
										RBIa,
										RBIa,
							Performed			
	100						Performed			

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SUMMARY OF FIELD A
TEST DA
PAHROC VALLE

5 JUN 81

TABLE A-

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T WEIGHT (PCF)	ABRASION TEST ASTM C 131 (PERCENT WEAR)	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS)				PETROGRAPHIC EXAMINATION ASTM C 295	ALKALI REACTIVITY		AGGREGATE USE CLASSIFICATION
		COARSE AGGREGATE		FINE AGGREGATE			SILICA METHOD, ASTM C 227 (LENGTH CHANGE, PERCENT)	CARBONATE METHOD, PROP. ASTM (LENGTH CHANGE, PERCENT)	
		$MgSO_4$	$NaSO_4$	$MgSO_4$	$NaSO_4$				
									RBIa,CB
									RBIa,CB
									RBIa,CB
	35.5	13.0		28.2					
									RBIb,CC2
									RBIb,CC2
									RBIa,CA1
									RBIa,CA1
									RBIa,CA1
									RBIa,CA1
									RBIa,CA1
						Performed			
100						Performed			

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SUMMARY OF FIELD AND LABORATORY
TEST DATA
PAHROC VALLEY, NEVADA

5 JUN 81 TABLE A-1 PAGE 1 OF 2

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES	DISTRIBUTION OF MATERIAL FINER THAN COBBLES (PERCENT)			OVERBURDEN
							GRAVEL	SAND	FINES	
	PA-A-(6, 7,8,9,10)			Blend(1.5in-No.4)						
	PA-A-(6, 7,8,9,10)			No.4-No.200						

FIELD OBSERVATIONS											
OVERBURDEN THICKNESS (FEET)	TOTAL TRENCH DEPTH (FEET; R= REFUSAL DEPTH)	DELETERIOUS MATERIALS (MATERIAL/DEPTHS/ STAGE)	PLASTICITY	HARDNESS	WEATHERING	SIEVE ANALYSIS,					
						3 IN.	2½ IN.	2 IN.	1½ IN.	1 IN.	¾ IN.
									100	78	51

2

LABORATORY TEST DATA

SIS, ASTM C 136 (PERCENT PASSING)									SPECIFIC GRAVITY AND ABSORPTION, ASTM C 127 AND C 128								FIN MO (PE
									COARSE AGGREGATE				FINE AGGREGATE				
									SPECIFIC GRAVITY			ABSORP. (PERCENT)	SPECIFIC GRAVITY			ABSORP. (PERCENT)	
½ IN.	⅜ IN.	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		
36	25	2															
		100	79.0	60.8	46.8	29.0	13.0	3.5					2.56	2.61	2.70	2.1	

4

INENESS ODULUS ERCENT)	UNIT WEIGHT (PCF)	ABRASION TEST ASTM C 131 (PERCENT WEAR)	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS)				PETROGRAPHIC EXAMINATION ASTM C 295	ALKALI REACTIVITY		AGGREGATE USE CLASSIFICATION
			COARSE AGGREGATE		FINE AGGREGATE			SILICA METHOD, ASTM C 227 (LENGTH CHANGE, PERCENT)	CARBONATE METHOD, PROP. ASTM (LENGTH CHANGE, PERCENT)	
			$MgSO_4$	$NaSO_4$	$MgSO_4$	$NaSO_4$				
	104.0	24.5	3.7							
2.71					17.4	2.9	Performed			

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SUMMARY OF FIELD AND
TEST DATA
PAHROC VALLEY, N

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TABLE A-1

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WEIGHT (PCF)	ABRASION TEST ASTM C 131 (PERCENT WEAR)	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS)				PETROGRAPHIC EXAMINATION ASTM C 295	ALKALI REACTIVITY		AGGREGATE USE CLASSIFICATION
		COARSE AGGREGATE		FINE AGGREGATE			SILICA METHOD, ASTM C 227 (LENGTH CHANGE, PERCENT)	CARBONATE METHOD, PROP. ASTM (LENGTH CHANGE, PERCENT)	
		$MgSO_4$	$NaSO_4$	$MgSO_4$	$NaSO_4$				
4.0	24.5	3.7							
				17.4	2.9	Performed			

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SUMMARY OF FIELD AND LABORATORY TEST DATA
PAHROC VALLEY, NEVADA

5 JUN 81 TABLE A-1 PAGE 2 OF 2

APPENDIX B

SUMMARY OF FIELD PETROGRAPHIC AND GRAIN-SIZE ANALYSES

FIELD PETROGRAPHIC AND GRAIN-SIZE ANALYSES

Field petrographic observations are presented in Table B-1. Field stations were established at various locations throughout the study area where detailed petrographic descriptions of potential basin-fill sources of aggregates were recorded. Detailed explanations for the column headings of Table B-1 are as follows:

COLUMN HEADING	EXPLANATION
MAP NUMBER	Map numbers are sequentially arranged identifiers of field petrographic stations occupied during the course of the aggregate study.
FIELD STATION	These designations are internal DARS identifiers of field petrographic designations.
LOCATION	The location column lists the geographic portion of the valley in which the field station is located (e.g., NE-northeast).
GEOLOGIC UNIT	The geologic unit listed is a term used to differentiate basin-fill deposits based on geomorphology. A geologic unit cross reference, outlining all units used, is included as Table F-3.
FIELD OBSERVATIONS	
<u>Clast Count</u>	Clast or petrographic counts are the main data collected during the field petrographic analysis. Data collected include lithology and percent present by size. Categorization by lithology is done to determine general percentages of nondeleterious and deleterious materials.
<u>Other Deleterious Clasts Present</u>	This column is reserved for recording additional types of materials present that are of poor quality for use as aggregate. Items mentioned include samples of rock types not sieved, counted, and described under clast count, such as: amorphous silica

	(chert, opal, chalcedony), volcanic glass, mica, chlorite, friable materials, low density clasts (ash, vesicles, pumice, cinders), gypsum, pyrite, organic material, and coatings (clay and caliche).
Size Distribution	The estimated occurrence of boulders and cobbles is based on the appraisal of an entire deposit only if the materials are observed in the banks of prominent stream channels. Size distribution information for gravel was generally recorded only at trench locations. Any gravel values given are expressed as a percent of the total amount of less than 3.0-inch material present. The numeral zero is used to indicate a size fraction not observed, and the letter R is used to indicate the rare occurrence of a size fraction (one to four percent).
Gradation	Gradation information was recorded at trench locations only.
Maximum Particle Size	Maximum particle size is defined as the intermediate diameter length of the most frequently occurring clast present in a deposit (in centimeters). Erratic oversized materials (boulders, large cobbles) are generally not represented as the maximum particle size.
Particle Shape	Shape of clasts are classified into the following six categories.
Angular (ANG)	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Sub-angular (SA)	Particles are similar to angular but have somewhat rounded edges.
Sub-rounded (SR)	Particles exhibit nearly plane sides but have well-rounded corners and edges.
Rounded (R)	Particles have smoothly curved sides and no edges.
Platey (P)	Particles are thin and flat with either rounded or nonrounded corners and edges.
Elongate (E)	Particles are several times longer than they are wide with rounded corners and edges.

Remarks	This column is used to describe the general site location of petrographic field stations; location terms used include: surface, shallow wash, stream channel bank or bottom, borrow pit, and road cut. Surface indicates analysis was performed on top of the stated geologic unit. Shallow wash indicates analysis was performed on top of the unit but at the bottom of a small swale. Stream channel bank or bottom indicates analysis was performed in an exposed section (incision) or within a minor stream channel deposit, respectively.

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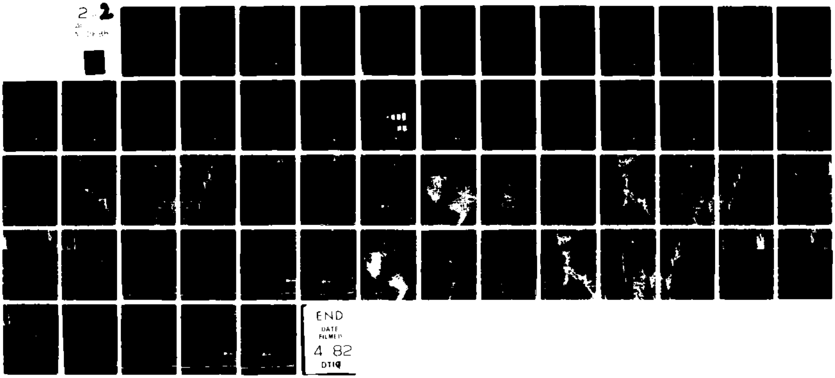

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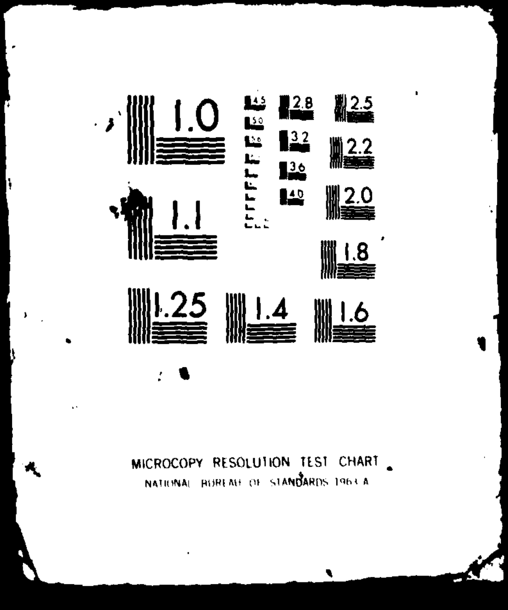

MICROCOPY RESOLUTION TEST CHART
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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	CLAST COUNT, > 1 IN. TO ≤ 3 IN. DIAMETE							
				NON-DELETERIOUS						DE	
				Qtz	Ls	Do	Gr	Vu	Vb	CALI-CHE	CHER
301	PA-1	Pahroc Valley, C	Aaf	34	46	12		4			
302	PA-2	Pahroc Valley, C	Aaf	12	48	28				6	
303	PA-3	Pahroc Valley, N	Aaf		80	20					
304	PA-4	Pahroc Valley, N	Aaf		88	12					
305	PA-5	Pahranagat Valley	Aaf		94	4					2
306	PA-6	Pahranagat Valley	Aaf	8	76	8					2

FIELD OBSERVATIONS															
TER (PERCENT)				CLAST COUNT, > ½ IN. TO ≤ 1 IN. DIAMETER (PERCENT)											OTHER DELETERIOUS CLASTS PRESENT
DELETERIOUS				NON-DELETERIOUS						DELETERIOUS					
CHERT	TUFF	GLASS	OTHER	Qtz	Ls	Do	Gr	Vu	Vb	CALICHE	CHERT	TUFF	GLASS	OTHER	
			4	10	72	14		2		2					Chalcedony, Caliche
	6			2	20	60		2		16					Caliche
					62	34				4					Caliche
					76	24									Caliche
2					76	6				12	6				Caliche
2			6	2	60	30					4			4	Caliche

2

OTHER ELETERIOUS STS PRESENT	SIZE DISTRIBUTION			GRADATION	MAXIMUM PARTICLE SIZE (CM)	PARTICLE SHAPE	REMARKS
	PERCENT OF TOTAL		<3" %				
	BOULDERS	COBBLES	GRAVEL				
alcedony, liche					5	SA,SR	Surface
liche	1	20			11	SA,SR	Stream Channel,Bottom
aliche					10	A,SA,SR	Shallow Wash
aliche					3	SA	Shallow Wash
aliche					4	SA,SR	Surface
aliche	0	20			10	SR,R	Road Cut

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SUMMARY OF FIELD PETROGRAPHIC
AND GRAIN-SIZE ANALYSES
PAHROC VALLEY, NEVADA

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APPENDIX C

TRENCH LOGS

EXPLANATION OF TRENCH LOGS

Trench logs were completed for excavated trenches. Each log presented in this appendix is chosen from a group of trench logs so that it represents the general aggregate conditions and properties of that entire group. Occasionally, the full compliment of trenches in a group was not excavated due to low gravel percentages and/or advanced caliche development found in the first one or two trenches of that group. Detailed explanations of the trench logs headings are as follows:

COLUMN HEADING		EXPLANATION
BULK SAMPLE		Representative samples were obtained by channel sampling a trench wall. Overburden and, in some trenches, dense caliche layers were avoided during the sampling procedure.
	II -	100 lb. sample (2 bags) for road-base aggregate testing.
	III -	400 lb. sample (55 gallon barrel) for concrete aggregate testing.
DEPTH		Depth corresponds to depth below ground surface in meters and feet.
LITHOLOGY		Graphic representation of soil types present in excavation.
USCS		Unified Soil Classification System symbols. For detailed information see Table F-1.
CONSISTENCY		The consistency of the in-situ deposit was estimated by visual observation of the soil in the trench walls, ease (or difficulty) of excavation of the trench, and trench-wall stability. Consistency descriptions of coarse-grained soils (GW, GP, GM, GC, SW, SP, SM, SC) are as follows:

	DESCRIPTION
Very Loose (VL)	Will not hold vertical cut (when dry).

Loose (L)	Will hold vertical cut, but caves if disturbed.
Medium Dense (MD)	Holds vertical cut, even when disturbed; easily excavated.
Dense (D)	Holds vertical cut, difficult to excavate.
Very Dense (VD)	Very difficult to impossible to excavate.

SOIL DESCRIPTION

Except in cases where samples were classified based on laboratory data, the descriptions are based on visual classification. The procedures outlined in ASTM D 2487-69, Classification of Soils for Engineering Purposes and D 2488-69, Description of Soils (Visual-Manual Procedure) were followed. Solid lines across the column indicate known changes in the strata at the depth shown.

Definitions of some of the terms and criteria used to describe soils and conditions encountered during the excavation follow:

Descriptive Name	Name of soil, as determined by USCS, preceded by an adjective indicating the size range of the most abundant secondary material present.
Particle Size	For coarse-grained soils (sands and gravels) the size range of the particles visible to the unaided eye was estimated as fine, medium, coarse, or a combined range (e.g., fine to medium). These terms approximately correspond to the following sieve sizes:

Gravel	Fine	No. 4 to 3/4-inch sieve
	Coarse	3/4-inch to 3-inch sieve
Sand	Fine	No. 200 to No. 40 sieve
	Medium	No. 40 to No. 10 sieve
	Coarse	No. 10 to No. 4 sieve

Particle Shape	See Appendix B explanation pages.
Gradation	Gradations listed are those determined from percent amounts of boulders, cobbles, and gravel present. Descriptive terms used include: poor and well.

Poor(ly)	Predominantly one size or a range of sizes, with some intermediate sizes missing.
Well	Wide range in grain sizes present, with substantial amounts of most intermediate sizes.
Secondary Material	Percentage present by dry weight. Trace 5-12 percent Little 13-20 percent Some > 20 percent (e.g., Some slightly plastic silt)
Plasticity of Fines	See Appendix A explanation pages
HCL Reaction	As an aid for identifying calcium carbonate coatings and cementation, soil samples were tested in the field for their reaction to dilute hydrochloric acid. The intensity of the HCL reaction was described as none, weak, or strong.
Caliche	Caliche is a term applied to calcareous material of secondary accumulation. In this study, the definition includes both the soluble calcium (and other) salts and the clastic material (gravel, sand, silt or clay) in which the salts exist. See Table F-2 for a description of the stages of caliche development.
Cobbles and Boulders	See Appendix A explanation pages.
Lithology	The various rock types found in an excavated deposit are listed in order of decreasing abundance.
Remarks	This column was provided for comments regarding difficulty of excavation, caliche development, and backhoe refusal. Refusal indicates the inability of a JCB 3DIII backhoe (Case 680 equivalent) with a 2-foot wide bucket to excavate a trench to completion.
SIEVE ANALYSIS	The numbers cited represent the percentage by dry weight of each of the following soil components.

GR	Coarse aggregate particles that pass a 3-inch (75 mm) sieve but are predominantly retained on a No. 4 (4.75 mm) sieve.
SA	Fine aggregate particles that almost entirely pass a No. 4 sieve but are predominantly retained on a No. 200 (0.075 mm) sieve.
FI	Soil particles that pass a No. 200 sieve (silt and clay).

All percentages shown on logs are the result of laboratory testing.

