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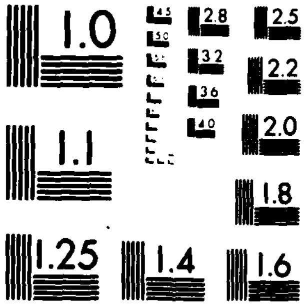

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MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION CONTERMINOUS UNITED STATES

VOLUME II
INTERMEDIATE SCREENING

PREPARED FOR
SPACE AND MISSILE SYSTEMS ORGANIZATION (SAMSO)
NORTON AIR FORCE BASE, CALIFORNIA

FUGRO
NATIONAL, INC.
Consulting Engineers and Geologists

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Coarse Screening was rapidly evaluated through suitability of conterminous U.S. + identified suitable areas in which to initiate more detailed Inter Screening + characterization points.

MX SITING INVESTIGATION

GEOTECHNICAL EVALUATION

CONTERMINOUS UNITED STATES

VOLUME II

INTERMEDIATE SCREENING

Prepared For:

U. S. Department of the Air Force
Space and Missile Systems Organization (SAMSO)
Norton Air Force Base, California 92409

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21 December 1977

ABSTRACT

Intermediate Screening literature-based studies evaluated 238,309 nm^2 of potentially suitable MX siting area defined from Coarse Screening of the conterminous United States. Siting criteria provided by SAMSO included geotechnical, topographic, cultural, quantity-distance and minimum parcel factors which were applied and documented on 438, 1:250,000 scale worksheets.

Suitable area totaling 112,130 nm^2 was grouped into twelve Candidate Siting Provinces (CSPs), each within established divisions of physiographic provinces. Suitable area was identified in 15 western states, and is distributed by CSP as follows: Central High Plains, 18,650 nm^2; Southern High Plains, 11,640 nm^2; Rio Grande, 5,100 nm^2; Highlands, 7,510 nm^2; Sonoran, 17,470 nm^2; Great Basin, 25,680 nm^2; Montana, 9,680 nm^2; Dakotas, 8,900 nm^2; Coastal Plain, 4,110 nm^2; Plateau, 1,890 nm^2; Wyoming Basin, 680 nm^2; and Northern Rockies, 820 nm^2. Suitable area encompassed surficial materials (84%) and excavatable rock (16%).

Surficial materials consist of alluvial basin fill in the Great Basin, Sonoran, Highlands, Rio Grande and Northern Rockies CSPs; unlithified Pliocene sedimentary formations in the Central and Southern High Plains CSPs; and glacial drift in the Dakotas CSP. Excavatable rock areas consist of lithified Tertiary to Cretaceous sedimentary formations occurring in the Central High Plains, Southern High Plains, Dakotas, Coastal Plains, Plateau, Wyoming Basin and Montana CSP's.

Terrain conditions vary from gently sloping, dissected desert bajadas and flat-lying plains to low rolling hills. Ground-water levels are generally unconfined and much greater than 50 feet in depth. Suitable areas are remote with low population densities. Land use varies from farming, ranching and grazing (easternmost CSPs) to open desert, range land and military reservations (westernmost CSPs).

Approximately 83,480 nm^2 of suitable area in the Central High Plains, Southern High Plains, Rio Grande, Highlands, Sonoran, and Great Basin CSPs appear most viable for MX Fine Screening/Characterization and Validation studies. The Dakotas and Northern Rockies CSPs are less desirable; field study of these areas should be deferred until detailed literature studies demonstrate they warrant MX siting consideration. Currently no further studies are planned for the Montana, Coastal Plain, Plateau, and Wyoming Basin CSPs.

FOREWORD

This report was prepared for the Department of the Air Force, Space and Missile Systems Organization (SAMSO) in compliance with conditions of Contract No. F04704-77-C-0010, CDRL Item 005A2 and deals with geotechnical screening of the conterminous United States for identifying candidate areas suitable for deploying the MX Land Mobile Advanced ICBM system.

This report presents the objectives, scope, study approach, and results of the Intermediate Screening study which is the second of a three-stage screening analysis. Coarse Screening preceded this study and provided the basis for the Intermediate Screening. The Fine Screening/Characterization study is the last stage in the overall screening studies. The end result of the screening process will be a prioritized list of Candidate Siting Regions geotechnically suitable for MX systems deployment.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF DRAWINGS

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 BACKGROUND AND SCREENING CRITERIA

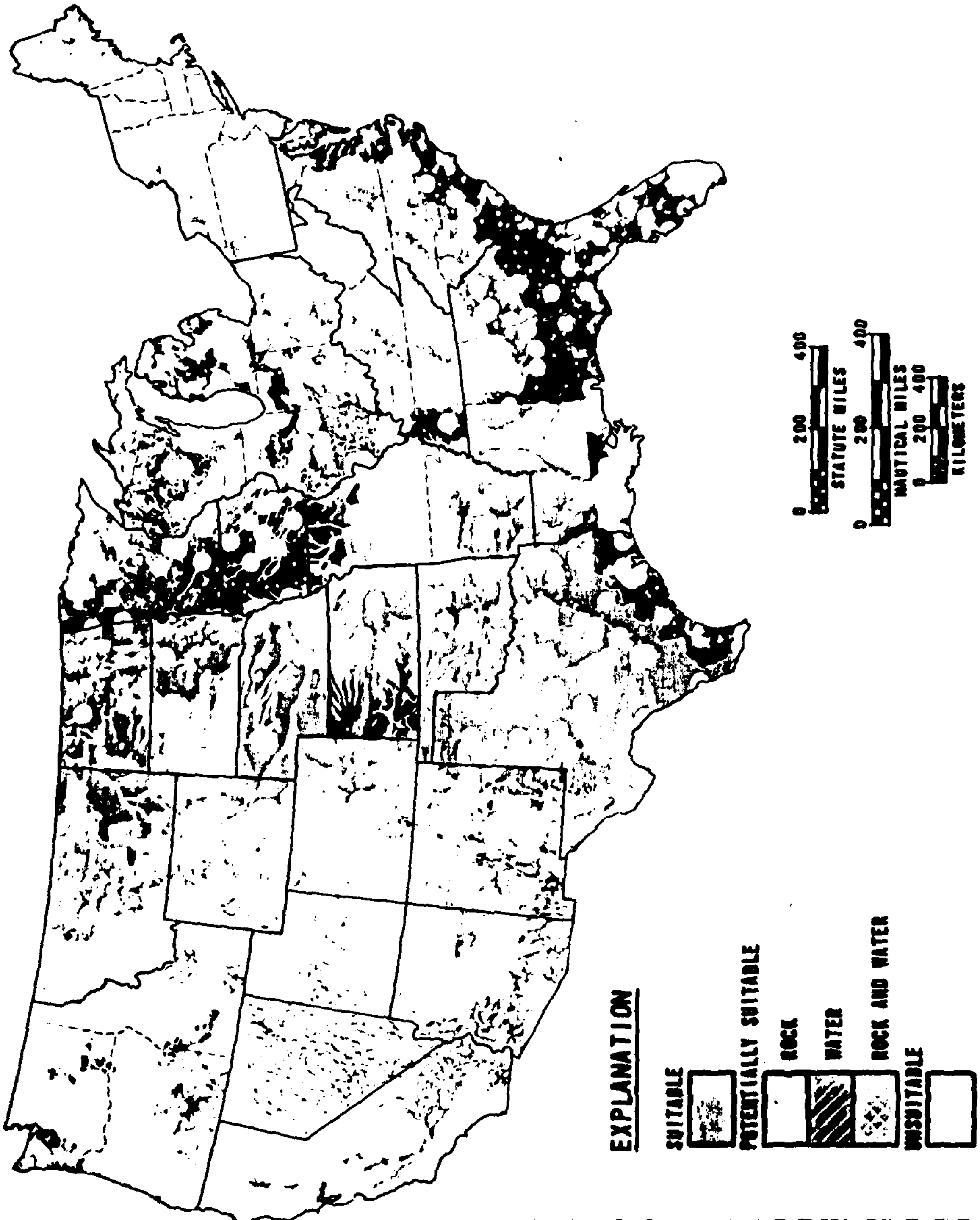
The MX geotechnical screening evaluation was formulated in December, 1976 in response to a directive by SAMSO to identify and evaluate all suitable land areas in the conterminous United States in which a land-mobile MX system could be deployed. Criteria used for judging suitability at each stage of the screening process were provided by SAMSO and are based upon current construction, vulnerability and hardness, cultural, and environmental requirements of both the trench and shelter MX basing modes. Land ownership conditions were not identified as screening criteria. Fugro National's geotechnical screening study was separated into three major tasks, Coarse Screening, Intermediate Screening, and Fine Screening/Characterization studies, in order to uniformly apply the given criteria with an increasing degree of detail over decreasing area.

The Coarse Screening study was initiated in January, 1977 and ended in May, 1977. The principal objective of Coarse Screening was to rapidly evaluate the suitability of the entire conterminous United States and identify suitable areas in which to initiate more detailed Intermediate Screening and possibly Characterization studies. To satisfy this objective the Coarse Screening study approach was to collect and apply the regional geotechnical, cultural, and quantity-distance data needed to satisfy the given criteria. Only rarely were data beyond the detail of the 1:250,000 map scale utilized.

As a result of Coarse Screening, approximately 793,809 square nautical miles (nm^2) of candidate suitable area remained in the conterminous United States, of which four distinct categories were recognized (Figure 1) as described below. The first category was clearly suitable and the remaining three were considered potentially suitable but inadequately defined with the Coarse Screening data base.

SUITABLE	
238,309 nm^2	1. Areas considered suitable for MX siting following application of Coarse Screening criteria.
POTENTIALLY SUITABLE	
268,495 nm^2	2. Areas of varied rock excavatability characteristics or where data were insufficient to adequately define rock conditions.
227,866 nm^2	3. Areas of varied ground-water depths or where data were insufficient to adequately define ground-water conditions.
59,139 nm^2	4. Areas of varied rock and ground-water conditions or where data were insufficient to adequately define rock and ground-water conditions.

The Defense Mapping Agency (DMAAC) in St. Louis, Missouri, had been performing a "cursory" screening of the United States from late 1976, utilizing criteria from SAMSO in Washington, D.C. While similar to Fugro National's Coarse Screening study, the criteria used were somewhat different and the approach to the application differed. DMAAC is providing SAMSO with separate documentation of their cursory screening evaluation.



COARSE SCREENING
CONTERMINOUS UNITED STATES

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
1

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The Intermediate Screening study was initiated by Fugro National in May, 1977. The limits for this study were provided by the boundaries of the suitable and potentially suitable area remaining following Coarse Screening (Figure 1). New screening criteria and a more detailed application of the Coarse Screening criteria were used in Intermediate Screening (Table 1). Criteria such as quantity-distance, and depth to rock and water remained unchanged from Coarse Screening, except for the increased detail of application. Cultural, topographic and minimum parcel determinations changed appreciably, especially in terms of application. A review of these criteria and their application during Intermediate Screening are presented in Appendix B.

SAMSO directed that the results of the Intermediate Screening evaluation be available by September 1977 in order that schedules of other on-going and planned MX siting programs would not be adversely impacted. To meet this requirement, the Intermediate Screening study was conducted jointly by the technical staffs of the DMAAC and Fugro National. By agreement, the DMAAC studied the eastern United States and Fugro National the western United States (Section 1.3.2; Figure 2). The results of both studies are contained in this report.

Fine Screening will proceed on the concept that all suitable area identified during Intermediate Screening satisfy baseline MX siting requirements and that no further area

CRITERIA		DEFINITION AND COMMENTS
SURFACE ROCK AND ROCK OCCURRING WITHIN A NOMINAL 50 FEET OF THE GROUND SURFACE		Rock is defined as any earth material which is not rippable by conventional excavation methods. Where available, seismic P-wave velocities were evaluated in the determination of rock conditions. In general, materials with velocities greater than 7000 fps were considered as rock.
SURFACE WATER AND GROUND WATER OCCURRING WITHIN A NOMINAL 50 FEET OF THE GROUND SURFACE		Surface water includes all significant lakes, reservoirs, swamps, and major perennial drainages. Water which would be encountered in a nominal 50-foot excavation was considered in the application of this criterion. Depths to ground water resulting from deeper confined aquifers were not considered.
TOPOGRAPHIC	Percent Grade:	Areas having surface gradients exceeding 10 percent as determined from maps at scale 1:250,000.
	Relative Relief:	Areas of characteristic terrain defined by a preponderance of slopes exceeding 5 percent as determined from maps at scales of 1:250,000, 1:62,500, and 1:24,000.
		Areas having drainage densities averaging at least two ten-foot deep drainages per 1000 feet (measured parallel to contours, as determined from maps at scales of 1:24,000).
CULTURAL	Quanitity/Distance:	Eighteen nautical mile exclusion arcs from cities having populations (1970) of 25,000 or more.
		Three nautical mile exclusion arcs from cities having populations (1970) of between 5,000 and 25,000.
	Land Use:	All significant federal and state forests, parks, monuments, and recreation areas.
		All significant federal and state wildlife refuges, grass lands, ranges, preserves and management areas.
		Indian reservations.
	Economic:	High potential economic resource areas including oil and gas fields, strippable coal, oil shale and uranium deposits, and known geothermal resource areas (kgra's).
		Industrial complexes such as active mining areas, tank farms and pipeline complexes.
	Minimum Parcel:	All parcels or aggregate parcels having total area less than 500 nm^2. Aggregate parcels must be a minimum of 150 nm^2 to be included in the aggregate total and must not be isolated from adjacent suitable parcels by distances greater than 10 nm or by grades greater than 10 percent. Individual parcels may be further reduced in area if the combined or individual alignment of county, state and federal paved highways, railroads, aqueducts, or perennial streams is sufficiently dense to restrict the emplacement of a straight 10 nm trench.

Shaded criteria are new or modified from Coarse Screening study

INTERMEDIATE SCREENING CRITERIA

MX SITING INVESTIGATION
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TABLE
1

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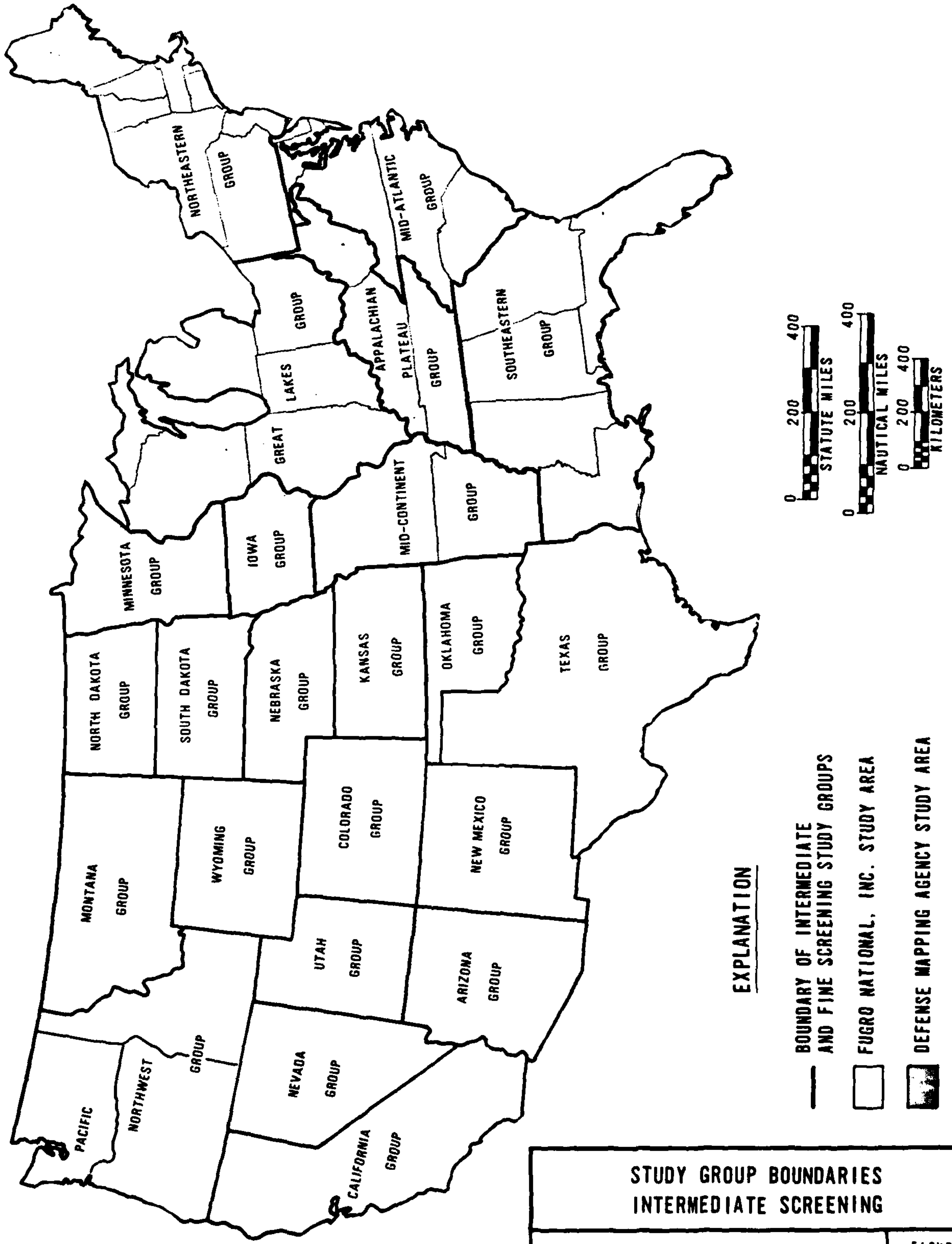

STUDY GROUP BOUNDARIES
INTERMEDIATE SCREENING

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
2

FUGRO NATIONAL, INC.

reduction will occur in these areas. Suitable areas, however, encompass broadly different geology, soil engineering, cultural and environmental conditions that will result in different total costs for acquisition, construction and operation for potential deployment areas. The Fine Screening studies will involve application of new siting criteria (being compiled by TRW) which, along with Characterization studies, will allow for ranking of the suitable areas and selection of preferred and alternate Candidate Siting Regions (CSR; Appendix D) in which to begin Validation studies near the middle of FY 78. The overall screening process leading to CSR selection is shown in Table 2.

In order to meet rigid MX program milestones, Characterization studies were initiated concurrently with Intermediate Screening. Whereas Fine Screening studies consider many technical disciplines important to MX, Characterization studies are planned to provide limited surface and subsurface geotechnical data in selected areas to determine construction characteristics and provide data for environmental and limited vulnerability and hardness (V and H) analyses of an entire CSP. Characterization studies were limited geographically in FY 77 to those areas identified as suitable from Coarse Screening and those DoD and BLM areas previously studied in FY 75 and FY 76 (Fugro National, 1975; 1976). Additional sites for Characterization studies will be selected based on the results of Intermediate Screening.

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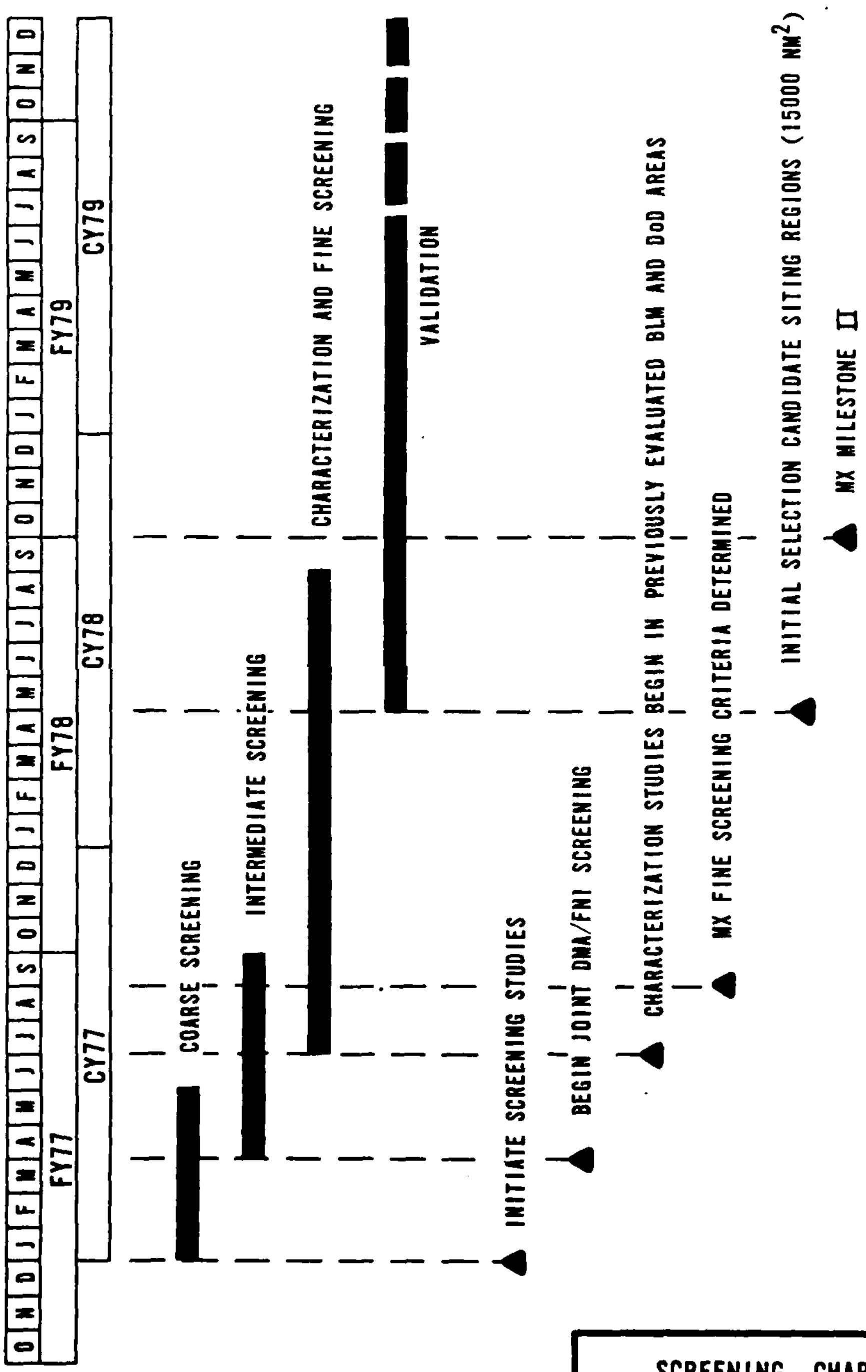

SCREENING, CHARACTERIZATION AND VALIDATION MILESTONES

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
2

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1.2 OBJECTIVES

The objectives of the Intermediate Screening evaluation were to:

1. Rapidly assess the suitability for MX siting of the areas remaining suitable and potentially suitable following Coarse Screening studies by applying new siting criteria provided by SAMSO, and by a more detailed application of existing geotechnical criteria. Areas were designated as suitable unless they clearly did not satisfy requirements of the basic technical criteria;

2. Provide sufficient technical documentation of the screening process to fully justify site selection decisions;

3. Provide results of the screening effort to the on-going environmental screening studies and to the MX facilities design and hardness modeling communities as needed; and

4. Group the suitable area from Intermediate Screening into Candidate Siting Provinces (CSPs) which possess similar geotechnical characteristics, thereby providing the basic units for future Fine Screening/Characterization studies.

1.3 SCOPE, APPROACH, AND DATA PRESENTATION

1.3.1 SCOPE

The investigation consisted of a detailed literature search of pertinent geotechnical publications and personal contacts (both written and oral) with geologists, hydrologists and others in state and regional offices to supplement and update data collected from published material. The literature search involved utilizing indexes from several sources:

1. State and Federal geological organizations (e.g., United States Geological Survey, Nevada Bureau of Mines and Geology);

2. Major non-governmental geological organizations (e.g., Geological Society of America, American Association of Petroleum Geologists); and

3. Computer searches in selected areas using Library of Congress, Geo-Ref., NTIS, NASA and Dissertation Abstracts.

No field work was performed for Intermediate Screening. Data were collected at various map scales, generally ranging from 1:500,000 to 1:24,000; reports without maps were also collected, but the relative degree of detail fell within this range. Any data pertinent to one or more of the screening criteria were analyzed and compiled on 1:250,000 scale base map worksheets.

Documentation of data sources followed the methods established in Coarse Screening, i.e., strict definition of the interpreted data limits and full citation of references used on the compilation worksheet. Literature search forms, and telephone and written communication forms were completed and filed for each data source. A listing of cited references and sources of personal communication used to compile this study is included in Appendix A.

1.3.2 APPROACH

The suitable and potentially suitable areas identified in Coarse Screening provided the baseline for DMAAC and Fugro National to begin Intermediate Screening. To expedite the screening process, SAMSO directed that a "single exclusion" approach be implemented in Intermediate Screening. This meant that application of any single primary screening criterion was adequate to class an area as unsuitable. The investigator was required first to apply the screening criterion which was anticipated to most quickly define suitable areas. This was a change from Coarse Screening for which each criterion was applied equally to all areas under consideration.

The 23 study groups determined from Coarse Screening (Figure 2) were used as basic units for data collection, analysis, compilation, and technical summaries. Fugro National was tasked by SAMSO to investigate those group areas within the western United States and the DMAAC was to study the eastern United States. Periodic Screening Coordination meetings were initiated among Fugro National, DMAAC, TRW and SAMSO personnel to facilitate consistent interpretation and application of the screening criteria and presentation of results. This report presents the integration of both the DMAAC and Fugro National Intermediate Screening study results.

1.3.3 DATA PRESENTATION

Report Section 2.0 presents a summary of results, conclusions and recommendations. Report sections 3.0 through 14.0 and the Operational Navigation Chart (ONC) overlay combinations (delivered only to SAMSO/MNND) present the technical details of the Intermediate Screening evaluation and summarize data by Candidate Siting Provinces in the western United States.

All detailed suitable area boundaries, exclusions and pertinent documentation are recorded on 438, 1:250,000 scale National Topographic Map series (NTMS) worksheets (Appendix Figure C-1). These maps have been photographically reduced for permanent filing at SAMSO.

Suitable area defined during Intermediate Screening are graphically depicted at several scales in various contexts:

1. Suitable area distribution in the western United States and Candidate Siting Province (CSP) boundaries at 1:5,000,000 scale (Drawing 1);
2. Suitable area with generalized exclusion boundaries presented on a series of 14, 1:1,000,000 scale acetate overlays and ONC basemaps (delivered only to SAMSO/MNND); and
3. A composite of the 1:1,000,000 scale ONC overlays transferred to a single 1:5,000,000 scale map of the conterminous United States (Drawing 2).

Exclusion areas presented in these graphics are generalized at the request of SAMSO. They denote regional exclusion trends and should not be interpreted as an accurate representation of the boundaries compiled on the 1:250,000 scale worksheets.

Detailed summaries of area exclusions for the conterminous United States are tabulated in two forms:

1. Summary notes on the major exclusions applied in each state, their spatial distribution and percentages are presented in Table 6 at the end of Section 2.0; and
2. A summary of detailed exclusions applied in each NTMS two degree quadrant is presented in Table C-1.

2.0 SUMMARY OF RESULTS, CONCLUSIONS & RECOMMENDATIONS

2.1 SUMMARY OF RESULTS

2.1.1 GENERAL

Table 3 presents suitable area calculations based on geographic distribution and ownership determined from Intermediate Screening results. The values shown were planimetered from the original compilation worksheets at a scale of 1:250,000. The significant figures have been retained although accuracies are estimated to be ± five percent. Land ownership values are estimated from assorted small scale maps prepared by federal and state agencies.

Suitable area delineated in Drawing 1 meets the siting criteria defined in Appendix B. In addition, suitable area further differentiated a non-rock, or unlithified category (generally consisting of alluvial basin fill and younger sedimentary formations) and an excavatable rock category consisting of lithified sedimentary formations (Drawing 1 and Table 5). For discussion purposes and to preclude confusion in this report, "suitable area," if not specifically qualified, may pertain to "non-rock" and/or "excavatable rock" categories.

2.1.2 DISTRIBUTION AND CHARACTERISTICS OF SUITABLE AREA

This section deals with suitable area in general. For the most part, however, discussions of composition and excavatability of materials are relative to suitable non-rock areas. Suitable excavatable rock areas are specifically discussed in Section 2.1.2.1.

STATE	TOTAL SUITABLE NM^2	INCLUSIVE CSP(S)	SUITABLE AREA		LAND OWNERSHIP CONDITIONS		
			NONROCK	ROCK	DoD AREA	BLM AREA	* OTHER (NM^2)
ARIZONA	15670	Highlands	3660		300	970	2390
		Great Basin	1990		0	1630	360
		Plateau	510	850	0	0	1360
		Sonoran	8660		1600	5890	1170
CALIFORNIA	9160	Sonoran	8450		1200	7250	0
		Great Basin	710		0	710	0
COLORADO	6180	Central High Plains	4920	1260	0	0	6180
IDAHO	1340	Northern Rockies	820		0	520	300
		Great Basin	520		0	310	210
KANSAS	4980	Central High Plains	4470	510	0	0	4980
MONTANA	9670	Montana		9670	0	1440	8230
NEBRASKA	3180	Central High Plains	3180		0	0	3180
NEVADA	19450	Great Basin	19090		1270	17330	490
		Sonoran	360		0	360	0
NEW MEXICO	13350	Highlands	3850		0	3660	190
		Central High Plains	1210		0	0	1210
		Southern High Plains	4830	30	0	4300	560
		Rio Grande	2900		680	2220	0
		Plateau		530	0	530	0
NORTH DAKOTA	4620	Dakotas	4470	150	0	0	4620
OKLAHOMA	1020	Central High Plains	1020		0	0	1020
SOUTH DAKOTA	4290	Dakotas	4280		0	0	4280
		Montana		10	0	0	10
TEXAS	15170	Central High Plains	2080		0	0	2080
		Southern High Plains	6560	220	0	0	6780
		Rio Grande	2200		0	0	2200
		Coastal Plain		4110	0	0	4110
UTAH	3370	Great Basin	3370		0	3190	180
WYOMING	680	Wyoming Basin		680	0	610	70
TOTAL	112130		94110	18020	5050	50920	56160

* Includes all private, state, and non-BLM, non-DoD federally owned lands.

DISTRIBUTION AND OWNERSHIP
OF SUITABLE AREA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
3

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Nine of the twelve Candidate Siting Provinces comprise approximately 94,110 nm^2 of suitable non-rock area, accounting for approximately 84% of the total suitable area identified during Intermediate Screening. These provinces form a broad U-shaped configuration over the west-central portion of the United States (Drawing 1), coinciding with the Basin and Range, Great Plains, Colorado Plateau and Northern Rockies physiographic provinces as defined by Fenneman (1931).

The amount of suitable non-rock area per CSP is listed below; percentages indicated are relative to the total suitable area identified in the conterminous United States (112,130 nm^2).

a. Central High Plains 16,880 nm^2 (15%)
b. Southern High Plains 11,390 nm^2 (10.2%)
c. Rio Grande 5,100 nm^2 (4.5%)
d. Highlands 7,510 nm^2 (6.7%)
e. Sonoran 17,470 nm^2 (15.6%)
f. Great Basin 25,680 nm^2 (22.9%)
g. Dakotas 8,750 nm^2 (7.8%)
h. Plateau 510 nm^2 (0.5%)
i. Northern Rockies 820 nm^2 (0.7%)

Suitable area in the Candidate Siting Provinces coinciding with the Basin and Range physiographic province (Great Basin, Sonoran, Highlands, and Rio Grande)are represented entirely by non-rock and have surficial materials consisting of alluvial basin-fill deposits of Quaternary age. The deposits are composed primarily of poorly to well-consolidated sand, gravel, silt and clay, which have relatively homogeneous physical characteristics. These alluvial sequences, which have accumulated in deep structural basins, generally range in thickness from 2,000 to 7,000 feet as measured in portions of the Great Basin and Sonoran CSPs (DMA, 1976; Eberly, 1976).

Surface features in the basin-fill areas are typically subdued, consisting of gently sloping bajada surfaces (generally less than 2% grade) incised by ephemeral drainages to depths generally in the range of one to ten feet. Runoff from seasonal storms is diverted via open ephemeral trunk streams or is captured in topographically closed basins draining into playa lakes. Ground water is moderately well documented, and is found generally unconfined at depths exceeding 100 feet.

The Central and Southern High Plains CSPs primarily correspond to the High Plains subprovince of the Great Plains physiographic province (Fenneman, 1931). These CSPs are extensively underlain by the Ogallala Formation, a Pliocene sedimentary formation that is thickest (up to 700 feet) in the westernmost suitable areas, attenuating to the east and south. The unit is heterogeneous, consisting of predominantly unconsolidated gravel, sand and silt; however, well-indurated interbeds of calcrete and opaline quartzite less than a few feet thick occur locally at variable depths. A highly indurated caliche caprock forms a resistant surface from a few inches to tens of feet thick over large portions of these CSPs. Pleistocene to Holocene windblown sand, silt, playa deposits, terrace deposits and river alluvium blanket over half of both CSPs ranging in thickness from zero to 140 feet.

Terrain is best characterized by flat-lying plains, broad river valleys and gently rolling hills. Drainage is predominantly ephemeral, assuming the regional gradient to the east and southeast. Perennial streams are widely spaced (one per 15 to 70 nm) with densities increasing in regions of greater rainfall to the east. Ground water depth is generally greater than 100 feet; however, local perched conditions have resulted from years of irrigation infiltration.

The Dakotas CSP conforms to the glaciated portion of the Missouri Plateau subprovince of the Great Plains physiographic province (Fenneman, 1931). Geologic and hydrologic conditions in the Dakotas CSP are inherently complex due to the heterogeneous nature of the Wisconsin stage glacial drift. The deposits consist of sorted outwash sediments and unsorted clayey tills, varying in thickness from zero to over 500 feet. Drift materials are composed of unconsolidated admixtures of clay, silt, sand, cobbles and boulders. The drift mantles an eroded preglacial surface of excavatable Tertiary-Cretaceous sandstone and shale formations.

Terrain conditions vary from relatively flat plains to rolling knob and kettle topography. Perennial drainage density is low. In localized areas of the CSP, small lakes may occupy some of the troughs in the rolling terrain, often indicating daylighted water-table conditions. Ground water levels are generally difficult to ascertain due to perched and artesian conditions that fluctuate over small areas.

The Plateau CSP lies within the Colorado Plateau physiographic province, a region characterized by relatively flat plateaus at high elevations. Approximately 20 percent of the suitable area consists of unconsolidated alluvial deposits; the remaining 80 percent is underlain by excavatable rock. Terrain within the suitable area is relatively flat, with stream density less than one per nm, and local relief rarely exceeding a few tens of feet. Little surface water occurs in the CSP and ground water is found mainly in the Bidahochi Formation and in the alluvial deposits generally at depths greater than 100 feet.

Distribution of suitable area within the Northern Rockies CSP corresponds to small portions of the Rocky Mountain and Snake River Plain physiographic provinces. Predominant surface materials consist of unconsolidated Holocene alluvium and slightly lithified but older, Plio-Pleistocene alluvium. Suitable area is contained within generally northwest trending valleys characterized by broad, flat bottoms surrounded by abruptly rising mountains. Large coalescing alluvial fans are the predominant landforms within the valleys. Open drainage conditions prevail; surface water is diverted into first and second order dendritic drainages with a depth of incision between 10 and 30 feet. Ground water varies from 50 to 900 feet in depth.

2.1.2.1 Distribution and Characteristics of Suitable Excavatable Rock Area

Suitable excavatable rock (Appendix B) totals 18,020 nm^2 and encompasses portions of the Central High Plains, Montana, Coastal Plain, Plateau, Wyoming Basin, Southern High Plains, and Dakotas CSPs (Drawing 1). The amount of excavatable rock per CSP is listed below; percentages indicated are relative to the total suitable area identified in the conterminous United States (112,130 nm^2).

a. Central High Plains 1770 nm^2 (1.6%)
b. Montana 9680 nm^2 (8.7%)
c. Coastal Plain 4110 nm^2 (3.7%)
d. Plateau 1380 nm^2 (1.2%)
e. Wyoming Basin 680 nm^2 (0.6%)
f. Southern High Plains 250 nm^2 (.2%)
g. Dakotas 150 nm^2 (.1%)

The geologic units in these areas consist predominantly of Tertiary to Cretaceous sedimentary formations which range in consistency from poorly consolidated to well indurated. Well-indurated members are estimated to comprise less than 50 percent of any excavatable rock area. Specific sedimentary formations comprising the excavatable rock area in each CSP are listed in Table 5, (at the end of Section 2.0).

It is beyond the scope of this report to characterize the complex lithologic/hydrologic conditions prevalent over each of these excavatable rock areas. An extensive field investigation would be necessary to delineate local, highly indurated rock units, thicknesses of overburden, depth of weathered zones, and complicated hydrologic conditions.

2.1.3 DISTRIBUTION OF UNSUITABLE AREA

Table 6 and Drawing 2 summarize the spatial distribution and relative percentages of area excluded by application of each major screening criteria. A detailed summary of exclusions used in the compilation of the 1:250,000 scale worksheets is presented in Table C-1 (Appendix C).

2.2 CONCLUSIONS

1. The 112,130 nm^2 of area found suitable for MX deployment is restricted to the western portion of the United States; no suitable areas were identified by DMAAC in the eastern portions of the United States.
2. Twelve (12) groupings of suitable area designated Candidate Siting Provinces (CSPs) are identified, each reflecting broadly similar topographic, geologic and hydrologic regimes.
3. Based on the investigation and discussions of priorities with SAMSO, approximately 83,480 nm^2 of suitable area is considered most viable for MX deployment (Table 4). These areas include all suitable non-rock areas contained within CSPs of the Basin and Range and Great Plains physiographic provinces, with the exception of an isolated parcel in northern Nebraska. The appropriate CSPs for Fine Screening/ Characterization field studies are as follows:
   a. Sonoran
   b. Great Basin
   c. Rio Grande
   d. Highlands
   e. Central High Plains
   f. Southern High Plains

   From a geotechnical standpoint, each of the above CSPs are relatively homogeneous and predictable. The first three CSPs listed have a greater relative abundance of existing data useful for MX siting than the latter three areas.
4. The Dakotas CSP is considered less desirable for MX siting due to:

a. The variability in thickness of glacial drift making depth to rock predictions difficult;

b. Complex hydrologic conditions and multiple water depths due to variability in thickness and permeability of the glacial drift,

c. High relative densities of utilities, road networks and population which would likely fragment suitable parcel areas in the event future screening or ranking criteria are applied.

5. The relatively small amount of suitable area and the isolated setting of the Plateau and Northern Rockies CSPs make them less desirable for future MX studies.

6. Suitability for siting in excavatable rock areas is often difficult to determine due to unknown factors such as overburden thicknesses, thickness and extent of indurated members, depth of weathered zones and sparse hydrologic data. It is likely that higher construction costs would be incurred and therefore, the Montana, Coastal Plain, Plateau and Wyoming Basin CSPs are considered less desireable for MX siting.

7. Because most of the suitable area within each CSP is rather remote and uninhabited, few studies have been done which develop the types of data required for MX system siting. Therefore, data deficiencies important to Fine Screening/Characterization studies exist for all or parts of most CSPs in the following categories:

a. Thickness and engineering characteristics of surficial deposits.
b. Compressional wave seismic velocities in shallow zones.
c. Specific data on, or defensible estimates of depth to rock and ground water, especially perched zones.
d. Nature and distribution of chemical precipitates, predominantly caliche (calcrete).
e. Surface distribution of individual basin-fill and soils units.
f. Topographic coverage at the 7-1/2 or 15 minute scale.

Analyses of collected data at a more detailed level of effort than was appropriate for Intermediate Screening would likely fill some data deficiencies in each CSP. Such analyses, however, would not yield sufficient information to preclude additional Fine Screening/Characterization studies in any CSP.

STATE	TOTAL SUITABLE NM^2	INCLUSIVE CSP(S)	RECOMMENDED SUITABLE AREA (NONROCK)	LAND OWNERSHIP CONDITIONS		
				DoD AREA	BLM AREA	*OTHER (NM^2)
ARIZONA	14310	Highlands	3660	300	970	2390
		Great Basin	1990	0	1630	360
		Sonoran	8660	1600	5890	1170
CALIFORNIA	9160	Sonoran	8450	1200	7250	0
		Great Basin	710	0	710	0
COLORADO	4920	Central High Plains	4920	0	0	4920
IDAHO	520	Great Basin	520	0	310	210
KANSAS	4470	Central High Plains	4470	0	0	4470
NEBRASKA	2630	Central High Plains	2630	0	0	2630
NEVADA	19450	Great Basin	19090	1270	17330	490
		Sonoran	360	0	360	0
NEW MEXICO	12790	Highlands	3850	0	3660	190
		Central High Plains	1210	0	0	1210
		Southern High Plains	4830	0	4300	530
		Rio Grande	2900	680	2220	0
OKLAHOMA	1020	Central High Plains	1020	0	0	1020
TEXAS	10840	Central High Plains	2080	0	0	2080
		Southern High Plains	6560	0	0	6560
		Rio Grande	2200	0	0	2200
UTAH	3370	Great Basin	3370	0	3190	180
TOTAL	83480		83480	5050	47820	30610

* Includes all private, state, and non-BLM, non-DoD federally owned lands.

DISTRIBUTION AND OWNERSHIP
OF RECOMMENDED SUITABLE AREA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
4

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2.3 RECOMMENDATIONS

1. Fine Screening/Characterization studies should be conducted in the CSPs listed in Table 4. The studies should be of a similar magnitude to those performed in Nevada and New Mexico to enable accurate determination of the MX siting environment. Field efforts should be concentrated in obtaining data in the construction zone and the areas of concern for environmental impact, with limited V and H consideration at this time. Analysis of these data should yield sufficient information to enable confident selection of one preferred and two alternate Candidate Siting Regions (CSR). Information pertaining to depths below approximately 300 feet should be collected as required by SAMSO.
2. Because of the short time frame remaining and potential for adverse weather conditions, Fine Screening/Characterization field studies as discussed above should proceed in the following order:
    a. Central High Plains
    b. Southern High Plains
    c. Rio Grande
    d. Highlands
    e. Sonoran
    f. Great Basin

    The initial results of Fine Screening/Characterization studies will be available in April 1978 for CSR ranking; a formal report would follow documenting the results.

3. Fine Screening/Characterization field programs should not be conducted in the following Candidate Siting Provinces unless those areas currently considered more desireable prove, through additional investigation, to be unsuitable:
    a. Montana
    b. Coastal Plain
    c. Plateau
    d. Wyoming Basin
4. Field studies should not begin in the Dakotas and Northern Rockies CSPs until a more detailed analysis of existing literature has been completed. The existing data base, which includes extensive Minuteman geotechnical information, may be sufficient to characterize the siting environment of the Dakotas CSP and satisfy Fine Screening/Characterization requirements.

CSP	TOTAL SUITABLE NM^2	GEOT		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Central High Plains	18,650	Aeolian, Lacustrine Fluvial, Alluvial Deposits	Holocene to Pleistocene	Poorly consolidated ad tures of sand, silt, g and clay, with minor ca layers
		Ogallala Formation	Pliocene	Unconsolidated to weak cemented beds of sand, el, silt and clay; mir lenses of indurated ca and crystaline quartzi
		Arikaree Formation	Miocene	Weak to moderately cer massive to poorly bedc hard, limy lenses of s stone
		Pierre Shale	Upper Cretateous	Dark, clayey shale wi tonitic beds, and limy cretions
		Niobrara Formation	Upper Cretateous	Fissile, chalky shale interbedded with thin massive limestone and
		Carlisle Shale	Upper Cretateous	Noncalcareous, fissle with minor sandstone a concretions
		Greenhorn Limestone	Upper Cretateous	Interbedded chalky sha thin limestone
		Graneros Shale	Upper Cretateous	Noncalcareous shale, w local sandstone lenti

GEOTECHNICAL SUMMARY

LITHOLOGY	GROUNDWATER	TERRAIN
consolidated admix- of sand, silt, gravel ay, with minor caliche	Water table unconfined to artesian in the Ogallala and Arikaree Formations, generally at depths exceeding 100 ft.; perched water occurs in local weathered zones of cretateous shales, and above impermeable layers within the Ogallala and Arikaree Formations.	High Plains Section: Flat upland plain; local relief varying from one to 40 feet; flatlands generally slope slightly to the east.
olidated to weakly ed beds of sand, grav- lt and clay; minor of indurated calcrete ystaline quartzite		Plains Border Section: Irregular topography caused by differentially eroded soft sediments; interstream divides generally flat with little relief; relief reaches 100 feet in eastern Kansas.
o moderately cemented e to poorly bedded, limy lenses of sand-		Colorado Piedmont: Broadly rolling topography; gentle ridges, cuestas, and buttes of low relief formed where structural arches or troughs occur; relief exceeds 100 feet near the northern limit of Colorado suitable area.
clayey shale with ben- c beds, and limy con- ns		
e, chalky shale, edded with thin to e limestone and marl		Raton Section: Moderately dissected plateau; relief less than 100 ft./nm, maximum slopes generally less than 3%.
careous, fissle shale inor sandstone and tions		
edded chalky shale and imestone		
careous shale, with sandstone lentils		

2

GEOTECHNICAL SUMMARY OF
CANDIDATE SITING PROVINCES
PAGE 1 OF 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
5

FUGRO NATIONAL, INC.

CSP	TOTAL SUITABLE NM^2	GEOTECH		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Southern High Plains	11,640	Aeolian, Lacustrine Fluvial, Alluvial Deposits	Holocene to Pleistocene	Poorly consolidated admi tures of sand, silt, grav and clay, with caliche
		Ogallala Formation	Pliocene	Unconsolidated to weakly cemented interbeds of cl silt, sand and gravel; interbeds of indurated caliche, silicified capro also present
Rio Grande	5,100	Unnamed Basin Fill	Quaternary to Miocene (?)	Poorly to well consolid deposits of poorly sort clay, silt, sand, grave cobbles and boulders
		Santa Fe Formation	Lower Pleistocene to Miocene (?)	Moderately to well cons dated gravel and sand, w minor silt, clay, calic and interbedded basalt

GEOTECHNICAL SUMMARY		
LITHOLOGY	GROUNDWATER	TERRAIN
y consolidated admix- of sand, silt, gravel lay, with caliche solidated to weakly ted interbeds of clay, sand and gravel; beds of indurated ne, silicified caprock present	Ground-water table generally is in excess of 100 feet deep; minor artesian conditions near Pecos, Texas	Llano Estacado: Featureless plain with occasional shallow drainage incisions; surface gradient eight to ten feet/nm southeasterly; minor local relief; natural depressions common on plain. Pecos Valley-Edwards Plateau: Flat to gently undulating terrain, sloping slightly east and south. Southern Pecos Valley-Edwards Plateau: Alluvial basins and valleys. Mexican Highlands Section: Broad alluvial valleys filled with coalescing alluvial fans, and bajadas; incision depths may reach 40 feet.
to well consolidated its of poorly sorted silt, sand, gravel, es and boulders ately to well consoli- gravel and sand, with silt, clay, caliche, nterbedded basalt	Ground water is generally unconfined and exceeds 100 feet in depth.	Broad, elongated desert basins, expressed as coalescing alluvial fans, ephemeral streams and floodplains, dunes, pediments, and playas; elevations of basins range from 3000 feet in the south to approximately 5800 feet in the north; drainage densities and depths of incision are generally 1/0.3 nm, and 5-10 feet, respectively.

2

GEOTECHNICAL SUMMARY OF
CANDIDATE SITING PROVINCES
PAGE 2 OF 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
5

FUGRO NATIONAL, INC.

CSP	TOTAL SUITABLE NM^2	GEOTEC		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Highlands	7,510	Unnamed Basin Fill	Holocene to Pliocene	Unconsolidated to poorl consolidated deposits o sand, silt, clay and gra
		Big Sandy Formation	Pleistocene to Pliocene	Mudstone with thin inte ded tuffs, most are zeo margins of formation co of coarser clastics and conglomerates with mino caliche.
Sonoran	17,470	Unnamed Basin Fill	Pleistocene to Pliocene	Unconsolidated to poorly solidated gravel, sand, and clay, with minor eva ites, caliche layers, an interbedded volcanic flo
		Bouse Formation and Imperial Formation	Pliocene	Poorly consolidated to w cemented claystone, silt stone and sandstone; re- stricted local exposure

GEOTECHNICAL SUMMARY

LITHOLOGY	GROUNDWATER	TERRAIN
dated to poorly ted deposits of t, clay and gravel with thin interbed- , most are zeolitic, f formation consist r clastics and ates with minor	Ground water is generally encountered at depths greater than 100 feet around basin borders; adjacent to playas ground water is commonly at depths less than 50 feet.	Broad, elongated desert basins, expressed as coalescing alluvial fans, ephemeral streams and floodplains, dunes, terraces, and playas; basin elevations range from 4200 feet in the west to 5500 feet in the east; approximately one half of the basins drain internally forming playas; average drainage density and depth of incision are 1/0.5 nm, and 5-10 feet respectively.
ated to poorly con- gravel, sand, silt, with minor evapor- che layers, and d volcanic flows solidated to well laystone, silt- sandstone; re- ocal exposure	Ground water table is generally unconfined at depths of 50 to over 100 feet; ground water less than 50 feet deep may be encountered in the vicinity of playas or faults (Mojave section) or near basin outflows (Sonoran Section)	Relatively flat, elongate desert basins expressed as coalesing alluvial fans and bajadas, ephemeral streams, dunes, pediments and terraces; basin elevations range from near sea level in the Salton Trough section to approximately 4,000 feet in southern Nevada; playas less frequent compared to Great Basin; average drainage density and depth of incision are 1-2 nm, and 1-20 feet, respectively.

2

GEOTECHNICAL SUMMARY OF CANDIDATE SITING PROVINCES
PAGE 3 OF 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
5

FUGRO NATIONAL, INC.

