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WITHDRAWAL/ACQUISITION M-X/MPS (M-X/MU. (U) HENNINGSON
DURHAM AND RICHARDSON SANTA BARBARA CA 02 OCT 81
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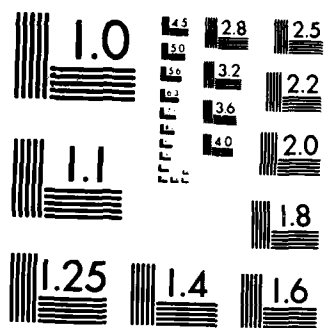
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ENVIRONMENTAL
TECHNICAL REPORT

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MINING AND GEOLOGY

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DEPLOYMENT AREA SELECTION
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DEPARTMENT OF THE AIR FORCE

M-X ETR-11

**ENVIRONMENTAL CHARACTERISTICS
OF ALTERNATIVE DESIGNATED
DEPLOYMENT AREAS:
MINING AND GEOLOGY**

Prepared For
U.S. Air Force
Ballistic Missile Office
Norton Air Force Base
California

Henningson, Durham & Richardson, Inc.
Santa Barbara, California

REVIEW COPY OF WORK IN PROGRESS

2 October 1981

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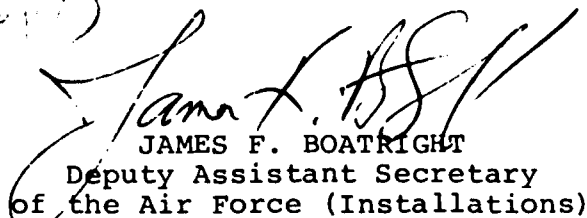
Federal, State and Local Agencies

On October 2, 1981, the President announced his decision to complete production of the M-X missile, but cancelled the M-X Multiple Protective Shelter (MPS) basing system. The Air Force was, at the time, of these decisions, working to prepare a Final Environmental Impact Statement (FEIS) for the MPS site selection process. These efforts have been terminated and the Air Force no longer intends to file a FEIS for the MPS system. However, the attached preliminary FEIS captures the environmental data and analysis in the document that was nearing completion when the President decided to deploy the system in a different manner.

The preliminary FEIS and associated technical reports represent an intensive effort at resource planning and development that may be of significant value to state and local agencies involved in future planning efforts in the study area. Therefore, in response to requests for environmental technical data from the Congress, federal agencies and the states involved, we have published limited copies of the document for their use. Other interested parties may obtain copies by contacting:

National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Telephone: (703) 487-4650

Sincerely,


JAMES F. BOATRIGHT
Deputy Assistant Secretary
of the Air Force (Installations)

1 Attachment
Preliminary FEIS

TABLE OF CONTENTS

	Page
1.0 Introduction	1
1.1 Importance of Geology in EIS Process and M-X Program	1
1.2 Definition of Geotechnically Suitable Areas	1
2.0 Geologic Setting	3
2.1 Nevada/Utah	3
2.1.1 Slope and Topography	3
2.1.2 Physical Description	5
2.2 Texas/New Mexico	5
2.2.1 Slope and Topography	5
2.2.2 Physical Description	6
3.0 Mining and Minerals	9
3.1 Nevada/Utah (Existing Setting)	9
3.1.1 Past and Present Production	9
3.1.1.1 Nevada	10
3.1.1.2 Utah	13
3.1.2 Mining Activity	13
3.1.2.1 Current and Historic Mining	13
3.1.2.2 Mining Activity in Nevada	23
3.1.2.3 Mining Activity in Utah	23
3.1.3 Mining Employment and Income	33
3.1.3.1 Nevada	33
3.1.3.2 Utah	33
3.1.4 Mining Claim and Leasing Activity, and	33
3.1.4.1 Nevada	33
3.1.4.2 Utah	38
3.2 Texas/New Mexico Existing Setting	41
3.2.1 Mineral Resources	41
3.2.1.1 Industrial and Saline Minerals	46
3.2.1.2 Metallic Commodities	47

	Page
3.3 M-X Impacts--Nevada/Utah	47
3.3.1 Land Withdrawal,	60
3.3.1.1 Nevada	61
3.3.1.2 Utah	64
3.3.2 Access Conflicts,	65
3.3.2.1 Construction	65
3.3.2.2 Operation	65
3.3.3 Competition for Labor,	67
3.4 M-X Impacts--Texas/New Mexico	67
3.5 Mitigations	69
3.5.1 Preemption of Land, and	70
3.5.2 Interference with Existing Mine Operations,	70
3.5.3 Competition for Labor and Resources	70
4.0 Seismicity -- Tectonic and	71
4.1 Introduction	71
4.2 Nevada/Utah	72
4.2.1 Tectonic Setting	72
4.2.2 Seismic Setting,	73
4.2.2.1 Geographic Distribution of Seismicity	73
4.2.2.2 Historic Seismicity	73
4.2.3 Quaternary Faults,	76
4.2.3.1 Nature of Faulting	76
4.2.4 Historic Earthquakes and Surface Rupture, and	81
4.2.5 Seismic Hazards in the Great Basin; ()	81
4.3 Texas/New Mexico	84
4.4 M-X Operating Bases	84
4.4.1 Beryl	84
4.4.2 Coyote Spring	84
4.4.3 Delta	86
4.4.4 Ely	86
4.4.5 Milford	86
4.4.6 Clovis	86
4.4.7 Dalhart	86
4.5 Mitigations	87

5.0	Soils - <i>Physical and</i>	89
5.1	Introduction	89
5.2	Soil Characteristics: Nevada/Utah Study Region	89
5.2.1	Physical Properties	89
5.2.2	~~Agronomic Properties~~ , <i>and</i>	91
5.2.3	Soil Characteristics of the Potential Operating Base Sites	92
5.2.3.1	Beryl, Utah	92
5.2.3.2	Coyote Spring, Nevada	95
5.2.3.3	Delta, Utah	95
5.2.3.4	Ely, Nevada	96
5.2.3.5	Milford, Utah	96
5.3	Soil Characteristics: Texas/New Mexico Study Region	96
5.3.1	Physical Properties	96
5.3.2	Agronomic Properties	98
5.3.3	Soil Characteristics of the Potential Operating Base Sites	99
5.3.3.1	Clovis, New Mexico	99
5.3.3.2	Dalhart, Texas	99
5.4	Water ~~Erosion~~ ;	101
5.4.1	Introduction	101
5.4.2	The Universal Soil Loss Equation	103
5.4.3	Determination of Water Erosion Impact Rankings	103
5.4.3.1	DDA Impact Rankings	103
5.4.3.2	OB Impact Rankings	105
5.5	M-X Impacts: Nevada/Utah	105
5.6	M-X Impacts: Texas/New Mexico	109
5.7	Future Water Erosion Impacts Without M-X	109
5.8	Mitigations	110
5.8.1	Air Force Programs	110
5.8.2	Other Mitigation Measures under Consideration	110
6.0	Paleontology; <i>Energy Resources; and</i>	113
6.1	Nevada/Utah	113
6.1.1	Paleozoic	113
6.1.2	Cenozoic	113

	Page
6.2 Texas/New Mexico	113
6.3 M-X Impacts - Nevada/Utah	115
6.3.1 Direct Impacts	115
6.3.2 Indirect Impacts	115
6.3.3 Significance Analysis	115
6.3.3.1 Coyote Spring OB	118
6.3.3.2 Beryl OB	118
6.3.3.3 Milford OB	118
6.3.3.4 Delta OB	119
6.3.3.5 Ely OB	119
6.4 M-X Impacts - Texas/New Mexico	119
6.4.1 Clovis OB	119
6.4.2 Dalhart OB	119
6.5 Mitigations	119
7.0 Energy Resources	121
7.1 Nevada/Utah	121
7.1.2 Geothermal	124
7.1.3 Energy Production	124
7.1.3.1 Nevada	124
7.1.3.2 Utah	125
7.2 Texas/New Mexico	128
7.2.1 Oil and Gas	128
7.2.2 Coal	131
7.2.3 Uranium	131
7.2.4 Geothermal	131
7.3 Impacts, Nevada/Utah	133
7.4 Impacts, Texas/New Mexico	133
7.5 Mitigations	134
8.0 Zeolites	135
8.1 Introduction	135
8.2 Geologic Occurrence and Natural Synthesis	135
8.3 Occurrence in the Development Area	135
8.3.1 Physical Occurrence	135
8.3.2 Future Exploration and Development	137

		Page
9.0	Bibliography of Cited and Supplementary Literature	141
Appendix A	Earth Resources Inventory by County for Nevada	175
Appendix B	Earth Resources Inventory by County for Utah	193
Appendix C	Mining Claims by County in Nevada	205
Appendix D	Mining Claims by County in Utah	209
Appendix E	Utah State Lands Containing Mineral Resources	213
Appendix F	The Universal Soil Loss Equation (USLE)	217
Appendix G	Laws Protecting Paleontological Resources	233

LIST OF FIGURES

No.		Page
2.1.1-1	Physiographic regions of the Great Basin	4
2.2.1-1	Major physiographic regions in the Texas/New Mexico deployment area	7
3.1.1-1	Geographic distribution of minerals industry activity in the Nevada/Utah study area	17
3.3.1-1	Distribution of patented and unpatented mining claims and Proposed Action conceptual project layout	63
4.2.2-1	Earthquake epicenters in western United States for the period 1961-1970	74
4.2.3-1	Faults in the vicinity of the Nevada/Utah study area	79
4.2.3-2	Historic surface fault ruptures	80
4.2.4-1	Surface rupture zones of Magnitude greater than 7 earthquakes since 1840, western Great Basin	82
4.2.5-1	General seismic constraints in Nevada and Utah	85
5.2.2-1	Soil types of the Nevada/Utah study area	95
5.4.1-1	Gully formation resulting from the concentrated flow of water through a culvert, Railroad Valley, Nevada	102
6.1.2-1	Pleistocene lake beds and Cenozoic fossil locales and the Proposed Action conceptual project layout	117
7.1-1	Oil and gas resource areas in Nevada/Utah	122
7.1-2	Geothermal resource areas in Nevada/Utah	123
7.2-1	Energy resources in the Texas/New Mexico study area	130
8.3.1-1	Locations of commercial interest for zeolites	136
8.3.1-2	Areas of possible zeolite occurrence in Nevada and Utah	139
F-1	R values for Nevada and Utah	216
F-2	R values for the Texas/New Mexico study region	217
F-3	Slope polygons for Delamar Valley, Nevada	218

VIII Blank

LIST OF TABLES

No.		Page
3.1.1-1	Nevada mineral production, 1970-1978	11
3.1.1-2	Gross yield of mines and minerals produced in Nevada study area counties, 1977	12
3.1.1-3	Principal mineral producers in Nevada for six selected counties, 1975	14
3.1.1-4	Mineral production in Utah	18
3.1.1-5	Mineral production and value in Utah study area counties, 1975	19
3.1.1-6	Principal mineral producers in Utah for selected counties	20
3.1.2-1	Estimated future mineral production statistics in selected Nevada counties	24
3.1.3-1	Mining employment in Nevada, 1950-1979	34
3.1.3-2	Employment in mines, mills, and smelters for selected Nevada counties, 1978, 1979, and 1980	35
3.1.3-3	Mining employment in Utah, 1960-1977	36
3.1.3-4	Employment and personal income in mining for selected Utah counties, 1977	37
3.1.4-1	Leases in effect in Nevada, 1978	39
3.1.4-2	Oil and gas leases in effect by county in Nevada, 1978	40
3.1.4-3	Utah outstanding leases on public lands, 1977	42
3.1.4-4	Unpatented and patented mining claims within geotechnically suitable areas	43
3.2.1-1	Value of mineral productions in Texas/New Mexico by county within study area, 1976	45
3.3.1-1	Analysis of M-X land interests requirements	66
3.3.3-1	Percentage of mining labor force subject to attractions to M-X, by category	68

No.		Page
5.2.2-1	Soil orders, suborders, and great groups predominating in the Nevada/Utah study region	93
5.4.3-1	Estimated potential water erosion (soil loss) impacts	104
5.4.3-2	Worksheet for determining relative overall valley impact rating	106
5.4.3-3	Estimated potential water erosion impacts at the operating base site	107
7.1.3-1	Known geothermal resource areas in Nevada	126
7.1.3-2	Identified remaining recoverable road reserves in Utah; selected coal fields	127
7.1.3-3	Geothermal energy in Utah study area	129
7.2.1-1	Current activity and future oil and gas development in the Texas/New Mexico study area	132
F-1	Values of the topographic factor, LS, for specific combinations of slope length and steepness	219
F-2	C factor values for construction sites	222
F-3	Practice factor P for surface condition for construction sites	223
F-4	Universal soil loss equation data worksheet for Delamar Valley, Nevada	225
F-5	Average USLE factors and estimated annual soil loss value	226
F-6	Water erosion data sheet for the Texas/New Mexico designated deployment area	229
F-7	Summary of operating base characteristics influencing water erosion potential	230

ENVIRONMENTAL CHARACTERISTICS OF ALTERNATIVE DESIGNATED DEPLOYMENT AREAS:

MINING AND GEOLOGY

1.0 INTRODUCTION

1.1 IMPORTANCE OF GEOLOGY IN EIS PROCESS AND M-X PROGRAM

The project will impact the geology of the siting area by the alteration of elements of topography and disruption of the surface. Potential changes in access to mineralized areas are also a concern. Alterations of the topography and disruption of the surface may result in an increased erosion potential in the siting region, especially during the construction phase. Changes in access to mineralized areas may either enhance or impede the exploration and development of economic mineral deposits.