BULK SAMPLE	DEPTH		LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS		
	METERS	FEET						GR	SA	FI
	0	0		SM	medium dense	SILTY SAND - OVERBURDEN				
	1 2	2 4 6		GW	medium dense	SANDY GRAVEL, fine to coarse, subrounded, well graded; some fine to coarse, subrounded sand; strong HCl reaction; stage II caliche from 3' to 4' and from 8.0' to 8.5'; some cobbles and rare boulder; limestone/dolomite, quartzite, minor volcanics.		55	44	1
		8			very dense		Refusal			
	3 4 5 6	10 12 14 16 18 20				TOTAL DEPTH 8.5 ft. (2.6m)				

TRENCH DETAILS

SURFACE ELEVATION : 4376 ft. (1334m)
DATE EXCAVATED : 30 October 1980
SURFACE GEOLOGIC UNIT : Aafg
TRENCH LENGTH : 15 ft. (4.6m)
TRENCH ORIENTATION : NNE - SSW

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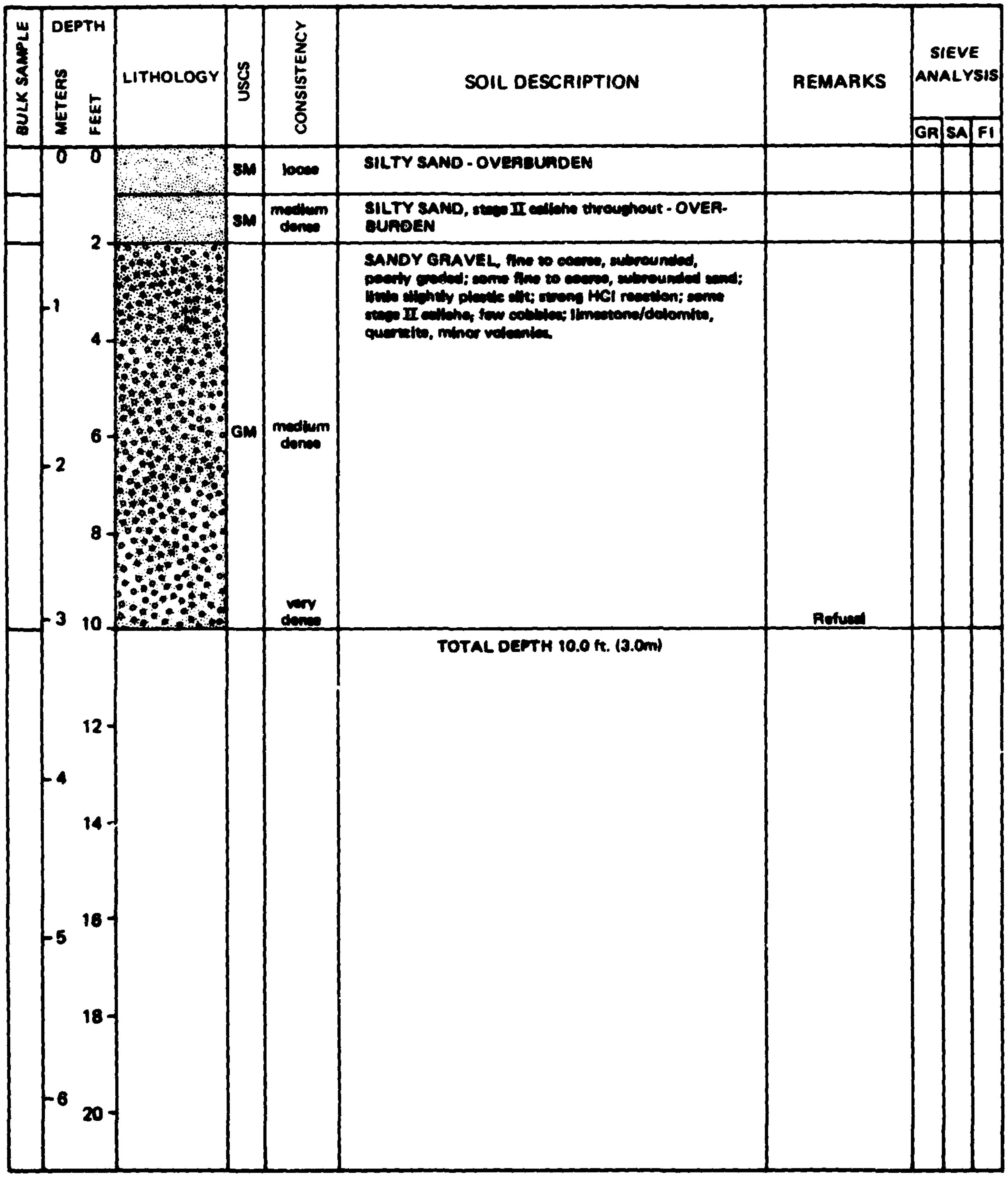
TRENCH LOG OF PA-A-1
PAHROC VALLEY, NEVADA

5 JUN 81

Figure C-1



BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SIEVE ANALYSIS SA	SIEVE ANALYSIS FI
	0	0	▒	SM	loose	SILTY SAND - OVERBURDEN				
		2	▒	SM	medium dense	SILTY SAND, stage II caliche throughout - OVERBURDEN				
	1 2 3	4 6 8 10	▓	GM	medium dense very dense	SANDY GRAVEL, fine to coarse, subrounded, poorly graded; some fine to coarse, subrounded sand; little slightly plastic silt; strong HCl reaction; some stage II caliche, few cobbles; limestone/dolomite, quartzite, minor volcanics.	Refusal			
	4 5 6	12 14 16 18 20				TOTAL DEPTH 10.0 ft. (3.0m)				

TRENCH DETAILS

SURFACE ELEVATION : 4365 ft. (1330m)
DATE EXCAVATED : 30 October 1980
SURFACE GEOLOGIC UNIT : Aafg
TRENCH LENGTH : 14 ft. (4.3m)
ENCH ORIENT ION : NNW - SSE

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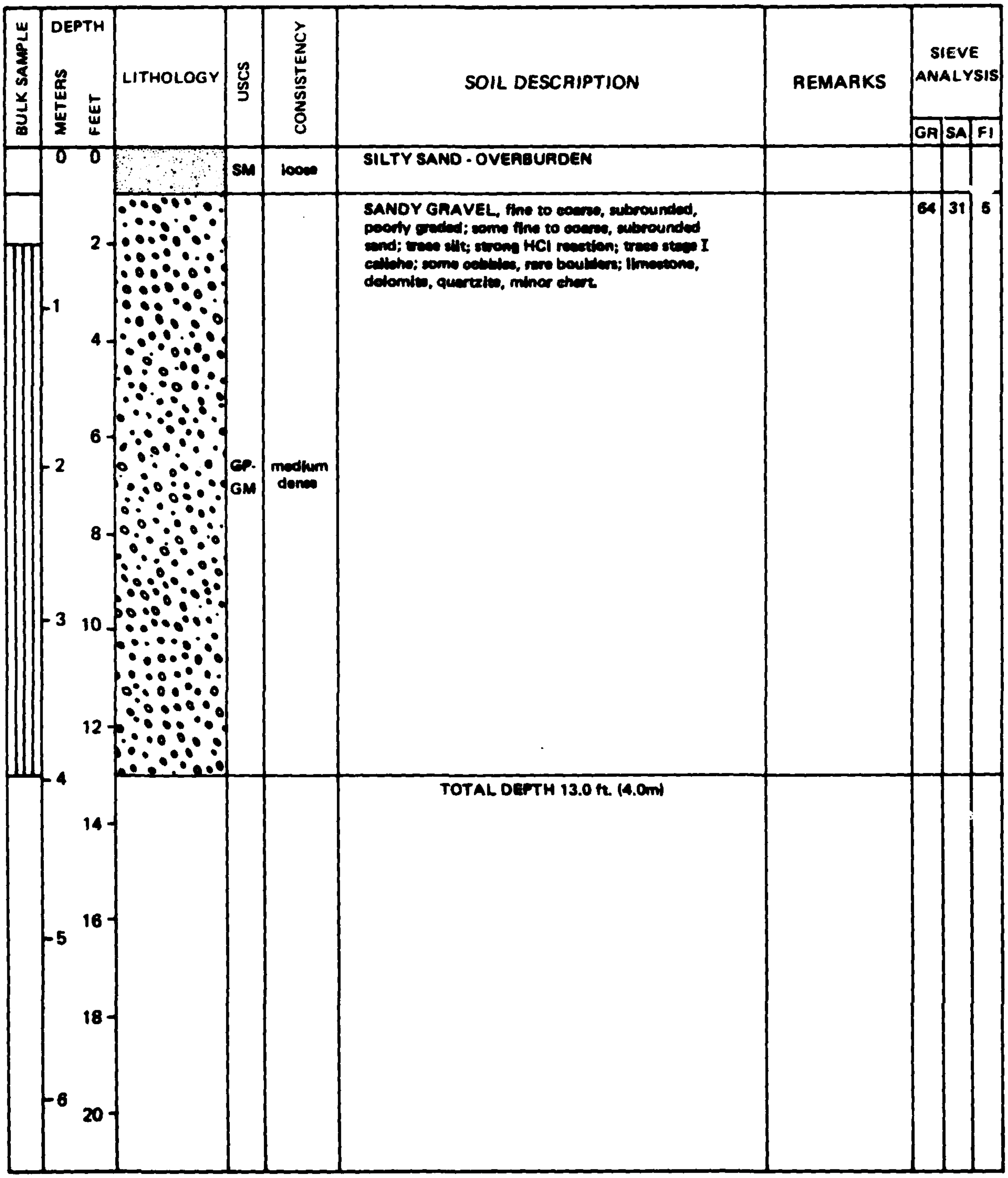
TRENCH LOG OF PA-A-4
PAHROC VALLEY, NEVADA

5 JUN 81 FIGURE C-2



USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS		
				GR	SA	FI
SM	loose	SILTY SAND - OVERBURDEN				
GP-GM	medium dense	SANDY GRAVEL, fine to coarse, subrounded, poorly graded; some fine to coarse, subrounded sand; trace silt; strong HCl reaction; trace stage I caliche; some cobbles, rare boulders; limestone, dolomite, quartzite, minor chert.		64	31	5
		TOTAL DEPTH 13.0 ft. (4.0m)				

TRENCH DETAILS

SURFACE ELEVATION : 4360 ft. (1329m)
DATE EXCAVATED : 31 October 1980
SURFACE GEOLOGIC UNIT : Aafg
TRENCH LENGTH : 15 ft. (4.6m)
TRENCH ORIENTATION : NNE - SSW

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TRENCH LOG OF PA-A-9
PAHRANAGAT VALLEY, NEVADA

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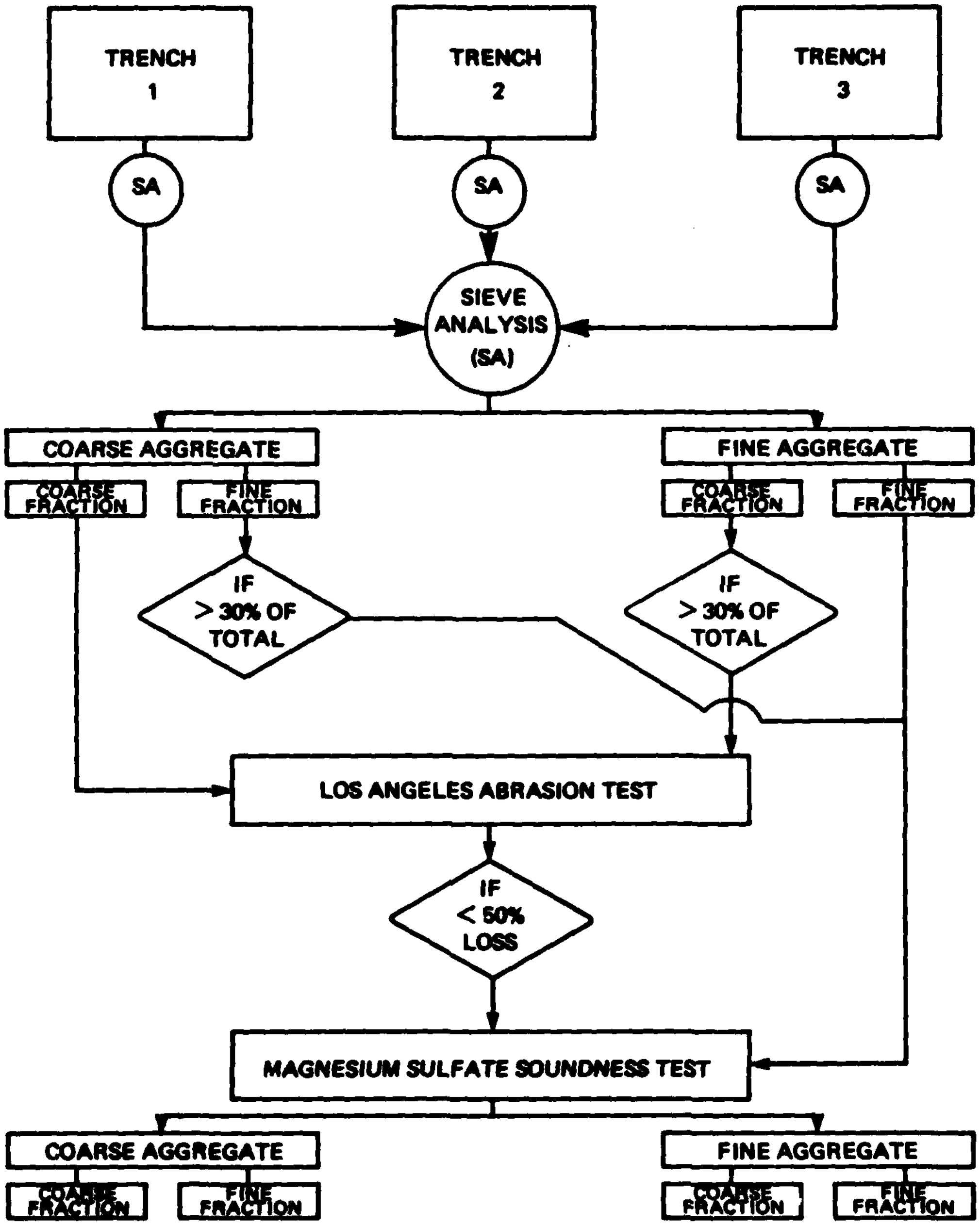
FIGURE C-3

APPENDIX D

FLOW DIAGRAM - ROAD-BASE AGGREGATES TESTING

FLOW DIAGRAM - CONCRETE TRIAL MIX DESIGN AND TESTING



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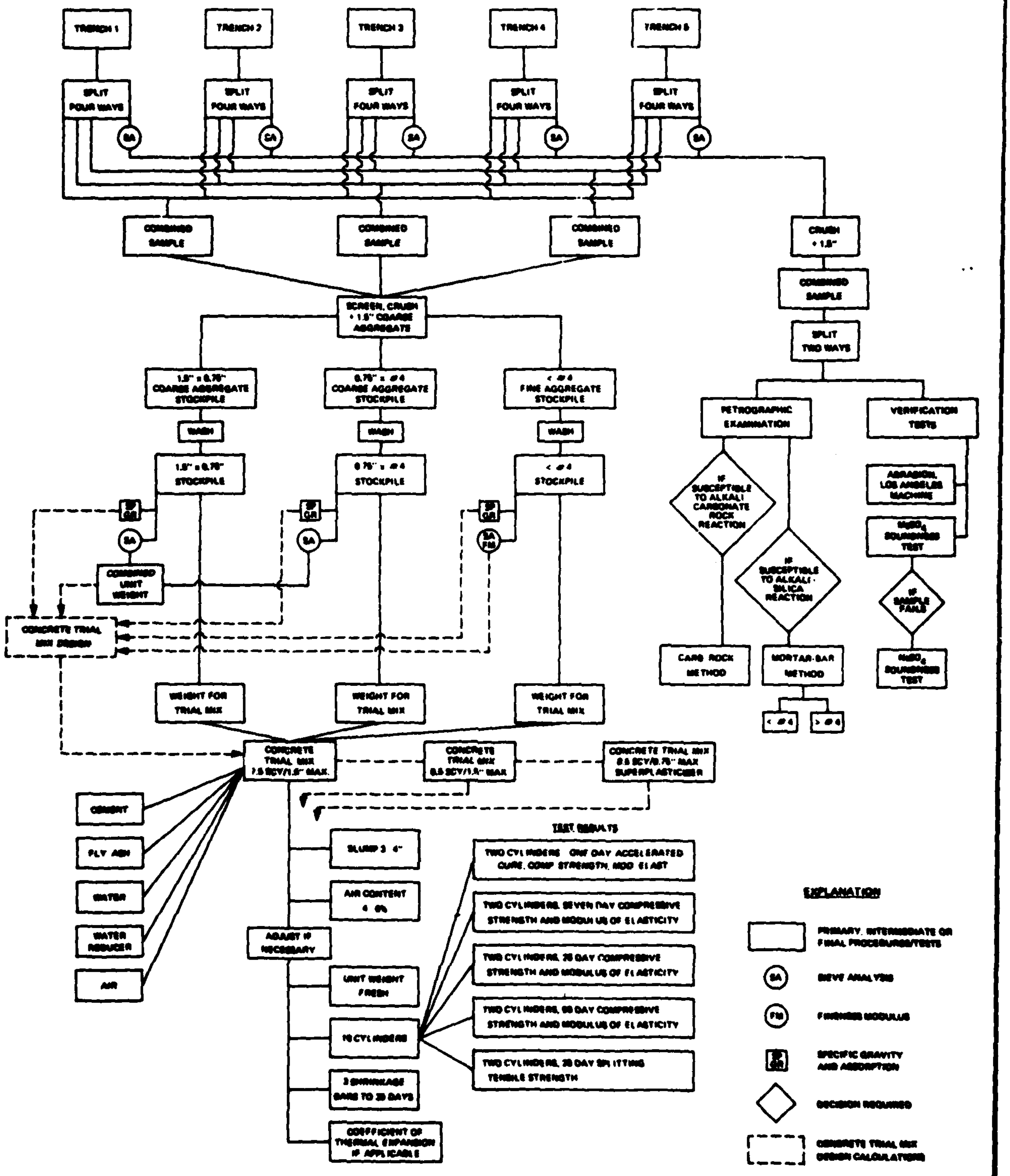
FLOW DIAGRAM –
ROAD-BASE AGGREGATES
TESTING

8 JUN 81

FIGURE D-1



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FLOW DIAGRAM – CONCRETE TRIAL MIX DESIGN AND TESTING

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FIGURE D-2

APPENDIX E

CHEMICAL ANALYSES OF CEMENT, FLY ASH, AND WATER USED IN CONCRETE TRIAL MIXES

	PROPERTY ANALYZED	TOTAL PERCENTAGE OF SAMPLE	MINIMUM OR MAXIMUM REQUIREMENTS
CEMENT ASTM C 150, TYPE II	SiO_2	26.8	20.0 MIN.
	AL_2O_3	1.95	6.0 MAX.
	Fe_2O_3	2.71	6.0 MAX.
	MgO	1.57	6.0 MAX.
	ALKALIES ($Na_2O + 0.658\ K_2O$)	0.53	0.60 MAX.
	LOSS ON IGNITION	0.56	3.0 MAX.
	SO_3	1.97	3.0 MAX.
	INSOLUBLE RESIDUE	0.61	0.75 MAX.
FLY ASH ASTM C 618, CLASS F	SiO_2	67.7	–
	AL_2O_2	17.2	–
	Fe_2O_3	8.34	–
	TOTAL	93.24	70.0 MIN.
	MgO	1.69	5.0 MAX.
	SO_3	0.14	5.0 MAX.
	Na_2O (OPTIONAL)	1.68	1.5 MAX.
	MOISTURE	0.08	3.0 MAX.
	LOSS ON IGNITION	0.83	12.0 MAX.
WATER CALIF. DEPT. TRANS. SEC. 90 - 2.03	pH	7.5	–
	COLOR	0 - 5	–
	SO_4	8 ppm	1300 ppm
	Cl	10.6 ppm	650 ppm
	OIL AND GREASE	NONE	NONE

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CHEMICAL ANALYSES OF CEMENT,
FLY ASH, AND WATER USED IN
CONCRETE TRIAL MIXES

5 JUN 81

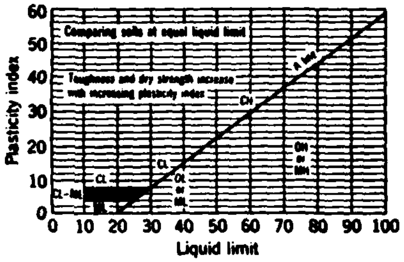
TABLE E-1

APPENDIX F

UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY OF CALICHE DEVELOPMENT

ERTEC WESTERN GEOLOGIC UNIT CROSS REFERENCE

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 For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *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 Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP* More than 12% *GM, GC, SM, SC* 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ 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 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ 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	
Fine-grained soils More than half of material is *smaller* than No. 200 sieve size	Identification Procedures on Fraction Smaller than No. 40 Sieve Size										
			Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)						
	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 For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)	 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.