CSP	TOTAL SUITABLE NM^2	GEOT		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Great Basin	25,680	Unnamed Basin Fill	Quaternary (?)	Poorly to well consoli deposits of boulders, sand, silt, and clay w minor volcanic tuff, a various degrees of cal development
Montana	9,680	Glacial and Terrace Deposits	Pleistocene	Loose to poorly consol glacial till (clay, sa gravel, boulders), and race materials (gravel silt)
		Fort Union Formation	Paleocene	Clayey shale, siltston sandstone; some limy b
		Hell Creek Formation	Cretateous	Interbedded sandstone, shaley clay and mudsto
		Pierre Shale	Upper Cretateous	Clayey shale, with conc tions and sandy member
		Bearpaw Shale	Upper Cretateous	Clayey shale, with bent beds and concretions

GEOTECHNICAL SUMMARY

LITHOLOGY	GROUNDWATER	TERRAIN
y to well consolidated its of boulders, gravel silt, and clay with volcanic tuff, and us degrees of caliche opment	Water table is generally more than 100 feet deep, but interpretation is complicated by interbasin flow and perched water conditions.	Relatively flat, elongate desert basins expressed as coalescing alluvial fans, ephemeral streams and floodplains, dunes, playas, terraces and pediments; elevations of basins are 6000 ft. to 6500 feet in the east to approximately 2500 feet in the west; distribution of playas is erratic; regional surface gradient is 10 to 12 feet/nm westerly; maximum relief adjacent to drainages is 10 to 25 feet.
to poorly consolidated al till (clay, sand, l, boulders), and ter- naterials (gravel, sand, ' shale, siltstone, and :one; some limy beds edded sandstone, ' clay and mudstone shale, with concre- and sandy members shale, with bentonic nd concretions	Ground water varies from 25 to 100 feet deep in the north depending upon thickness of glacial drift. The water table in sandstone ranges from 50 to 500 feet.	Glaciated Portion: Broad, undulating plains; moderately dissected with incision of 10 to 20 feet; scattered kames and eskers of less than 50 feet relief; several large terminal moraines. Non-glaciated Portion: Moderately to well dissected plain with low, rolling hills; local relief varies from 0 to 30 feet.

2

GEOTECHNICAL SUMMARY OF
CANDIDATE SITING PROVINCES
PAGE 4 OF 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
5

FUGRO NATIONAL, INC.

CSP	TOTAL SUITABLE NM^2	GEOTE		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Dakotas	8,900	Judith River Formation	Middle Cretateous	Massive, cross-bedded stone, and sandy shale
		Colorado Shale	Lower Cretateous	Clayey shale, with conc tions, and sandy units
		Oahe Formation	Pleistocene (Wisconsinian Stage) to Holocene	Aeolian silt and sand deposits
		Cole Harbor Group	Pleistocene	Unconsolidated to poor consolidated glacial (clay, silt, sand, grav boulders), and lacustri deposits (sand, and si
		Fort Union Group	Paleocene	Poorly consolidated to erately cemented sands siltstone, claystone, some limestone and lig
		Hell Creek Formation	Upper Cretateous	Sandy shales, sands, c aceous shales, and thi nite beds
		Fox Hills Formation	Upper Cretateous	Sandy shale, siltstone poorly consolidated sa stone interbedded with well indurated sandsto
		Pierre Shale	Upper Cretateous	Massive to fissile non calcareous shales and stones
		Niobrara Formation	Upper Cretateous	Thickly bedded calcare shale and marl, thin b bentonite, and some ch limestones

GEOTECHNICAL SUMMARY

LITHOLOGY	GROUNDWATER	TERRAIN
cross-bedded sand- d sandy shale		
ale, with concre- d sandy units		
ilt and sand	Depth of ground water is highly variable; difficult to determine precisely due to poor documentation; perched and artesian conditions are reported to be common.	Missouri Plateau section: Relatively flat to irregularly rolling plain with disseminated knobs and kettles; ponds and swamps in many depressions. Western Lake section: Flat to slightly rolling morainal plains, with numerous areas of eskers, kames, and end moraines.
dated to poorly ted glacial till , sand, gravel, and lacustrine (sand, and silt)		
nsolidated to mod- emented sandstone, claystone, with stone and lignite		
es, sands, carbon- les, and thin lig-		
e, siltstone, and solidated sand- rbedded with ated sandstone		
fissile non- shales and silt-		
dded calcareous arl, thin beds of and some chalky		

2

GEOTECHNICAL SUMMARY OF CANDIDATE SITING PROVINCES PAGE 5 OF 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
5

FUGRO NATIONAL, INC.

CSP	TOTAL SUITABLE NM^2	G		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Coastal Plain	4,110	Terrace and Alluvial Deposits	Quaternary	Sand, gravel, and s
		Uvalde Gravel	Pliocene	Caliche-cemented gra chert, quartz, and ign clasts
		Yequa Formation	Upper Eocene	Poorly indurated san and laminar clay
		Laredo Formation	Upper Eocene	Fine-grained, ferrugi sandstone and clay
		Sparta Sand	Middle Eocene	Fine-grained quartz stone, with minor si and interbedded silt
		Cook Mountain Formation	Middle Eocene	Gypsiferous clay, wi and lignite, minor glauconite; fine-gra calcareous sandstone
		El Pico Clay	Middle Eocene	Clay, in part gypsif fine-grained sandsto bedded to massive
		Queen City Sand	Middle (?) Eocene	Friable to indurated stone with interbeds clay
		Weches Formation	Middle (?) Eocene	Sand, clay some marl

GEOTECHNICAL SUMMARY

LITHOLOGY	GROUNDWATER	TERRAIN
avel, and silt	Unconfined water table generally deeper than 50ft.; artesian conditions complicate true depth to ground water in scattered portions of the CSP.	Broad, relatively flat plain sloping southeasterly; 30 to 50 feet/nm; maximum local relief approximately 50 feet; terraces and cuestas formed from slightly dipping exposed sedimentary formations.
cemented gravel-sized artz, and igneous		
ndurated sandstone nar clay		
ined, ferruginous e and clay		
ined quartz sand- ith minor silty clay rbedded siltstone		
ous clay, with silt ite, minor te; fine-grained, s sandstone		
part gypsiferous; ined sandstone, thin- massive		
o indurated; silt- h interbeds of		
y some marl		

2

GEOTECHNICAL SUMMARY OF CANDIDATE SITING PROVINCES
PAGE 6 OF 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
5

FUGRO NATIONAL, INC.

CSP	TOTAL SUITABLE NM^2	GE		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Coastal Plain (cont.)		Bigford Formation	Lower (?) Eocene	Calcerous clay/sandy and sandstone, with shale and minor lim concretions.
		Carrizo Sand	Lower (?) Eocene	Weakly cemented sand locally well indurat shale interbedded wi sandstone beds, loca cretions
		Indio Formation	Lower (?) Eocene	Fine-grained sandsto sandy carbonaceous s with numerous concre
		Kincaid Formation	Lower (?) Eocene	Fossiliferous shale, conitic sandstone, s limestone
		Escondido Formation	Upper Cretaceous	Fossiliferous siltst limestone, mudstone, fine-grain sandstone
		Olmos Formation	Upper Cretaceous	Interfingering lense sandstone and clay, f inous concretions an ified wood common, w coal
		San Miguel Formation	Upper Cretaceous	Fossiliferous sand, limestone, clay
		Upson Clay	Upper Cretaceous	Slightly calcareous fossiliferous

GEOTECHNICAL SUMMARY

LITHOLOGY	GROUNDWATER	TERRAIN
clay, sandy clay one, with fissile minor limestone s.	Unconfined water table generally deeper than 50ft.; artesian conditions complicate true depth to ground water in scattered portions of the CSP.	Broad, relatively flat plain sloping southeasterly; 30 to 50 feet/nm; maximum local relief approximately 50 feet; terraces and cuestas formed from slightly dipping exposed sedimentary formations.
ented sandstone, ll indurated; rbedded with thin beds, local con-		
ed sandstone, naceous shale, us concretions		
us shale, glau- dstone, sandy		
us siltstone, mudstone, with sandstone		
ing lenses of nd clay, ferrug- etions and silic- common, with some		
us sand, sandy clay		
careous clay, s		

2

GEOTECHNICAL SUMMARY OF
CANDIDATE SITING PROVINCES
PAGE 7 OF 9

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	TABLE 5

FUGRO NATIONAL, INC.

CSP	TOTAL SUITABLE NM^2	GE		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Plateau	1,890	Mixed Eolian and Modern Alluvial Deposits	Holocene	Unconsolidated sand,
		Bidahochi Formation	Pliocene	Sandstone, tuff, ben and mudstone; minor ded basalt
		Baca Formation	Paleocene	Interbedded arkosic stone, sandy siltsto conglomerate
		Mancos Shale	Upper Cretaceous	Fossiliferous marine stones, and mudstone
		Chinle Formation	Upper Triassic	Clayey shale and san with minor limestone
Wyoming	680	Eolian, Lacustrine, Fluvial and Alluvial Deposits	Holocene to Upper Pleistocene (?)	Unconsolidated to po solidated sand, grav bles, silt, and clay
		Unnamed Lake Beds	Upper Pleistocene	Uncemented to poorl cemented beds of cla and sand
		Green River Formation	Middle Eocene	Fissile oil shale an stone; minor sandsto limestone

GEOTECHNICAL SUMMARY

LITHOLOGY	GROUNDWATER	TERRAIN
lated sand, and silt	Ground water is generally found unconfined within the Bidahochi Formation and thicker alluvial units; water table depths generally exceed 100 feet but may range from 50 to 700 feet.	Level to slightly undulatory plateau surface; regional gradient 19 feet/nm (0.3% grade); surface has slight to moderate dissection; local stream channel relief to a few tens of feet; major dissections separate main plateau into smaller flat surfaces.
tuff, bentonite, ne; minor interbed-		
d arkosic sand- dy siltst and te		
ous marine silt- d mudstones		
le and sandstone, limestone		
ated to poorly con- sand, gravel, cob- , and clay	Ground water generally under artesian conditions in permeable beds of cretaceous bedrock. Depth to water table varies from 150 to 300 feet.	Mildly undulating plain composed of small basins, flats and playas; maximum surface gradient is less than 1%; moderately to well dissected basin floors; dissection depth varies from 5 to 20 feet.
to poorly eds of clay, silt,		
shale and silt- r sandstone, and		

2

GEOTECHNICAL SUMMARY OF
CANDIDATE SITING PROVINCES
PAGE 8 OF 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
5

FUGRO NATIONAL, INC.

CSP	TOTAL SUITABLE NM ^{2}	GEOT		
		GEOLOGIC UNIT	AGE	LITHOLOGY
Wyoming (cont.)		Battle Spring Formation	Middle Eocene	Poorly to moderately i ated sandstone, clayst and shale
		Wasatch Formation	Middle Eocene	Claystone and shale; c aceous shale: coal, sa stone, and conglomerat
Northern Rockies	820	Unnamed Basin Fill	Holocene	Unconsolidated to poor consolidated alluvium sisting of poorly sort mixtures of silt, sand gravel

GEOTECHNICAL SUMMARY		
HOLOGY	GROUNDWATER	TERRAIN
derately indur- ne, claystone		
d shale; carbon- coal, sand- nglomerate		
ed to poorly alluvium con- oorly sorted ad- silt, sand, and	Depth to ground water varies from 50 to 900 feet depending on thickness of alluvium and amount of surface runoff.	Birch Creek, Little Lost Creek Valleys: broad coalescing alluvial fans, some well defined; continuous terraces, flat to moderately dissected; slopes are generally less than 2%; incision depths 10 to 30 feet. Snake River Plain: Low relief plain with "sink" areas

2

GEOTECHNICAL SUMMARY OF CANDIDATE SITING PROVINCES
PAGE 9 OF 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
5

FUGRO NATIONAL, INC.

STATE	ONC REFERENCE	EXCLUDED AREA (%) *				SUITABLE AREA	
		TOPOGRAPHY	ROCK	WATER	CULTURAL		
Alabama	G-20,21 H-24,25	40		7	53		Populatio state; mi exclude t state; sh state.
Arizona	G-18,19	20	15	10	45	10	Indian res monuments Plateau i relief an and Range
Arkansas	G-20	30		30	40		Relative and west- Ouachita and the Mi ground wat southweste minimum pa
California	F-16 G-18	15	10	5	65	5	Population Pacific Bo (cultural) mountains; Los Angele ground wat Joaquin an Sonoran De
Colorado	F-17A G-19	65	25	2	5	3	Slopes gre exclude po ters, mini ests (cult Mountains.
Connecticut	F-19				100		Large conc New Englan
Delaware	G-21			35	65		Surface wa of the Coa ters (cult land.

* Relative percentages estimated from Drawing 1.

REMARKS
Population centers (cultural) exclude the northern portion of the state; minimum parcel (cultural) and relative relief (topography) exclude the southern Coastal Plain or the southern portion of the state; shallow ground water excludes the central portion of the state.
Indian reservations, recreation areas, national forests, parks, and monuments (cultural), and shallow ground water exclude the Colorado Plateau in the northeastern portion of the state; rock, relative relief and slopes greater than 10% (topography) exclude the Basin and Range province in the southwestern portion of the state.
Relative relief and slopes greater than 10% exclude the northwest and west-central portions of the state in the Ozark, Boston, and Ouachita mountains; eastern and southeastern portions of the state and the Mississippi River Alluvial Plain are excluded by shallow ground water; West Gulf Coastal Plain in the south-central and southwestern portions of the state are excluded by economic and minimum parcel areas (cultural), and shallow ground water.
Population centers (cultural) exclude coastal regions of the Pacific Border province; national and state parks and forests (cultural) exclude the Cascade-Sierra Mountains, i.e. the inland mountains; slopes greater than 10% (topography) exclude the Klamath, Los Angeles ranges and the Lower California province; shallow ground water excludes the California and Salton troughs in the San Joaquin and Salton Sea areas; rock excludes large portions of the Sonoran Desert in the southeastern portion of the state.
Slopes greater than 10% and relative relief (topography), and rock exclude portions of the Southern Rocky Mountains; population centers, minimum parcel areas, and national and state parks and forests (cultural) exclude the eastern margin of the Southern Rocky Mountains.
Large concentrations of population centers (cultural) exclude the New England Upland section, the vast majority of the state.
Surface water and shallow ground water exclude the Embayed section of the Coastal Plain, eastern portion of the state; population centers (cultural) exclude the Piedmont and New England provinces inland.

2

DISTRIBUTION AND NATURE OF UNSUITABLE AREA
PAGE 1 OF 7

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 6

FUGRO NATIONAL, INC.

STATE	ONC REFERENCE	EXCLUDED AREA (%) *				SUITABLE AREA	
		TOPOGRAPHY	ROCK	WATER	CULTURAL		
Florida	H-24,25			80	20		Surface Peninsul ground wa Gulf Coa
Georgia	G-21 H-24,25	15		25	60		Shallow Plain; m clude th excludes
Idaho	F-16	15	20		63	2	Rock exc and the northern national ulation
Illinois	F-18 G-20,21	3		2	95		Minimum relief (northern graphy) high pot graphy)
Indiana	F-18 F-20,21	15			85		Minimum relief (
Iowa	F-17,18	40		5	55		Shallow Lowlands portion lief (to state; p relative portions
Kansas	G-19,20	30		20	40	10	Relative the nort tion cen central the sout

* Relative percentages estimated from Drawing 1.

REMARKS
urface water and population centers (cultural) exclude the Florida eninsula;relative relief (topography), surface water, shallow round water and minimum parcel areas (cultural) exclude the East ulf Coastal Plain.
hallow ground water excludes the Sea Island section of the Coastal lain; minimum parcel areas and population centers (cultural) exlude the central portion of the state; relative relief (topography) xcludes the Northern Blue Ridge and Valley and Ridge provinces.
ock excludes most of the Columbia Plateau, Basin and Range province nd the Middle and Northern Rocky Mountains in the southeastern and orthern portions of the state; slopes greater than 10% (topography) ational and state parks and forests, minimum parcel areas and poplation centers (cultural) comprise the remaining exclusion.
inimum parcel areas, population centers (cultural), and relative relief (topography) exclude the Central Lowland Till Plains in the orthern and central portions of the state; relative relief (toporaphy) excludes the western and central portions of the state; igh potential coal resources (cultural) and relative relief (toporaphy) exclude the southern half of the state.
inimum parcel areas, population centers (cultural), and relative relief (topography) exclude the state.
hallow ground water excludes the glaciated areas of the Central Lowlands; minimum parcel areas (cultural) exclude the north-central ortion of the state; stream density (cultural), and relative relief (topography) exclude the western and southern sections of the state; population centers, minimum parcel areas (cultural), and relative relief (topography) exclude the eastern and southeastern ortions of the state.
elative relief and slopes greater than 10% (topography) exclude he north-central and northeastern portions of the state; populaion centers (cultural) generally exclude the central and eastentral portions of the state; economic areas (cultural) exclude he southwestern portions of the state.

2

DISTRIBUTION AND NATURE OF UNSUITABLE AREA

PAGE 2 OF 7

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	TABLE 6

FUGRO NATIONAL, INC.

STATE	ONC REFERENCE	EXCLUDED AREA (%) *				SUITABLE AREA	
		TOPOGRAPHY	ROCK	WATER	CULTURAL		
Kentucky	G-20,21	59		1	40		Relativ exclude of the exclude Lakes.
Louisiana	G-20 H-24			35	65		Surface of the water e mum parc state; ial Pla
Maine	F-19	40		45	15		Shallow New Engl minimum land po
Maryland	G-21	5		15	80		Shallow portions exclude
Massachusetts	F-19				100		Overlap
Michigan	F-18	20		45	35		Relative shallow of the s parcel a forests
Minnesota	F-17,18	3		77	20		Shallow exclude and rela Till Pla
Mississippi	G-20 H-24	20		25	55		Shallow Tombigbe parcel state; r the stat clude th graphy)

* Relative percentages estimated from Drawing 1.

ABLE EA	REMARKS
	Relative relief (topography), and population centers (cultural) exclude the dissected Appalachian Plateau in the eastern portion of the state; minimum parcel areas and population centers (cultural) exclude all portions of the state west of the Kentucky/Barclay Lakes.
	Surface water and shallow ground water exclude the coastal portions of the state; minimum parcel areas (cultural) and shallow ground water exclude the southern portion of the state; economic and minimum parcel areas (cultural) exclude the northern portion of the state; shallow ground water excludes the eastern Mississippi Alluvial Plain.
	Shallow ground water, surface water, and rock exclude the northern New England Upland portion of the state; population centers, and minimum parcel areas (cultural) exclude the southern Seaboard Lowland portion of the state.
	Shallow ground water and surface water exclude the eastern coastal portions of the state; overlapping population centers (cultural) exclude the remainder of the state.
	Overlapping population centers (cultural) exclude the entire state.
	Relative relief (topography) and rock exclude the northern peninsula; shallow ground water and surface water exclude the northern portion of the southern peninsula; relative relief (topography), minimum parcel areas, population centers, oil and gas fields, and state forests (all cultural) exclude the southern portion of the state.
	Shallow ground water, surface water, and national forests (cultural) exclude the majority of the state; minimum parcel areas (cultural) and relative relief (topography) exclude the southern Dissected Till Plains.
	Shallow ground water and surface water exclude the Mississippi and Tombigbee Rivers Alluvial Plains; population centers and minimum parcel areas (cultural) exclude the southern portion of the state; relative relief (topography) excludes the central third of the state; minimum parcel areas and national forests (cultural) exclude the north-central portion of the state; relative relief (topography) excludes the eastern border of the state.

DISTRIBUTION AND NATURE OF UNSUITABLE AREA
PAGE 3 OF 7

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
6

UGRO NATIONAL, INC.

STATE	ONC REFERENCE	EXCLUDED AREA ( ) *				SUITABLE AREA	
		TOPOGRAPHY	ROCK	WATER	CULTURAL		
Missouri	F-17,18 G-20	55		5	40		Relative shallow minimum the nort parcel a rock and in the s water ex
Montana	F-16,17	65	15	2	10	8	Relative exclude relative tion of water ex and slop tion of
Nebraska	F-17	60		20	15	5	Populati southern water ex relative the rema
Nevada	F-16 G-18	45	30	10	5	10	National (cultural lative re most of Basin Pr
New Hampshire	F-19	75			25		Relative the Appal slopes g national
New Jersey	F-19 G-21	5		10	85		Shallow portion exclude
New Mexico	G-19 H-23	10	35	5	40	10	Economic tural) e state; re River po areas, (

* Relative percentages estimated from Drawing I

REMARKS

Relative relief (topography), minimum parcel areas (cultural) and shallow ground water, exclude the northwest portion of the state; minimum parcel areas (cultural) and shallow ground water exclude the northeast portion of the state; economic areas and minimum parcel areas (cultural) exclude the western portion of the state; rock and relative relief (topography) exclude the Ozark Plateau in the south and south-central portion of the state; shallow ground water excludes the southeastern Mississippi River Alluvial Plain.

Relative relief and slopes greater than 10% (topography) generally exclude the western Northern Rocky Mountain portion of the state; relative relief (topography) excludes the eastern Great Plains portion of the state; population centers (cultural) and shallow ground water exclude the central portion of the state; relative relief and slopes greater than 10% (topography) exclude the remaining portion of the state.

Population centers and minimum parcel areas (cultural) exclude the southern portion of the state; surface water and shallow ground water exclude the central or High Plains portion of the state; relative relief and slopes greater than 10% (topography) comprise the remaining exclusion.

National game refuges, national forests, and Indian reservations (cultural) exclude parts of the northern portion of the state; relative relief, slopes greater than 10% (topography) and rock exclude most of the mountain ranges within the Nevada portion of the Great Basin Province.

Relative relief and slopes greater than 10% (topography) exclude the Appalachian Mountains portion of the state; relative relief, slopes greater than 10% (topography), population centers and national forests (cultural) exclude the remainder of the state.

Shallow ground water and surface water exclude the Coastal Plain portion of the state; overlapping population centers (cultural) exclude the remainder of the state.

Economic areas, national forests, and Indian reservations (cultural) exclude the northwestern Colorado Plateau portion of the state; relative relief (topography) excludes the central Rio Grande River portion of the state; population centers and minimum parcel areas, (cultural) exclude parts of the Southern High Plains.

2

DISTRIBUTION AND NATURE OF
UNSUITABLE AREA
PAGE 4 OF 7

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
6

FUGRO NATIONAL, INC.

STATE	ONC REFERENCE	EXCLUDED AREA (%) *				SUITABLE AREA	
		TOPOGRAPHY	ROCK	WATER	CULTURAL		
New York	F-18,19	40		10	50		The Adir of the s slopes g clude th
North Carolina	G-21	20		20	60		Shallow Plain po the west
North Dakota	F-17A	20		25	45	10	Economic tion cen ed, irre than 10% (cultura shallow tural) e
Ohio	F-18 G-21	15			85		Relative eau port ters (cu
Oklahoma	G-19,20A	7	10	40	40	3	Shallow Great Pl excludes excludes populati central,
Oregon	F-16	10	25	5	60		Rock, na central cel area slopes g central state fo face wat graphy) state.
Pennsylvania	F-18,19 G-21	40			60		Populati tural) a

* Relative percentages estimated from Drawing 1.

REMARKS

The Adirondack State Park (cultural) excludes the northeast portion of the state; population centers (cultural), relative relief, slopes greater than 10% (topography), and shallow ground water exclude the remaining portions of the state.

Shallow ground water and surface water excludes the eastern Coastal Plain portion of the state; relative relief (topography) excludes the western Piedmont and Blue Ridge provinces.

Economic areas, minimum parcel areas, Indian reservations, population centers and national grasslands (cultural) exclude scattered, irregular-shaped areas throughout the state; slopes greater than 10%, relative relief (topography), and population centers (cultural) exclude the western Great Plains portion of the state; shallow ground water, surface water, and population centers, (cultural) exclude the eastern portion of the state.

Relative relief (topography) excludes the eastern Appalachian Plateau portion of the state; minimum parcel areas, and population centers (cultural) exclude the western portion of the state.

Shallow ground water excludes most of the Central Lowlands and Great Plains portions of the state; relative relief (topography) excludes the eastern Ozark Plateau and Ouachita province; rock excludes the north-central, and southwest portions of the state; population centers and oil and gas fields (cultural) exclude the central, south-central, and panhandle portions of the state.

Rock, national and state parks and forests (cultural) exclude the central Cascade Mountain Range portion of the state; minimum parcel areas, population centers (cultural), and relative relief and slopes greater than 10% (topography) exclude the remaining central portions and eastern portions of the state; national and state forests and parks (cultural), shallow ground water and surface water, relative relief, and slopes greater than 10% (topography) exclude the coastal Pacific Border province portion of the state.

Population centers, state forests, minimum parcel areas (all cultural) and relative relief, (topography) exclude the entire state.

2

DISTRIBUTION AND NATURE OF UNSUITABLE AREA
PAGE 5 OF 7

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
6

FUGRO NATIONAL, INC.

STATE	ONC REFERENCE	EXCLUDED AREA (%) *				SUITABLE AREA	
		TOPOGRAPHY	ROCK	WATER	CULTURAL		
Rhode Island	F-19				100		Populat
South Carolina	G-21	5		30	65		Shallow eastern graphy) Mountai
South Dakota	F-17A	20		25	45	10	Shallow of the border lief, a west to
Tennessee	G-20,21	55		2	43		Relativ centers shallow the wes
Texas	G-19,20A H-23,24A	15	20	5	57	3	Rock ex ground relativ western areas, clude n
Utah	F-16 G-18,19	10	44	32	10	4	Shallow Salt La
Vermont	F-19	75		3	22		Relativ most of the nor
Virginia	G-21	20		5	75		Shallow mum par the sta of the
Washington	F-16	10	25	5	60		Rock, r clude t Cascade nationa remaind

* Relative percentages estimated from Drawing 1.

REMARKS
Population centers (cultural) exclude the entire state.
Shallow ground water and population centers (cultural) exclude the eastern Coastal Plain portion of the state; relative relief (topography) excludes the western Piedmont Province/Appalachian Mountains portion of the state.
Shallow ground water and surface water exclude the eastern portion of the state; Indian reservations (cultural) exclude the southern border and parts of the northern portion of the state; relative relief, and slopes greater than 10% (topography) exclude the northwest to east-central portion of the state.
Relative relief (topography), minimum parcel areas, and population centers (both cultural) exclude the eastern portion of the state; shallow ground water, and minimum parcel areas (cultural) exclude the western half of the state.
Rock excludes the Central Lowlands portion of the state; shallow ground water and surface water excludes coastal areas of the state, relative relief, and slopes greater than 10% exclude eastern and western portions of the state; population centers, minimum parcel areas, and national and state parks and forests (all cultural) exclude northern and southeastern portions of the state.
Shallow ground water and surface water exclude the western Great Salt Lake and Sevier River portions of the state.
Relative relief, and slopes greater than 10% (topography) exclude most of the state; shallow ground water and surface water excludes the northwest corner of the state.
Shallow ground water, surface water, population centers, and minimum parcel areas (cultural) exclude the Coastal Plain portion of the state; relative relief excludes the western Appalachian portion of the state.
Rock, relative relief, and slopes greater than 10% (topography) exclude the southeastern Columbia Plateau and the central Northern Cascade Mountains; population centers, minimum parcel areas, and national and state forests and parks (all cultural) exclude the remainder of the state.

DISTRIBUTION AND NATURE OF UNSUITABLE AREA
PAGE 6 OF 7

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
6

FUGRO NATIONAL, INC.

STATE	ONC REFERENCE	EXCLUDED AREA ( ) *				SUITABLE AREA	
		TOPOGRAPHY	ROCK	WATER	CULTURAL		
West Virginia	F-18 G-21	70			30		Rock, rel populatio
Wisconsin	F-17,18	15		60	25		Shallow g and India populatic portions western a
Wyoming	F-16,17	62		2	35	1	Relative the Middl and natio the south

* Relative percentages estimated from Drawing 1.

ILE	REMARKS
	Rock, relative relief, slopes greater than 10% (topography), and population centers (cultural) exclude the entire state.
	Shallow ground water, surface water; national and state forests, and Indian reservations (cultural) exclude most of the state; population centers (cultural) exclude the eastern and southern portions of the state; relative relief (topography) excludes the western and southwestern portions of the state.
	Relative relief and slopes greater than 10% (topography) exclude the Middle Rocky Mountain portion of the state; population centers and national and state parks and forests (all cultural) exclude the southeastern and northwestern corners of the state.

2

DISTRIBUTION AND NATURE OF
UNSUITABLE AREA
PAGE 7 OF 7

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
6

FUGRO NATIONAL, INC.

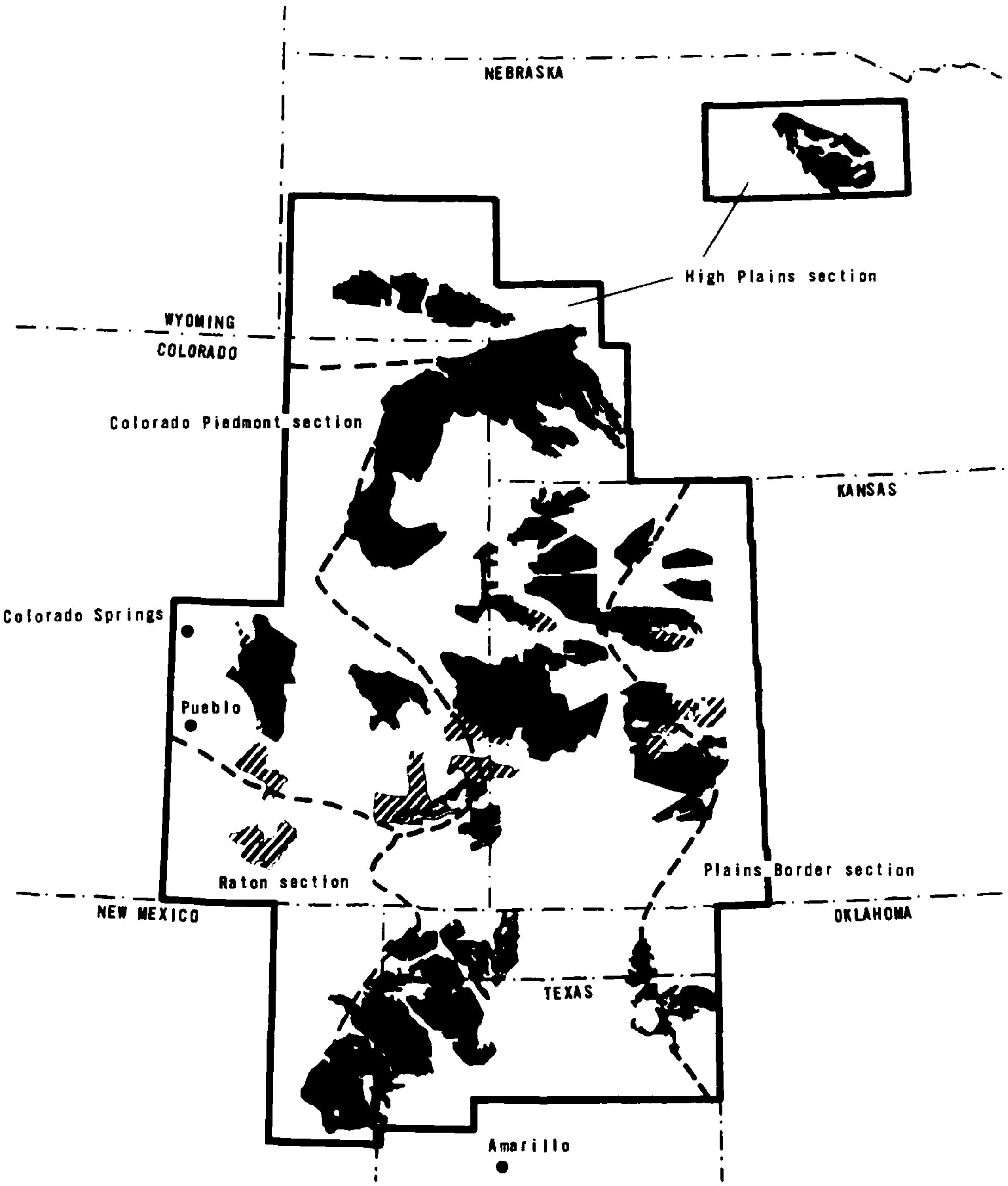
3.0 CENTRAL HIGH PLAINS CSP

3.1 GENERAL SETTING

The Central High Plains CSP encompasses approximately 18,650 nm^2 of suitable area covering portions of Nebraska, Colorado, Kansas, New Mexico, Oklahoma and Texas (Figure 3). Distribution of suitable area within this CSP corresponds to the Great Plains physiographic province (Fenneman, 1931), an area characterized by flat-lying plains, broad river valleys and gently rolling hills. The CSP is informally subdivided into four sections for purposes of this discussion, each corresponding to a physiographic subprovince with differing geotechnical conditions (Fenneman, 1931). They are the High Plains, Plains Border, Colorado Piedmont and the Raton sections (Figure 3).

The High Plains section covers portions of all states mentioned above, and typifies the majority of suitable area in the CSP. Contiguous parcels are irregular in shape, primarily defined by topographic and cultural exclusions (Appendix C). Parcel sizes range from 180 to 4450 nm^2.

The High Plains section is flanked to the east by the Plains Border and to the west by the Colorado Piedmont and Raton sections. Parcels in these sections are generally scattered, small in size (up to 930 nm^2), contain greater percentages of excavatable rock (Section 3.3.1), and have a sharper more rugged terrain. Geotechnical conditions in the Plains Border, Colorado Piedmont and Raton sections are commonly atypical of the CSP as a whole and contain physical properties and features which may be transitional to adjacent physiographic provinces such as the Central Lowlands and the Southern Rocky Mountains.



--- PHYSIOGRAPHIC SECTION BOUNDARY

■ SUITABLE

▨ SUITABLE ROCK

CENTRAL HIGH PLAINS CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
3

FUGRO NATIONAL, INC.

3.2 SUMMARY OF RESULTS

1. Four distinct divisions of the Central High Plains CSP were recognized as possessing different geologic, geomorphic, soils, topographic and/or hydrologic characteristics. These divisions are the High Plains, Plains Border, Colorado Piedmont, and Raton sections.

2. The Ogallala and Arikaree formations are the principal Mio-Pliocene surficial geologic units present in the High Plains and Raton sections. These formations are lithologically similar consisting of weakly cemented sands, gravels and silts, with minor interbeds of calcrete and quartzite. Covering much of the Ogallala Formation is a "limestone-like" caprock, usually less than a few feet thick.

3. Suitable area composed of excavatable rock occurs extensively in the Colorado Piedmont and Plains Border sections. These units consist of interbedded Upper Cretaceous shale, sandstone, chalk, and limestone.

4. Wind-blown sand and silt and fluvial deposits cover extensive portions of suitable area. Wind-blown sands occur primarily in Nebraska and southern Kansas. Fluvial deposits are developed extensively near the site of present drainage channels and basins. Wind-blown loess covers most of the High Plains section.

5. Ground water is unconfined in the Ogallala and Arikaree formations and generally occurs at depths greater than 100 feet. Ground-water tables have been declining at the rate

of two to five feet per year in the High Plains section. In the Cretaceous Pierre Shale within the Colorado Piedmont and Raton sections, ground water is predominately greater than 50 feet deep.

6. Perched ground-water conditions are rare but could be expected in weathered zones of the Pierre Shale in the Colorado Piedmont section and in areas underlain by near surface impermeable layers within the Ogallala or Arikaree formations of the High Plains section.

7. Terrain in all areas is characteristically flat or gently rolling. The overall gradient is easterly and averages ten to 16 feet per nm. Dissected terrain and areas of greater relief occur locally in the Raton, Colorado Piedmont and Plains Border sections.

8. Ninety percent of the Central High Plains is privately owned, with the remaining 10 percent consisting of state school lands, parks, and miscellaneous federal lands.

9. Population density is low, consisting predominately of small agrarian communities. Mixed agricultural and grazing are the dominant land use. Existing military facilities in the CSP include six Air Force bases surrounding the suitable area from 20 to 150 nm away.

3.3 CHARACTERISTICS OF SUITABLE AREA

3.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Suitable area in the Central High Plains CSP occupies a region of extensive flat-lying Cretaceous to Tertiary sedimentary formations which are commonly overlain by variable thicknesses of loess and other wind-blown deposits. These surficial units will be discussed in order of areal predominance from youngest to oldest.

Much of the siting province is covered by Holocene to Pleistocene age wind-blown sand and silt, playa deposits, terrace deposits, volcanic ash and river alluvium. Variable thicknesses of loess, sand and fluvial deposits, ranging from zero to 40 feet, occur extensively over most of western Kansas, Nebraska, Oklahoma panhandle and east central Colorado. In the Plains Border section, deposits range in thickness from less than one foot to 140 feet or more along the Colorado-Kansas border (Krieger, 1957; Hodson, 1963). All of these surficial deposits should be easily excavatable.

Areas designated as suitable are underlain entirely by Tertiary fluvial deposits of the Pliocene Ogallala Formation and to a lesser extent, by the Miocene Arikaree Formation. The Ogallala Formation ranges from over 500 feet thick in the western portion of the CSP to less than a foot along its eastern margin (Bayne, 1956a, 1956b; Wenzel and others, 1941), and consists of mixtures of sand, gravel, silt and clay. Beds of silt and gravel within the formation are generally lenticular, grading both laterally and vertically from one lithologic type to another over short distances (Bayne, 1956a, 1956b). They are weakly to well cemented by calcium carbonate, locally forming at various depths minor calcrete layers less than a few feet thick. In some cases siliceous replacement of the calcified layer forms a well indurated opaline quartzite (Frye and Swineford, 1946). A highly indurated "limestone-like" caliche caprock locally forms a resistant layer ranging from a few inches to a few feet thick over scattered portions of the CSP. Seismic P-wave velocities for near surface sediments of both the Ogallala and Arikaree formations are estimated to be in the range of 4000-5000 feet per second (Gillmore, 1977, oral communication).

The Miocene Arikaree Formation exhibits many of the same lithologic and physical properties of the Ogallala Formation. Though slightly more indurated, it is often mistaken for the Ogallala Formation in exposure and in the shallow subsurface.

The Arikaree Formation was mapped by previous investigators as covering large portions of northeastern Colorado, however, recently published geologic studies in Colorado conclude that the Ogallala Formation is exposed in these sections and overlies the Arikaree Formation (Tweto, 1979).

A series of Cretaceous formations are exposed in portions of western Kansas and southeast Colorado. This suite of older sedimentary formations comprise all the excavatable rock identified in the Central High Plains. The lithologic units are, in order of increasing age, the Pierre Shale, Niobrara

Formation, Carlile Shale, Greenhorn Limestone, and Graneros Shale. Collectively they comprise 1000 feet of intercalated shale, sandstone, limestone, chalky-shale, and marl with many concretionary interbeds (Hodson, 1965). Seismic P-wave velocities are estimated to be less than 5000 feet per second (Gillmore, 1977, oral communication).

3.3.2 HYDROLOGIC CONDITIONS

3.3.2.1 Surface Hydrology

Drainages in the CSP generally trend from west to east at a rate of approximately ten to 16 feet per nm. Density of streams and rivers flowing through the region is low (on the average less than one per 40 nm), due to the 1) high porosity and permeability of the underlying strata, 2) high evapo-transpiration rate, and 3) low rainfall. Density is lowest in the Colorado Piedmont and Raton sections (one per 70 nm) increasing to an average of approximately one per 35 nm in the High Plains, then increasing again in the easternmost Plains Border section (one per 15 nm) where rainfall increases and evapo-transpiration rates decline. From north to south, the Elkhorn, North and South Platte, Republican, Smoky Hills, Arkansas, Cimarron, Canadian, and Red rivers are the major perennial rivers that flow through the region. Flood plains of these rivers are as much as several miles across. Numerous perennial tributaries join these water courses at irregular intervals, their numbers generally increasing steadily eastward.

Perennial lakes are not common in the suitable areas of the Central High Plains CSP. Most of the lakes and streams are ephemeral, containing water only for short periods of time following severe thunderstorms. Little of the runoff from these storms reaches the perennial stream network, as most is either absorbed as ground-water recharge or evaporated. Due to the nature of the storms in this region, flash-flooding is highly probable in localized areas.

3.3.2.2 Ground-Water Hydrology

The Ogallala and Arikaree formations are the principal aquifers in the Central High Plains CSP. Permeability of these formations ranges from very good to poor depending on the degree of cementation and compaction of the sediments (Kansas Geological Survey, 1971). Weist (1965) indicates that the Arikaree Formation is the least permeable of the two, due to its generally greater degree of induration. Water in these two formations is generally unconfined; however, locally it may be perched or under slight artesian pressure due to the presence of overlying and/or underlying impermeable layers (Cronin and Myers, 1964).

The ground-water table generally exceeds a depth of 100 feet along higher, flatter portions of the interstream divides. In deeply dissected areas or in river valleys, the ground-water table is often near the lowest exposed surfaces. Springs that flow from the Ogallala Formation are usually the result of either a perched water table or deeply incised drainage patterns that expose older, less permeable rock, underlying the Ogallala Formation. The latter condition is often found along the eastern boundary where the Ogallala Formation is thinnest.

Ground-water levels in the Central High Plains have been declining as much as two to five feet per year (Cronin, and Myers, 1964; Ellis and Pederson, 1976; Sapik and Geomatt, 1973; Pabst and Jenkins, 1976a, 1976b). This condition is most prevalent in agricultural areas, where irrigation pumping is in excess of the natural recharge rate.

Where excavatable Cretaceous shales are exposed, weathered zones may extend 30 to 40 feet below the surface. In these areas isolated perched ground-water conditions may be present; however, this is apparently rare because depth to ground water is normally greater than 50 feet (Gillmore, 1977, oral communication). Sandstone, shale and limestone members are generally impermeable within Cretaceous units of the CSP.

3.3.3 TERRAIN CONDITIONS

Terrain conditions in the Central High Plains CSP are best characterized by flat-lying plains, broad river valleys and rolling hills and valleys. Ground surface elevations range from between 4000 to 5000 feet along the western border to approximately 2000 feet on the eastern edge. This translates into a regional easterly gradient of ten to 16 feet per nm (0.19 to 0.30 percent grade) across the CSP (Fenneman, 1931).

The four physiographic sections comprising the Central High

Plains CSP (Section 3.1) reflect a wide range of landscapes. The High Plains section is most widely known for the extreme flatness of the upland plains along the southern Kansas-Colorado and northern Texas-New Mexico border. Locally, relief is low, usually not exceeding a few tens of feet. Among the few relief features on the High Plains are saucer-like depressions or basins varying in diameter from roughly 30 feet to a mile, and in depth from a few inches to 30 or 40 feet (Fenneman, 1931). The basins retain water temporarily after it rains, and a few of the deeper ones contain water perennially. The High Plains predominantly slope slightly to the east, resulting in a general easterly drainage pattern (Prescott, 1952, 1953, 1955).

In the Plains Border section most of the overlying Cenozoic deposits have been eroded away exposing Cretaceous chalk, shale, and limestone. Wind, rain, and running water have differentially eroded the softer sediments leaving a generally rougher topography (Hodson and Wahl, 1960; Prescott, 1952). Drainages in the area assume the easterly regional gradient of 0.3 percent. The south flanks of the drainage divides slope rather gently to the streams; the north flanks have low steep slopes and interstream divides that are generally flat with little relief (Fenneman, 1931). Areas of greatest dissection (two to four channels per nm) are in the eastern portion of Kansas with local relief on the order of 100 feet per nm.

The Colorado Piedmont is situated west of the High Plains section and adjacent to the eastern flanks of the Rocky Mountains (Figure 3). The Piedmont is an erosional surface cut upon Tertiary and older Cretaceous rocks in the region. Upper Cretaceous formations, generally composed of shale, have been eroded into broadly rolling topography. Terrain is often influenced by structural trends in the region. For example, where structural arches, troughs, or folds occur in areas of tilted, more resistant sandstone or limestone beds, gentle ridges, cuestas and buttes of generally low relief are formed (Fenneman, 1931). Relief is greatest (greater than 100 feet per nm) near the incised South Platte (defining the northern limits of Colorado suitable area) and Arkansas rivers, dividing parcels of older Cretaceous rocks in the southern Colorado Piedmont. Throughout the section the degree of dissection averages two channels per nm.

Suitable area in the Raton section is limited to excavatable rock in southern Colorado. This relatively small parcel (231 nm^2) is situated in a slight to moderately dissected plateau region (two channels per nm). Terrain is relatively flat with maximum slopes generally less than three percent. Local relief is generally less than 100 feet per nm.

Sand dunes are scattered throughout most of the Central High Plains and are common to all areas discussed except the Raton section. Sand hills vary in size from a few square miles to a few hundred square miles. The dunes may exhibit relief on the order of severl hundred feet with slopes exceeding five percent.

3.3.4 CULTURAL CONDITIONS

3.3.4.1 Demography

Population density within the Central High Plain CSP is low, consisting predominantly of small agrarian communities sited at the junction of major road and rail arteries. There are no cities of 25,000 population or greater within the siting province and only three cities of this size, Pueblo, Colorado Springs, and Amarillo, are within 25 miles of suitable area (Figure 3). Only seven towns in the siting region have populations between 5000 and 25,000 and all of these are located in Texas and Kansas. Approximately two dozen towns with populations between 1000 and 5000 are scattered throughout the southern half of the CSP. The majority of towns in this region have populations in the hundreds, and the general trend is for population density to decrease northward in the CSP.

Cultural improvements such as major road and pipeline networks, aqueducts and railroads (Appendix B), generally are not sufficiently dense to restrict MX siting. Exceptions to this occur in the border region of central and northern Colorado and Kansas where oil and gas pipelines can reach a density of one per ten nm.

Existing military facilities for support in the Candidate Siting Province are:

- Cannon Air Force Base, Clovis, New Mexico;
- Vance Air Force Base, Enid, Oklahoma;
- Ent Air Force Base, and Peterson Field, Colorado Springs, Colorado;

- o Lowry Air Force Base, Denver, Colorado; and
- o Warren Air Force Base, Boulder, Wyoming

3.3.4.2 Land Use

Agriculture constitutes the primary use of land within the Central High Plains CSP. Cultivated farmland accounts for approximately 60 to 80 percent of the suitable area, the latter percentage being more common in the eastern areas. Farming generally occurs on the flat to gently rolling topography of the upland plains, and grazing is relegated to the hilly and somewhat more rugged terrain which is unsuitable for irrigation.

Land ownership is almost entirely private in the CSP, with less than ten percent of the total suitable area owned by county, state or federal agencies. The few parcels that are not owned privately are set aside by the individual states for school lands and parks. In Nebraska and Texas, Section 16 of each Township is set aside for school lands.

3.3.4.3 Economic Base

Petroleum and natural gas production are the most important non-agricultural economic considerations in the Central High Plains CSP. Wells are scattered intermittently throughout the CSP with the heaviest density in Texas and decreasing to the north. All oil and gas fields of high potential have been excluded and only low potential sites remain. Other low potential deposits of future economic consideration are uranium, sodium salts, volcanic ash, limestone, clay, and sand and gravel (Burchett, 1973; Texas Bureau of Economic Geology, 1977).

4.0 SOUTHERN HIGH PLAINS CSP

4.1 GENERAL SETTING

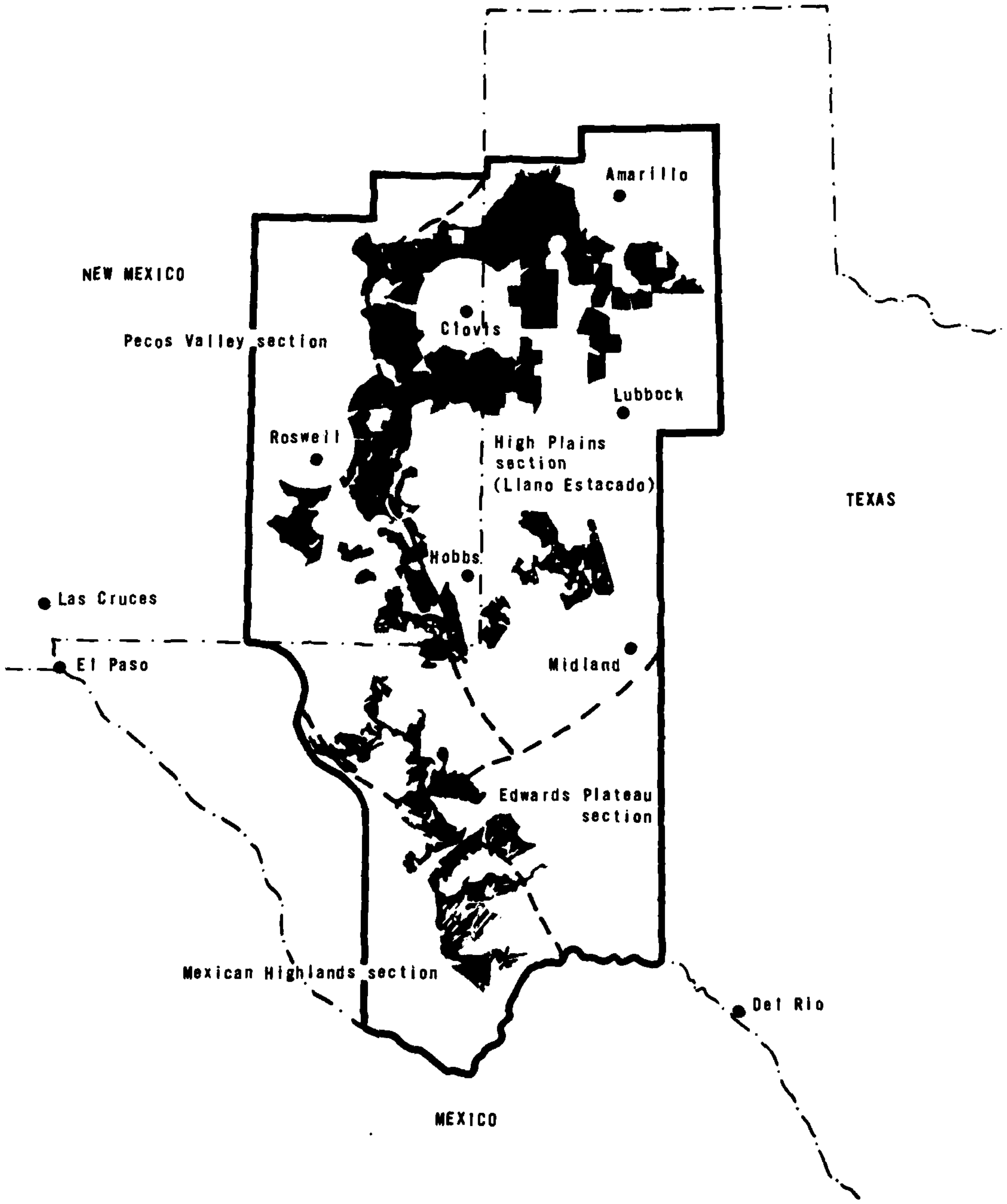
The Southern High Plains CSP consists of approximately 11,640 nm^2 of suitable area covering portions of Texas and New Mexico (Figure 4). Distribution of suitable area within this CSP corresponds principally to the Great Plains physiographic province (Fenneman, 1931), an area characterized by flat-lying plains, rolling hills and valleys, and occasional incision by stream channels. A small portion of suitable area located in the southern end of the CSP lies within the Basin and Range physiographic province and consists of broad alluvium-filled valleys or basins bounded by north to northwest trending fault-controlled mountain ranges.

