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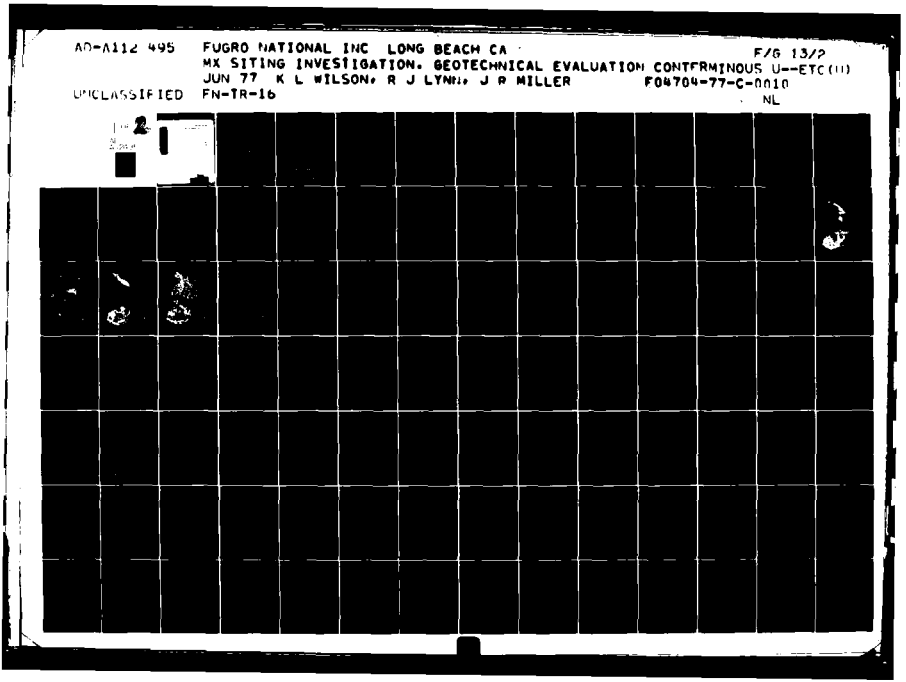

MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION CONTERMINOUS UNITED STATES

VOLUME I
COARSE SCREENING

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

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COARSE SCREENING REPORT

MX SITING INVESTIGATION

CONTERMINOUS UNITED STATES

Prepared for:

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Norton Air Force Base, California 92409

By:

Fugro National, Inc.
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1 June 1977

ABSTRACT

At the request of SAMSO, a three stage screening program was begun to evaluate the conterminous United States (CONUS) for MX siting. In the initial stage, Coarse Screening, the following primary exclusion criteria were applied: surface rock, or rock within fifty feet of the ground surface unless of a rippable nature; surface water or ground water within fifty feet of the surface; cultural features; quantity-distance relationships; and topographic grade greater than ten percent. Of the total CONUS area 238,309 nm^2 were identified as suitable or potentially suitable for MX siting.

Suitable areas have a higher likelihood of remaining viable MX siting area in further screening studies unless additional criteria are added. Substantial amounts of potentially suitable area were defined on the basis of an inadequate data base in these areas. These are likely to be reduced significantly in the more detailed Intermediate Screening studies.

The suitable area was divided into 23 groups primarily on the basis of state boundaries and similar geotechnical conditions. These groups were ranked according to the confidence level for the data used in the screening process, and the number of unit siting regions of 5000 nm^2 contained in each. The highest ranked suitable areas occur in the Basin and Range and Central High Plains physiographic provinces.

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, and deals with the screening of the conterminous United States (CONUS) for identifying candidate areas suitable for deploying the MX Land Mobile Advanced ICBM system.

This report presents the scope, approach, and results of the Coarse Screening study, which is the first of a three-stage screening program. Intermediate Screening and Fine Screening/ Characterization studies will build upon the results of the preceding study. The end result of the screening process will be a prioritized listing of the technically suitable Candidate Siting Provinces for MX system deployment.

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1.0 INTRODUCTION

1.1 BACKGROUND

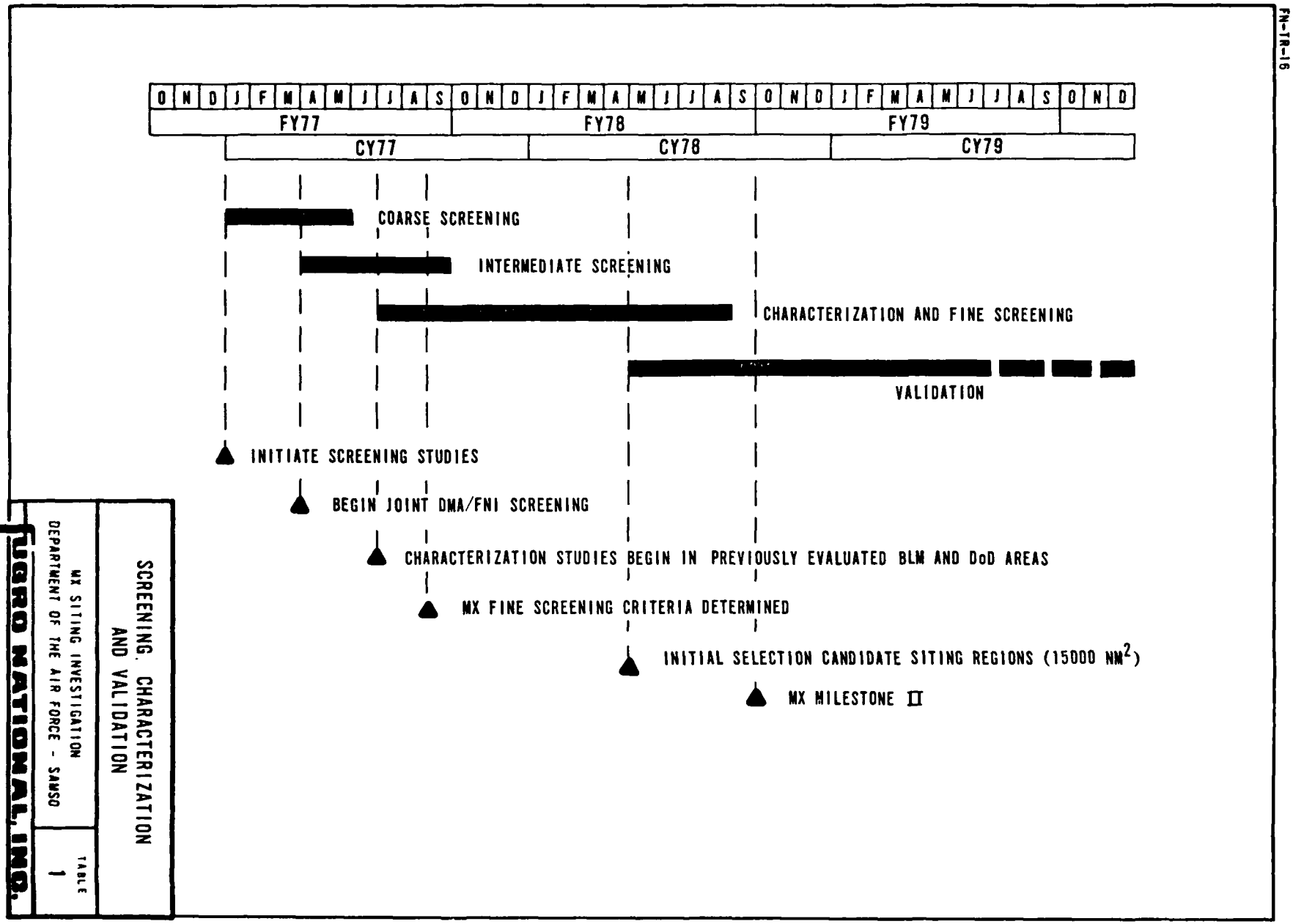
The screening study approach was formulated in December, 1976 in response to a request by SAMSO for a uniform evaluation of the entire conterminous United States utilizing a well-documented approach of data gathering and compilation in order to substantiate future MX site selection decisions.

Coarse Screening was initiated upon verbal SAMSO authorization on 10 January 1977 and the formalized details of the overall screening approach were presented in a Level 2 program plan submitted to SAMSO on 1 March 1977. The direct progression from Coarse to Fine Screening was modified by SAMSO late in the finalization of this Coarse Screening study. An intermediate step (Intermediate Screening) was proposed to expedite analysis of the large suitable area identified in the Coarse Screening study. An Intermediate Screening report will document this study.

Coarse Screening was designed to provide the technical basis to define reasonable alternative siting areas in which more detailed MX geotechnical and environmental screening studies can proceed. The screening criteria and their application to the CONUS area for Coarse Screening are, by design, simple. Screening of the CONUS area with these basic technical criteria allowed for large areas of the CONUS to be dismissed from present MX siting considerations. It was anticipated both in the formulation of the overall geotechnical screening program and in

the scope of Coarse Screening that more specific siting criteria would be added in later Intermediate and Fine Screening stages, thus necessitating an increasingly more detailed approach and scope over smaller size areas. Coarse Screening as presented herein provides an expedient and fully documented methodology for analyzing the entire CONUS area, eliminating unsuitable regions relatively early in the overall MX siting process, and identifying areas that will require additional evaluation by follow-on screening and characterization studies.

Table 1 shows the screening milestones as established by SAMSO. The three-staged screening approach will provide an increasingly narrow focus of attention on the most reasonable, viable candidate sites, ultimately leading to selection of preferred and alternate Candidate Siting Regions (CSR) by early FY 78 and initiation of geotechnical validation studies.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COARSE SCREENING
INTERMEDIATE SCREENING
CHARACTERIZATION AND FINE SCREENING
VALIDATION
INITIATE SCREENING STUDIES
BEGIN JOINT DMA/FNI SCREENING
CHARACTERIZATION STUDIES BEGIN IN PREVIOUSLY EVALUATED BLM AND DoD AREAS
MX FINE SCREENING CRITERIA DETERMINED
INITIAL SELECTION CANDIDATE SITING REGIONS (15000 NM^2)
MX MILESTONE II
FN-TR-16
SCREENING, CHARACTERIZATION AND VALIDATION
TABLE 1
MX SITING INVESTIGATION
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1.2 OBJECTIVES, APPROACH, SCOPE, AND EXCLUSION CRITERIA

1.2.1 OBJECTIVES

The objectives of Coarse Screening were:

1. To provide and implement an expedient method of evaluating MX siting suitability of the entire conterminous United States based upon the basic geotechnical and cultural screening criteria provided by SAMSO (Section 1.2.4), and
2. To identify reasonable alternative siting areas in which to initiate more detailed Intermediate and Fine Screening/ Characterization activities.

With concurrence by SAMSO our established approach was to evaluate the potential suitability of all areas within the conterminous United States and exclude only those areas which clearly did not satisfy conditions of the basic technical criteria. Study areas were given a general ranking according to their degree of suitability. Depending upon the requirements of SAMSO, the highest technically ranked areas may not necessarily be given the highest priority for future study.

1.2.2 APPROACH

The Coarse Screening study involved principally the collection and review of regional geotechnical data at various scales and degrees of completeness, and discussions with state and federal technical staff who have expertise in a particular region. The data were compiled on worksheets with the results presented here at a scale of 1:5,000,000 (Drawing 1).

To facilitate study logistics and data collection, the conterminous United States area was divided into study areas based on the American Association of Petroleum Geologists (AAPG) Geological Highway Map series. This map series has boundaries which coincide with state borders and roughly encompass major physiographic provinces. Overall, these maps provided baseline geological information and served as data acquisition limits for screening personnel.

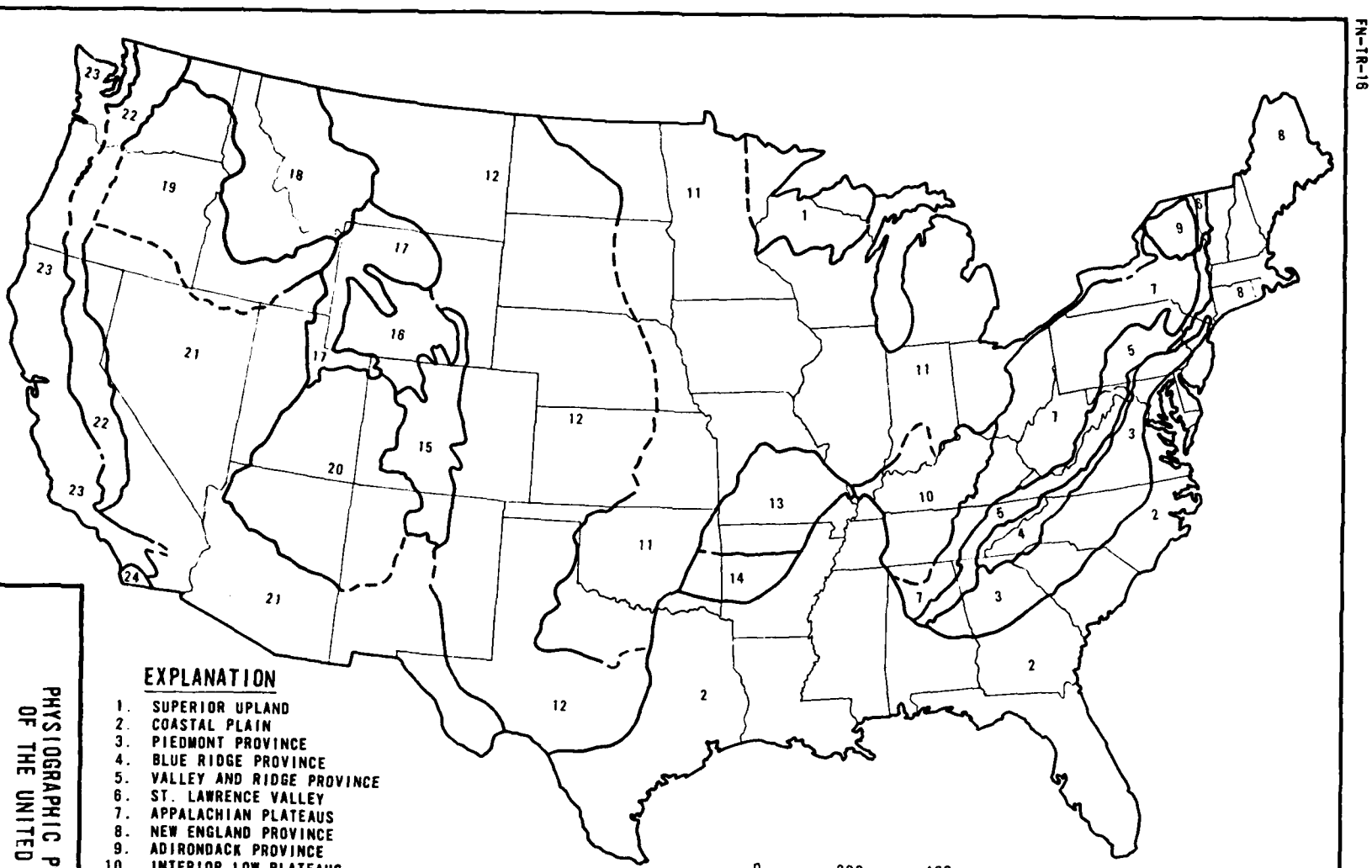
Data were analyzed and summarized by the recognized physiographic divisions (Figure 1) as presented by Fenneman (1946). These divisions encompass broadly similar topographic, geomorphic, hydrologic and geological conditions.

Area calculations used in this report are based on data derived from digitized and computerized map information for the suitable and potentially suitable MX siting areas. The data are accurate to within one to two percent of the actual depicted areas. The largest deviations occur in those states whose total area include offshore islands or inland waterways, neither of which were considered in the screening analysis.

1.2.3 SCOPE

The investigation consisted of the following efforts:

1) Literature search at major local university libraries and analysis of data pertinent to the screening criteria.
2) Personal contacts (oral and written) with geologists, hydrologists, and others in state and regional offices to corroborate and supplement data collected from published



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PHYSIOGRAPHIC PROVINCES OF THE UNITED STATES

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FIGURE 1

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material. Discussions generally included availability of published data and the current state of knowledge in a particular area.