1.2 DEFINITION OF GEOTECHNICALLY SUITABLE AREAS

Important considerations in the way the geology affects the project are established by the definition of the geotechnically suitable area (ETR-1). These considerations include depth to bedrock, slope, and topographic character, engineering suitability of soil, distance from faults, and presence of economic mineral areas. All of these considerations are dependent on the local or regional geology. If the depth to bedrock is too shallow, the excavation of shelters is not only difficult and uneconomical, but affects the survivability of the system. If the slopes are too steep or the topography too complex, the transporter road construction is difficult and costly. Elements of the system should not be located within 1,000 ft (300 m) of capable faults, and structural elements of the system should withstand expected ground accelerations in the region. High potential mineral deposits are to be avoided in project siting. Another geologic consideration is the location of suitable sources of aggregate material within the project area is considered for utilization for construction of the system.

Specific screening criteria were applied to areas suitable for M-X siting. Geotechnical criteria were applied first to eliminate any areas with bedrock or water table within 50 ft of the ground surface and any areas with slopes exceeding 10 percent, or of otherwise unsuitable topography (numerous steep slopes, deep drainages, etc.). Criteria which include establishing a clear zone around cities, towns, and transportation corridors were applied to eliminate areas which are not compatible with project use requirements.

Following the application of construction and operational screening criteria, the suitable areas in the Nevada/Utah siting region generally consist of long narrow valleys, which tend to run in a north-south direction. The total available suitable area is approximately 16,000 sq mi (41,600 sq km), roughly twice the size required to site the system, thus allowing for flexibility.

Within the Texas/New Mexico siting region, the major divisions between suitable areas are man-made rather than natural, as illustrated in Chapter 3 of the DEIS, Figure 3.3.1.1-1. The suitable area is transected by numerous railroads and

highways, thus consisting of large, homogeneous areas of land which are bisected by transportation networks. The total available suitable area in Texas/New Mexico is approximately 8,000 sq mi (20,800 sq km), slightly larger than the area needed to accommodate a full system.

2.0 GEOLOGIC SETTING

2.1 NEVADA/UTAH

SLOPE AND TOPOGRAPHY (2.1.1)

The Nevada/Utah siting region is located in the Great Basin section of the Basin and Range physiographic province. This province is characterized by steep mountains, bounded by northerly trending normal faults and separated by alluvium filled basins. The mountain ranges stand out from the valleys, with elevations 3,000 to 5,000 ft (1,000 to 1,700 m) greater than the basin floors. The basins are partly filled by sediment eroded from the bordering mountain ranges. The sediment forms alluvial fans generally coalesced into bajadas that slope from the foot of the mountains to the alluvial floodplains or playas in the center of the valley.

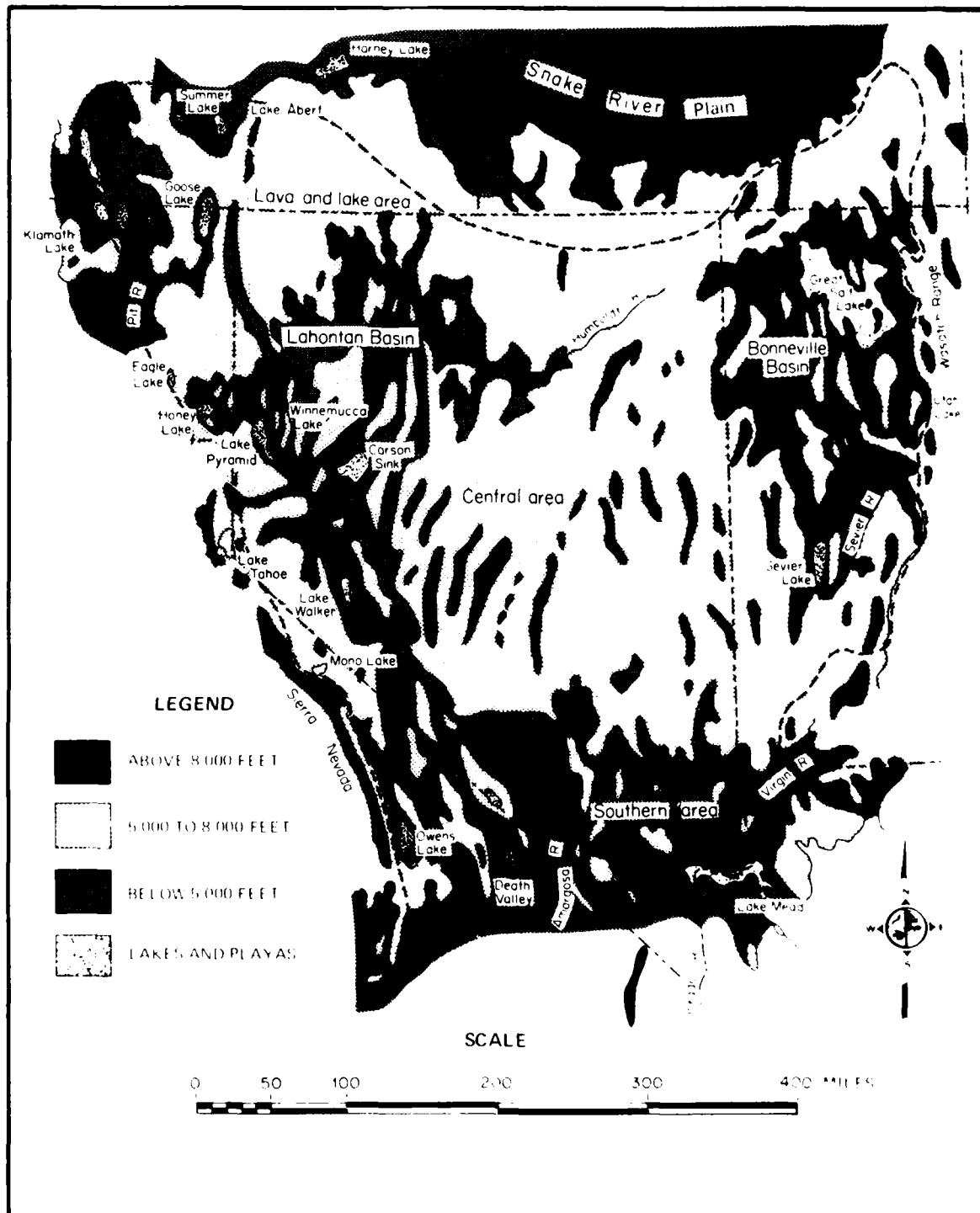
The mountains, alluvial fans, valley floors, and playas all have distinctly different slopes. The mountains characteristically have slopes of 30 to 35 percent, with some 100 percent or greater. The alluvial fans and bajadas form the transition between the steep mountain slopes and the valley floor. Slopes on the bajadas are generally 5 to 15 percent, with the steeper slopes closer to the mountains. The valley floors most frequently have slopes between 1 and 5 percent, while the playas usually have no definable slope.

Physiographically, the Great Basin is divided into five regions: the Central area, the Bonneville Basin, the Lahontan Basin, the Southern area, and the Lava and Lake area (see Figure 2.1.1-1). The M-X deployment area is in the Central area and the Bonneville Basin, while the Coyote Spring OB is in the southern area.

The Central area is characterized by valleys that are mostly 5,000 ft in altitude. Some valleys are closed, but none contain perennial lakes. Dry lake beds and alluvial flats make up approximately 10 percent of this area and the remaining part is almost equally divided between the mountains and the alluvial fans sloping from them. Some of the valleys drain to the Lahontan Basin via the Humboldt River.

The Bonneville Basin covers most of western Utah. It is structurally similar to the Central area, but lower in elevation. Most of the basins are less than 5,000 ft in elevation, but are slightly higher in southwestern Utah. Playas and alluvial flats are extensive and make up about 40 percent of the basin. Mountains cover almost one-fourth of the Bonneville Basin and alluvial fans cover the rest. Most drainage is to Great Salt Lake and Sevier Lake as there is no external drainage. Sevier Lake is mostly dry, although it would be perennial if it received the water that is consumed by irrigation.

Slope and topography are two of the criteria used to determine geotechnically suitable areas. As sites are chosen and examined, additional details will become apparent. Areas with slopes greater than 10 percent (with a high percentage of slopes exceeding 5 percent) are not geotechnically suitable for deployment of the system. Other areas excluded for topographic reasons are those having drainage densities averaging at least two 10-ft (3 m) deep drainages every 1,000 ft (300 m).



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Figure 2.1.1-1. Physiographic regions of the Great Basin.

PHYSICAL DESCRIPTION (2.1.2)

The Great Basin region of the Basin and Range Province is underlain by a Precambrian igneous and metamorphic complex, which is exposed in the south, but overlain by a thick sequence of Paleozoic rocks throughout most of the region. The Paleozoic sedimentary sequence (miogeosynclinal on the east, eugeosynclinal on the west) includes thick Cambrian sandstones and Ordovician-Mississippian limestones. The upper Paleozoic section contains conglomerates and other clastic rocks deposited near local uplifts formed during the Mississippian-Pennsylvanian Antler Orogeny. Mesozoic units, once present in the Basin and Range, were largely removed by erosion subsequent to the regional uplift produced during the Laramide Orogeny. This Mesozoic (Jurassic-Cretaceous) compressional event also produced thrusting, intrusion of granitic batholiths, and severe deformation of the Paleozoic sedimentary sequence (Dott and Batten, 1976).

During early Tertiary time, the eastern half of the Great Basin was covered with lowland swamps, lakes, and floodplains; the western half was a low upland, an erosional remnant of the Mesozoic "mobile belt" uplift. In middle Tertiary time, Basin and Range type faulting commenced; linear mountain ranges and intervening intermontane basins, which collected sediments eroded from the ranges, began to form at that time. Basaltic and limited andesitic volcanics, including lavas, tuffs, and agglomerates, were extruded in association with this extensional faulting. The faulting continued and increased in intensity into Pliocene and Pleistocene time.

Since late Tertiary time, the topography of the Great Basin has consisted of isolated, subparallel, north-south-trending ranges that rise abruptly above the desert plains of sediment-filled intermontane basins. The basin sediments generally consist of two facies: (1) coarse, conglomeratic bajada and alluvial fan deposits along the basin margins and (2) fine-grained playa and floodplain deposits in the central parts of the basins (Thornbury, 1965).

The Quaternary sediments in the Great Basin are dominantly alluvial and lacustrine in origin, but locally include aeolian, glacial, and glaciofluvial units. The study of these sediments, and the soils and landforms developed on them, is of particular importance to the study of Quaternary faulting in the region. Many of the basins in the region include extensive lacustrine sediments and shorelines produced during cool and/or wet pluvial episodes, which appear to have been synchronous with times of expanded glacial activity in the mountains of the western United States. Lake Bonneville, the largest of the pluvial lakes, covered approximately 50,000 sq km of northwestern Utah, eastern Nevada, and southeastern Idaho. Great Salt Lake is a remnant of Lake Bonneville. Lake Lahontan, the second largest of the lakes, covered approximately 25,000 sq km of northwestern Nevada, northeastern California, and southeastern Oregon. A total of 110 former pluvial lakes have been identified in the Great Basin (Flint, 1971).