The CSP is subdivided into four sections for the purpose of discussion, each corresponding to a physiographic section with different geotechnical conditions. These sections include the High Plains, herein called the Llano Estacado, the Pecos Valley, the Edwards Plateau, and the Mexican Highlands (Figure 4).

The Llano Estacado contains the majority of suitable area in the CSP, covering portions of the panhandle of Texas and southeastern New Mexico. Suitable area consists of several large, contiguous parcels, as well as smaller, irregularly shaped parcels primarily defined by cultural and economic exclusions (Appendix C). Parcel sizes range from approximately 150 to 1200 nm^2 in the CSP. The Llano Estacado is flanked to the west and southwest by the Pecos Valley section and to the southeast by the Edwards Plateau section (Figure 4).

Several contiguous parcels in the Llano Estacado extend westward into the Pecos Valley section and southward into the Mexican Highlands section. Geotechnical conditions of suitable area in the southern portion of the Pecos Valley-Edwards Plateau sections differ somewhat from those to the north, and contain physical properties which may be transitional with suitable area in the Mexican Highlands section to the west and south.

Suitable area within the Mexican Highlands section is restricted to relatively narrow alluvial basins defined by rock and topographic exclusions (Appendix C). Suitable area is generally small within the section, however, parcels are contiguous with additional suitable area in the Pecos Valley-Edwards Plateau sections to the north.



SOUTHERN HIGH PLAINS
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
4

FUGRO NATIONAL, INC.

4.2 SUMMARY OF RESULTS

1. The Southern High Plains CSP contains approximately 11,640 nm^2 of suitable area corresponding to portions of the Great Plains and Basin and Range physiographic provinces. The CSP has been divided into the Llano Estacado, Pecos Valley, Edwards Plateau and Mexican Highlands sections.
2. The Ogallala Formation underlies the Llano Estacado section and is extensively covered by surficial deposits consisting of Quaternary alluvium, aeolian sands and silts, and playa deposits.
3. Thick deposits of alluvium compose the suitable area in the Pecos Valley, Edwards Plateau and Mexican Highlands sections. These units are a minimum of 300 feet thick, consisting of admixtures of sand, gravel, silt and clay.
4. Ground water is predominately unconfined within the CSP and is generally encountered at depths greater than 100 feet. The water table is declining at a rate of up to five feet per year in heavily cultivated portions of the Llano Estacado.
5. Terrain conditions on the Llano Estacado are characterized by a flat plain intermittently incised by tributary drainages and numerous shallow playas. Relatively flat to undulating terrain and broad alluvial valleys characterize the Pecos Valley and Mexican Highlands sections.
6. The CSP is almost entirely privately owned with agriculture being the chief land use. Petroleum and natural gas production are the principal economic considerations.
7. Population density is relatively low, consisting of small,

scattered communities. Existing military facilities include three Air Force bases situated in the northern portion of the CSP.

4.3 CHARACTERISTICS OF SUITABLE AREA

4.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Suitable area in the Southern High Plains CSP is extensively underlain by Cretaceous and Tertiary sedimentary formations as well as thick sequences of Quaternary alluvium and other surficial deposits. These units will be discussed, youngest to oldest, according to their physiographic section within the CSP.

The Llano Estacado is mantled by a series of areally extensive Quaternary deposits consisting of alluvium, wind-blown sand, terrace and playa deposits. These deposits generally consist of unconsolidated clays, silts, sands and gravels, that range in thickness from zero to approximately forty feet (Cronin, 1964; Flawn, 1969; Fisher, 1974; Groat, 1976). Wind-blown cover sand is the most prevalent deposit overlying the entire Llano Estacado. It is up to 30 feet thick in places. According to Lotspeich and Coover (1962), surficial deposits generally become finer grained and thicker towards the northeast due to the prevailing winds blowing from the southwest since Pleistocene time. All of the surficial deposits are easy to excavate, however, there are minor localized concentrations of caliche in the Quaternary deposits which may pose some excavation difficulties.

The Pliocene Ogallala Formation underlies the Quaternary deposits on the Llano Estacado, ranging in thickness from zero in the south to over 500 feet in the northwest portion of the CSP (Frye and Leonard, 1959; Cronin, 1969). It is composed of

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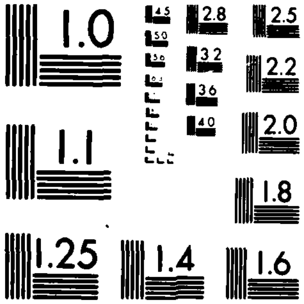

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0

intercalated clay, silt, sand, and gravel (Frye and Leonard, 1959; Mattox and Miller, 1970). Caliche commonly caps the unconsolidated sediments of the Ogallala Formation. The degree of induration of the caliche is highly variable, ranging from soft, friable caliche to hard silicified caprock. There are generally two distinct hard caprock layers overlain and underlain by more friable caliche (Brown, 1956). According to Brown (1956), the thickness of the caliche varies from three to four feet on bedrock highs to 150 feet or more beneath depressions. In general the Ogallala Formation materials are easy to excavate, but will be locally difficult due to the nature of the caprock (Texas Bur. of Econ. Geol., 1977).

The Pecos Valley-Edwards Plateau sections are unlike the Llano Estacado due primarily to the absence of the underlying Ogallala Formation. Mescalero Ridge, a caprock escarpment, forms the western boundary of the Llano Estacado and separates it from the Pecos Valley section. Underlying the Pecos Valley section are sedimentary formations of Permian to Cretaceous age. Surficial materials consist of Quaternary alluvium, wind-blown sand, caliche, playa and terrace deposits. These units are a minimum of 300 feet thick and are composed of admixtures of sand, gravel, silt, and clay (Kelley, 1971). With the exception of the caliche, the surficial materials are easily excavatable.

Thick deposits of Quaternary alluvium consisting of unconsolidated clay, silt, sand, gravel, and caliche, overlie Cretaceous limestone formations which dip gently south and east with the slope of the surface in the Edwards Plateau section of the CSP

(Fenneman, 1931). The alluvial deposits are as much as several hundred feet thick and are thinnest where they wedge out against outcrops of older rocks on the sides of the valleys. In the larger valleys, such as in southern and western Pecos County, Texas, the thickness of alluvium ranges from 200 to 350 feet (Armstrong and McMillion, 1961). In general, the alluvial deposits of the Pecos Valley-Edwards Plateau section will be easy to excavate, however difficulty will be encountered in zones where caliche is massive (Texas Bur. of Econ. Geol., 1977).

Areas designated as suitable within the Mexican Highlands section are underlain entirely by thick deposits of Quaternary alluvium. The alluvial deposits are up to several thousand feet thick in the centers of basins (King, 1965) and consist of sand and gravel with lesser amounts of silt and clay cemented by caliche. These deposits generally become finer towards the center of the valleys and basins, away from the source. The basin-fill deposits are composed predominantly of calcareous detritus derived from Cretaceous rocks to the north (Graves, 1954). All of the surficial deposits within the Mexican Highlands section should be easily excavatable except for areas with localized heavy concentrations of caliche.

4.3.2 HYDROLOGIC CONDITIONS

4.3.2.1 Surface Hydrology

Drainages in the CSP generally trend from northwest to southeast at a rate equal to the present gradient of the land surface, about nine feet per nm (Frye and Leonard, 1964). From north to south, tributaries of the Canadian, Red, Brazos, Colorado, and Pecos rivers are the major perennial streams that flow through the CSP. Flood plains of these rivers are on the order of one nm wide. The number of perennial tributaries is greatest in the northern portion of the CSP. In the Mexican Highlands section to the south, most of the drainages are ephemeral.

Perennial lakes are not common in the suitable area of the CSP. With the exception of several large playas found on the Llano Estacado, most playas in the CSP are ephemeral in nature, containing water only for short periods of time following severe thunderstorms. A large amount of runoff is collected in these playas after storms. Very little runoff is recharged into the underlying formations as most of the water is evaporated into the atmosphere.

4.3.2.2 Ground-Water Hydrology

The Ogallala Formation is the principal aquifer on the Llano Estacado. Ground water is generally unconfined and in excess of 100 feet deep. Locally it may be perched or under slight artesian pressure due to the presence of overlying or underlying impermeable caliche layers (Cronin, 1964). Springs that flow from the Ogallala Formation are either the result of a perched water table or deeply incised drainage channels that expose older, less permeable rock underlying the Ogallala Formation. The latter is often found on the eastern boundary of the Llano Estacado, along the caprock escarpment.

According to Cronin (1964), the water table on the Llano Estacado has declined as much as five feet per year. This decline is most prevalent in dense agricultural areas where large-scale pumping for irrigation is in excess of the natural recharge rate.

The principal aquifers in the Pecos Valley-Edwards Plateau and the Mexican Highlands sections are Cretaceous limestone and Quaternary alluvium (Armstrong and McMillion, 1961). Much of the runoff in these areas is recharged back into the permeable alluvium after heavy thunderstorms. The depth to ground water is generally greater than 100 feet and unconfined. However, locally it may be perched or under slight artesian pressure due to the presence of local caliche layers.

4.3.3 TERRAIN CONDITIONS

Terrain conditions in the Southern High Plain CSP are best characterized by flat plains and broad river valleys in the Llano Estacado, Pecos Valley and Edwards Plateau sections, and by fault-controlled alluvial basins separated by high relief mountain ranges in the Mexican Highlands. The following discussion relates to the wide-range of landscapes present within each CSP.

The Llano Estacado is characterized by a flat plain incised occasionally by tributaries of the Canadian, Red and Brazos rivers. The present gradient of the land surface is about eight to ten feet per nm in a southeasterly direction (Frye and Leonard, 1964; Cronin, 1964). Relief is on the order of

2000 feet with a maximum elevation of about 5000 feet in the western portion of the section. Along the eastern and western boundaries of the Llano Estacado, a prominent caprock escarpment defines the limits of the Ogallala Formation. Throughout the Llano Estacado, the surface is remarkably flat and is virtually undissected, except along the caprock escarpment where re-entrant canyons extend several miles into the plain (Lotspeich and Coover, 1962).

The most characteristic surficial features of the plain are the numerous playas or natural depressions which range in size from a few inches in depth and a few yards in diameter to more than 50 feet in depth and more than one nautical mile in diameter (Havens, 1966). These playas are located throughout the entire plain and occur up to once per nm^2.

Terrain conditions in the Pecos Valley-Edwards Plateau sections are characterized by relatively flat to gently undulating terrain, sloping slightly east and south. In Pecos and Reeves Counties (Trans-Pecos region, West Texas) the floor of the basins slope 15 to 18 feet per nm toward the Pecos River (Armstrong and McMillion, 1961; Ogilbee and Wesselman, 1962). Elevations of suitable area within this section range from 2,500 feet near the Pecos River to about 5,000 feet in the southern portion of the section, along the foothills. The terrain is slightly dissected by the Pecos River, and its tributaries have an average spacing of approximately one nautical mile.

The southern portion of the Pecos Valley-Edwards Plateau section is transitional with the Mexican Highlands section to the south. Suitable area in the southern portion of the section near the Mexican Highlands occurs primarily in basins surrounded by gently dipping cuestas and mesas composed of Cretaceous sedimentary rocks and Tertiary volcanic rocks.

Terrain conditions in the Mexican Highlands section are characterized by north to northwesterly trending alluvial basins separated by mountain ranges of high relief. Landforms within this section are typical of the Basin and Range physiographic province, consisting of coalescing alluvial fans and bajadas. Average basin elevations are on the order of 3000 feet in the southern portion of the section to about 4500 feet in the north. The gradient of these alluvial fans may be up to 100 feet per nm decreasing towards the center of the basin. These alluvial fans are incised by intermittent drainages, some up to 40 feet deep (King, 1965), with an average spacing of two to four per nautical mile.

4.3.4 CULTURAL CONDITIONS

4.3.4.1 Demography

The Southern High Plains CSP contains a moderate population density for an agricultural area. Cities with a population of 25,000 people or greater, adjacent to suitable area, are Hobbs, Roswell and Clovis, New Mexico, and Amarillo, Lubbock and Midland, Texas. They are all within the northern half of the CSP (Figure 4). The majority of the towns between 5,000 and 25,000 population are small agrarian communities sited along major road and railroad arteries. Population density decreases southward across the CSP. No major cities or towns are located in the Mexican Highlands section.

Existing military reservations in the CSP are: Cannon AFB, west of Clovis, New Mexico; Walker AFB, two nm south of Roswell, New Mexico; and Reese AFB, west of Lubbock, Texas, approximately 16 nm from suitable area. There are no military installations in the Southern Pecos Valley-Edwards Plateau or Mexican Highlands sections.

4.3.4.2 Land Use

Agriculture constitutes the primary land use within the CSP. Where the land is relatively flat, farming predominates, while areas of rolling topography are primarily used for cattle grazing. Cultivated farm land accounts for approximately 80 percent of the suitable area on the Llano Estacado and Pecos Valley sections. The principal land use in the Mexican Highlands and Edwards Plateau sections is cattle grazing.

Land ownership in Texas is almost entirely private with only one section per township being reserved by the state for school lands. The New Mexico portion of the CSP is approximately 60 percent privately owned; the remainder is BLM land. Most of the private land is farmed, while the BLM land is leased to oil companies.

4.3.4.3 Economic Base

Petroleum and natural gas products are the most important non-agricultural economic consideration in the CSP. The heaviest density of oil and gas fields are in the Llano Estacado section. Only low potential oil and gas fields remain in the suitable areas.

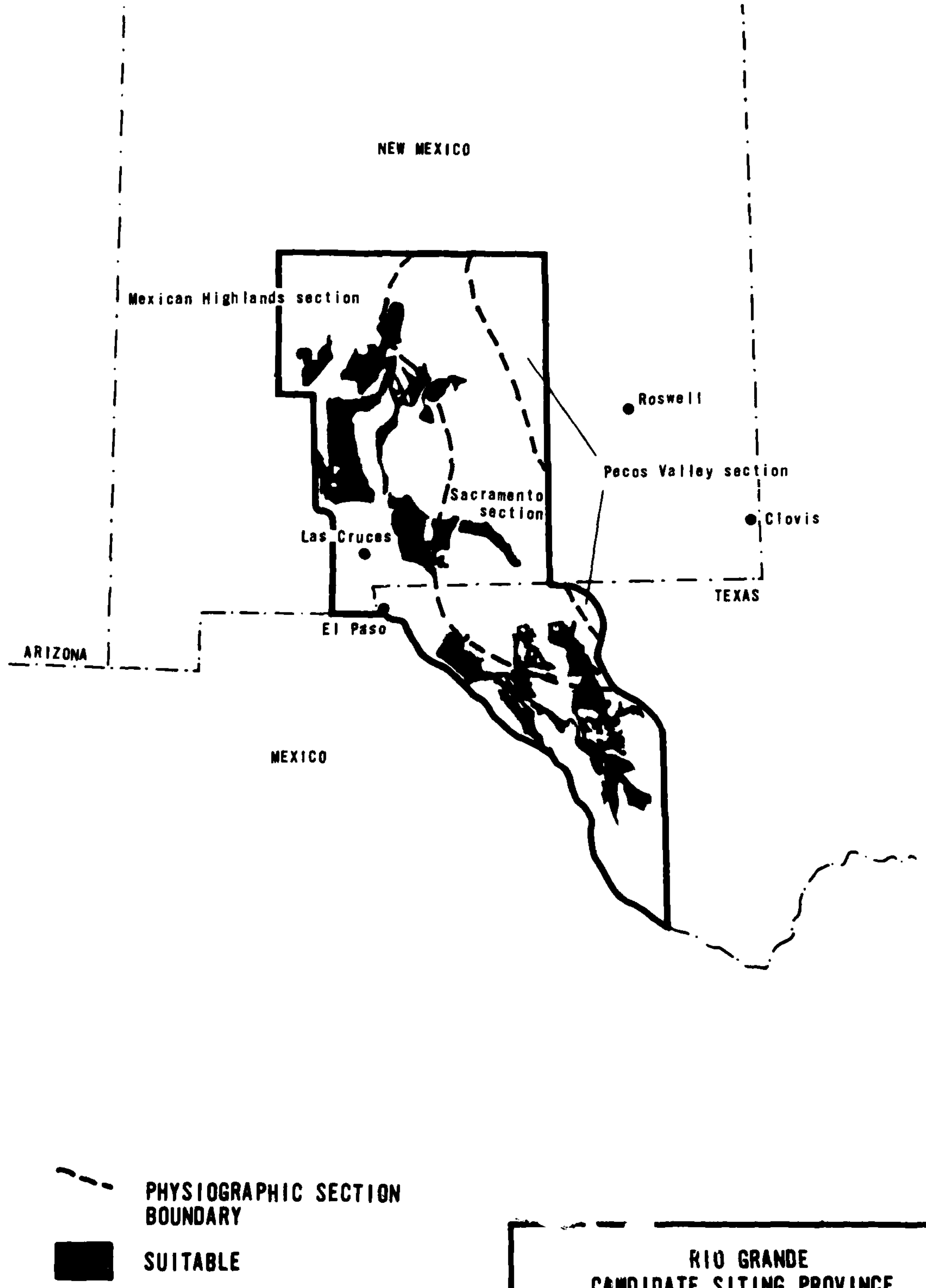
Low potential uranium deposits occur within the Triassic Doachum Group underlying the Ogallala Formation on the Llano Estacado. No active mining is being attempted to date because uranium concentrations are localized and discontinuous and compose only a small percentage of the formation in which they occur (St. Clair and others, 1976). In New Mexico, evaporite minerals are being mined from Permian beds in the Carlsbad Potash District near Carlsbad, New Mexico (Bur. of Reclamation, 1976).

5.0 RIO GRANDE CSP

5.1 GENERAL SETTING

The Rio Grande CSP encompasses approximately 5100 nm^2 of suitable area in south-central New Mexico and west Texas (Figure 5). This CSP lies within the Mexican Highlands and Sacramento sections of the Basin and Range physiographic province (Fenneman, 1931), which is characterized by relatively flat, alluvium-filled valleys separated by rugged, high relief mountain ranges.

The Rio Grande CSP is a system of north to northwest trending en echelon basins extending through New Mexico to the Trans-Pecos/ Big Bend region of Texas (Groat, oral communication, 1977). These basins are generally bounded by normal faults and filled with thick accumulations of local detritus (Bridwell and others, 1975). The suitable areas are bounded primarily by rock and topographic exclusions.



RIO GRANDE
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
5

FUGRO NATIONAL, INC.

5.2 SUMMARY OF RESULTS

1. The Rio Grande CSP contains 5100 nm^2 of suitable area within the Basin and Range physiographic province. The Basin and Range Province is further subdivided into the Mexican Highlands and Sacramento sections on the basis of physiography.
2. Quaternary alluvial fan deposits are the principal surficial units present throughout the CSP. These consist of poorly sorted gravel, sand, boulders, and cobbles derived from the surrounding mountains.
3. Dune and sheet sand, terrace deposits, and stream alluvium cover lesser portions of the suitable area. Dune and sheet sands are found in the Tularosa and Salt Basins, and sheet sand is found in the northern Jornada del Muerto. Terrace deposits are found adjacent to the Rio Grande River. Minor amounts of modern stream alluvium is deposited locally upon all surficial units.
4. The Miocene (?) to early Pleistocene Santa Fe Formation is an alluvial/fluvial sequence with localized interbedded basalts found in the Jornada del Muerto, New Mexico. Correlative deposits are found in Texas along the Rio Grande River.
5. The Rio Grande River is the only perennial river in the CSP. Basins not connected to the Rio Grande River and its tributaries are closed systems and drain internally onto flats and into playa lakes.
6. Ground water is generally unconfined in the Quaternary basin fill and occurs at depths greater than 100 feet. Ground-

water tables have been declining slowly at a rate of 0.1 to 1.2 feet per year.

7. Terrain in all areas is characterized by flat, elongated valleys surrounded by rugged mountains. Dissected terrain occurs closest to the mountain fronts, however, drainage density increases away from the mountains from approximately one per 1800 feet near the mountains to one per 150 feet in the central basin areas.
8. Population centers are generally concentrated along the Rio Grande River in New Mexico; populations in Texas are limited to towns of 1000 to 5000 population situated along major thoroughfares.
9. Approximately 55 percent of the suitable area in the Rio Grande CSP is under the auspices of the BLM; 35 percent lies within the White Sands Missile Range/Ft. Bliss Military Reservation complex and the remaining ten percent is privately owned.

5.3 CHARACTERISTICS OF SUITABLE AREA

5.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Suitable area in the Rio Grande CSP consists of the Miocene(?) to Middle Pleistocene Santa Fe Formation and a thick sequence of basin fill composed of alluvial fan, terrace, and playa deposits. These deposits are in turn overlain by localized sheet and dune sands.

Sheet and dune sand deposits are generally found locally in closed or formerly closed basins. The sand, composed primarily of gypsum, was derived from salt deposits left after the evaporation of water in playas. Specifically, these deposits can be found in the Tularosa Basin and the northern Jornada del Muerto in New Mexico, and at Salt Basin in Texas. Sheet sands in the Jornada del Muerto have an estimated thickness of only a few feet. These deposits are unconsolidated and mobile except where they have been stabilized by vegetation. In Salt Basin hills of gypsiferous clay are also present. Modern stream alluvium comprises the youngest deposits in the basin fill sequence, representing aggradation upon active surfaces of transport. These deposits are very thin and consist of unconsolidated sediments of sand, gravel, and small cobbles.

Alluvial fans are the predominant basin fill deposit exposed in the Rio Grande CSP. Quaternary fan deposits have coalesced to form an alluvial apron or bajada slope around all bedrock exposures in the CSP. The deposits range from less than a foot thick at the mountain front to several hundreds to thousands of feet thick in the basins (Ruhe, 1967; Seager and Hawley, 1973). The deposits consist of poorly sorted gravel, sand, boulders, and cobbles derived from the surrounding mountains. Two or more generations of alluvial fans are identified in the CSP (Kottlowski, 1960; Seager and others, 1971). The significance of relative fan ages is in the degree of consolidation and cementation. The older fans are generally higher topographically and are present closest to the mountain fronts. They occur as small, isolated masses (commonly less than five nm^2), separated from their source area by younger alluvial fans.

The younger fans are topographically lower and are found further from the mountain fronts. These commonly form a broad, gently sloping surface that flanks the older alluvial fans. The younger fans are poorly to moderately consolidated, composed principally of sand, gravel and silt (Fugro National, 1975). Cobble to gravel-sized material is commonly covered by a white calcium carbonate coating, however, induration of the materials with caliche is minimal (Kottlowski, 1960; Seager and others, 1971).

Undifferentiated river terrace deposits of both the ancestral and present Rio Grande River are present in the Jornada del Muerto in New Mexico, and the Hueco Bolson in Texas. Deposits are moderately indurated with caliche and are poorly to moderately consolidated. The exact thickness and areal extent is unknown. These deposits consist of well sorted gravel, sand, and silt. Gravel consists of both exotic and locally derived fragments.

The Miocene (?) to early Pleistocene Santa Fe Formation is found in south-central New Mexico in the western and southern portions of the Jornada del Muerto. Similar, possibly correlative deposits are described in Texas along the Rio Grande River (Albritton and Smith, 1965). The thickness of the Santa Fe Formation is extremely variable, ranging from 400 feet in the Jornada del Muerto (Kottlowski, 1956) to as great as 6000 feet in the Hueco and Mesilla Bolsons (Kottlowski and Lemone, 1969).

The Santa Fe Formation is composed primarily of piedmont-slope alluvium, including alluvial fan and medium to coarse-grained fluvial deposits with fine-grained playa deposits making up a relatively small proportion of the basin-fill sequence (King, 1969; King and others, 1971). Deposits are moderately to well consolidated depending upon the degree of induration by caliche. A calichefied gravel layer, ranging from ten feet thick in the Jornada del Muerto to one hundred feet thick in the Mesilla Valley, overlies large portions of the Santa Fe Formation (Kottlowski, 1960; Kottlowski and Lemone, 1969; Seager and others, 1971).

Interbedded basalts, described in the Santa Fe Formation, may be correlative with the Uvas Basalt described by Seager and others (1971). The depth and extent of the interbedded basalts are not fully documented in the CSP, and no occurrences of interbedded volcanics have been reported in Texas.

5.3.2 HYDROLOGIC CONDITIONS

5.3.2.1 Surface Hydrology

The Rio Grande River is the only perennial stream in the CSP. It flows southerly through a series of open basins in New Mexico and Texas and is perennial from Colorado south to Albuquerque and at Caballo Reservoir, New Mexico.

Runoff after heavy rains is channelized down ephemeral stream valleys or occurs as sheet flow across flat alluvial plains, eventually reaching the Rio Grande River. Basins not connected to the Rio Grande River or its tributaries are closed hydrologic systems that divert runoff into central low-lying flats or playa lakes. Salt Flats, east of El Paso and south of Del City, is typical of the playa areas which collect runoff after heavy rains. Much of the water evaporates shortly after a storm, however, some water does seep into the unconsolidated sediments of the alluvial valleys, recharging ground-water zones (Knowles and Kennedy, 1958).

5.3.2.2 Ground-Water Hydrology

Quaternary basin fill is the major shallow aquifer in the Rio Grande CSP. Ground water is generally unconfined and found at depths greater than 100 feet below ground surface within the valleys of the CSP (Wilson, oral communication, 1977). The thick caliche layer, which caps much of the Santa Fe Formation greatly retards the downward percolation of water, and may cause shallow perched water (Knowles and Kennedy, 1958). Ground-water levels have been slowly declining at a rate of 0.1 to 1.2 feet per year with the recent increase in population of this area.

5.3.3 TERRAIN CONDITIONS

Terrain conditions in the Rio Grande CSP are best characterized by nearly flat valleys surrounded by rugged mountains. Elevations in valleys range from 3000 feet in the southern portion of the CSP to approximately 5800 feet in the north, with adjacent mountains as high as 12,000 feet.

Suitable valleys are surrounded by mountain fronts of greater than ten percent topographic grade. Basin gradients near valley axes, are gentle (less than one percent), increasing in slope (one to three percent) along the valley flanks. Valley flanks are dissected by shallow, intermittent streams with incision generally less than five to ten feet. Dissection decreases away from the mountains due to the gentler gradients toward valley axes. Drainages generally trend east-west, normal to the regional structural grain.

5.3.4 CULTURAL CONDITIONS

5.3.4.1 Demography

Much of the suitable area (approximately 35 percent) in the Rio Grande CSP in New Mexico lies within the White Sands Missile Range/Ft. Bliss Military Reservation complex. The largest cities in the CSP are: Las Cruces, ten miles west of WSMR; and El Paso, adjacent to FBMR in Texas. In New Mexico, population centers are concentrated along the Rio Grande River. Population density in Texas is low and consists primarily of small communities (between 1000 and 5000 population) located along major highways and railroads.

5.3.4.2 Land Use

Of the suitable area in the Rio Grande CSP in New Mexico approxmately 35 percent is DoD controlled; the BLM has jurisdiction over 55 percent of the area, and the remaining ten percent is privately owned. Private land lies adjacent to the Rio Grande River and is used primarily for agriculture.

Land ownership is almost entirely private in Texas. Land is used primarily for grazing.

5.3.4.3 Economic Base

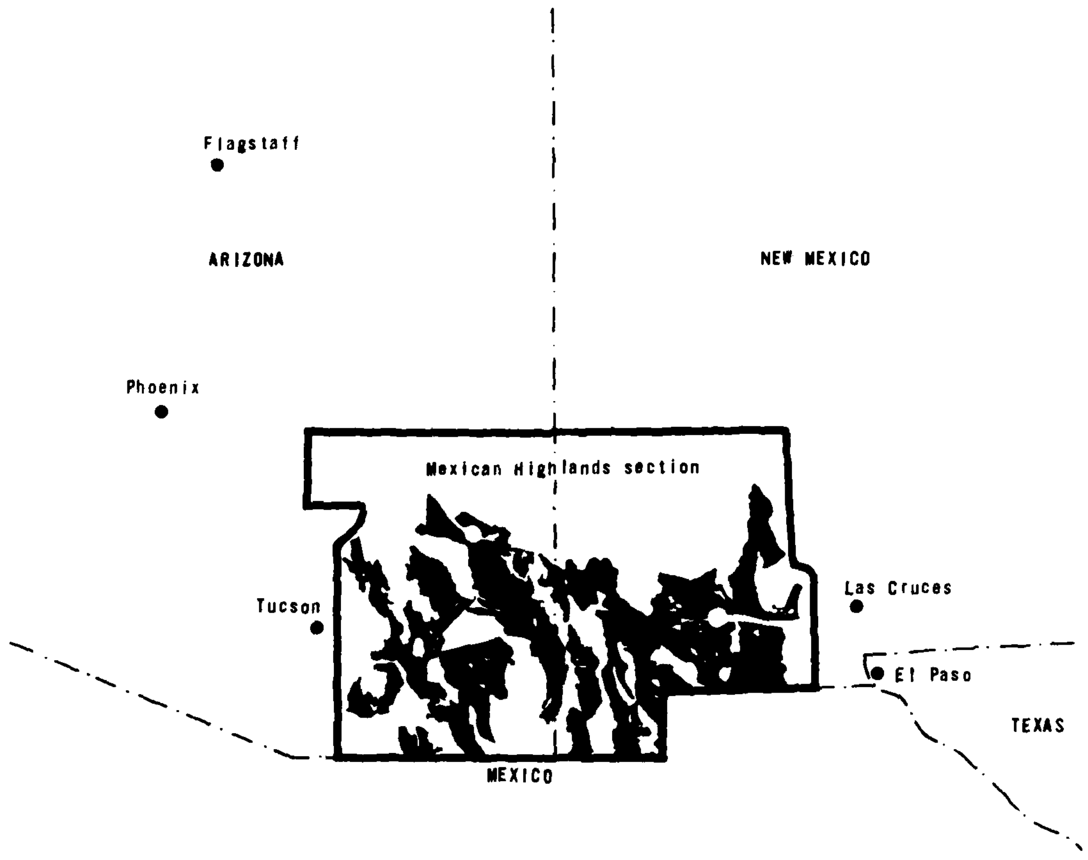
Coal is the most important economic consideration in the Rio Grande CSP. Adjacent areas on the periphery of suitable area in New Mexico are the Engle, Carthage, and Jornada del Muerto coal fields. The Engle coal field contains low grade subbituminous coal, but it is not currently being mined. The Carthage and Jornada del Muerto coal fields are both in production. In Texas there are outcrops of bituminous coal-bearing strata, within upper Cretaceous formations, that are actively being mined in the Big Bend area and west of Marfa.

Known Geothermal Resource Areas scattered along the Rio Grande River define a diffuse zone of low potential geothermal and hydrothermal activity extending along the Texas-Mexico border, from El Paso to the Big Bend area in Texas, and from near Socorro to Radium Springs, New Mexico (Texas Bur. of Econ. Geol., 1977; Jiracek, 1976).

6.0 HIGHLANDS CSP

6.1 GENERAL SETTING

Suitable area in the Highlands CSP comprises approximately 7510 nm^2 in southwest New Mexico and southeast Arizona (Figure 6). The Highlands CSP is situated interjacent to the Rio Grande and Sonoran CSP's (east and west, respectively), and is bounded on the south by the international border with Mexico (Drawing 1). The CSP is wholely contained within the Mexican Highlands section of the Basin and Range physiographic province (Fenneman, 1931), a region characterized by elongate, fault-controlled basins which generally trend north to northwest. Suitable area occurs essentially in individual alluvium-filled basins and contiguous basins connected by passes of less than ten percent grade. Suitable area is primarily defined by rock and topographic exclusions from the intervening mountain ranges.



■ SUITABLE

HIGHLANDS
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
6

FUGRO NATIONAL, INC.

6.2 SUMMARY OF RESULTS

1. Suitable area in the Highlands CSP comprises approximately 7510 nm^2 in southwest New Mexico and southeast Arizona, corresponding to elongated structural valleys which trend roughly north to northwest.
2. Suitable area is composed of Tertiary to Holocene basin-fill materials primarily composed of unconsolidated to moderately consolidated coarse-grained detritus derived from adjacent highlands. These deposits are primarily expressed as alluvial fans with subordinate amounts of stream alluvium, playa and terrace deposits. Fine-grained Plio-Pleistocene fluvio-lacustrine deposits are extensively exposed in southeast Arizona.
3. No perennial drainages are present in the CSP. Interior ephemeral drainage into closed basins predominates. Ephemeral drainages average approximately two per nm.
4. Ground water is unconfined in most cases and generally encountered at depths greater than 100 feet in the basin-fill, however, shallower zones may extend around the central playas.
5. Terrain is generally represented by mildly sloping (less than 2 percent) bajadas within elongated valleys.
6. Population density is low over most of the suitable area. Three large population centers (over 25,000) border the suitable areas; Las Cruces, New Mexico, and Tucson and Phoenix, Arizona.

7. Approximately 50 percent of the suitable area is under the jurisdiction of the BLM; 45 percent is private and state holdings; and five percent is DoD controlled. Private land is used primarily for agricultural purposes.
8. Non-agricultural economic resources in the CSP include six large copper deposits in Arizona and New Mexico and two Known Geothermal Resource Areas (KGRA's) in New Mexico.

6.3 CHARACTERISTICS OF SUITABLE AREA

6.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Suitable area in the Highlands CSP consists of a Tertiary to Quaternary sequence of unconsolidated to moderately consolidated basin fill, primarily deposited as older and younger alluvial fan deposits, with lesser localized occurrences of modern stream alluvium, playa and terrace deposits. Total thickness of the basin-fill sequence has been measured in deep core holes to range from 450 to 6170 feet (Trauger and Herrick, 1962; Trauger, 1972). The lower section of this sequence may contain well indurated to lithified fanglomerates, tuffs and agglomerates or conglomerates. These correspond to the Gila Conglomerate found throughout Arizona and western New Mexico. Thick sections of Plio-Pleistocene fluvio-lacustrine deposits are present in portions of southwestern Arizona. These are known locally as the Big Sandy Formation.

Alluvial fan materials comprise the youngest and oldest deposits in the basin-fill sequence. The fans are composed of poorly sorted admixtures of gravel, sand, silt and clay derived from local source material in the adjacent rock highlands (Melton, 1965). Composition, texture and other physical properties of the basin-fill deposits vary throughout the Highlands CSP depending mainly upon:

1. Distance from shedding sources (mountains);
2. Rock types present in the source areas; and
3. Mode of sediment transport and depositional environment.

Generally, particle size distribution grades from an abundance of boulders, cobbles, gravel and sand near the mountain front, to clay, silt and fine sand near the central portion of the valley.

Alluvial fans have aggraded to several topographic levels around the valley flanks. The coarser grained facies (generally the topographically highest and relatively oldest fans) are the most consolidated and often, dependent on the source material, susceptable to late-stage caliche cementation, which may increase induration to "unexcavatable" (Bull, 1968). Older well-indurated fanglomerates (Miocene(?) in age), though generally not exposed, are thought to compose thick sections of the deeper basin-fill sequence near the valley axis. The younger fans are finer-grained, and composed predominantly of silt, sand and clay with minor gravel.

Contemporaneous with the active aggradation of young fans is the development of modern stream alluvium and playa deposits. Modern stream alluvium is a heterogeneous mixture of subangular to well-rounded boulders, gravel, sand, silt, and clay, whereas, the playa deposits consist of unconsolidated silt and clay with small amounts of sand (Trauger and Herrick, 1962).

Plio-Pleistocene fluvio-lacustrine deposits are documented only in southeast Arizona and are apparently correlative with the Big Sandy Formation described by Sheppard and Gude (1972) near Wickiup. The eastern boundary of these materials appears to be the Peloncillo Mountains on the Arizona-New Mexico border. The southern and western boundaries are approximately coincident with the southwest boundary of the Mexican Highlands physiographic province.

The Big Sandy Formation has an exposed thickness of about 245 feet and consists mainly of green and brown mudstone and thin interbedded tuffs, most of which are zeolitic. Coarser fluviatile clastic rocks, including conglomerate, are found locally. To the east, the thicknesses of the fluvio-lacustrine materials increase to as much as two to three thousand feet (Melton, 1965). Eaton (1972), Marlowe (1961) and Seff (1962) describe the Big Sandy Formation in the Safford Valley, Arizona as predominantly containing freshwater chemical limestone with lesser silt, sand and clay. Streams from the adjacent mountains locally deposit gravel in alluvial fans which then interfinger with the fine-grained basin fill. At the west end of Safford Valley, these fills have been intruded by ring dikes, volcanic pipes, and diatremes.

6.3.2 HYDROLOGIC CONDITIONS

6.3.2.1 Surface Hydrology

No perennial drainages exist in the Highlands CSP. San Simon Wash in San Simon Valley is a tributary of the Gila River and is the only major ephemeral system. The Highlands CSP has predominantly closed basin conditions. Seasonal runoff from heavy rains is diverted into widespread playa lakes or low-lying areas by poorly defined ephemeral drainages (Doty, 1960). Three playas of significance are, Willcox Playa in Sulphur Springs

Valley, Arizona, Playas Lake in Playas Valley, New Mexico, and and South Alkali Flats in Animas Valley, New Mexico. Drainage density near the mountains rarely exceeds two per nm. Proceeding basinward, drainage density increases up to one per 150 feet in the lower elevations.

6.3.2.2 Ground-Water Hydrology

Ground water is contained principally within Quaternary basin-fill deposits consisting of sand, clay and gravel. In the basins, most of the drainage is toward the playas. Depth to water is deeper than 100 feet near the mountain fronts and the edges of the basins, and shallowest (less than 50 feet) in the areas of the excluded playas (Brown & Schumann, 1969). Lake bed deposits associated with paleoplayas may act as a confining layer which greatly retards the downward percolation of water and may indicate areas of shallow perched water. Ground-water levels have been progressively declining with the recent increase of irrigation in the arid lands of the southwest.

6.3.3 TERRAIN CONDITIONS

Terrain conditions in the Highlands CSP are best characterized by flat, elongated valleys separated by intervening mountain ranges. Landforms present within suitable area are coalescing alluvial fans and bajadas, ephemeral streams, pediments, terraces, and playas. The basins trend north to northwest in response to the regional structural framework. Basins are invariably contiguous with adjacent basins along structural strike. Elevations range from 4200 feet in the west to 5500 feet in the east, with the intervening mountains as high as 11,000 feet.

Suitable area within the basins are surrounded by mountain fronts of greater than ten percent topographic grade. Gentle bajada slopes skirt the mountain fronts, evenly grading to the valley axis at slopes generally less than two percent. At the topographically lowest portion of the valley, surface gradients are commonly less than 0.1 percent. In closed basins, playas form a flat surface up to 50 nm^2 in size. The periphery of the playa may be mantled by younger fan deposits.

Pediments are represented by planated rock shelves generally occurring in the CSP in pass areas and mountain re-entrants. The pediment surfaces frequently serve as surfaces of material transport and are commonly overlain by a veneer of sand to boulder sized residual or alluvial material. Most pediments in the CSP are actively aggrading, with deposits concealing the basinward extent of the planated rock shelf. The concealed nature of the pediment makes it difficult to delineate the basinward edge.

Areas of relatively high local relief are found closest to the mountain fronts where dissection may exceed ten feet. Stream densities rarely exceed two per nm. Proceeding basinward, drainage density increases up to one per 150 feet at the lower elevations, and depth of incision decreases to less than a foot.

6.3.4 CULTURAL CONDITIONS

6.3.4.1 Demography

The Highlands CSP is a sparsely populated region. Areas with the greatest populations (larger than 25,000) are Phoenix and Tucson, Arizona to the west of suitable area and Las Cruces, New Mexico to the east. Towns with populations between 5,000 and 25,000 include Douglas and Safford, Arizona, and Silver City, Deming, and Clifton, New Mexico. The remaining towns generally have considerably less than 2500 population and serve as service areas along major thoroughfares.

Pipelines from the El Paso Natural Gas Company and Southern Pacific Pipe Lines, Inc., the Southern Pacific Railroad, and Interstate 10 (I-10) are all located in a narrow corridor running eastwest from Las Cruces through Tucson to Phoenix.

Existing military facilities in the area are:

- Ft. Huachuca, Sierra Vista, Arizona; and
- White Sands Missile Range/Ft. Bliss Military Reservation, Las Cruces, New Mexico.

6.3.4.2 Land Use

Grazing constitutes the primary use of land within the Mexican Highlands CSP. Most of this CSP consists of low quality grazing land in the form of non-commercial forest and woodlands, unproductive non-reserved, and unproductive-reserved areas (Bureau of Reclamation, 1976). Approximately 50 percent of the suitable area is BLM controlled, with 45 percent under private ownership. Five percent (300 nm^2) of the land is Dod controlled.

6.3.4.3 Economic Base

Copper production is the most important economic consideration in the CSP, with six large copper mines currently in production. None of the mines are located within suitable area.

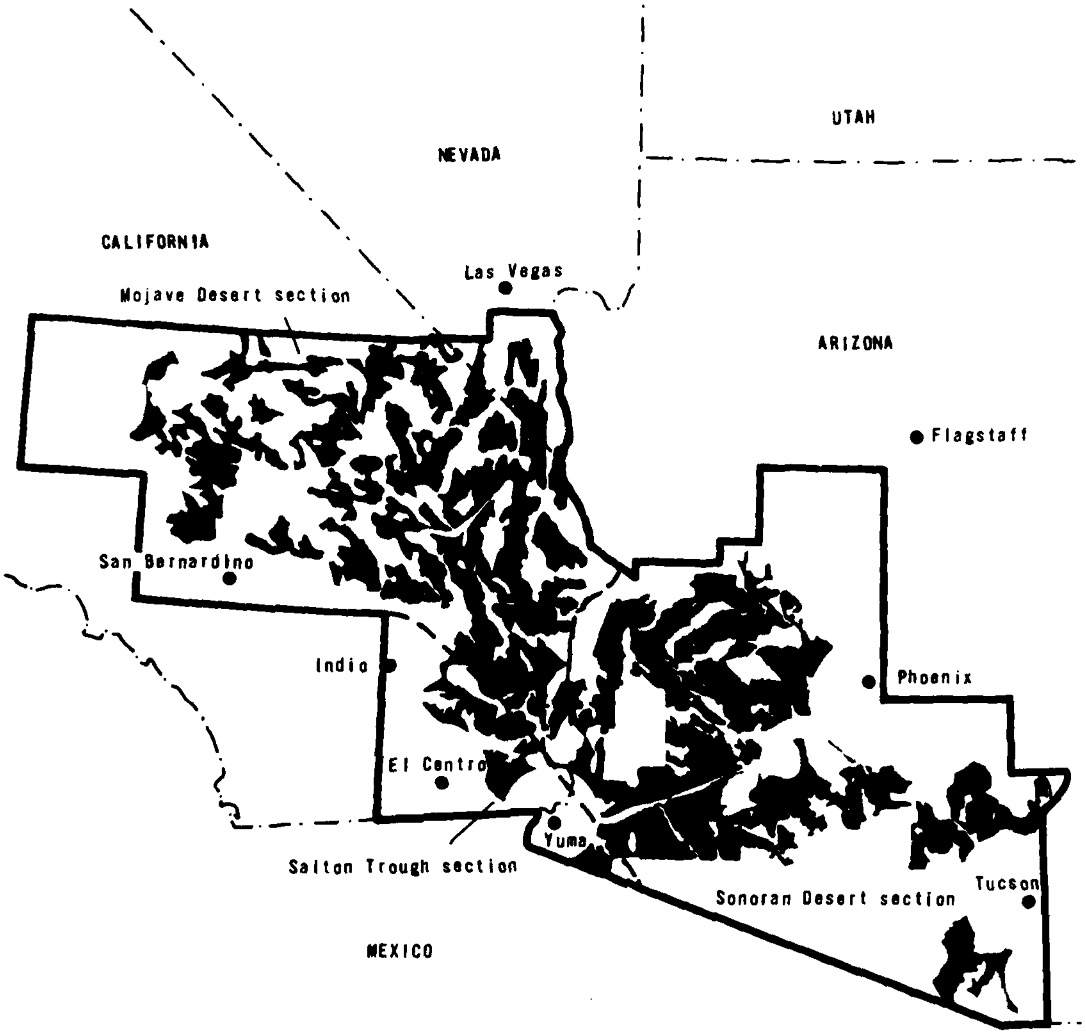
There are two Known Geothermal Resource Areas (KGRA's) in the New Mexico portion of the CSP. Mineral leases have been purchased in Lightning Dock on the east side of Animas Valley and the area is currently being drilled (Jiracek, 1976). The second KGRA is the Mangas Trench region, currently not under development. High geothermal gradients have been recognized in Safford Valley, Arizona, but ERDA and the state of Arizona have not designated the area a KGRA as yet.

7.0 SONORAN CSP

7.1 GENERAL SETTING

The Sonoran CSP consists of approximately 17,470 nm^2 of suitable area in parts of California, Arizona, and Nevada (Figure 7). All of the suitable area of the Sonoran CSP lies within the Basin and Range physiographic province (Fenneman, 1931). It is a region characterized by broad, elongate fault-controlled basins which generally trend north to northwest in response to regional tectonic structure (Millet and Barnet, 1970). Suitable area occurs essentially in individual alluvium filled basins and contiguous basins connected by passes of less than ten percent grade. The Sonoran CSP abuts the Great Basin CSP to the north and the Highlands CSP to the east. Its southern limits are defined by the Mexican border (Drawing 1).

For convenience of discussion, the CSP is informally divided into three sections, roughly corresponding to physiographic subprovinces recognized by Fenneman (1931). These are the Mojave Desert, the Sonoran Desert, and the Salton Trough sections (Figure 7).



SONORAN
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
7

FUGRO NATIONAL, INC.

7.2 SUMMARY OF RESULTS

1. The Sonoran CSP contains approximately 17,470 nm^2 of suitable area, covering portions of California, Arizona, and Nevada and lies entirely within the Basin and Range physiographic province.
2. Three distinct divisions; the Mojave Desert, Sonoran Desert, and Salton Trough sections, are recognized within the CSP, based primarily on different topographic, lithologic, and hydrologic characteristics.
3. Basin fill is comprised predominantly of Quaternary alluvial fan deposits intertonguing with significantly thick sections of lacustrine, fluvial and estuarine deposits. Active and stabilized sheet and dune sands mantle numerous areas. Basin-fill materials are generally composed of gravel, sand, silt, and clay, ranging in thickness from 2000 to 5000 feet.
4. The only perennial drainage in the CSP is the Colorado River, which divides the Mojave and Sonoran sections. Drainage in the Sonoran section is provided by an open system of ephemeral streams which primarily trend north and west to the Colorado River. The Mojave and Salton Trough sections are characterized by interior drainage, where runoff is collected in closed basins forming playa lakes or, in the case of the Salton Trough section, the Salton Sea.
5. Water table within the basins is encountered in most places, at depths greater than 100 feet. Water levels have

been declining at various rates, up to ten or more feet per year in suitable area near Phoenix.

6. Terrain in the desert basins is relatively flat; bajada slopes along the valley flanks, grade to the valley axis at generally less than two percent slope. Drainage density is light (one to two per nm), with incision depths ranging from one to 20 feet.
7. Population density is low, increasing near smaller (5,000 to 25,000 population) agrarian towns scattered throughout the CSP. Farming is the primary land use.
8. Seventy-seven percent of the suitable area is federally controlled BLM land; 16 percent is DoD land. The remaining area is mixed state and privately owned and is concentrated near population centers.
9. Ten military facilities are situated in or adjacent to the CSP.

7.3 CHARACTERISTICS OF SUITABLE AREA

7.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Suitable area in the Sonoran CSP consists of an unconsolidated to well consolidated alluvial valley-fill sequence which occupies deep structural basins characteristic of the Basin and Range physiographic province. The uppermost 1000 to 3000 feet is thought to be generally Pliocene to Pleistocene in age, consisting of gravel, sand, silt and clay deposited primarily under alluvial, fluvial, estuarine and lacustrine environments (Dibblee, 1954; Metzger, 1968). Deep drill hole data indicates the lower section is probably Miocene or older in age, consisting of thick sequences of fanglomerates, evaporites, and bedded sedimentary rocks (Eberly and Stanley, 1976; Metzger, 1968; El Paso Natural Gas Company, 1968, 1970). These materials generally range from 2000 to 5000 feet thick in the Sonoran Desert section and are suggested to exceed thicknesses of 18,000 feet in the Salton Trough (DMA, 1976; Eberly, 1975; Dibblee, 1954; Sharp, 1972; Biehler, 1968).

In terms of areal predominance, alluvial fans are the most extensive of the basin-fill deposits, roughly covering more than 75 percent of the suitable area in the Sonoran CSP. The fans are composed of detritus derived locally from adjacent rock highlands, aggraded to several topographic base levels around the valley flanks. The coarser grained sediments occur nearest the mountain fronts (generally the oldest and topographically highest fans). These are the more indurated fans, commonly containing labe-stage caliche development to 60 inches thick in surficial and buried soil horizons (Fugro National, Inc., 1976). The coarser fans grade toward the valley axis, the distal portions being removed and redeposited as finer grained younger fans near the flat basin centers. The younger fans are active surfaces of sediment transport and are locally mantled with sand, gravel, and silt from modern stream deposition. Caliche in the younger fans is generally disseminated and does not pose excavation problems.

Contemporaneous with the deposition of alluvial fan deposits are the Plio-Pleistocene fluvial and estuarine deposits. The major fluvial deposits in the Sonoran CSP were deposited by the ancestral Colorado River and its tributaries, the Gila, Santa Maria/Bill Williams and Hassayampa rivers. Fluvial deposits form terraces tens to hundreds of feet thick, that thin rapidly within several miles normal to the river channel (Metzger, 1968; Olmstead and others, 1973; Fugro National, Inc., 1975).

Estuarine deposits, resulting from the influx of the Gulf of California in Pliocene time, include the Bouse Formation and its postulated equivalent, the Imperial Formation (Metzger, 1968; Metzger and others, 1973; Smith, 1970). Surface exposures of the Bouse Formation are confined to incised areas near the Colorado River. The Imperial Formation underlies large portions of suitable area east of the Salton Sea. These deposits consist of unconsolidated to well indurated claystone, siltstone and sandstone. The Bouse and Imperial Formations are up to 900 and 4,000 feet thick, respectively, however they are relatively restricted in surface exposure.

Late Tertiary to Quaternary basalt flows occur in scattered locations throughout the Sonoran CSP. Younger flows have been demonstrated to be intercalated with the near surface basin-fill deposits in the central and western Sonoran Desert section (Fugro, 1974). The potential for this condition elsewhere, especially near the Amboy and Pisgah flows in the central Mojave Desert section, is good.