3) Compilation of the collected data upon separate worksheet overlays at scale 1:2,500,000. The worksheet overlays depict:
   a. Surface rock, rock within a nominal 50 feet of the ground surface, areas of rippable rock or where the data are inadequate to define rock conditions
   b. Surface water, ground water within a nominal 50 feet of the ground surface and areas where the data were inadequate to define ground-water conditions
   c. Topographic grade greater than ten percent
   d. Cultural exclusions (Section 1.2.4)
   e. Quantity/Distance exclusion (Section 1.2.4)
   f. Minimum area exclusions (Section 1.2.4)

The data for each of the overlays were compiled separately to preserve the uniqueness of the data base and to facilitate total and partial exclusion analyses. In addition, this allowed for modification of individual screening criteria.

1.2.4 SCREENING CRITERIA

The basic screening criteria shown in Table 2 were furnished by SAMSO, and consider geotechnical, cultural, quantity-distance relations and minimum area requirements for a deployed land-based MX system. The criteria were applied concurrently and at compatible scales throughout the CONUS area.

Geotechnical criteria includes topographic grade and minimum depths to rock and ground water, all critical considerations for MX systems design cost, construction, and operation. Cultural and quantity-distance criteria consider potential MX system coexistence conflicts. The minimum area criterion was applied following all the other criteria, its purpose being to eliminate small spatially detached parcels of suitable area.

FN-TR-16

CRITERIA[1]	DEFINITION AND COMMENTS[2]
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 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.
CULTURAL	All significant federal and state forests, parks, monuments, and recreation areas. All significant federal and state wildlife refuges, ranges, preserves and management areas, and indian reservations.
QUANTITY/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.
TOPOGRAPHIC	All areas having surface gradients exceeding 10 percent as determined from maps at scale 1:500,000.
MINIMUM PARCEL (SECONDARY CRITERIA)	All parcels or aggregate parcels having total area less than 500 nm^2. Individual parcels must be less than 10 nm from adjacent suitable parcels to be included in the aggregate total.

NOTES: (1) Data used in applying the siting criteria were compiled on separate overlays and composited to form the final exclusion map.
(2) Additional data concerning application and limitations of each exclusion criterion are included in Appendix B.

COARSE SCREENING CRITERIA

MX SITING INVESTIGATION
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TABLE 2

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2.0 SUMMARY OF RESULTS, CONCLUSIONS AND RECOMMENDATIONS

2.1 SUMMARY OF RESULTS

1. Approximately 35 percent (793,809 nm^2) of the conterminous United States was classed as suitable or potentially suitable for MX deployment. The remaining 65 percent (1,467,170 nm^2) was excluded from present consideration for MX siting.

2. The exclusion criterion having the greatest affect on area reduction was quantity/distance. Approximately 1,060,000 nm^2 was excluded, primarily in the northeast Great Lakes region, coastal Florida, and southern California.

3. The scarcity of data related to rock and water depths at the Coarse Screening study level resulted in the identification of large potentially suitable areas which have insufficient data to adequately define surface rock, depth to rock, and depth to ground-water conditions.

4. The screening criterion which had the least overall effect on area reduction was depth to water with approximately 210,000 nm^2 excluded. However, this could be misleading since adequate subsurface water data were difficult to obtain at the Coarse Screening level of investigation.

5. The mountainous regions of the United States were excluded on the basis of topography and exposed rock conditions. These criteria combined with cultural criteria accounted for the exclusion of the majority of the western United States.

Shallow ground water was the principal exclusion in the Pacific Northwest region and in the Mississippi Embayment of the southeastern region of the United States.

6. Inadequately defined surface rock conditions and/or depth to rock occurs mostly in the Great Plains, Central Lowland, and New England physiographic provinces of the central and northeastern United States.

7. Inadequately defined ground-water conditions occur mostly in the northeast portion of the Central Lowland and in the Coastal Plain physiographic provinces of the southeastern United States.

8. Areas of both inadequately defined rock and ground-water conditions occur mostly in the glaciated northeast portion of the Central Lowland physiographic province.

9. Approximately 70 percent of total suitable area occurs in the Basin and Range, Great Plains, and Central Lowlands physiographic provinces of the western and central United States.

2.2 CONCLUSIONS

1. Based on the ranking evaluation of suitable area (Section 3.6), the Basin and Range physiographic province of the western United States appears best suited for MX siting. This is based on the large quantity of suitable land, the more clearly defined geologic and hydrologic conditions of the region, and the high level of confidence in geologic and hydrologic data available.

2. The central portion of the United States may yield large areas of suitable land for MX siting after Intermediate and Fine Screening/Characterizations. However, the geologic and hydrologic conditions of the area appear less favorable overall and are less well defined than in the Basin and Range physiographic province.

3. The eastern portion of the United States is, in general, considered the least suitable for MX siting as a result of the minimal amount of clearly identified suitable land remaining and the preponderance of large areas having inadequately defined rock and water conditions.

4. Areas identified as having either inadequately defined rock or water conditions are expected to be found largely unsuitable during Intermediate Screening studies.

5. Areas identified as having both inadequately defined rock and water conditions are expected to be found almost entirely unsuitable following Intermediate Screening studies.

2.3 RECOMMENDATIONS

1. Intermediate Screening studies should proceed simultaneously in all groups having suitable and potentially suitable areas as identified in this Coarse Screening analysis.

2. Concurrent with Intermediate Screening, Fine Screening/ Characterization studies should begin in selected suitable areas in the Basin and Range and Great Plains physiographic provinces, based on the results of the previous DoD and BLM studies and this Coarse Screening study.

3. The Fine and Intermediate Screening studies should have levels of documentation similar to those used in this study (i.e., all siting criteria should be applied to each area) to facilitate both traceability of results and to provide sufficient flexibility to accommodate changes or redirections in the MX siting study.

3.0 RESULTS

3.1 GENERAL

Application of the screening criteria resulted in the total exclusion of approximately 65 percent of the conterminous United States (Drawing 1). This excluded area will not be considered in future screening and other MX siting studies unless baseline MX siting requirements are changed. Table 3 summarizes the results of the application of the siting criteria on the conterminous United States. The values shown were determined by estimating area from individual worksheet overlays. Summation of the individual totals will not result in the total area excluded since many areas are unsuitable by overlapping exclusions.

The areal effect of each of the exclusion criteria is shown on Figures 2 through 6. These figures are reduced versions of the 1:2,500,000 scale worksheet overlays and serve to illustrate the distribution of the excluded areas and the overlapping relationship of many exclusions.

The remaining non-excluded area total 793,809 nm^2 includes four categories:

1. Suitable area (238,309 nm^2),
2. Potentially suitable area having surface and/or subsurface rock conditions which are inadequately defined (268,495 nm^2),
3. Potentially suitable area having ground-water conditions which are inadequately defined (227,866 nm^2), and
4. Potentially suitable area having surface and/or subsurface rock and ground-water conditions which are inadequately defined (59,139 nm^2).

EXCLUSION CRITERIA	AREA EXCLUDED BY CRITERIA (nm^2)	AREA NOT EXCLUDED BY CRITERIA (nm^2)
SURFACE ROCK, ROCK WITHIN 50 FEET OF THE GROUND SURFACE	540,000	1,720,980
SURFACE WATER, GROUND WATER WITHIN 50 FEET OF THE SURFACE	210,000	2,050,980
AREAS HAVING GRADES EXCEEDING 10 PERCENT	510,000	1,750,980
CULTURAL EXCLUSIONS (Section 1.2.4)	405,000	1,855,980
QUANTITY/DISTANCE EXCLUSIONS (Section 1.2.4)	1,060,000	1,200,980
MINIMUM AREA EXCLUSION	5,000	2,255,980

AFFECTS OF SCREENING CRITERIA ON AREA REDUCTION, CONTERMINOUS UNITED STATES

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TABLE 3

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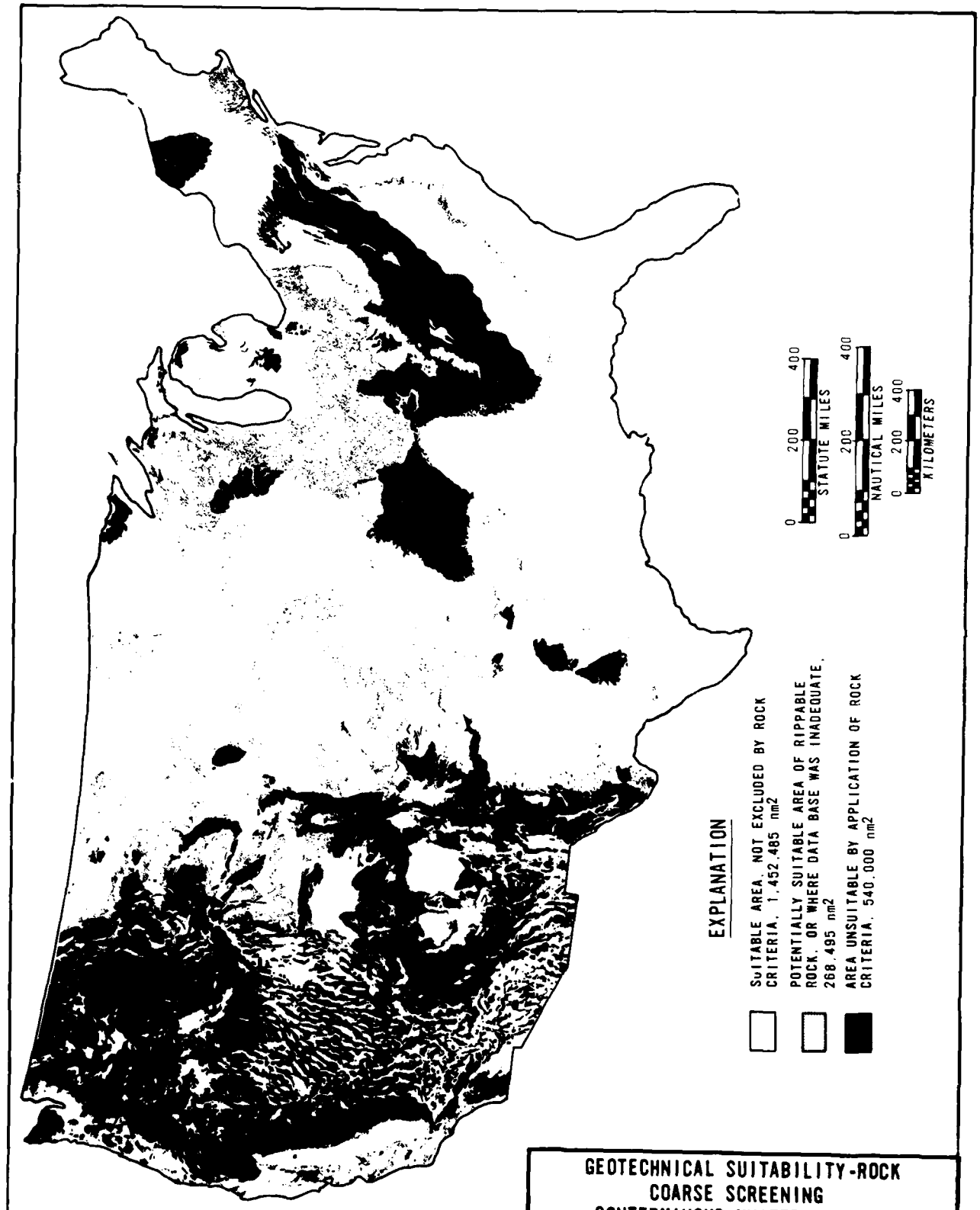

GEOTECHNICAL SUITABILITY-ROCK
COARSE SCREENING
CONTERMINOUS UNITED STATES

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FIGURE 2

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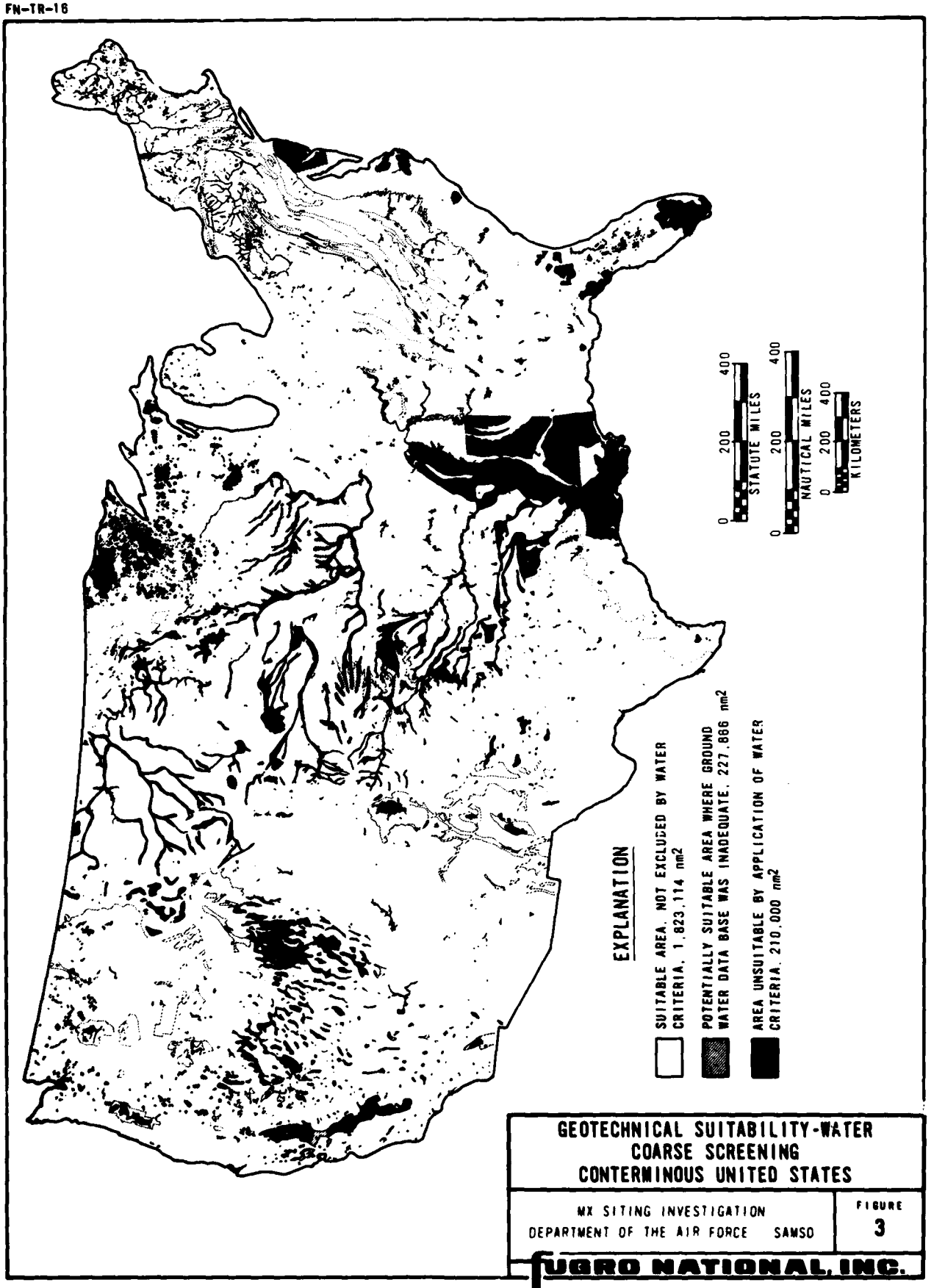