2.2 TEXAS/NEW MEXICO

SLOPE AND TOPOGRAPHY (2.2.1)

The M-X deployment area in Texas/New Mexico is situated in the Great Plains physiographic province, essentially a flat, featureless plain. The plains slope gently eastward with an average gradient of about ten feet per mile. The average

elevation of the area is approximately 3,500 ft with very low relief. Widely spaced (approximately 20 mi) drainages, which are usually dry, provide some relief. Tributary drainages are poorly developed because of the low rainfall and flat gradient. Following heavy rains, surface runoff occasionally reaches tributaries but generally percolates into the subsurface before entering drainage channels. Playa surfaces (of negligible slope) dot the landscape. The playas range in size from a few feet to a mile or so in diameter.

Two physiographic regions are distinguishable in the Texas/New Mexico deployment area. These are the East-Central Plains and the High Plains (Figure 2.2.1-1). The East-Central Plains are west of the High Plains, the High Plains Escarpment separating the two regions. In most places this escarpment is a prominent topographic feature, which is approximately 100 to 300 ft higher than the Plain, but in a few places (particularly in the south) the edge of the High Plains is marked by only a gradual slope.

The East-Central Plains are characterized by gently undulating to rolling uplands interspersed with relatively smooth valleys and basins. Isolated small mountains, hills, mesas, and volcanic cinder cones are found within the area, particularly in the central and northern section. Rugged and steeply sloping land occurs along the larger streams, as well as around the mesas and cones. Elevations over most of the area range from 4,000 to 7,000 ft with some small mountains and hills rising to 8,000 ft or more.

Three rivers provide principal drainageways: the Pecos, Canadian, and Cimarron. In the western part of New Mexico, however, surface drainage flows into closed basins.

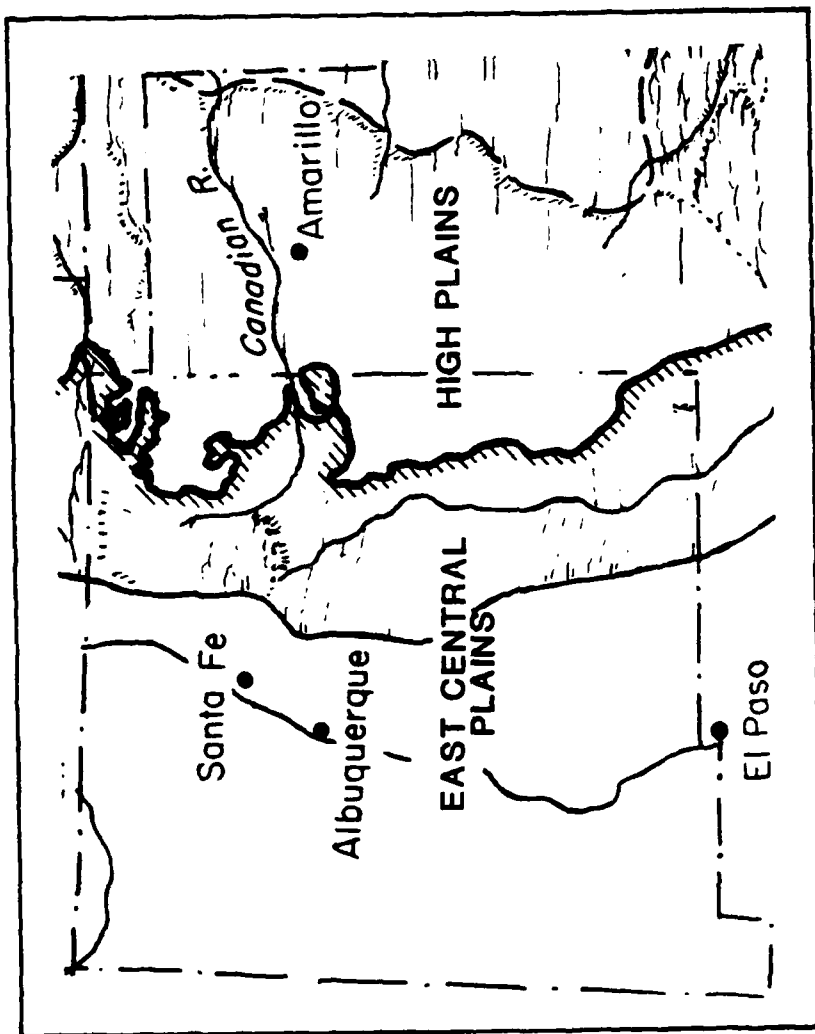
The High Plains are an extensive plain in which the gently sloping, smoothing surface is broken only by a few drainageways and playas. Minor areas of sandy soils having undulating or dune-like topography exist, and rugged and steeply sloping lands comprise the breaks contiguous to larger stream valleys and to the basalt or lava cones of the north. Elevations range from 3,000 to 5,000 ft.

Most drainages originating within the High Plains are intermittent and those with definite stream channels generally traverse the area in a southeasterly direction. Numerous smaller drainages fade out within a few miles or drain into shallow depressions where they form playas. These playas contain water only following periods of heavy precipitation. They are generally circular and range from a few feet to as much as 50 ft below the level of the surrounding plains.

The regional slope of the surface of the High Plains is 0.15 percent to the southeast. Along the western escarpment the slopes range from 1 to 5 percent, although the escarpment itself ranges from 20 to 30 percent. Generally slopes would not be a factor in constraining the project in the Texas/New Mexico deployment area.

PHYSICAL DESCRIPTION (2.2.2)

The Texas/New Mexico study region is underlain by the Ogallala Formation of Pliocene age. The Ogallala Formation extends from central Texas to South Dakota and was formed as an alluvial apron along the front of the Rocky Mountains. The



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Figure 2.2.1-1. Major physiographic regions in the Texas/New Mexico deployment area.

Ogallala consists of coalesced alluvial fans and materials subsequently redeposited downslope by fluvial processes. The formation was deposited on an erosional surface cut into the older bedrock and is generally thickest where it was deposited in ancient river valleys. The Ogallala thins out to the south.

The physical character of the Ogallala, while similar throughout the region, is highly variable both laterally and vertically. Generally there is a basal conglomerate and sandy to silty deposits with occasional channel sands or gravels higher in the section. Near the top of the unit there is a major caliche layer which forms the resistant "caprock" exposed along the edges of the plain. The presence of this caliche layer is one of the main reasons for the preservation of the region's level topography.

The topography over the Ogallala Formation is dotted with shallow depressions in which Pleistocene materials associated with the larger playas were deposited. During the Pleistocene, many of the present playas held permanent water bodies. Pleistocene stream terrace deposits are found along the drainage ways crossing the Ogallala Formation. In addition to Pleistocene and recent alluvial sediments, there are some lacustrine and dune deposits accumulated in small deflation-solution basins or lateral basins on the floor of the few valleys.

Where the major stream channels have cut completely through the Ogallala Formation the underlying Paleozoic and Triassic sedimentary bedrock is exposed. In the western part of the area the sedimentary rock is relatively thin over the Precambrian basement. However, in the east and south the thicker sedimentary units comprise important source and reservoir rocks for oil and gas.

The absence in the High Plains of the extensive volcanic deposits that characterized many areas in the Great Basin has precluded the formation and deposition of the parent material for zeolitization.

3.0 MINING AND MINERALS

Mining is an important issue in the Nevada/Utah siting region because of its position in the economy of the area. It is of minor importance in the Texas/New Mexico region, although major extraction of oil and gas occurs on the periphery of the M-X deployment area. Mining is the second largest economic activity in Nevada, next to tourism and gambling, and is also of high economic importance in Utah. In the siting area mining is the most important industry, particularly in the vicinity of Tonopah, Ely, and Pioche.

Nevada is the nation's number one producer of barite, magnesite, and mercury and is second in the nation in the production of gold. Utah is the leading producer of beryllium and is second in the production of copper, vanadium, and potash. With the rise in prices of most metals there has been an increased interest in mineral exploration using high technology. Some deposits that have been considered marginal may become economic to exploit.

The development of new mines takes generally five to ten years or more from the time of discovery. Old deposits could be reopened as the value of minerals increases past an economical threshold. Other than economics, controlling factors would be the accessibility of the locations, the availability of water, and the availability of a sufficiently skilled labor pool. The mineral industry is presently undergoing growth throughout the Nevada/Utah area. For example, estimates indicate a 60 percent growth in the mining industry in Nevada by the year 2000--an increase of about 20 active mines (Nevada Bureau of Mines and Geology, 1972). More recent data shows this estimate to be low. Several public comments indicated a more reasonable estimate would be 22 new mines by 1985. Except for oil and gas extraction, mineral resources are of minor economic importance in the Texas/New Mexico area. Some exploration for uranium is occurring there, however, and there is interest in nonmetallic resources, particularly gypsum.

3.1 NEVADA/UTAH (EXISTING SETTING)

PAST AND PRESENT PRODUCTION (3.1.1)

The Nevada mining industry, although second to the tourist-gaming industry, brings in more than five times as much money as agriculture, the third largest industry. For over a century, the state has been an important mineral producer, with gold and copper the leading products of value. More than 200 economically valuable metallic and nonmetallic minerals are known to exist in Utah.

Most metallic deposits in the Great Basin predate the formation of the Basin and Range topography. The mineralization is associated with Paleozoic and Mesozoic faulting and volcanism, while the basin and range faulting began during the mid-Cenozoic. Most of the mineral deposits located to date are found in the mountain ranges, where the mineralization is exposed and more readily discovered. Because the mineralization predates the formation of the Basin and Range, it is likely that mineralization also occurs in the bedrock beneath the valley alluvium. As technological advances occur in mineral exploration techniques, some of these deposits will be discovered and exploited. It is now possible to develop mineral deposits buried beneath the shallow alluvial cover along the edges of the mountain

ranges, and some fault-dropped extensions of deposits occurring in the adjacent mountain ranges are currently being developed. Anaconda's Hall Molybdenum mine and Smoky Valley Mining's Round Mountain gold mine are two examples of recent discoveries beneath shallow alluvial cover.

Nevada (3.1.1.1)

The value of Nevada's mineral output, including petroleum, rose to \$369.4 million in 1980, an increase of 55 percent from that in 1979. The increased value was primarily a result of increased gold production and price escalation. Twenty-six mineral commodities were produced in the state: 9 metals, 16 nonmetallic materials, and mineral fuel. Metals accounted for 45 percent of total production value, and nonmetallics 55 percent. Most of the metallic mineral production came from the northern three-quarters of the state, with the southern quarter producing most of the nonmetallic minerals (gypsum, limestone, and clays).

In 1978, for the first time in more than 50 years, gold replaced copper as the state's leading mineral commodity, followed by sand and gravel in third place, and barite in fourth. Nevada ranked first in the nation in production value of barite, magnesite and mercury, and second in gold. The state's copper industry, from the early 1930s to the late 1970s, accounted for about three fourths of the total minerals output, but in 1978 the three top producers shut down, citing poor copper market conditions and environmental restrictions as the reasons for their closures. Nevada's largest zinc producer also closed during the same year owing to depressed market conditions. Table 3.1.1-1 summarizes the state's mineral production from 1970 to 1980. The decline of copper from its preeminent rank is clearly indicated.

Three principal companies mined and processed about 95 percent of Nevada's output of copper from low-grade ore at highly mechanized open-pit mines. These companies are: Kennecott, operator of several open-pit mines at McGill, near Ely, White Pine County; Anaconda, operator of the Yerington Mines, Weed Heights, Lyon County and the Victoria Mine in southeastern Elko County; and Duval Corporation, a subsidiary of Pennzoil, operator of two open-pit copper mines near Battle Mountain, Lander County.

Nevada ranks second in United States gold output, accounting for about 27 percent of domestic production. Carlin Gold Mining Company, a wholly owned subsidiary of Newmont Mining, operates an open-pit gold mine near Carlin, Elko County. Carlin is the second largest gold mine in the United States, and produces about 80 percent of Nevada's gold. The remainder comes from small-scale mining operations and is a by-product of other metallic mining in the state. Several new gold mines including Smoky Valley Mining's Round Mountain mine, Anselco's Alligator Ridge mine, and Freeport's Jerritt Canyon mine, are being developed that should make Nevada the number one gold-producing state. New silver mines, including Candelaria, Taylor, and 16 to 1 will substantially increase the Nevada silver production.

The overall M-X deployment area in Nevada overlaps a substantial segment of the state's minerals industry. Six counties within the proposed M-X deployment area in Nevada, Esmeralda, Eureka, Lander, Lincoln, Nye, and White Pine, accounted for over 58 percent of the total state minerals output in the late 1970s (see Table 3.1.1-2). Output by mineral commodity in the six-county area is shown in

Table 3.1.1-1. Nevada mineral production 1970-1980 in millions of dollars.