Consolidation of the basin fill sequence is primarily a function of depth. Limited seismic velocities from nuclear power plant investigations in both fluvial and alluvial fan materials indicate roughly correlative results for similar basin fill compositions (Fugro, 1975, 1976; Southern California Edison Co., 1974). Measured P-wave velocities in the upper 25 to 75 feet of unconsolidated material generally range from 1000 to 3000 feet per second; velocities for deeper (greater than 75 feet) well-consolidated deposits range from 3000 to 6500 feet per second (Fugro, 1975). Lithified fanglomerate in the subsurface produce velocities ranging from 7000 to 8500 feet per second. The presence of various amounts of caliche within the basin fill may produce higher velocities (Mattick and others, 1973).

7.3.2 HYDROLOGIC CONDITIONS

7.3.2.1 Surface Hydrology

The Colorado River is the only perennial stream in the CSP, trending north-south between the Mojave Desert and Sonoran Desert sections. In the Sonoran Desert section, runoff is primarily channeled into major ephemeral drainages such as the Gila, Santa Maria/Bill Williams and Hassayampa rivers, all of which eventually drain into the Colorado River. The Mojave Desert section has predominantly closed basin drainage conditions, except near the Colorado and Mojave rivers. Seasonal runoff is diverted into playa lakes and low-lying areas where the water may stand for several weeks (Blanc and Cleveland, 1961). Drainage in the Salton Trough section is diverted into the Salton Sea, the only natural perennial standing body of water in the CSP.

7.3.2.2 Ground-Water Hydrology

Ground water in the Sonoran CSP is stored primarily within the clastic sediments which fill the broad intermontane basins. Permeability of these sediments is generally good except for areas with finer grained lacustrine deposits. The water table in the basins is largely unconfined and generally over 100 feet deep in areas away from major drainages. Within the Mojave Desert section, shallow ground water (50 feet or less from the surface) is found primarily in the vicinity of playas and along the upper reaches of ephemeral streams such as the Mojave River. Shallow water can also be expected to occur within short proximity of the Colorado River (Moyle, 1974).

Flowing springs are scattered throughout the Mojave Desert, but are rarely found in the Sonoran Desert. Springs are generally found north of the San Bernardino Mountains. They are located along the base of alluvial fans, where faults have truncated water-bearing strata and formed barriers or partial barriers to ground-water flow.

The Sonoran Desert section contains very few areas of shallow ground water. These generally coincide with a narrow corridor fluctuating up to two to five miles from major ephemeral drainages such as the Gila and Hassayampa rivers. Ground water commonly attains its shallowest depths near valley outflows where subsurface rock, forming ground-water barriers, often backs up underflow until water table levels are sufficiently elevated to flow over into adjacent valleys (Metzger, 1957). Shallow ground water in the Salton Trough is found primarily in the immediate vicinity of the Salton Sea (Moyle, 1974).

Declining water table levels are common in the Sonoran CSP where large overdrafts have been caused by pumping for irrigation. Large declines on the order of ten feet or more per year are not uncommon in the agricultural areas west and south of Phoenix (Arizona Water Commission, 1975), and in some cases have resulted in land subsidence and earth fissuring. Areas of artesian head decline are also common in the central and western Mojave Desert section (Department of Water Resources, 1960).

7.3.3 TERRAIN CONDITIONS

Most of the Sonoran CSP exhibits typical Basin and Range topography. Desert basins are surrounded by mountain ranges having relatively steep bedrock slopes, with dissected alluvial fans dipping gradually away from the foot of the mountains out onto the relatively flat basin floor. Bajada slopes grade to the valley axis at generally less than two percent.

Elevations in the valleys range from near sea level in the Salton Trough section to approximately 4,000 feet in southern Nevada. Relief between the basins and adjacent mountain ranges often exceeds 2000 feet. The upper portions of the fans (those with slopes ranging from three to seven percent) generally have lower drainage density but exhibit deeper dissection, with local relief often exceeding 20 to 50 feet. The lower central basin floors have a higher drainage density but shallower incision, except near major tributaries. Basin floors are often nearly flat; exceptions are areas of sand dunes which may have significant relief (up to 700 feet; Basset and Kupfer, 1964) with slopes exceeding five percent.

7.3.4 CULTURAL CONDITIONS

7.3.4.1 Demography

Population density in the Sonoran CSP is low with large population centers situated predominantly near the periphery. Cities with populations over 25,000 include: San Bernardino, Indio, and El Centro, California; Las Vegas, Nevada; and Yuma, Phoenix, and Tucson, Arizona (Figure 7). Less than a dozen towns of populations 5,000 to 25,000 are located within the CSP. Many geographic place names are either uninhabited or contain settlements of only a few tens of people.

The three major transportation arteries in the CSP are Interstate highways I-8 and I-10, which run east-west across the Sonoran CSP, and I-15 which runs northeast from San Bernardino to Las Vegas. Paved state and federal roads, as well as several railroads, connect major towns, usually following routes along valley floors. Much of the area, however, is far from paved highways and is served only by dirt and gravel roads, often requiring the use of four-wheel drive vehicles. Cultural improvements such as major road and pipeline networks, aqueducts, and railroads (Appendix B) are not sufficiently dense to restrict MX siting. Existing military facilities in the CSP are:

- Edwards Air Force Base, California;
- Twentynine Palms Marine Corps Base, California;
- El Centro Naval Facility, California;
- Naval Ordnance Test Station, California;
- Nellis Air Force Base, Nevada;
- Yuma Proving Grounds, Arizona;
- Luke Air Force Base, Arizona;
- Marine Corps Air Station, Arizona;
- Williams Air Force Base, Arizona;
- Davis-Monthan Air Force Base, Arizona.

7.3.4.2 Land Use

Approximately 16 percent (2800 nm^2) of the Sonoran CSP is DoD land, primarily situated in southwestern Arizona in the Luke Bombing and Gunnery Range and the Yuma Proving Grounds. BLM land comprises another 77 percent (13,500) of the CSP, with the remainder being mostly state or privately owned. Most of the BLM land is used for grazing or is leased under special homestead conditions; most private land is used for irrigation farming.

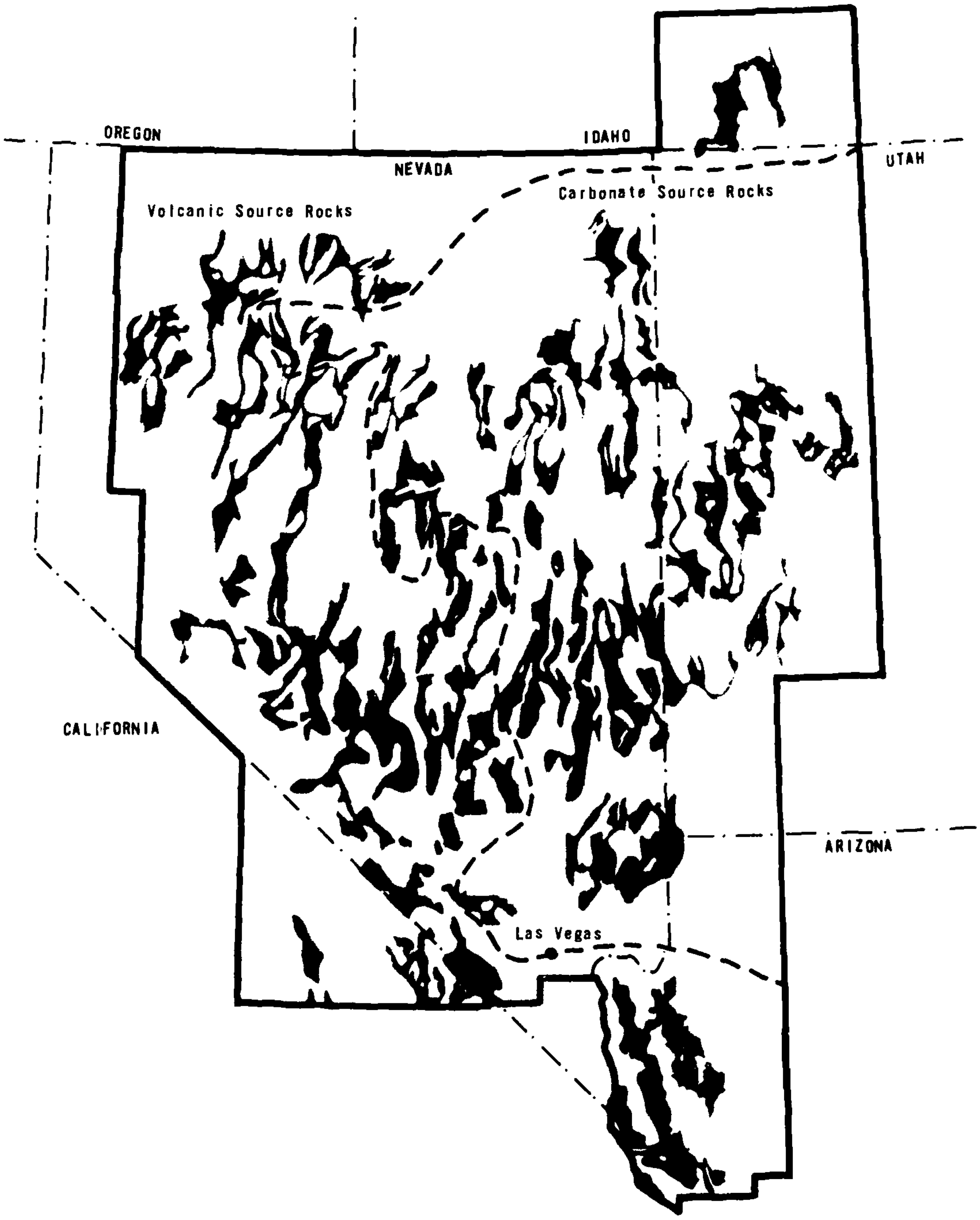
7.3.4.3 Economic Base

The most important mineral deposits within suitable area are associated with the dry lake sediments in the Mojave Desert section in California. Such industrial minerals as potash, bromine, borax, sodium sulfate and carbonate, calcium chloride, phosphate, pumicite, salt, clay, lithium, and diatomaceous earth are present in the playa lake basins. Many of these resources have been mined in recent years from several dry lakes (Blanc and Cleveland, 1961; California Division of Mines and Geology, 1968). Other deposits of lesser importance found within the Sonoran CSP include sand, gravel, and limestone (Bassett and Kupfer, 1964).

8.0 GREAT BASIN CSP

8.1 GENERAL SETTING

The Great Basin CSP encompasses approximately 25,680 nm^2 of suitable area covering portions of Nevada, Utah, Idaho, California, and Arizona (Figure 8). All of the suitable area within this CSP is contained within the Great Basin physiographic province (Fenneman, 1931), an area characterized by north to northwest trending elongate valleys separated by mountain ranges of high relief. Suitable area occurs essentially in individual alluvium filled basins and contiguous basins connected by passes of less than ten percent grade. Suitable area is bounded primarily by rock and topographic exclusions associated with the intervening mountain areas.



GREAT BASIN CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE · SAMSO

FIGURE
8

FUGRO NATIONAL, INC.

8.2 SUMMARY OF RESULTS

1. The Great Basin CSP contains approximately 25,680 nm^2 of suitable area, covering portions of Nevada, Utah, Arizona, California, and Idaho, and lies entirely within the Basin and Range physiographic province.
2. All suitable area is comprised of Quaternary basin-fill deposits, generally alluvial and lacustrine in origin and grading in size from boulders and cobbles near mountain fronts to silt and clay in the central portions of the valleys. Caliche is a common cementing agent in these deposits.
3. Perennial drainage within the CSP consists of the Raft, Humboldt, and Colorado rivers; very few perennial lakes exist in the CSP. Basins are characterized predominantly by internal drainage, with runoff directed to central playa areas.
4. Ground water is generally unconfined within the basin fill and found at depths greater than 100 feet below the ground surface. Ground water is also present in volcanic, carbonate, and sedimentary (clastic) rocks.
5. Terrain in the desert basins is gently sloping, consisting of alluvial fans and bajadas, lake deposits, ephemeral streams, sand dunes, pediments, and stream and lake terraces. Gradients range from less than two to greater than ten percent. Drainage density can be as great as 20 per nm to less than five per nm. Depth of incision of the drainages generally ranges from between five to 25 feet.
6. Population density within the Great Basin CSP is very low. The only potential resource considerations within suitable

areas at this time are sand and gravel and petroleum. These are considered very low potential. Stock grazing is the major land use of open area in the public domain.

7. Approximately 90 percent of the area is federally controlled BLM land; the remainder is owned by state, private, and other federal agencies.
8. Six military facilities are situated in or adjacent to the CSP.

8.3 CHARACTERISTICS OF SUITABLE AREA

8.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Suitable areas within the Great Basin CSP lie entirely within intermontane valleys. These valleys are composed wholly of Quaternary age basin-fill deposits that have resulted from wind, water, and gravity erosion of the adjacent highland areas. Alluvial fans and bajadas are the predominant landforms often occupying as much as 70 percent of the valley area. Playas are the second most common land form, but generally occupy less than five percent of the total area.

The Great Basin CSP is informally subdivided into two sections based on distribution of rock types. This division is based upon the preponderance of either volcanic or carbonate rocks in the outcropping mountain areas adjacent to the valleys, and the influence these two rock types have on the particle size distribution, cementation, and density characteristics of the basin fill. Scattered small areas of clastic sedimentary rock also occur, however, these are relatively insignificant and have been included with the two larger categories for sake of discussion. The carbonate/volcanic division occurs in the Nevada portion of the Great Basin CSP and roughly divides the state in half (Figure 8). The Utah portion of the Great Basin CSP falls in the carbonate rock section of this division. The Arizona, California, and Idaho portions fall in the volcanic rock section.

Other factors that influence the nature of the basin-fill deposits are; distance from the source area, mode of sediment transport, depositional environment, and depth of burial Generally, particle size distribution grades from an abundance of boulders, cobbles, gravel and sand near the mountain front to clay, silt, and fine sand near the valley axes.

Variation in grain-size distribution of basin-fill materials with differing source rock type has been noted by Williams and others (1963). In general, the coarsest basin fill corresponds to limestone, quartzite, and welded volcanic tuff sources. In areas where welded and non-welded volcanic tuffs predominate, gravel, cobble, and boulder fractions are noted to be less.

Caliche, a secondary accumulation of calcium carbonate, is the most common cementing agent of the basin fill, with degree of development and areal extent varying with local conditions. Alluvial fans, stream terraces and pediments are landforms that will likely have some form of caliche development. Generally, the older the deposits associated with these landforms, the more well developed the caliche. In addition, those suitable areas with abundant carbonate rock (limestone, dolomite) are likely to have a greater abundance of caliche.

Seismic compressional (P) wave velocities of the basin fill are largely unknown. Most weakly cemented basin-fill deposits are likely to have P-wave velocity ranges of 1000 to 4500 fps in the upper 30 to 50 feet (Fugro National, 1977 unpublished data).

Thickness of the basin fill varies from valley to valley, dependent primarily on basin shape, and past and present tectonic and climatic episodes. Review of available data shows that a thickness of several thousand feet can be expected in the central portions of suitable valley areas (Defense Mapping Agency, 1976). Basin-fill deposits tend to thin closer to the mountain fronts. Data on the type of rock underlying the basin fill is generally lacking. However, it is expected that such rock is, for the most part similar to that exposed in the adjacent mountain ranges.

Periods of volcanism in the Great Basin CSP have, in some areas, contributed interbeds of volcanic rocks to the basin fill. Due to the lack of data on the basin-fill materials, the extent and number of basins containing volcanic interbeds are unknown. However, the likelihood of buried volcanic flows and tuffs is much greater in the volcanic rock sections of the CSP (Thordarson and others, 1967; Figure 8). Interbedded materials consist of agglomerates, air-fall and ash-flow tuffs which are welded to various degrees, and volcanic flows of rhyolitic to basaltic composition (Stewart, and Carlson, 1974).

8.3.2 HYDROLOGIC CONDITIONS

8.3.2.1 Surface Hydrology

Closed-basin conditions, characterized by ephemeral streams that flow into central playas, predominate in the Great Basin CSP. Open-basin conditions are characterized by a primary and secondary system of ephemeral channels that drain adjacent valleys and flow out of the immediate region to the main perennial trunk stream. From north to south, the Raft, Humbolt, and the Colorado rivers are the major perennial rivers that flow through the region.

Density of perennial streams and rivers that flow in the CSP is extremely low due to the high porosity and permeability of the underlying strata, the high evapo-transpiration rate, and low rainfall. Flood plains on those rivers are as much as several miles across. Perennial lakes are not common in the suitable areas of the Great Basin CSP. Most of the lakes and streams are ephemeral in nature, containing water only for short periods of time following severe thunderstorms. Little of the runoff from these storms reaches the perennial stream network, as most of it is absorbed as ground-water recharge or evaporated. Due to the nature of the storms that frequent this region, flooding is highly probable in localized areas.

8.3.2.2 Ground-Water Hydrology

Ground water in the Great Basin CSP is primarily represented by basin-fill aquifers, but aquifers are also present within volcanic, clastic, and carbonate rocks. The complex interrelationships of aquifers between and within individual valleys of the Great Basin CSP are not yet well defined. Based on hydrologic reports for the states of Utah, Idaho, California, and Nevada, and other information on static ground water levels in Nevada, the ground water in the suitable area of the Great Basin CSP generally lies more than 100 feet below the ground surface.

8.3.3 TERRAIN CONDITIONS

The Great Basin CSP exhibits typical Basin and Range topography. Desert basins are surrounded by mountain ranges having relatively steep bedrock slopes, with dissected alluvial fans dipping gradually away from the foot of the mountains out onto the relatively flat basin floor. Bajada slopes grade to the valley axis at generally less than two percent but may range up to ten percent near mountain re-entrants.

Elevations in the valleys range from 1200 feet in eastern California to approximately 6500 feet in western Utah. Relief between the basins and adjacent mountain ranges often exceeds 2500 feet. The upper portions of the alluvial fans (those with slopes ranging from five to 20 percent) will generally have lower drainage density but will exhibit deeper dissection, with local relief often exceeding 25 feet. The lower central basin floor is often nearly flat. Drainage densities are generally higher with shallower incision, except near major tributaries. Isolated areas of sand dunes on basin floors may have significant relief with slopes exceeding five percent.

8.3.4 CULTURAL CONDITIONS

8.3.4.1 Demography

The Great Basin CSP suitable areas encompass sparsely populated regions. Populations consist of small mining and agricultural communities situated at the junction of major road and rail arteries. The only large city of population 25,000 or greater in the CSP is Las Vegas, located in southern Nevada. Large towns (5000 to 25,000 population) located in or near the suitable area are Ely, Winnemucca, and Battle Mountain in northern Nevada.

Cultural improvements such as state and federal highways, railroads, electrical transmission lines, and oil and gas lines are not sufficiently dense to restrict MX siting, however, they commonly combine with other exclusions to form minimum parcel exclusions (Table C-1). Most of the area is served by dirt and gravel roads, often requiring the use of four-wheel drive vehicles.

Existing military or government reservations in the area are:
- Nellis Air Force Base, Las Vegas, Nevada;
- Indian Springs Auxillary Air Force Base; Indian Springs, Nevada;
- Tooele Army Depot, Tooele, Utah;
- Nevada Test Site Base Operations, Mercury, Nevada;
- Fort Irwin, California.

8.3.4.2 Land Use

BLM is the principal controlling agency for most of the Great Basin CSP suitable area. Portions of the CSP are state owned, privately owned, or under the control of federal agencies other than the BLM. (Table 3). These three categories of non-BLM ownership total approximately five percent of the total CSP area. State lands consist of one to four sections per township, set aside for schools. Approximately five percent of the suitable area is under DoD control, lying within the Nellis Bombing and Gunnery Range, central Nevada, and the Dugway Proving Grounds, western Utah. The primary use of the BLM land is stock grazing on land leased to local ranchers. A small portion of BLM lands is used for farming where water conditions permit.

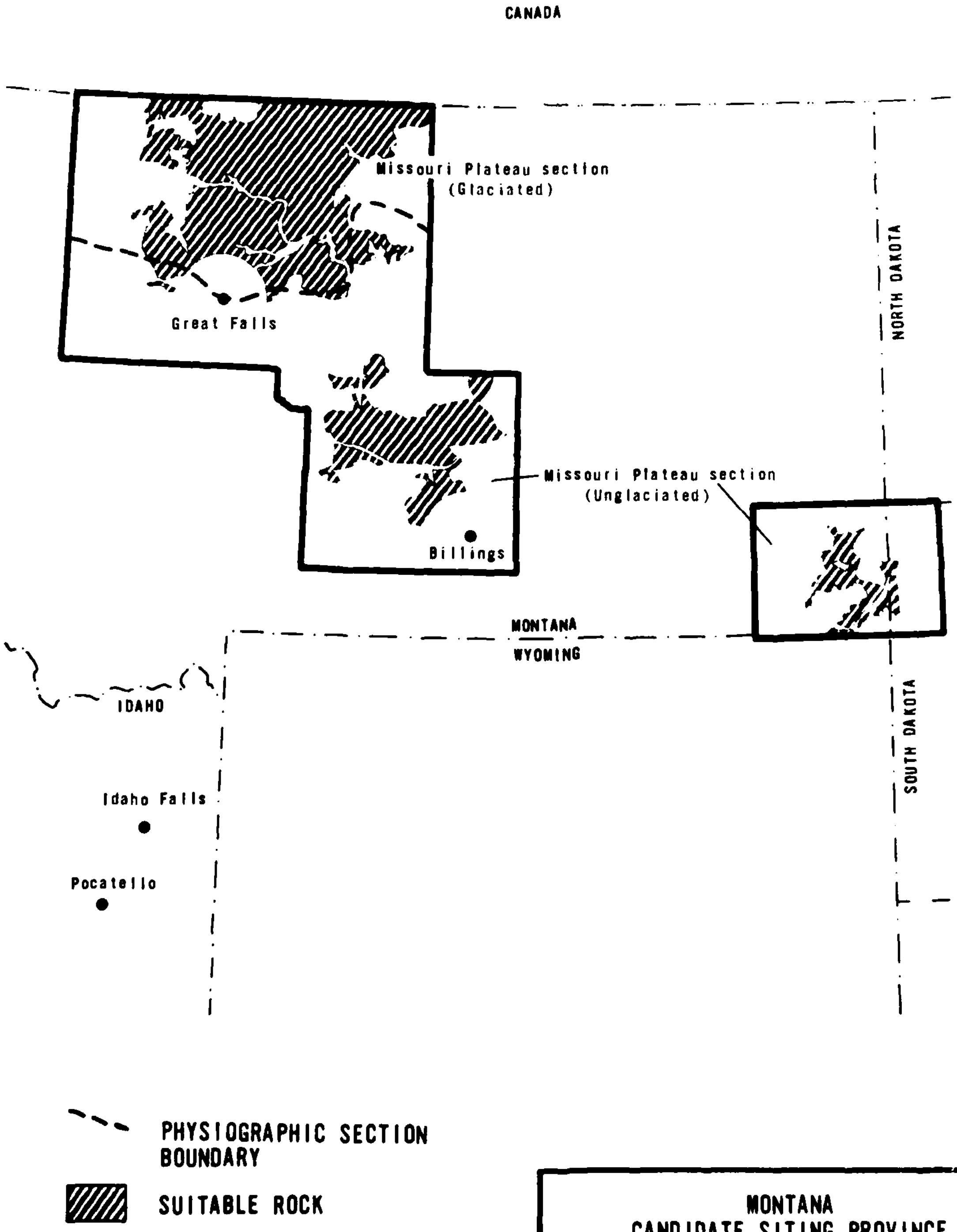
8.3.4.3 Economic Base

There are no current mining activities or forecasts for future mining operations within suitable area of the CSP (Nev. Bur. Mines and Geology, 1973). There are significant ongoing mining activities in Nevada and Utah, but they do not extend into suitable valley areas. All of the suitable areas have possible low potential for commercial sand and gravel resources. There has been ongoing exploration for oil in the eastern part of Nevada, and there are producing or exploratory wells scattered throughout the state. So far, there has only been one producing oil field which is in Railroad Valley, Nevada. Known Geothermal Resource Areas (KGRA) exist in Nevada and Utah. However, there are, at this time, no known geothermal areas located in suitable area.

9.0 MONTANA CSP

9.1 GENERAL SETTING

The Montana CSP encompasses approximately 9680 nm^2 of suitable excavatable rock areas in north central, central and southeastern Montana with a small portion extending into northwestern South Dakota (Figure 9). It lies entirely within the Missouri Plateau section of the Great Plains physiographic province as defined by Fenneman (1931). The Missouri Plateau is a vaguely defined highland area sloping gradually eastward from the Rocky Mountains. Suitable area lies within broadly terraced river valleys, peneplained interstream uplands, and high interstream areas of coalescing alluvial fans, bounded by interspersed, isolated volcanic mountains (Fenneman, 1931). To facilitate characterization of large areas, suitable parcels in the Missouri Plateau CSP are separated into glaciated and non-glaciated sections (Figure 9). The parcels in the non-glaciated section are irregular in shape and are bounded primarily by cultural and hydrologic exclusions. Suitable parcels in the glaciated section are bounded primarily by topographic exclusions.



MONTANA
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
9

FUGRO NATIONAL, INC.

9.2 SUMMARY OF RESULTS

1. The Montana CSP consists entirely of suitable excavatable rock and totals 9,680 nm^2. The CSP corresponds to the Missouri Plateau subprovince of the Great Plains physiographic province, which is further divided into non-glaciated and glaciated sections.
2. The glaciated parcels lie in north-central Montana, total 6,640 nm^2 and are characterized by generally less than 50 feet of clay, sand, gravel and boulder till deposits overlying largely excavatable Cretaceous sedimentary shale and sandstone formations.
3. Non-glaciated area in central Montana totals 2,340 nm^2 and is characterized by generally less than 50 feet of easily excavatable stream terrace deposits of sand, gravel, silt and clay which cover 25 percent of the area. Largely excavatable Cretaceous to Tertiary shale, sandstone and siltstone underlie the terrace deposits and are exposed at the surface in the remaining 75 percent of the area.
4. Non-glaciated area in southeastern Montana and northwestern South Dakota totals 700 nm^2. The Pierre Shale is exposed over approximately 95 percent of the area.
5. The Missouri and Marias rivers flow southeast through the glaciated section with small perennial streams occurring at intervals of ten to 15 nm. The non-glaciated areas are transected by the Musselshell and Little Missouri rivers with lesser perennial streams separated by 15 to 20 nm.

6. Ground water in the glaciated region varies from 50 to 100 feet in depth depending on the thickness of the glacial drift. Depth to the water table in the non-glaciated parcels is generally greater than 50 feet.
7. Elevations in the CSP range from 2700 feet to 6200 feet above sea level, with the maximum average gradient being less than one percent. Maximum drainage density averages roughly ten shallowly incised ephemeral channels per nautical mile.
8. Population within the CSP is sparse and limited to small towns and scattered ranches and farms. Quantity-distance exclusions for Great Falls and Billings bound the non-glaciated and central glaciated areas, respectively. Approximately 85 percent of the CSP consists of privately-owned land.
9. A small portion of the central unglaciated area is underlain by low potential coal deposits. No other current or potential mineral resources are known within the suitable area of the CSP.

9.3 CHARACTERISTICS OF SUITABLE AREAS

9.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Suitable area in the Montana CSP occupies a region of extensive, essentially flat-lying, Cretaceous to Tertiary sedimentary formations that are overlain in the north by various thicknesses of glacial drift and various stream terrace deposits.

The glaciated section of the Montana CSP is covered almost entirely by a veneer of Pleistocene glacial drift which ranges in thickness from zero to 100 feet but is less than 50 feet thick over much of the area (M. Miller, oral communication, 1977). Till deposits predominate and generally consist of unsorted, poorly consolidated, heterogeneous mixtures of clay, sand, gravel and boulders that vary widely in size and shape.

The section designated non-glaciated, in fact, has limited glaciated areas which are not depictable at this level of investigation. While these areas exhibit no significant deposits of glacial drift (Fenneman, 1931; Colton and others, 1961), they have fluvial stream terrace deposits that cover approximately 25 percent of the suitable area in the central portions of the CSP. These deposits consist of unconsolidated to poorly consolidated accumulations of gravel, sand, silt and clay, and range in thickness from zero to 200 feet (Ellis and Meinzer, 1924).

The Tertiary to Cretaceous sedimentary formations which underlie all portions of the suitable area are exposed at the surface in roughly 75 percent of the central and southeastern portions of the CSP, and are generally less than 50 feet below ground surface in the remaining portions of the CSP. The Cretaceous Judith River Formation underlies approximately 40 percent of the glaciated portions of the CSP and small portions of the unglaciated areas. The upper two-thirds of this unit consists of massive cross-bedded sandstone; the lower one-third is a sandy shale (Ross and others, 1955; Armstrong, oral communication, 1977). Although detailed engineering properties for this unit are generally not available, estimated seismic p-wave velocities of 6500 to 7700 fps have been assigned (Armstrong, oral communication, 1977). Surface and near surface portions of this unit are also known to have weathered zones that may extend to depths of several feet (Armstrong, oral communication, 1977).

The Colorado Shale underlies over 50 percent of the glaciated portions and minor portions of the unglaciated areas of the CSP in central Montana. It consists predominantly of clayey shale which is easily ripped. Construction of highways in this formation has identified possible near surface expansive materials and slope stability problems (Armstrong, oral communication, 1977).

The remaining units underlying the glaciated section consists of a shale, clay and sandstone sequence composed of the Cretaceous Eagle Sandstone, Telegraph Creek and Claggett formations; and the Triassic Ellis Group and Sundance Formation.

In the unglaciated section, the Cretaceous Pierre Shale is present at or very near the surface in nearly 95 percent of the suitable areas in south-eastern Montana. It consists predominantly of dark clayey shale, with interbedded sand members and calcareous concretions. The unit is considered to be rippable but only marginally where resistant oil shale is encountered (Armstrong, oral communication, 1977).

The remaining suitable area is underlain by generally rippable Tertiary to Cretaceous sedimentary formations of minor extent. The most notable of these is the Tertiary Fort Union Formation that underlies small portions of suitable area in central and southeastern Montana. It is composed of clayey shale, siltstone, interbedded coal and well-indurated sandstone (Ross and others, 1955; Armstrong, oral communication, 1977). The sandstone units may be present at the near surface, with rippability dependent upon bedding-plane orientations and fracture density. Other formations of limited extent in the CSP include the Cretaceous Hell Creek Formation and Bearpaw Shale, composed of clayey shale and sandstone.

9.3.2 HYDROLOGIC CONDITIONS

9.3.2.1 Surface Hydrology

Major drainages in the glaciated portion of the CSP trend east-southeast at gradients that seldom exceed four feet per nm. The Missouri River passes through the southeastern corner of the area; the Marias River to the north, and the smaller Milk River to the northeast run subparallel to the Missouri River and intersect it beyond the limits of the suitable area. Other, minor perennial streams flow southeast, generally at intervals of ten to 15 nm. Ephemeral streams are sparse and only moderately incised.

The Tiber Reservoir along the Marias River covers an estimated 100 nm^2 and is the largest body of standing water in the entire CSP. Numerous scattered perennial and ephemeral lakes and reservoirs,generally less than two nm^2, occur throughout the glaciated area.

Suitable parcels within the non-glaciated area contain only limited surface water. Numerous ephemeral and a few perennial streams at 15 to 20 nm spacings trend southeast into the east flowing Musselshell River. Several small perennial and seasonal lakes occur near the river as well as a 15 to 20 nm^2 area of marshland.

The Little Missouri River and its minor tributary, Boxelder Creek,flow northeast at a gradient of five to ten feet per mile and make up the only significant perennial water in the southeastern Montana-northwestern South Dakota suitable area. Ephemeral drainages are dense and generally trend southeast. A possibility of occasional flash flooding exists in all non-glaciated suitable areas due to the proximity of highland areas, poorly incised drainages and summer thunderstorms.

9.3.2.2 Ground-Water Hydrology

In the glaciated portions of the CSP, ground-water depth varies with the thickness of the glacial drift and ranges from an estimated 50 to 100 feet (Miller, oral communication, 1977). The drift is heterogeneous in nature making it almost impossible to determine the true configuration of the water table. Most of the water is found in buried channel gravels, very few of which have been accurately located.

Non-glaciated suitable area in the central CSP generally contains ground water at depths greater than 50 feet in the various Cretaceous formations, as well as the Tertiary Fort Union Formation. Quaternary terrace deposits may in some instances hold ground water at depths less than 50 feet but, like the glacial debris of the glaciated region, depth to water is variable due to the heterogeneous nature and variable thickness of the terrace deposits (Miller, oral communication, 1977).

Ground water in suitable area occurs principally within the coal beds of the Tongue River Member of the Fort Union Formation in the southeastern portions of the CSP, and is estimated to be at depths ranging from 50 to 500 feet. The Pierre Shale is an extremely poor aquifer in this area and contains essentially no ground water (Miller, oral communication, 1977).

9.3.3 TERRAIN CONDITIONS

Terrain conditions in the glaciated section of the CSP are best characterized by broad, undulating and moderately dissected plains that slope gently to the east-southeast. Maximum elevation approaches 4200 feet in the west, dropping at an average grade of less than 0.5 percent to a minimum of 2700 feet in the east. Major southeast trending ephemeral drainage channels occur approximately every one-half nm with maximum relief on the order of ten to 20 feet. Smaller ravines with less than ten feet of relief are found at intervals of roughly 500 to 1000 feet. In general, dissection increases south of the Marias River. Aside from several large terminal moraines adjacent to the Sweetgrass Hills, a few scattered kames and eskers of less than 50 feet relief make up the only significant landforms in the glaciated area.

The non-glaciated portion of the CSP is best described as a moderate to well dissected plain characterized by low rolling hills. In the central non-glaciated parcel, a maximum elevation of roughly 6200 feet occurs in the west, while a minimum of 3200 feet is observed in the east. This yields a maximum average gradient of less than one percent. Dissection is moderate with major ephemeral channels at one-half nm intervals and minor gullies occur every 600 to 1000 feet. Relief within the ephemeral drainage system probably does not exceed 20 feet.

The well-dissected plain encompassing the suitable area in southeastern Montana has a maximum relief of 325 feet and a corresponding maximum average slope of less than 0.1 percent along a northwest trend. Elevation in the area does not exceed 3575 feet above sea level. Numerous ephemeral streams and gullies trend southeast and are spaced at intervals from 200 to 1000 feet. Local relief ranges from zero to 30 feet.

9.3.4 CULTURAL CONDITIONS

9.3.4.1 Demography

Population within the Montana CSP is sparse. Several small towns of less than 5000 inhabitants occur along east-west trending Interstate 2 that bisects the glaciated, suitable excavatable rock region. Great Falls, a city of over 60,000 people, lies 18 nm south of the glaciated area while Billings, with nearly 62,000 inhabitants, is located 18 nm southeast of the larger, non-glaciated parcel. Population centers for the remainder of the CSP are limited to a few small railroad towns and numerous scattered ranches and farms.

Road networks, railroads, pipelines and aqueducts are sparse. Malstrom Air Force Base in Great Falls is the closest existing military base.

9.3.4.2 Land Use

Approximately 85 percent of the land within the glaciated and the larger non-glaciated suitable rock regions is privately owned. The remaining 15 percent is essentially BLM land. The privately-owned land consists of scattered farms and ranches of relatively low productivity. In the non-glaciated suitable rock areas of southeastern Montana and northwestern South Dakota, the land is primarily privately-owned with the remainder divided between state and public lands. As with the more northerly regions, ranching and farming account for most of the privately-owned property (Bureau of Land Management, 1967; Short and others, 1976).

9.3.4.3 Economic Base

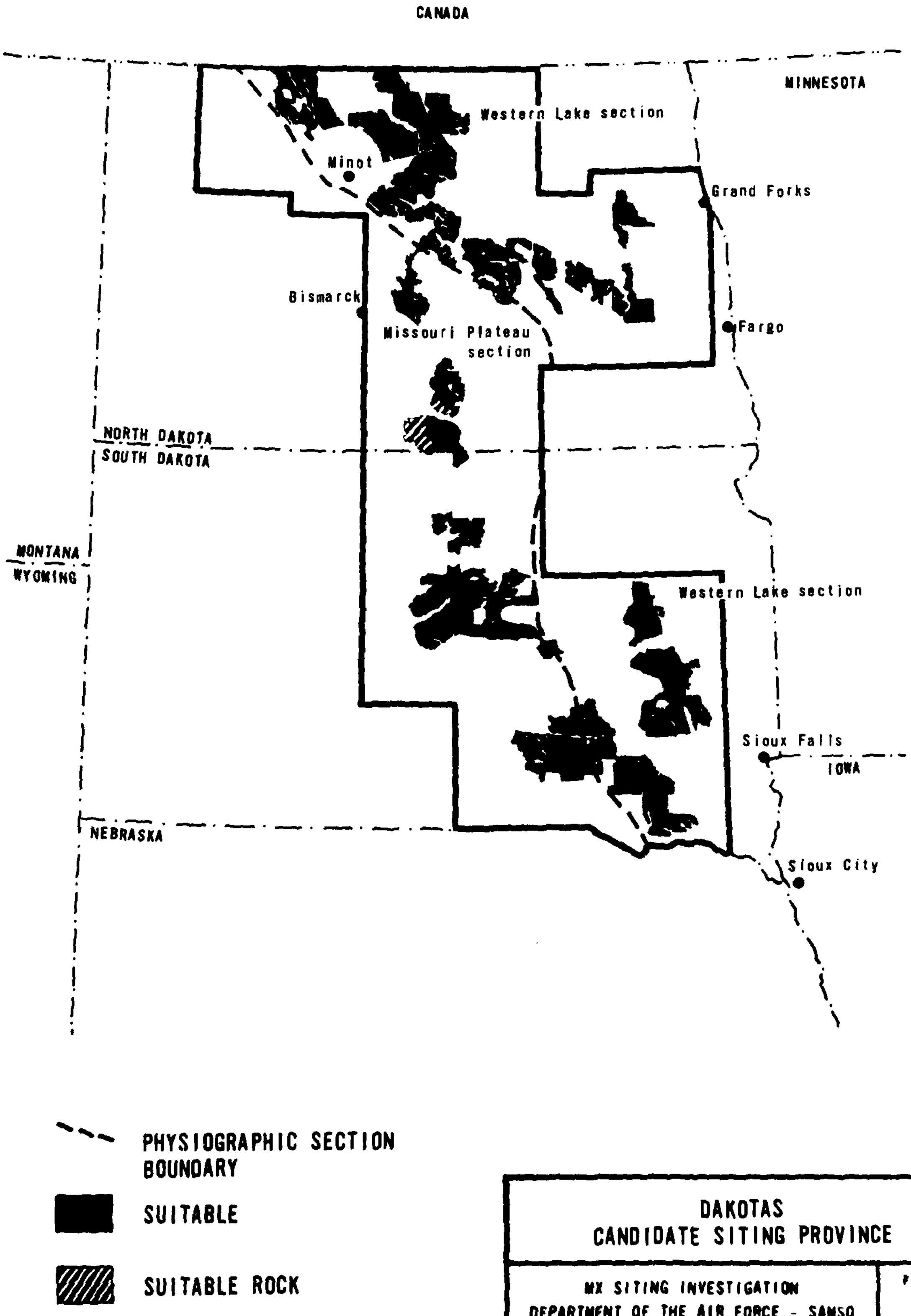
Within the boundaries of the CSP, a few, relatively minor, scattered oil and gas fields constitute excluded areas (Mapco Inc., 1977). The eastern half of glaciated suitable area is underlain by beds of subbituminous coal within the Judith River Formation, but the grade, thickness and overburden of the deposit assign it a low economic potential (Combo, 1950, U.S. Geological Survey, 1968, 1974; White, oral communication, 1977). Coal of a slightly higher grade in the Tongue River Member of the Fort Union Formation underlies the eastern third of the central non-glaciated parcel. These deposits represent thinner beds within the outskirts of the Bull Mountain Coal Field which has not been commercially active since the 1920's (Combo, 1950, U.S. Geological Survey, 1968; Hotchkiss, oral communication, 1977). Although there has been recent exploration within the core of the Bull Mountain Field, the portions underlying suitable area are considered to be of low or moderate economic potential (White, oral communication, 1977).

With the exception of minor scattered sand, gravel or limestone quarries, no additional current or potential resources are known within the Montana suitable area.

10.0 DAKOTAS CSP

10.1 GENERAL SETTING

The Dakotas CSP encompasses approximately 8900 nm^2 of suitable area including 150 nm^2 suitable excavatable rock covering portions of North and South Dakota east of the Missouri River (Figure 10). Irregular clusters of suitable parcels form a north-trending strip extending from the Canadian to Nebraska borders. The parcels are nearly equally divided between two physiographic provinces, which aids in characterizing large areas of suitable geotechnical conditions. These are the Missouri Plateau section of the Great Plains physiographic province in the west and the Western Lake section of the Central Lowlands to the east. Suitable areas are bounded primarily by water and cultural exclusions.



DAKOTAS
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
10

FUGRO NATIONAL, INC.

10.2 SUMMARY OF RESULTS

1. There are approximately 8900 nm^2 of suitable area including 150 nm^2 of suitable excavatable rock within the Dakotas CSP.
2. The CSP corresponds to two physiographic provinces; the Missouri Plateau section of the Great Plains Province and the Western Lake section of the Central Lowlands Province.
3. The surficial materials of this area consist almost entirely of unconsolidated Wisconsin glacial drift, which ranges from zero to over 500 feet thick.
4. The Cretaceous Fox Hills Formation, composed of sandy shale, siltstone, and sandstone, comprises a small area of excavatable rock in the central portion of the Missouri Plateau section.
5. Excavatable rock composed of Tertiary and Cretaceous sandstone and shale formations underlies the glacial drift. The most extensive bedrock unit is the Pierre Shale.
6. Drainage density is sparse, being greatest on the slopes between highland and lowland areas. Small lakes and swamps fill many of the numerous swales on the Missouri Plateau and Western Lake sections.
7. Ground-water conditions are inherently complex due to the heterogeneous nature of the glacial drift. The water table may be shallow in places. Perched and artesian conditions are also present.
8. Terrain varies from relatively flat lacustrine and morainal plains to rolling knob and kettle topography. Local relief on these landforms ranges to 50 feet.

9. Cultural conditions are characterized by small agrarian communities and a dispersed network of roads and pipelines; Minot Air Force Base lies within the CSP.
10. Suitable area is private and state owned. Primary land use and industry of the CSP are livestock and grain crop farming.
11. Non-agricultural resources chiefly consist of low potential lignite coal and petroleum production.

10.3 CHARACTERISTICS OF SUITABLE AREA

10.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Suitable area in the Dakotas CSP occupies a region of essentially flat-lying Cretaceous to Tertiary sedimentary formations overlain by variable but generally thick (over 50 feet) deposits of glacial drift. Due to the variable thickness of drift and the lack of published data, the underlying bedrock formations were also evaluated for suitability, even though only a small portion of the CSP is designated as excavatable rock. All formations, especially Cretaceous shale (Pierre and Niobrara formations) were determined to be suitable excavatable rock except where resistant sandstone or limestone layers are present, or where small zones of Precambrian metasediments are present in South Dakota (Bump, written communication, 1977). The formations increase in age, from east to west and include the Paleocene Fort Union Formation, and the Upper Cretaceous Hell Creek, Fox Hills, Pierre and Niobrara formations.

Holocene dune sand deposits are present east and west of the Souris River in the Western Lake section of North Dakota, primarily in McHenry County. The dunes are relatively thick (ranging up to 50 to 75 feet) and are stabilized with vegetation (Bluemle, 1975, 1977). Other wind-blown deposits consist of the Oahe Formation, a thin mantle of Pleistocene to Holocene loess (generally less than six feet thick) which covers much of the Dakotas (Clayton and others, 1976).

Early to late Wisconsin glacial drift comprises the predominant lithologies at or very near the surface in the CSP. These glacial deposits are called the Cole Harbor Group, and consist mostly of tills, with lesser amounts of outwash and lacustrine sediments. The drift is heterogenous, consisting of unconsolidated to semi-consolidated admixtures of clay, silt, sand, cobbles and boulders. It is generally rich in clay, being largely derived from local Cretaceous shales (U.S. Geological Survey, 1975). Deposits generally range in thickness from less than 50 feet to over 500 feet, with an average thickness of over 100 feet (Bluemle, 1971; Colton and others, 1961; U.S. Geological Survey, 1973, 1975).

Areas of thin glacial drift (less than 50 feet) are known to occur within both the Missouri Plateau and Western Lake sections (Bluemle, 1971; Hedges, 1968). Published isopach maps depicting accurate thicknesses of drift less than 100 feet in North and South Dakota are unavailable.

The Paleocene Fort Union Formation includes the Tongue River, Cannonball and Ludlow members. The Tongue River Member is composed of poorly consolidated sandstone, siltstone, claystone, lignite and small lenses of limestone (usually less than two feet thick); it has a minimum thickness of about 225 feet (Jacob, 1976; Freers, 1973). The Cannonball Member is a marine sequence of poorly consolidated sandstone and mudstone interfingering with the Ludlow Member. In Burleigh County, North Dakota the Cannonball Member has an average thickness of approximately 275 feet (Cvancara, 1976a). The Ludlow Member is hundreds of feet thick and consists predominantly of non-marine sandstones, organic clays, and abundant lignites. Individual units of this formation range from nonindurated to moderately indurated (U.S. Geological Survey, 1975; Moore, 1976). The exact thickness in the suitable area is unknown, but is conservatively estimated to be several hundreds of feet thick.

The uppermost Cretaceous formation, the Hell Creek, is a nonmarine succession several hundred feet thick composed of sandy shale, poorly consolidated sandstones, carbonaceous clay and thin lignite beds (Frye, 1969; U. S. Geological Survey, 1975; Moore, 1976). The Hell Creek Formation underlies suitable area from northwestern to central North Dakota.

The Fox Hills Formation outcrops over about one-third of the suitable area in the border area of North and South Dakota. This unit has four members including shales, siltstones, and poorly consolidated sandstones with interbedded, well indurated sandstones. The uppermost member is an indurated siliceous sandstone which, in Emmons County, caps buttes. In most places, the Fox Hills Formation is approximately 300 feet thick (Cvancara, 1976b).

The Pierre Shale is the most areally extensive unit underlying the glacial drift. It is predominantly composed of massive to fissile, non-calcareous siltstone and shale, divided into many members (Bluemle, 1965; U.S. Geological Survey, 1975). The shale may contain ferruginous and limestone concretions, bentonite beds, marl zones and organic clay shale (Hedges, 1975).

In south-central South Dakota, the total thickness of the Pierre Shale exceeds 600 feet (Hedges, 1975); in central North Dakota, the thickness varies due to preglacial topography from approximately 250 feet to 1100 feet (Bluemle, 1965).

The Niobrara Formation is composed of 40 to 200 feet of thickly bedded calcareous shale and marl, thin beds of bentonite, and a lower section of chalky limestone (Bluemle, 1965; Christensen, 1974; Steece and Howells, 1965; U.S. Geological Survey, 1973, 1975).

10.3.2 HYDROLOGIC CONDITIONS

10.3.2.1 Surface Hydrology

Hydrologic conditions in the Dakotas CSP differ between the two major sections. The Missouri Plateau section includes an eastern plateau area (Coteau du Missouri) and a western slope that grades to the Missouri River (Coteau Slope). Few streams or lakes occur within suitable area on the Coteau du Missouri, however, in other portions of the CSP, it is densely spotted with small lakes indicating day-lighted water table conditions. Water levels in many of the lakes fluctuate seasonally, drying in the summer.

Streams are predominantly ephemeral on the Coteau Slope, draining west and south to the Missouri River. Drainage density is generally low, averaging approximately one per several nautical miles. The break between the Missouri Plateau section and the Western Lake section is marked by the Missouri Escarpment. A relatively high density (up to two per nm) of ephemeral stream channels trend subparallel off the escarpment onto the

Western Lakes section lowlands where they converge into perennial streams. The streams lead east and south to the James River or northeast to the Souris River. Swamps and lakes are also prevalent in the Western Lake section.

The average annual precipitation in eastern North and South Dakota is 19 inches, but great variations occur from year to year producing periods of successive dry or wet years (U.S. Geological Survey, 1973, 1975). Floods occur in many small tributary streams during excessively wet periods, and frequently develop into devastating proportions along the larger rivers (U.S. Geological Survey, 1973).

10.3.2.2 Ground-Water Hydrology

Glacial outwash deposits of sand and gravel are the principle aquifers in the Dakotas CSP and are irregularly distributed over the region from the surface to various depths within the subsurface (U. S. Geological Survey, 1973, 1975). Water-table conditions generally apply in these deposits. Glacial sediments in the CSP as a whole, however, are highly variable in composition and permeability, both laterally and vertically, producing artesian and perched conditions (Crosby, Hopkins, Lindvig, oral communications, 1977). Observation well levels vary from flowing at ground surface to several hundred feet deep over relatively small areas. Little net gain or loss has occurred in water levels over the region in this century (Crosby, Hopkins, oral communications, 1977).

U.S. Soil Conservation Service surveys of South Dakota's Davison, Hand, Hughes, and Sully counties, and North Dakota's Renville and Wells counties, note numerous soil units with seasonally high water tables of less than five feet below ground surface. The hundreds of small natural lakes forming exclusion areas on the Missouri Plateau suggest a high water table in that section (W. S. Eisenlohr, 1972; C. E. Sloan, 1970, 1972).

Shallow ground water occurs over much of the glaciated portion of the Dakotas, and may be present within the CSP, but hydrologic generalizations over large areas in glacial drift are not reliable without supporting investigations.

10.3.3 TERRAIN CONDITIONS

Terrain conditions in the Dakotas CSP are characterized by nearly flat to irregularly rolling landforms of glacial drift and morainal remnants with a generally low drainage density.

Dead-ice moraines occupy the highland (Coteau du Missouri) region with elevations ranging from 1600 to 2200 feet and local relief up to 50 feet. Topographically they are a disordered succession of knobs and kettles, with ponds or swamps in many of the depressions. The Coteau Slope maintains an approximate gradient of 50 feet per nm (less than one percent slope) to the west and southwest off the flanks of the highlands. The Missouri Escarpment is a relatively smooth bedrock surface mantled with a thin veneer of drift material that slopes to the northeast and east at 100 feet per nm (two percent slope).