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UNIFIED SOIL CLASSIFICATION SYSTEM

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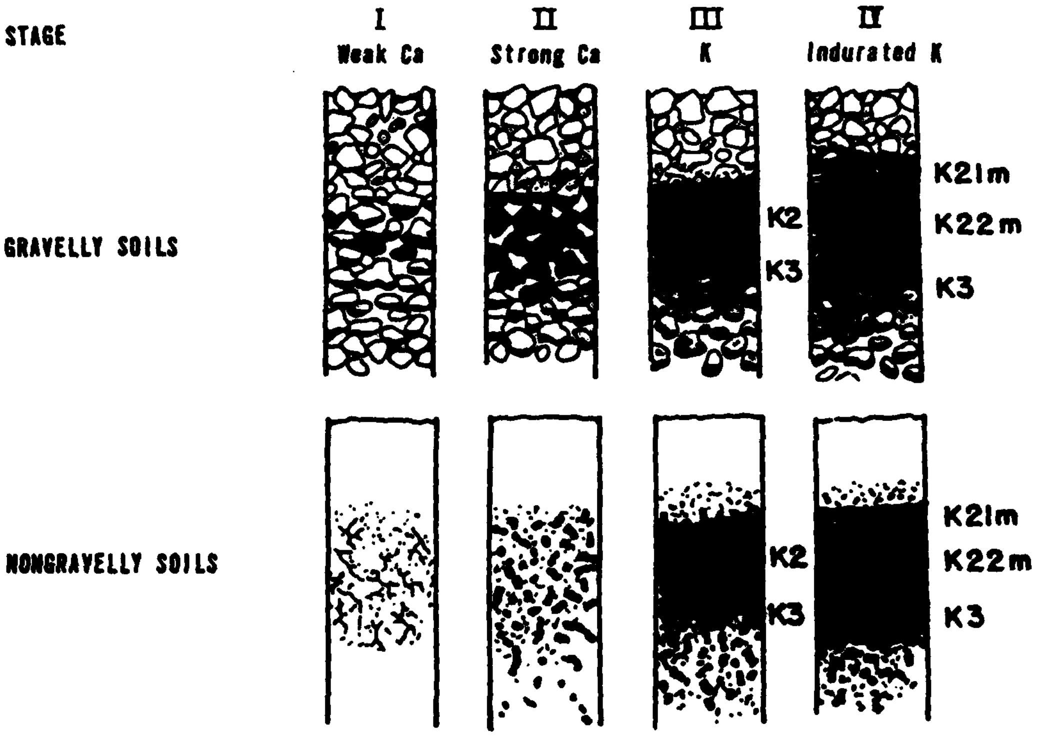
TABLE F-1

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

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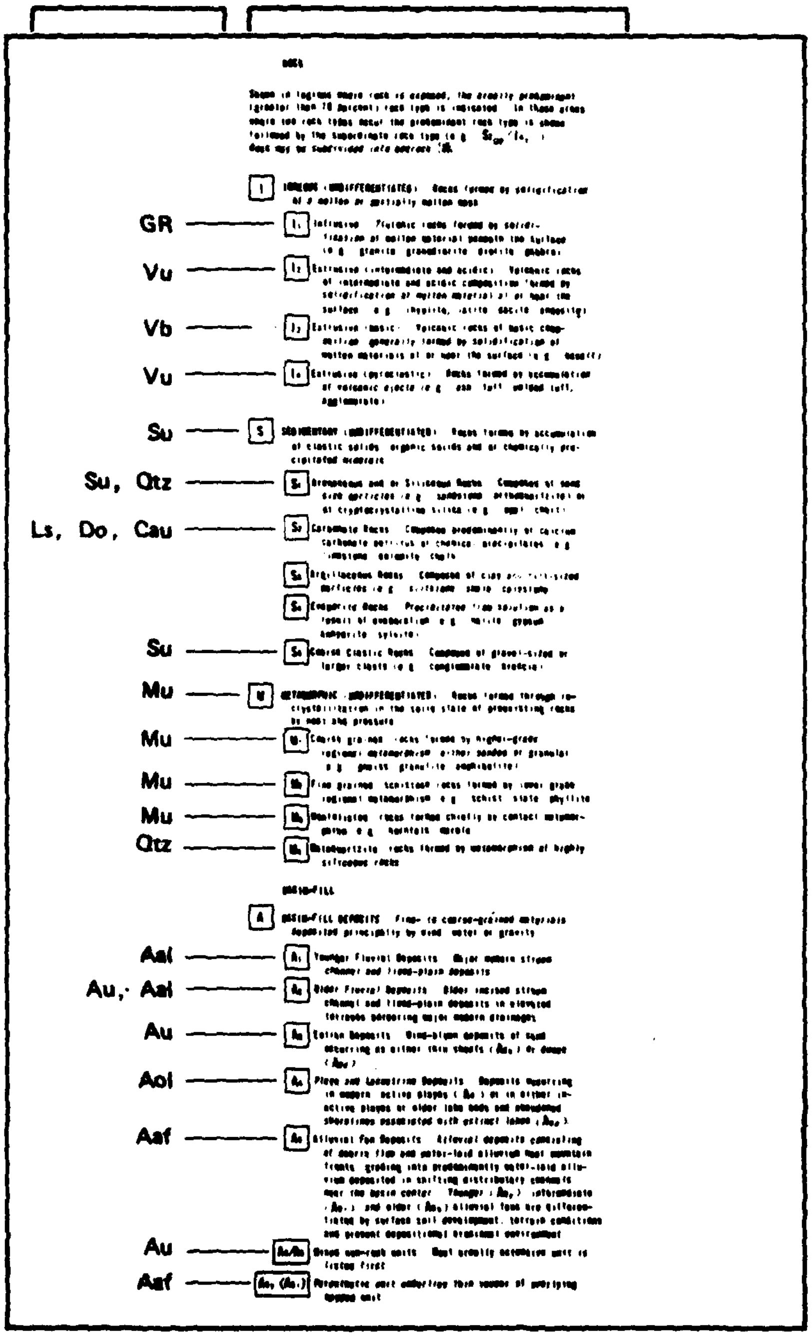
SUMMARY OF CALICHE DEVELOPEMENT

5 JUN 81

TABLE F-2

U ARSA POTENTIAL AGGREGATE SOURCE SYMBOLS

ERTEC WESTERN GEOLOGIC UNIT UNIT EXPLANATION



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ERTEC WESTERN GEOLOGIC UNIT CROSS REFERENCE

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TABLE F-3

APPENDIX G

CROSS REFERENCE FROM MAP
NUMBER TO VERIFICATION ACTIVITY

CROSS REFERENCE FROM MAP NUMBER TO VERIFICATION ACTIVITY

Included in this appendix is one table that is presented to allow cross reference to be made from this aggregate resources study to an appropriate verification study. Map numbers in the number series 400 to 599 on Drawing 1 are keyed to an in progress Verification report of Pahroc Valley, Nevada (E-TR-27-PA-I and II). If detailed information is required from a verification activity, the following search procedure can be used: determine the location of the activity required on Drawing 1, note the map number, refer to that map number in Table G-1, read from that table the verification activity type and number, refer to the appropriate verification report for the data required.

Table Number	Title
G-1	Cross Reference from Map Number to Verification Activity, Pahroc Valley, Nevada

MAP NUMBER	ACTIVITY LOCATION	MAP NUMBER	ACTIVITY LOCATION
401	GS - 30	423	CS - 12
402	T - 3	424	GS - 22
403	GS - 9	425	P - 3
404	CS - 8	426	GS - 5
405	GS - 8	427	GS - 21
406	T - 4	428	GS - 32
407	GS - 28	429	CS - 13
408	GS - 27	430	GS - 4
409	T - 6	431	T - 2
410	P - 8	432	CS - 15
411	GS - 26	433	GS - 12
412	CS - 3	434	GS - 7
413	GS - 3	435	P - 4
414	GS - 10	436	GS - 11
415	P - 7	437	GS - 20
416	GS - 25	438	GS - 18
417	GS - 29	439	CS - 17
418	T - 5	440	GS - 19
419	P - 6	441	GS - 6
420	GS - 24	442	P - 2
421	GS - 23	443	GS - 13
422	GS - 31	444	GS - 14

T - TRENCH
B - BORING
P - TEST PIT
CS - SURFACE SAMPLE
GS - GEOLOGIC STATION

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CROSS REFERENCE FROM MAP NUMBER
TO VERIFICATION ACTIVITY
PAHROC VALLEY, NEVADA

5 JUN 81 TABLE G-1 1 OF 2

MAP NUMBER	ACTIVITY LOCATION	MAP NUMBER	ACTIVITY LOCATION
445	GS - 17	467	GS - 48
446	CS - 19	468	GS - 44
447	GS - 16	469	GS - 49
448	P - 1	470	GS - 43
449	T - 1	471	GS - 37
450	GS - 15	472	GS - 41
451	GS - 1	473	GS - 42
452	P - 12	474	GS - 38
453	GS - 2	475	GS - 33
454	GS - 47		
455	GS - 34		
456	GS - 40		
457	CS - 23		
458	GS - 46		
459	GS - 45		
460	P - 9		
461	GS - 39		
462	CS - 25		
463	GS - 35		
464	P - 10		
465	GS - 36		
466	CS - 27		

T - TRENCH
B - BORING
P - TEST PIT
CS - SURFACE SAMPLE
GS - GEOLOGIC STATION

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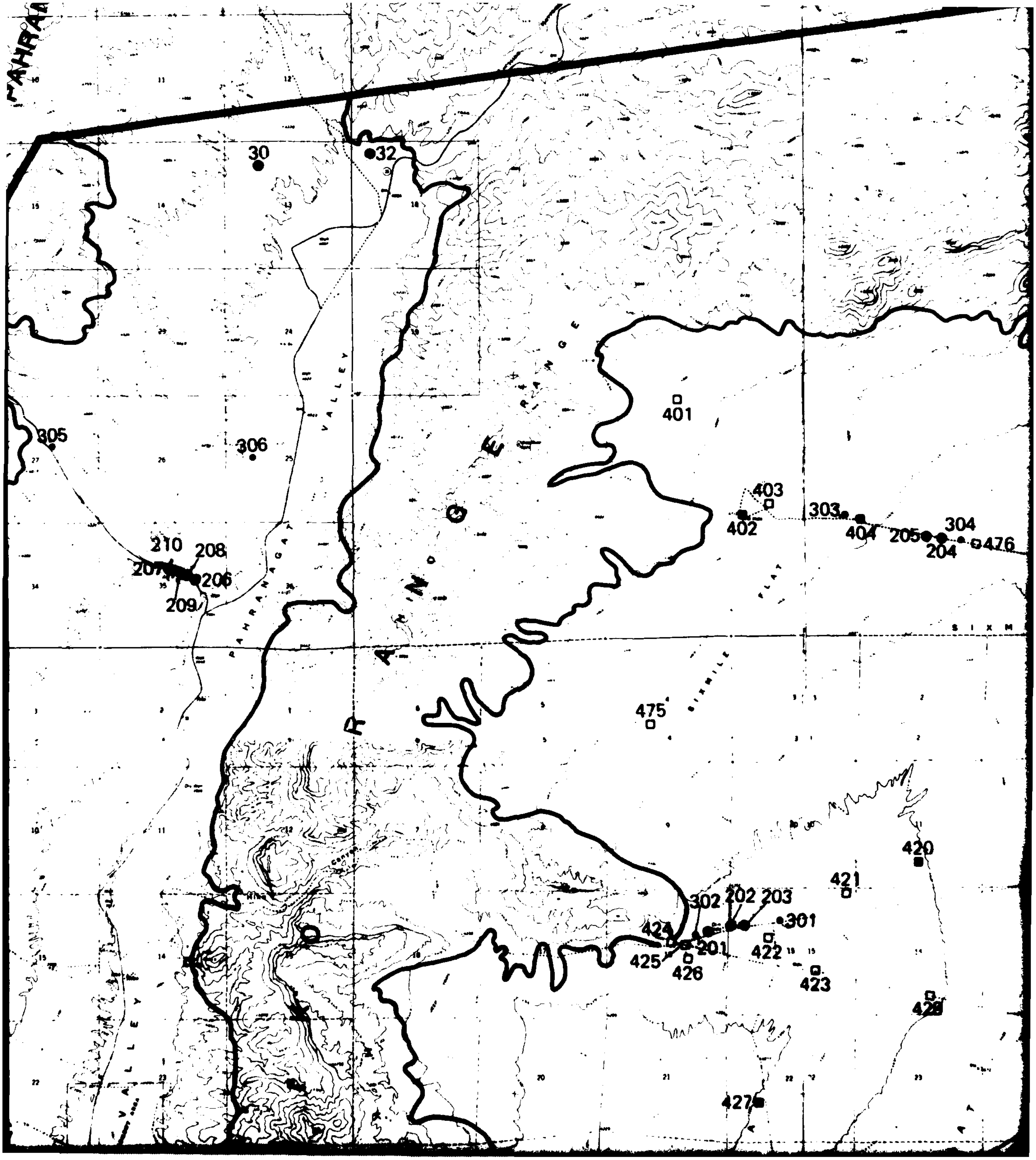
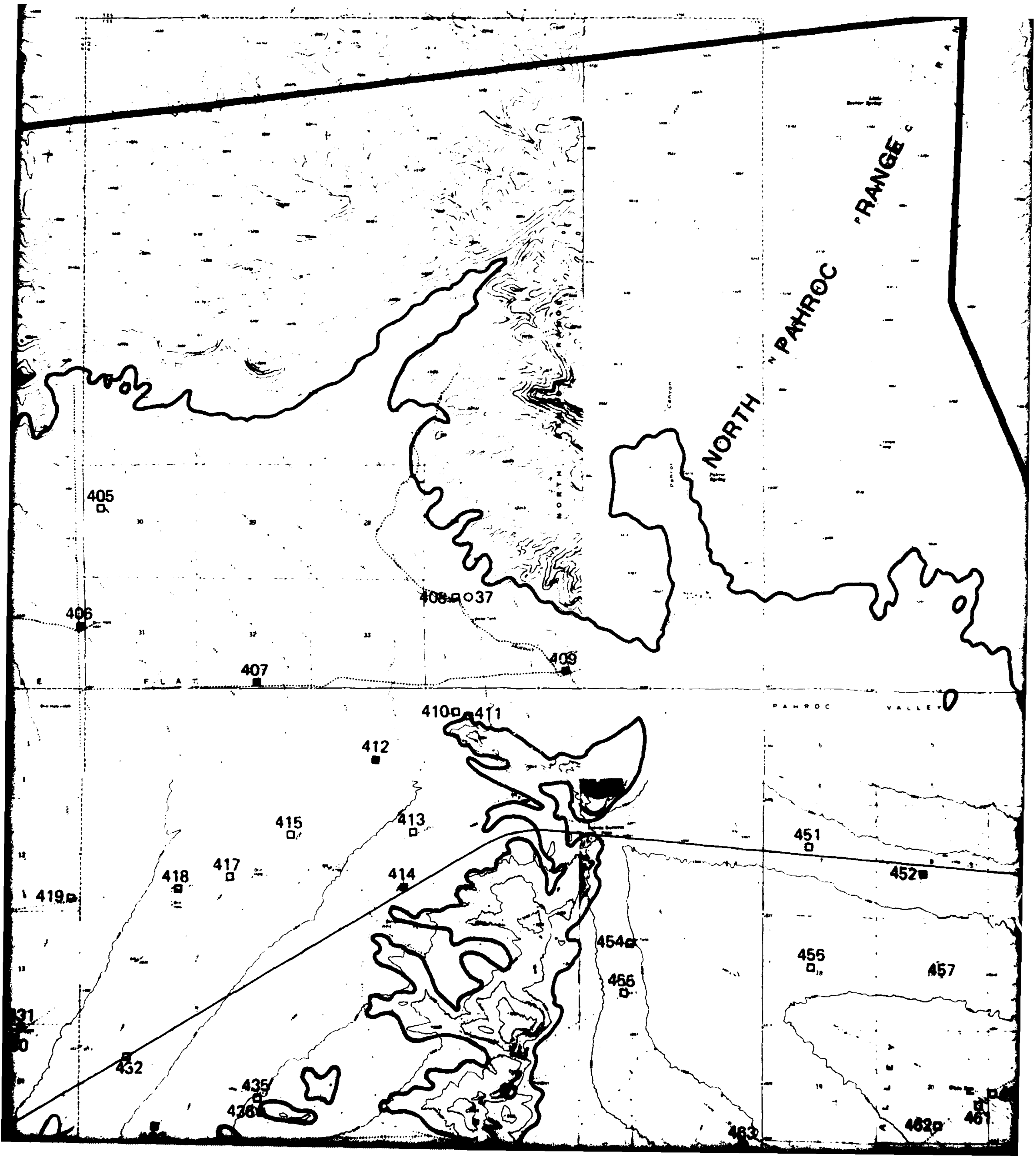
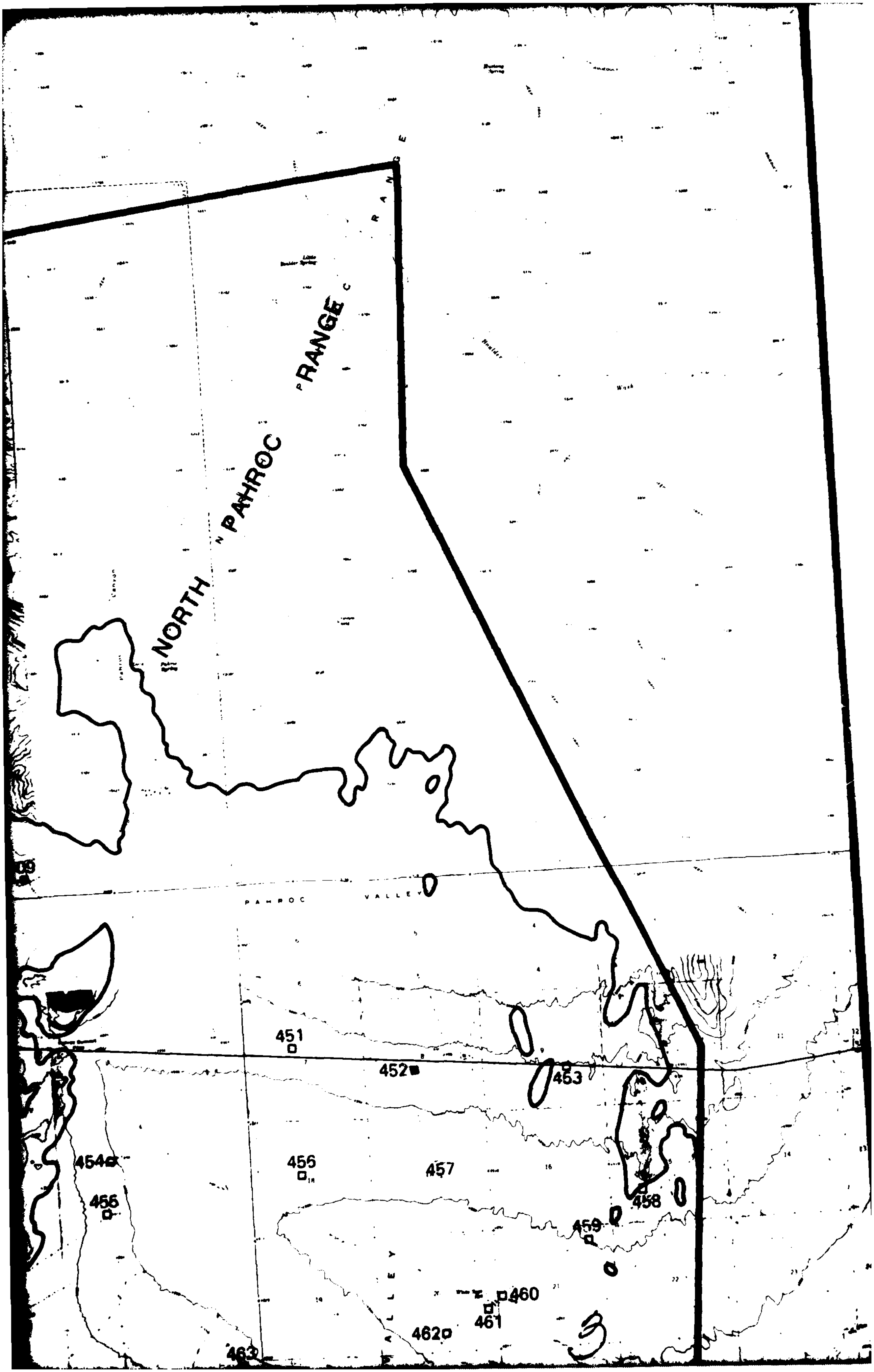
CROSS REFERENCE FROM MAP NUMBER
TO VERIFICATION ACTIVITY
PAHROC VALLEY, NEVADA