Mineral	1970		1977		1978		1979		1980	
	Value	Percent of Total	Value	Percent of Total	Value	Percent of Total	Value	Percent of Total	Value	Percent of Total
Copper	123.1	66.1	77.9	31.0	27.2	13.5	0.25 ²	0.1	W	-
Gold	17.5	9.4	40.5	16.1	45.1	22.4	61.5	25.8	153.7	41.6
Barite	1.5	0.8	20.7	8.2	18.9	9.4	34.3	14.3	61.9	16.8
Sand and Gravel	9.8	5.3	22.1	8.8	23.0	11.4	21.4	9.0	23.9	6.5
Silver	1.3	0.7	2.2	0.9	1.9	1.0	5.9	2.5	3.6	1.0
Stone	2.7	1.4	4.4	1.8	5.8	2.9	6.4	2.7	5.0	1.4
All Other ¹	30.4	16.3	83.5	33.2	79.3	39.4	108.4	45.5	121.3	32.8
Total	186.3	100.0	251.3	100.0	201.2	100.0	238.1	99.9	369.4	100.0

T491/10-2-81/F

¹Includes clays, gemstones, gypsum, iron ore, lead, petroleum, tungsten, zinc, diatomite, fluorspar, lime, lithium minerals, magnesite, mercury, molybdenum, perlite, pumice and salt, and items withheld (W).

²Incomplete data.

Sources: U.S. Department of Interior, Bureau of Mines, Mineral Yearbook Domestic Areas, for 1970; U.S. Department of Interior, Bureau of Mines, Mineral Industry Survey, for 1977; U.S. Department of Interior, Bureau of Mines, Minerals in the Economy of Nevada (1979), for 1978; U.S. Department of Interior, Bureau of Mines, The Mining Industry of Nevada in 1980, 1981.

Table 3.1.1-2. Gross yield of mines and minerals produced in Nevada study area counties (1977).

County	\$000 ¹	Percent of Total (State)	Minerals Produced in 1976 In Order of Value
Esmeralda	N/D	N/D	Mercury, diatomite, sand and gravel
Eureka	29,681	15.5	Gold, iron ore, stone, mercury
Lander	27,728	14.5	Copper, gold, barite, silver, lead, zinc
Lincoln	5,350	2.8	Stone, sand and gravel, perlite, zinc
Nye	21,595	11.3	Magnesite, petroleum, fluorspar, sand and gravel, molybdenum, gold
White Pine	26,536	13.8	Copper, gold, lime, silver
Study Area Total	110,890	57.8+	

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¹ State total is \$191,605,000.

Sources: University of Nevada, Bureau of Business Economic Research, Nevada Review of Business and Economics (Sumner, 1978), p. 21 adapted; Bureau of Mines, Minerals Yearbook, 1976, (reprint), p. 3.

N/D = No data.

Table 3.1.1-2. Copper, gold, and barite are the minerals of major economic value. There are also plentiful supplies of stone, sand, and gravel for construction purposes. Figure 3.1.1-1 presents a generalized geographic distribution of minerals industry activity in Nevada. Table 3.1.1-3 identifies the principal minerals producers of the six county area in 1975 by commodity.

Utah (3.1.1.2)

Historically, Utah's metallic mineral resources have been the major components of the state's minerals industry. In 1980, production of copper, gold, and silver was valued at \$502 million and accounted for almost 66 percent of the total value of Utah's nonfuel mineral production (Table 3.1.1-4).

The production of copper exceeded that of all other metals, and in 1980 accounted for 46 percent of the state's total mineral production value. According to the U.S. Bureau of Mines, approximately 3 percent of the world's and 14 percent of the nation's new copper is produced annually by Utah.

Utah is the largest producer of beryllium ore in the United States and ranks in the top four in the production of gold, silver, lead, and molybdenum. Utah is also an important producer of zinc and iron.

Deposits of nonmetallic and industrial minerals are widely distributed throughout the state and sand and gravel are among Utah's most valuable nonmetallic minerals. Salt and gypsum are other major nonmetallic mineral products. Although most nonmetals produced are used to supply local market demands, the state exports potash, salt, gypsum, and magnesium chloride.

Utah's coal, oil shale, and producing oil and gas fields occur predominantly in the eastern portion of the state. Current petroleum exploration is active in the Overthrust Belt in western Utah. Geothermal potential is high in the Roosevelt Hot Springs area of western Utah.

It can be inferred that Beaver, Juab, and Millard counties are minor contributors to the minerals output of Utah, and supplies of stone, sand, and gravel are in plentiful supply in the five-county area of west-central Utah (Iron, Beaver, Millard, Juab, and Tooele). For Utah counties within or adjacent to the area of M-X development, the proportionate share of present mineral output is small compared to the entire state--little more than 3.0 percent in 1975 (Table 3.1.1-5).

The minerals produced in greatest quantity and value are nonmetallic. Table 3.1.1-6 presents mineral output in order of value for four counties in west-central Utah as of the mid-1970s and identifies the principal minerals producers for the same area and period by commodity.

MINING ACTIVITY (3.1.2)

Current and Historic Mining (3.1.2.1)

Distinct landmarks in the history of Nevada are the Comstock boom in the 1870s and the Tonopah-Goldfield boom in the early 1900s. Thereafter, a less spectacular growth has brought the mining industry greater strength and stability

Table 3.1.1-3 Principal mineral producers in Nevada for six selected counties (1975).

Commodity and Company	Code	County	Commodity and Company	Code	County
Barite			Lime		
NL Industries	A	Elko	Morrison & Weatherly	D	White Pine
Dresser Industries	A	Lander	Chemical Products		
FMC Corp.	A	Lander	Magnesite		
Milchem Inc.	A	Lander	Basic Inc.	A	Nye
Copper			Perlite		
Anaconda	B	Elko	DeLamar Perlite Co.	C	Lincoln
Duvall Corp.	B	Lander	Petroleum		
Kennecott Copper	B	White Pine	Fly Crude Oil	E	Nye
Flourspar			Toiyabe Oil Inc.	E	Nye
J. Irving Crowell, Jr.	C	Nye	Western Oil Lands Inc.	E	Nye
Gold			Pumice		
Atlanta Gold Mine	B	Lincoln	Cind-R-Lite Block Co.	A	Nye
Carlin Gold Mining	A	Elko, Eureka	Sand and Gravel		
Cortez Gold Mines	A	Lander	Stewart Brothers Co.	A	Nye
Iron Ore			Wells-Cargo Inc.	A	Nye
Nevada-Barth Co.	A	Eureka	W.M.X. Transit Mix Inc.	A	Nye
Lead					
Pan American Mine	B	Lincoln			

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A = Open pit mine.
 B = Surface mine.
 C = Underground mine.
 D = Rotary kilns.
 E = Producing crude oil wells.

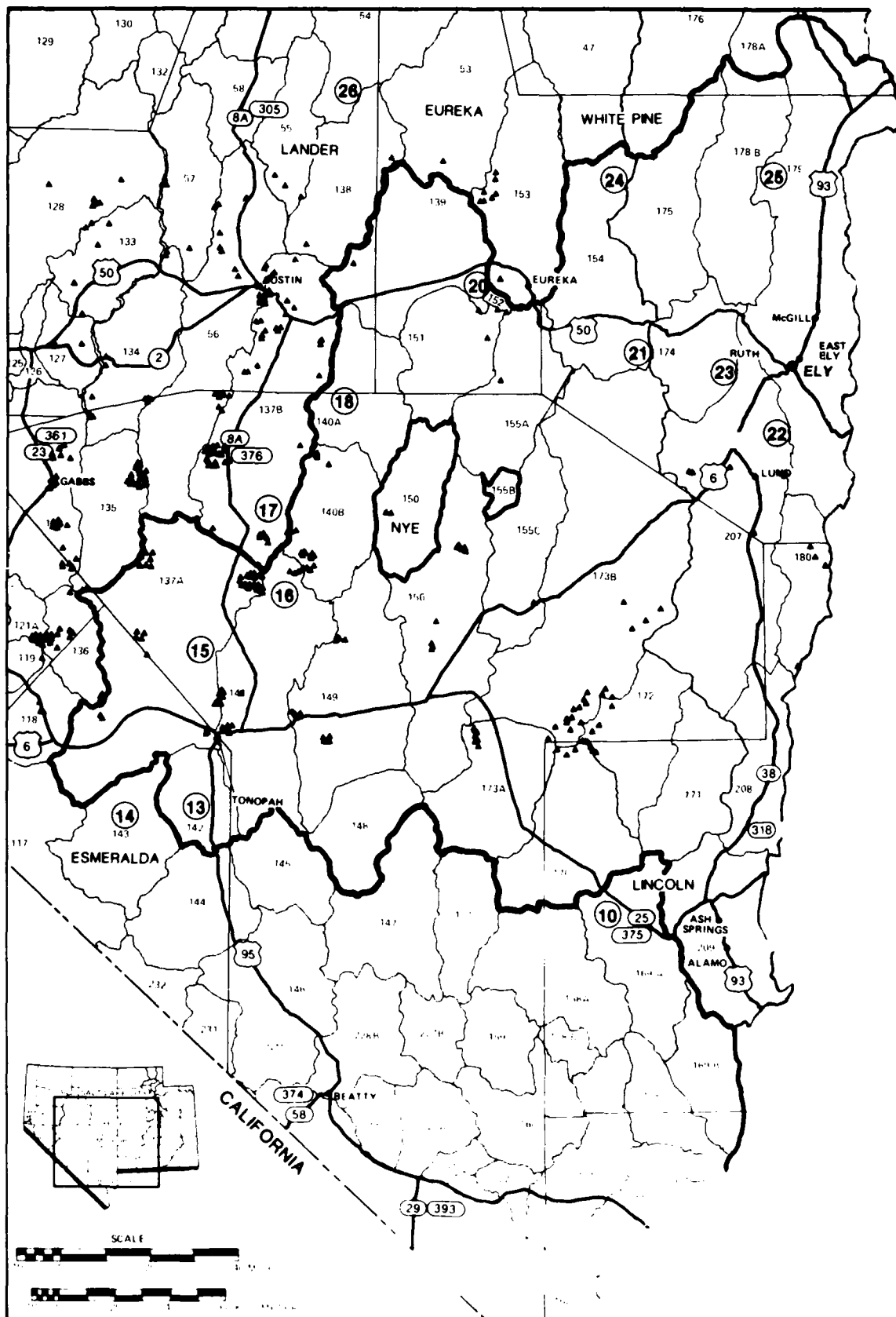
Source: U.S. Bureau of Mines, Minerals Yearbook 1975, Vol. II Area Reports: Domestic (1978) pp. 484-5.