The morainal plains of the Western Lake section are relatively flat to slightly rolling, with numerous areas of pronounced glacial landforms such as eskers, kames and end moraines (U.S. Geological Survey, 1973; Hedges, 1968). Elevations in this lowland area range from 1000 to 1600 feet. The Souris Lake deposits, northeast of Minot in North Dakota, provide the flattest area in the CSP. Dune fields to the south of the lake plain, however, have 50 to 75 feet of relief and are mobile during periods of drought (Bluemle, 1977).

10.3.4 CULTURAL CONDITIONS

10.3.4.1 Demography

Population density in the Dakotas CSP is dispersed, centered mainly in towns of less than 1000 inhabitants and as individual farms. Cities with populations greater than 25,000 are Bismarck and Minot, North Dakota, both directly adjacent to suitable areas.

The density of cultural improvements such as major roads, railroads, aqueducts, and oil and gas pipelines, is relatively low. Existing military support facilities near the CSP consist of Minot Air Force Base, seven nautical miles from the suitable area north of Minot, North Dakota.

10.3.4.2 Land Use

The primary industry within the Dakotas CSP is agriculture, based on both livestock and grain crop farming. Land ownership is almost entirely private, with only a small percentage withheld for state school lands.

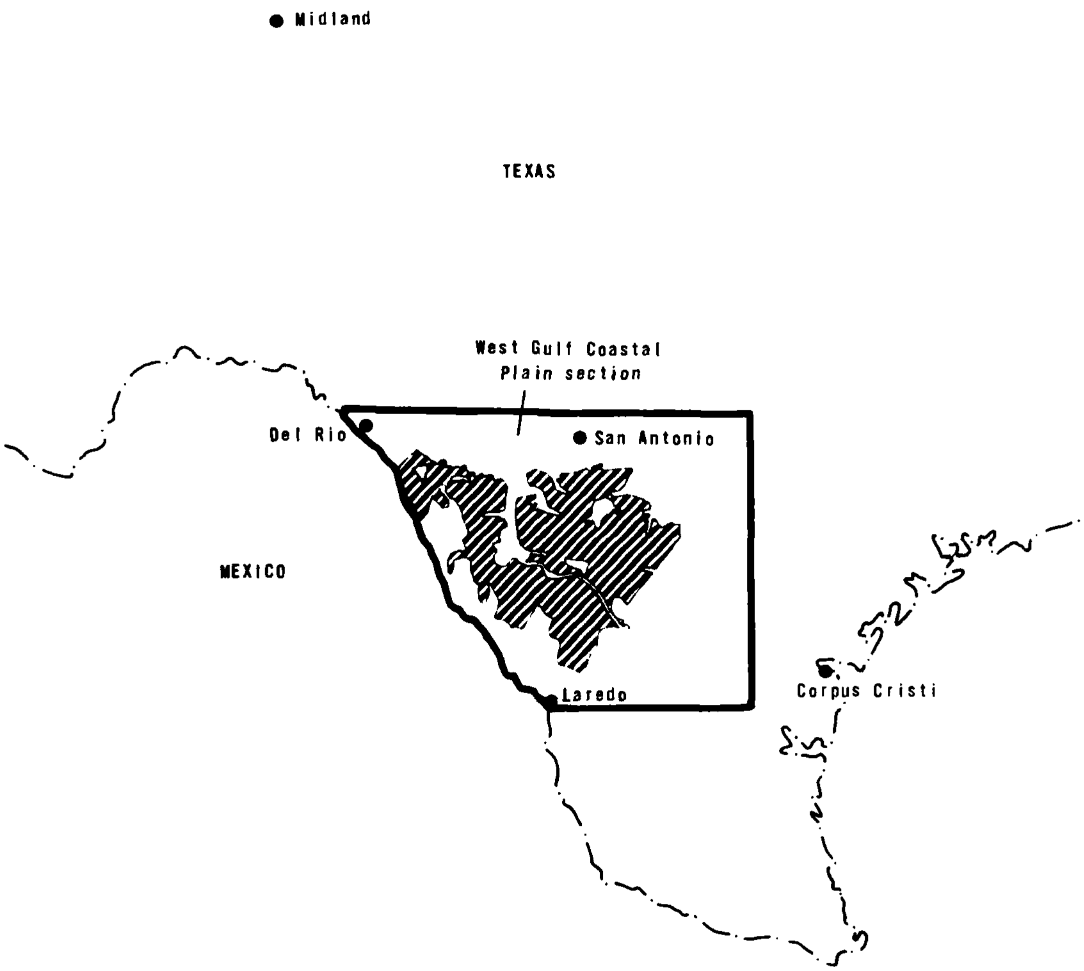
10.3.4.3 Economic Base

Lignite coal and petroleum resources, located primarily north and east of Minot, North Dakota, are the most important non-agricultural economic considerations in the Dakotas CSP (Brandt, 1953; U. S. Geol. Survey, 1975). Low potential resources of the area include sand and gravel, clay and uranium (Osterwald and Dean 1957; Schroeder, 1976a, 1976b). Hot water aquifers and high geothermal gradients exist under most of the suitable area in South Dakota (Schoon and McGregor, 1974; U. S. Geol. Survey, 1975), but no plan for their large-scale use is presently being considered (Gunderson, oral communication, 1977).

11.0 COASTAL PLAIN CSP

11.1 GENERAL SETTING

The Coastal Plain CSP contains approximately 4110 nm^2 of suitable area located in south-central Texas between the towns of Del Rio and Laredo (Figure 11); the entire CSP consists of excavatable rock. Suitable area lies entirely within the West Gulf Coastal Plain section of the Coastal Plain physiographic province (Fenneman, 1931) and is characterized by a relatively flat plain with terraces and low cuestas trending parallel to the strike of the underlying formations. The suitable area is encompassed within a single, nearly contiguous parcel, transected by the Nueces River in a north to northwesterly direction. The suitable area boundaries are defined primarily by topographic, rock and cultural conditions (Appendix C).



▨ SUITABLE ROCK

COASTAL PLAIN
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
11

FUGRO NATIONAL, INC.

11.2 SUMMARY OF RESULTS

1. The Coastal Plain CSP comprises approximately 4110 nm^2 of an excavatable rock sequence composed of Tertiary and Cretaceous sedimentary formations.
2. Thin deposits of unconsolidated terrace gravels and stream alluvium occupy modern drainages and flood plains.
3. The Leona, Nueces and Frio rivers are the main perennial streams in the CSP, running northwest to southeast through suitable area.
4. Ground water occurs under unconfined and artesian conditions at depths greater than 50 feet. The major aquifers are the Carrizo Sand and Leona Formation.
5. Terrain conditions are characterized by a broad, flat plain with low terraces and cuestas striking parallel to the underlying formations. Maximum elevations range from 1000 feet in the northwest to a low of 500 feet in the southeast, with local relief of approximately 50 feet not uncommon.
6. Population density is low with the majority of the people living in scattered agrarian communities. Logistical support may be provided by Air Force bases located within 20 to 25 nm of suitable area.
7. Nearly all suitable land identified is privately owned. Land use is primarily mixed farming and grazing.
8. Non-agricultural resources occurring within the CSP consist of small, scattered oil and gas fields.

11.3 CHARACTERISTICS OF SUITABLE AREA

11.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Surficial deposits in the Coastal Plain CSP are composed primarily of a series of excavatable Tertiary and Cretaceous sedimentary formations which lie in bands roughly parallel to the Gulf of Mexico coastline. These units are oldest in the Texas interior, becoming younger towards the southeast.

Younger, unconsolidated deposits occur as Tertiary terrace gravels which cap most hills and ridges within the CSP, and Quaternary alluvium consisting of sand, gravel and silt which occurs as valley fill along all major drainages (Turner and others, 1960). These deposits are relatively thin to nonexistent over suitable area but may be as thick as 50 feet within flood plains (Alexander and White, 1966).

The Tertiary-Cretaceous sequence composing the excavatable rock is predominately indurated sandstone and clay, interbedded with sand, shale, limestone and lenses of gravel (Groat, 1976; Mason, 1960). The fourteen formations that comprise this suite of rocks were determined to be excavatable on the basis of a recent study by the Texas Bureau of Economic Geology (1977) that was initiated to evaluate this specific parameter. Three major formations comprising approximately 75 percent of the excavatable rock area are the Yequa Formation, Laredo Formation and El Pico Clay. These formations each range in thickness from 400 to over 1000 feet thick (Groat, 1976).

Undoubtedly, well indurated members are present within each suitable formation, however, each unit was evaluated on the basis of the predominant materials and the areal extent of that unit.

11.3.2 HYDROLOGIC CONDITIONS

11.3.2.1 Surface Hydrology

Drainages within the suitable area generally trend in a southeasterly direction, down the regional dip, at a rate of 30 to 50 feet per nm. Drainage is primarily handled by ephemeral streams during severe seasonal thunderstorms. Perennial streams are limited to the Leona, Nueces and Frio rivers. Drainage density and degree of dissection appear to increase toward the south and are greatest near Laredo, Texas.

11.3.2.2 Ground-Water Hydrology

Ground water is generally defined at depths greater than 50 feet within the principal aquifers of the Carrizo Sand and Leona Formation of Tertiary and Quaternary age, respectively. The water table is under both unconfined and artesian conditions. Generally, in areas where the water-bearing formations crop out, the water table will be unconfined; down dip of these areas, the water table may be confined and under artesian pressure (Follett, 1974; Alexander and White, 1966; Mason, 1960). Areas of shallow ground water may exist locally throughout the CSP but are difficult to ascertain due to artesian condition (Ratzlaff, Baker, oral communications, 1977).

Extensive irrigation has resulted in large declines in the water-table since the 1920's. Water level declines in areas of aquifer outcrops (unconfined conditions), have averaged about one foot per year. In the artesian areas, water levels declined as much as 230 feet prior to 1957 (Mason, 1960).

Recharge of the principal aquifers is by infiltration of runoff following seasonal thunderstorms, however, most run off is eventually lost by evapotranspiration (Mason, 1960; Turner and others, 1960).

11.3.3 TERRAIN CONDITIONS

Terrain conditions in the Coastal Plain CSP are best characterized by a broad, relatively flat plain, sloping gently toward the southeast. Local relief is on the order of 50 feet with a maximum elevation of 1000 feet in the northwestern portion of the CSP to an elevation of 500 feet in the southeast. This translates into a regional gradient of approximately 30 to 50 feet per nm (less than one percent) southeastward.

Landforms in the suitable area consist of two main terraces: one forming high narrow divides with relief on the order of 60 feet; and a lower, broader terrace. Between these two terraces are gentle cuestas formed by the outcropping of resistant beds of the Leona Formation which generally dip to the east and southeast at approximately 60 feet per nm (Turner and others, 1960). Present relief has resulted from degradation by the Nueces, Frio and Leona rivers and their tributaries (Mason, 1960).

11.3.4 CULTURAL CONDITIONS

11.3.4.1 Demography

Population densities within the CSP are relatively low, consisting predominately of small agrarian communities situated along major road and railroad arteries. Two cities of greater than 25,000 population are Laredo and Del Rio to the south and northwest of suitable area, respectively (Figure 11). Towns of between 5000 and 25,000 people are Crystal City, Carrizo Springs, Eagle Pass, and Pearsall. Smaller towns of less than 5000 people are scattered throughout the CSP.

Existing military support facilities for the CSP include the Laredo Air Force Base located approximately 20 nm south of the suitable area, and Lackland and Kelly Air Force bases located adjacent to San Antonio, about 25 nm north of the suitable area.

11.3.4.2 Land Use

Agriculture constitutes the principal land use in the Coastal Plain CSP. This area is one of the principal sources of winter vegetables in the United States. Farming generally predominates on the flatter expanses of the CSP, while slightly rolling topography is used for cattle grazing.

Land ownership is almost entirely private in the CSP. One section per township is held for school land by the State of Texas.

11.3.4.3 Economic Base

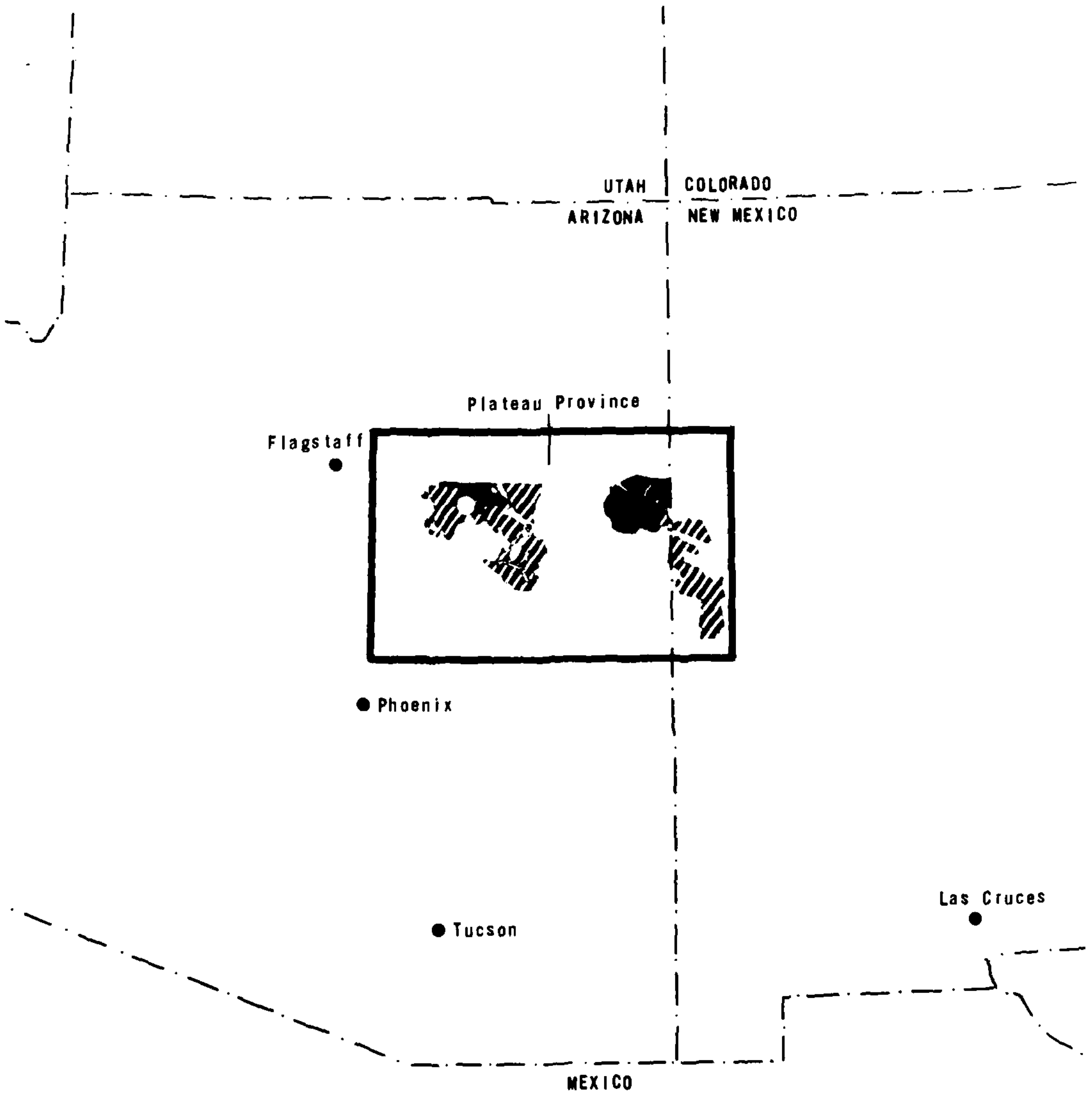
Non-agricultural resources occurring within or adjacent to the Coastal Plain CSP include numerous petroleum and natural gas fields, lignite coal and uranium. Oil and gas is being actively produced within suitable area; bituminous coal is being mined from upper Cretaceous strata near the town of Eagle Pass, and uranium is being exploited to the east of the CSP from Tertiary formations (St. Clair and others, 1976). A potential lignite occurrence is located adjacent to the CSP in a belt trending northeast along the Coastal Plain. No lignite is currently being mined within the CSP.

12.0 PLATEAU CSP

12.1 GENERAL SETTING

The Plateau CSP consists of approximately 1890 nm^2 of suitable area in parts of east-central Arizona and west-central New Mexico (Figure 12). All of the suitable area lies within the Colorado Plateau physiographic province (Fenneman, 1931), a region characterized by high (mostly over 5,000 feet in elevation) relatively flat plateaus and broad mesas founded upon essentially horizontally-bedded rocks. These plateaus are often separated from one another by steep scarps or canyons (Fenneman, 1931).

Suitable area in the CSP is divided into four irregularly shaped parcels that range in size from 175 to 800 nm^2; parcel boundaries are defined by topographic and cultural exclusions. Suitable area forms a narrow, discontinuous belt extending from eastern Coconino County in Arizona to Valencia and Catron counties in western New Mexico. Nearly 75 percent of the suitable area consists of excavatable rock that occur predominately in the western and southeastern portions of the CSP.



■ SUITABLE

▨ SUITABLE ROCK

PLATEAU
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
12

FUGRO NATIONAL, INC.

12.2 SUMMARY OF RESULTS

1. The Plateau CSP consists of 1890 nm^2 of suitable area in the Colorado Plateau physiographic province in Arizona and New Mexico, a region characterized by relatively flat plateaus at high elevation.
2. Approximately 75 percent of the suitable area consists of excavatable rock; the remaining area is covered by unconsolidated surficial deposits of variable thickness.
3. Little surface water occurs in the Plateau CSP; the Little Colorado River is the only perennial drainage.
4. Ground water is found mainly in the Bidahochi Formation and in alluvial deposits. Water table is deeper than 100 feet in most places.
5. Relief is low throughout the CSP. Terrain is generally flat with low to moderate stream dissection.
6. The Plateau CSP is a sparsely populated region. No town over 25,000 population occurs within the CSP.
7. Nearly all the land in the CSP is used for grazing; suitable area is almost equally divided between Federal and private ownership.
8. No important high-potential resources are located within suitable areas.

12.3 CHARACTERISTICS OF SUITABLE AREA

12.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Much of the Plateau CSP consists of relatively flat-lying excavatable rock either at the surface or buried at shallow depths by a veneer (less than 150 feet) of alluvial material. The excavatable rock units, from youngest to oldest, include the Bidahochi Formation (Pliocene), the Baca Formation (Paleocene), the Mancos Shale (Upper Cretaceous), and the Chinle Formation (Upper Triassic).

The Bidahochi Formation, which comprises approximately 25 percent of the suitable area, consists of 500 to 1000 feet of sandstone, tuff, bentonite, and mudstone of fluvial and lacustrine origin. Some interbedded basalt flows have been reported in the Bidahoci Formation, but their precise locations have not been fully documented (New Mexico Geological Society, 1959).

Nearly 10 percent of the suitable area is underlain by the Baca Formation which is exposed only in New Mexico. The Baca Formation consists of less than one foot to 700 feet of interbedded arkosic sandstone, sandy siltstone, and conglomerate, and is largely of terrestrial origin (New Mexico Geological Society, 1959).

The Mancos Shale is exposed only in New Mexico, and underlies about 10 percent of the suitable area. It consists of approximately 300 feet of fossiliferous marine mudstone and siltstone (New Mexico Geological Society, 1959).

The underlying Chinle Formation comprises about 35 percent of the suitable area, mostly in Arizona. It is composed of clay shale and clayey sandstone with minor limestone. The sediments of the Chinle are largely of fluvial origin, reaching a thickness of 1500 feet east of Holbrook, Arizona (Wilson, 1962).

Deposits of unconsolidated sand, silt, gravel, and clay occur in many areas of the Plateau CSP. These deposits consist of eolian sheet and dune sands mantling excavatable rock, and alluvial sediments along stream channels (Fenneman, 1931). The eolian sands are most widespread in Apache County, Arizona, near the New Mexico border. Thicknesses range from zero to 150 feet, and are quite variable (Mann, 1976). Stream-deposited alluvium consisting of silt, sand, gravel and clay occupies low areas along stream drainages. These deposits are especially widespread along the Little Colorado River and its major tributaries. Thicknesses of alluvial sediments are variable but seldom exceed 150 feet (Mann, 1976, 1977).

12.3.2 HYDROLOGIC CONDITIONS

12.3.2.1 Surface Hydrology

The Little Colorado River, the only perennial stream in the CSP, cuts diagonally across northeastern Arizona and drains into the Grand Canyon. Most of the CSP is drained by scattered ephemeral streams which flow into the Little Colorado River during seasonal rains. Flash flooding may occur locally during these periods of heavy rainfall. There are no natural perennial lakes in the Plateau CSP.

12.3.2.2 Ground-Water Hydrology

Much of the water used in the Plateau CSP is obtained from deep aquifers hundreds of feet below the surface. The Coconino aquifer, composed of the upper member of the Supai Formation, the Coconino Sandstone, and the Kaibab Limestone (all Permian in age), are the main sources of ground water. Much of the Coconino aquifer is unconfined and water occurs at depths of over 600 feet. Areas of artesian conditions do exist, however, especially in southeastern Navajo County, Arizona, where an artesian head of up to 500 feet brings static water levels near the ground surface in the vicinity of the Little Colorado River. In most areas, however, the piezometric surface is more than 100 feet deep (Mann, 1976).

The most important near-surface aquifers are the Bidahochi Formation and alluvial deposits. Water table in the Bidahochi Formation is unconfined, and occurs at depths generally ranging from 50 to 700 feet beneath the ground surface (Mann, 1976). Ground water within some of the thicker alluvial deposits is usually present where percolating water is restricted by underlying permeable beds. The Moenkopi Formation, a mudstone unit not exposed in suitable area, is the confining unit in many areas (Mann, 1976).

Occurrences of naturally flowing springs or perched water are not common in the Plateau CSP; artesian conditions occur locally in the deeper aquifers but are uncommon in the Bidahochi Formation (Harper and Anderson, 1976; Mann, 1977). Static ground water levels are stable in most areas due to the low level of water usage.

12.3.3 TERRAIN CONDITIONS

Suitable area in the Plateau CSP consists mostly of a level plateau surface formed by relatively flat-lying sedimentary rocks. Major drainages have cut canyons into the plateau surface; these deeply dissected areas are excluded by their steep topography, but separate the suitable area into several parcels. Within the parcels, the plateau surface has little relief; the greatest being along stream channels where it is seldom more than a few tens of feet. Elevations increase gradually from about 4800 feet in the west to about 7700 feet in the east, resulting in a regional gradient of 19 feet per nm (0.3 percent grade). The plateau surfaces have undergone slight to moderate dissection by ephemeral streams. Drainage incision reaches a maximum of 100 feet along localized reaches of tributaries adjacent to deep canyons in the extreme eastern part of the CSP. Slopes exceed five percent in most dissected areas.

12.3.4 CULTURAL CONDITIONS

12.3.4.1 Demography

The Plateau CSP is a very sparsely populated region. Flagstaff, Arizona, 25 nm to the west, is the only nearby city with over 25,000 residents. Smaller towns include Winslow and Holbrook, Arizona, both adjacent to the suitable area. Flagstaff, Winslow and Holbrook all lie along the route of Interstate 40 and the main line of the Santa Fe Railroad, the two most important transportation arteries in the region. A few other state and federal-paved highways serve the CSP, but much of the area is remote and not served by improved roads.

Existing military installations in or adjacent to the CSP are:

1. Navajo Army Depot, Flagstaff, Arizona;
2. Fort Wingate Army Depot, Gallup, New Mexico.

12.3.4.2 Land Use

Most of the land in the Plateau CSP is used for grazing. In Arizona, about 70 percent (950 nm^2) of the suitable area within the CSP is privately-owned, while in New Mexico only about 10 percent (50 nm^2) is private. BLM lands make up the remainder of the area.

12.3.4.3 Economic Base

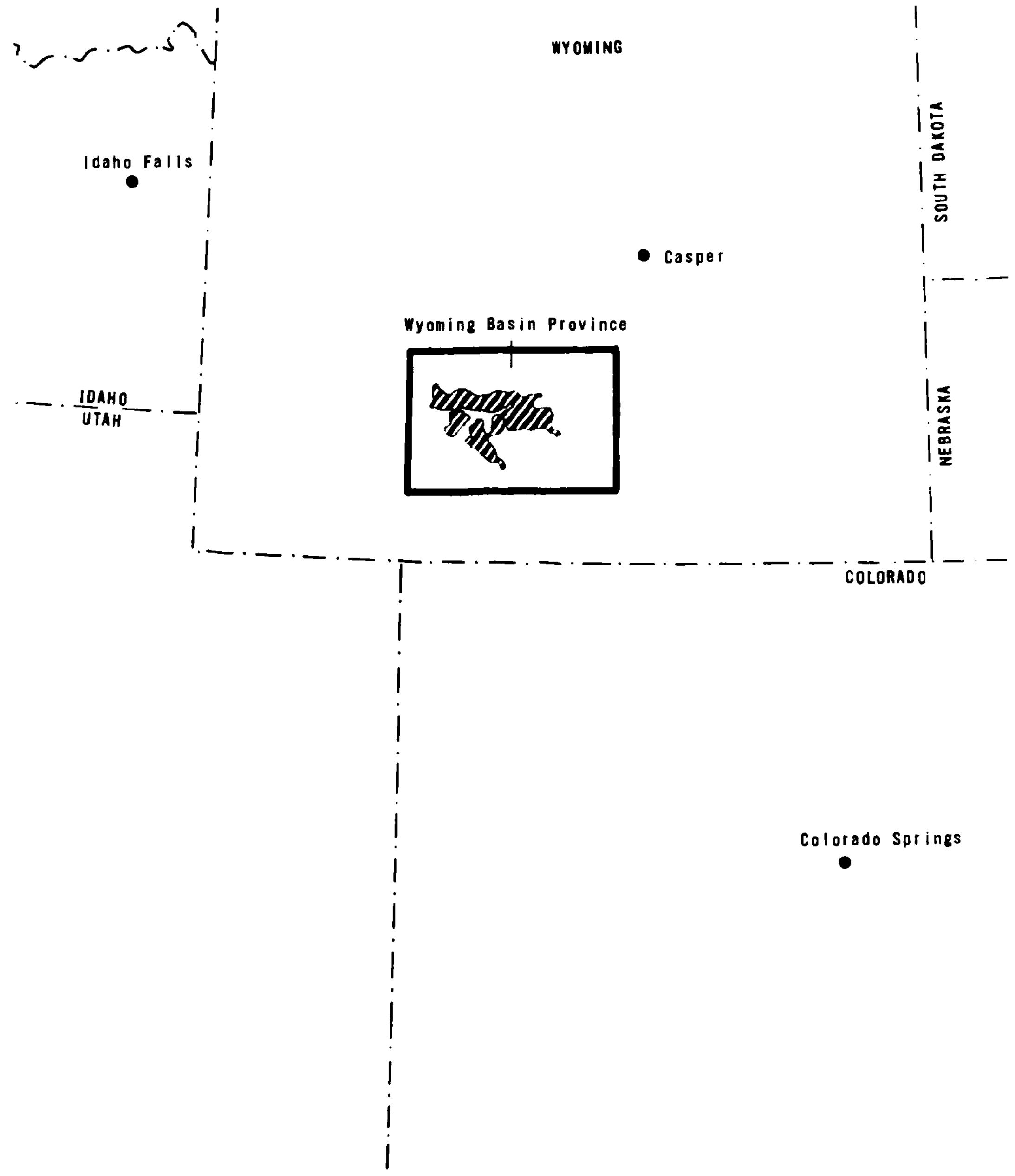
Cattle ranching provides the main economic base for much of the Plateau CSP. Few mineral resources are being exploited within the CSP, but large coal reserves occur to the north in the low-grade deposits of the Gallup-Zuni field. Numerous low-potential uranium prospects also dot the Plateau CSP, but none are known to have been developed. Salt is the only mineral presently mined within the CSP area, at Salt Lake in New Mexico (New Mexico Geological Society, 1959).

13.0 WYOMING BASIN CSP

13.1 GENERAL SETTING

The Wyoming Basin CSP encompasses approximately 680 nm^2 of suitable area in south central Wyoming (Figure 13); the entire CSP consists of excavatable rock. Suitable area of the CSP is confined to the Great Divide section of the Wyoming Basin physiographic province (Fenneman, 1931) and is characterized by generally flat-lying Tertiary sedimentary formations overlain by varied thicknesses of unconsolidated to moderately consolidated surficial deposits to 50 feet thick.

Suitable area lies entirely within a single irregularly shaped parcel primarily defined by rock, water, and topographic exclusions.



WYOMING BASIN
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
13

FUGRO NATIONAL, INC.

13.2 SUMMARY OF RESULTS

1. The Wyoming Basin CSP consists of a single 680 nm^2 parcel of suitable excavatable rock overlain by a discontinuous veneer of unconsolidated to moderately consolidated surficial deposits; the rock consists of excavatable Tertiary sedimentary formations.
2. Approximately 30 percent of the area is overlain by easily excavatable surficial deposits consisting of 30 to 50 feet of lacustrine clay, silt, and sand; stable to semi-stable dune sand, and flood-plain deposits of sand, gravel, and silt.
3. Underlying the surficial deposits, and exposed over 70 percent of the area is an interfingering sequence of Middle Eocene formations consisting of shale and sandstone interbedded with minor claystone, siltstone, limestone, and conglomerate. Most of the units are thought to be rippable with local exceptions in areas of well indurated sandstone and conglomerate units.
4. The CSP is characterized by internal drainage where secondary ephemeral tributaries drain to several low playas. Drainage density rarely exceeds two per nautical mile.
5. Ground water is found at various depths below ground surface usually ranging between 150 and 300 feet.
6. Elevations within the CSP range between 6500 to 7500 feet. Maximum surface gradients do not exceed one percent. Relief of five to 20 feet is encountered along incised drainages.

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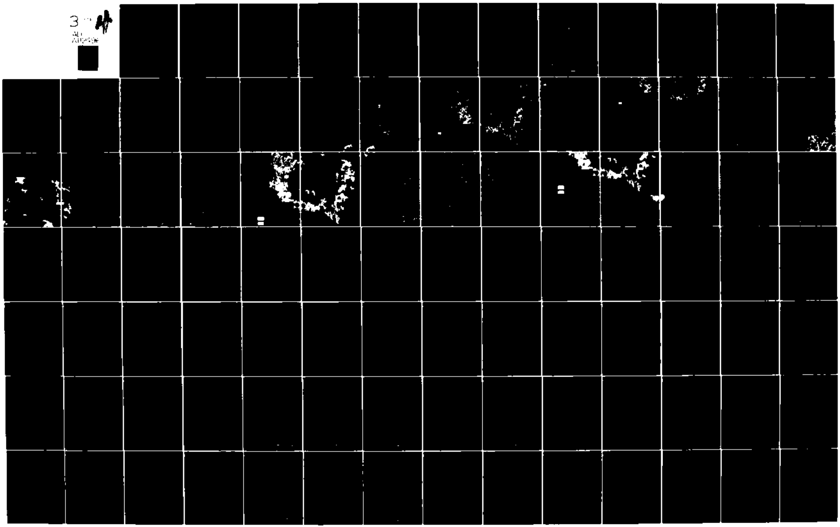

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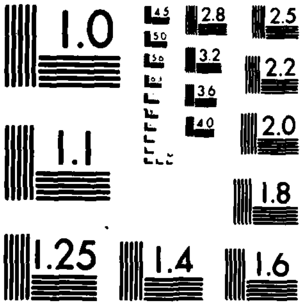


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963 A

7. Casper and Rock Springs, Wyoming, lie within 150 nm and 50 nm, respectively, of suitable area. Only a few scattered farms and ranches are located in the CSP, which is 90 percent federally owned.
8. The closest existing military facility is 220 nm to the east near Cheyenne, Wyoming.

13.3 CHARACTERISTICS OF SUITABLE AREA

13.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Surficial geology in the Wyoming Basin CSP is dominated by nearly horizontal strata of three interfingering Middle Eocene formations. Approximately 30 percent of the area is covered by nearly equal portions of Late Pleistocene to Holocene lacustrine, fluvial and wind-blown sand deposits.

Late Pleistocene to Holocene lacustrine deposits are present primarily in the southern and southeastern portions of the CSP, generally occupying the topographically lowest portions of the area. They consist of clay, silt and fine sand and are less than 50 feet thick. Stable to semi-stable sand dune deposits overlie or border the lacustrine deposits and consist of well-sorted quartz sand that reaches a maximum thickness of 30 feet (Root and others, 1973).

Stream channel and floodplain deposits form the remaining portions of surficial deposits in the CSP. They consist of unconsolidated to poorly consolidated sand, gravel and silt and are less than 50 feet thick. These deposits are found primarily in the northwestern and central portions of the CSP and are associated with primary or secondary ephemeral drainages in the area. All of the surficial deposits should be easily excavatable (Root and others, 1973).

The Green River and Battle Springs formations interfinger with and overlie the Wasatch Formation in the CSP. Surface exposures of these Eocene formations form the remaining 70 percent of suitable area within the CSP as well as underlying all the surficial deposits. The Battle Springs Formation is the most areally extensive of these formations cropping out in the central and northeastern portions of the CSP. It consists of poorly to moderately indurated sandstone, variegated claystone and shale that attains thicknesses of nearly 2800 feet in the eastern portions of the CSP.

The Tipton Shale Member of the Green River Formation crops out in the central portions of the CSP. It consists of siltstone and oil shale that range in thickness from 200 to 500 feet.

Oldest of the Eocene strata, the Wasatch Formation crops out in the western and central portions of the CSP and underlies the surficial deposits as well as the Green River and Battle Springs formations in the CSP. It consists of variegated claystone and shale with interbeds of moderately indurated sandstone and conglomerate. The Eocene formations within the CSP are thought to be rippable with the exception of the more indurated sandstone and conglomerate units (Root and others, 1973).

13.3.2 HYDROLOGIC CONDITIONS

13.3.2.1 Surface Hydrology

All surface drainage within the Wyoming Basin CSP is internal, characterized by ephemeral streams draining to central lowland areas or playas. Ephemeral drainages generally flow to the southeast in the western portions of the CSP and to the southwest in the eastern portions with average stream gradients of approximately 10 to 15 feet per nm. Density of these intermittent streams rarely exceeds two per nm. Flash flooding is not expected to pose a serious problem in most of the CSP, however, intense periods of rainfall may periodically inundate playa areas.

13.3.2.2 Ground-Water Hydrology

Ground-water depths in the area are only generally reported. Any significant occurrences of ground water are expected to be restricted to the permeable members of the Wasatch, Battle Springs and Green River formations. Water-bearing units of these formations are under moderate artesian pressures and generally lie at depths of 150 to 300 feet (Welder, 1968; Welder and McGreevey, 1966; Root and others, 1973).

Occurrences of perched ground water have not been documented but may be expected, at least locally in most units in the area.

13.3.3 TERRAIN CONDITIONS

Terrain conditions within the Wyoming Basin CSP are best characterized by a mildly undulating plain comprised of small basins, flats and playas.

Maximum elevations of approximately 7500 feet occur in the northeast portion of suitable area while the minimum elevation of approximately 6500 feet occurs some 15 nm to the south. The gradient within the area of maximum relief approaches one percent but rarely exceeds 0.1 percent throughout the rest of the CSP.

The basin floor ranges from moderately to highly dissected (five to 20-foot depths) with major channels occurring at intervals of approximately one-half nm. Numerous small gullies less than five feet deep occur at 300 to 500-foot spacings.

13.3.4 CULTURAL CONDITIONS

13.3.4.1 Demography

Cultural improvements within the Wyoming Basin are very limited. Several improved dirt roads and two reservoirs are contained within the CSP, but, except for scattered ranches and farms, there are no settlements. Casper, Wyoming, a city of over 40,000 inhabitants, is approximately 150 nm from the nearest suitable parcel by road while Rock Springs with a population exceeding 11,000, is within 50 nm. Existing military facilities consist of Warren Air Force Base, 220 nm to the east in Cheyenne, Wyoming.

13.3.4.2 Land Use

Approximately 90 percent of the Wyoming Basin CSP is federally-controlled public land. The remaining ten percent is about equally divided between state and private land. A small portion of the private land is used for ranching and some of the federal land may be open for grazing (Root and others, 1973).

13.3.4.3 Economic Base

The entire CSP is underlain at various depths by coal-bearing strata of the Wasatch Formation. Most of this coal is subbituminous in grade and of high sulfur content. Some of the deeper beds are known to be as thick as 42 feet and contain as much as 0.051 percent uranium. Overburden thickness generally ranges between 1500 and 3000 feet which puts it well beyond the present economic limits of either strip or deep mining (Root and others, 1973).

Uranium in very low concentrations is widespread throughout the eastern half of the CSP. Some uranium ore was extracted from the Wasatch Formation in the early 1950's but these small scale operations are no longer active. Higher concentrations of uranium have recently been discovered in the sands and conglomerates of the Battle Springs Formation. It seems probable that major production may be undertaken in these areas within the next few years (Root and others, 1973).

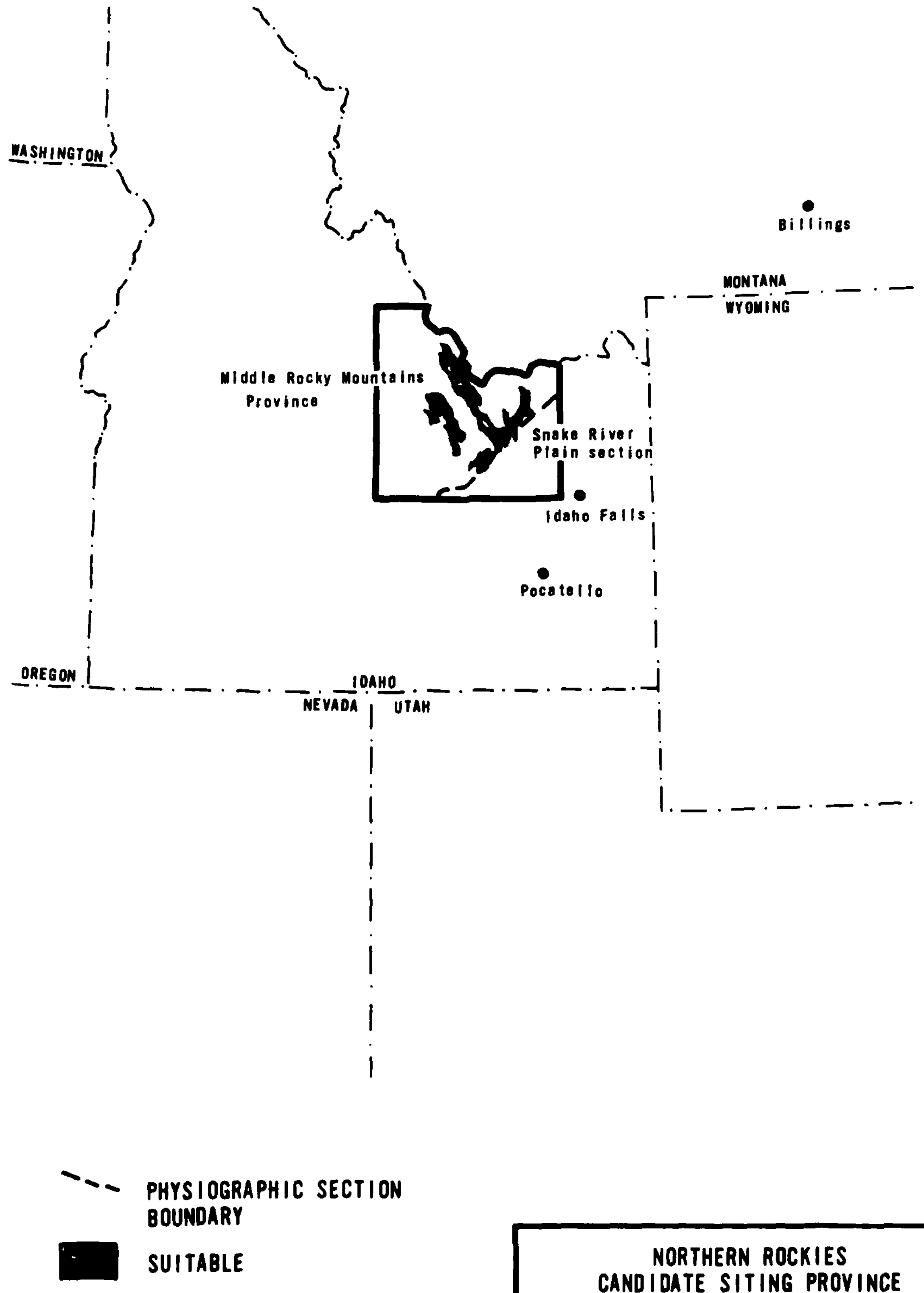
14.0 NORTHERN ROCKIES CSP

14.1 GENERAL SETTING

The Northern Rockies CSP encompasses approximately 820 nm^2 of suitable area in a sparsely populated area of northeastern Idaho (Figure 14). Distribution of suitable area within the CSP corresponds to small portions of the Rocky Mountains and Snake River Plain physiographic provinces (Fenneman, 1931).

Suitable area within the Rocky Mountain province is confined to Birch Creek and Little Lost River valleys (to which geographical references will be made) with a combined total area of approximately 500 nm^2. Both are generally northwest trending valleys that are characterized by broad low relief river basins bounded by abruptly rising mountains.

Suitable area within the Snake River Plain province totals 320 nm^2 and is defined by the alluvial plain of the Snake River. This area is characterized by alluvial fan, stream and lake deposits, overlying fractured basalts of the Snake River Basalt Group.



NORTHERN ROCKIES
CANDIDATE SITING PROVINCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
14

FUGRO NATIONAL, INC.

14.2 SUMMARY OF RESULTS

1. Suitable area in the Northern Rockies CSP totals 820 nm^2 of contiguous area.
2. Holocene to Plio-Pleistocene alluvium is exposed over more than 95 percent of the suitable area. Holocene deposits of sand, gravel, silt, and clay overlie more consolidated and cemented older basin-fill deposits in Little Lost River and Birch Creek valleys, and fractured basalt on the Snake River Plain.
3. Volcanic tuff and tuffaceous sediments crop out in the northern part of Birch Creek Valley but encompass less than five percent of the total suitable area.
4. Perennial streams with intermittant tributaries within Little Lost River and Birch Creek Valleys drain to the Snake River Plain. There, nearly all surface water infiltrates highly permeable "sink" areas.
5. Ground-water depths usually exceed 50 feet in the mountain valleys and are 200 feet deep or greater on the Snake River Plain.
6. Terrain conditions in the Birch Creek and Little Lost River Valleys are characterized by northwest-southeast trending alluvial valleys, with gently sloping flanks (from two to five percent) comprised of coalescing alluvial fans. Valley floors range in elevation from 5000 to 7000 feet with local relief of approximately ten to 30 feet. The Snake River Plain has very low relief except for "sink" areas which are gentle depressions of tens of feet over three to four miles.

7. Population density is low throughout the suitable area. The nearest large concentrations of population are Idaho Falls and Pocatello (both approximately 40,000), situated approximately 30 nm to the southeast of suitable area.
8. More than 60 percent of the land area is controlled by the BLM; it is primarily used for livestock grazing by a sparse, rural population.
9. No major military installation exist in or very near this area.

14.3 CHARACTERISTICS OF SUITABLE AREA

14.3.1 DISTRIBUTION AND CHARACTERISTICS OF SURFICIAL MATERIALS

Surface materials in the Northern Rockies CSP are composed of Holocene and "older," Plio-Pleistocene (?) alluvium deposited primarily as alluvial fans, and stream alluvium with minor flood-plain and lake deposits (Ross, 1961). The source material is derived from the mountainous bedrock areas adjacent the Birch Creek and Little Lost River valleys and the Snake River Plain, and is composed of water-washed silt, sand, and gravel (Ross, 1961). Grain size generally decreases away from the mountain fronts bordering both the mountain valleys and the Snake River Plain. Finer grained sand, silt, and clay have been deposited in lakes and small depressions on the basalt that covers the Snake River Plain, accumulating in thicknesses ranging up to 150 feet within suitable parcels (Nace, and others, 1957; Stearns and others, 1939).

Older Plio-Pleistocene (?) alluvium crops out in bands which are topographically highest in the alluvial sequence, situated directly adjacent to the mountain ranges bordering both the valley basins and the Snake River Plain. These deposits are lithologically similar to the actively aggrading fans presently forming along the valley flanks, however the sediments are slighly more indurated by calcareous cementation and have been observed tilted up to 40 degrees (Ross, 1961). These outcrops are truncated by, or overlain by Holocene fan deposits over most of the suitable area.

The entire alluvial sequence as described by Ross (1961), is determined to be rippable. Considerations which may affect the overall excavatability of this sequence are the presence of moderately consolidated tuffs and tuffaceous sediments as exposed within Birch Creek Valley, localized areas of calcareous cementation, and the presence of boulders up to three feet in diameter along the topographically higher portions of the fans (Ross, 1961).

14.3.2 HYDROLOGIC CONDITIONS

14.3.2.1 Surface Hydrology

Drainage within the Northern Rockies CSP is characterized by open drainage basins with dendritic drainage patterns, the major trunk streams of which connect Birch Creek and Little Lost River Valleys with the Snake River Plain. Trunk streams within Birch Creek Valley drain to the northeast and southwest while the Little Lost River Valley drains only to the southeast. Many intermittent creeks flow from the surrounding mountains toward the valley axes. Some flow perennially in the upper reaches, but few reach the valley floors except during periods of high runoff.

At least four perennial streams intermittently supported by the water table, flow from adjacent mountain valleys out onto the Snake River Plain. These streams all disappear rapidly through permeable channels and underlying fractures in the basalt, locally called "sinks" (Robertson and others, 1974). These "lost" streams include Little Lost River, Big Lost River, Birch

Creek, and Medicine Lodge Creek, each having its respective sink area. Even though surface water disappears rapidly through the sinks, scattered small marshes (less than one per nm^2) do persist in these local areas (U.S. Geol. Survey, 1969).

14.3.2.2 Ground-Water Hydrology

Intermittent influent tributaries feed the ground-water table within the alluvial fans of Birch Creek and Little Lost Creek valleys. The water table in these areas may be 300 feet or greater beneath the surface (Clebsch and others, 1974).

The perennial streams flowing out onto the Snake River Plain feed the relatively deep water table of that area. Water percolates through the porous surface sediments, down through highly permeable joints and fractures in the underlying basalt. The water table surface generally ranges from 200 feet near "sinks," to greater than 900 feet (Robertson, and others, 1974).

Ground-water conditions within the Northern Rockies CSP are generally unaltered, resulting from the poorly to undeveloped nature of the region. Increasing local demands for irrigation water may lower the water table surface in the future (Gomm, oral communication, 1977).

14.3.3 TERRAIN CONDITIONS

Local mountains surrounding the CSP range from 9000 to 11,000 feet in elevation. Valley floors drain from approximately 7000 feet to 5000 feet on the Snake River Plain. Birch Creek and Little Lost Creek Valleys are characterized by broad alluvial valleys trending northwest-southeast, the floors of which usually have gentle slopes (less than two percent) toward the Snake River.

Large coalescing alluvial fans are the predominant landforms within this CSP. They originate in the mountains bordering both the open plain and the valley basins and have slopes generally ranging from two to five percent. The valleys are thought to be fault controlled on the eastern sides (Clebsch, and others, 1974); the eastern slopes of the mountains are generally steeper than those on the west.

Where drainages emerge from the mountains on the western slopes, they break up into distributary channels, many of which become ill defined in a relatively short distance. Some cannot be traced continuously even as far as the outer borders of the fans. However, the steeper eastern mountain slopes are more deeply incised (ten to 30 feet) by streams with channels that are well marked far out onto the valley floors. Drainage densities for both east and west flanks generally average two per nm.

The Snake River Plain has very low relief, except for "sink" areas which are gentle depressions of several tens of feet deep over three or four nautical miles.

Part of the Little Lost River Valley is bordered by a fairly well defined and continuous set of flat to moderately dissected terraces. However, some of the streams that emerge from the mountains have deposited small fans on top of them (Ross, 1961).

14.3.4 CULTURAL CONDITIONS

14.3.4.1 Demography

The portion of Idaho containing the Northern Rockies CSP is a sparsely populated predominantly rural area. Local small towns with populations less than 300 are distributed within and around the Northern Rockies CSP. The largest town within ten nm is Arco which has a population of approximately 1200, bringing the total local population to less than 3000 within a radius of approximately 25 nm. The major cities nearest the area are concentrated along the Snake River, at least 30 nm to the southeast. These cities, Idaho Falls and Pocatello, both have populations of approximately 40,000.

Access to the suitable area is provided by several state and federal highways and numerous gravel and dirt roads. U.S. highways 20 and 26 connect the CSP to Idaho Falls and Interstate 15 to the east. Primary State highways 22 and 28 are also important routes within the suitable area.

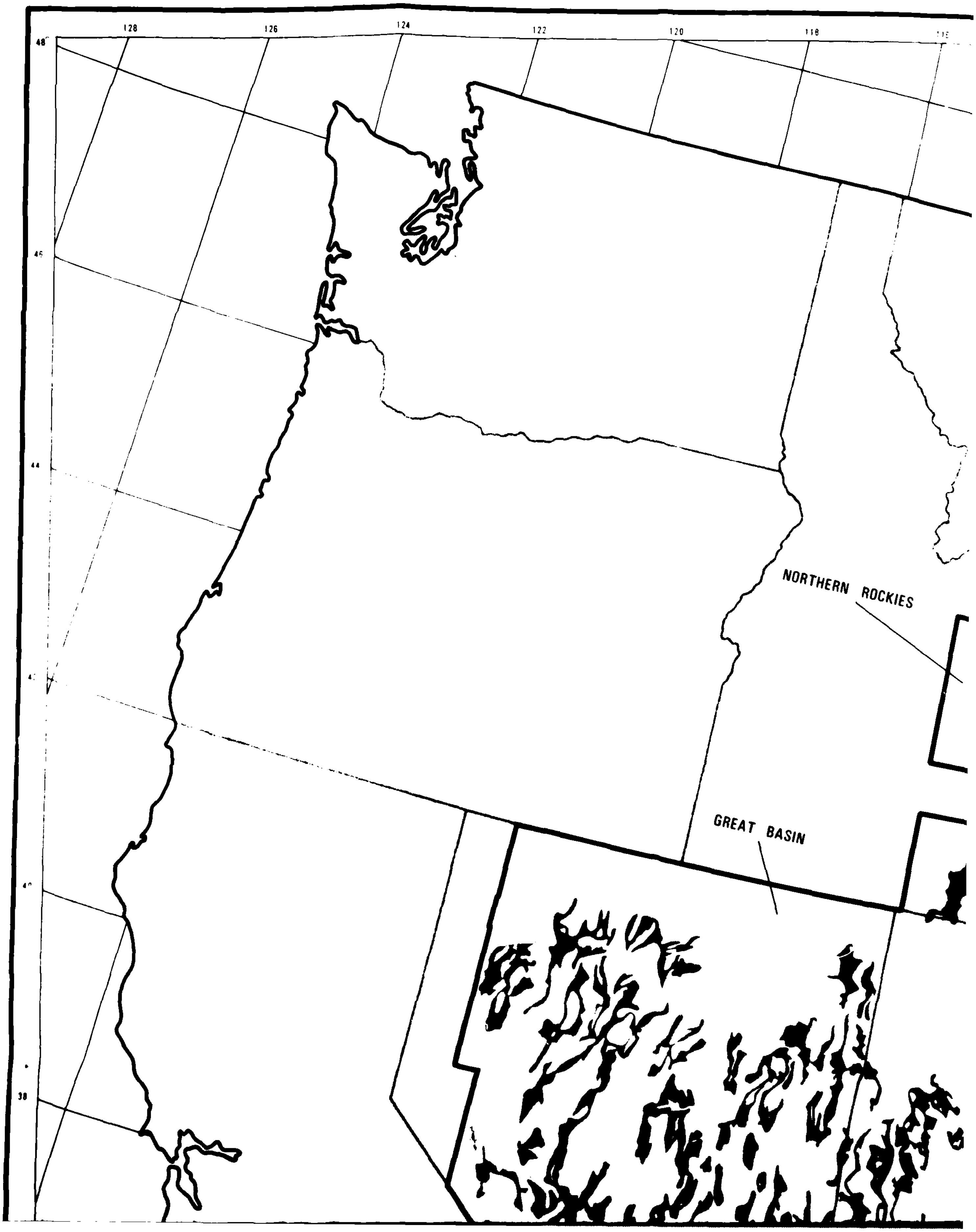
14.3.4.2 Land Use

The southernmost portion of suitable area (approximately 140 nm^2) is contained within the boundaries of the Idaho National Engineering Laboratory (formerly the National Reactor Testing Station), which is actively involved in radioactive waste disposal. Excluding this portion of land, approximately 25 percent of the suitable area is privately owned, approximately 15 percent is owned by the state and the remaining 60 percent is controlled by the BLM.