GEOTECHNICAL SUITABILITY-WATER
COARSE SCREENING
CONTERMINOUS UNITED STATES

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FIGURE 3

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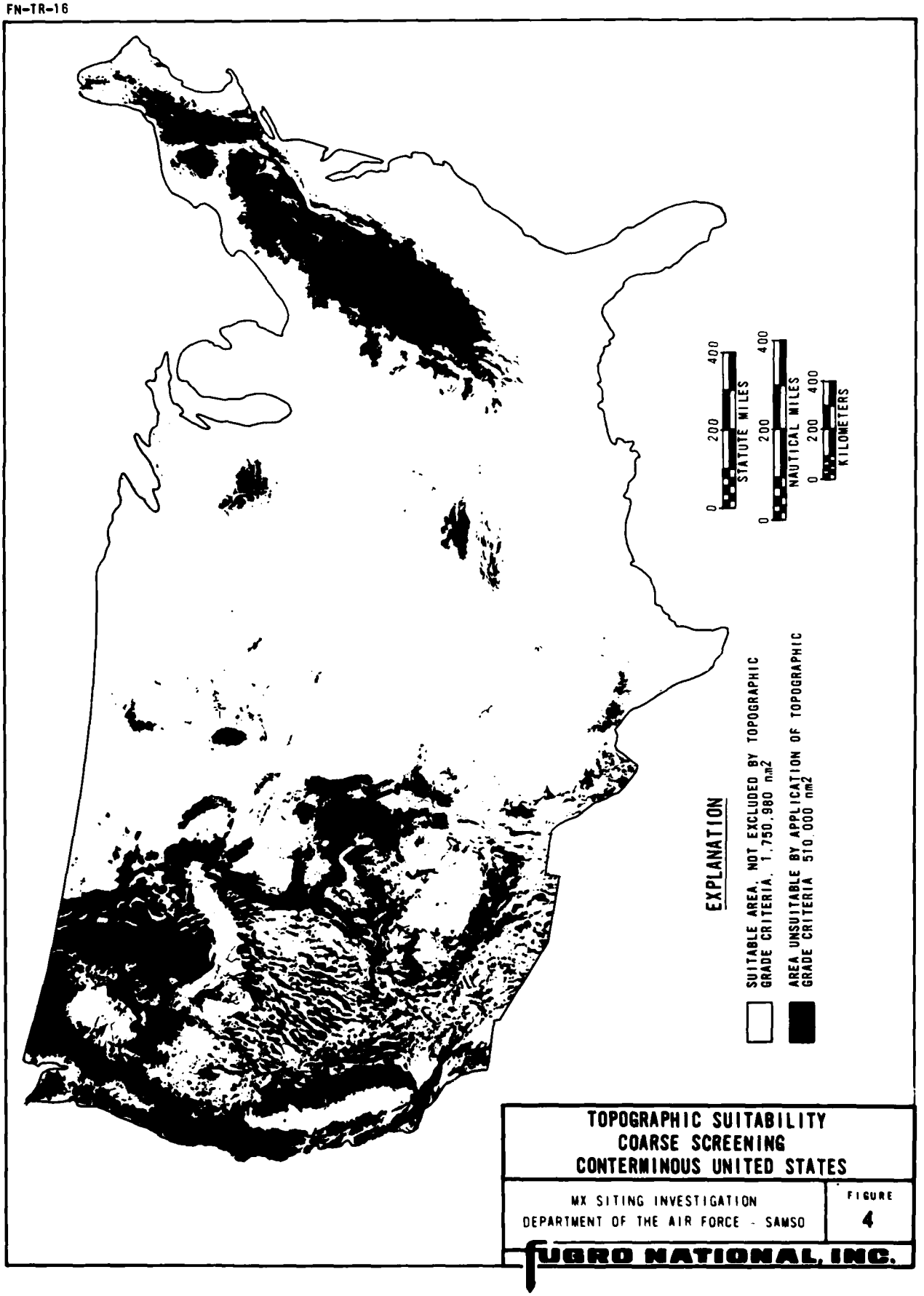

TOPOGRAPHIC SUITABILITY
COARSE SCREENING
CONTERMINOUS UNITED STATES

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FIGURE
4

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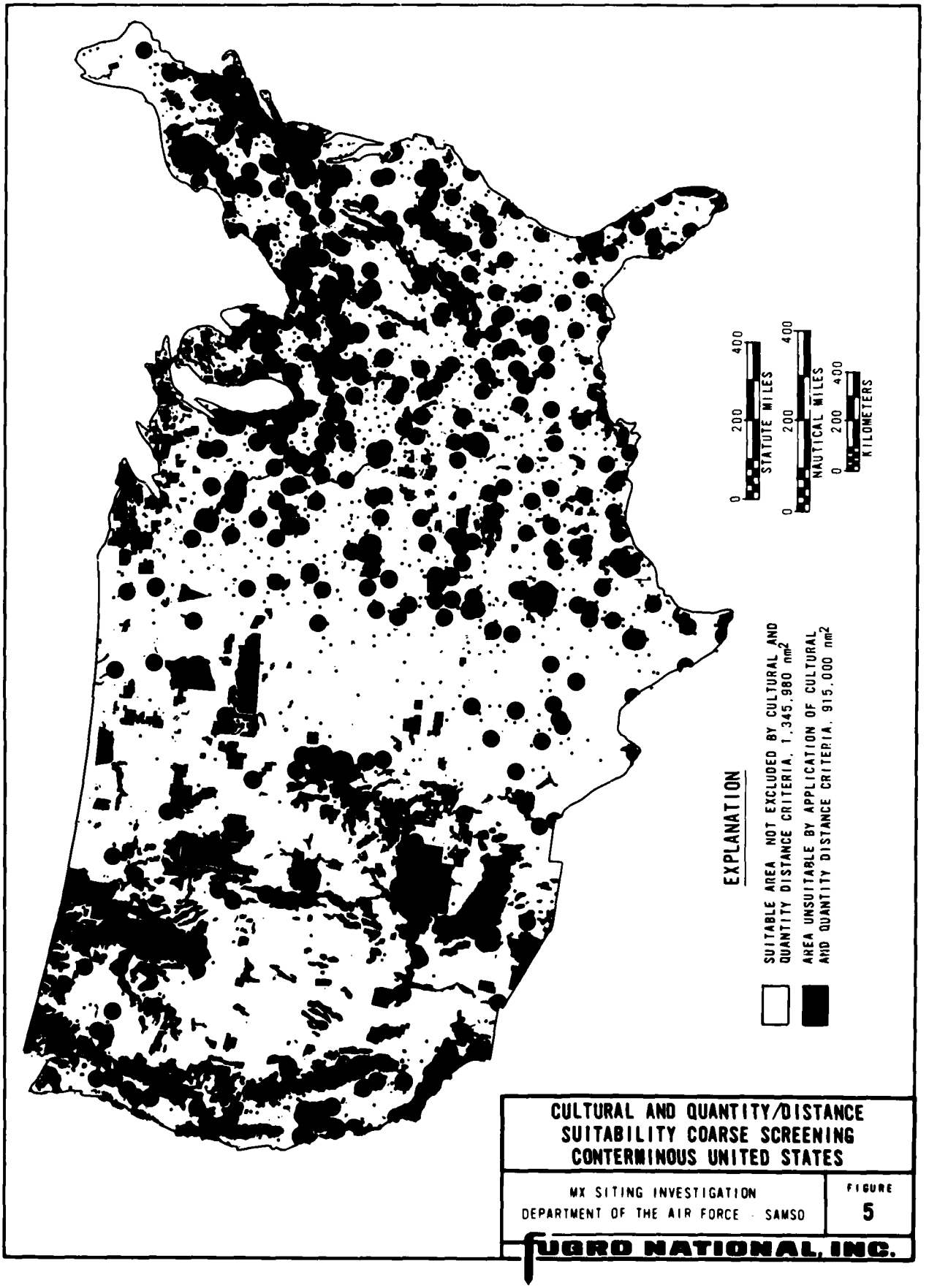

CULTURAL AND QUANTITY/DISTANCE SUITABILITY COARSE SCREENING CONTERMINOUS UNITED STATES

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FIGURE 5

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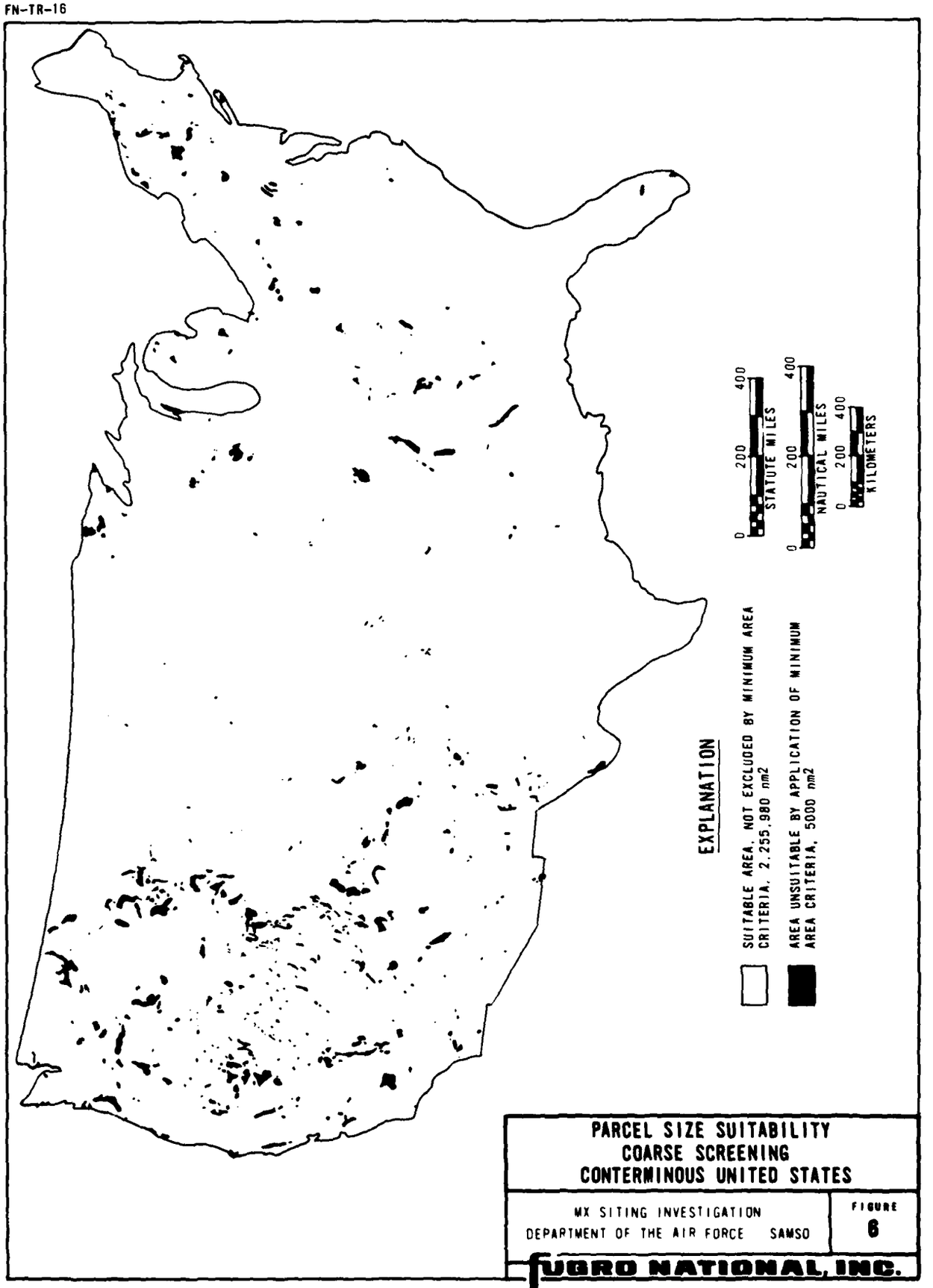

PARCEL SIZE SUITABILITY
COARSE SCREENING
CONTERMINOUS UNITED STATES

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DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 6

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3.2 SUITABLE AREA

Suitable land area encompasses broadly differing geologic, hydrologic, soils engineering, environmental, and cultural siting conditions that are summarized in Section 3.4. The majority of the suitable area occurs in three distinct physiographic provinces: The Great Plains, Basin and Range, and Coastal Plain (Texas) provinces.

Suitable area in the Great Plains physiographic province is characterized by irregularly shaped land parcels that often individually exceed several thousand square nautical miles. These large land parcels are generally defined by the boundaries of Tertiary continental deposits.

The Basin and Range physiographic province is characterized by numerous alluvium-filled valleys of several hundred square nautical miles each that are separated by generally north trending mountain ranges. The suitable area of the Basin and Range physiographic province encompasses portions of Nevada, southern Arizona, southeast California, central and southwest New Mexico and western Utah.

The Texas Coastal Plain is the largest single contiguous land parcel of suitable area recognized in the Coarse Screening study. It totals over 30,433 nm^2 and extends from the international border northeast nearly to the Texas-Oklahoma-Arkansas state borders. This area is defined by deposits of Tertiary continental and marine sand, and clay.

3.3 POTENTIALLY SUITABLE AREA

Potentially suitable areas are present in many areas of the conterminous United States. The following sentences briefly describe these areas and their broad characteristics.

The areas where depth to rock conditions are inadequately defined occur principally in the Great Plains, northern Rocky Mountains, north and central Texas, and in the northeastern portion of the United States. Variable thicknesses of heterogeneous glacial till deposits overlying rock predominates in the northeastern and northern Great Plains areas. Potentially suitable area in central and northern Texas, the northern Rocky Mountains, and the Great Plains correspond to exposed geologic units which have poorly defined excavation (rippability) characteristics.

Areas where ground-water conditions are inadequately defined occur primarily along the eastern and Gulf seaboards and the Great Lakes region. Variable depths to ground water, or general lack of data are the principal reasons these areas are defined as potentially suitable.

Areas where both inadequately defined ground-water and rock conditions occur are primarily in the states adjoining the Great Lakes, where glacial till and variable hydrologic conditions are present.

3.4 CHARACTERISTICS OF SUITABLE AND POTENTIALLY SUITABLE AREA

3.4.1 GENERAL

The characteristics of the suitable and potentially suitable areas are generally typified by certain physiographic provinces of the United States, each of which encompass broadly similar topographic, geomorphologic, hydrologic, and geologic environments. The physiographic provinces of the United States are shown in Figure 1.

The majority of the suitable and potentially suitable areas are confined primarily to six major physiographic provinces:

1. Basin and Range
2. Great Plains
3. Central Lowlands
4. Coastal Plain
5. Piedmont
6. New England

3.4.2 BASIN AND RANGE PROVINCE

The Basin and Range physiographic province is characterized by isolated mountain ranges separated by broad aggraded desert plains composed of thick sequences of alluvium. These broad and elongate valleys are sparsely populated and contain sediments whose general ease of excavation has been well documented. Water occurrences are generally well below 50 feet and shallow rock occurs near the mountain fronts or as buried volcanic flows in the valleys. These suitable valley areas cover large portions of several western states, including: California,

Nevada, Utah, Arizona, and New Mexico; and small portions of Oregon, Idaho, and Texas.

3.4.3 GREAT PLAINS PROVINCE

The Great Plains physiographic province contains large regions of potentially suitable and suitable areas. Extensive suitable areas consist of thick glacial drift which form the surface of dissected plateaus and low rolling hills. In the unglaciated regions of the northern Great Plains, extensive exposed rock (chiefly shales, siltstones, and sandstones) with inadequately defined excavation characteristics are present and classed as potentially suitable siting areas.

The gently rolling topography of the northern Great Plains gradually changes to the relatively flat fluviatile plains and the low rolling terrain of the young plateaus in the southern Great Plains. Excavatable surface rock conditions (poorly cemented relatively young Tertiary sandstone and siltstone) in the southern Great Plains have resulted in large areas of potentially suitable land.

3.4.4 CENTRAL LOWLAND PROVINCE

The Central Lowland physiographic province includes several mid-western states with characteristics ranging from old glaciated plateaus in Michigan and Wisconsin to mature plateaus in Central Texas. The terrain likewise varies from low rolling hills in the north to nearly flat plains in the south. Exposed rock with uncertain excavatability characteristics has resulted in widespread areas of the Central Lowland being designated as potentially suitable.

The major part of the Great Lakes region (northeasterly portion of the province) is mantled with thick sequences of unconsolidated, glacially derived tills, loess, morainal and outwash plain deposits. This area is considered potentially suitable due tc inadequately defined ground-water conditions.

Suitable areas are primarily confined to eastern North and South Dakota and western Iowa where favorable ground-water conditions are combined with low, gently rolling topography of rippable glacial till.