5 JUN 81

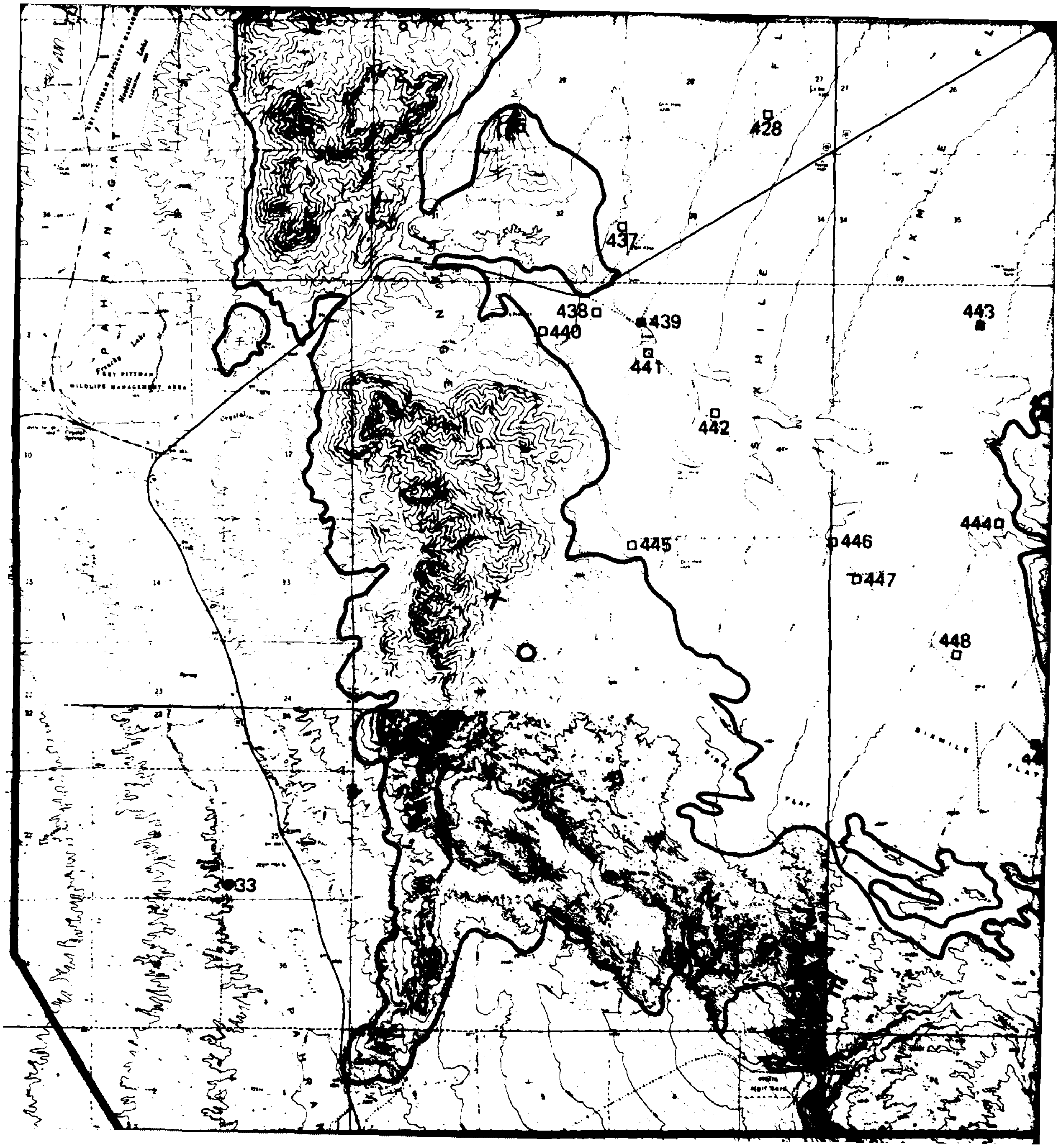
TABLE 6-1 2 OF 2

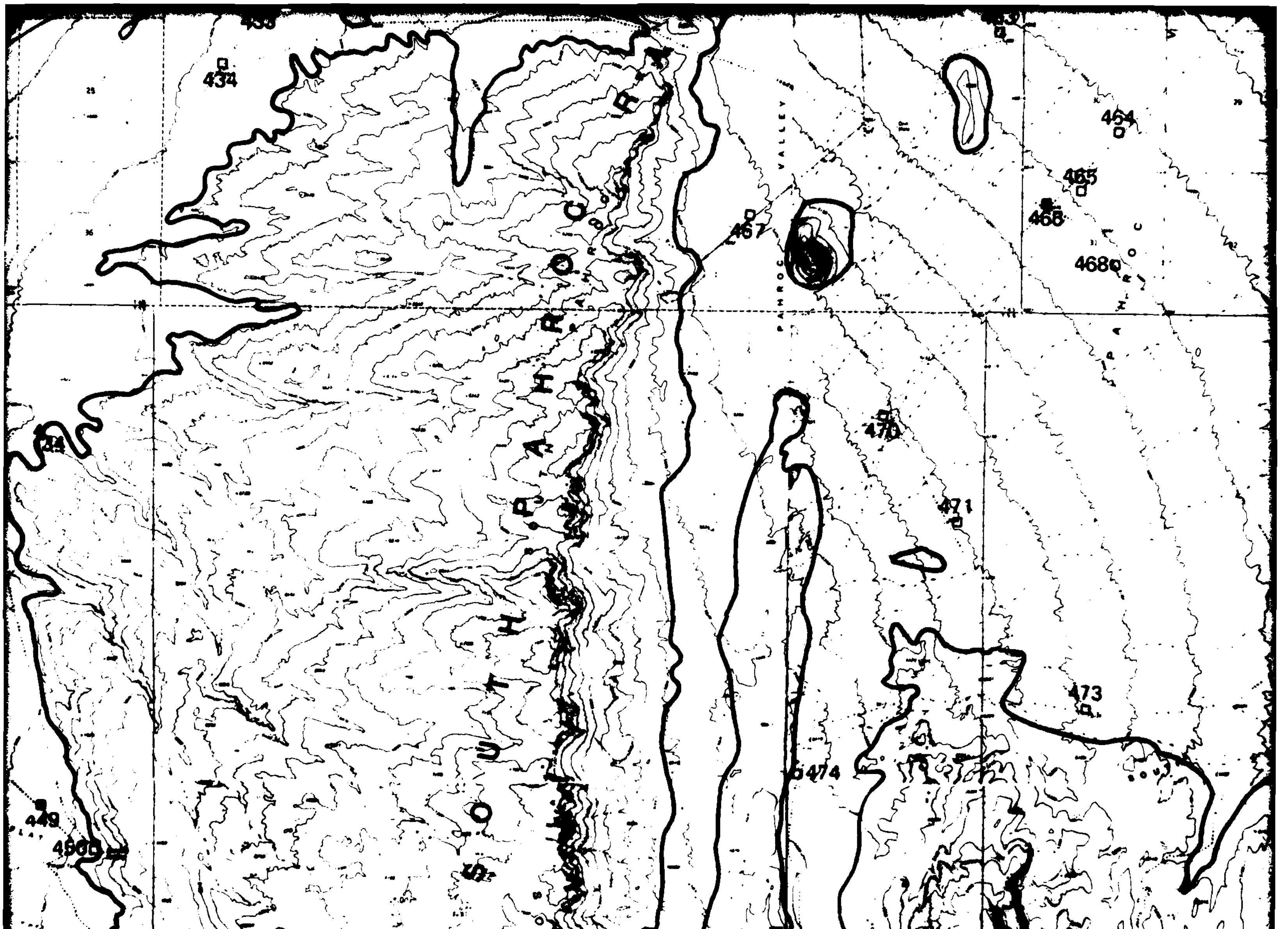

30
32
305
306
210
208
207
206
209
VALLEY
PAHRANAGAT
RANGE
401
403
402
303
404
205
304
204
476
SIX M
FLAT
SIXMILE
475
420
421
302
202
203
301
424
201
422
425
426
423
428
427
VALLEY

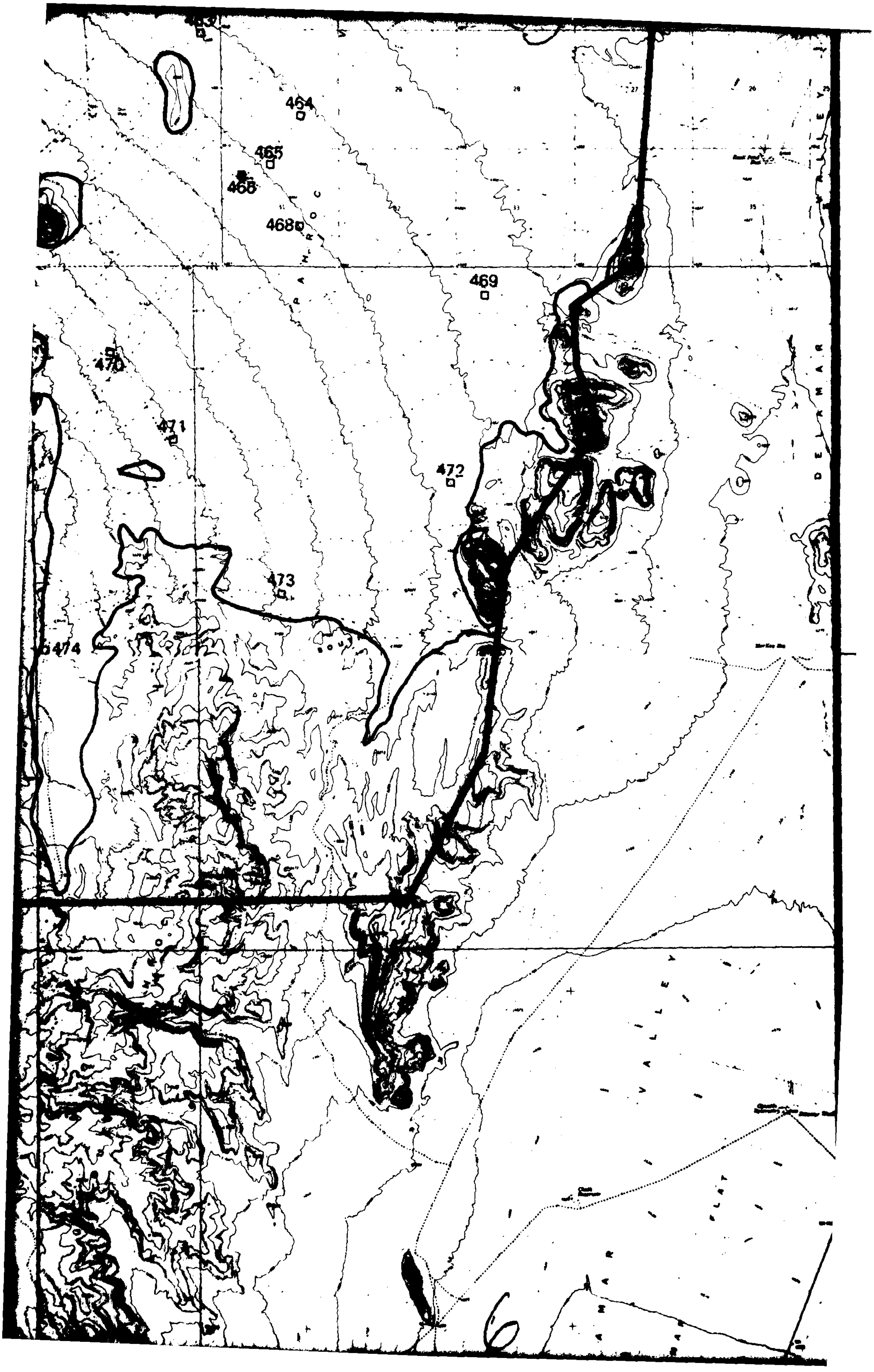

NORTH PAHROC RANGE
405
406
407
408
37
409
410
411
412
413
414
415
417
418
419
FLAT
PAHROC VALLEY
451
452
454
456
457
466
432
435
436
463
462
461



NORTH PAHROC RANGE
Little Boulder Spring
Boulder Wash
PAHROC VALLEY
09
451
452
453
454
456
456
457
458
459
460
461
462
463
VALLEY
3


428
437
438
439
440
441
442
443
444
445
446
447
448
33
PAHRANAGAT
KEY PITTMAN WILDLIFE MANAGEMENT AREA
LAS VEGAS
SIX MILE
SIX MILE FLAT


SOUTH PAHROC RANGE
SOUTH HIKO RANGE
PAHROC VALLEY
434
464
465
466
467
468
470
471
473
474
449
4600



463
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DELAMAR
VALLEY
FLAT
6

H

EXPL

ERTEC WESTERN AGGREGATE RESOURCES STUDY FIELD STATIONS

VALLEY SPECIFIC AGGREGATE RESOURCES STUDY
(MAP NUMBERS FROM 1 TO 199)

BASIN FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

▲ DATA STOP, SAMPLED AND TESTED

△ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY * *
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL
AND ROCK SAMPLE LOCATIONS; 300 TO 399 FOR FIELD
PETROGRAPHIC STATIONS)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

▲ DATA STOP, SAMPLED AND TESTED

PETROGRAPHIC FIELD STATIONS

• DATA STOP

M

115°00'

ANATION

EXISTING ERTEC WESTERN TEST DATA LOCATIONS ***
(MAP NUMBERS FROM 400 TO 599)

■ DATA STOP, SAMPLED AND TESTED

□ DATA STOP

* SEE DRY LAKE, MULESHOE, DELAMAR, PAHROC VSARS REPORT (FN-TR-37-a) FOR DETAILED INFORMATION.