14.3.4.3 Economic Base

Suitable area is used almost exclusively for livestock grazing except for a few sand and gravel quarries. In the past, heavy metal mining was done in the mountains but has ceased to be economically important (Gomm, oral communication, 1977).

MX SITING INVESTIGATION
CONTERMINOUS UNITED STATES



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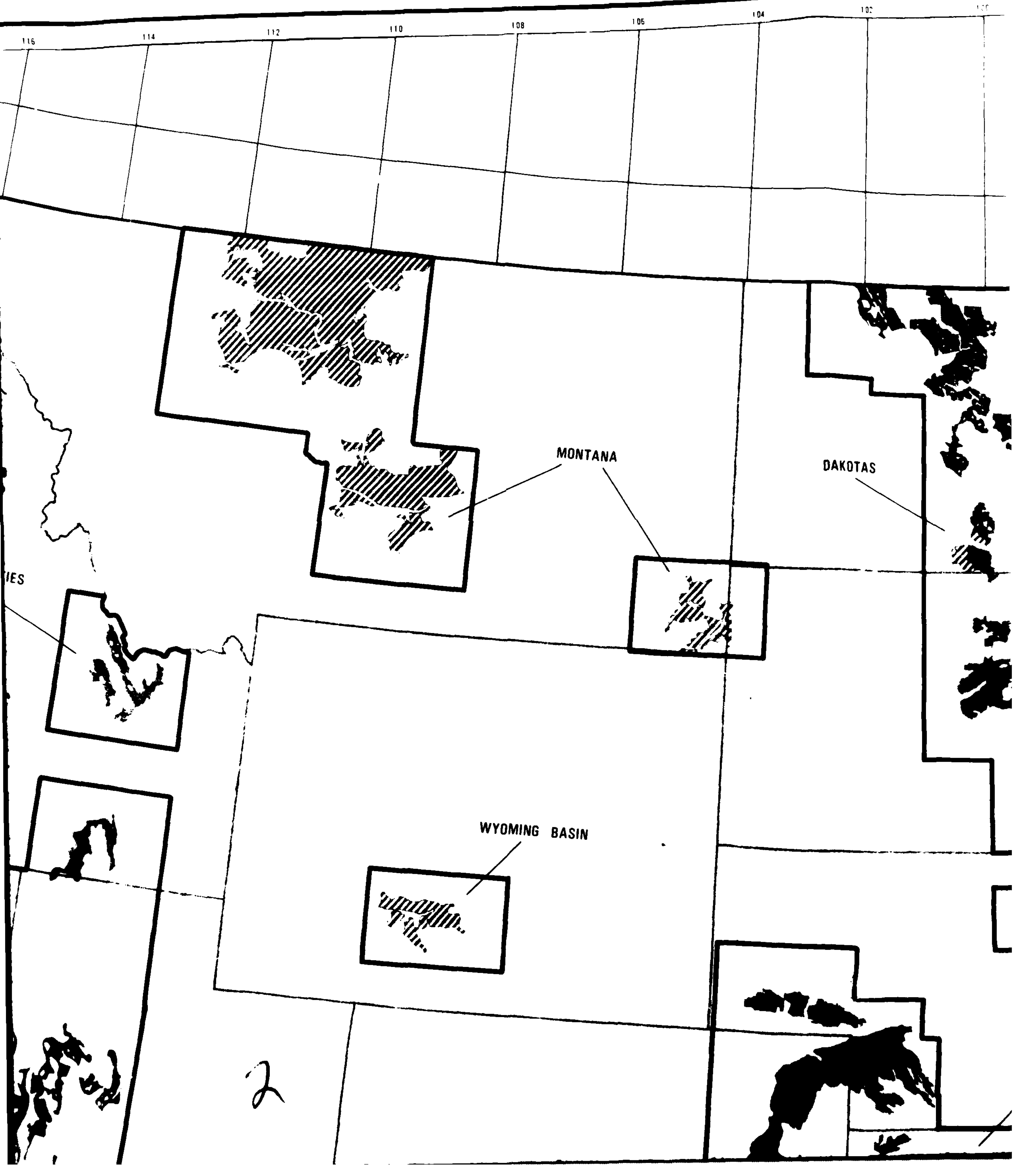

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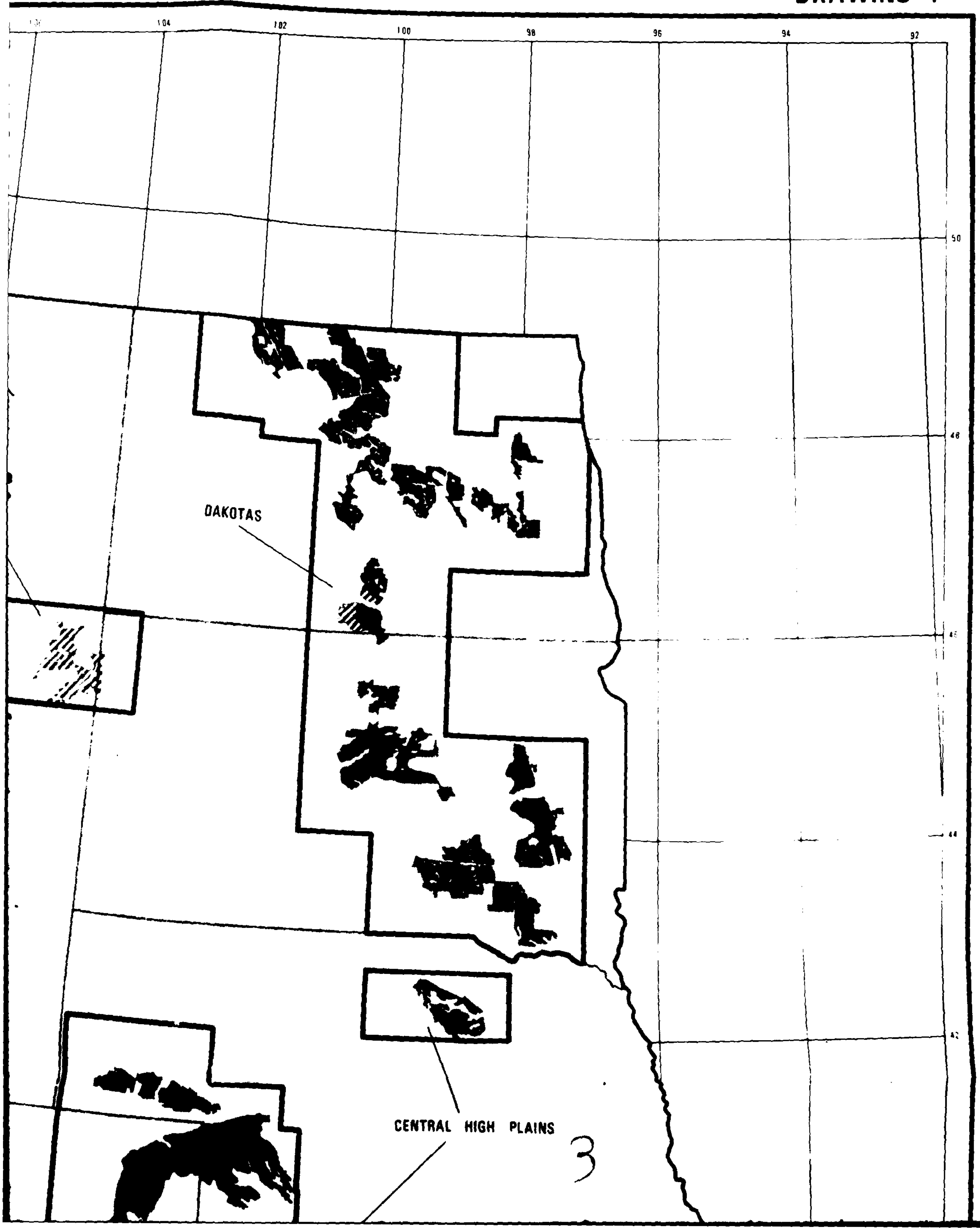

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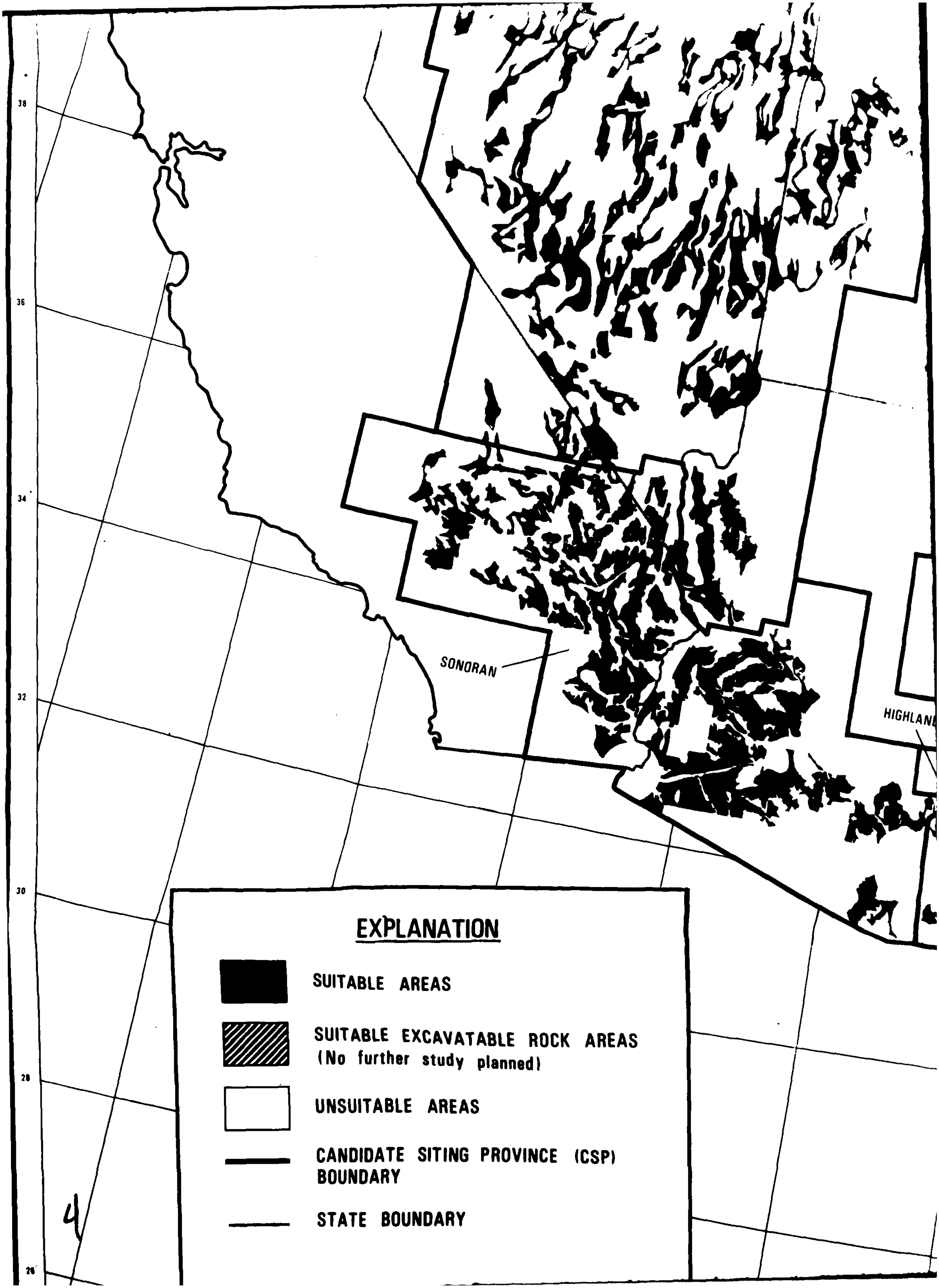


EXPLANATION

■ SUITABLE AREAS

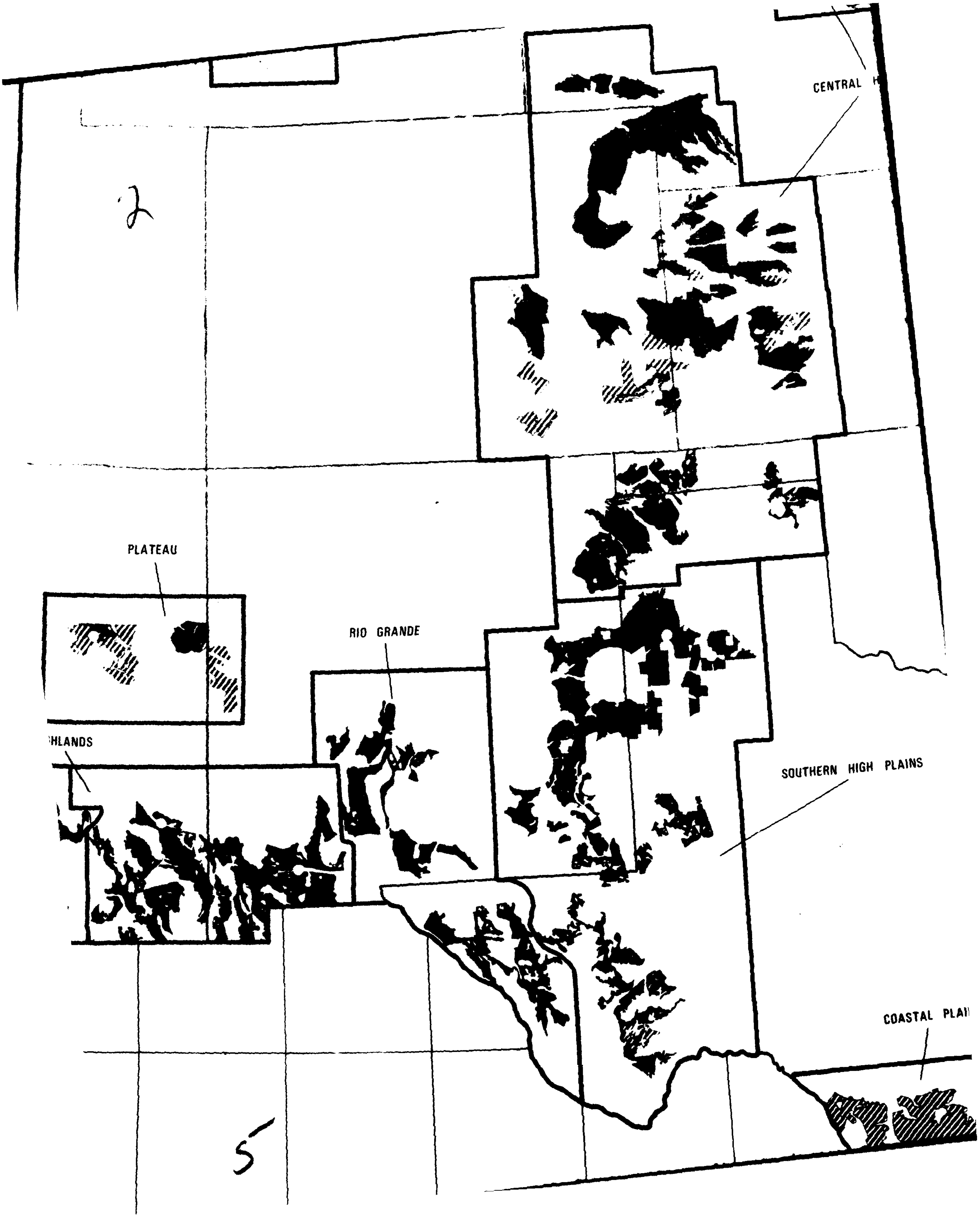
▨ SUITABLE EXCAVATABLE ROCK AREAS (No further study planned)

□ UNSUITABLE AREAS

━ CANDIDATE SITING PROVINCE (CSP) BOUNDARY

— STATE BOUNDARY

4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HLANDS
SOUTHERN HIGH PLAINS
COASTAL PLAI
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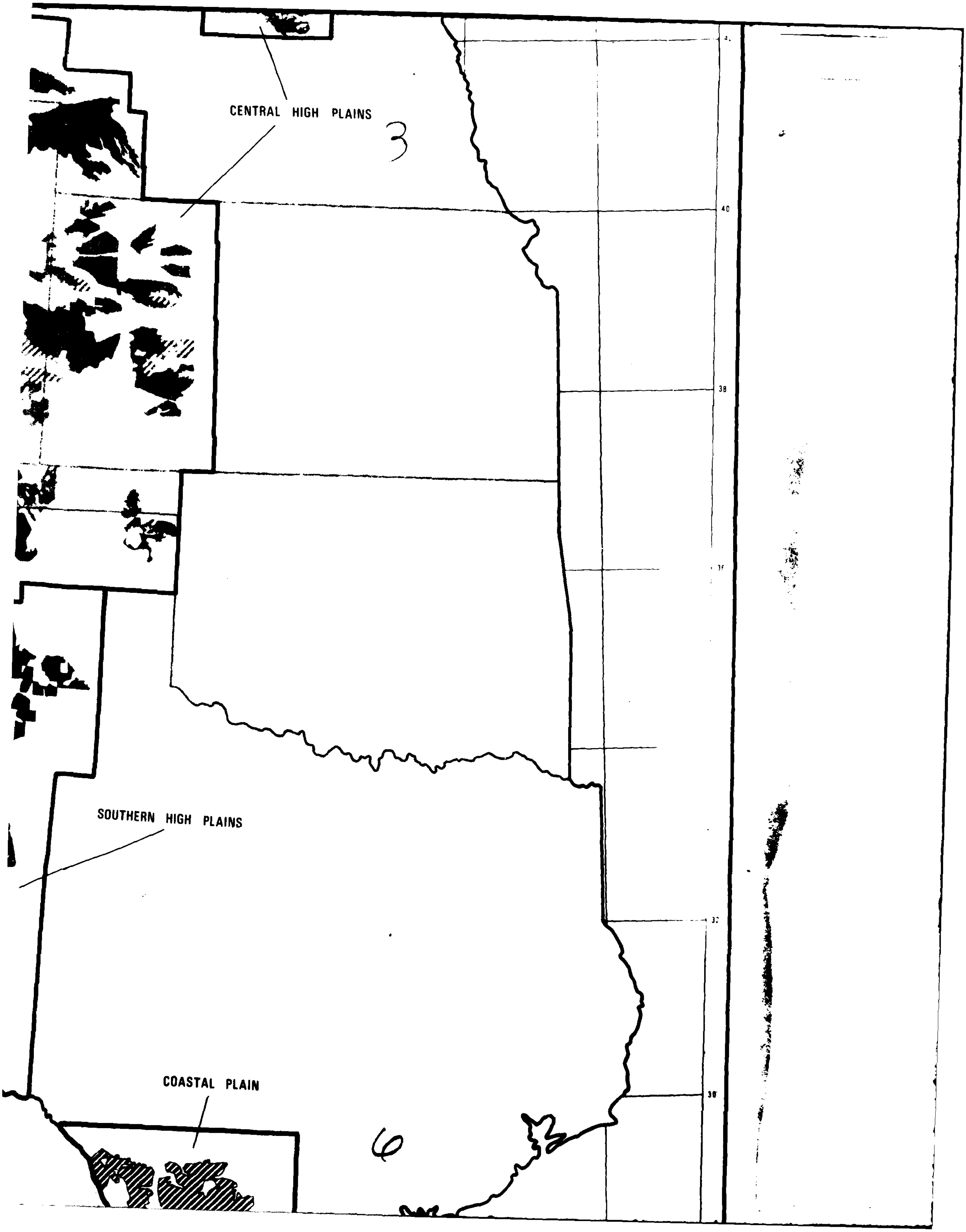
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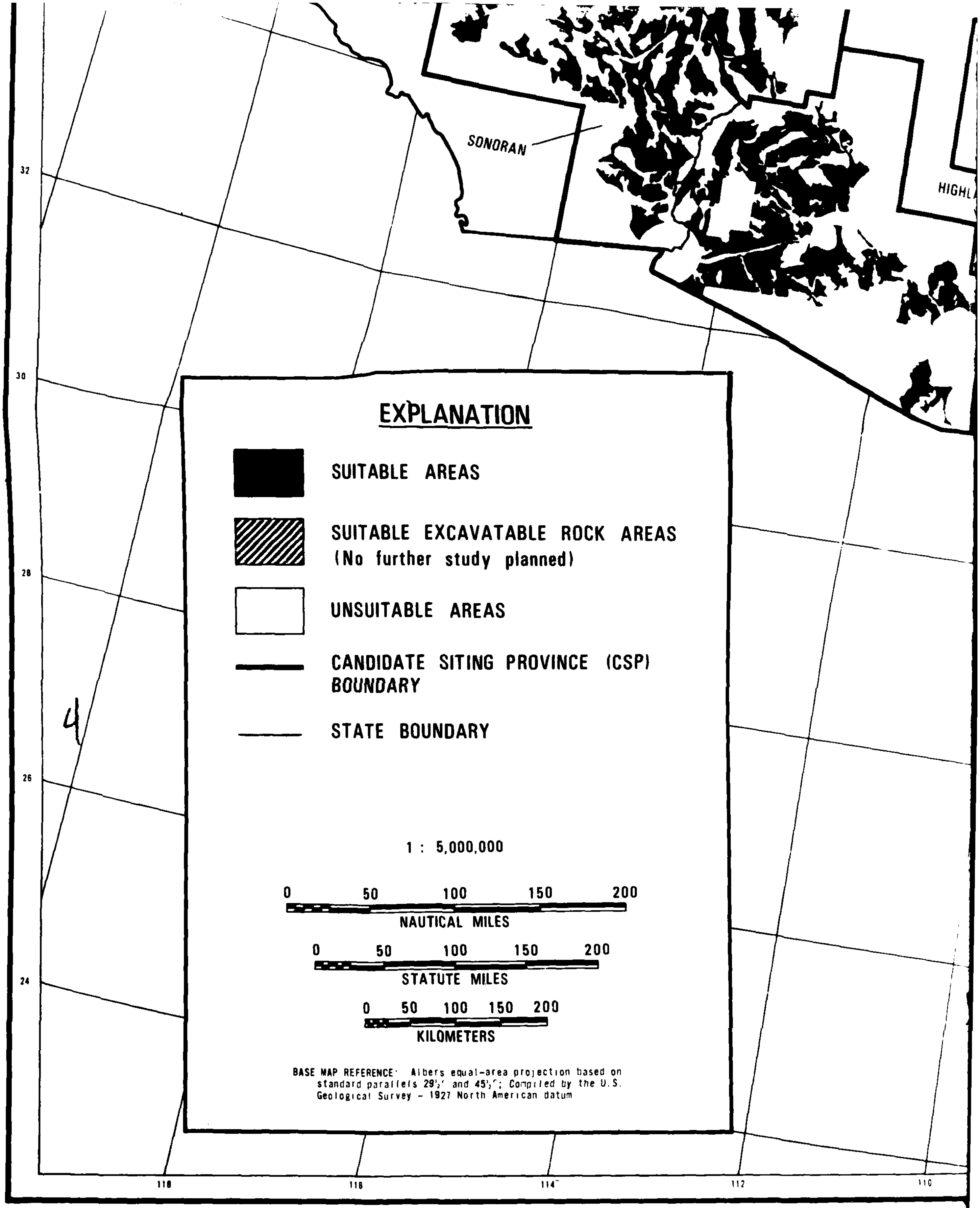
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EXPLANATION
■ SUITABLE AREAS
▨ SUITABLE EXCAVATABLE ROCK AREAS (No further study planned)
☐ UNSUITABLE AREAS
▬ CANDIDATE SITING PROVINCE (CSP) BOUNDARY
— STATE BOUNDARY
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BASE MAP REFERENCE: Albers equal-area projection based on standard parallels 29½° and 45½°; Compiled by the U.S. Geological Survey - 1927 North American datum

4

FN-TR-17

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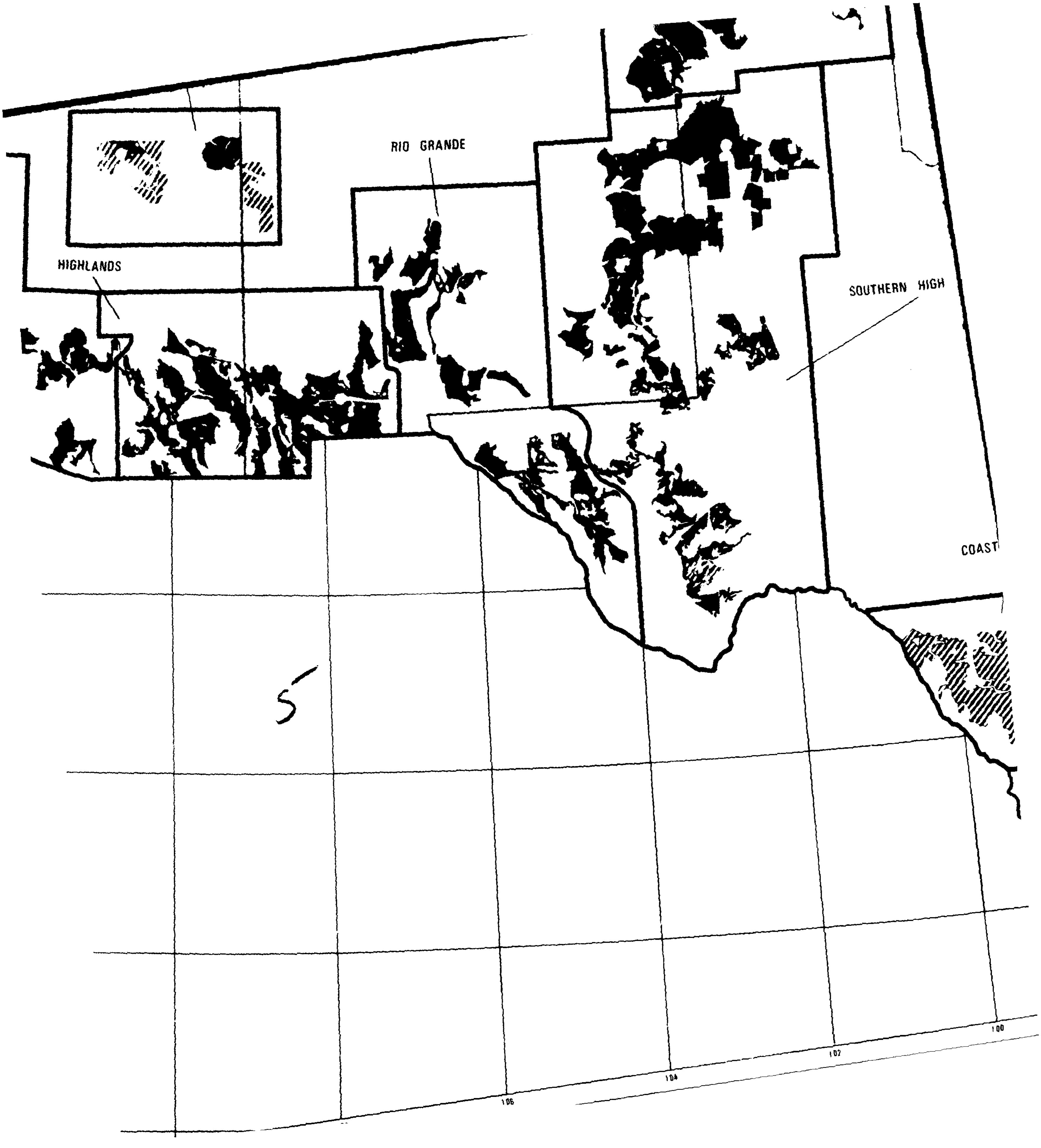

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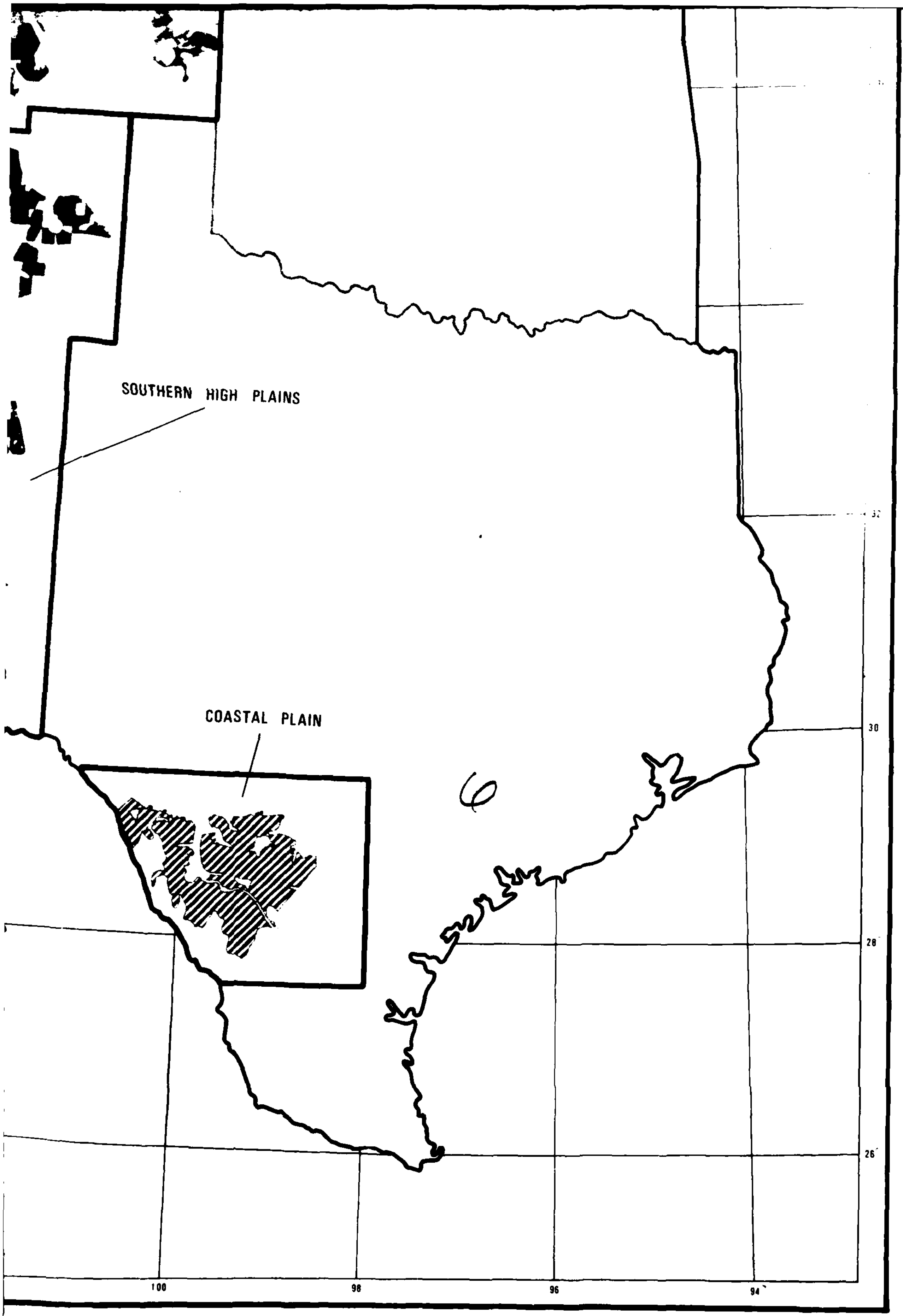

FUGRO NATIONAL, INC.

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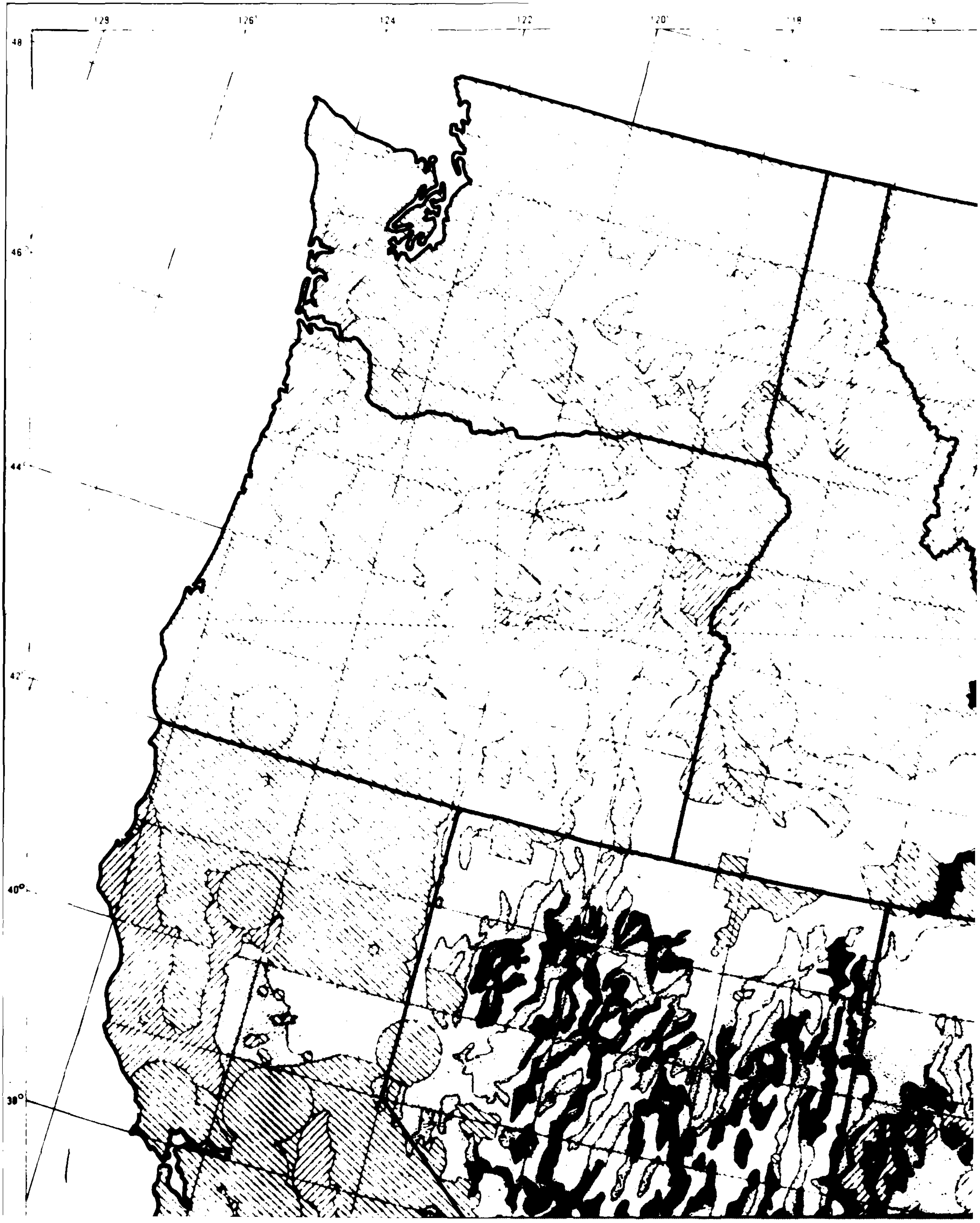
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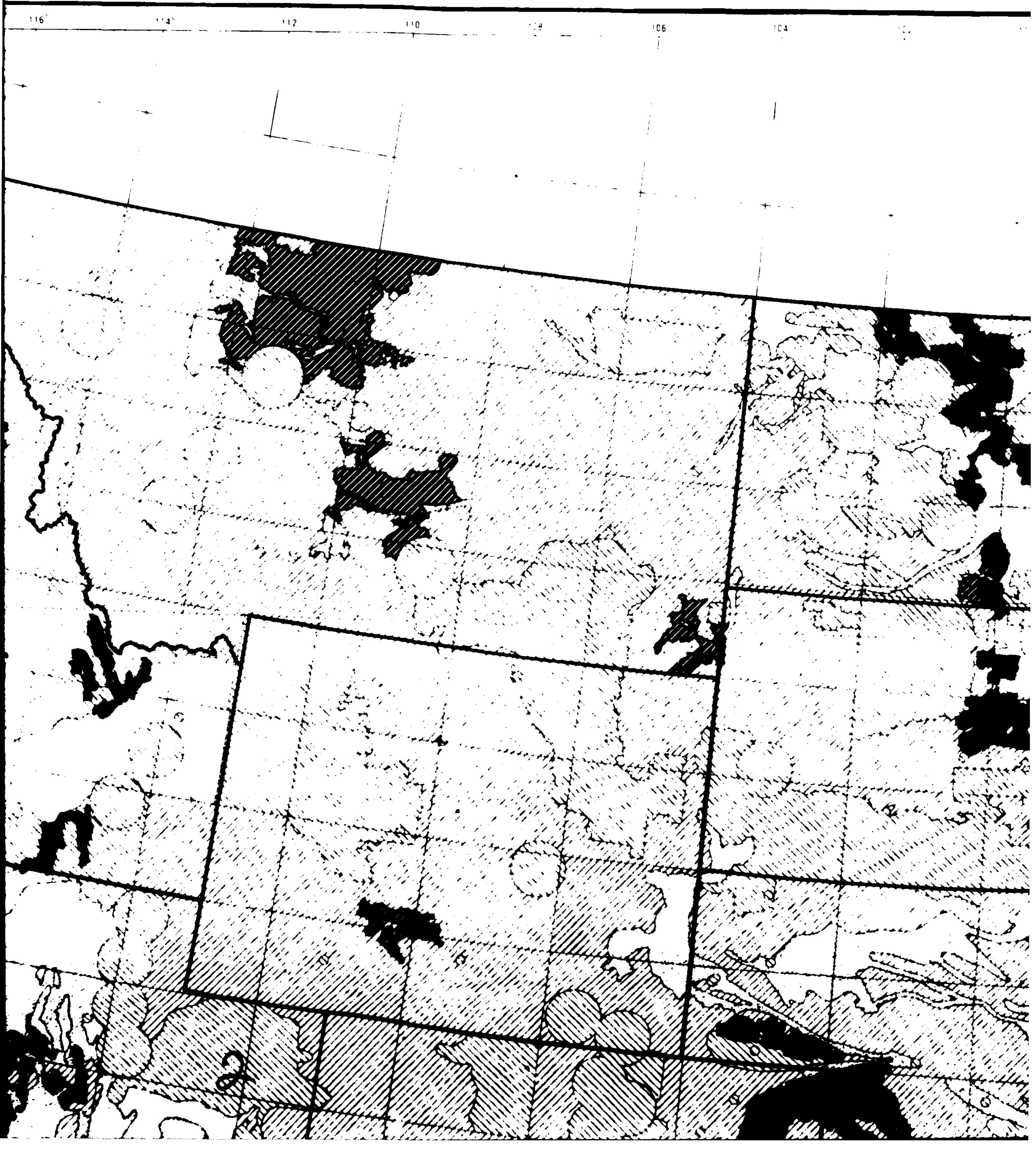
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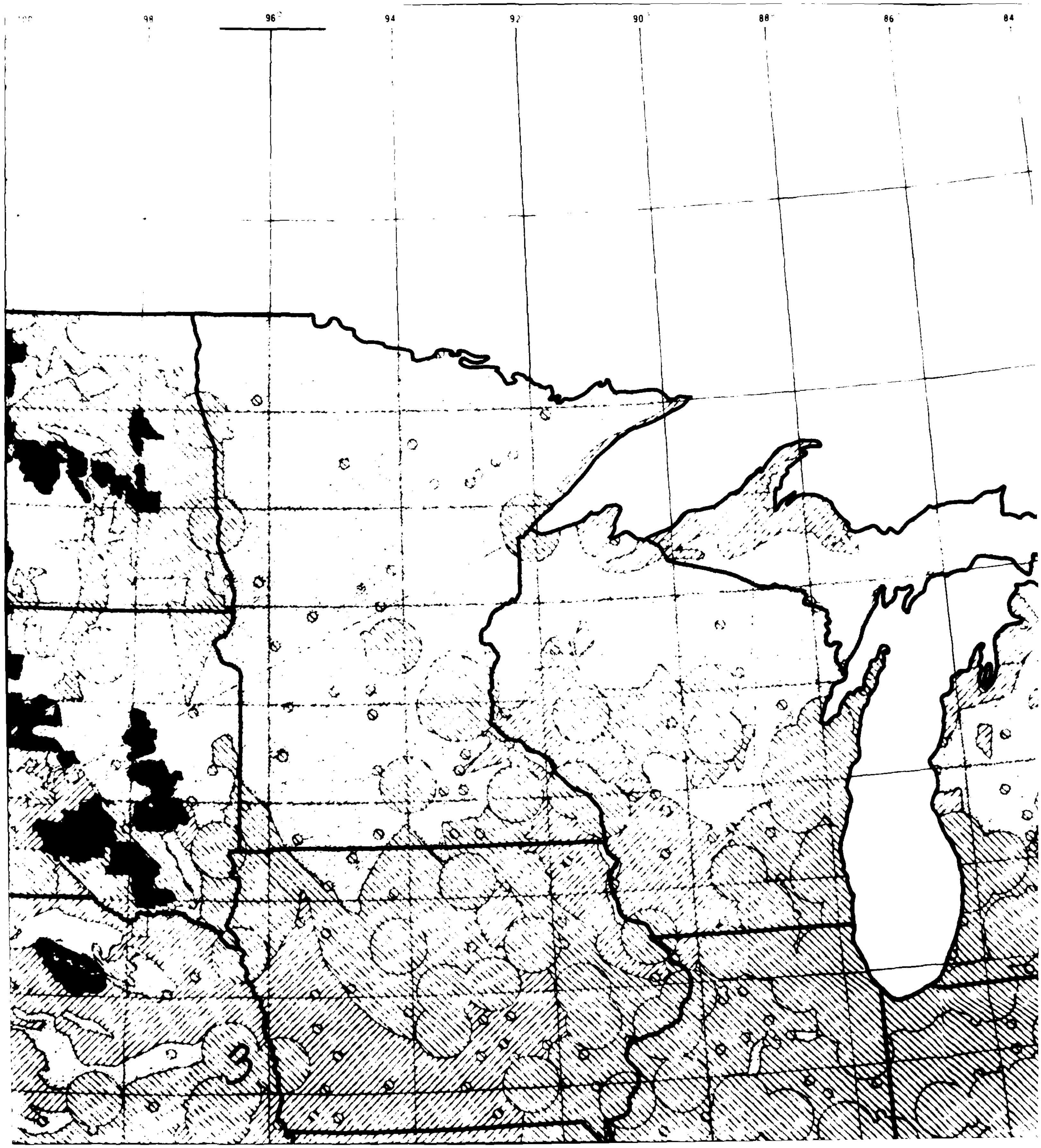
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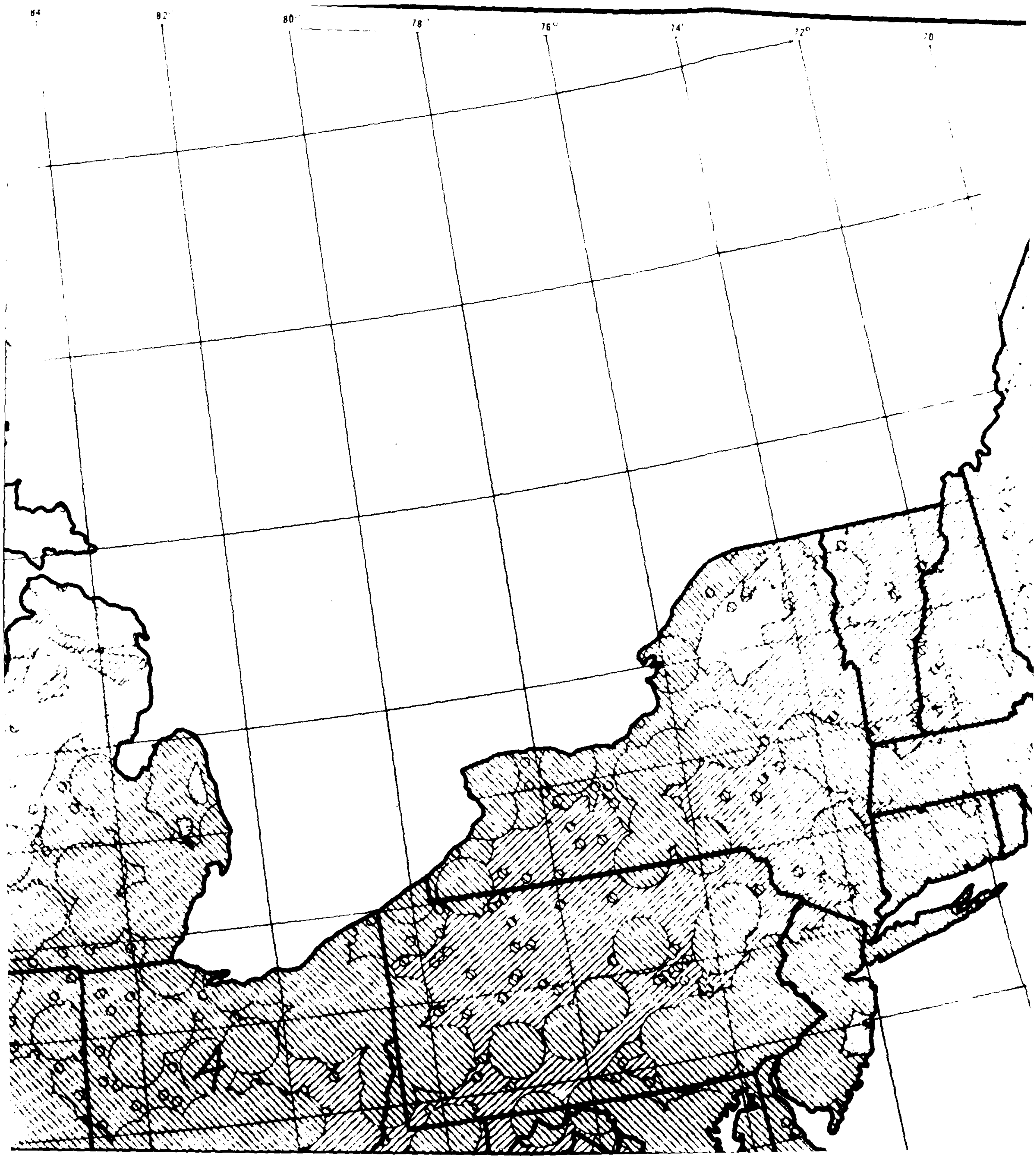
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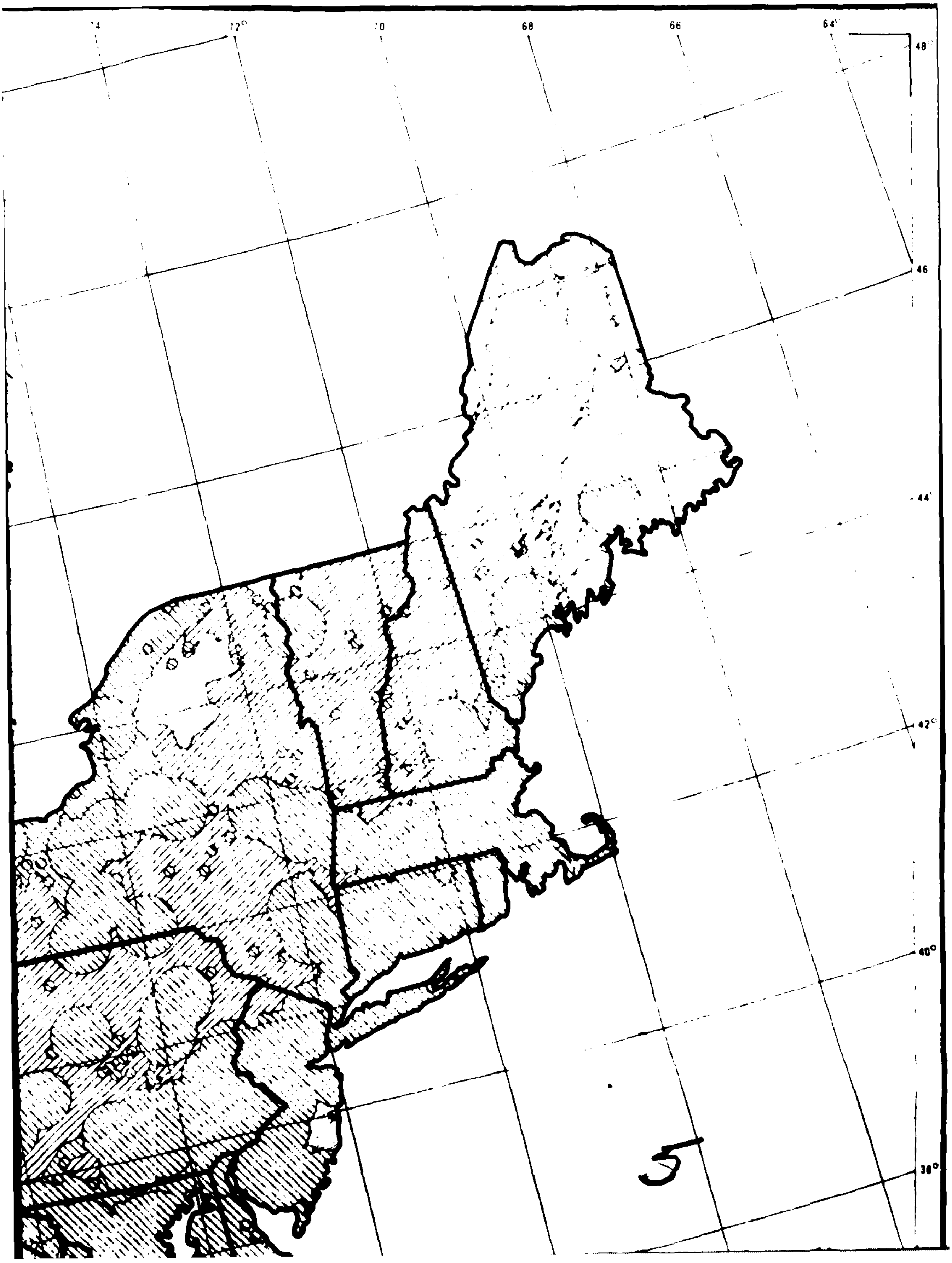