3.4.5 COASTAL PLAIN PROVINCE

The Coastal Plain physiographic province is characterized by terraced coastal plains, floodplains and deltas. Shallow ground water is believed to pervade most of the Coastal Plain; however, it could not be clearly defined at the Coarse Screening level of investigation and is designated as a potentially suitable siting area. In the terraced coastal plain region of Arkansas, Louisiana, and Mississippi, favorable ground-water conditions have combined with unconsolidated to poorly consolidated clays, silts, and sands to form large segments of suitable area.

3.4.6 PIEDMONT PROVINCE

The Piedmont physiographic province is composed of thick sequences of interbedded limestones, sandstones, siltstones, and shales which have been extensively weathered to form low rolling topography. These exposed strata have uncertain excavation characteristics and are considered as potentially suitable.

3.4.7 NEW ENGLAND PROVINCE

Potentially suitable areas of New England are primarily confined to Maine, where exposed rock has been extensively weathered or covered with an unknown thickness and extent of glacial till. The paucity of data has resulted in this area having surface and subsurface rock conditions that are inadequately defined.

3.5 RANKING ANALYSIS

3.5.1 APPROACH

3.5.1.1 Determination of Group Study Areas

The suitable and potentially suitable area identified from the results of Coarse Screening were divided into 23 individual study groups for ranking and Intermediate Screening studies (Figure 8). Group boundaries in all instances are coincident with state boundaries and were governed by:

1. Broad similarity of geotechnical conditions occurring in the area;
2. Uniform level of existing data and similarity of the acquisition process for future screening studies; and
3. Convenience of data management.

3.5.1.2 Ranking Criteria

Area ranking was kept simple since (1) other screening studies will follow immediately which may alter the amount and relative density of suitable area, and (2) the small-scale data utilized will not support a detailed, complex ranking. The two principal ranking factors for the 23 study groups are quantity of suitable area (objective factor), and confidence level in the data evaluated (subjective factor).

The approximately 238,309 nm^2 of suitable area identified from Coarse Screening studies provide the most reasonable basis for ranking of the study groups. The potentially suitable siting areas are, by definition, areas in which the confidence level of available data is uniformly low. These areas could become

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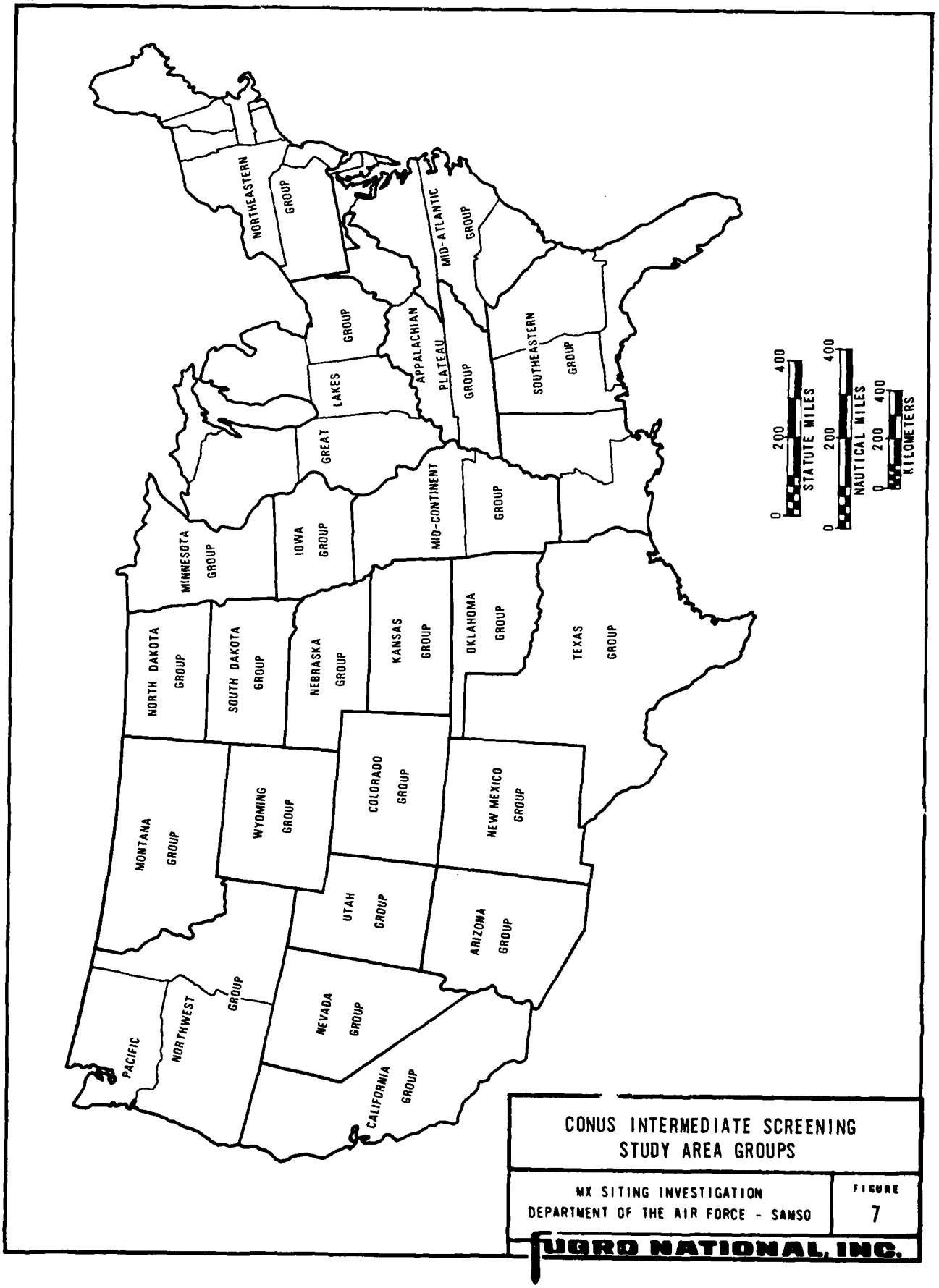

CONUS INTERMEDIATE SCREENING
STUDY AREA GROUPS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7

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suitable, but for the most part, will probably be excluded after Intermediate Screening. For this reason, it was decided not to consider potentially suitable area in the ranking process.

Suitable areas were identified utilizing different data sources of various scales and quality. These differences create variable confidence levels in the data evaluated which were then applied as scaling factors to the suitable areas. The confidence level in the data evaluated is a factor subject to judgement. For example, recent detailed investigations provide a higher level of confidence in area suitability than do old reconnaissance level investigations. Though somewhat subjective, these differences are real and judgements about them are largely reproducible by other evaluators.

3.5.2 APPLICATION OF RANKING CRITERIA

3.5.2.1 Suitable Area

Most estimates to date indicate that the entire MX system can be deployed within an area 4000 to 6000 nm^2. This is a small fraction of the approximately 238,309 nm^2 of suitable area that resulted from Coarse Screening. In the ranking process a simple average of 5000 nm^2 was selected as a scaling factor. Dividing suitable area (a) in each fine screening group by 5000 nm^2 provides a simple multiple (b) of unit siting regions. Ten of the 23 groups (primarily in the east and northcentral groups) have less than one unit siting region.

3.5.2.2 Confidence Level of Data

The scaling factor for confidence level of data (c) is based on a scale of zero to ten; zero representing no data (no confidence), one to three representing a low confidence level, four to six a moderate confidence level, and seven to ten a high confidence level in the data evaluated. After assignment of the confidence level scaling factor (c) to a study group, the number was multiplied by the number of unit siting regions (b) to arrive at the total score for that group. Based on their total scores, the study groups were then ranked as high, medium, or low in rank (Table 4). Small (2 or 3 points) differences in assignment do not substantially change the final ranking. Also, the level of confidence in data is relatively high in all suitable areas relative to inadequately defined areas.

3.5.3 RANKING EVALUATION

Table 4 summarizes the ranking evaluation that was performed on all 23 study groups; of these groups, the five highest ranking areas occur in the Basin and Range, and Central High Plains physiographic provinces. Four groups rank in the medium category and 14 groups rank low.

INTERMEDIATE SCREENING STUDY GROUP	(a) SUITABLE AREA (nm^2) (1)	(b) UNIT DEPLOYMENT AREAS a/5,000 nm	(c) CONFIDENCE LEVEL OF DATA	TOTAL SCORE (b x c)	RANKING (2)		
					HIGH	MED	LOW
APPALACHIAN	0	0	-	0			X
ARIZONA	13,572	2.7	8	22	X		
CALIFORNIA	13,677	2.7	9	24	X		
COLORADO	11,487	2.3	4	9			X
GREAT LAKES	0	0	-	0			X
IOWA	0	0	-	0			X
KANSAS	284	.05	6	.3			X
MID-ATLANTIC	0	0	-	0			X
MID-CONTINENT	5,766	1.2	3	4			X
MINNESOTA	0	0	-	0			X
MONTANA	20,509	4.1	3	12		X	
NEBRASKA	30,904	6.2	4	25	X		
NEVADA	16,315	3.3	7	23	X		
NEW MEXICO	9,526	1.9	6	11		X	
NORTH DAKOTA	28,125	5.6	4	22	X		
NORTHEASTERN	(3)	0	-	0			X
OKLAHOMA	4,172	.83	4	3			X
PACIFIC NORTHWEST	3,514	.70	2	1			X
SOUTH DAKOTA	18,264	3.7	4	15		X	
SOUTHEASTERN	9,224	1.8	2	4			X
TEXAS	30,433	6.1	3	18		X	
UTAH	1,815	.36	6	2			X
WYOMING	8,981	1.8	3	5			X

(1) Suitable area tallies are approximate.

(2) High Ranking – ≥20 Total Score
Medium Ranking – 11 to 19 Total Score
Low Ranking – ≤10 Total Score

(3) Negligible: Suitable Area less than 100 nm^2.

TABLE 4

RANKING OF SUITABLE AREAS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

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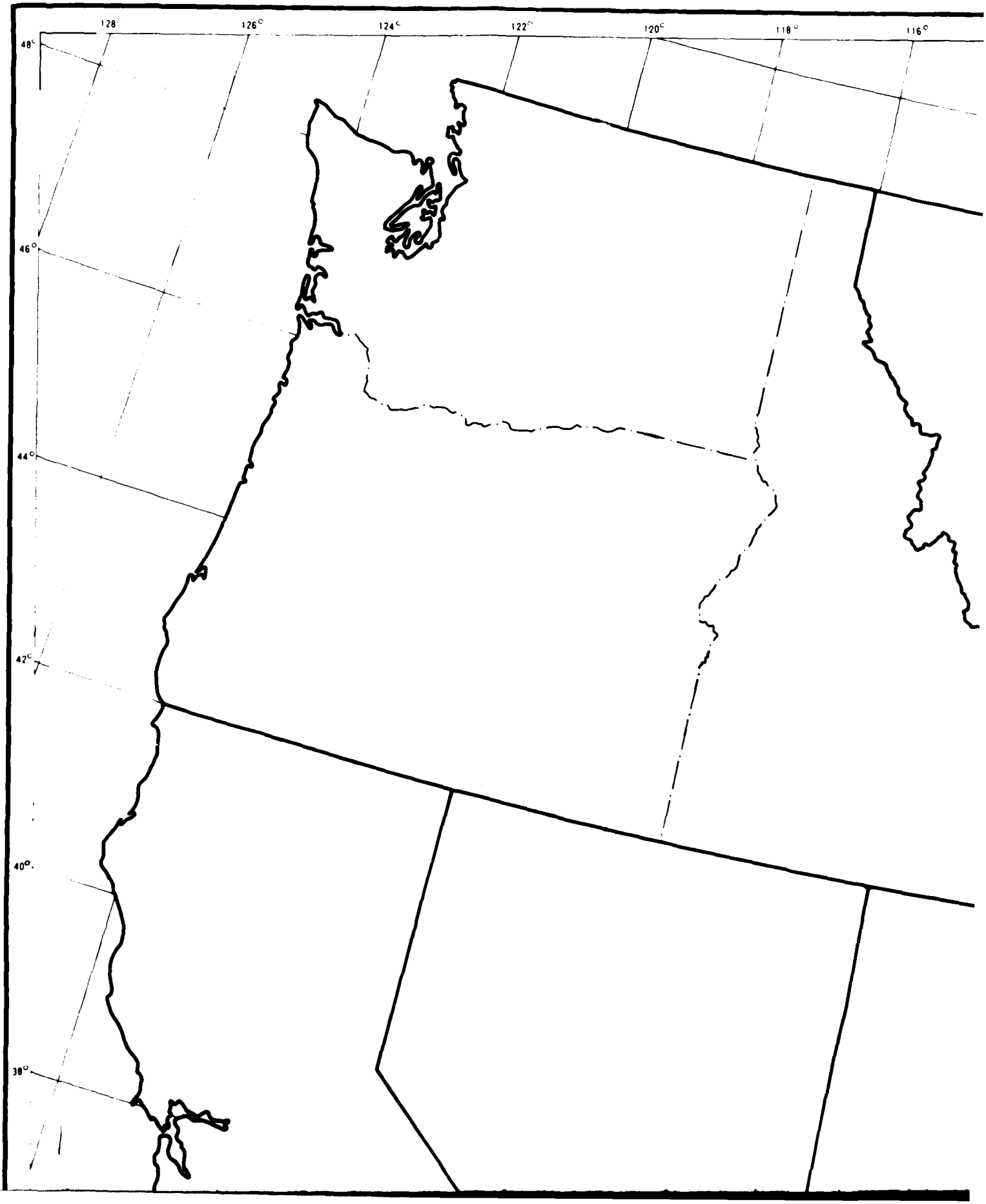
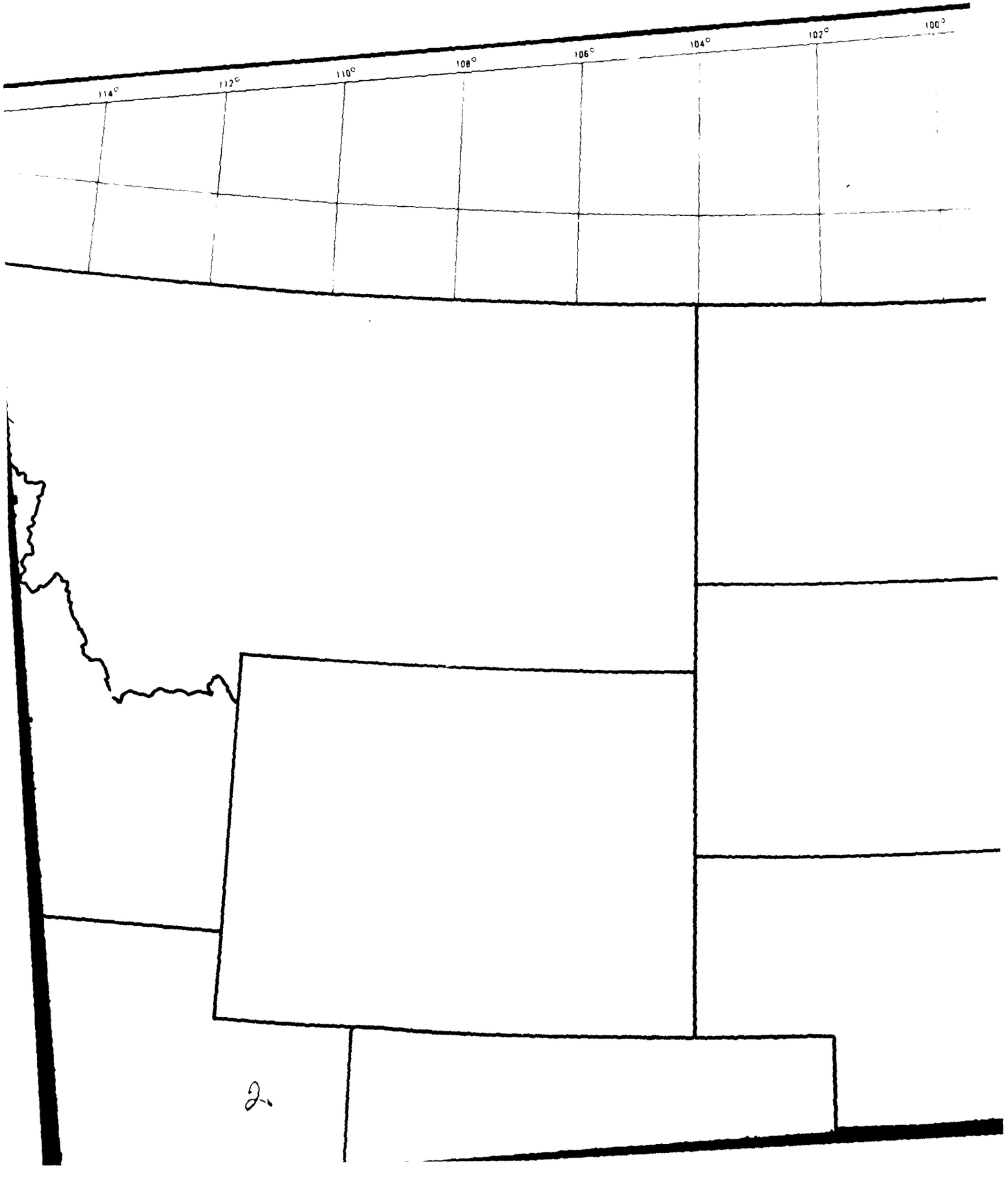
MX SITING INVESTIGATION
CONTERMINOUS UNITED STATES