IMPORTANT MINING DISTRICTS

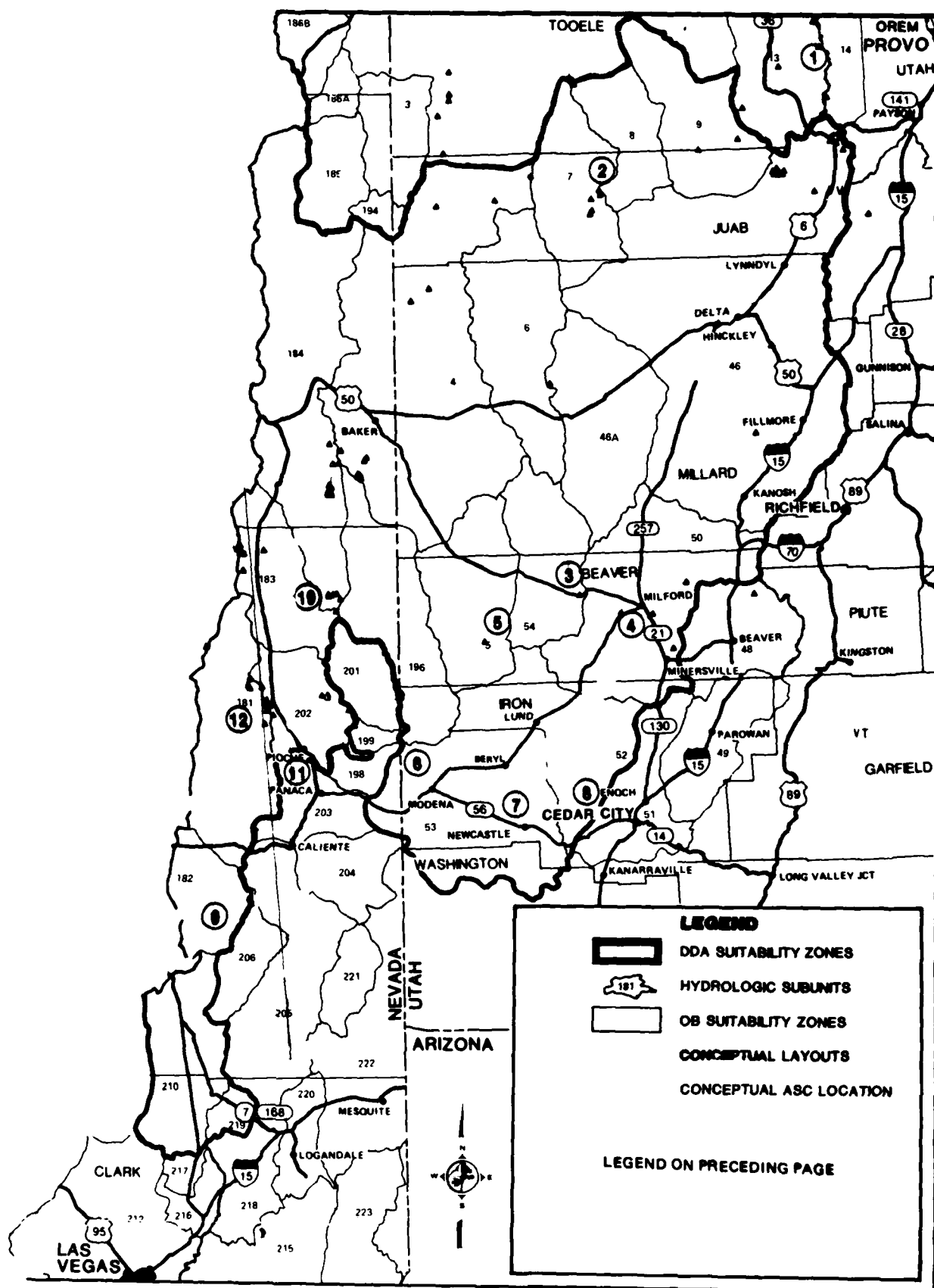
- 1 MERCUR
- 2 SPOR MOUNTAIN
- 3 SAN FRANCISCO
- 4 MILFORD (STAR)
- 5 PINE GROVE
- 6 STATELINE
- 7 ESCALANTE
- 8 IRON SPRINGS
- 9 DELMAR
- 10 TEM PIUTE
- 11 PIOCHE
- 12 BRISTOL
- 13 GOLDFIELD
- 14 SILVER PEAK
- 15 HALL (MAMMOTH)
- 16 MANHATTAN
- 17 ROUND MOUNTAIN
- 18 NORTHUMBERLAND
- 19 ATLANTA
- 20 EUREKA (WINDFALL)
- 21 HAMILTON (WHITE PINE)
- 22 WARD
- 23 ROBINSON
- 24 ALLIGATOR RIDGE
- 25 CHERRY CREEK
- 26 CORTEZ

(26) MAJOR MINING DISTRICTS

▲ MINOR MINES



4704-C-1



4704-C-1

Figure 3.1.1-1. Geographic distribution of minerals industry activity in the Nevada/Utah study area.

Table 3.1.1-4. Mineral production in Utah.

Mineral	1978		1979		1980	
	Value of Production (\$ in Millions)	Percentage of Total	Value of Production (\$ in Millions)	Percentage of Total	Value of Production (\$ in Millions)	Percentage of Total
Metals						
Copper	273.2	45.5	396.0	52.6	341.7	45.9
Gold	45.6	7.6	80.2	10.6	116.5	15.7
Iron Ore	21.2	3.5	19.4	2.6	-	-
Lead	1.9	0.3	-	-	-	-
Silver	15.6	2.6	27.2	3.6	43.8	5.9
Zinc	2.4	0.4	-	-	-	-
Uranium Ore	58.2	9.7	-	-	-	-
Nonmetals						
Clays	0.9	0.1	1.2	0.2	1.4	0.2
Gemstones	0.1	Negligible	0.1	Negligible	0.1	Negligible
Gypsum	2.8	0.5	6.6	0.9	2.3	0.3
Lime	7.2	1.2	8.3	1.1	11.1	1.5
Salt	13.5	2.2	14.7	1.9	13.9	1.9
Sand and Gravel	21.8	3.6	18.6	2.5	18.1	2.4
Stone	9.9	1.6	11.3	1.5	12.1	1.6
Items not Disclosed ¹	125.9	21.0	169.5	22.5	182.9	24.6
Total	600.3	100.0	753.4	100.0	744.3	100.0

T091/10-2-81/F

¹Includes asphalt, beryllium, carbon dioxide, cement, clays (kaolin and fuller's earth), magnesium compounds, molybdenum, phosphate rock, potassium salts, pumice, sand and gravel (industrial), sodium sulfate, and vanadium.

Source: Utah Geological and Mineral Survey, Utah Mineral Industry Activity Review, July 1979, pp. 2, 20.

Table 3.1.1-5. Mineral production and value in Utah study area counties (1975).

County	Value		Minerals Produced, In Order of Value
	\$000	Percentage of State	
Beaver	176	Negligible	Sand and gravel
Iron (1974)	14,727	1.5	Iron ore, sand and gravel
Juab	627	Negligible	Fluorspar, clays, gypsum, sand and gravel
Millard	*	Negligible	Gypsum, stone, pumice, beryllium, sand and gravel
Tooele	12,100	1.3	Potassium salts, salt, lime, sand and gravel
Study Area Total	27,640+	2.9	
Utah Total	966,407	100.0	

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*Withheld to avoid disclosing individual company confidential data.

Source: U.S. Bureau of Mines, Minerals Yearbook 1975: Volume II Area Reports, Domestic, p. 749.

Table 3.1.1-6. Principal mineral producers in Utah for selected counties.

Commodity and Company	Type of Activity	County
Beryllium		
Brush Wellman, Inc.	Open pit mine, chemical processing plant	Millard
Clays		
Filtrol Corporation	Open pit-underground mine	Juab
Fluorspar		
Spor Bros.	Open pit-underground mine	Juab
U.S. Energy Corp.	Open pit mine	Juab
Willden Fluorspar Co.	Underground mine	Juab
Iron Ore		
CF&I Steel Corp.	Three open pit mines	Iron
U.S. Steel Corp.	Open pit mine	Iron
Utah International Inc.	Two open pit mines, crushing, screening and beneficiation plant	Iron
Lime		
Utah-Marblehead Lime Co.	Rotary kiln plant	Tooele
The Flintkote Co.	Rotary kiln plant	Tooele
Potassium Salts		
Kaiser Aluminum and Chemical Corp.	Brine processing plant	Tooele
Salt		
American Salt Co.	Lake brine processing plant	Tooele
Stone		
Utah Calcium Co. Inc.	Quarry	Tooele
General Dynamics	Quarry	Tooele

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Source: U.S. Bureau of Mines, Minerals Yearbook, 1975: Volume II Area Reports, Domestic (1978), pp. 760-761.

than it has ever had. This has been climaxed within the past three to five years by the rise in the price of the noble and base metals, and also nonmetallic mineral products. The current technological demand for mineral and energy resources has reached an all-time high. In many instances stockpiles have become depleted and attempts toward replenishment are in force.

Nevada's modern mining history began around the middle of the 19th century with the discovery of lead, zinc, and silver deposits at Goodsprings, and the silver-gold deposits around Virginia City. The mining boom in California had begun to fade and the tide of miners turned to the Territory of Nevada. Statehood came to the territory partly as a consequence of the Union's need for the precious metals to finance the Civil War. Another effect of the early mining activities was widespread development of water resources to provide not only domestic water but water for the treatment of the ores the mines produced.

Entry into the 20th century brought several changes to the mining situation in both Nevada and Utah. Utah, although it had shown some earlier mining potential, did not go through the spectacular boom and bust cycles of Nevada. With the advent of the Tonopah-Goldfield boom in Nevada, three highly important changes occurred: (1) prospecting techniques and mineralization concepts changed, becoming more sophisticated and more efficient, (2) roads and means of transportation improved greatly so that equipment could be brought to isolated mining camps and ore taken out, and (3) the extractive part of the mining industry acquired new ore-dressing, milling, and metallurgical technology.

A newly invented metallurgical process was particularly adaptive to the gold and silver ores from Nevada, ensuring more rapid and complete extraction. This was the cyanidation process. In lieu of the old, laborious amalgamation method of extracting the precious metals from their ores by use of mercury, the new technique actually dissolved them from the host rock. Thus less metals were left in the tailings dumps. This process, coupled with improved, large-scale crushing equipment, made it profitable to mine and process relatively low-grade ore deposits.

About 1915, another new extractive design was introduced that had even more widespread application than the older method. This was the process of flotation, involving exposure of tiny ore mineral particles to air bubbles rising through a slurry of ground ore. The resulting foam is skimmed off as rich concentrates to be shipped to the smelter, and the waste rock is disposed of as tailings. The flotation process opened the door for effective treatment of the base metals and accounted for the development of one of the world's largest copper open-pit mines at Bingham Canyon, 18 mi west of Salt Lake City, and of the large deposits of low-grade copper ore at Ely in eastern Nevada.

Utah, unlike Nevada, is primarily a manufacturing state. It is also physiographically divisible into regions other than the Great Basin which it shares with Nevada. Separated from the Basin and Range Province by the Wasatch Front, the eastern portion of Utah includes the Colorado Plateau, the Unita Basin, and a small portion of the Central Rockies. Obviously, these divisions change the pattern of mineralization and mining in the state. Mining of fuel minerals is Utah's second leading revenue producer. The leading metal commodities are copper, uranium, and molybdenum.

Mining Potential

The present-day availability of good roads and airports in the Great Basin has transformed it into an easily accessible region despite its lack of population and urban concentration. It is no longer a problem to bring in advanced mining and milling equipment because of the availability of transportation. Extensive exploratory programs are being conducted throughout Nevada and Utah with highly sophisticated techniques and instruments unknown just a few years ago. Survey traverses are now measured by laser beams or microwave pulses.

Nevada is one of the most heavily mineralized states. By the very nature of its geology, Nevada claims few locales that do not contain metallic or nonmetallic deposits. Future exploration will probably extend into the alluvial-filled valleys where mineralized extensions may exist beneath the valleyfill. The only resource exceptions are coal, oil and gas. But, even there, a good possibility exists that the overthrust belt of Paleozoic carbonate rocks in eastern Nevada and western Utah may yield large quantities of oil and gas. Deep tests of this belt have already produced sufficient evidence of hydrocarbons to warrant exploration.

It has been estimated recently by the Nevada Bureau of Mines and Geology that leach extraction from mined ores will become the principal concentration process for some metals, such as copper. For vat-leaching, new water requirements are 200,000 gal per 1,000 tons of ore treated, with 50,000 gal of water actually consumed. Heap-leaching, similar to leaching in situ, will have new water requirements of 600,000 gals per 2,000 lbs of metal produced, with 200,000 gal of water actually consumed (Baker, Sachbold, and Stoll, 1972).

In most areas, transmission lines, pipelines and supplies of oil and gas are scarce or nonexistent. Therefore, competition of the mining industry with other industries or projects for both water and power could constrain mining operations in some places.

Construction Resources

Another long-range development in the history of minerals of Nevada and Utah was initiated shortly after the turn of the 20th century with the production of industrial rocks and minerals. Before that, though, salt was harvested from playas to be used in a process for extracting silver, building stone was quarried for construction, and other nonmetals were mined for local consumption. However, mineral developments following World War I were much more important because they were aimed primarily at wide markets, in particular, California.

The industrial mineral deposits in Nevada and Utah are large enough to support mining and manufacturing operations for many years. Such commodities as gypsum for plasterboard, limestone for cement, and silica for glassmaking are not in short supply. They do not pass through a cycle of abundance and exhaustion in 25 years or less as have some of the metallic deposits, particularly in Nevada.

Public comments expressed concern that the DEIS did not adequately assess the availability and quality of concrete and road-base aggregates in the M-X deployment area or the impacts that M-X utilization of available sources will have on local industry. However, aggregate studies conducted by Ertec Western, Inc. for

this project indicate that plentiful resources of acceptable quality stone, sand and gravel are available for construction purposes.

Detailed aggregate resource studies were performed for six locations in the Nevada/Utah deployment region; Pine and Wah Wah valleys in Utah and Delamar, Muleshoe, Dry Lake, and Pahroc valleys in Nevada. All six studies determined that "there are sufficient quantities of aggregates available for the construction of the M-X missile system" in each of the locations investigated.