** SEE CORRESPONDING MAP NUMBER IN APPENDICES A AND B FOR DETAILED INFORMATION.

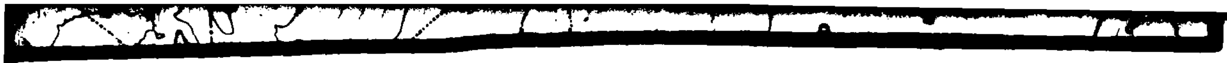
*** SEE CORRESPONDING MAP NUMBER AND ACTIVITY TYPE IN APPENDIX G FOR REFERENCE TO THE IN PROGRESS PAHROC VALLEY VERIFICATION REPORT (E-TR-27-PA-I AND II).

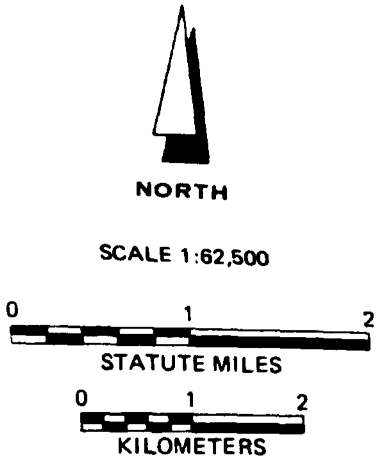
SYMBOLS

━━ STUDY AREA BOUNDARY

—— ROCK/BASIN–FILL CONTACT

a



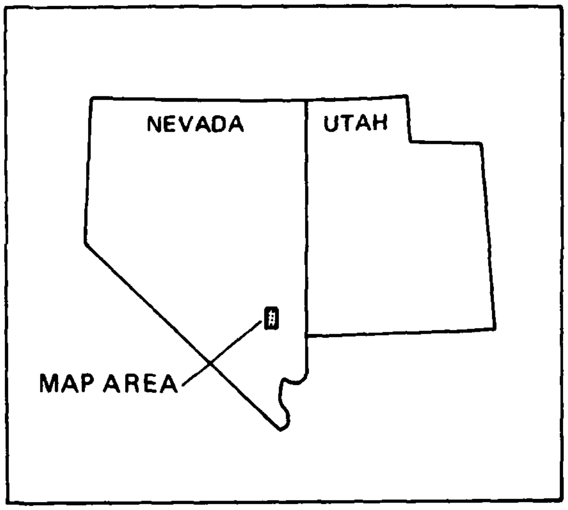


VSARS
ION.

ICES A AND B

VITY TYPE IN
RESS PAHROC
AND II).

LOCATION MAP



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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

FIELD STATION AND SELECTED EXISTING DATA SITE LOCATIONS DETAILED AGGREGATE RESOURCES STUDY PAHROC STUDY AREA, NEVADA

5 JUN 81

DRAWING 1


Aaf
Aaf
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206
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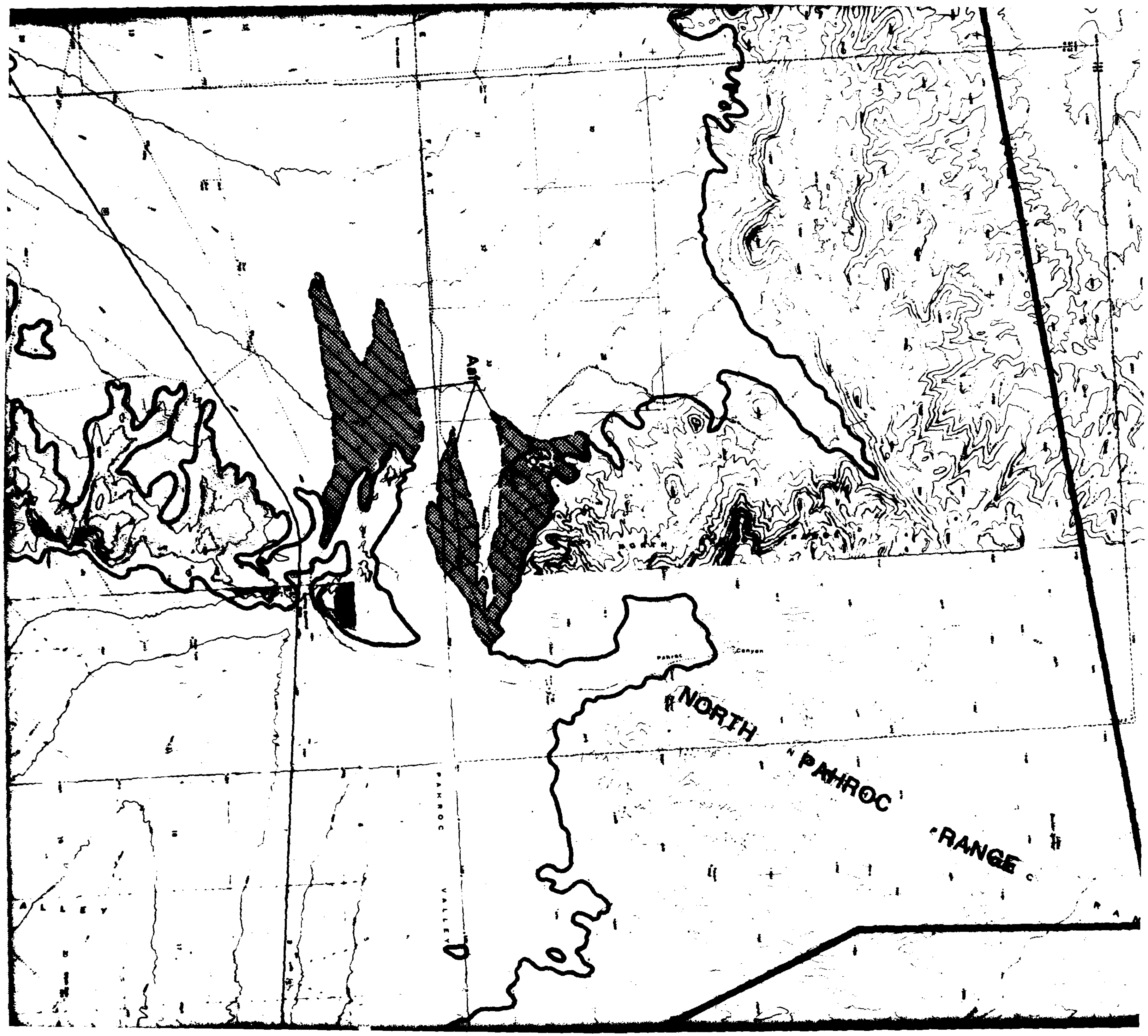
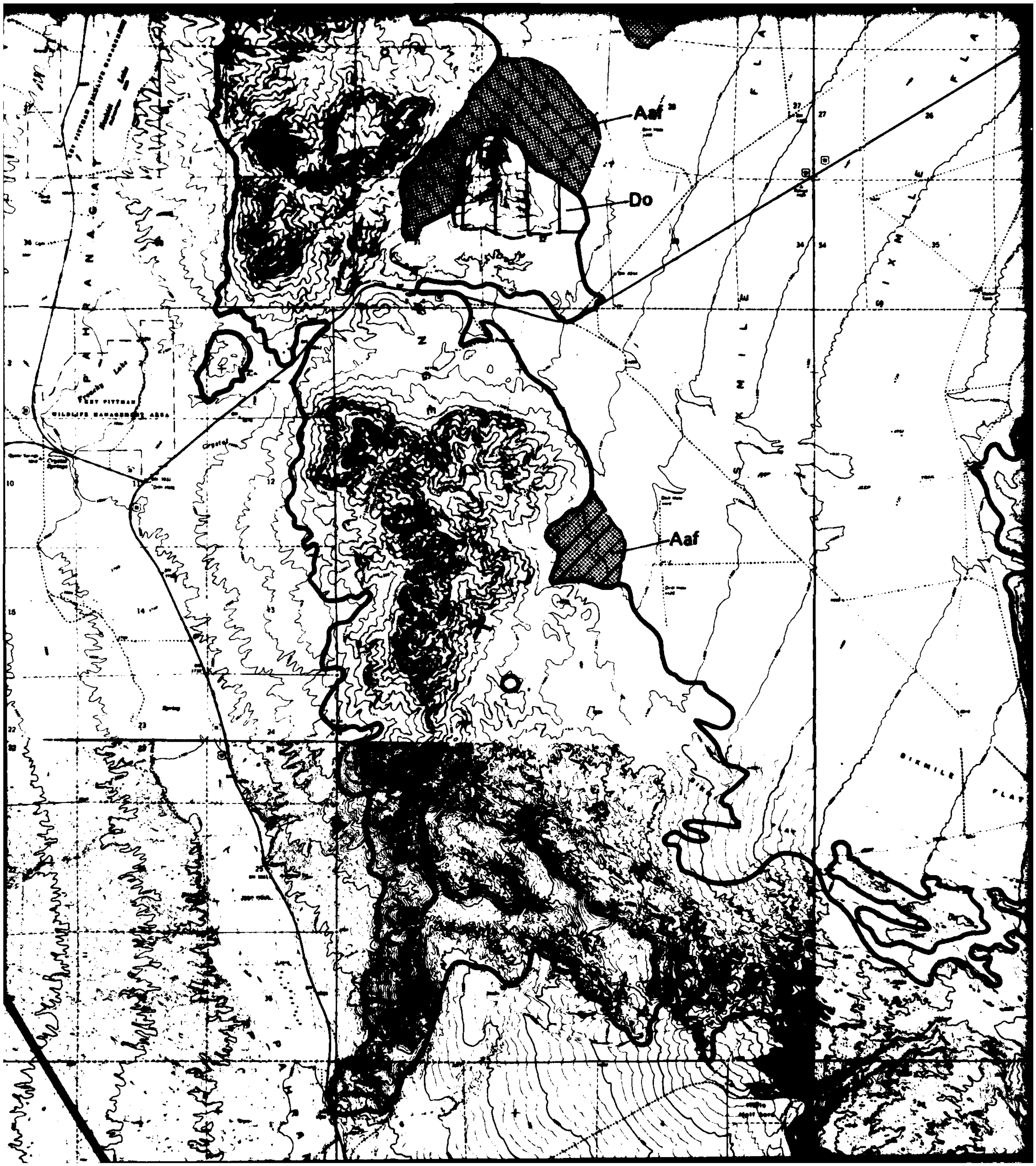
Aaf
Aaf


NORTH PAHROC RANGE
PAHROC VALLEY
FLAT
Asf
D
Pahroc Canyon


RANGE
C
Boulder
Wash
VALLEY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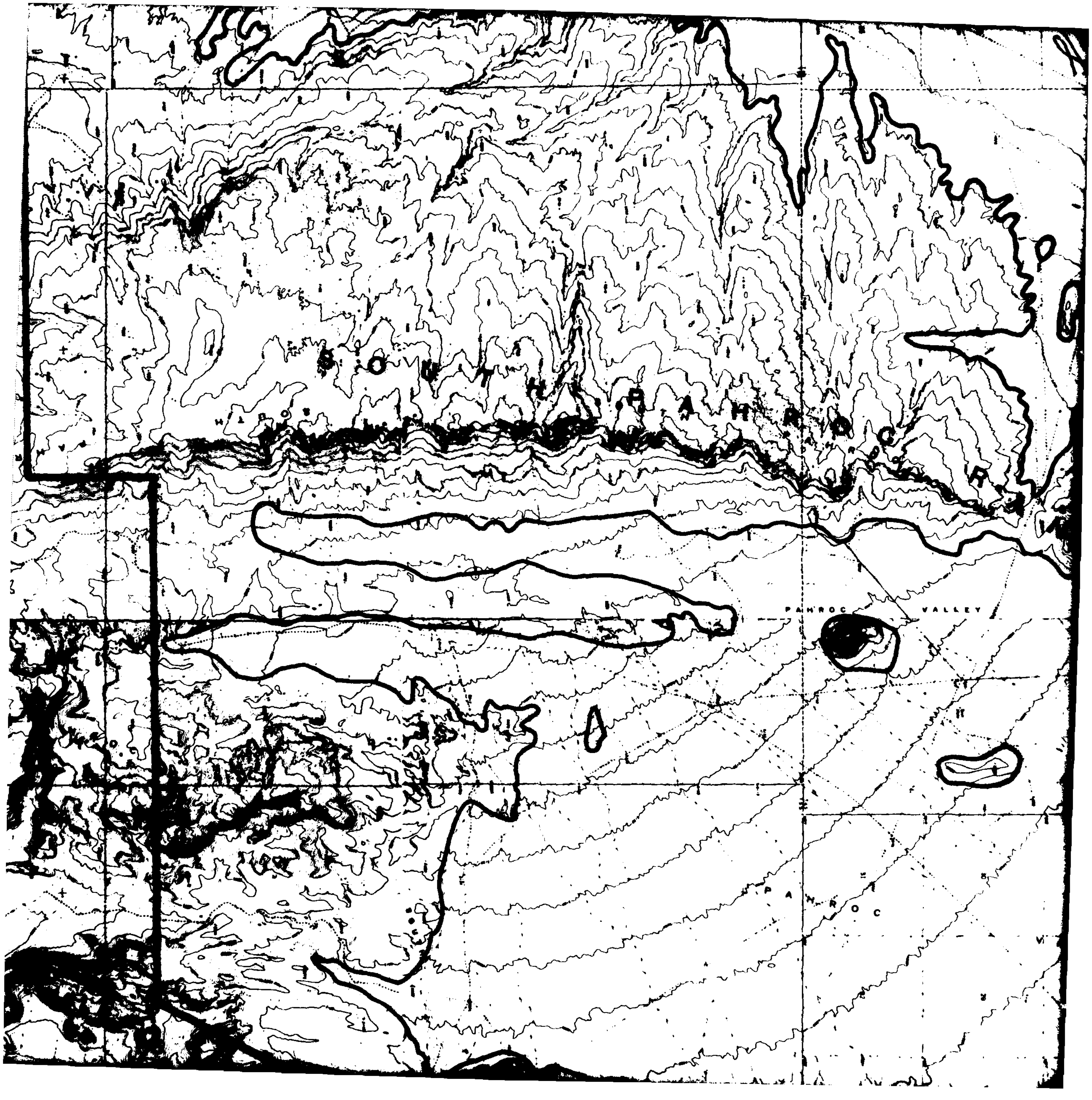
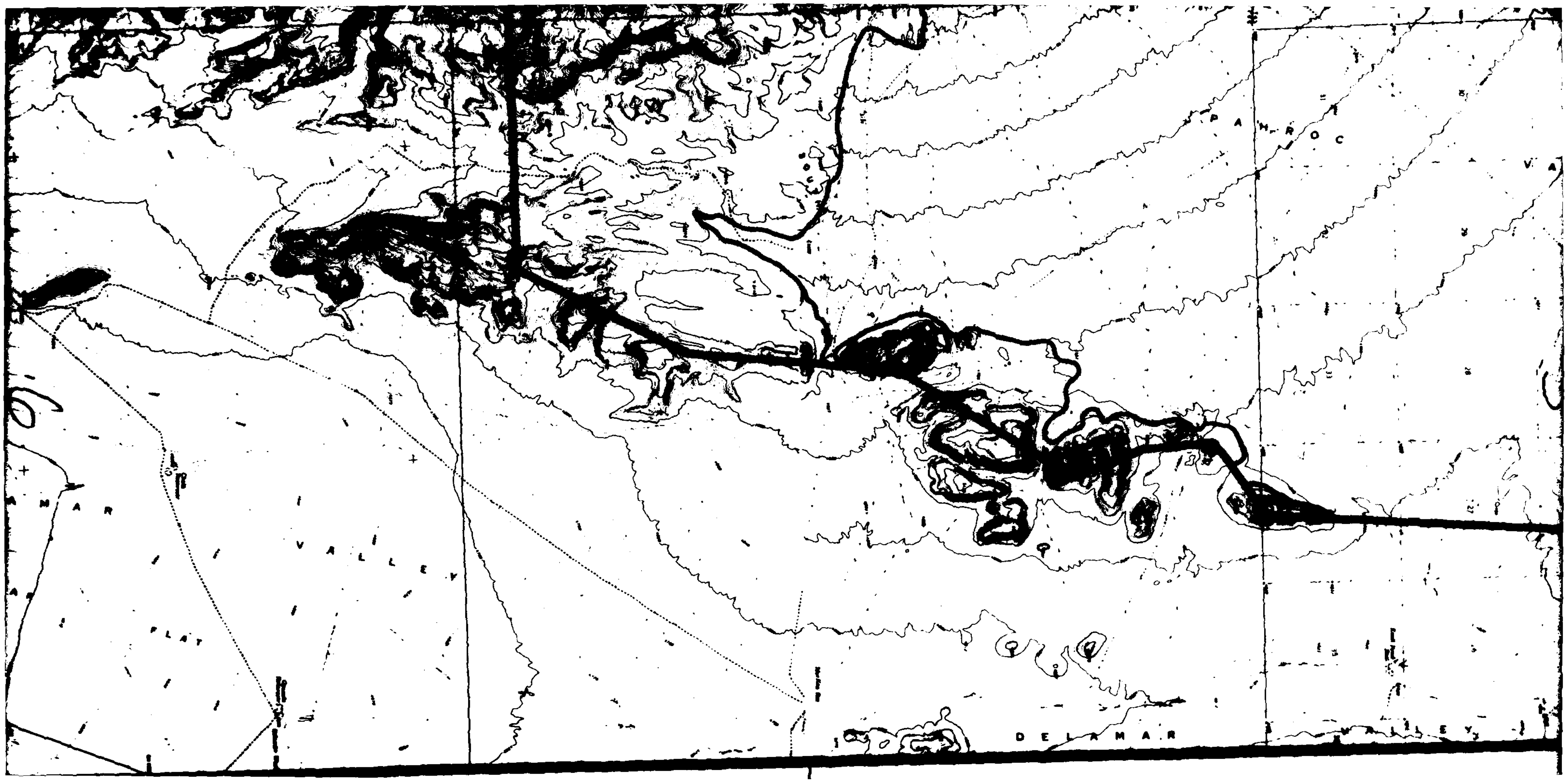
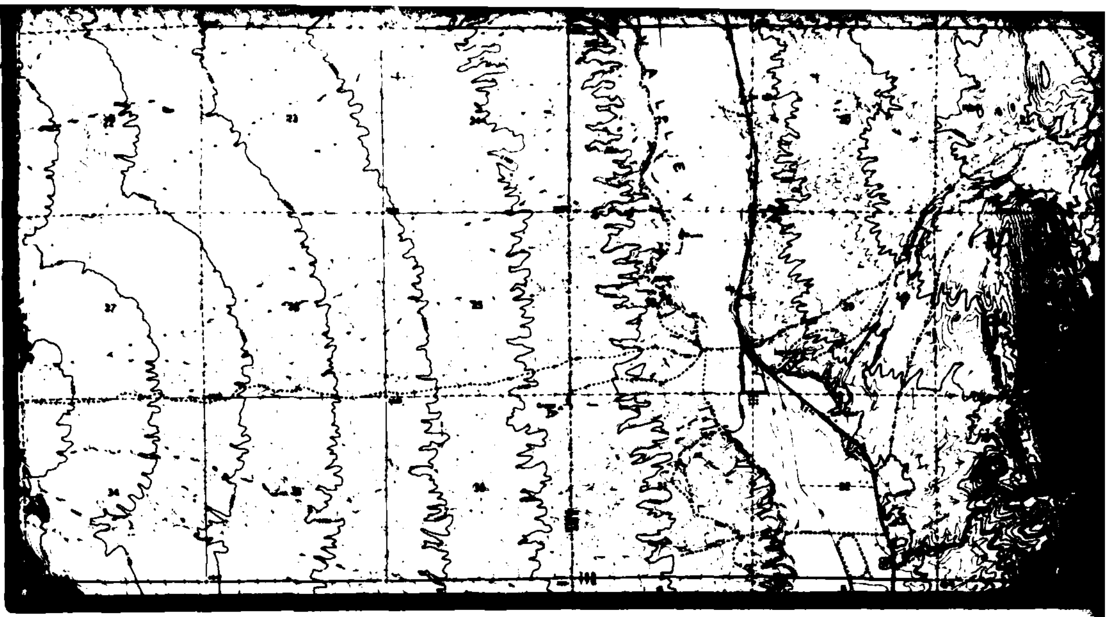