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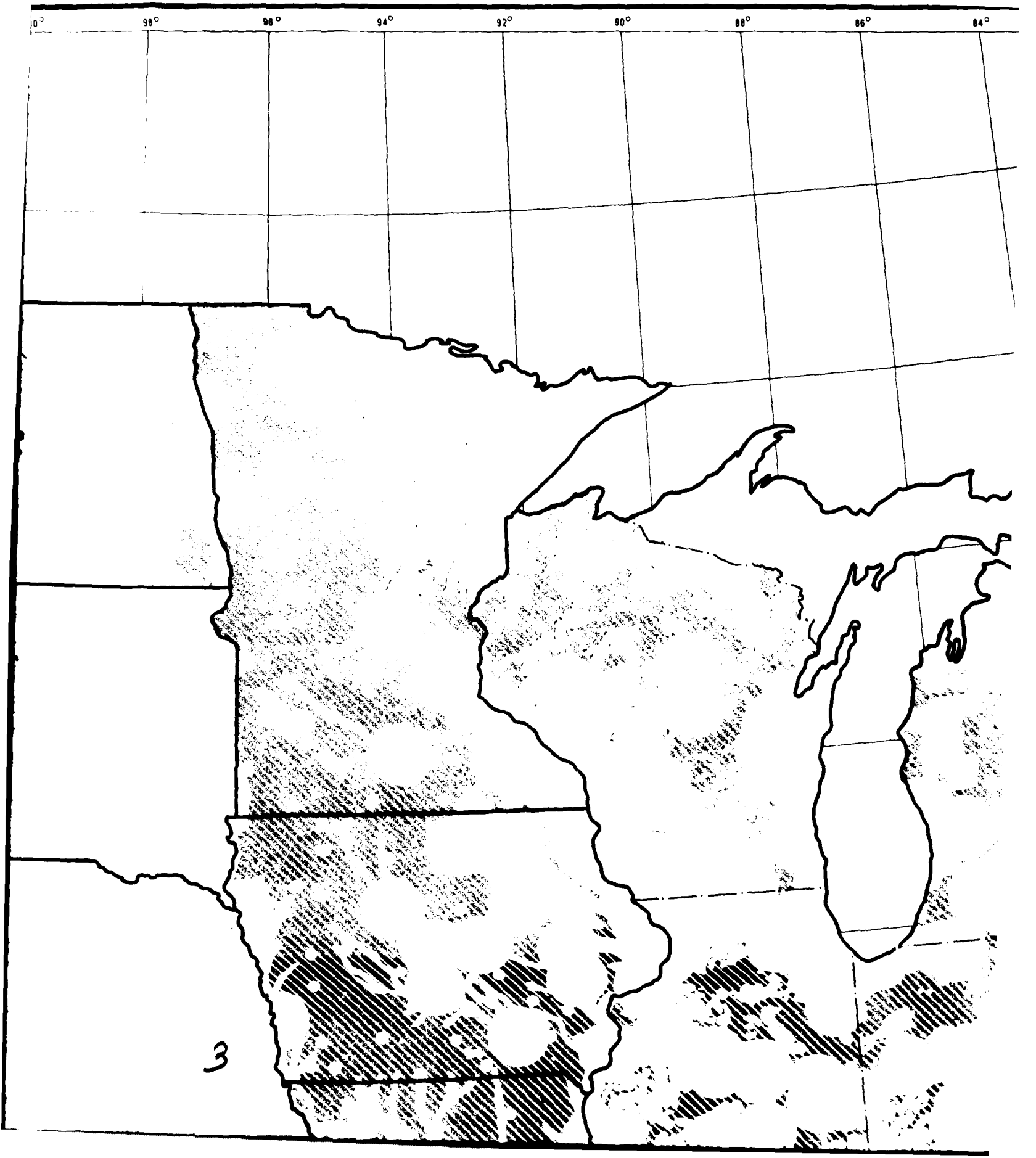
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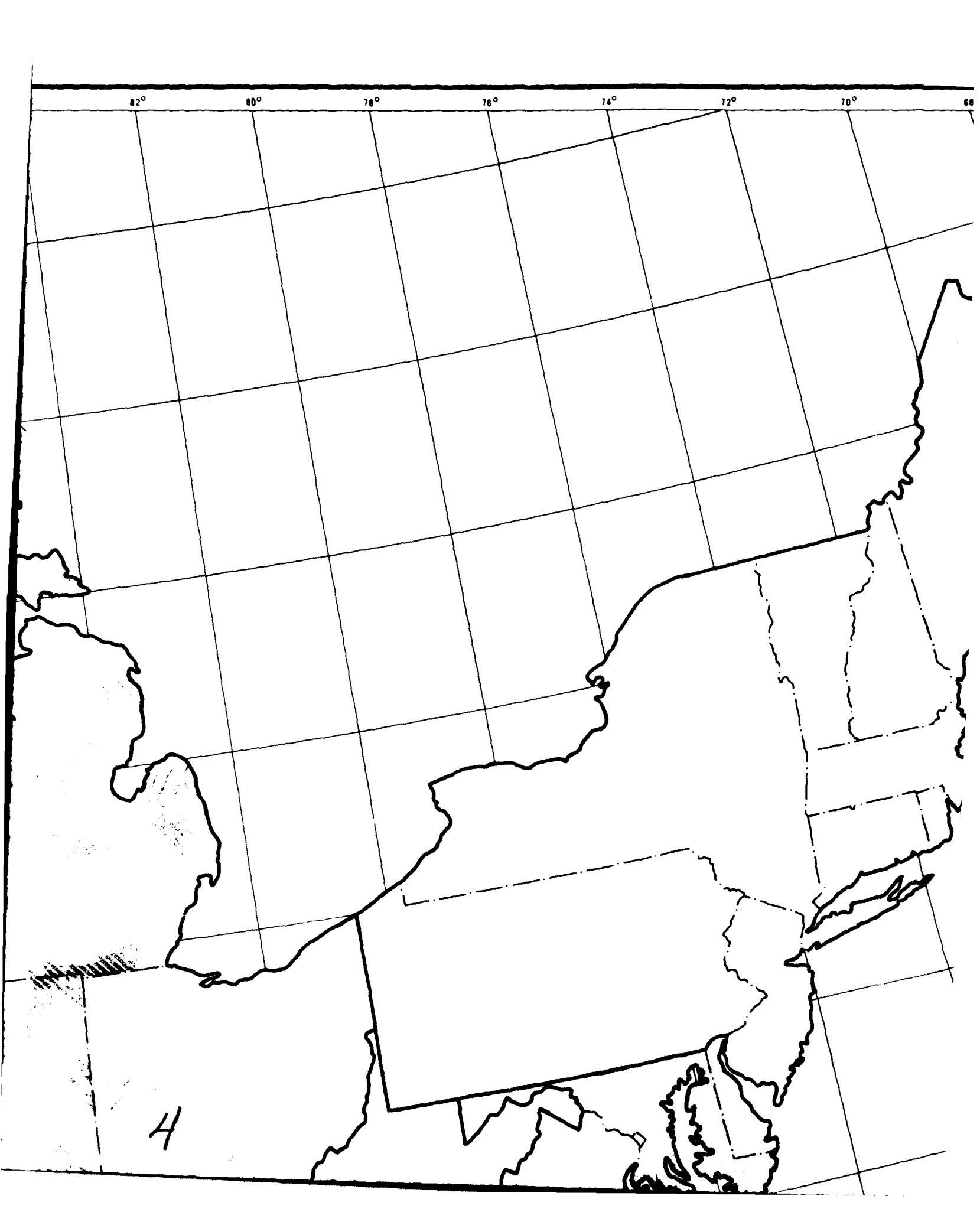
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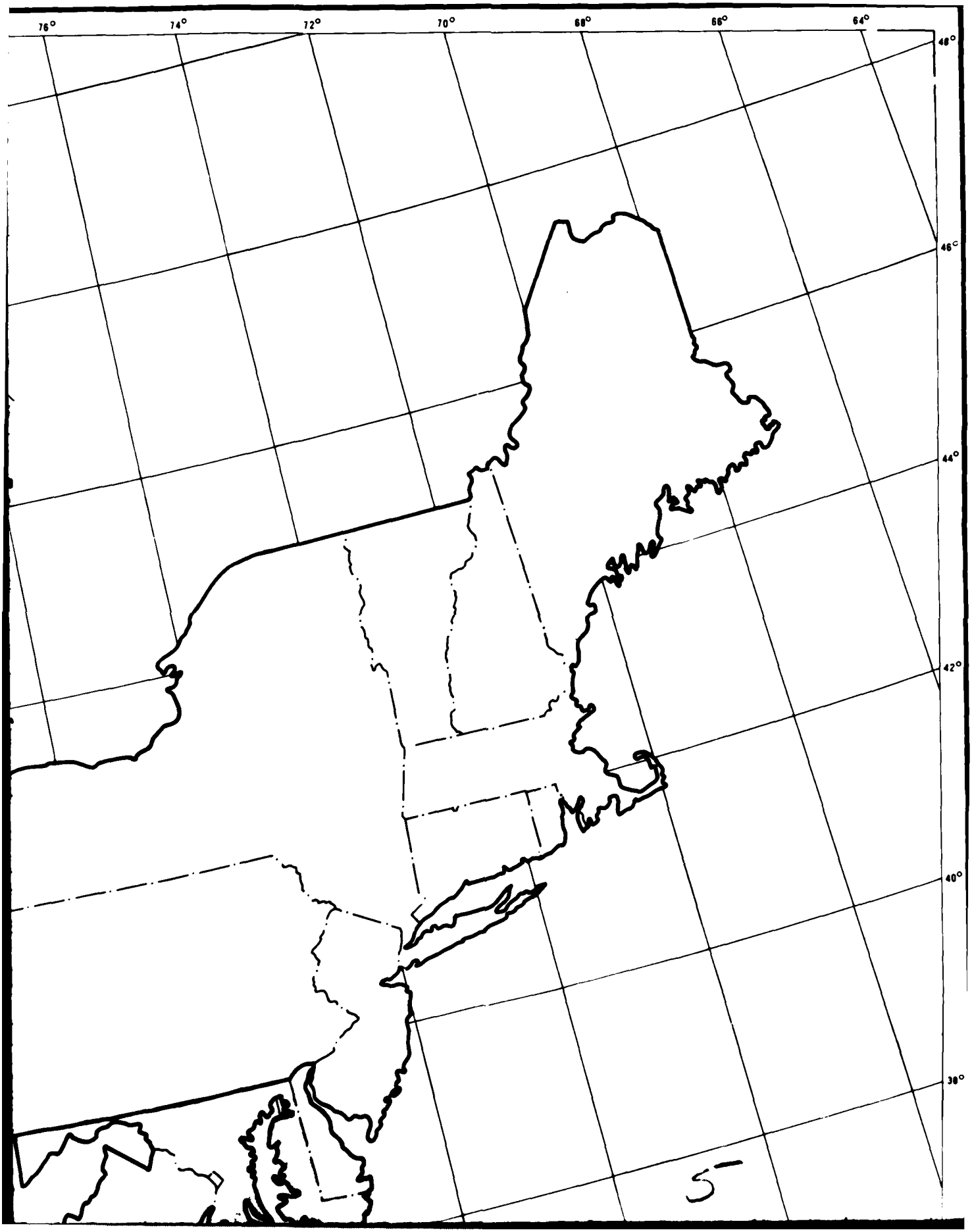
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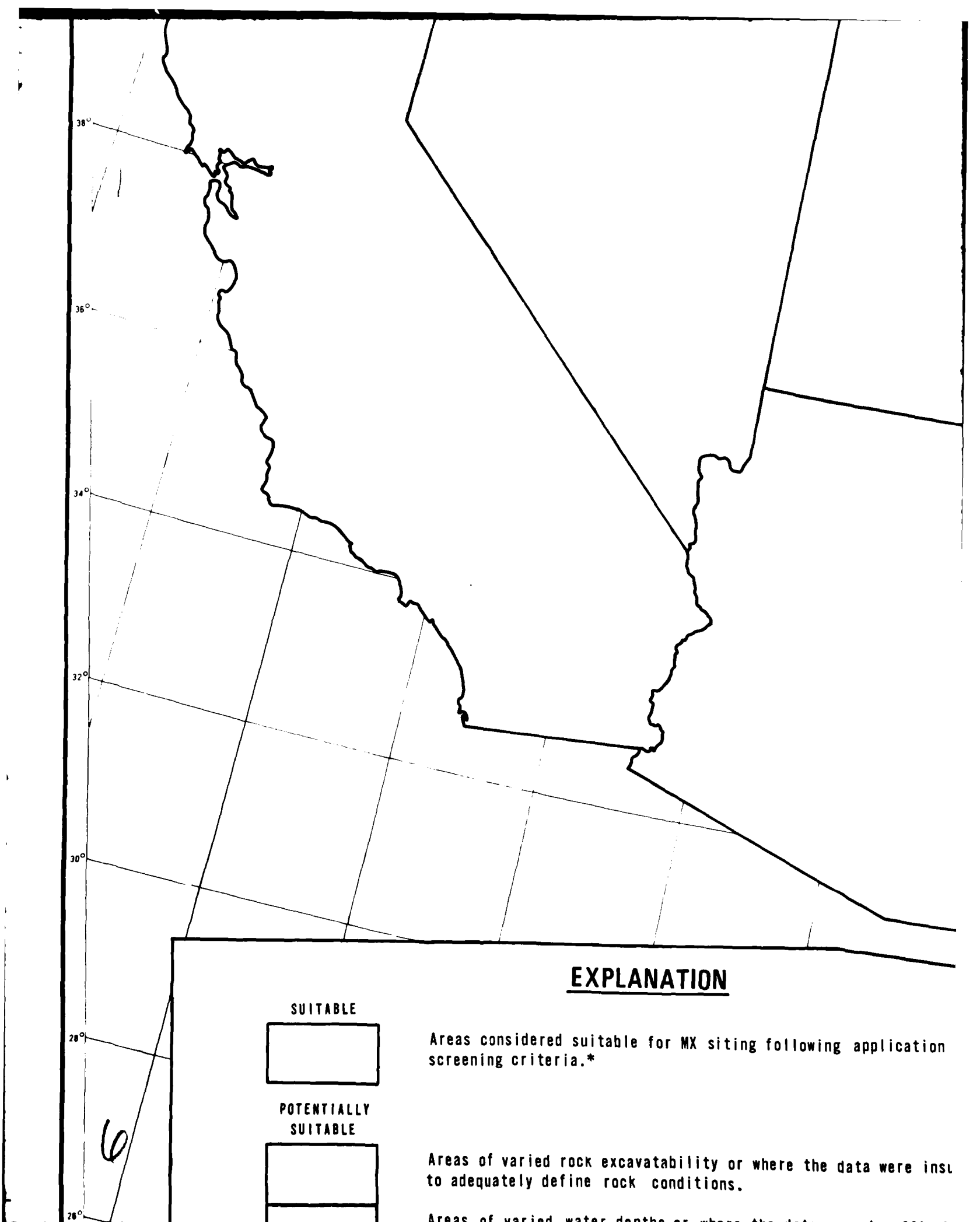