Additional studies have been conducted in ten other valleys in the Nevada/Utah deployment area. Although not as comprehensive as the detailed studies, results indicate sufficient quantities of aggregates are available for M-X construction. There is no indication that the same conclusions will not be reached for the other valleys where aggregate studies have yet to be performed.

Nonconstruction Resources

A list of active mines, claims, leases and principal ore-bodies for both Nevada and Utah can be found in Appendices A through E of this report.

Mining Activity in Nevada (3.1.2.2)

Table 3.1.2-1 presents forecast trends for additional mineral products expected to increase the regional list of known mineralization; that is, expected to be produced with time and increased demand. The six counties comprising the prime M-X study area are included (Esmeralda, Eureka, White Pine, Nye, Lincoln, and Lander).

The estimates taken from Bulletin 82, "Forecasts for the Future Minerals," of the Nevada Bureau of Mines and Geology, are considered limited prognostications for increased mining production to the year 2020 because of the recent increases in mining activity and mineral value. Comparison of the estimated number of mines and employment in Table 3.1.2-1 for 1980 with the actual values from 1980 from Table 3.1.3-2 (in upcoming Section 3.1.3) shows major discrepancies.

Mining Activity in Utah (3.1.2.3)

Utah's role in U.S. mineral supply ranks the state first in production of beryllium concentrates and second in copper, vanadium, and potash. It is third in molybdenum and uranium production with large reserves already blocked out. The molybdenum deposit of Pine Grove Associates in the study area is a major new discovery.

Within the M-X study area in central and southwestern Utah there is presently a high level of oil, gas, and uranium exploration.

In addition to the M-X project, within the Utah study area, there are several other major projects scheduled for construction between now and 1985. These include two electric power generating plants, four large metal mining operations, and five manufacturing plants. Development of energy and mineral resources are sure to increase economic growth in the M-X study area even without M-X. M-X influence on related socioeconomic conditions may be detrimental to efforts to extract needed mineral resources and petroleum.

Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 1 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
Esmeralda County						
1970						
Mercury, Diatomite, Sand and Gravel, Talc, Gem and Semiprecious Stones, Saline Playa Deposits *						
1970 Total	8		2,006	2,005	102	4,063
1980						
Diatomite, tons	1	40,000	58	29	48	1,200
Sand and Gravel, tons	1	12,000	1	9Nil	1	12
Gem and Semiprecious Stones, tons	1	1	-	-	1	5
Saline Playa Products, tons	1	50,000	4,010	4,005	50	10,000
1980 Total	4		4,069	4,034	100	11,217
2000						
Gold and Silver, tons ore	1	300,000	278	123	180	3,000
Molybdenum, tons	1	1,000	212	118	70	3,440
Diatomite, tons	1	60,000	87	44	72	1,800
Sand and Gravel, tons	1	20,000	2	1	1	20
Stones, tons	1	50,000	10	5	10	150
Talc, Soapstone and Pyrophyllite, tons	1	50,000	172	91	100	1,000
Gems and Semiprecious Stones, tons	1	1	-	-	1	10
Saline Playa Products, tons	2	120,000	9,693	1,006	120	24,000
2000 Total	9		10,454	1,388	544	33,420
2020						
Gold and Silver, tons ore	2	600,000	555	246	360	6,000
Mercury, flasks	1	5,000	88	39	57	2,100
Molybdenum, tons	1	2,000	424	236	140	6,880

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Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 2 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
Esmeralda County (continued)						
2020 (continued)						
Barite, tons	1	100,000	86	45	50	750
Diatomite, tons	1	40,000	58	29	48	1,200
Sand and Gravel, tons	1	24,000	2	Nil	1	24
Stone, tons	1	50,000	10	5	10	150
Talc, Soapstone and Pyrophyllite, tons	1	100,000	344	182	200	2,000
Gem and Semiprecious Stones, tons	1	1	-	-	1	10
Saline Playa Products, tons	2	170,000	13,753	1,436	170	34,000
2020 Total	12		15,320	2,218	1,037	53,114
Eureka County						
1970						
Antimony, Gold and Silver, Iron Ore, Barite, Sand and Gravel*						
1970 Total	5		176	53	198	3,644
1980						
Gold and Silver, tons ore	1	750,000	338	132	152	7,500
Iron Ore, long tons	1	100,000	36	19	25	1,000
Sand and Gravel, tons	1	12,000	1	1	1	12
1980 Total	3		375	152	178	8,512
2000						
Gold and Silver, tons ore	2	1,150,000	662	274	352	11,500
Iron Ore, long tons	1	50,000	19	9	13	500
Lead and Zinc, tons	1	20,000	33	47	28	6,200
Vanadium, tons	1	1,000	364	132	50	7,200
Barite, tons	1	25,000	22	12	13	187
Sand and Gravel, tons	1	20,000	2	Nil	1	20
2000 Total	7		1,154	474	457	25,607

T3373/6-13-81

Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 3 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
Eureka County (continued)						
2020						
Gold and Silver, tons ore	2	1,000,000	808	354	500	10,000
Iron Ore, long tons	1	500,000	184	92	127	5,000
Lead and Zinc, tons	1	40,000	170	94	56	12,400
Vanadium, tons	2	3,000	1,092	396	150	21,600
Barite, tons	2	200,000	172	91	100	1,500
Sand and Gravel, tons	1	24,000	2	1	1	24
Geothermal Power, MWH	1	160,000	104	76	30	800
2020 Total	10		2,532	1,104	964	51,324
Lander County						
1970						
Copper, Gold and Silver, Mercury, Barite, Fluorspar, Sand and Gravel, Gems and Semiprecious Stones*						
1970 Total	11		4,391	1,495	446	20,433
1980						
Copper, tons	1	15,000	7,504	3,364	502	17,400
Gold and Silver, tons ore	1	600,000	234	87	91	6,000
Barite, tons	5	200,000	172	91	100	1,500
Sand and Gravel, tons	1	49,000	4	1	1	45
Zeolites, tons	1	75,000	65	29	35	3,750
Gems and Semiprecious Stones, tons	1	-	-	-	1	5
Geothermal Power, MWH	1	80,000	52	38	15	400
1980 Total	11		8,031	3,610	745	29,100

T3378/6-18-81

Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 4 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
Lander County (continued)						
2000						
Copper, tons	2	30,000	17,044	6,634	952	34,800
Gold and Silver, tons ore	1	200,000	162	71	100	2,000
Uranium, tons U_3O_8	1	100	162	71	100	1,200
Barite, tons	5	400,000	344	182	200	3,000
Sand and Gravel, tons	1	60,000	6	2	1	60
Zeolites, tons	1	450,000	152	83	60	22,500
Gem and Semiprecious Stones, tons	2	-	1	-	4	20
Geothermal Power, MWH	1	400,000	206	163	30	2,000
2000 Total	14		18,077	7,206	1,447	65,580
2020						
Copper, tons	2	40,000	25,440	8,720	1,200	46,400
Uranium, tons U_3O_8	1	200	323	142	200	2,400
Barite, tons	5	49,000	430	228	250	3,750
Sand and Gravel, tons	1	49,000	5	1	1	49
Zeolites, tons	1	450,000	152	83	60	22,500
Gem and Semiprecious Stones, tons	2	-	1	-	4	20
Geothermal Power, MWH	1	560,000	274	221	30	2,800
Saline Playa Products, tons	1	50,000	4,060	430	50	10,000
2020 Total	14		30,685	9,825	1,795	87,919
Lincoln County						
1970						
Lead and Zinc, Fluorspar, Sand and Gravel, Stone*						
1970 Total	6		10	5	25	251

T3378/6-18-81

Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 5 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
Lincoln County (continued)						
1980						
Lead and Zinc, tons	1	20,000	232	157	98	6,200
Tungsten, tons	1	800	260	136	160	5,600
Fluorspar, tons	1	5,000	9	5	5	250
Sand and Gravel, tons	1	37,000	3	1	1	37
Stone, tons	2	57,000	8	4	20	171
1980 Total	6		562	303	284	12,258
2000						
Lead and Zinc, tons	1	10,000	98	51	60	3,100
Tungsten, tons	1	1,600	520	272	320	11,200
Fluorspar, tons	1	10,000	18	10	10	500
Sand and Gravel, tons	1	40,000	3	1	1	40
Stone, tons	2	60,000	12	6	20	180
2000 Total	6		651	340	411	15,020
2020						
Lead and Zinc, tons	1	10,000	98	51	60	3,100
Manganese, tons	1	30,000	92	36	42	1,500
Tungsten, tons	1	1,200	390	204	240	8,400
Sand and Gravel, tons	1	49,000	4	1	1	49
Stone, tons	3	265,000	60	30	50	705
Zeolites, tons	1	450,000	152	83	60	22,500
Petroleum, barrels	1	200,000	4	2	3	600
2020 Total	9		800	407	456	36,944

T3378/6-18-81

Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 6 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
Nye County						
1970						
Fluorspar, Refractories, Sand and Gravel, Stone, Petroleum*						
1970 Total	6		279	165	294	4,172
1980						
Gold and Silver, tons ore	2	250,000	553	294	220	2,500
Iron Ore, long tons	1	200,000	76	36	51	2,000
Tungsten, tons	1	150	49	26	30	1,050
Barite, tons	3	150,000	129	68	75	1,125
Fluorspar, tons	2	45,000	77	41	45	2,250
Refractories, tons	1	500,000	558	304	250	2,500
Sand and Gravel, tons	1	111,000	10	3	2	111
Stone, tons	1	50,000	7	3	10	150
Gem and Semiprecious Stones, tons	1	-	-	-	1	5
Petroleum, barrels	1	150,000	19	17	6	450
1980 Total	14		1,478	792	690	12,141
2000						
Gold and Silver, tons ore	2	450,000	381	168	240	4,500
Iron Ore, long tons	1	200,000	76	36	51	2,000
Molybdenum, tons	1	4,500	952	529	315	15,480
Tungsten, tons	1	150	49	26	30	1,050
Barite, tons	3	300,000	258	136	150	2,250
Fluorspar, tons	1	50,000	86	45	50	2,500
Refractories, tons	1	750,000	837	456	375	3,750
Sand and Gravel, tons	1	140,000	12	4	3	140
Stone, tons	1	50,000	10	5	10	150

T3378/6-18-81

Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 7 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
Nye County (continued)						
2000 (continued)						
Zeolites, tons	1	225,000	119	63	66	11,250
Gem and Semiprecious Stones, tons	1	1	-	-	1	10
Geothermal Power, MWH		80,000	52	38	15	499
2000 Total	15		2,832	1,506	1,306	43,480
2020						
Copper, tons	1	10,000	1,023	383	425	11,600
Gold and Silver, tons ore		400,000	323	142	200	4,000
Molybdenum, tons	1	6,000	1,272	708	420	20,640
Uranium, tons U ₃ O ₈	1	150	243	107	150	4,800
Barite, tons	4	550,000	473	250	275	4,125
Fluorspar, tons	1	150,000	258	136	150	7,500
Refractories, tons	1	750,000	837	456	375	3,750
Sand and Gravel, tons	1	170,000	15	4	3	170
Stone, tons	1	50,000	10	5	10	150
Zeolites, tons	1	600,000	202	111	80	30,000
Gem and Semiprecious Stones, tons	1	1	-	-	1	10
Geothermal Power, MWH	1	160,000	104	76	30	800
Petroleum, barrels	1	300,000	37	34	6	900
Saline Playa Products, tons	1	100,000	8,120	860	100	20,000
2020 Total	17		12,917	3,272	2,225	105,445

T3378/6-18-81

Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 8 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
White Pine County						
1970						
Copper, Sand and Gravel, Stone*						
1970 Total	3		3,419	1,730	1,474	57,218
1980						
Beryllium, tons	1	100	49	26	30	1,520
Copper, tons	2	45,000	5,041	2,520	1,500	52,000
Gold and Silver, tons ore	2	250,000	214	94	135	2,500
Lead and Zinc, tons	1	10,000	127	71	42	3,100
Sand and Gravel, tons	1	161,000	14	4	3	161
Stone, tons	1	74,000	10	5	15	222
Petroleum, barrels	1	100,000	4	2	3	300
1980 Total	9		5,459	2,722	1,728	60,003
2000						
Beryllium, tons	2	200	98	52	60	3,040
Copper, tons	2	60,000	6,705	3,352	1,995	69,600
Lead and Zinc, tons	1	10,000	127	71	42	3,100
Fluorspar, tons	1	10,000	18	10	10	500
Sand and Gravel, tons	1	160,000	24	4	3	160
Stone, tons	2	300,000	61	30	60	900
Petroleum, barrels	1	400,000	4	2	3	1,200
2000 Total	10		7,037	3,521	2,173	78,500

T3378/6-18-81

Table 3.1.2-1. Estimated future mineral production statistics in selected Nevada counties (Page 9 of 9).