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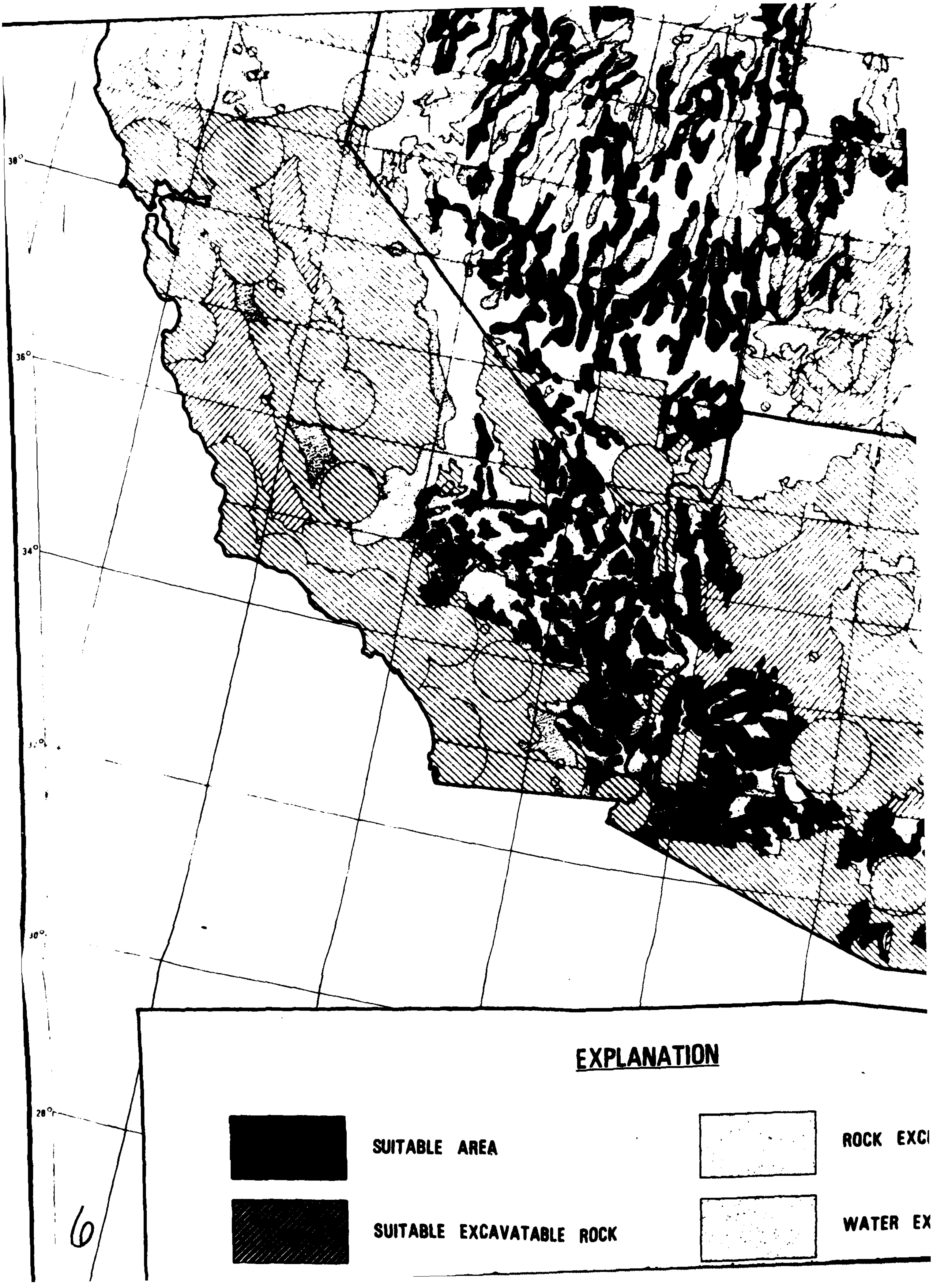
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EXPLANATION
SUITABLE AREA
SUITABLE EXCAVATABLE ROCK
ROCK EXC
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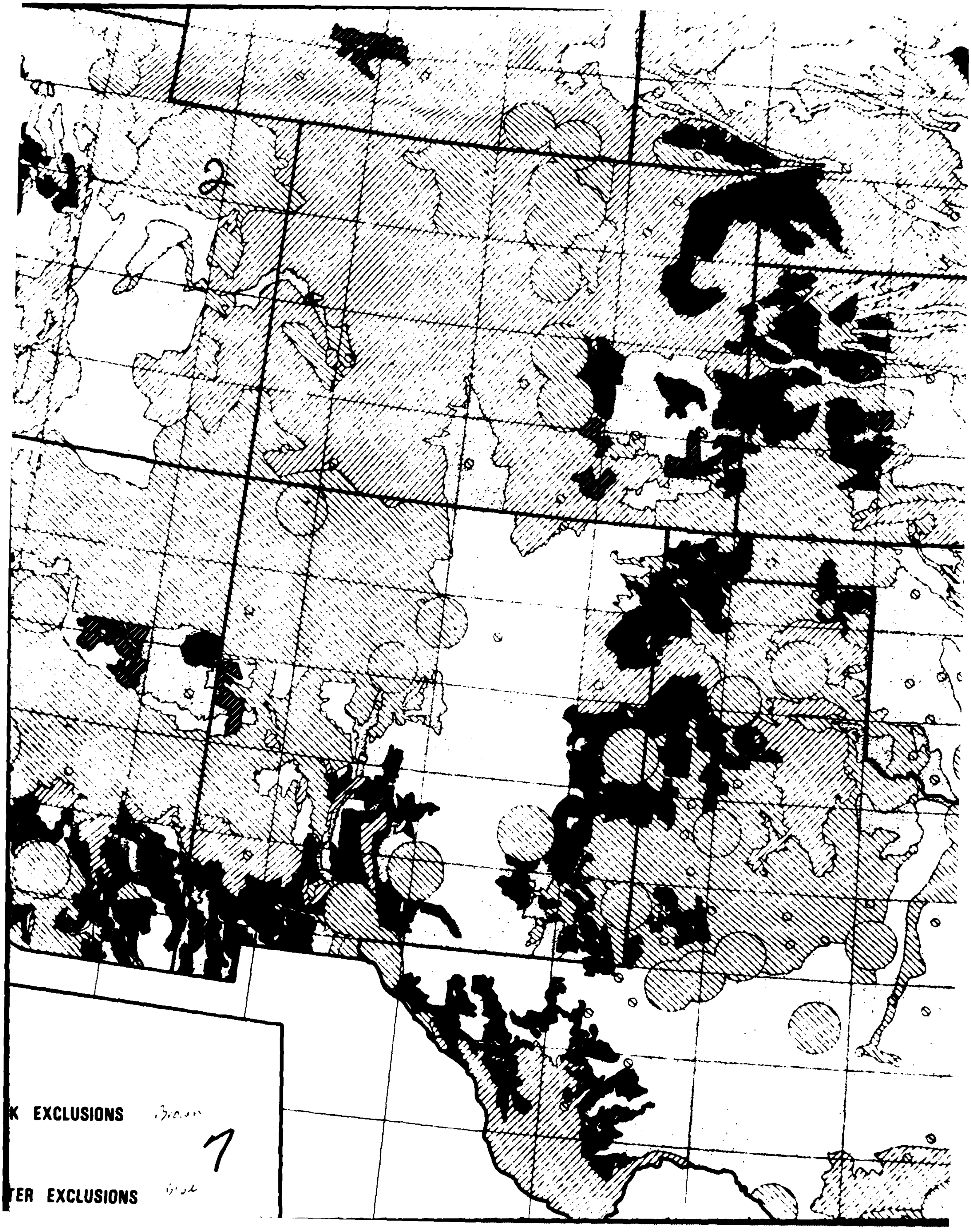

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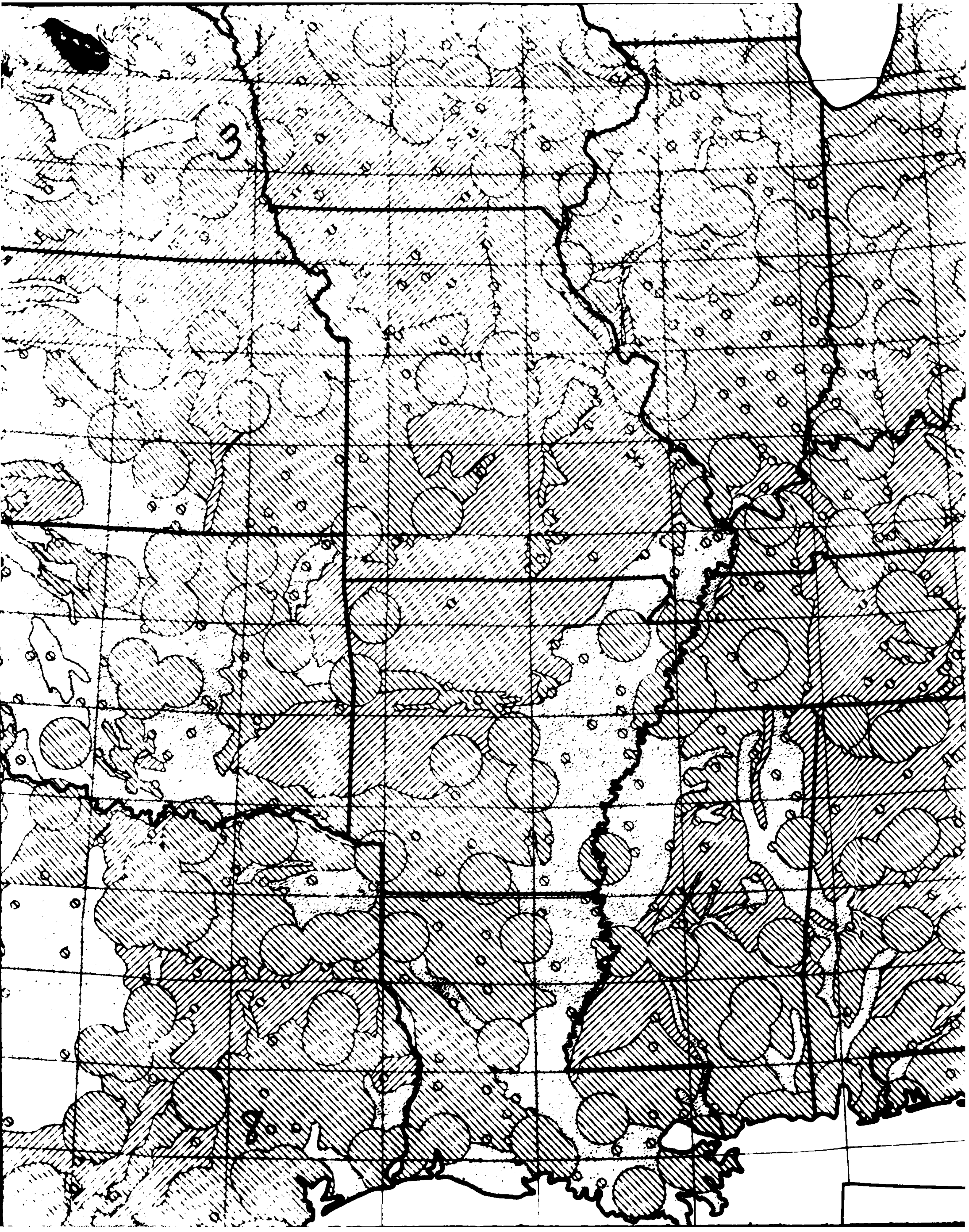
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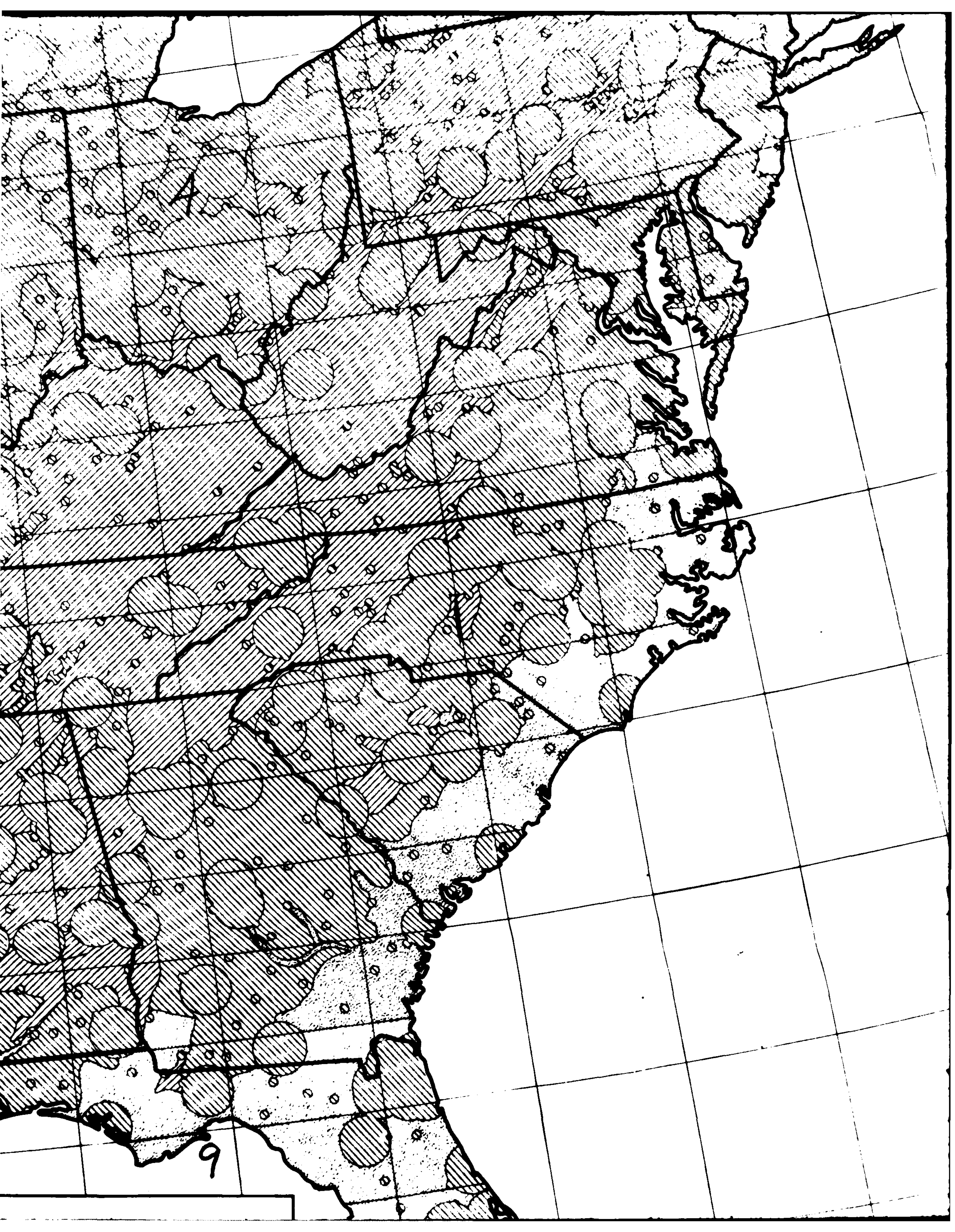
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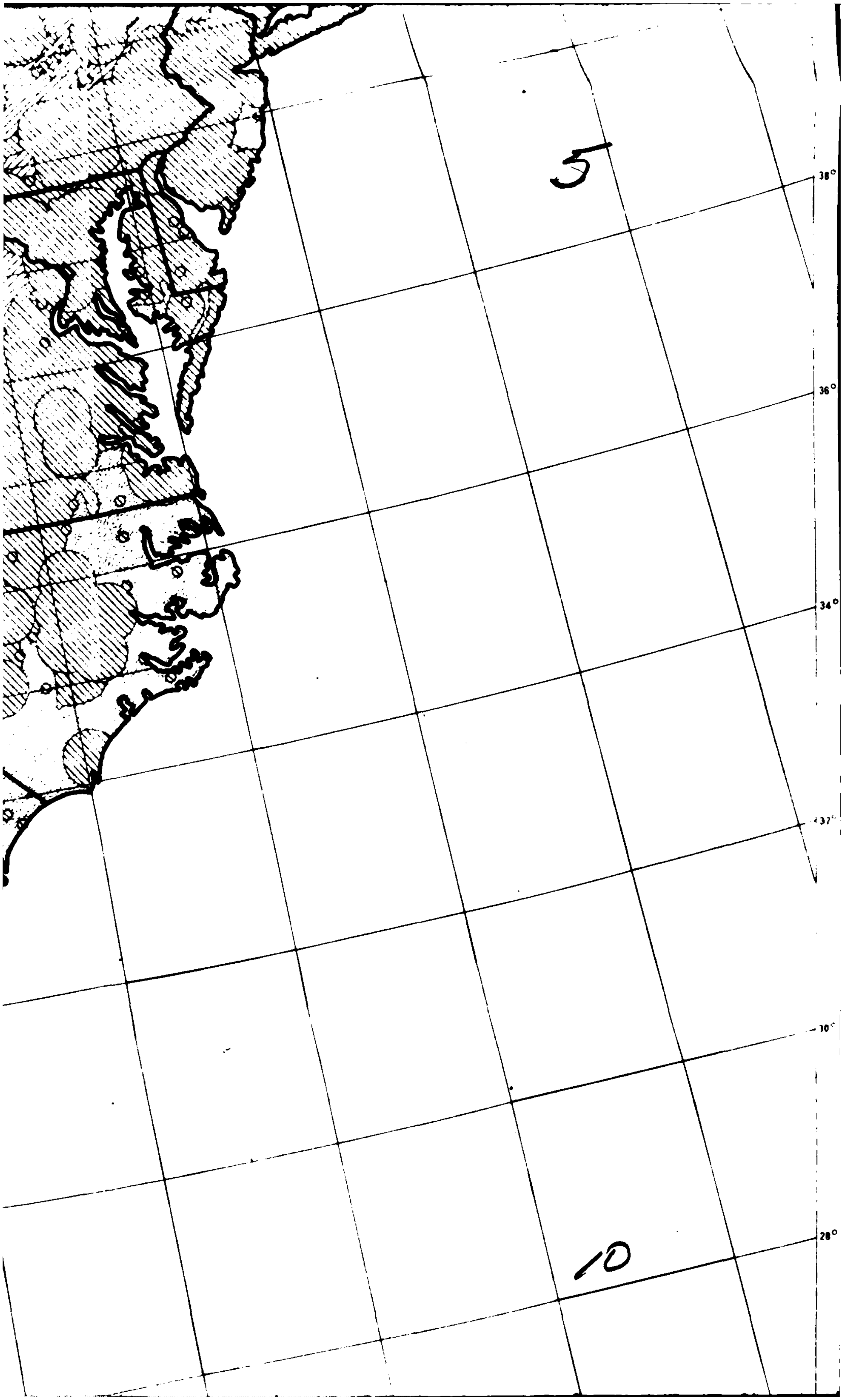
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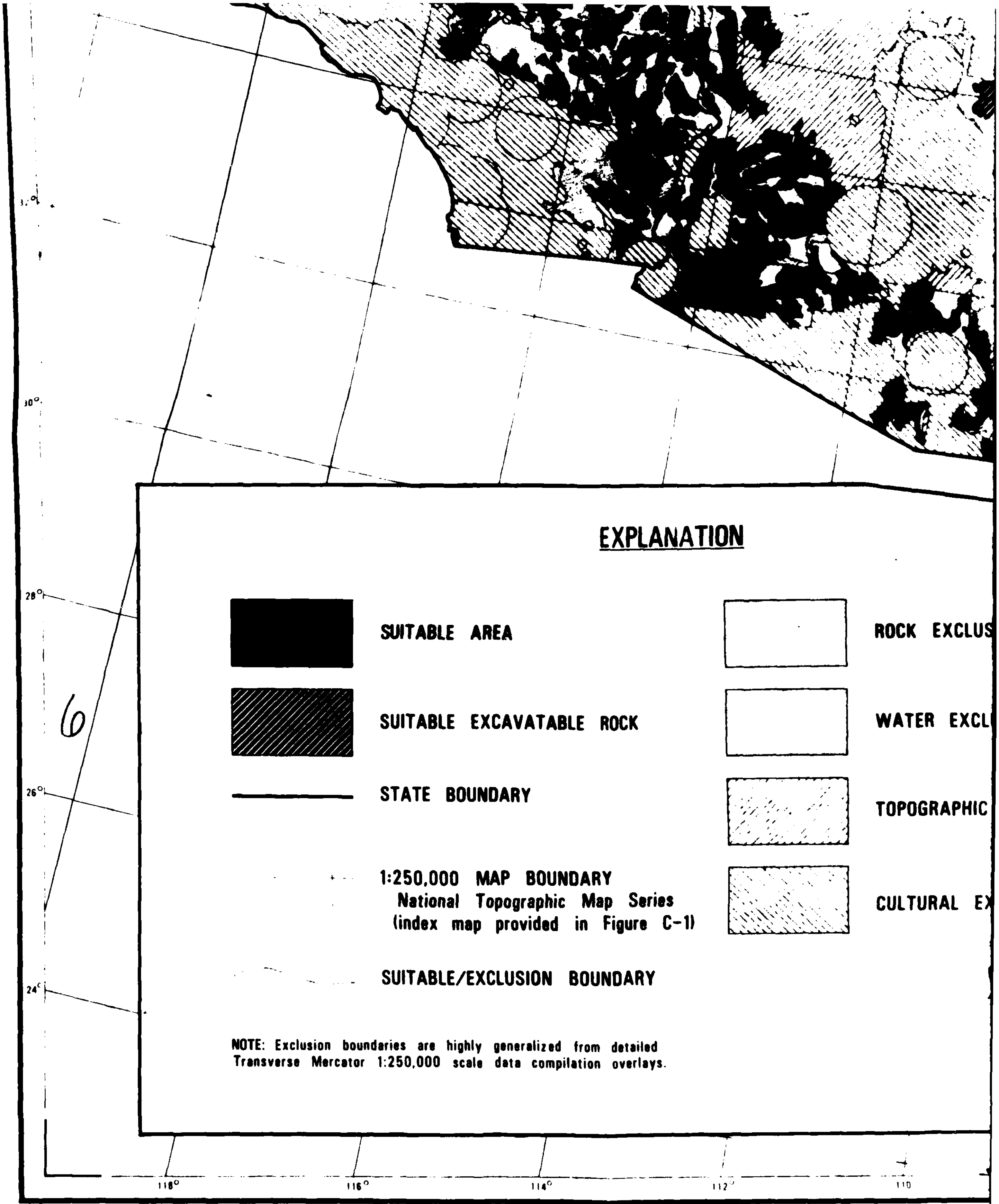
EXPLANATION
SUITABLE AREA
SUITABLE EXCAVATABLE ROCK
STATE BOUNDARY
1:250,000 MAP BOUNDARY
National Topographic Map Series
(index map provided in Figure C-1)
SUITABLE/EXCLUSION BOUNDARY
ROCK EXCLUS
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CULTURAL EX
NOTE: Exclusion boundaries are highly generalized from detailed Transverse Mercator 1:250,000 scale data compilation overlays.
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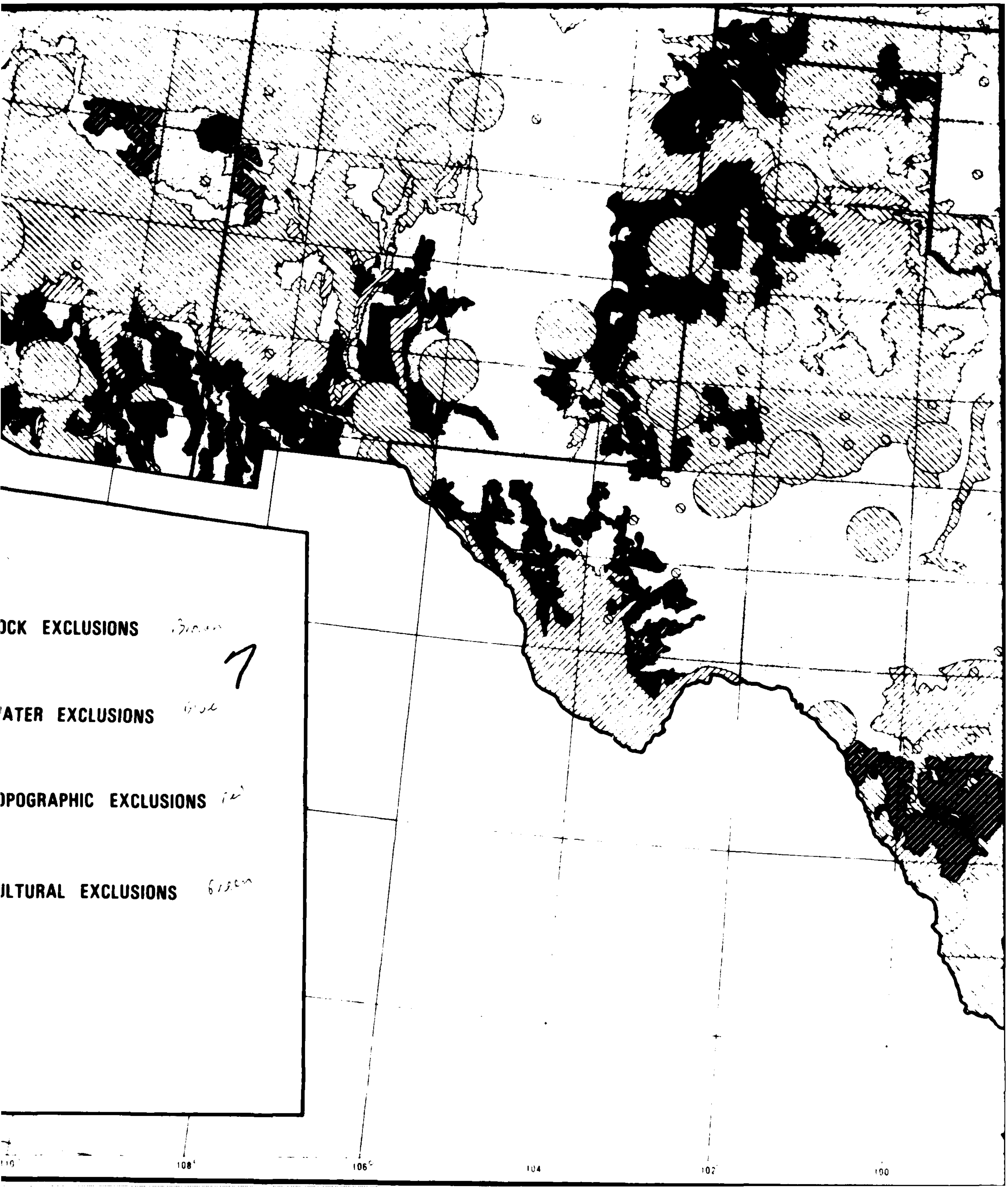
OCK EXCLUSIONS Brown
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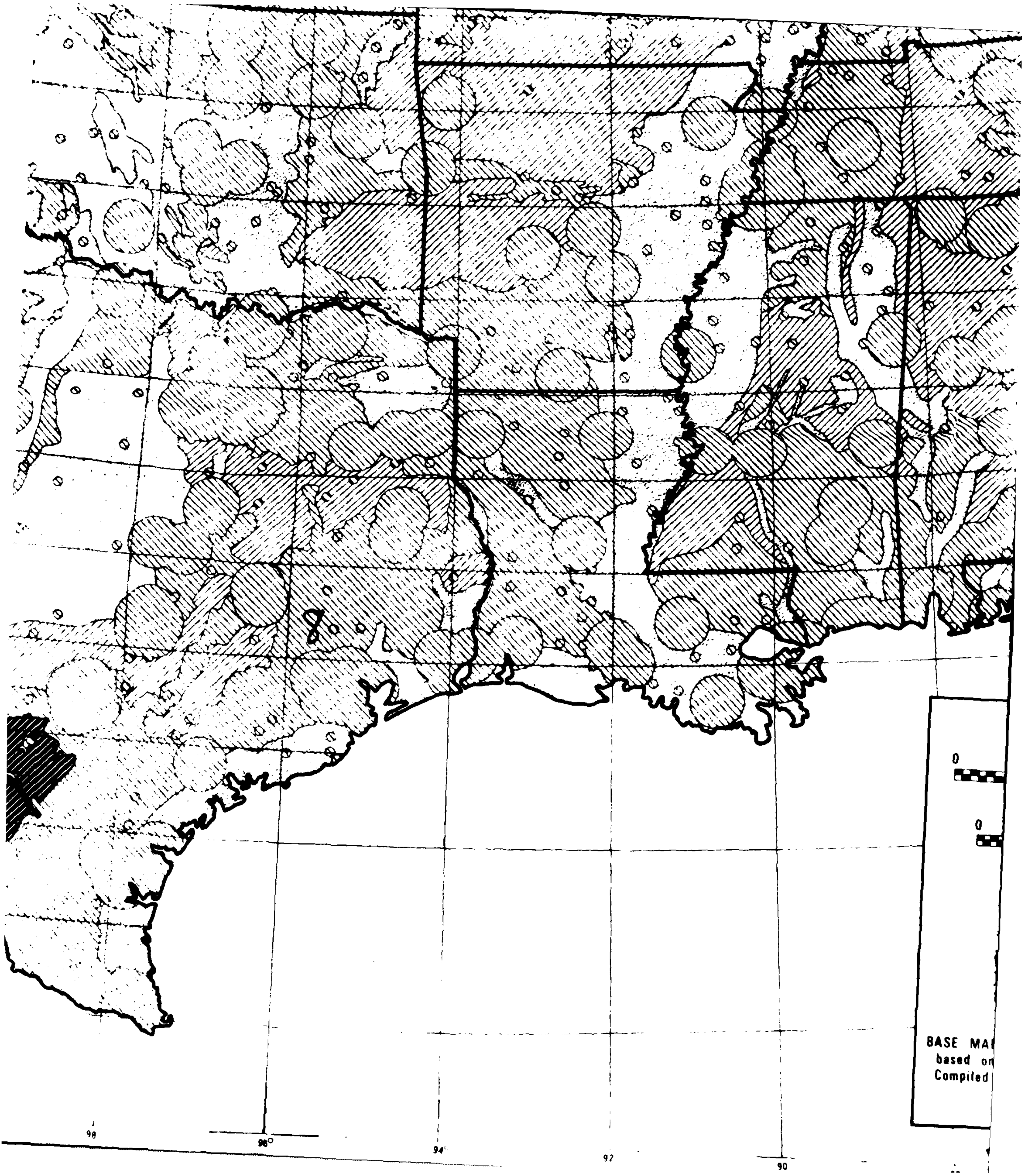
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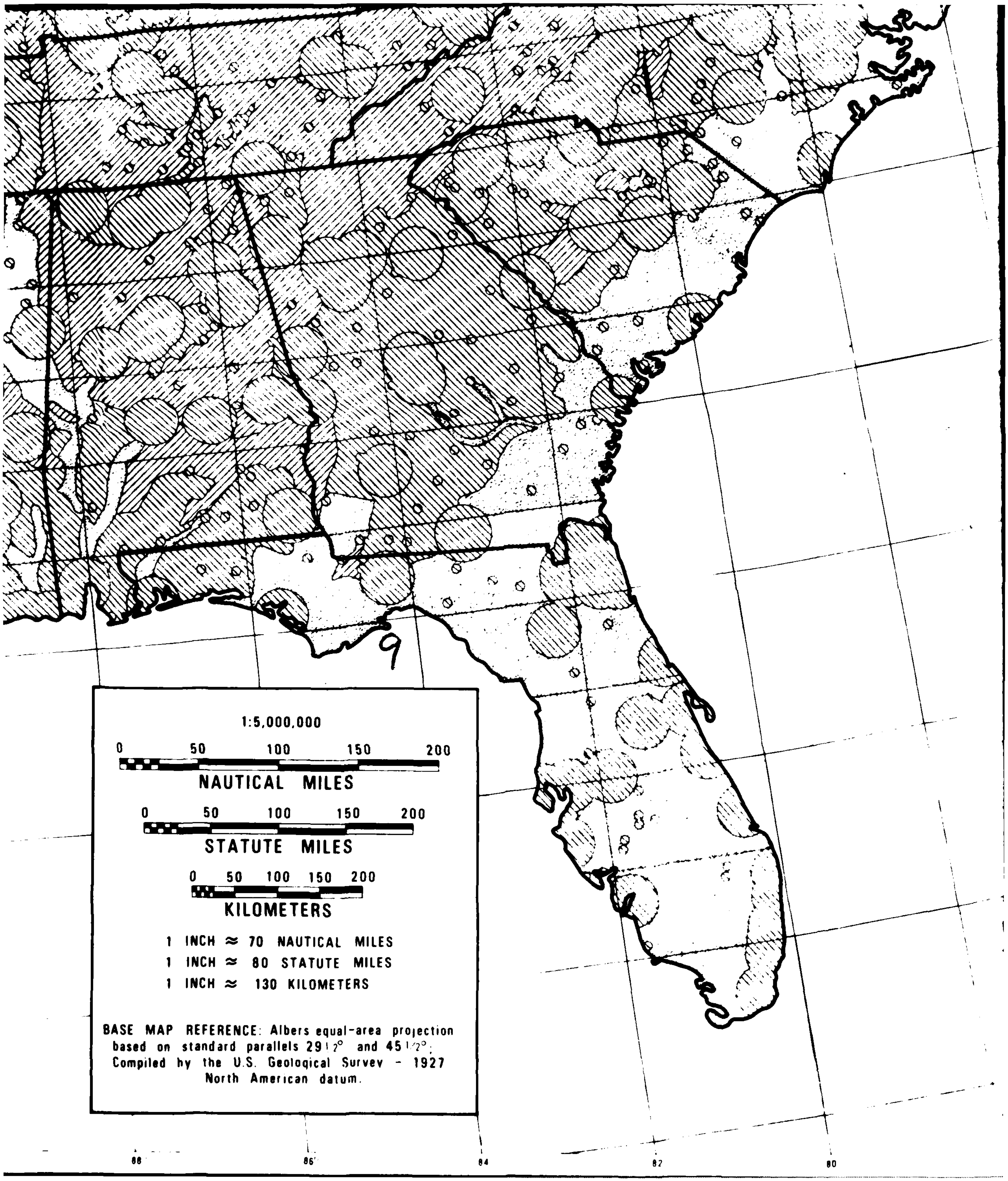
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1 INCH ≈ 130 KILOMETERS
BASE MAP REFERENCE: Albers equal-area projection based on standard parallels 29 1/2° and 45 1/2°; Compiled by the U.S. Geological Survey - 1927 North American datum.
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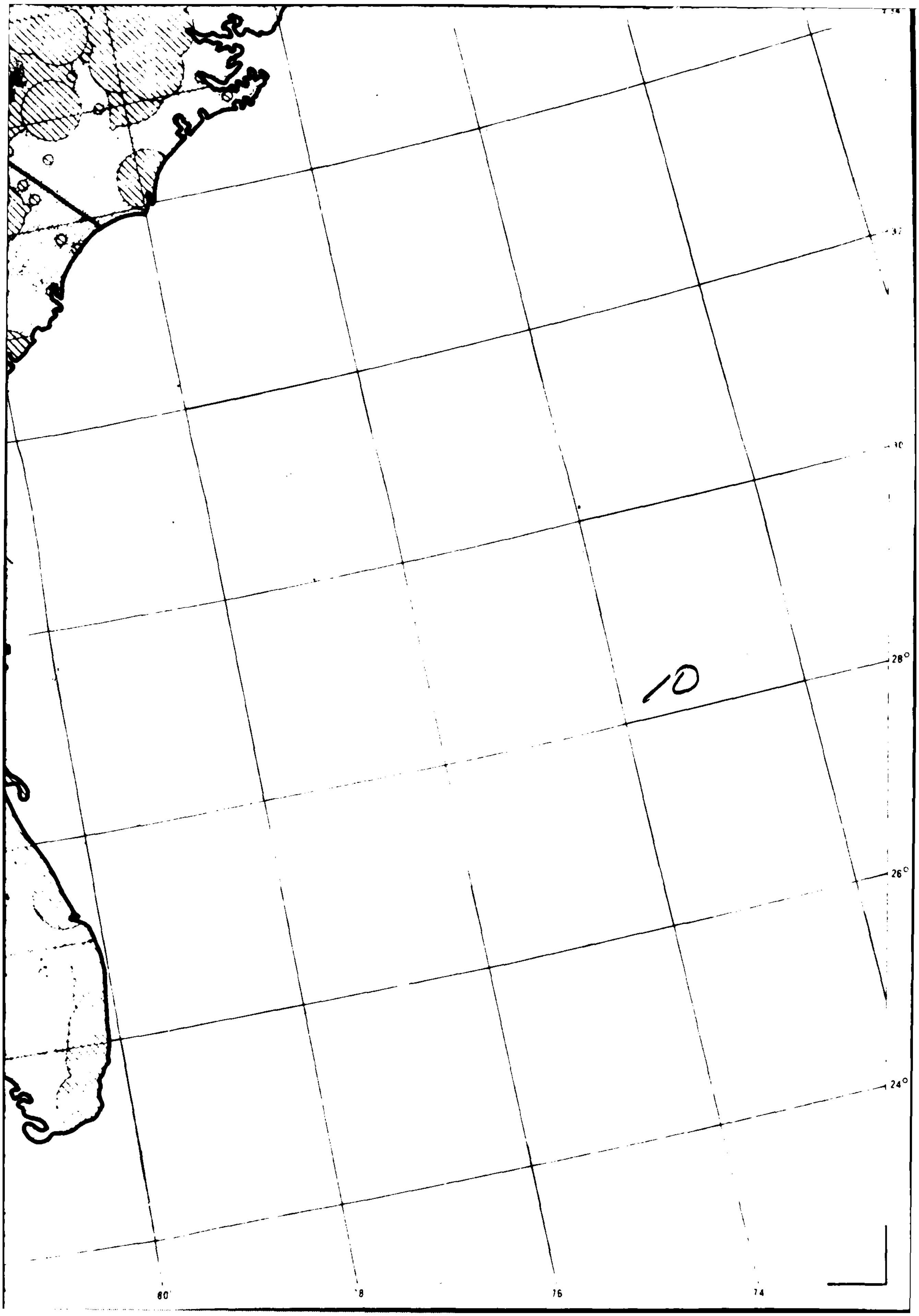

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APPENDIX A

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May - September 1977

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May - September 1977

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May - September 1977

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May - September 1977

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SURFACE ROCK AND ROCK WITHIN 50 FEET OF GROUND SURFACE

Rock is defined in this study as those earth materials which are not readily rippable with conventional excavation methods. Seismic P-wave velocities greater than 7000 fps has been suggested as a criterion for differentiation. Since few results are available for seismic velocity studies of near surface materials, most evaluations are based on lithologic descriptions, columnar sections on maps and in reports, and on discussions with local geologists familiar with each particular unit. Bedrock contacts were determined from state geologic maps in conjunction with more detailed local maps and reports when available.

Unsuitable rock areas are, in general, composed of or underlain by the geologically oldest and densest rocks, generally containing both intrusive and extrusive igneous rocks, metamorphic rocks, and massive well-lithified sedimentary rocks. These areas generally correspond to mountainous terrain which is for the most part, unsuitable from topographic exclusions.

The non-excluded category is subdivided into two area categories--"suitable" and "suitable excavatable rock". Suitable areas are generally the geologically youngest deposits, composed of unconsolidated, moderately-consolidated and weakly-lithified geologic formations and soil material which can be readily excavated with conventional equipment to a nominal depth of 50 feet. These deposits are generally composed of alluvium, loess, glacial till and soil, and occupy intermontane valleys and broad expanses of the interior plains.

Suitable excavatable rock is generally assigned to lithified sedimentary formations, the predominant members of which can be excavated with conventional equipment to a nominal depth of 50 feet. These regions of suitable "excavatable rock" rarely exceed Cretaceous in age and, for the most part, consist of poorly to moderately indurated formations of shale and sandstone.

SURFACE WATER/GROUND WATER WITHIN 50' OF SURFACE

Ground water exclusions are difficult to delineate based on the incompleteness of available data. Large areas of less populated regions of the United States lack sufficient data on which to assess the existence of shallow water. Considering supportive data, only surface water, ground water in the saturated zone in unconfined aquifers or ground water in confined (artesian) aquifers which would be encountered in excavations to 50 feet were considered exclusions in this study. Principal data sources include water-supply papers, hydrologic atlases and state reports published by the U.S. Geologic Survey. Additionally, much information was obtained from various state and county level reports, computer listings of water levels in wells and conversations with prominent local hydrologists. Lakes, major rivers, flood plains, reservoirs, and marsh areas were all defined on the basis of U.S. Geological Survey two degree maps. Areas of maximum or questionable occurrences of surface water were examined on 15' or 7 1/2' topographic maps when such coverage was available. In analyzing well data, every effort was made to differentiate a shallow water table from water brought near the surface as a result of artesian pressure in order to accurately portray the water conditions to be encountered in near surface excavations.

In areas with available data, dates of collection vary greatly and the most current data available can be as much as 20 to 30 years old. The dynamic nature of ground water and its dependence on seasonal precipitation variations, river levels, and pumping or natural discharge rates generally make depth to water determinations difficult.

CULTURAL EXCLUSIONS

Cultural exclusion, as defined for Intermediate Screening, is a broad term which includes the following individual categories: quantity/distance, land use, economic, road/pipeline/stream densities, and minimum parcel size.

Quantity/Distance

An exclusion area defined by a three nm radius surrounds all municipalities of 5,000 to 25,000 inhabitants, and an area defined by an 18 nm radius surrounds municipalities of greater than 25,000 inhabitants. Population data were based on the 1970 census, as presented in the U.S. Bureau of Census, Census of Population (1970), U.S. Summary (for cities 5000 - 25,000 population), the National Geographic Society, Atlas of the World (1975) (for cities greater than 25,000), and calls to local officials where borderline conditions were suspected. All data were plotted at the compilation scale of 1:250,000 with city locations taken from the U.S. Geological Survey Map of the United States and, where necessary, from state highway maps or other common atlases.

Land Use

Land use exclusions included Indian reservations, national parks, monuments, grasslands and forests, and state and federal wildlife refuges, game ranges, and wilderness areas. Most boundaries were taken directly from the U.S. Geological Survey topographic maps. National grasslands and recent land ownership additions were taken from state maps published by the Bureau of Land Management.

Economic

Economic exclusions included oil, gas, coal, uranium and geothermal fields as well as other areas of active mineral recovery. Areas containing a well-documented high potential for commercial mining or resource recovery were also considered unsuitable for MX siting. The boundaries of the resource areas were obtained from U.S. Geological Survey state resource and coal maps, various state and county maps and maps of oil and gas fields obtained from private industry.

Road, Pipeline, Stream, and Aqueduct Densities

An area where the density of paved roads, railroads, aqueducts, active pipelines, perennial streams or any combination thereof described a parcel that was too small to accomodate a straight ten nm length of trench within its boundaries, was considered unsuitable for MX siting. Perennial streams were defined on the basis of U.S. Geological Survey two degree maps; roads and railroads on state highway maps; and pipelines on maps by federal, state and county agencies or private industry oil and gas maps.

Minimum Parcels

A great deal of area has been excluded on the basis of minimum parcel size, particularly in the eastern U.S. in conjunction with the road/pipeline/ stream density criteria defined above. All parcels or aggregate parcels having a total area less than 500 nm^2 were excluded. In order to be included in the aggregate total, individual parcels must be a minimum of 150 nm^2 and must not be separated from adjacent suitable parcels by distances greater than ten nm and by grades greater than ten percent. Minimum parcels were established on the U.S. Geological Survey 1:250,000 scale sheets using a template or planimeter for area determinations.

TOPOGRAPHIC GRADE

The topographic grade screening criteria includes both percent topographic grade and relative relief (rugged terrain) considerations.

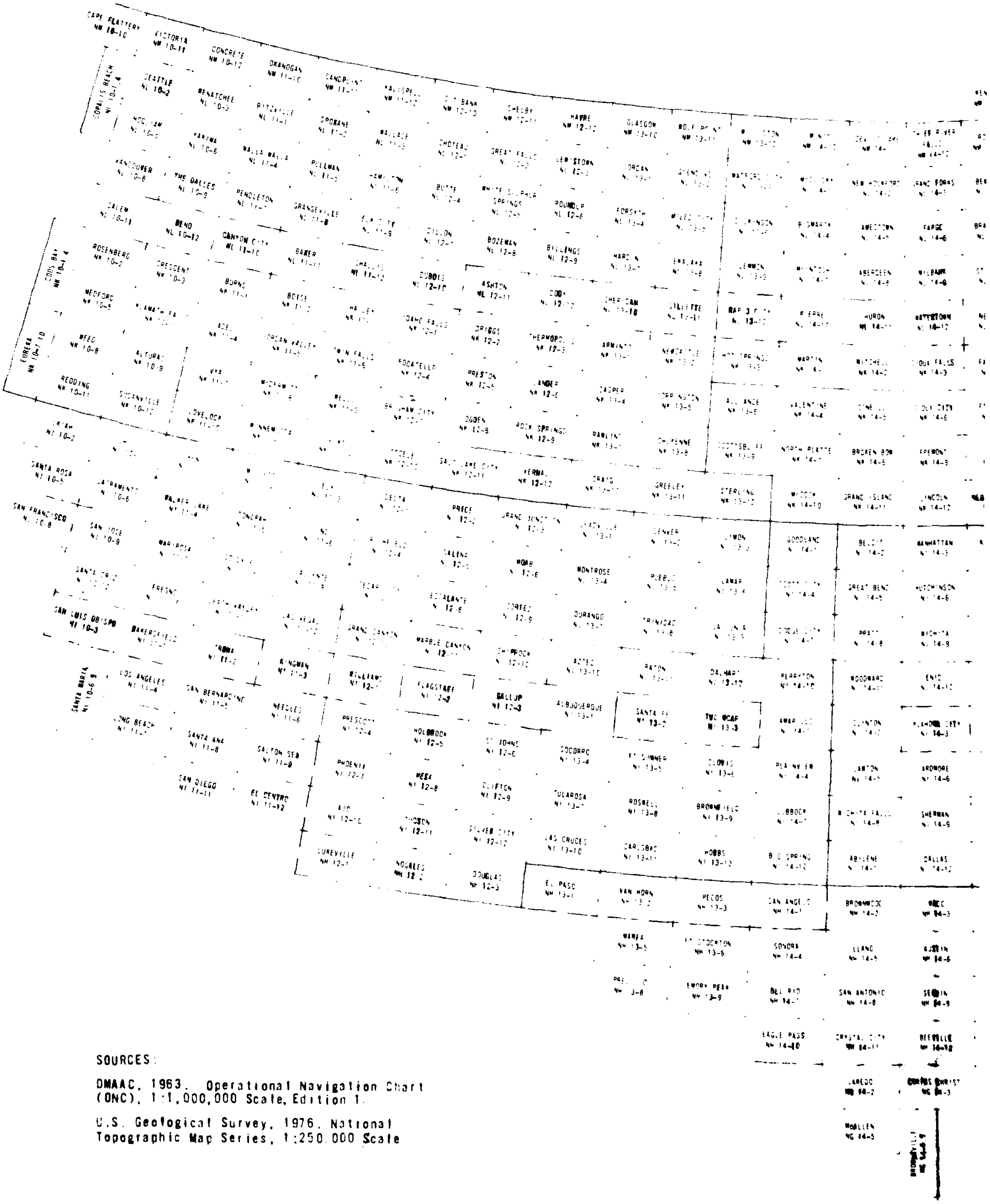
Areas of greater than ten percent topographic grade were considered unsuitable. Areas of greater than ten percent topographic grade were compiled from a scale of 1:250,000 using U.S. Geological Survey National Topographic Map Series. Contour spacings were used to determine slope angles on maps with contour intervals varying from 50 to 200 feet, depending on topographic conditions. The ten percent slope boundary was determined after calculating the necessary contour spacing of each 1:250,000 scale topographic sheet.

The relative relief portion of the topographic grade criteria consists of two parts: (1) all areas of characteristic terrain defined by a preponderance of slopes exceeding five percent were excluded, and (2) areas found to average at least two ten-foot deep drainages per 1000 feet were excluded. Determination of the slope was primarily carried out on maps of 1:250,000 scale, but analysis of maps of 1:62,500 or 1:24,000 scale was required where topographic contour signatures suggested potential prohibitive terrain conditions. Slope analysis techniques were identical to those used for the ten percent topographic grade. The 1000-foot distance was measured parallel to the topographic contours on the maps of 1:24,000 scale containing suspected prohibitive drainage conditions.

APPENDIX C

OPERATIONAL NAVIGATION CHART & NATIONAL TOPOGRAPHIC MAP INDEX

SUMMARY OF UNSUITABLE AREA



SOURCES:

DMAAC, 1963. Operational Navigation Chart (ONC), 1:1,000,000 Scale, Edition 1.

U.S. Geological Survey, 1976. National Topographic Map Series, 1:250,000 Scale

OPERATIONAL NAVIGATION CHART
AND NATIONAL TOPOGRAPHIC MAP
SERIES INDEX

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
C-1

FUGRO NATIONAL, INC.