SOUTH PAHROC R
PAHROC VALLEY
PAHROC



PAHROC
VALLEY
FLAT
DELAMAR
VALLEY

4



ERTEC WESTERN AGGREGATE RESOURCES STUDY FIELD STATIONS

VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY *
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

▲ DATA STOP, SAMPLED AND TESTED

△ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY * *
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL
AND ROCK SAMPLE LOCATIONS; 300 TO 399 FOR
FIELD PETROGRAPHIC STATIONS)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

○ DATA STOP

BASIN–FIL

R[illegible] ■

RBIb ▨

RBII ▨

M

115° 00'

EXPLANATION

AGGREGATE CLASSIFICATION SYSTEM

AND ROCK SOURCES* * *

■ ☐	BASIN FILL ROCK	BASIN–FILL OR ROCK SOURCES CONTAINING MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON ACCEPTABLE LABORATORY AGGREGATE TEST RESULTS.
▨	BASIN FILL	BASIN–FILL SOURCES CONTAINING MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON CORRELATION WITH CLASS RBIa SOURCE AREAS.
▨	BASIN FILL	POTENTIAL BASIN–FILL SOURCES OF MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON PHOTOGEOLOGIC INTERPRETATIONS, FIELD OBSERVATIONS, AND LIMITED OR INCONCLUSIVE SIEVE ANALYSIS AND/OR ABRASION DATA.
☐		UNSUITABLE SOURCES OF BASIN–FILL MATERIALS THAT MAY LOCALLY CONTAIN POTENTIALLY SUITABLE SOURCES OF AGGREGATES OF LIMITED EXTENT. UNTESTED SOURCES OF ROCK MATERIALS THAT MAY CONTAIN POTENTIALLY SUITABLE CRUSHED-ROCK AGGREGATES (SEE TEXT FOR ADDITIONAL INFORMATION).

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MPLETE CLASSIFICATION SYSTEM IS SHOWN, ALTHOUGH ALL
FILL OR ROCK SOURCES MAY NOT BE PRESENT WITHIN

GEOLOGIC UNITS †

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† SEE APPENDIX TABL

SYMBOLS ††

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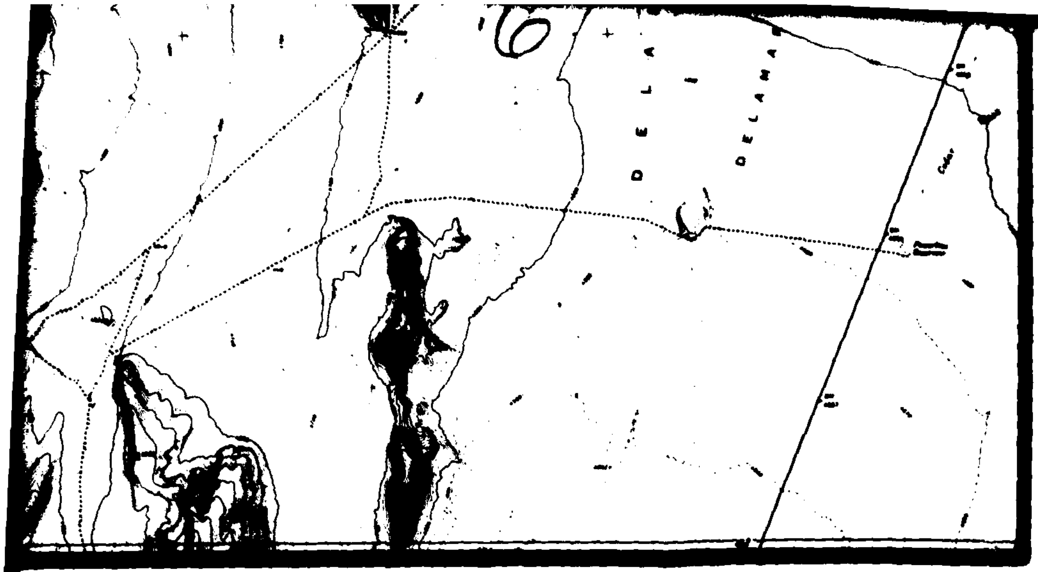
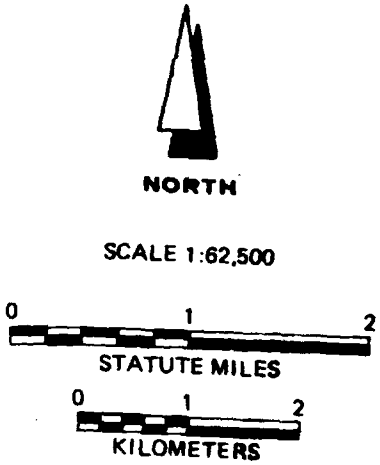
†† GEOLOGIC ROCK
APPROXIMATELY





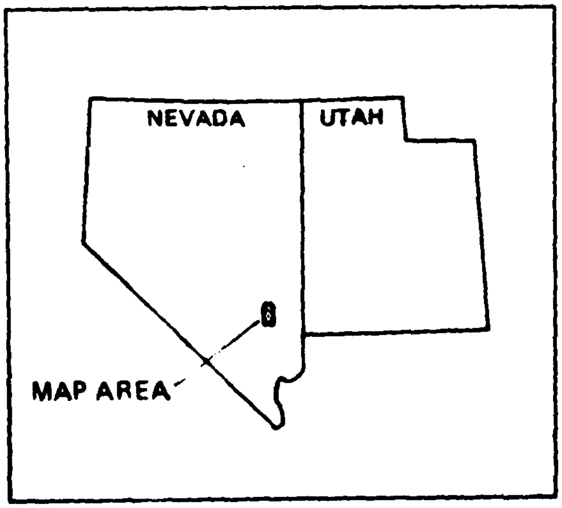
SIN–FILL UNITS

LUVIAL FAN DEPOSITS (A5)

CK UNITS

OLOMITE ROCKS (S2)

LOCATION MAP



E F-3 FOR SYMBOL EXPLANATION AND COMPARISON

STUDY AREA BOUNDARY

ROCK/BASIN–FILL CONTACT

GEOLOGIC ROCK CONTACT

BASIN–FILL CONTACT

BASIN–FILL CONTACTS ARE

ERTEC WESTERN AGGREGATE [illegible]

VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY *
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

▲ DATA STOP, SAMPLED AND TESTED

△ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY * *
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL AND ROCK SAMPLE LOCATIONS; 300 TO 399 FOR FIELD PETROGRAPHIC STATIONS)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

○ DATA STOP

M

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

▲ DATA STOP, SAMPLED AND TESTED

PETROGRAPHIC FIELD STATIONS

• DATA STOP

* SEE DRY LAKE, MULESHOE, DELAMAR, PAHROC VSARS REPORT (FN-TR-37-e) FOR DETAILED INFORMATION.

* * SEE CORRESPONDING MAP NUMBER IN APPENDICES A AND B FOR DETAILED INFORMATION.

AGGREGATE CLASSIFICATION SYSTEM

BASIN–FILL AND ROCK SOURCES* * *

RBIa	▦	BASIN FILL	BASIN–FILL OR ROCK SOURCES CONTAINING MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON ACCEPTABLE LABORATORY AGGREGATE TEST RESULTS.
	◫	ROCK	
RBIb	▧	BASIN FILL	BASIN–FILL SOURCES CONTAINING MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON CORRELATION WITH CLASS RBIa SOURCE AREAS.
RBII	▨	BASIN FILL	POTENTIAL BASIN–FILL SOURCES OF MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON PHOTOGEOLOGIC INTERPRETATIONS, FIELD OBSERVATIONS, AND LIMITED OR INCONCLUSIVE SIEVE ANALYSIS AND/OR ABRASION DATA.
	▭		UNSUITABLE SOURCES OF BASIN–FILL MATERIALS THAT MAY LOCALLY CONTAIN POTENTIALLY SUITABLE SOURCES OF AGGREGATES OF LIMITED EXTENT. UNTESTED SOURCES OF ROCK MATERIALS THAT MAY CONTAIN POTENTIALLY SUITABLE CRUSHED-ROCK AGGREGATES (SEE TEXT FOR ADDITIONAL INFORMATION).

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* * * A COMPLETE CLASSIFICATION SYSTEM IS SHOWN, ALTHOUGH ALL BASIN–FILL OR ROCK SOURCES MAY NOT BE PRESENT WITHIN THE STUDY AREA.

GEOLOGIC UNITS

BASIN–FILL UNITS

Aaf	ALLUVIAL FAN DEPOSITS	(A5)

ROCK UNITS

Do	DOLOMITE ROCKS	(S2)

† SEE APPENDIX TABLE F-3 FOR SYMBOL EXPLANATION AND COMPARISON

SYMBOLS††

━━━━	STUDY AREA BOUNDARY
────	ROCK/BASIN–FILL CONTACT
— —	GEOLOGIC ROCK CONTACT
- - - -	BASIN–FILL CONTACT

†† GEOLOGIC ROCK AND BASIN–FILL CONTACTS ARE APPROXIMATELY LOCATED AND MAY VARY LOCALLY.

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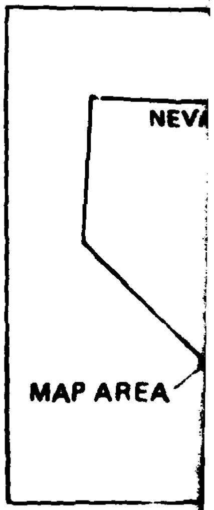

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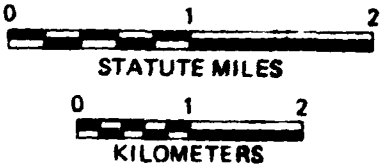
ROAD-BASE A
DETAILED AG
PAHROC

5 JUN 81

NORTH

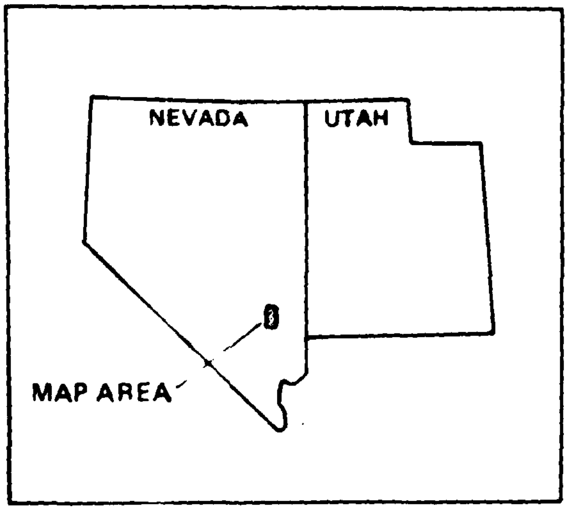
SCALE 1:62,500



SITS (A5)

(S2)

LOCATION MAP



EXPLANATION AND COMPARISON

UNDARY

L CONTACT

CONTACT

TACT

CONTACTS ARE
AY VARY LOCALLY.