Commodity and Units	Number of Mines	Quantity	New Water Requirement Millions of Gallons	Water Consumed Millions of Gallons	Number of Persons Employed	Value at 1970 Prices Thousands of Dollars
White Pine County (continued)						
2020						
Beryllium, tons	2	300	147	78	90	4,560
Copper, tons	2	60,000	22,148	7,688	2,175	69,600
Lead and Zinc, tons	1	10,000	127	71	42	3,100
Tungsten, tons	2	800	260	136	160	5,600
Sand and Gravel, tons	1	146,000	14	4	3	146
Stone, tons	2	300,000	63	31	60	900
Geothermal Power, MWH	2	160,000	104	76	30	800
Petroleum, barrels	1	200,000	27	24	6	600
2020 Total	13		22,890	8,108	2,566	85,306

T3378/6-13-81

*Statistics for individual items withheld to avoid disclosing confidential data.

Source: Forecasts for the Future - Minerals, Nevada Bureau of Mines and Geology, 1972.

Production of bituminous coal in Utah has rapidly escalated and will continue to do so because of stockpiling and anticipation of demand from various projects, including Intermountain Power Project near Delta. Current production of coal is on the order of 900,000 tons per month. The state ranks 16th within the 22 coal producing states.

MINING EMPLOYMENT AND INCOME (3.1.3)

Nevada (3.1.3.1)

Employment in mining in Nevada accounts for slightly over 1 percent of the total employment in the state. Before the war (1940), this sector accounted for over 15 percent of state employment, and its share has steadily declined to the present (see Table 3.1.3-1). For the past two decades, mining employment has fluctuated between 3,000 and 4,500. Based on historic trends, early projections to the mid-1980s did not forecast any significant employment growth (Nevada Employment Security Department, 1977). However, most recent employment data suggest a spectacular jump in mining activity; 1980 employment in Nevada accounted for over 8,000 jobs (State of Nevada Industrial Commission, 1981).

Employment data (1978) for mines, mills, and smelters (a slightly larger employment grouping than mining alone) are shown in Table 3.1.3-2. The distribution is by county with focus on the six-county possible deployment areas within the state. Over 50 percent of mining related employment is found in this six-county area, with heavy concentration in Lander, Nye, and White Pine counties. Dependence of these Nevada counties on mining activities as expressed in proportion of 1977 personal income derived there from is also shown in Table 3.1.3-3.

Utah (3.1.3.2)

Mining employment in Utah in 1977 was about 15,000 and accounted for approximately 3 percent of employment (see Table 3.1.3-3).

Mining employment in the five west-central Utah counties of the M-X deployment area was less than 500 (see Table 3.1.3-4). The proportion of personal income (see Table 3.1.3-4) derived from mining in these counties was not significantly removed from that of the average share for the state as a whole (5.2 percent).

MINING CLAIM AND LEASING ACTIVITY (3.1.4)

Nevada (3.1.4.1)

Dependency of the mining industry on public lands is minimal--by nature of the current mining law--due primarily to the patent process which transfers public land to private land status once a profitable claim for locatable minerals is discovered. However, future production will depend to a large extent on geologic exploration of the public lands.

The objective of the BLM's mineral management program is to make mineral commodities available to meet national and local needs by ensuring orderly and timely resource development, protection of the environment, and receipt of fair market value for minerals leased or sold.

Table 3.1.3-1. Mining employment in Nevada,
1950-1979 (in thousands).

Year	Employment All Sectors	Employment Mining	Percent of Total Employment
1950	60,400	3,900	6.5
1960	109,100	4,600	4.2
1970	207,600	4,200	2.0
1977	307,500	3,400	1.1
1979 (June)	376,500	4,000	1.1

T096/10-2-81/a

Source: Nevada Employment Security Department;
University of Nevada, Bureau of Business
and Economic Research, Nevada Review
of Business and Economics, Summer
1978, p. 14; Fall 1979, p. 20.

Table 3.1.3-2. Employment in mines, mills, and smelters for selected Nevada counties, 1978, 1979, and 1980.

County	1978			1979			1980		
	Operations	Percentage of State	Employment	Operations	Percentage of State	Employment	Operations	Percentage of State	Employment
Esmeralda	23	6.2	143	22	5.4	106	26	5.5	165
Eureka	13	3.3	335	16	4.0	294	23	4.8	465
Lander	34	8.7	714	40	9.9	819	49	10.4	1,087
Lincoln	15	3.8	379	11	2.7	302	14	3.0	321
Nye	29	7.4	652	39	9.7	792	39	8.2	1,894
White Pine	22	5.6	556	14	3.5	149	22	4.6	542
Study Area Total	157	40.5	2,779	122	35.2	2,462	173	36.6	4,476
All other counties	233	59.5	2,197	262	64.9	1,964	300	63.4	3,694
Total	390	100.0	4,976	404	100.0	4,426	473	100.0	8,170

T097/9-11-81/F

Source: State of Nevada Industrial Commission, Directory of Nevada Mine Operations Active During Calendar Year 1978, 1979, 1980.

Table 3.1.3-3. Mining employment in Utah, 1960-1977 (in thousands).

Year	Total Nonagricultural	Total Mining Employment	Percent Share
1960	264,400	13,800	5.2
1970	358,700	12,700	3.5
1977	486,600	15,000	3.1

T099/10-2-81/a

Sources: Utah Department of Employment Security; University of Utah, Bureau of Economic and Business Research, Utah! Facts, 1978, II:21,22.

Table 3.1.3-4. Employment and personal income in mining for selected Utah counties, 1977.

County	Total Nonagricultural Employment	Mining Employment	Percentage of Total	Share of Total Personal Income Derived From Mining (Percent)
Tooele	9,817	87	0.9	Negligible
Juab	1,652	59	3.6	5.6 (1975) ¹
Millard	1,865	58	3.1	4.3
Beaver	1,134	29	2.6	3.4
Iron	5,295	217	4.1	7.4
All Other Counties	466,790	14,593	3.1	-
Utah Total	486,553	15,043	3.1	5.2

T4950/10-2-81(b)

¹ 1977 data not shown to avoid disclosure of confidential information.

Sources: Utah Department of Employment Security; University of Utah, Bureau of Economic and Business Research, 1978, p. IV-14; U.S. Bureau of Economic Analysis, 1979.

Currently, minerals on public lands are made available under three separate systems: location, leasing, and material sale.

- (1) Location. This system covers typical metal deposits (gold, silver, copper, iron, etc.) and all minerals not included in the other two systems. Mineral rights are acquired by mining claims. When a valuable deposit is discovered, the mining claims involved may be patented and full title to both land and minerals granted.
- (2) Leasing. Oil and gas, sodium, potassium phosphates, coal, oil shale, asphaltic materials, and geothermal steam are available through mineral leasing. Leases are issued on specific acreages for a specific period of time, and the lessee pays yearly rentals or royalties on any minerals or energy produced.
- (3) Material Sale. Common sand, gravel, and other construction materials are available through material sale or for governmental agencies and nonprofit organizations by free-use permits.

The minerals industry in Nevada and Utah views the public lands as an area for mineral exploration and development. The greater the area of public land available for geologic exploration, the greater the potential for mineral industry growth. Geologic exploration is constantly increasing industry knowledge of economically exploitable mineral deposits.

There were 6,315 active leases involving 9.3 million acres (3.7 million ha) in Nevada during 1978, 471 more than in 1977. Of this total, 5,871 leases involving 8.6 million acres (3.4 million ha) were for oil and gas, and most of the increase was for oil and gas leases in eastern Nye County.

It is estimated that 75,000 mining claims exist on the public lands of Nevada. As required by the Federal Land Policy and Management Act of 1976, miners began recording their claims on public lands with the Bureau of Land Management in 1977. By the end of 1978, about 35,000 mining claims had been registered with the BLM, about 75 percent of which were new claims that did not exist prior to the passage of the law.

Table 3.1.4-1 shows the breakdown of Nevada leases in effect in 1978 by mineral type.

Table 3.1.4-2 indicates the 1978 distribution of Nevada oil and gas leases by county as well as 1978 distribution of Nevada geothermal leases.

Utah (3.1.4.2)

A major use of Utah land is the mining and/or extraction of metals, energy fuels, and nonmetallic minerals.

Nearly 20 million acres (8 million ha) of federally administered land and some 6 million acres (2.4 million ha) of state land in Utah are presently leased to individuals and companies engaged in minerals and energy resources exploration and production.

Table 3.1.4-1. Leases in effect, 1978 (Nevada).

Type of Lease	Number	Acreage (Million)	Yearly Rental (\$ in Millions)
Oil and Gas	5,871	8.57	7.8
Geothermal	415	0.67	1.2
Sodium	12	0.02	Negligible
Potassium	11	0.02	Negligible
Other (silica, sand and gravel)	6	0.003	Negligible
Total	6,315	9.28	9.1

T106/9-11-81/F

Source: BLM, Nevada Statistics, 1978, p.18.

Table 3.1.4-2. Oil and gas leases, and geothermal leases in effect by county, 1978 (Nevada).

County	Oil and Gas		Geothermal			
	Number of Leases	Acres	Number of Leases		Acreage	
			Non-Competitive	Competitive	Non-Competitive	Competitive
Churchill	116	154,584	103	33	171,595	56,669
Clark	293	436,990	-	-	-	-
Douglas	-	-	2	-	2,191	-
Elko	1,000	1,894,891	6	1	7,665	2,418
Esmeralda	9	8,783	16	1	28,688	2,546
Eureka	386	660,060	10	6	6,428	8,834
Humboldt	4	2,763	42	2	77,945	3,200
Lander	143	252,531	9	5	17,975	6,437
Lincoln	607	1,155,033	-	-	-	-
Lyon	-	-	10	10	9,126	13,682
Mineral	10	9,217	8	-	10,538	-
Nye	1,803	1,929,000	26	1	53,471	1,311
Pershing	3	3,100	60	14	86,912	28,546
Storey	-	-	1	-	543	-
Washoe	1	1,155	23	9	22,023	14,492
White Pine	1,496	2,456,205	17	-	39,079	-
Totals	5,871	8,964,312	333	82	534,179	138,133

T4954/9-11-81/F

Source: BLM, Nevada Statistics, 1978.

More than 95 percent of the Bureau of Land Management leases are for coal, oil and gas. On state lands, oil and gas leases account for 63 percent and coal leases for 10 percent of total lease acreage. Table 3.1.4-3 presents the distribution by commodity of outstanding leases on Utah public lands as of 1977.

Sand and Gravel

There are many developed material sites within the M-X deployment area. Most are located adjacent to the principal highways and are the source of materials for road repair and maintenance. Commercial operations are located near all population centers in the Nevada deployment area and there are some relatively small commercial sand and gravel operations serving the more populated areas along the eastern part of the Utah potential deployment area.

Potential aggregate resources are available throughout the deployment area. Alluvial fan deposits are a potential major source of aggregates. Carbonate rock source areas for fan deposits would provide better quality aggregate than volcanic source areas. The highest quality aggregates would come from well-graded channel deposits or lake shore gravels. The rock deposits in the mountains range in quality from good to poor. Cost of recovery of bedrock aggregates could be greater than the alluvial material because of the methods required for recovery.

Mining Claims

Siting selection for M-X candidate sites has been made to a very large extent on federal land. Mining claim ownership in state and private ownership land (i.e., patented claims owned in fee simple) is approximately 1.5 percent of the M-X area in Nevada. In Utah, the same categories, including state-owned land (unpatented claims), amount to 13.3 percent of the state's M-X project area. Table 3.1.4-4 shows the distribution of unpatented and patented mining claims in relevant siting valleys and basins of both Nevada and Utah.

An earth resources inventory by county for Nevada and Utah indicating the locations of past and current mining activity can be found in Appendix A of this report. The commodities mined and the total value of production through 1976 is also given for the metal mining districts of Nevada. Nonmetallic minerals, oil and gas, and geothermal potential are also included as are locations of known aggregate source areas.