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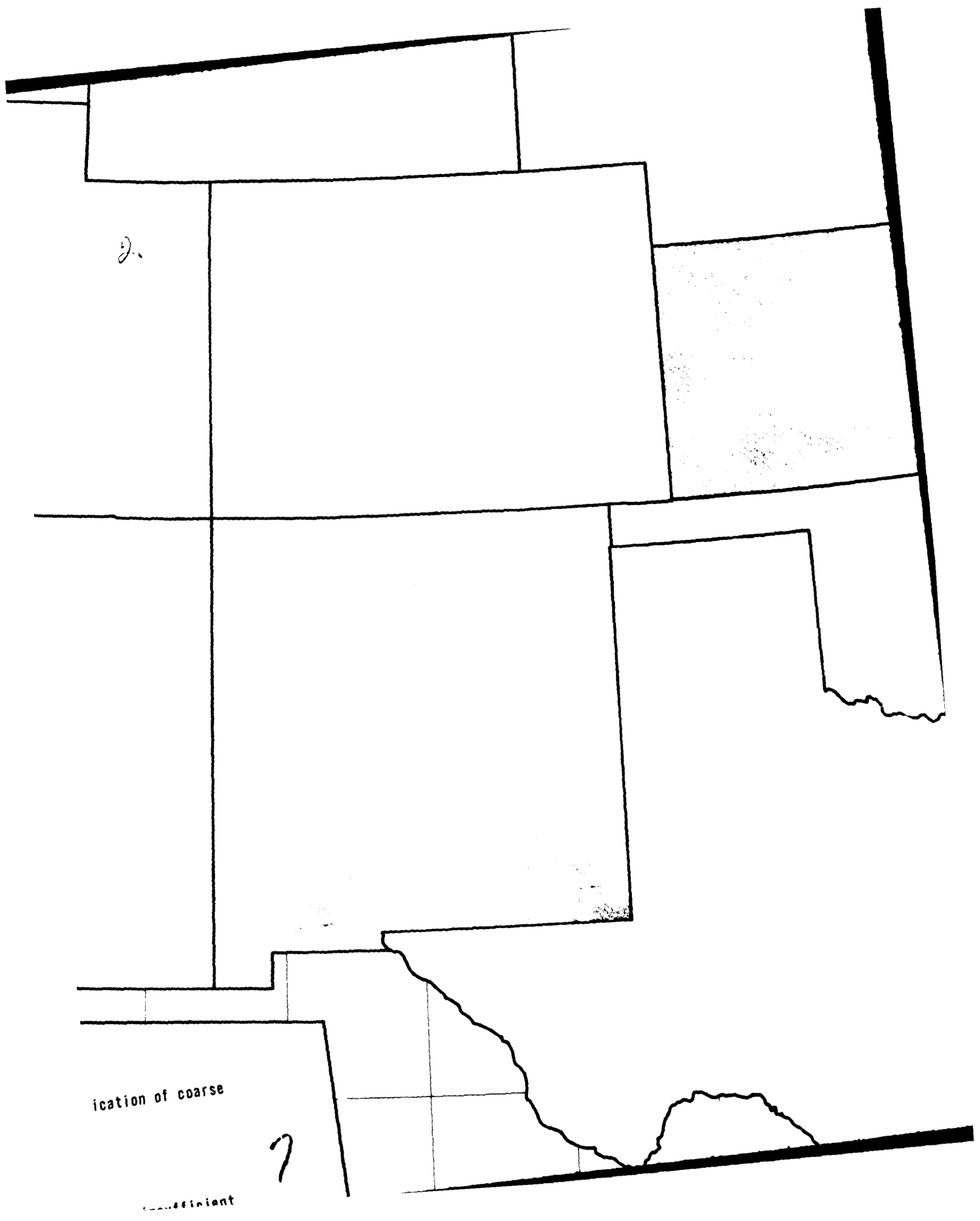
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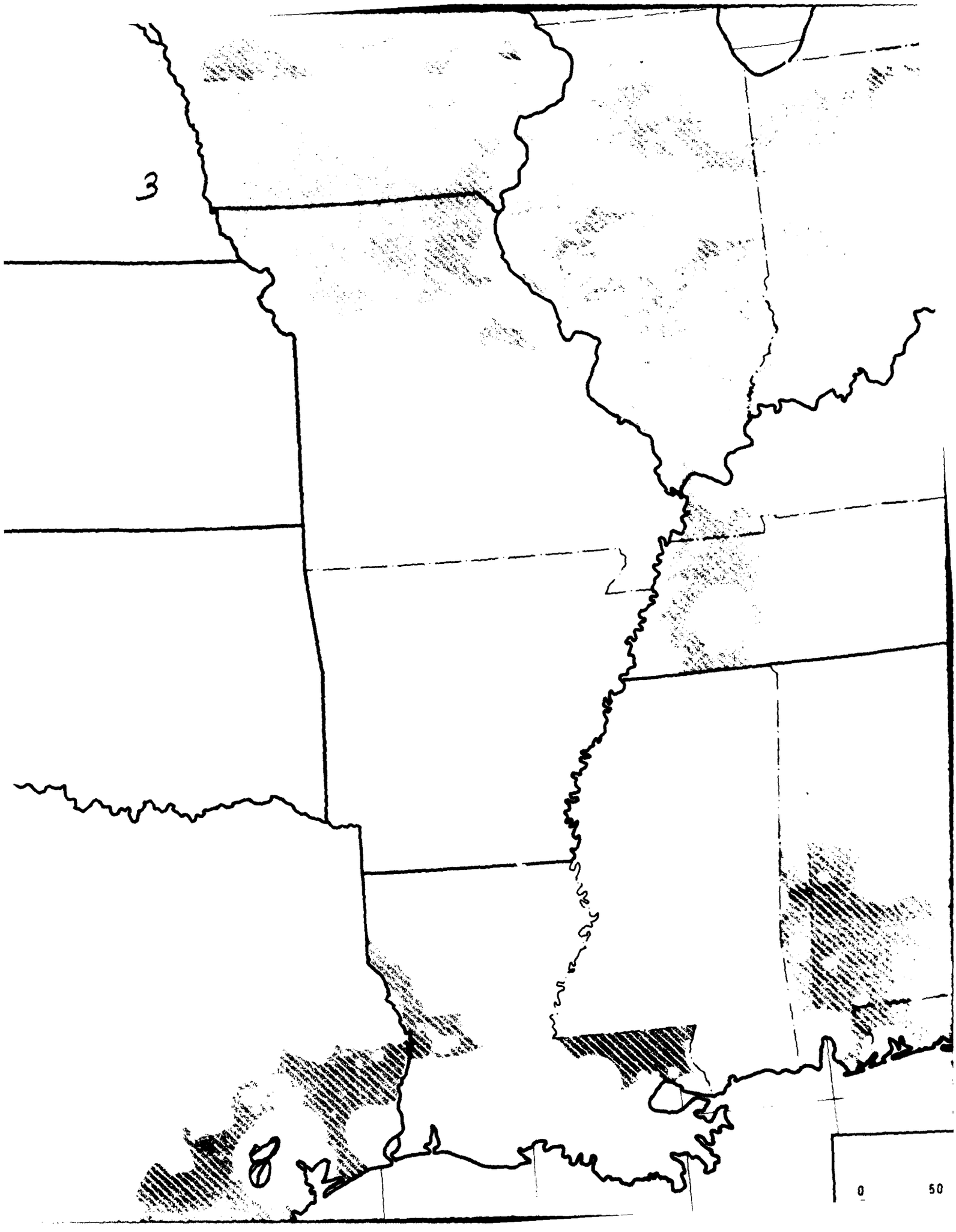
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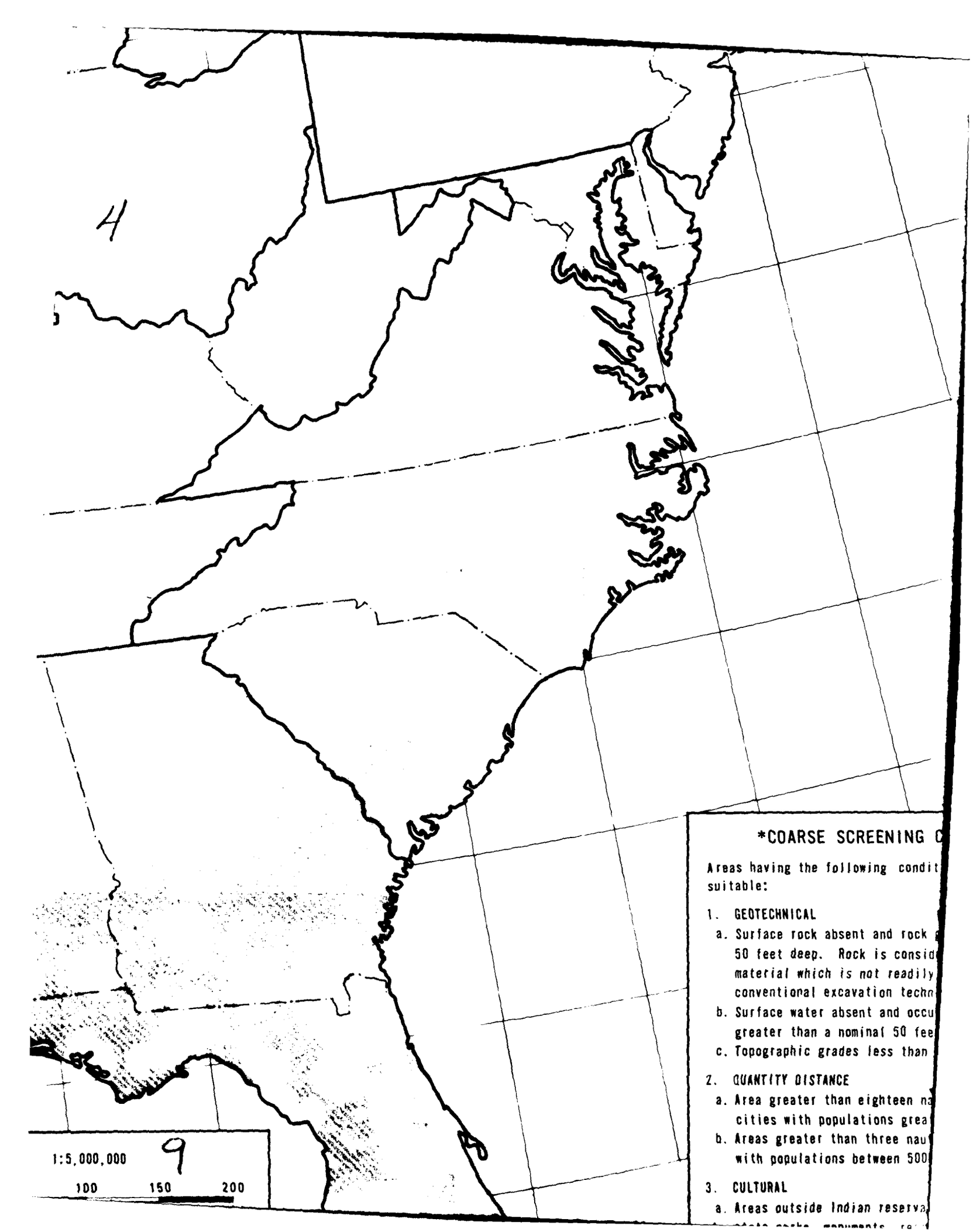
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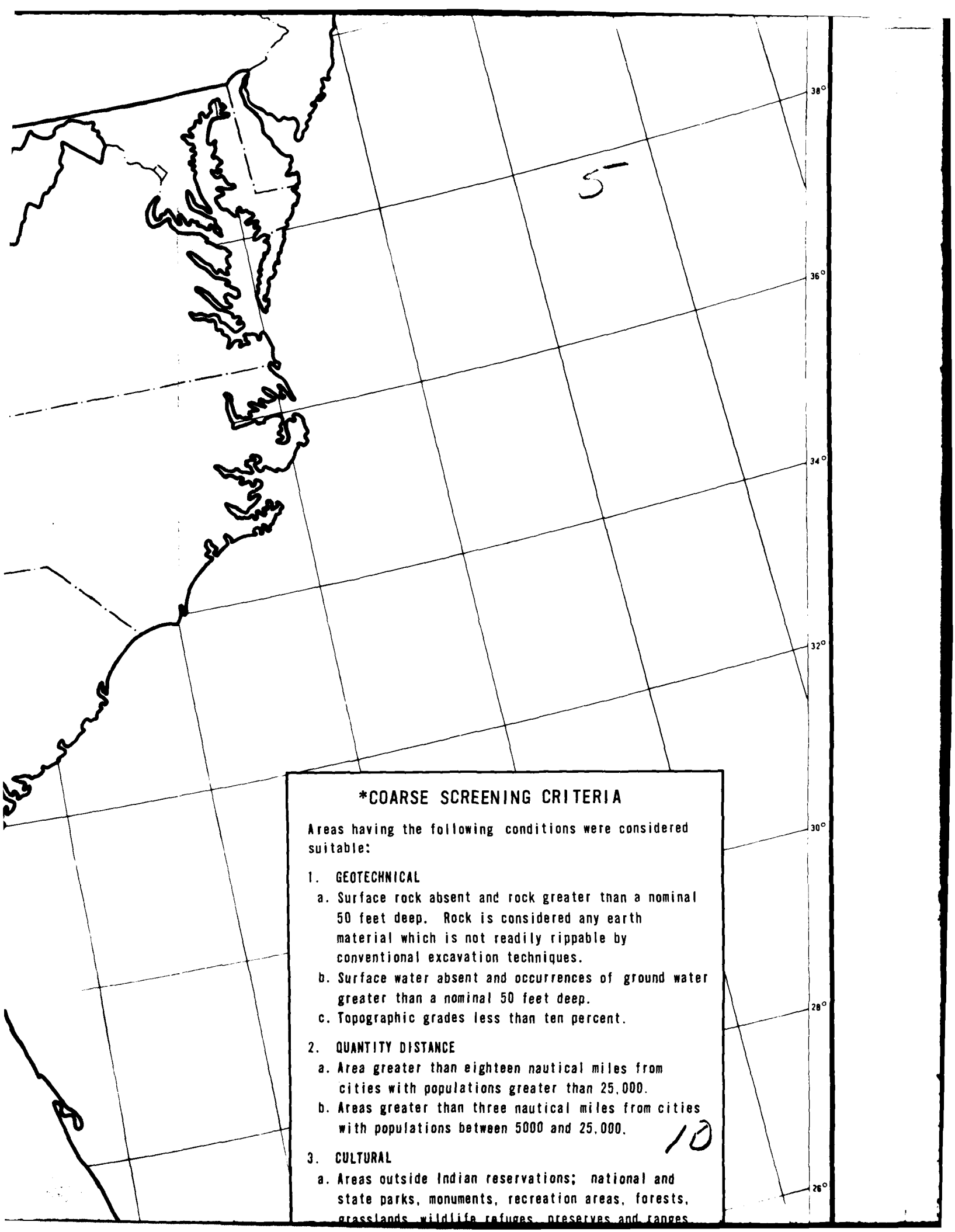
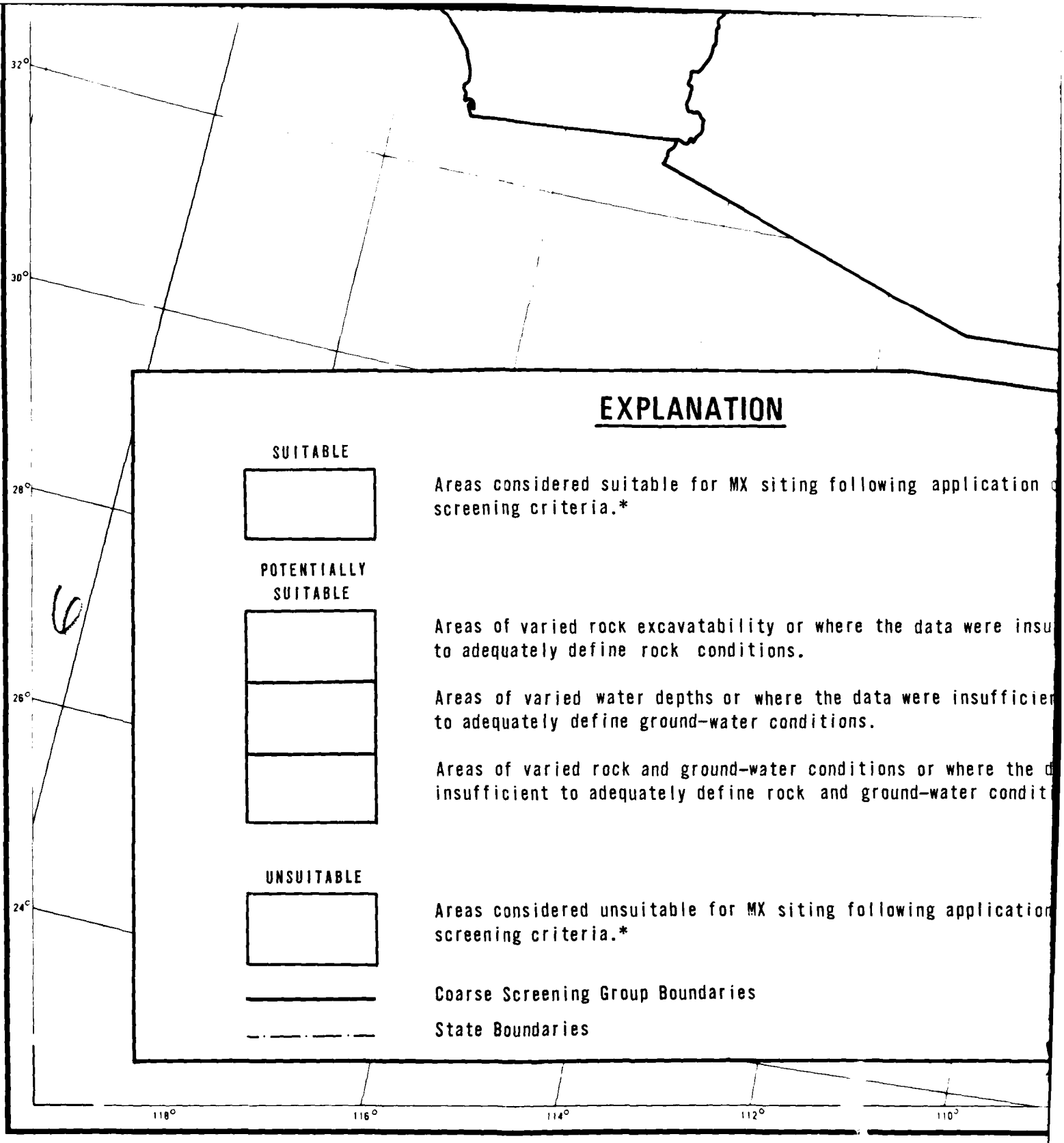