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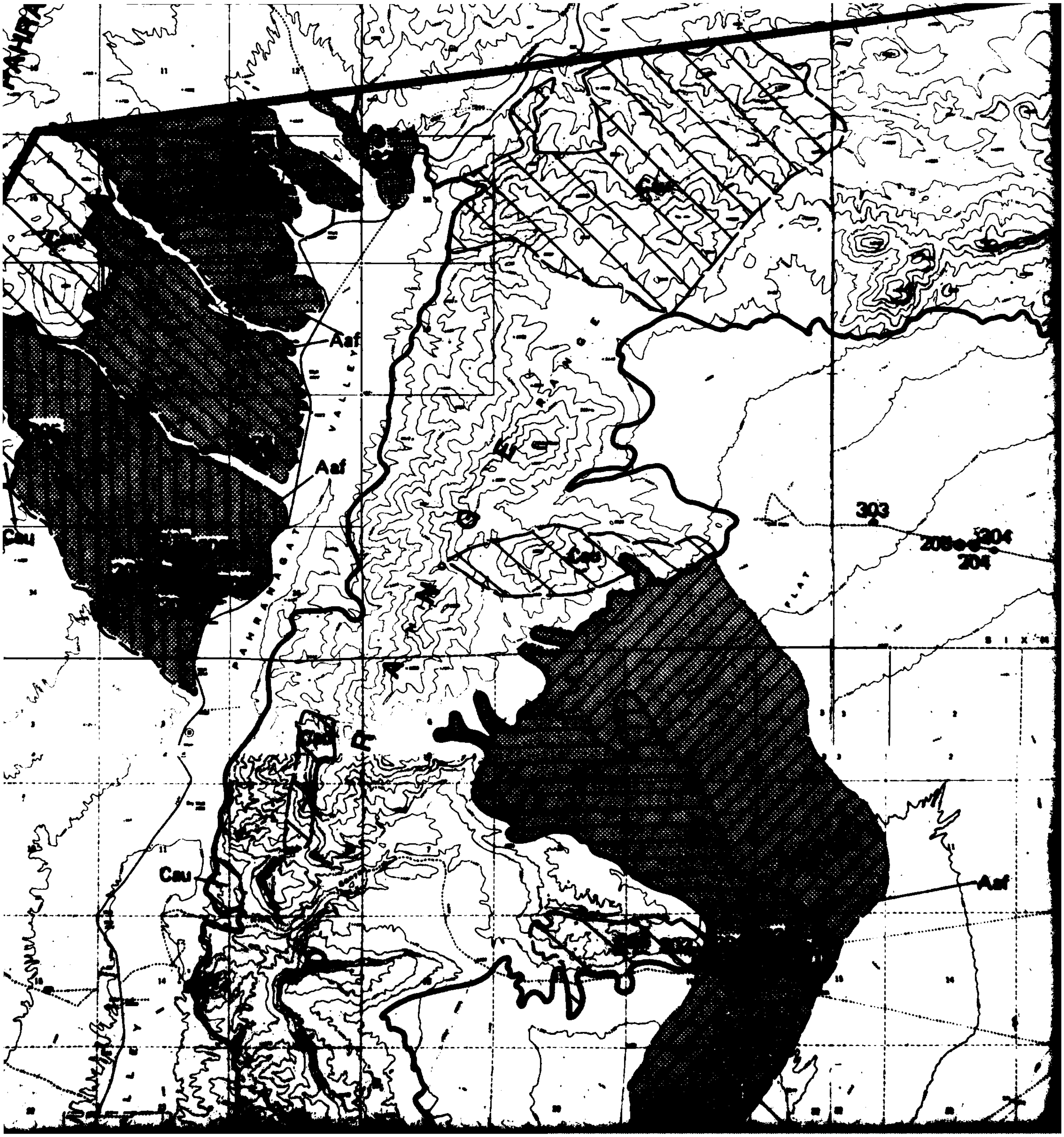
The Earth Technology Corporation

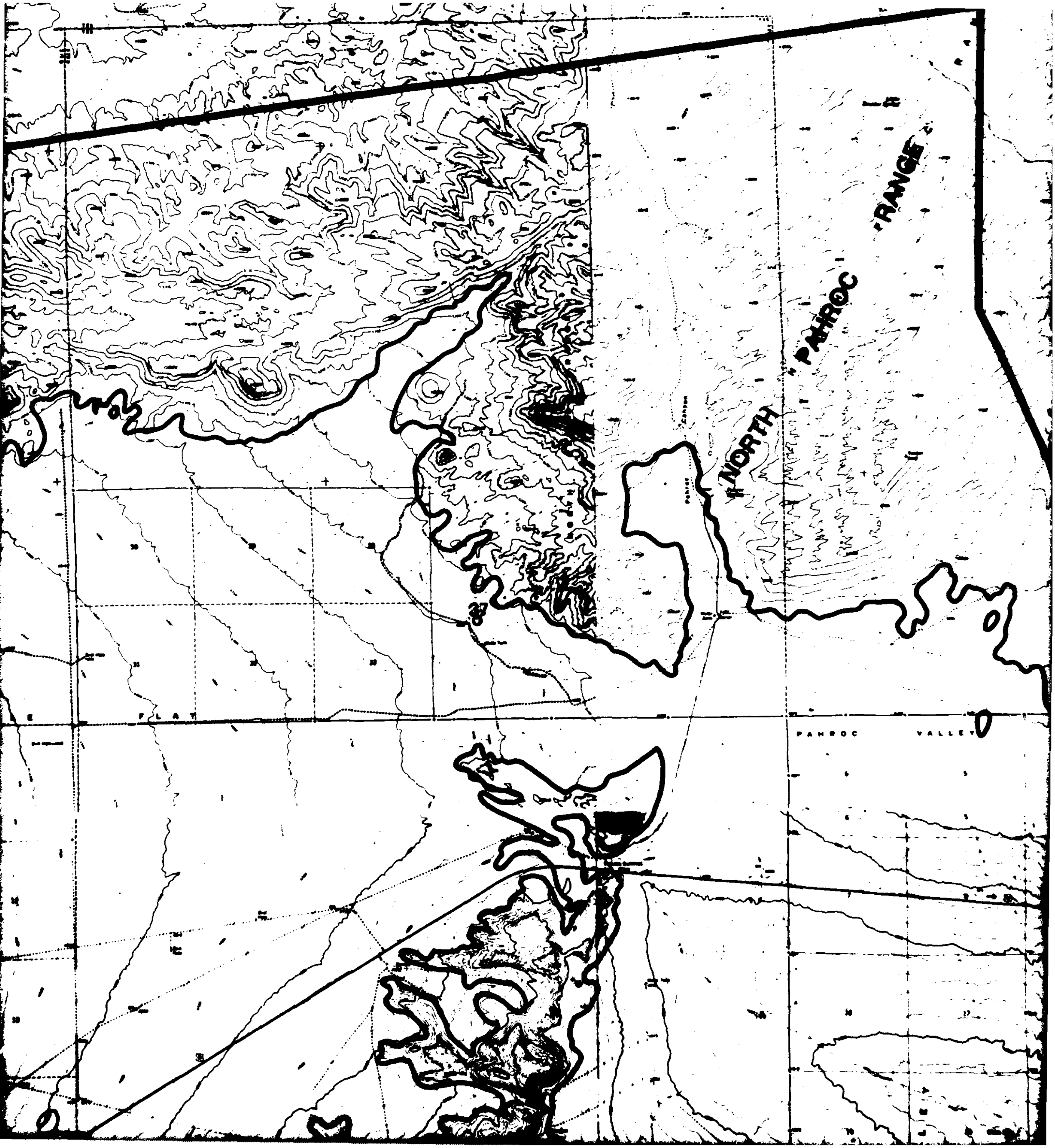
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

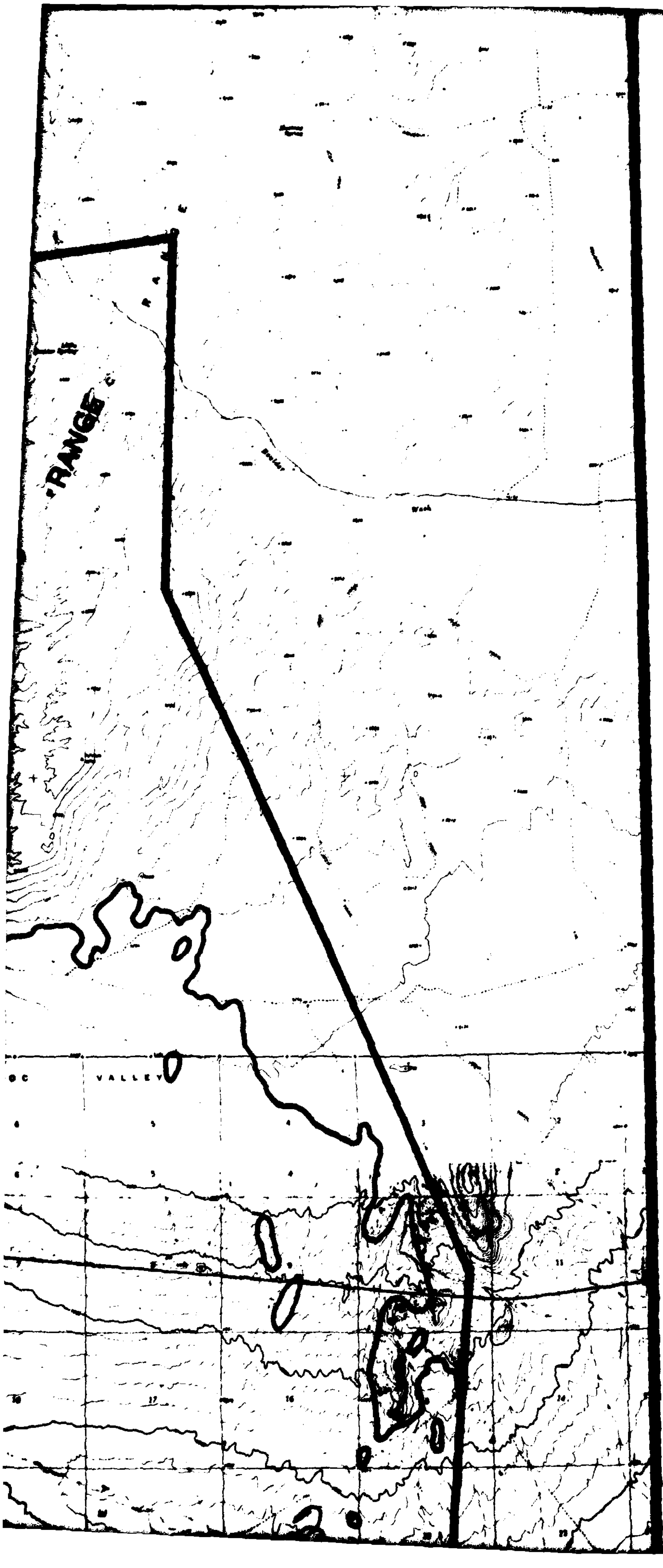
ROAD-BASE AGGREGATE RESOURCES MAP
DETAILED AGGREGATE RESOURCES STUDY
PAHROC STUDY AREA, NEVADA

5 JUN 81

DRAWING 2


Aaf
Aaf
Cau
303
208
204
204
Cau
Aaf


NORTH PAHROC RANGE
PAHROC VALLEY
E FLAT
37


RANGE
Wash
OC
VALLEY
6
5
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3
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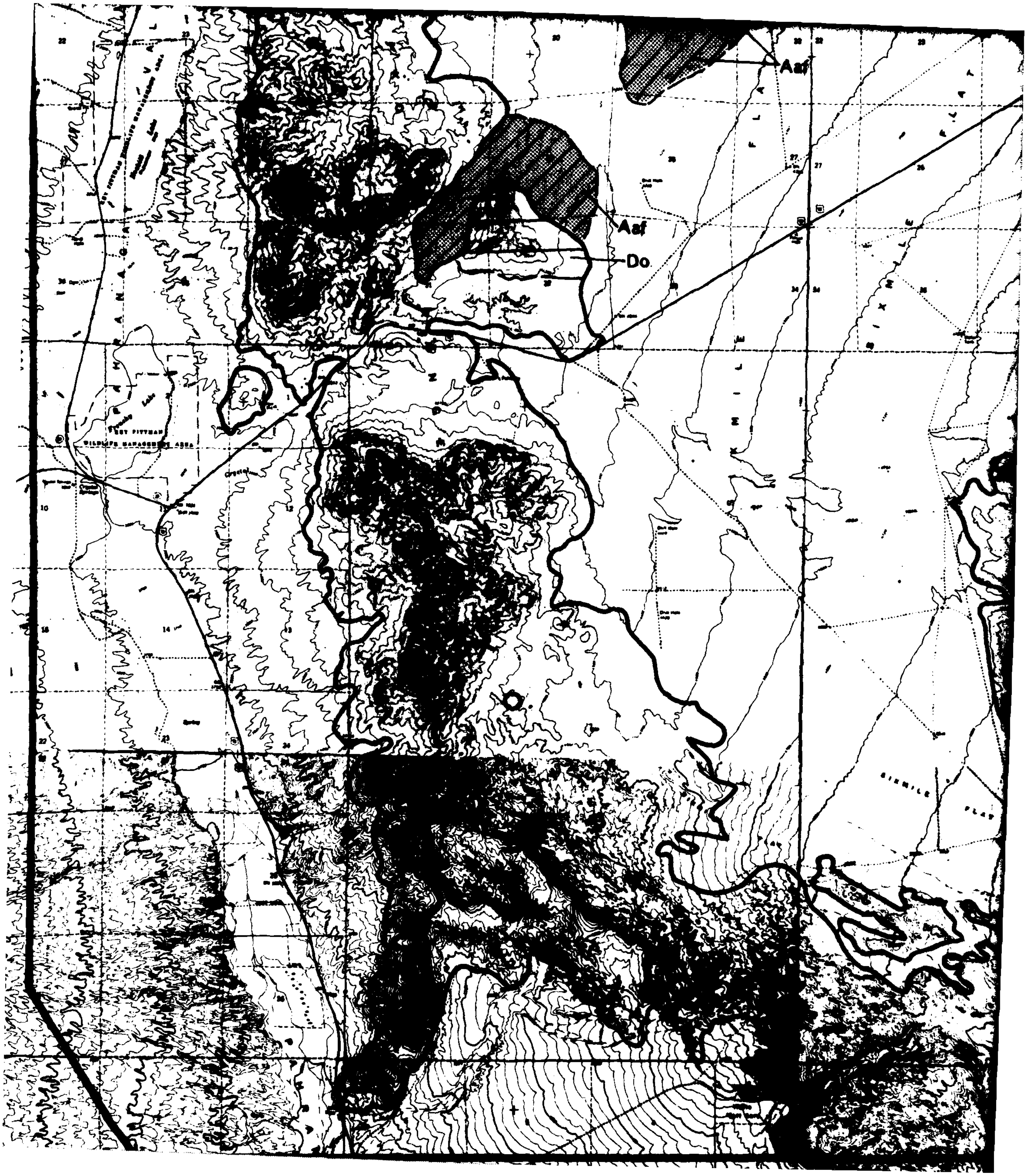
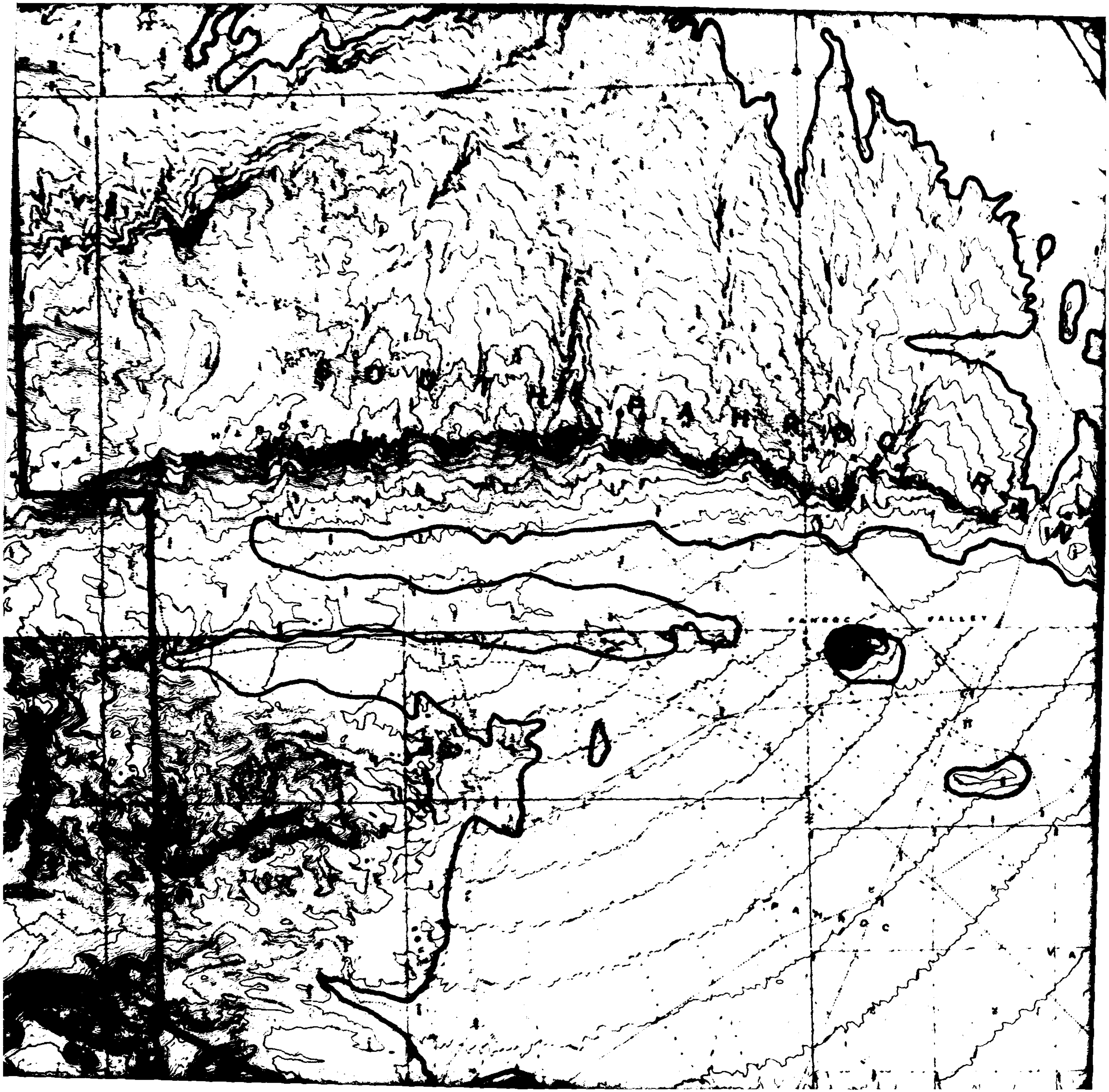
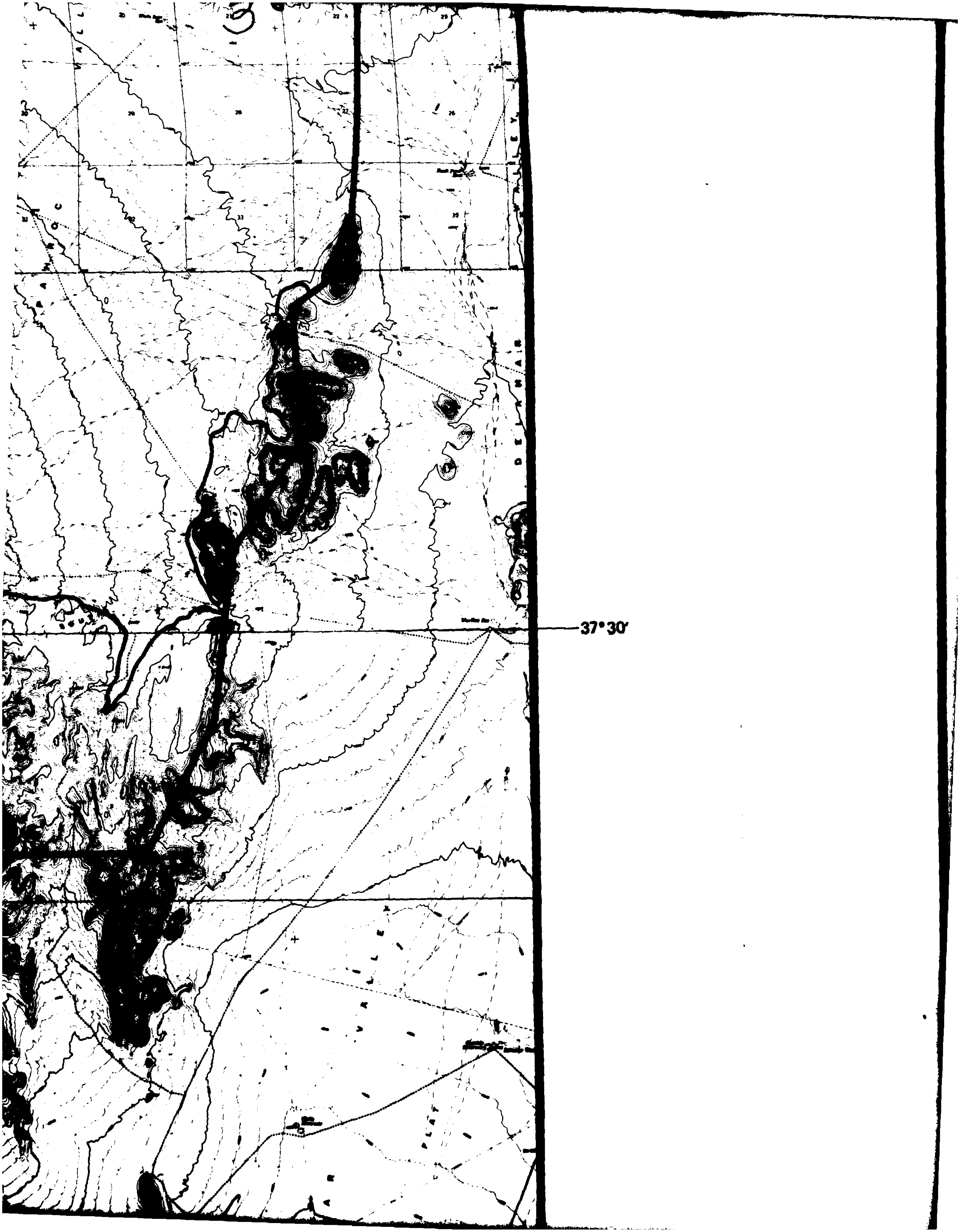
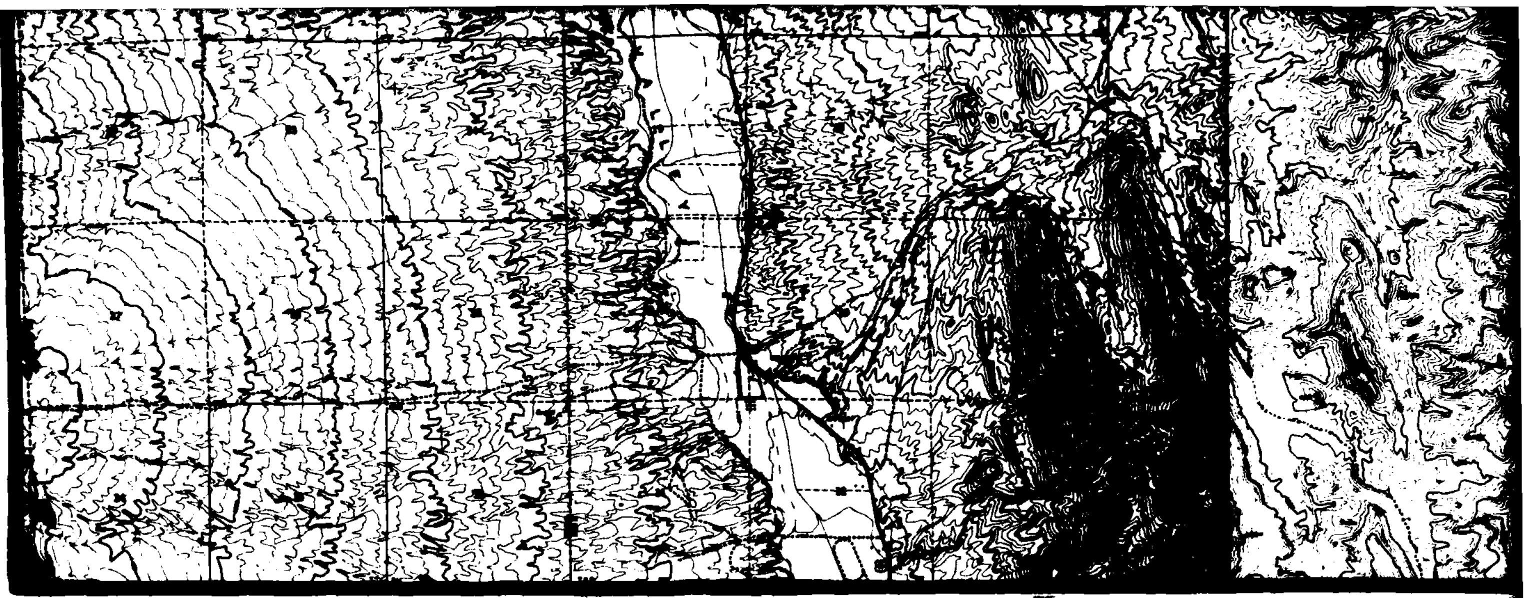