ONC F-16

GENERALIZED EXCLUSIONS | TOPOGRAPHIC | ROCK | WATER | CULTURAL

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

SPECIFIC SITING CRITERIA

NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Cape Flattery	NM 10-10	WA													0	
Victoria	NM 10-11	WA													0	
Concrete	NM 10-12	WA													0	
Okanogan	NM 11-10	WA													0	
Sandpoint	NM 11-11	WA, ID													0	
Kalispell	NM 11-12	MT													0	
Cut Bank	NM 12-10	MT	0			X					X			X		S
Shelby	NM 12-11	MT	X	X		X					0			X		S
Havre	NM 12-12	MT	0	X		X	X		X	X	X			X		S
Copalis Beach	NL 10-1,4	WA													0	
Seattle	NL 10-2	WA	X			X	0	X		X				X		
Wenatchee	NL 10-3	WA													0	
Ritzville	NL 11-1	WA	X		X	X		X		X				X	0	
Spokane	NL 11-2	WA, ID	X			X	0	X	X	X				X	X	
Wallace	NL 11-3	MT, ID													0	
Choteau	NL 12-1	MT	X	X		X	X	0	X	X				X	X	S
Great Falls	NL 12-2	MT	X	X		X	0				X			X		S
Lewistown	NL 12-3	MT	0	X		X	X		X	X	X			X		S
Hoquiam	NL 10-5	WA, OR	0			X	X	X						X	X	
Yakima	NL 10-6	WA													0	
Walla Walla	NL 11-4	WA	X		0	X	X					X		X	X	

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA INTERMEDIATE SCREENING PAGE 1 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE C-1

FUGRO NATIONAL, INC.

ONC F-16			GENERALIZED EXCLUSIONS													
NATIONAL TOPOGRAPHIC MAP SERIES INDEX			TOPOGRAPHIC		ROCK	WATER	CULTURAL									
			SPECIFIC SITING CRITERIA													
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Pullman	NL 11-5	WA, ID	0		X	X	X	X		X				X	X	
Hamilton	NL 11-6	ID, MT													0	
Butte	NL 12-4	MT													0	
White Sulphur Springs	NL 12-5	MT	0	X		X	X							X		S
Roundup	NL 12-6	MT	X	X		X	X		X		0			X		S
Vancouver	NL 10-8	OR, WA													0	
The Dalles	NL 10-9	OR, WA													0	
Pendleton	NL 11-7	OR, WA	X		X	X	X	0		X				X	X	
Grangeville	NL 11-8	OR, ID, WA													0	
Elk City	NL 11-9	ID, MT													0	
Dillon	NL 12-7	MT, ID	0				X	X						X	X	
Bozeman	NL 12-8	MT	0	X			X							X	X	
Billings	NL 12-9	MT	0	X		X	X	X	X	X	X			X		S
Salem	NL 10-11	OR													0	
Bend	NL 10-12	OR	0			X	X	X		X				X	X	
Canyon City	NL 11-10	OR	X			X		0						X		
Baker	NL 11-11	ID, OR	0		X	X	X	X				X		X	X	
Challis	NL 11-12	ID													0	
Dubois	NL 12-10	ID, MT	X		X	X		0						X	X	S
Ashton	NL 12-11	WY, ID, MT													0	
Cody	NL 12-12	WY	X	X		X	X	0			X			X		

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 2 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-16

GENERALIZED EXCLUSIONS | TOPOGRAPHIC | ROCK | WATER | CULTURAL

NATIONAL TOPOGRAPHIC
MAP SERIES
INDEX

SPECIFIC SITING CRITERIA

NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Coos Bay	NK 10-1,4	OR													0	
Roseburg	NK 10-2	OR													0	
Crescent	NK 10-3	OR	X		X	X	X	0						X	X	
Burns	NK 11-1	OR	0		X	X		X	X			X		X		
Boise	NK 11-2	OR, ID	0		X	X	X					X		X	X	
Hailey	NK 11-3	ID	X		X	X	X	0						X	X	
Idaho Falls	NK 12-1	ID	X		X	X	X	X	X					X	0	S
Driggs	NK 12-2	ID, WY	X			X	X	0	X			X			X	
Thermopolis	NK 12-3	WY	X	X		X	X	X		0	X			X		
Medford	NK 10-5	OR													0	
Klamath Falls	NK 10-6	OR	X		X	X	X	0				X		X	X	
Adel	NK 11-[illegible]	OR	0		X	X			X					X	X	
Jordan Valley	NK 11-5	OR, ID	X		X	X				X				X	0	
Twin Falls	NK 11-6	ID	X			X	X	X				X		X	0	
Pocatello	NK 12-4	ID	X		0	X	X	X					X	X	X	S
Preston	NK 12-5	WY, ID	X	X		X		0			X			X		
Lander	NK 12-6	WY	X	X		X		0		X	X			X		S
Eureka	NK 10-7, 10	CA													0	
Weed	NK 10-8	CA													0	
Alturas	NK 10-9	CA													0	
Vya	NK 11-7	NV	0		X	X			X	X				X		S

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA INTERMEDIATE SCREENING

PAGE 3 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-16			GENERALIZED EXCLUSIONS		TOPOGRAPHIC		ROCK	WATER	CULTURAL						
NATIONAL TOPOGRAPHIC MAP SERIES INDEX NAME	NUMBER	STATE	SPECIFIC SITING CRITERIA 10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
McDermitt	NK 11-6	NV	0		X	X		X		X				X		S
Wells	NK 11-9	NV	0		X	X		X						X		S
Bringham City	NK 12-7	UT													0	S
Ogden	NK 12-8	UT, WY	X	0		X	X	X						X		
Rock Springs	NK 12-9	WY	0	X		X	X				X			X		S
Redding	NK 10-11	CA	X	X		X	X	0						X		
Susanville	NK 10-12	CA													0	
Lovelock	NK 11-10	NV	0		X	X				X				X		S
Winnemucca	NK 11-11	NV	0		X	X				X				X		S
Elko	NK 11-12	NV	0		X	X	X	X	X	X				X		S
Tooele	NK 12-10	UT	X		X	0	X	X								S
Salt Lake City	NK 12-11	UT	X			X	0	X		X	X			X	X	
Vernal	NK 12-12	UT, CO	X	X		X		0		X	X			X		

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 4 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-17

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL							
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Havre	NM 12-12	MT	0			X	X		X	X	X			X		S
Glasgow	NM 13-10	MT	X	0		X				X	X			X		
Wolf Point	NM 13-11	MT	X	X		X			X	0	X			X		
Williston	NM 13-12	ND	X	0		X	X		X		X			X		S
Minot	NM 14-10	ND	X	X		X	0		X		X			X		S
Devils Lake	NM 14-11	ND	X	X		0	X			X				X		S
Thief River Falls	NM 14-12	ND, MN	X	X		0	X		X					X		
Roseau	NM 15-10	MN														
International Falls	NM 15-11	MN		X		0	X	X				X				
Lewistown	NL 12-3	MT	0	X		X	X		X	X	X			X		S
Jordan	NL 13-1	MT	0	X		X					X			X		
Glendive	NL 13-2	MT	0	X		X	X				X			X		
Watford City	NL 13-3	ND	0	X		X		X	X	X	X			X		
McClusky	NL 14-1	ND	X	X		0	X		X	X	X			X		S
New Rockford	NL 14-2	ND	X	X		0								X		S
Grand Forks	NL 14-3	ND, MN	X	X		X	X		X					0		S
Bemidji	NL 15-1	MN														
Hibbing	NL 15-2	MN		X		0	X	X		X	X	X				
Roundup	NL 12-6	MT	X	X		X	X		X		0			X		S
Forsythe	NL 13-4	MT	X	0		X			X	X	X			X		
Miles City	NL 13-5	MT	0	X		X	X				X			X		

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 5 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-17 NATIONAL TOPOGRAPHIC MAP SERIES INDEX			GENERALIZED EXCLUSIONS		TOPOGRAPHIC		ROCK	WATER	CULTURAL					
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Dickinson	NL 13-6	ND	X	0		X		X			X			X		
Bismarck	NL 14-4	ND	X	X		X	X		X	0	X			X		S
Jamestown	NL 14-5	ND	X	X		0	X							X		S
Fargo	NL 14-6	ND, MN	X			X	X	X		X				0		S
Brainerd	NL 15-4	MN														
Duluth	NL 15-5	MN, WI				0	X	X	X	X		X				
Billings	NL 12-9	MT	0	X		X	X	X	X	X	X			X		S
Hardin	NL 13-7	MT	X	X		X				X	0			X		
Ekalaka	NL 13-8	MT	0	X		X		X			X			X		S
Lemmon	NL 13-9	SD	X	0		X		X			X			X		S
McIntosh	NL 14-7	SD	X	X		X				0				X		S
Aberdeen	NL 14-8	SD	X	X		0	X		X					X		S
Milbank	NL 14-9	SD, MN	X	X		X			X	0				X		
St. Cloud	NL 15-7	MN														
Stillwater	NL 15-8	MN, WI		X		0	X			X		X				
Cody	NL 12-12	WY	X	X		X	X	0			X			X		
Sheridan	NL 13-10	WY	0	X		X	X	X			X			X		
Gillette	NL 13-11	WY	X	X		X	X	X			0			X		
Rapid City	NL 13-12	SD	X	0		X	X	X	X		X			X		
Pierre	NL 14-10	SD	X	X		X	X	X		0				X		S
Huron	NL 14-11	SD	X	X		0	X			X				X		S

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SPECIFIC SITING CRITERIA

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 6 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-17

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPO-GRAPHIC		ROCK	WATER	CULTURAL								
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Watertown	NL 14-12	SD, MN	X	X		0	X							X		S
New Ulm	NL 15-10	MN														
St. Paul	NL 15-11	MN, WI		X		X	0		X			X				
Thermopolis	NK 12-3	WY	X	X		X	X	X		0	X			X		
Arminto	NK 13-1	WY	0	X		X	X				X			X		
Newcastle	NK 13-2	WY	X	X		X		0			X			X		
Hot Springs	NK 13-3	SD	X	X		X	X	X		0				X		
Martin	NK 14-1	SD	X	X		X		X		0			X	X		
Mitchell	NK 14-2	SD	X	X		X	X			0			X	X		S
Sioux Falls	NK 14-3	SD, IA, MN	X	X		X	X						X	X	X	S
Fairmont	NK 15-1	MN, IA														
Mason City	NK 15-2	MN, IA		X		X	X					0	0			
Lander	NK 12-6	WY	X	X		X		0		X	X			X		S
Casper	NK 13-4	WY	X	0	X	X					X			X		S
Torrington	NK 13-5	WY	X	0		X	X	X			X			X		
Alliance	NK 13-6	NE	X	0		X	X	X			X			X		
Valentine	NK 14-4	NE	X	X		0		X	X					X		
O'Neill	NK 14-5	NE, SD	X	X		0				X				X		S
Sioux City	NK 14-6	NE, SD, IA	X	0		X	X			X				X		S
Ft. Dodge	NK 15-4	IA														
Waterloo	NK 15-5	IA		0		X	X					X	X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA INTERMEDIATE SCREENING

PAGE 7 OF 30

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE C-1

FUGRO NATIONAL, INC.

ONC F-17

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL									
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Rock Springs	NK 12-9	WY	0	X		X	X				X			X		S
Rawlins	NK 13-7	WY	0	X			X	X								S
Cheyenne	NK 13-8	WY	X	X		X	0				X			X		
Scottsbluff	NK 13-9	NE	X	X		0	X		X		X			X		S
North Platte	NK 14-7	NE	X	0		X	X	X						X		S
Broken Bow	NK 14-8	NE	X	0		X	X							X		
Fremont	NK 14-9	NE	X	X		X	0						X	X	X	
Omaha	NK 15-7	NE, IA					0									
Des Moines	NK 15-8	IA		X		X	0	X				X	X			
Vernal	NK 12-12	UT, CO	X	X		X		0		X	X			X		
Craig	NK 13-10	CO	0	X		X		X			X			X	X	
Greeley	NK 13-11	CO	X	X		X	0	X			X			X	X	
Sterling	NK 13-12	CO	X	0		X		X			X			X		S
McCook	NK 14-10	NE	X	0		X	X							X		S
Grand Island	NK 14-11	NE		X		X	0							X		
Lincoln	NK 14-12	NE	X	0		X	X							X		
Nebraska City	NK 15-10	NE, MO, IA	X	0	X	X				X	X					
Centerville	NK 15-11	MO, IA		0		X	X					X	X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 8 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-18

NATIONAL TOPOGRAPHIC
MAP SERIES
INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL									
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
International Falls	NM 15-11	MN		X		0	X	X				X				
Quetico	NM 15-12	MN				0		X								
Thunder Bay	NM 16-10	MI				0		X								
Hibbing	NL 15-2	MN				0	X	X		X	X	X				
Two Harbors	NL 15-3	MN, WI		X		0		X								
Hancock	NL 16-1,2	MI, MN				0	X	X	X	X		X				
Duluth	NL 15-5	MN, WI				0	X	X	X	X		X				
Ashland	NL 15-6	WI, MN, MI				0	X	0		X		X				
Iron River	NL 16-4	WI, MI		X	X	X		0			X	X				
Marquette	NL 16-5	MI		0		0	X	X	X			X				
Sault Sainte Marie	NL 16-6	MI														
Blind River	NL 17-4	MI				0										
Stillwater	NL 15-8	MN, WI		X		0	X			X		X				
Rice Lake	NL 15-2	WI		X		0	X	X		X		X	X			
Iron Mountain	NL 16-7	WI				0	X	X		X	X	X	X			
Escanaba	NL 16-8	MI, WI				0	X	X				X	X			
Cheboygan	NL 16-9	MI		0		X	X	X		X						
Alpena	NL 17-7	MI				0	X	X								
St. Paul	NL 15-11	MN, WI		X		X	0		X			X				
Eau Claire	NL 15-12	WI, MN		X		X	X			X	X	0	X			
Green Bay	NL 16-10	WI		X		X	0	X		X		0	X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 9 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-18

NATIONAL TOPOGRAPHIC
MAP SERIES
INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL									
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Manitowoc	NL 16-11	WI, MI				0	X	X					X	X		
Traverse City	NL 16-12	MI		X		X	X	0			X					
Tawas City	NL 17-10	MI		X		0		X				X				
Mason City	NK 15-2	IA, MN		X		X	X					0	0			
La Crosse	NK 15-3	WI, IA, MN		0		X	X	X	X			X	X			
Madison	NK 16-1	WI				0	0	X	X			X	X			
Milwaukee	NK 16-2	MI, WI		X		0	X	X			X	X	X			
Midland	NK 16-3	MI				X	X	X			X	0				
Flint	NK 17-1	MI		0		X	X					X	X			
Toronto	NK 17-3	NY				X	0	X		X	X	X	X			
Rochester	NK 18-1	NY				X	0	X				X	X			
Waterloo	NK 15-5	IA		0		X	X					X	X			
Dubuque	NK 15-6	IA, WI, IL		0		X	0	X				X	X			
Rockford	NK 16-4	WI, IL		X		X	0					X	X			
Racine	NK 16-5	MI, WI, IL				0	X	X				X	X			
Grand Rapids	NK 16-6	MI				X	0	X				X	X			
Detroit	NK 17-4	MI				X	0	X	X			X	X			
Erie	NK 17-5	OH, PA				0	X	X					X			
Buffalo	NK 17-6	NY, PA	X			X	0	X		X		X	X			
Elmira	NK 18-4	NY	X			X	X	X	X		X	0	0			
Des Moines	NK 15-8	IA		X		X	0	X				X	X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 10 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-18

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

SPECIFIC SITING CRITERIA

			GENERALIZED EXCLUSIONS											
			TOPOGRAPHIC		ROCK	WATER	CULTURAL							
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Davenport	NK 15-9	IA, IL		X		X	0	X	X			X	X			
Aurora	NK 16-7	IL				X	0	X	X		X	X	X			
Chicago	NK 16-8	IN, IL, MI				X	0	X			X	X	X			
Ft. Wayne	NK 16-9	IN, MI, OH				X	X	X				0	0			
Toledo	NK 17-7	OH, MI				0	0	X	X			X	X			
Cleveland	NK 17-8	OH, PA				X	0	X			X	X	X			
Warren	NK 17-9	PA	0	X		X	X	X	X		X	X	X			
Williamsport	NK 18-7	PA	0			X	X	X				X				
Centerville	NK 15-11	MO, IA		0		X	X					X	X			
Burlington	NK 15-12	IL, IA, MO		0		X	X	X	X			X	X			
Peoria	NK 16-10	IL				X	0	X				X	X			
Danville	NK 16-11	IN, IL				X	0				X	X	X			
Muncie	NK 16-12	IN, OH				X	0	X				X	X			
Marion	NK 17-10	OH		X		X	0		X			X	X			
Canton	NK 17-11	OH, PA, WV	X	X		X	0	X			X	X	X			
Pittsburgh	NK 17-12	PA	X		X	X	0	X			X	X	X			
Harrisburg	NK 18-10	PA	0			X	X	X				X	X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 11 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE C-1

FUGRO NATIONAL, INC.

ONC F-19

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL										
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Edmonston	NL 19-2	ME		0		X						X				
Campbellton	NL 19-3	ME				0										
Quebec	NL 19-4	ME		X		0										
Presque Isle	NL 19-5	ME		0		X		X	X			0				
Woodstock	NL 19-6	ME				X						0	X			
Sherbrook	NL 19-7	ME, NH	0			X					X	X				
Millinocket	NL 19-8	ME		X		X	X	X				0				
Fredericton	NL 19-9	ME				0						X				
Kingston	NL 18-10	NY				0	X									
Ogdensburg	NL 18-11	NY	X	X		X	X					0				
Lake Champlain	NL 18-12	NY, VT	0			X	X	X			X	X				
Lewiston	NL 19-10	NH, ME	0			X	X	X								
Bangor	NL 19-11	ME		0		X	X	X				X	X			
Eastport	NL 19-12	ME				0			X			X				
Rochester	NK 18-1	NY				X	0	X				X	X			
Utica	NK 18-2	NY		0		X	0	X	X			X	X			
Glens Falls	NK 18-3	NY, VT	0	X		X	X	X								
Portland	NK 19-1	ME, NH	X			X	0	X				X	X			
Bath	NK 19-2	ME				0	X	X								
Elmira	NK 18-4	NY	X			X	X	X	X		X	0	0			
Binghamton	NK 18-5	NY	0			X	X					X	X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 12 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC F-19

GENERALIZED EXCLUSIONS | TOPOGRAPHIC | ROCK | WATER | CULTURAL

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

SPECIFIC SITING CRITERIA

NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Albany	NK 18-6	NY,VT,NH,MA	X	X		X	0	X				X	X			
Boston	NK 19-4	MA,NH				X	0	X	X			X	X			
Williamsport	NK 18-7	PA	0			X	X	X				X				
Scranton	NK 18-8	PA,NY,NJ	X	X		X	0	X	X			X	X			
Hartford	NK 18-9	CT,NY	X	X		X	0	X	X			X	X			
Providence	NK 19-7	RI,MA,CT				X	0					X	X			
Harrisburg	NK 18-10	PA	0			X	X	X				X	X			
Newark	NK 18-11	NJ,PA	X			X	0	X	X		X	X	X			
New York	NK 18-12	NY				X	0	X	X				X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 13 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
1

FUGRO NATIONAL, INC.

ONC G-18

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

NAME	NUMBER	STATE	TOPO GRAPHIC		ROCK	WATER	CULTURAL									
			10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Ukiah	NJ 10-2	CA	O	X		X	X	X	X	X	X			X	X	
Chico	NJ 10-3	CA													O	
Reno	NJ 11-1	NV	O		X	X	X	X	X	X				X		S
Millett	NJ 11-2	NV	X		O	X		X						X		S
Ely	NJ 11-3	NV	O		X	X	X	X		X				X		S
Delta	NJ 12-1	UT	X		X	O		X			X			X	X	S
Price	NJ 12-2	UT	X			X	X	X			X			X	O	
Santa Rosa	NJ 10-5	CA	X	X		X	O							X		
Sacramento	NJ 10-6	CA	X	X		X	O	X		X				X	X	
Walker Lake	NJ 11-4	NV,CA	X		X	X		O		X				X		S
Tonopah	NJ 11-5	NV	X		X	X		O						X		S
Lund	NJ 11-6	NV	O		X	X		X		X				X		S
Richfield	NJ 12-4	UT	X		X	X		X			X			X	O	S
Salina	NJ 12-5	UT	X		X	X								X	O	
San Francisco	NJ 10-8	CA													O	
San Jose	NJ 10-9	CA	X			X	O	X						X		
Mariposa	NJ 11-7	CA,NV	X		X	X	X	O		X				X	X	
Goldfield	NJ 11-8	NV,CA	O		X	X		X						X		S
Caliente	NJ 11-9	NV	O		X	X		X	X					X		S
Cedar City	NJ 12-7	UT	O		X	X	X	X			X			X	X	S
Escalante	NJ 12-8	UT													O	

X EXCLUSION PRESENT

O PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 14 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-18			GENERALIZED EXCLUSIONS		TOPOGRAPHIC	ROCK	WATER	CULTURAL							
NATIONAL TOPOGRAPHIC MAP SERIES INDEX			SPECIFIC SITING CRITERIA												
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Santa Cruz	NJ 10-12	CA	0	X		X	X				X	X	X	X		
Fresno	NJ 11-10	CA	X		X	X	0							X	X	
Death Valley	NJ 11-11	CA, NV	X		X	X		0						X	X	S
Las Vegas	NJ 11-12	NV, AZ	0		X	X	X	X	X	X				X		S
Grand Canyon	NJ 12-10	AZ	X		X	X		0		X				X	X	S
Marble Canyon	NJ 12-11	AZ													0	
San Luis Obisbo	NI 10-3	CA	0	X	X	X	X	X			X			X		
Bakersfield	NI 11-1	CA	X	X	X	X	0	X	X	X	X			X	X	S
Trona	NI 11-2	CA	X		0	X	X	X						X		S
Kingman	NI 11-3	AZ, CA, NV	0		X	X	X	X		X				X		S
Williams	NI 12-1	AZ	X	X	0	X		X		X				X	X	S
Flagstaff	NI 12-2	AZ	X	X	X	X	X			0				X		S
Santa Maria	NI 10-6,9	CA													0	
Los Angeles	NI 11-4	CA			X						X			X	0	
San Bernardino	NI 11-5	CA	X		X	X	0	X						X		S
Needles	NI 11-6	AZ, CA	0		X	X		X		X				X		S
Prescott	NI 12-4	AZ	0		X	X	X	X						X	X	S
Holbrook	NI 12-5	AZ	X		X	X	X	0		X				X		S
Long Beach	NI 11-7	CA													0	
Santa Ana	NI 11-8	CA	X			X	0	X		X				X		
Salton Sea	NI 11-9	CA, NV	X		0	X	X	X	X	X				X		S

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 15 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-18

NATIONAL TOPOGRAPHIC
MAP SERIES
INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL									
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Phoenix	NI 12-7	AZ	X		X	X	0		X	X				X		S
Mesa	NI 12-8	AZ	X		X	X	X	0		X				X		S
San Diego	NI 11-11	CA	X				0	X		X				X		
El Centro	NI 11-12	CA, AZ	X		X	X	0	X	X					X		S
Ajo	NI 12-10	AZ	0		X	X	X		X	X				X		S
Tucson	NI 12-11	AZ	X	X	X	X	0	X		X				X		S
Lukeville	NH 12-1	AZ													0	
Nogales	NH 12-2	AZ	X	X	X	X	X	0		X				X		S

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 16 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-19

GENERALIZED EXCLUSIONS | TOPOGRAPHIC | ROCK | WATER | CULTURAL

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

SPECIFIC SITING CRITERIA

NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Ely	NJ 11-3	NV	0		X	X	X	X		X				X		S
Delta	NJ 12-1	UT	X		X	0		X			X			X	X	S
Price	NJ 12-2	UT	X			X	X	X			X			X	0	
Grand Junction	NJ 12-3	CO,UT	0			X	X			X	X	X		X		
Leadville	NJ 13-1	CO													0	
Denver	NJ 13-2	CO	X	X		X	X	0			X			X	X	S
Limon	NJ 13-3	CO	X			X					X		X	X	X	S
Goodland	NJ 14-1	KS	X	X		X	X				X		0	X	X	S
Lund	NJ 11-6	NV	0		X	X		X		X				X		S
Richfield	NJ 12-4	UT	X		X	X		X			X			X	0	S
Salina	NJ 12-5	UT	X		X	X								X	0	
Moab	NJ 12-6	UT,CO	0			X		X			X			X	X	
Montrose	NJ 13-4	CO	X	X			X	0			X			X	X	
Pueblo	NJ 13-5	CO	X	X		X	0	X						X	X	S
Lamar	NJ 13-6	CO	X	X		0	X				X	X			X	S
Scott City	NJ 14-4	KS	X	X		X					X		0	X	X	S
Caliente	NJ 11-9	NV	0		X	X		X	X					X		S
Cedar City	NJ 12-7	UT	0		X	X	X	X			X			X	X	S
Escalante	NJ 12-8	UT													0	
Cortez	NJ 12-9	CO,UT													0	
Durango	NJ 13-7	CO	X			X	X	0		X				X	X	

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 17 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-19

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL									
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Trinidad	NJ 13-8	CO	O	X		X	X	X			X			X	X	S
La Junta	NJ 13-9	CO	X	X		X	X	X			X			X	O	S
Dodge City	NJ 14-7	KS	X		X	X	X				O			X		S
Las Vegas	NJ 11-12	NV, AZ	O		X	X	X	X	X	X				X		S
Grand Canyon	NJ 12-10	AZ	X		X	X		O		X				X	X	S
Marble Canyon	NJ 12-11	AZ													O	
Shiprock	NJ 12-12	NM, AZ					X	X		O	X					
Aztec	NJ 13-10	NM	X		X	X	X	X		X	O				X	
Raton	NJ 13-11	NM	X		O	X	X	X			X			X	X	
Dalhart	NJ 13-12	NM, TX, OK	O		X	X	X	X			X			X		S
Perryton	NJ 14-10	TX, OK	X	X		X	X				O			X		S
Kingman	NI 11-3	AZ, CA, NV	O		X	X	X	X		X				X		S
Williams	NI 12-1	AZ	X	X	O	X		X		X				X	X	S
Flagstaff	NI 12-2	AZ	X		X	X	X	X		O						S
Gallup	NI 12-3	NM, AZ	X		X	X	X	X		O	X			X		S
Albuquerque	NI 13-1	NM	X		X	X	X	X		X	O			X	X	
Santa Fe	NI 13-2	NM	X		X	X	X							X	O	
Tucumcar	NI 13-3	NM, TX	X	X	X	X	X				X			X	O	S
Amarillo	NI 14-1	TX	X	X		X	X				O			X		S
Prescott	NI 12-4	AZ	O		X	X	X	X						X	X	S
Holbrook	NI 12-5	AZ	X		X	X	X	O		X				X		S

X EXCLUSION PRESENT

O PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 18 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-19			GENERALIZED EXCLUSIONS													
NATIONAL TOPOGRAPHIC MAP SERIES INDEX			SPECIFIC SITING CRITERIA													
			TOPO-GRAPHIC		ROCK	WATER	CULTURAL									
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FFET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
St. Johns	NI 12-6	NM,AZ	X	X	X	0	X	X		X	X			X		S
Socorro	NI 13-4	NM	X		X	X	X	X		0	X			X	X	S
Ft. Sumner	NI 13-5	NM			X	X		X						X	0	S
Clovis	NI 13-6	NM,TX	X		X	X	0		X					X	X	S
Plainview	NI 14-4	TX	X	X		X	X				X			0		S
Phoenix	NI 12-7	AZ	X		X	X	0		X	X				X		S
Mesa	NI 12-8	AZ	X		X	X	X	0		X				X		S
Clifton	NI 12-9	AZ,NM	X	X	X	X	X	X		0				X		S
Tularosa	NI 13-7	NM	X	X	X	X		0	X		X			X	X	S
Roswell	NI 13-8	NM	X		X	X	X	X		X	X			X	0	S
Brownfield	NI 13-9	TX,NM	X		X	X	X		X		0			X		S
Lubbock	NI 14-7	TX	X	X		X	X				X			0		S
Ajo	NI 12-10	AZ	0		X	X	X		X	X				X		S
Tucson	NI 12-11	AZ	X	X	X	X	0	X		X				X		S
Silver City	NI 12-12	NM,AZ	0	X	X	X		X			X			X		S
Las Cruces	NI 13-10	NM	0		X	X	X	X			X			X		S
Carlsbad	NI 13-11	NM	X		X	X	X	X			X			X	X	S
Hobbs	NI 13-12	NM,TX	X		X	X	X				0			X		S
Big Spring	NI 14-10	TX	X	X	X	X	0				X			X		S
Lukeville	NH 12-1	AZ													0	
Nogales	NH 12-2	AZ	X	X	X	X	X	0		X				X		S

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 19 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-19

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL								
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Douglas	NH 12-3	AZ,NM	X		0	X	X	X						X		S
El Paso	NH 13-1	TX,NM	X		X		0							X		S
Van Horn	NH 13-2	TX	X		0	X	X				X			X		S
Pecos	NH 13-3	TX	X		0	X	X				X			X		S
San Angelo	NH 14-1	TX	X		0	X	X				X			X		

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 20 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-20 NATIONAL TOPOGRAPHIC MAP SERIES INDEX			GENERALIZED EXCLUSIONS SPECIFIC SITING CRITERIA		TOPO-GRAPHIC		ROCK	WATER	CULTURAL					
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Goodland	NJ 14-1	KS	X	X		X	X				X		0	X	X	S
Beloit	NJ 14-2	KS	0	X		X					X			X		
Manhattan	NJ 14-3	KS	X	X		X	0				X			X		
Kansas City	NJ 15-1	KS, MO	X	X		X	0		X	X	X	X	X	X		
Moberly	NJ 15-2	MO		X		X	X	X	X			0	0			
Quincy	NJ 15-3	MO, IL		X		X	X	X	X			0	0			
Decatur	NJ 16-1	IL					0				X	X	X			
Scott City	NJ 14-4	KS	X	X		X					X		0	X	X	S
Great Bend	NJ 14-5	KS	X	X		X	X				X			X		S
Hutchinson	NJ 14-6	KS	X	X		X	0				X			X		
Lawrence	NJ 15-4	KS, MO		X		X	0				X	0	0	X		
Jefferson City	NJ 15-5	MO		0		X	X	X			X	X	X			
St. Louis	NJ 15-6	MO, IL		X		X	0	X			X	X	X			
Belleville	NJ 16-4	IL				X	X				X	0	0			
Dodge City	NJ 14-7	KS	X		X	X	X				0			X		S
Pratt	NJ 14-8	KS	X	X		0	X				X			X		S
Wichita	NJ 14-9	KS	X	X		X	0				X			X		
Joplin	NJ 15-7	KS, MO	X	X		X	X				0	0	0	X		
Springfield	NJ 15-8	MO		0		X	X	X				X	X			
Rolla	NJ 15-9	MO	0			X	X	X				X	X			
Paducah	NJ 16-7	IL, MO KY		X		X	0	X			X	X				

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 21 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

ONC G-20			GENERALIZED EXCLUSIONS		TOPOGRAPHIC	ROCK	WATER	CULTURAL							
NATIONAL TOPOGRAPHIC MAP SERIES INDEX			SPECIFIC SITING CRITERIA												
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS SUITABLE AREA
Perryton	NJ 14-10	TX,OK	X	X		X	X	X			0			X	S
Woodward	NJ 14-11	OK													
Enid	NJ 14-12	OK			X	X	0			X	X			X	
Tulsa	NJ 15-10	OK,MO AR	X	0		X	0	X			X	X	X	X	
Harrison	NJ 15-11	MO,AR	0	X		X	X	X				X	X		
Polar Bluff	NJ 15-12	MO,AR		0		X	X	X	X			X	X		
Dyersburg	NJ 16-10	MO,TN KY		X		X	X	X	X			0	0		
Clinton	NI 14-2	OK	X		X	0	X				X			X	X
Oklahoma City	NI 14-3	OK	X			X	0				X				
Ft. Smith	NI 15-1	OK,AR	X		X	X	0	X			X	X	X		X
Russellville	NI 15-2	AR	0	X		X	X	X				X	X		
Memphis	NI 15-3	AR,TN	X			0	X		X						
Blytheville	NI 16-1	TN,AR		X		X	X	X				0	0		
Lawton	NI 14-5	OK,TX	X		X	0	X				X			X	X
Ardmore	NI 14-6	OK													
McAlester	NI 15-4	OK,AR	0			X	X	X			X	X	X	X	
Little Rock	NI 15-5	AR	X			X	0	X				X	X		
Helena	NI 15-6	AR,MS				X	X	X	X			X			
Tupelo	NI 16-4	MS,AL				X	X	0				X	X		
Wichita Falls	NI 14-8	TX	X	X	X	X	X				X			0	
Sherman	NI 14-9	TX,OK	X	X	X	X	0				X			X	

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 22 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-20

NATIONAL TOPOGRAPHIC
MAP SERIES
INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL								
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Texarkana	NI 15-7	TX, OK AR	X			X	0	X			X	X	X	X	X	
El Dorado	NI 15-8	AR				X	X		X		X	0	0			
Greenwood	NI 15-9	MS, AR				X	X	X	X			0	X			
West Point	NI 16-7	MS, AL		0		X	X	X	X			X	X			
Abilene	NI 14-11	TX	X	X	0	X	X				X			X		
Dallas	NI 14-12	TX	X	X	X	X	0				X			X		
Tyler	NI 15-10	TX	X	X		X	X				X	0	0	X		
Shreveport	NI 15-11	LA				X	X	X			X	0	0			
Jackson	NI 15-12	MS, LA		X		0	X	X				X	X			
Meridian	NI 16-10	MS, AL		0		X	X	X		X		X	X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 23 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-21

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL								
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Cincinnati	NJ 16-3	OH, IN				X	0	X				X	X			
Columbus	NJ 17-1	OH	0			X	0	X				X	X	X		
Clarksburg	NJ 17-2	WV, OH PA	X	X		X	0	X				X	X			
Cumberland	NJ 17-3	WV, MD PA	0			X	X	X				X	X			
Baltimore	NJ 18-1	MD, PA	X	X		X	0	X				X	X			
Wilmington	NJ 18-2	DE, NJ PA, MD				X	0	X	X			X	X			
Louisville	NJ 16-6	KY, IN OH	0	X		X	0	X				X	X			
Huntington	NJ 17-4	WV, KY OH	0	X		X	X	X			X	X	X	X		
Charleston	NJ 17-5	WV, OH	0			X	X	X			X					
Charlottesville	NJ 17-6	VA, WV	0				X	X				X	X			
Washington	NJ 18-4	MD, VA		X		0	X	X	X			X	X			
Salisbury	NJ 18-5	MD, DE				0	X	X	X			X	X			
Winchester	NJ 16-9	KY	X	X			X	X			X	X	X			
Jenkins	NJ 17-7	KY, WV VA	0				X		X		X	X	X	X		
Bluefield	NJ 17-8	VA, WV	0			X	X	X	X		X	X	X	X		
Roanoke	NJ 17-9	VA	0	X		X	X	X				X	X	X		
Richmond	NJ 18-7	VA, MD				X	0	X	X		X	X	X			
Eastville	NJ 18-8	VA, MD				0	X	X	X							
Corbin	NJ 16-12	KY, TN	0	X		X	X	X	X		X					
Johnson City	NJ 17-10	TN, KY, VA, NC	0			X	X	X	X			X	X			
Winston-Salem	NJ 17-11	NC, VA	0			X	X	X				X	X			

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 24 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC G-21

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL									
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Greensboro	NJ 17-12	NC,VA	X	X		X	0					X	X	X		
Norfolk	NJ 18-10	VA,NC				0	X	X				X	X	X		
Chattanooga	NI 16-3	TN,NC	0			X	0	X			X	X	X	X		
Knoxville	NI 17-11	TN,NC SC	0			X	X	X			X	X	X	X		
Charlotte	NI 17-2	NC,SC	X			X	0	X				X	X	X		
Raleigh	NI 17-3	NC				X	0	X				X	X	X		
Rocky Mount	NI 18-1	NC				0	X	X	X			X	X			
Manteo	NI 18-2	NC				0	X	X	X							
Rome	NI 16-6	AL,GA	0			X	0	X			X	X	X			
Greenville	NI 17-4	SC,GA	0			X	0	X				X	X			
Spartanburg	NI 17-5	SC,NC		0		X	0	X	X			X	X	X		
Florence	NI 17-6	NC,SC		X		0	X					X	X	X		
Beaufort	NI 18-4	NC				0	X	X					X			
Atlanta	NI 16-9	GA,AL	0			X	0					X	X			
Athens	NI 17-7	GA,SC				X	X	X	X			0	0			
Augusta	NI 17-8	GA,SC		X		X	X	X	X			0	0	X		
Georgetown	NI 17-9	SC,NC				0	X	X				X	X			
Phoenix City	NI 16-2	AL,GA		X		X	X	X	X			0	X	X		
Macon	NI 17-10	GA		X		X	X	X				0	0			
Savannah	NI 17-11	GA,SC				0	X	X	X			X	X			
James Island	NI 17-12	SC				0	X	X	X							

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 25 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC H-23

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS

SPECIFIC SITING CRITERIA

			TOPOGRAPHIC		ROCK	WATER	CULTURAL									
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Douglas	NH 12-3	AZ, NM	X		0	X	X	X						X		S
El Paso	NH 13-1	TX, NM	X		X	X	0							X		S
Van Horn	NH 13-2	TX	X		0	X					X			X		S
Pecos	NH 13-3	TX	X		0	X	X				X			X		S
San Angelo	NH 14-1	TX	X		0	X	X				X			X		
Brownwood	NH 14-2	TX	X	X	0	X	X				X			X		
Waco	NH 14-3	TX	X	X	X	X	0	X			X			X		
Marfa	NH 13-5	TX	0	X	X	X					X			X		S
Ft. Stockton	NH 13-6	TX	0	X	X	X	X				X			X		S
Sonora	NH 14-4	TX	X	X	0						X			X		
Llano	NH 14-5	TX	X	X	0	X	X				X			X		
Austin	NH 14-6	TX	X	X	X	X	0	X			X			X		
Presidio	NH 13-8	TX	0	X										X		
Emory Peak	NH 13-9	TX	X	X	X			0						X	X	S
Del Rio	NH 14-7	TX	X	X	0	X	X				X			X		S
San Antonio	NH 14-8	TX	0	X	X	X	X				X			X		S
Seguin	NH 14-9	TX	X	0		X	X				X			X		
Eagle Pass	NH 14-10	TX		X	0	X	X				X.			X		S
Crystal City	NH 14-11	TX		X		X	X				0			X		S
Beeville	NH 14-12	TX				X	X		X		0			X		
Laredo	NG 14-2	TX	X	X	X	X	X				0			X		S

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA INTERMEDIATE SCREENING

PAGE 28 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE C-1

FUGRO NATIONAL, INC.

ONC H-23

NATIONAL TOPOGRAPHIC
MAP SERIES
INDEX

GENERALIZED EXCLUSIONS | TOPOGRAPHIC | ROCK | WATER | CULTURAL

SPECIFIC SITING CRITERIA

NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Corpus Christi	NG 14-3	TX				0	X				X			X		
McAllen	NG 14-5	TX	X	X	X	X	X				0			X		
Brownsville	NG 14-6,9	TX				0	X				X					

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 27 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

AD-A112 496 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION GEOTECHNICAL EVALUATION CONTERMINOUS UN--ETC(U)
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UNCLASSIFIED FN-TR-17
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4 of 4

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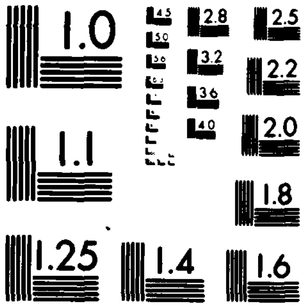


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ONC H-24

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

NAME	NUMBER	STATE	GENERALIZED EXCLUSIONS 10% SLOPES	RELATIVE RELIEF	TOPOGRAPHIC BEDROCK WITHIN 50 FEET	ROCK WATER WITHIN 50 FEET	WATER POPULATION CENTERS	CULTURAL STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Waco	NH 14-3	TX	X	X	X	X	0	X			X			X		
Palestine	NH 15-1	TX	X	X		X	0	X			X			X		
Alexandria	NH 15-2	LA, TX	X	X		X	X	0			X	X	X	X		
Natchez	NH 15-3	MS, LA		0		X	X	X			X	X	X			
Hattiesburg	NH 16-1	MS, AL		X		X	0	X	X		X	X	X			
Andalusia	NH 16-2	AL		0		X	X	X			X	X	X			
Dothan	NH 16-3	GA, AL		X		X	X		X	X		0	X			
Austin	NH 14-6	TX	X	X	X	X	0	X			X			X		
Beaumont	NH 15-4	TX	X	X		X	X	X			0			X		
Lake Charles	NH 15-5	LA, TX	X	0		0	X	X			X		X	X		
Baton Rouge	NH 15-6	LA				X	0				X	X	X			
Mobile	NH 16-4	MS, LA, AL				X	0	X				X	X			
Pensacola	NH 16-5	FL, AL				0	X	X				X	X			
Tallahassee	NH 16-6	FL, GA		X		X	X	X	X				X			
Seguin	NH 14-9	TX	X	0		X	X				X			X		
Houston	NH 15-7	TX				X	0				X			X		
Port Arthur	NH 15-8	LA, TX				0	X		X						0	
New Orleans	NH 15-9	LA				0	X		X		X					
Breton Sound	NH 16-7	LA				0	X		X		X					
Apalachicola	NH 16-9	FL				0		X	X							
Beeville	NH 14-12	TX				X	X		X		0			X		

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 28 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

ONC H-24

NATIONAL TOPOGRAPHIC MAP SERIES INDEX

GENERALIZED EXCLUSIONS | TOPOGRAPHIC | ROCK | WATER | CULTURAL

SPECIFIC SITING CRITERIA

NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Bay City	NH 15-10	TX				0	X				X					
Corpus Christi	NG 14-3	TX				0	X				X			X		

X EXCLUSION PRESENT

0 PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 29 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

FN-TR-17

ONC H-25

NATIONAL TOPOGRAPHIC
MAP SERIES
INDEX

			GENERALIZED EXCLUSIONS			TOPO-GRAPHIC	ROCK	WATER	CULTURAL						
			SPECIFIC SITING CRITERIA												
NAME	NUMBER	STATE	10% SLOPES	RELATIVE RELIEF	BEDROCK WITHIN 50 FEET	WATER WITHIN 50 FEET	POPULATION CENTERS	STATE & NAT'L PARKS, FORESTS	WILDLIFE REFUGES	INDIAN RESERVATIONS	RESOURCE AREAS	DRAINAGE DENSITIES	ROAD/PIPELINE DENSITIES	MINIMUM PARCELS	COARSE SCREEN EXCLUSIONS	SUITABLE AREA
Dothan	NH 16-3	AL, GA		X		X	X		X	X		O	X			
Waycross	NH 17-1	GA		X		O	X	X	X			X	X			
Brunswick	NH 17-2	GA				O	X	X	X				X			
Tallahassee	NH 16-6	FL, GA		X		X	X	X	X				X			
Valdosta	NH 17-4	GA, FL				O	X	X	X			X	X			
Jacksonville	NH 17-5	FL, GA				O	X	X								
Apalachicola	NH 16-9	FL				O		X	X							
Gainesville	NH 17-7	FL				O	X		X				X			
Daytona Beach	NH 17-8	FL				O	X	X	X				X			
Plant City	NH 17-10	FL				O	X	X	X				X			
Orlando	NH 17-11	FL				X	O		X				X			
Tampa	NG 17-1,4	FL				X	O		X				X			
Ft. Pierce	NG 17-2	FL				O	X	X		X						
West Palm Beach	NG 17-5	FL				O	X		X	X						
Miami	NG 17-8	FL				O	X	X					X			
Key West	NG 17-11	FL				O	X	X	X							

X EXCLUSION PRESENT

O PRIMARY EXCLUSION ACCOUNTING FOR MOST EXCLUDED AREA RELATIVE TO OTHER CRITERIA

S SUITABLE AREA PRESENT

SUMMARY OF UNSUITABLE AREA
INTERMEDIATE SCREENING
PAGE 30 OF 30

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

MX SITING TERMINOLOGY

The MX siting terminology presented here was submitted to SAMSO on 28 July 1977. It addresses preferred word usages for MX siting studies. Any term not modified in some way as described below will be considered general in nature and revert to its common usage (e.g. in the Phoenix area or the region of San Francisco). A graphic description of MX siting terminology is presented as Figure D-1.

Conterminous United States (CONUS) - The contiguous 48 states.

Candidate Siting Province (CSP) - An area potentially suitable for deployment of the MX system generally encompassing more than 6000 square nautical miles which, in a broad sense, is homogenous with respect to most of the important characteristics governing siting of a total MX system. The specific Candidate Siting Provinces for MX are shown on Drawing 1.

Candidate Siting Region (CSR) - Potentially suitable area between 4000 and 6000 square nautical miles within one, or encompassing portions of more than one, Candidate Siting Province which allows for full MX deployment.

Candidate Deployment Area (CDA) - An area encompassing between 500 and 1000 square nautical miles of potentially suitable area with either naturally or artificially defined boundaries designated for convenience of study, discussion and data depiction.

The Candidate Deployment Area could be composed of two to four parcels and should have a specific place name description.

Candidate Deployment Parcel (CDP) - An area of 150 to 500 square nautical miles potentially suitable for MX siting which, when aggregated with others, forms a Candidate Deployment Area. Each parcel will have a specific geographic description. (In the Basin and Range physiographic province a parcel may correspond to a geographic valley or in Texas to some agri-economic unit.)

Candidate Deployment Site (CDS) - A non-specific (i.e. not finally approved) site proposed for some element of the MX system within a chosen Deployment Area (i.e. trench or shelter site).

Candidate - One of some group of regions, areas or sites being considered for MX deployment. Removal of candidate from a specifically named region, area or site term indicates selection by SAMSO/MNND.

Prime - Modifier used to indicate the highest ranking province, region, area, or site. If not an interdisciplinary ranking, then a qualifier will be used such as "prime geotechnical candidate siting area".

Site - Location of some specific activity or reference point. The term will always be modified to a precise meaning or be clearly understood from the context of the discussion.

Examples of siting terminology usage may be:

"...the Great Basin CSP..."

"...the High Plains CSR is in the northern portion of the Southern Great Plains CSP."

"...Dry Lake CDP..."

"...CDS #244 within Dry Lake DA."

SUGGESTED ABBREVIATIONS

Conterminous United States - CONUS

Candidate Siting Province - CSP

Siting Province - SP

Candidate Siting Region - CSR

Siting Region - SR

Candidate Deployment Area - CDA

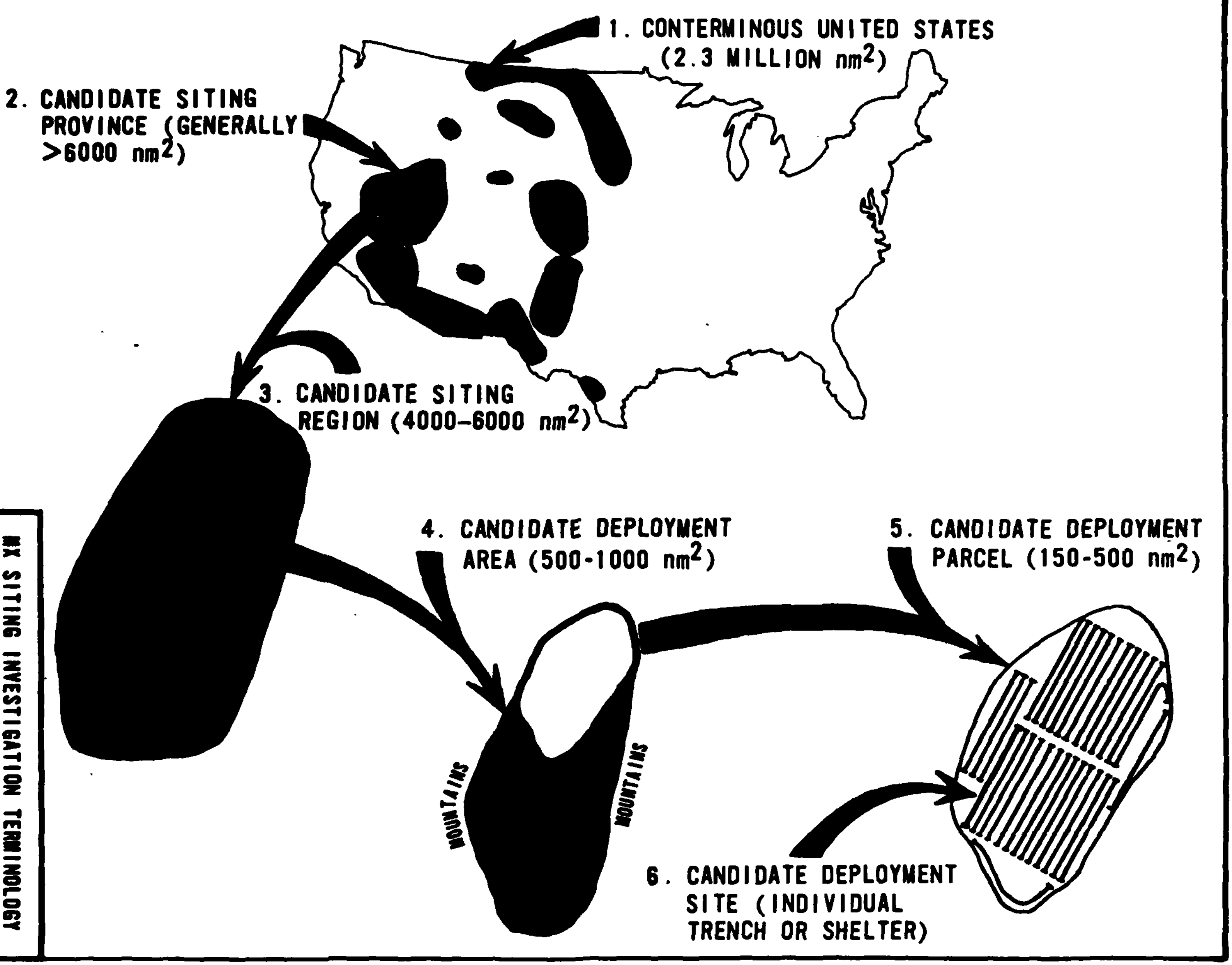
Deployment Area - DA

Candidate Deployment Parcel - CDP

Deployment Parcel - DP

Candidate Deployment Site - CDS

Deployment Site - DS



MX SITING INVESTIGATION TERMINOLOGY INTERMEDIATE SCREENING CRITERIA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
D-1

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