*COARSE SCREENING CRITERIA

Areas having the following conditions were considered suitable:

1. GEOTECHNICAL
   a. Surface rock absent and rock greater than a nominal 50 feet deep. Rock is considered any earth material which is not readily rippable by conventional excavation techniques.
   b. Surface water absent and occurrences of ground water greater than a nominal 50 feet deep.
   c. Topographic grades less than ten percent.
2. QUANTITY DISTANCE
   a. Area greater than eighteen nautical miles from cities with populations greater than 25,000.
   b. Areas greater than three nautical miles from cities with populations between 5000 and 25,000.
3. CULTURAL
   a. Areas outside Indian reservations; national and state parks, monuments, recreation areas, forests, grasslands, wildlife refuges, preserves and ranges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Coarse Screening Group Boundaries
State Boundaries

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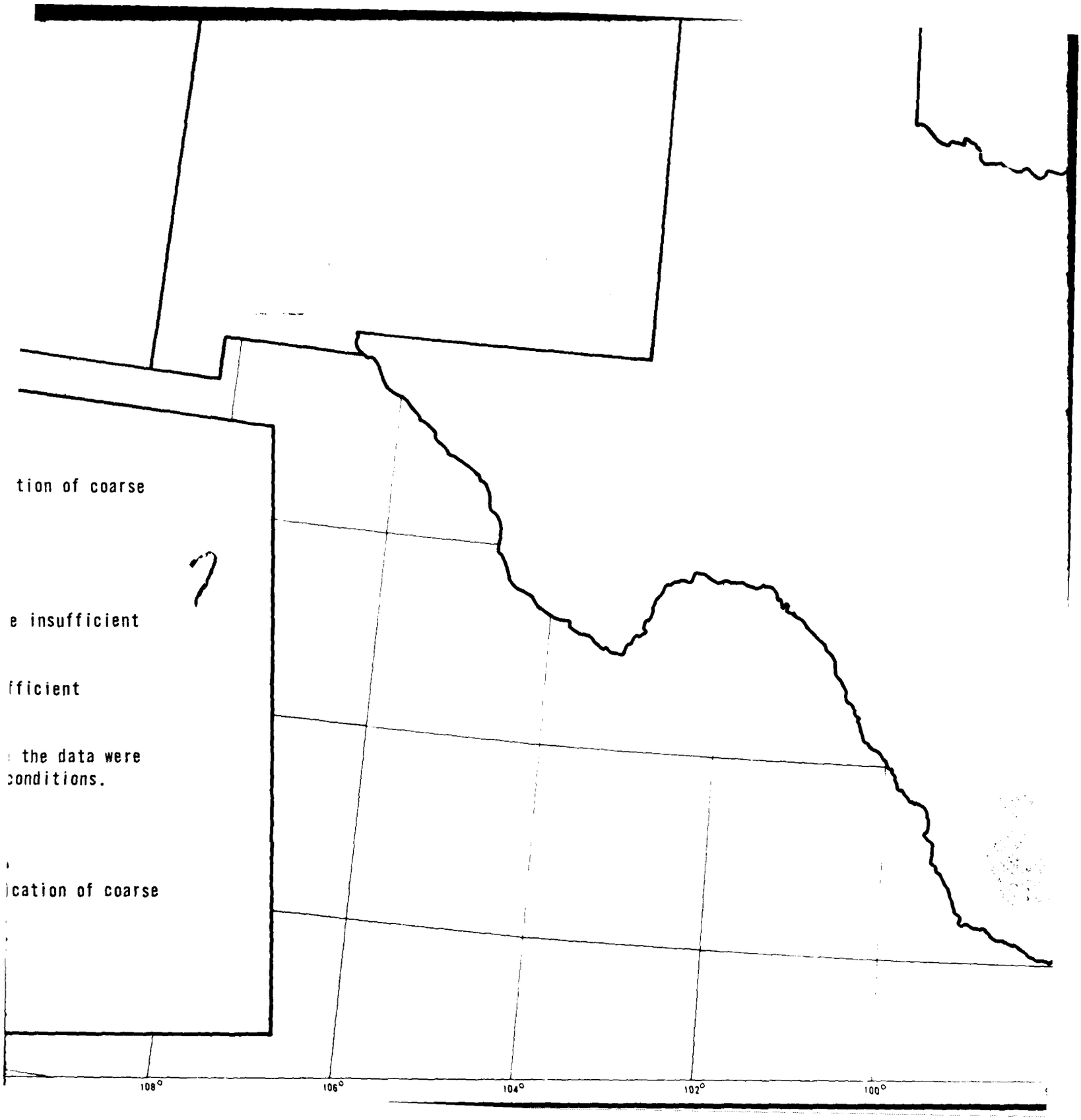
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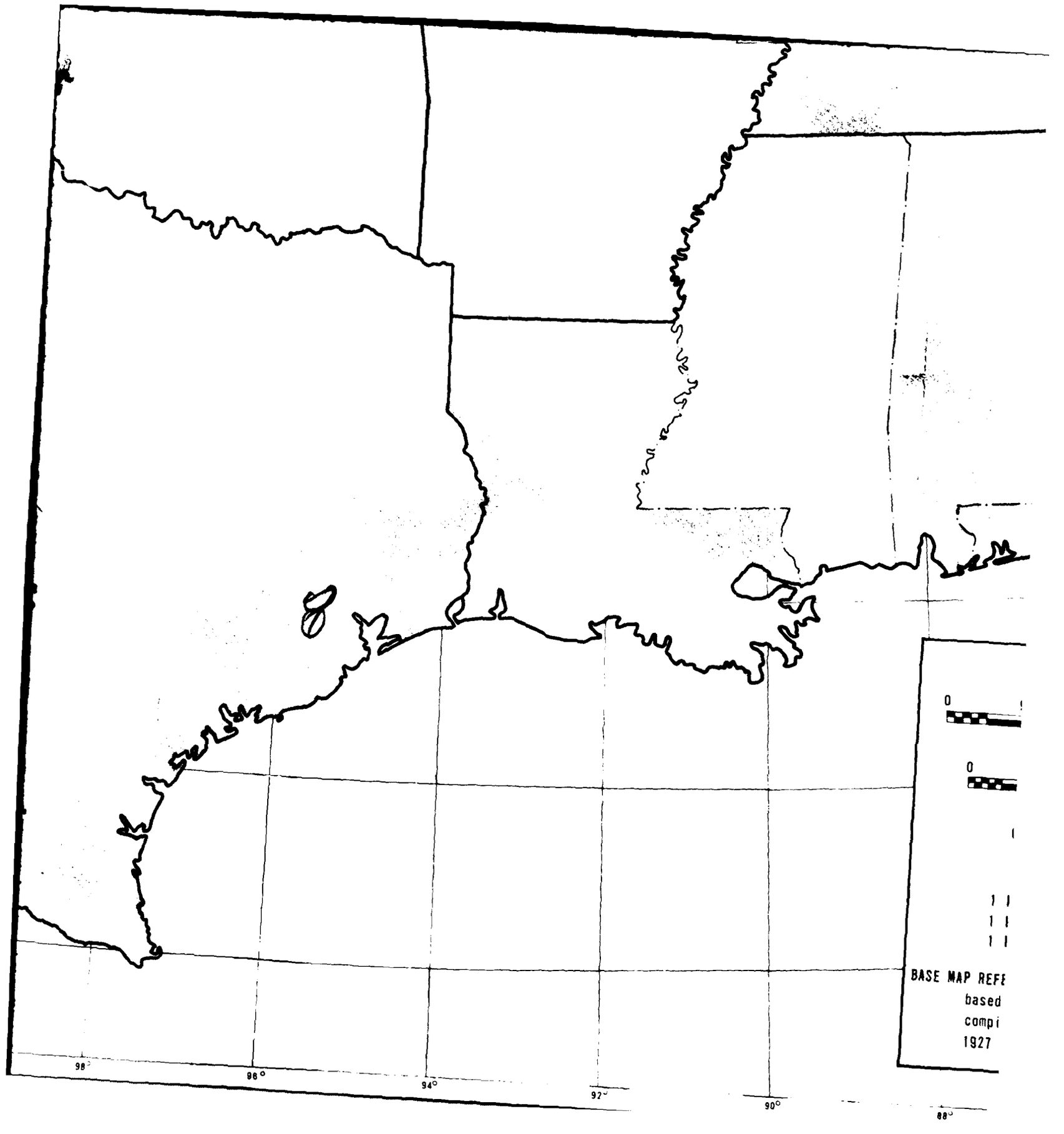
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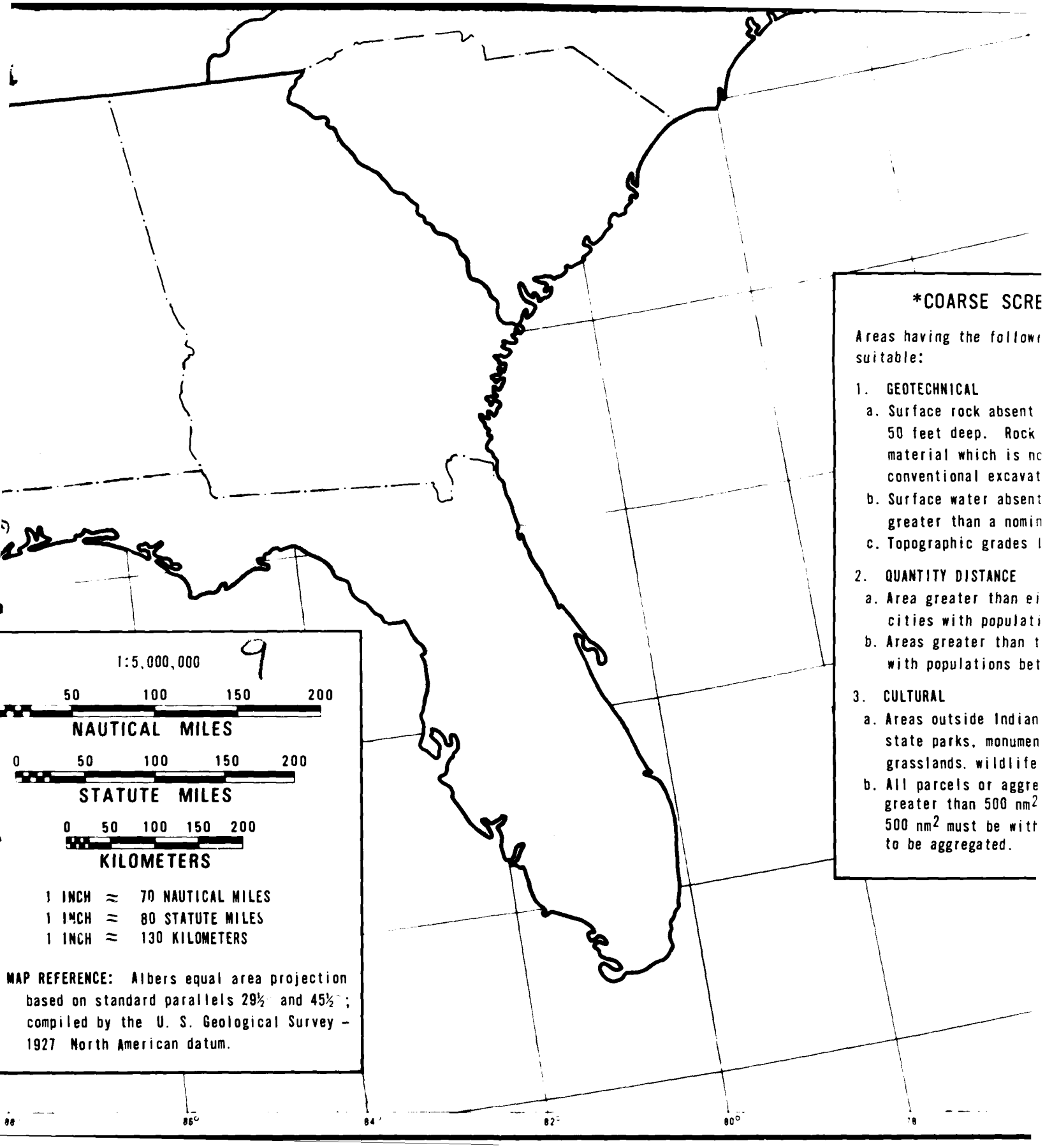
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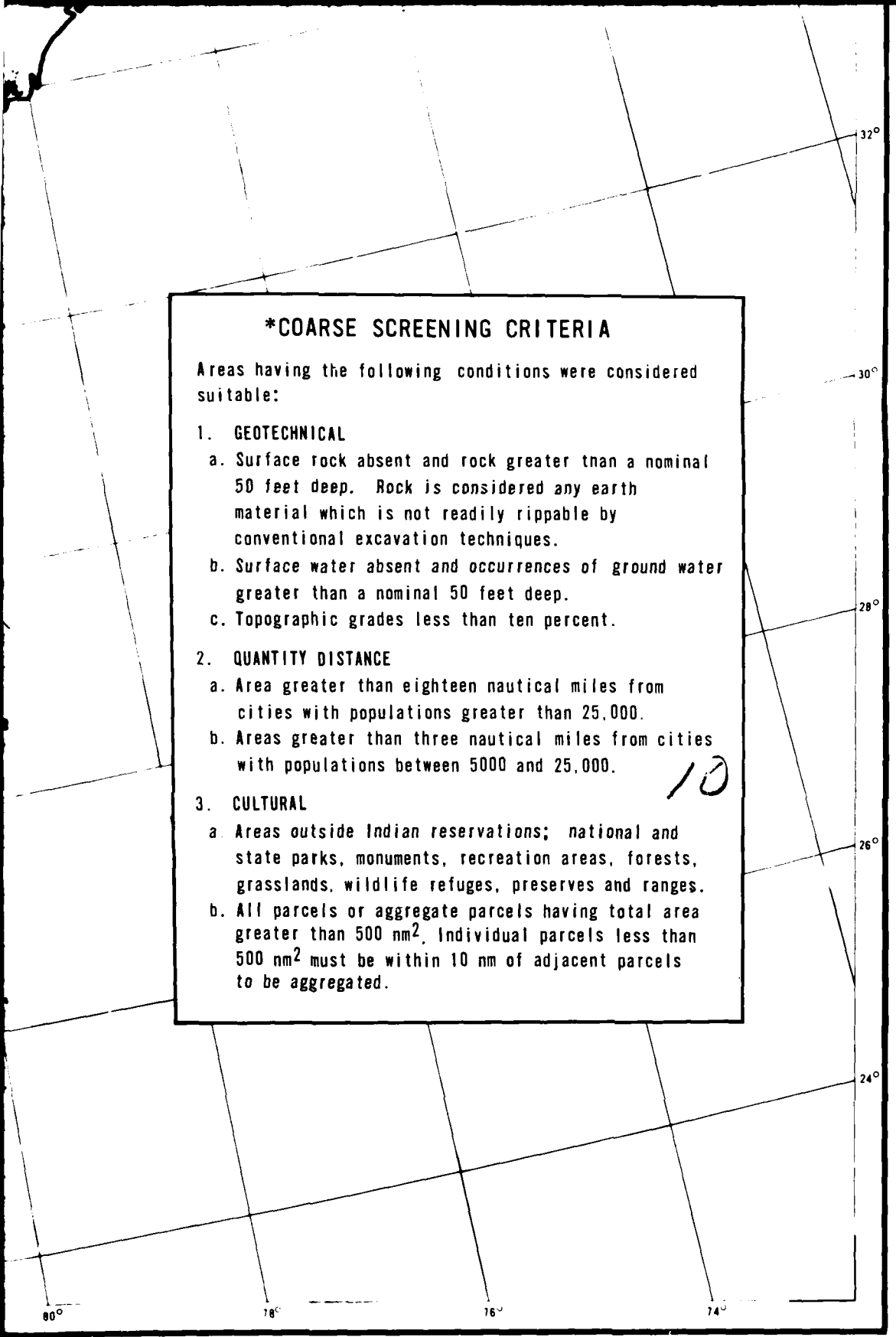