Aaf
Aaf
Do


SOUTH PAHROC RANGE
PAHROC VALLEY
PAHROC


3
37° 30′
DELAMAR
VALLEY
FLAT



EGATE RESOURCES STUDY FIELD STATIONS

FIC AGGREGATE RESOURCES STUDY *
MBERS FROM 1 TO 199)

LL UNITS (COARSE AND/OR FINE AGGREGATES)

DATA STOP, SAMPLED AND TESTED

DATA STOP

ITS (CRUSHED-ROCK AGGREGATES)

DATA STOP, SAMPLED AND TESTED

DATA STOP

REGATE RESOURCES STUDY * *
BERS FROM 200 TO 299 FOR BASIN–FILL
K SAMPLE LOCATIONS; 300 TO 399
D PETROGRAPHIC STATIONS)

LL UNITS (COARSE AND/OR FINE AGGREGATES)

DATA STOP, SAMPLED AND TESTED

AGGREGATE CLASSIFICATION SYSTEM ***

BASIN–FILL AND ROCK SOURCES

CA1	▩	BASIN FILL	BASIN–FILL OR RO AGGREGATES THA CONCRETE WITH 2 STRENGTHS EQUA 6500 PSI.
	□	ROCK	
CA2	▩	BASIN FILL	BASIN–FILL OR RO AGGREGATES THA CONCRETE WITH 2 STRENGTHS LESS T
	□	ROCK	
CB	▤	BASIN FILL	BASIN–FILL OR RO AGGREGATES POT IN CONCRETE; BAS TORY AGGREGAT
	□	ROCK	
CC1	▨	BASIN FILL	BASIN–FILL OR RO AGGREGATES POT IN CONCRETE; BAS CLASS CA1 OR CA2
	▧	ROCK	
CC2	▨	BASIN FILL	BASIN–FILL SOUR POTENTIALLY SUI BASED ON CORRE AREAS.

115° 00'

EXPLANATION

CK SOURCES CONTAINING
T PRODUCED TRIAL MIX
DAY COMPRESSIVE
TO OR GREATER THAN

K SOURCES CONTAINING
PRODUCED TRIAL MIX
AY COMPRESSIVE
HAN [illegible] PSI.

K SOURCES CONTAINING
TIALLY SUITABLE FOR USE
D ON ACCEPTABLE LABORA-
TEST RESULTS.

K SOURCES CONTAINING
TIALLY SUITABLE FOR USE
ON CORRELATION WIT.
URCE AREAS.

CONTAINING AGGREGATES
LE FOR USE IN CONCRETE,
ION WITH CLASS CB SOURCE

8

GEOLOGIC UNITS †

BASIN–FILL UNITS

Aaf	ALLUVIAL FAN DEPOSITS

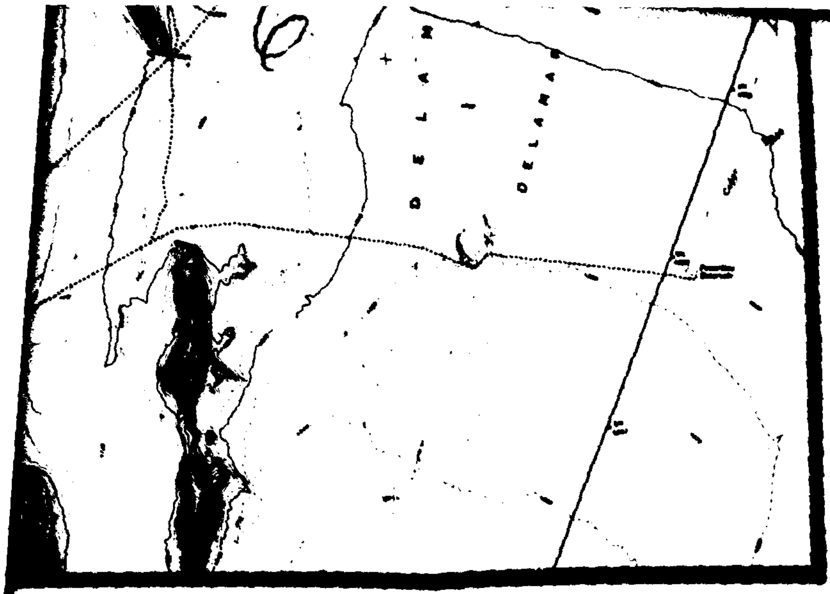
ROCK UNITS

Do	DOLOMITE ROCKS
Cau	CARBONATE ROCKS UNDIFFERENTIATED

† SEE APPENDIX TABLE F-3 FOR SYMBOL EXPLANATION AND CO

SYMBOLS ††

▬	STUDY AREA BOUNDARY
—	ROCK/BASIN–FILL CONTACT
— —	GEOLOGIC ROCK CONTACT



ꞏS (A5)

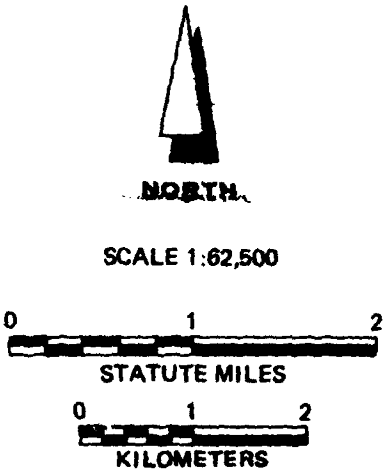
(S2)

NDIFFERENTIATED (S2)

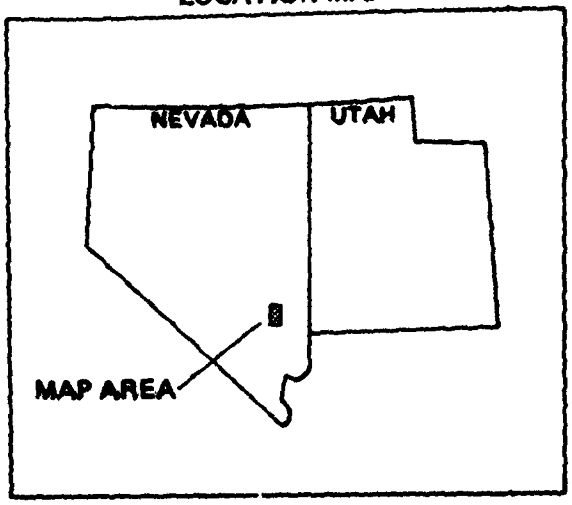
PLANATION AND COMPARISON.

RY

NTACT



LOCATION MAP



VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY *
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

▲ DATA STOP, SAMPLED AND TESTED

△ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY * *
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL
AND ROCK SAMPLE LOCATIONS; 300 TO 399
FOR FIELD PETROGRAPHIC STATIONS)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

▲ DATA STOP, SAMPLED AND TESTED

PETROGRAPHIC FIELD STATIONS

• DATA STOP

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* SEE DRY LAKE, MULESHOE, DELAMAR, PAHROC VSARS REPORT (FN-TR-37-a) FOR DETAILED INFORMATION.

* * SEE CORRESPONDING MAP NUMBER IN APPENDICES A AND B FOR DETAILED INFORMATION.

BASIN–FILL AND ROCK SOURCES

CA1	▓	BASIN FILL	BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES THAT PRODUCED TRIAL MIX CONCRETE WITH 28-DAY COMPRESSIVE STRENGTHS EQUAL TO OR GREATER THAN 6500 PSI.
	▯	ROCK	
CA2	■	BASIN FILL	BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES THAT PRODUCED TRIAL MIX CONCRETE WITH 28-DAY COMPRESSIVE STRENGTHS LESS THAN 6500 PSI.
	□	ROCK	
CB	▤	BASIN FILL	BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON ACCEPTABLE LABORATORY AGGREGATE TEST RESULTS.
	□	ROCK	
CC1	▧	BASIN FILL	BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON CORRELATION WITH CLASS CA1 OR CA2 SOURCE AREAS.
	⧅	ROCK	
CC2	▨	BASIN FILL	BASIN–FILL SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON CORRELATION WITH CLASS CB SOURCE AREAS.
	░		BASIN–FILL SOURCES CONTAINING FINE AGGREGATES USED WITH CRUSHED-ROCK SAMPLES FOR CERTAIN CONCRETE TRIAL MIXES.
	□		UNSUITABLE SOURCES OF BASIN–FILL MATERIALS THAT MAY LOCALLY CONTAIN POTENTIALLY SUITABLE SOURCES OF AGGREGATES OF LIMITED EXTENT. UNTESTED SOURCES OF ROCK MATERIALS THAT MAY CONTAIN POTENTIALLY SUITABLE CRUSHED-ROCK AGGREGATES (SEE TEXT FOR ADDITIONAL INFORMATION).

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• • • A COMPLETE CLASSIFICATION SYSTEM IS SHOWN, ALTHOUGH ALL BASIN -FILL OR ROCK SOURCES MAY NOT BE PRESENT WITHIN THE STUDY AREA.

† SEE

SYMB

††

BASIN–FILL UNITS

Aaf	ALLUVIAL FAN DEPOSITS	(A5)

ROCK UNITS

Do	DOLOMITE ROCKS	(S2)
Cau	CARBONATE ROCKS UNDIFFERENTIATED	(S2)

† SEE APPENDIX TABLE F-3 FOR SYMBOL EXPLANATION AND COMPARISON.

YMBOLS ††

━━━	STUDY AREA BOUNDARY
───	ROCK/BASIN–FILL CONTACT
— —	GEOLOGIC ROCK CONTACT
– – –	BASIN–FILL CONTACT

†† GEOLOGIC ROCK AND BASIN–FILL CONTACTS ARE APPROXIMATELY LOCATED AND MAY VARY LOCALLY.

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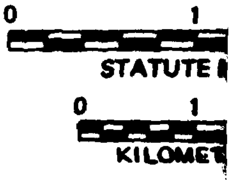
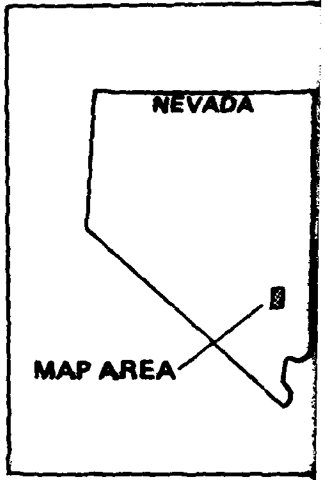
NO

SCALE 1:6



LOCATION



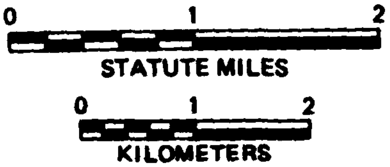
Ertec
The Earth Technology Corporation

CONCRETE AGGR
DETAILED AGGRE
PAHROC ST

5 JUN 81

[illegible]

SCALE 1:62,500



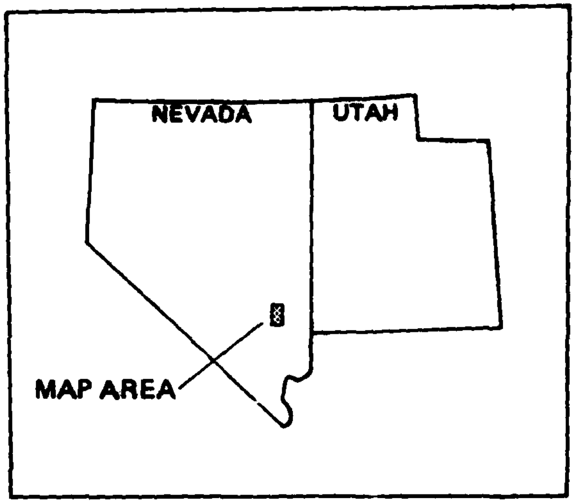
(A5)

(S2)

FERENTIATED (S2)

ATION AND COMPARISON.

LOCATION MAP



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CTS

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The Earth Technology Corporation

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

CONCRETE AGGREGATE RESOURCES MAP
DETAILED AGGREGATE RESOURCES STUDY
PAHROC STUDY AREA, NEVADA

5 JUN 81

DRAWING 3