*COARSE SCREENING CRITERIA

Areas having the following conditions were considered suitable:

1. GEOTECHNICAL
   a. Surface rock absent and rock greater than a nominal 50 feet deep. Rock is considered any earth material which is not readily rippable by conventional excavation techniques.
   b. Surface water absent and occurrences of ground water greater than a nominal 50 feet deep.
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2. QUANTITY DISTANCE
   a. Area greater than eighteen nautical miles from cities with populations greater than 25,000.
   b. Areas greater than three nautical miles from cities with populations between 5000 and 25,000.
3. CULTURAL
   a. Areas outside Indian reservations; national and state parks, monuments, recreation areas, forests, grasslands, wildlife refuges, preserves and ranges.
   b. All parcels or aggregate parcels having total area greater than 500 nm^2. Individual parcels less than 500 nm^2 must be within 10 nm of adjacent parcels to be aggregated.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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Item No. 20 - Abstract

At the request of SAMSO, a three stage screening program was begun to evaluate the conterminous United States (CONUS) for MX siting. In the initial stage, Coarse Screening, the following primary exclusion criteria were applied: surface rock, or rock within fifty feet of the ground surface unless of a rippable nature; surface water or ground water within fifty feet of the surface; cultural features; quantity-distance relationships; and topographic grade greater than ten percent. Of the total CONUS area 238,309 nm^2 were identified as suitable or potentially suitable for MX siting.

Suitable areas have a higher likelihood of remaining viable MX siting area in further screening studies unless additional criteria are added. Substantial amounts of potentially suitable area was defined on the basis of an inadequate data base in these areas. These are likely to be reduced significantly in the more detailed Intermediate Screening studies.

The suitable area was divided into 23 groups primarily on the basis of state boundaries and similar geotechnical conditions. These groups were ranked according to the number of unit siting regions, each 5000 nm^2 suitable areas within the group and to the confidence level for the data used in the screening process. The highest ranked suitable areas occur in the Basin and Range and Central High Plains Physiographic Provinces.

APPENDIX A

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3.0 RESULTS

3.1 GENERAL

Application of the screening criteria resulted in the total exclusion of approximately 65 percent of the conterminous United States (Drawing 1). This excluded area will not be considered in future screening and other MX siting studies unless baseline MX siting requirements are changed. Table 3 summarizes the results of the application of the siting criteria on the conterminous United States. The values shown were determined by estimating area from individual worksheet overlays. Summation of the individual totals will not result in the total area excluded since many areas are unsuitable by overlapping exclusions.

The areal effect of each of the exclusion criteria is shown on Figures 2 through 6. These figures are reduced versions of the 1:2,500,000 scale worksheet overlays and serve to illustrate the distribution of the excluded areas and the overlapping relationship of many exclusions.

The remaining non-excluded area total 793,809 nm^2 includes four categories:

1. Suitable area (238,309 nm^2),
2. Potentially suitable area having surface and/or subsurface rock conditions which are inadequately defined (268,495 nm^2),
3. Potentially suitable area having ground-water conditions which are inadequately defined (227,866 nm^2), and
4. Potentially suitable area having surface and/or subsurface rock and ground-water conditions which are inadequately defined (59,139 nm^2).

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APPENDIX B

COARSE SCREENING EXCLUSION CRITERIA

Surface Rock and Depth to Rock

Surface Water and Depth to Water

Cultural

Quantity Distance

Topographic

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 have been suggested as a criteria for differentiation. Since little data are available for seismic velocity studies of near surface materials, most evaluations are based on interpretations of lithologic descriptions, columnar sections on maps and in reports, and on discussions with local geologists familiar with each particular unit.

Data regarding surface and shallow rock were taken from various sources. Initial compilation was done using AAPG Geologic Highway Series Maps at a scale of 1:1,875,000. Bedrock contacts were determined from these maps except in the Great Plains and Great Lakes groups where contacts were determined from state geologic maps and the Geologic Map of the United States (1:2,500,000 scale, 1974).

Those areas excluded as rock are, in general, composed of or underlain by the geologically oldest rocks, containing either intrusive or extrusive igneous rocks, metamorphic rocks, or massive well-lithified sedimentary rocks. These areas generally correspond to mountainous terrain which is for the most part, unsuitable due to topographic grade.

The non-rock category includes those areas considered the most viable as potential siting areas. These areas of non-rock are generally the geologically youngest deposits, composed of unconsolidated, semi-consolidated, or weakly-lithified geologic

formations, or 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.

Between the rock and non-rock categories are areas characterized by surface and shallow rock conditions which could not be adequately defined witin the scope of the Coarse Screening investigation. These areas (Drawing 1) are generally considered as potentially suitable from the available data, and have a relatively high probability of being excluded during Intermediate Screening. As a rule, in such areas where it could not be determined that at least 50 percent of the lithologic unit being considered was "rock", the area was not excluded. Instead, it was designated as an area with an inadequate data base with additional investigation necessary.

Data used in making rock evaluations were, in most cases, of a regional nature and subject to local variations. Formations which cover large areas and which are laterally variable could not be given detailed local consideration. Thus, in some areas rock units may be weathered or fractured to shallow depths (less than 50 feet) and be excavatable, whereas, unconsolidated sediments may be locally cemented or underlain by shallow bedrock of unknown nature. The excluded areas shown are well documented making the final estimate somewhat conservative. Some modification of the present rock/non-rock area boundaries will probably occur as more detailed data are collected during Intermediate and Fine Screening.

SURFACE WATER/GROUND WATER WITHIN 30-50' OF SURFACE

Large areas of less populated regions of the United States lack sufficient data to assess the existence of shallow water. Surface water, ground water in the saturated zone of unconfined aquifers or ground water in confined (artesian) aquifers which would be encountered in excavations to 30 to 50 feet were considered as exclusions in this study.

Principal data sources include the U. S. Geological Survey Water-Supply Papers and Hydrologic Atlas Series', and various state publications. Much data are available in the form of individual well-point measurements, but it was not within the scope of this study to plot and contour such data. In general, only existing maps showing 30' to 50' depth to water contours in unconsolidated deposits were used. Lakes, major rivers, reservoirs, and swamp/marsh areas were all defined either from the map of the United States (scale 1:2,500,000, 1972) or from various state topographic maps (scale 1:500,000) in states with extensive swamp or marsh areas. These areas of known surface or shallow water are compiled at a scale of 1:2,500,000 and plotted on the hydrology overlay.

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 tables and their dependence on seasonal precipitation, variations in river levels, and pumping or natural discharge rates generally make depth to water determinations difficult. Furthermore, records do not

often indicate whether wells with water levels within the upper 50 feet are static or a result of artesian aquifers. Such levels may therefore be "artificially" high and not truly indicative of the water conditions to be encountered in near-surface excavations.

CULTURAL EXCLUSIONS

Cultural exclusions included Indian Reservations, National Parks, Monuments, Forests and Grasslands; and state and federal wildlife refuges, game ranges, and wilderness areas. Minimum distance exclusions from boundaries were not used since they are too small for depiction at the scale of 1:2,500,000. All boundaries were taken from the U. S. Geological Survey, BLM map of the United States (1964, 1:2,500,000).

QUANTITY/DISTANCE

Quantity/distance exclusions used in the Coarse Screening study are related to population centers. An exclusion area defined by a three nm radius surrounds all municipalities of 5,000 to 25,000 inhabitants. An area defined by an 18 nm radius surrounds municipalities of greater than 25,000 inhabitants. All 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 to 25,000 population) and the National Geographic Society, Atlas of the World (1975) (for cities greater than 25,000). All data were plotted at the scale of 1:2,500,000 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.

TOPOGRAPHIC GRADE

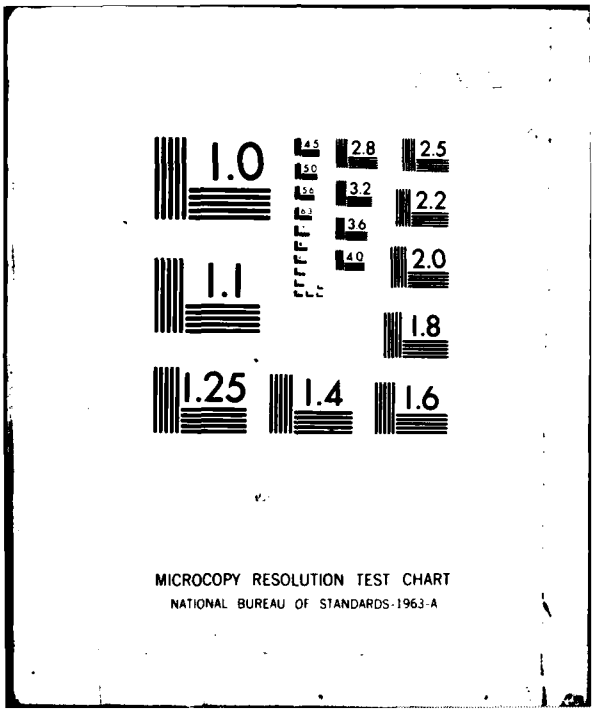
Data from maps showing areas of greater than ten percent topographic grade were compiled from a scale of 1:500,000 using U. S. Geological Survey State Topographic Maps. Contour spacings were used to determine slope angles on maps with contour intervals varying from 50 to 500 feet, depending on topographic conditions. The ten percent slope boundary was determined after calculating the necessary contour spacing of each topographic sheet. Prepared slope maps were then photographically reduced and transferred to a scale of 1:2,500,000.

APPENDIX C

AREAL DISTRIBUTION OF

SUITABLE AND POTENTIALLY SUITABLE AREAS

AD-A112 495 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION CONTERMINOUS U--ETC(U)
JUN 77 K L WILSON, R J LYNN, J R MILLER F04704-77-C-0010
UNCLASSIFIED FN-TR-16 NL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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

INTERMEDIATE SCREENING STUDY GROUP	SUITABLE AREA (nm^2)	POTENTIALLY SUITABLE AREA (nm^2)			(a) PRIMARY EXCLUSION FACTORS	PRINCIPAL PHYSIOGRAPHIC PROVINCE (INCLUSIVE)
		ROCK CONDITIONS INADEQUATELY DEFINED	GROUND-WATER CONDITIONS INADEQUATELY DEFINED	ROCK AND GROUND-WATER CONDITIONS INADEQUATELY DEFINED		
NEVADA	16,315.25	0	0	0	Depth to rock Topography	Basin and Range
ARIZONA	13,572.25	3,561.93	0	4.40	Cultural Depth to rock	Basin and Range
CALIFORNIA	13,676.63	1,339.40	1,368.80	0	Topography Depth to rock	Basin and Range
NEW MEXICO	9,525.61	7,347.39	7,007.72	3,194.26	Depth to rock Cultural	Basin and Range Great Plains
UTAH	1,815.19	3,457.35	0	123.71	Topography Depth to rock	Basin and Range
OKLAHOMA	4,171.75	19,114.83	3.81	0	Quantity Distance Depth to water	Great Plains Central Lowland
TEXAS	30,433.04	65,947.12	17,251.58	0	Depth to rock Quantity/Distance	Great Plains Coastal Plain
NORTH DAKOTA	28,124.81	8,192.21	1,162.55	265.85	Depth to rock Depth to water	Great Plains Central Lowland
SOUTH DAKOTA	18,263.85	10,777.29	181.81	0	Depth to rock Cultural	Great Plains Central Lowland
NEBRASKA	30,904.12	11,273.11	19.80	0	Depth to rock	Great Plains
COLORADO	11,486.49	10,890.31	776.37	0	Topography Depth to rock	Great Plains
MONTANA	20,508.78	29,337.54	10.32	0	Depth to rock Cultural Topography	Great Plains
MID-CONTINENT	5,765.50	7,856.25	8,342.87	2,459.82	Depth to rock Depth to water	Great Plains Central Lowland
WYOMING	8,981.41	29,280.48	0	19.61	Cultural	Wyoming Basin

MID-CONTINENT	5,765.50	7,856.25	8,342.87	2,459.82	Topography Depth to rock Depth to water	Great Plains Central Lowland
WYOMING	8,981.41	29,280.48	0	19.61	Cultural Topography	Wyoming Basin Great Plains
KANSAS	284.06	24,460.69	14,901.41	2,299.87	Quantity Distance Depth to water	Great Plains Central Lowland
SOUTHEASTERN	9,223.63	0	55,842.17	9,457.56	Depth to water Quantity/Distance	Coastal Plain
GREAT LAKES	0	11.83	35,922.73	27,845.36	Quantity Distance	Central Lowland
PACIFIC NORTHWEST	3,514.07	0	8,970.23	385.34	Depth to rock Topography	Basin and Range Columbia Plateau
MID-ATLANTIC	0	13,885.10	23,602.80	2,416.40	Quantity Distance Depth to rock	Piedmont Coastal Plain
MINNESOTA	0	0	27,745.17	4,036.37	Depth to rock Cultural	Central Lowland
IOWA	0	0	20,275.60	3,511.26	Quantity Distance	Central Lowland
NORTHEASTERN	71.67	16,141.39	0	2,787.62	Topography Quantity Distance	New England
APPALACHIAN PLATEAU	0	5,562.69	5,005.65	327.66	Depth to rock Topography	Interior Low Plateau
TOTAL	226,636.11	268,436.91	228,391.39	59,135.29		

(a) Primary exclusion factors are those criteria which were primary in the exclusion of land within each intermediate screening study group. These appear in order of importance within each study group, with the exception of the Montana and Kansas Groups in which they were of nearly equal importance.

AREAL DISTRIBUTION OF SUITABLE AND POTENTIALLY SUITABLE AREAS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE C-1

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