3.2 TEXAS/NEW MEXICO EXISTING SETTING

MINERAL RESOURCES (3.2.1)

The major minerals produced in the area of interest are oil, natural gas, sand and gravel, natural carbon dioxide, lime, and scoria. Previous production of gypsum and building stone has been reported, but there appears to be no current production. Potential deposits of copper, gold, uranium, potash, salt, high calcium limestone, vanadium, and diatomaceous earth have been identified, but no production has been reported (see Table 3.2.1-1).

Table 3.1.4-3. Utah outstanding leases on public lands (1977).

Commodity	Number	Acreage (Million Acres)
Coal	198	0.3
Potassium (Potash)	20	0.04
Phosphate	8	0.009
Hard Rock ¹	1	Negligible
Gibsonite, Bituminous Sands, Asphalt	12	0.003
Geothermal	227	0.4
Oil and Gas	15,834	19.3
Total	16,300	20.052

T109/9-11-81/F

¹"Any locatable or salable mineral on acquired lands", e.g. copper, gold, silver, iron, antimony, arsenic, etc.

Source: BLM, Facts and Figures for Utah (1977), p. 26.

Table 3.1.4-4. Unpatented and patented mining claims within geotechnically suitable areas (Page 1 of 2).

Valley	Unpatented Claims		Patented Claims	
	Number of Claims	Acres ²	Number of Claims	Acres
Hot Creek (Nevada)	149	2,882	1	5
Reveille	5	90	-	-
Little Smoky	7	126	-	-
Big Sand Springs	5	90	-	-
Railroad	69	1,242	-	-
Penoyer	91	1,838	-	-
Garden	86	1,548	-	-
Tikaboo	33	594	-	-
White River	35	630	-	-
Coal	331	5,958	-	-
Pahroc	7	90	-	-
Steptoe	131	2,358	-	-
Cave	227	4,886	-	-
Muleshoe	5	90	-	-
Dry Lake	-	-	-	-
Delamar	13	234	17	330
Lake	479	8,622	167	2,674
Spring	43	774	20	318
Snake (Utah)	169	2,704	-	-
Hamlin	11	176	-	-

T4953/9-11-81/F

Table 3.1.4-4. Unpatented and patented mining claims within geotechnically suitable areas (Page 2 of 2).

Valley	Unpatented Claims		Patented Claims	
	Number of Claims ¹	Acres ²	Number of Claims	Acres
Tule	500	8,000	7	121
Pine	406	6,496	-	-
Fish Springs Flat	2,614	41,824	-	-
Wah Wah	43	688	2	30
Whirlwind	115	1,840	-	-
Sevier Lake	300	4,800	-	-
Dugway	1,766	28,256	-	-
Escalante Desert	221	3,536	138	2,023
Sevier Desert	1,795	28,720	2	9
Black Rock Desert	33	528	-	-
Totals	9,917	159,620	354	5,510

T4953/9-11-81/F

¹Valid unpatented claims post 1953.

²18 acres per claim average for Nevada; 16 acres per claim average for Utah.

Source: Woodward 1980.

Table 3.2.1-1. Value of mineral production in Texas/New Mexico by county within study area.

County	Value (1976) (dollars)	Minerals	Percent of State Total (1976)	Value (1979) (dollars)
Texas (\$18.1 Billion)				
Bailey	W	Stone		
Cochran	169,270,000	Petroleum, Natural Gas	0.9	
Dallam	W	Natural Gas		
Oldham	4,496,000	Petroleum, Natural Gas, Sand and Gravel	0.02	
Parmer	W	Stone		
Sherman	42,439,000	Petroleum, Natural Gas	0.2	
Hartley	W	Natural Gas		
Deaf Smith	W	Limestone (Caliche)		
New Mexico (\$2.5 Billion)				
Chaves	20,387,000	Petroleum, Natural Gas, Sand and Gravel, Stone	0.8	37,145,000
Curry	W	Sand and Gravel		
DeBaca	W	Sand and Gravel		
Harding	80,000	Carbon Dioxide	0.003	
Quay	W	Sand and Gravel, Stone		
Roosevelt	19,048,000	Petroleum, Natural Gas, Stone	0.75	30,500,000
Union	W	Pumice, Sand and Gravel, Stone		

T4952/10-2-81

W - Figures withheld to prevent disclosure of single company production; state totals do not include county withheld values.

Source: U.S. Bureau of Mines, Minerals Yearbook, 1976.

Industrial and Saline Minerals (3.2.1.1)

Numerous deposits of sand and gravel have been identified in Tertiary and Quaternary alluvium. Many of the stratigraphically located deposits have been mined extensively on an intermittent basis for use in highway and railroad construction or as a concrete aggregate. Production has been reported in numerous locations throughout the evaluation area. Other nonmetallic commodities worthy of note are listed and discussed below.

Numerous cinder cone deposits of scoria have been identified in the volcanic region near the Capulin Crater in northwestern Union County, New Mexico. Two deposits, as identified on the Raton Army Map Service (AMS) sheet, have had some production. Most of the material produced was used for railroad ballast.

Large areas containing gypsum deposits have been identified in Oldham County, Texas, and Chaves and De Baca counties, New Mexico. The gypsum occurs as impure lenses of gypsum bearing rocks intercalated with other rocks of the Guadalupe series of Permian age. Some previous production has been reported near Acme, northeast of Roswell in Chaves County, New Mexico. No current production is reported.

Sandstone and limestone have been mined for building stone in two locations in the study area. Sandstone and limestone have been mined in a quarry east of Roswell for use in that city. Near Tucumcari in Quay County, New Mexico, sandstone was quarried for local use. There are no records of any current production of building stone in the study area.

Natural high-purity carbon dioxide has been identified in the highly porous Abo Sandstone of the Santa Rosa Formation. The gas is thought to have been produced by either the action of igneous rocks on limestone or from the igneous magmas themselves, thereafter, being trapped in the porous sandstone or arkose. The carbon dioxide is being collected through drill holes in the Des Moines field in Union County and the Bueyeros fields in Harding County, New Mexico.

Potash mineralization is known to exist in two alkali lake beds, Coyote Lake in Bailey County and Silver Lake in Cochran County, Texas. There has been no reported production or reserve information.

A large area containing numerous rich potash beds has also been identified in Texas and New Mexico. This area, known as the Texas-New Mexico Potash Field, contains numerous potash beds (evaporite beds of Permian age) in the strata of the Great Permian Basin. This field extends into the evaluation area in southeastern Chaves County, New Mexico. Although no production has been reported in Chaves County, the area just south of Chaves County and east of Carlsbad produces 90 percent of the domestic potash production, which indicates the entire field has high potential for potash development.

Most of the study area is underlain by many salt beds of various thicknesses; the total combined thickness of salt is several thousand feet. There has been no reported production and no data on the total amount of salt available.

High-calcium limestones have been identified in many parts of New Mexico, including the San Andres Limestone of Permian age which covers a large portion of

western Chaves County, New Mexico. No deposits have been mapped out in the study area, and no production has been recorded even though the area has high potential.

Metallic Commodities (3.2.1.2)

Copper mineralization has been found in some sandstone beds of the Dockum Group in Union County and in a "Red Beds" Sandstone above the Santa Rosa Sandstone of Dockum age in Quay County, New Mexico. The copper mineralization occurs as replacements between the grains of the sandstone bed. The deposits are of low grade and intermittent and there appears to be no record of any production.

Gold mineralization has been identified in small quartz veins associated with volcanic rocks in Union and Harding counties, New Mexico. The gold deposits are very low grade and intermittent and no production has been recorded.

Potential uranium deposits have been identified in Quay County, New Mexico and Oldham County, Texas. The uranium occurs as epigenetic, peneconcordant deposits in sandstone and limonite zones of the Chinle Formation and Ogallala Formation. There are no data on total reserves, but the deposits appear to be small with little potential and no production has been recorded.

A potential deposit of vanadium and one of diatomaceous earth have been identified in Hartley County, Texas (Garner, 1979). There has been no production, and data on geological setting and total reserves could not be found.

3.3 M-X IMPACTS--NEVADA/UTAH

The mining industry, as it grows in the future, will interact with many of the issue areas of concern. Primary interactions are with labor resources and water resources. The interactions with the labor supply would secondarily affect population growth and relocation, housing, local government, and quality of life. The interactions with the water supply could secondarily affect grazing, cropland, and aquatic species. Other interactions of a somewhat lesser magnitude could occur with land ownership, energy, construction resources, transportation, wilderness, biologic parameters, and air quality.

The available labor force in the Nevada/Utah study area is small and there are no large population centers with a readily available labor force. The scenario envisioned for the opening of any new large mine includes the importation of a suitable labor force. Evidence of this is seen in the current situation at Tonopah where the development of the Anaconda molybdenum mine, requiring approximately 1,000 employees, is resulting in an in-migration to the area. Basically it can be assumed that any large-scale mineral deposit would be developed if it is economical to pay the employees a high enough wage to induce migration to the area. Therefore, the mining industry is not totally dependent on the locally available labor force. The in-migration of new labor in response to the development of a large mine would change the growth rate and possibly the location of population centers in the area, depending upon the location of the mine.

Public comments expressed a concern for the potential competition for labor and the impact this could have on the mining industry. These concerns are expressed by the following comment:

PUBLIC COMMENT ON THE DRAFT EIS:

"This situation is not possible because the competition for labor during M-X construction "would preclude" mineral development. This is stated on page 54. Many of the large companies have stated that the inflated costs and labor competition with M-X would drive them from the Great Basin. Mines pay taxes and M-X will not. This period of no mineral development would be 10 years and comes at a critical time when exploration and development is gaining momentum. The mining industry is just beginning to discover the deeper deposits in this area and it is going to require time and resources to extensively explore.

"Table 3.3.3-1 depicts M-X potential for attracting labor from mining ventures. The text does not elaborate on the fact that most of exploration work force is nonunion. This situation would favor project-jumping by labor, debilitating many exploration efforts." (B0123-8-276)

The superimposition of the M-X program onto this scenario brings to light an interesting effect. Even though at the beginning of the M-X construction phase there is predicted to be some competition for labor between M-X and existing mining establishments, as the construction phase of M-X ends there would become available a large labor force. This labor force would contain transferable skills necessary for mining and would already be present in the Nevada/Utah area. If large-scale mining development could be planned to occur as M-X construction ended, the labor force could transfer to the mining industry.

Development of a mineral deposit requires water, both for domestic and process uses and the availability of a water supply would affect the operation of a mine. If a mineral deposit occurred in an area where water was available only at a high cost through importation or deep pumping, then the development of that deposit might not be economical. Most of the hydrographic unit valleys in Nevada and Utah have a limited amount of water available as perennial yield, and state law prohibits the mining of groundwater. Therefore, if a mining concern develops most of the water potential in a particular valley, other users arriving later would be prevented from using any water. This would particularly apply to agricultural users who could not afford to develop high cost water sources.

M-X construction water use occurring during a short time span would only temporarily constrain other types of development within each valley area. If water sources for M-X construction are developed within each valley, at the end of construction some water could become available for other uses. The five alternative locations of the operating base are in areas of questionable water availability and use of local water at these sites would preclude other uses.

The calculation of negative impacts to the economic sector dependent on mining resulting from deployment of the M-X system is based on three factors: 1) land use preemption, 2) M-X proximity to minerals and energy activities, and 3) resource competition as a result of M-X activity.

The land use preemption factor can be expressed as a ratio of M-X facilities to total public lands acreage in the area of deployment. Such ratios are calculated

for individual counties of Nevada and Utah, based on M-X facilities distribution by county. Use of a facilities overlay and a base map that precisely locates mining activities claims and mineral deposits facilitates these calculations. The mining industry raised concern that this analysis did not consider ancillary facilities such as mills or tailings ponds in its land preemption. These facilities usually require a large block of land and are generally located in the valleys. Studies for subsequent tiered decisionmaking will identify these ancillary facilities.

The effects of proximity or impingement are more difficult to quantify. However, investigation by map overlay of precise locations of M-X facilities, mines, claims and mineral deposits will indicate where access problems exist as a result of M-X deployment. The effects of impeded access on working or prospecting operations requires subjective estimation, but impingement effects can be directly related to the more precisely calculatable land preemption factor.

The third factor attempts to quantify the resource attraction of M-X that results in drain of labor, equipment, and materials from existing local economic activities. Such potential resource drain from mining or any other local economic activity is difficult to measure with precision.

An opposing set of factors represents the positive impact of M-X on the minerals and energy resources industries. These factors are (a) increased demand, as a result of M-X construction activities, for local raw minerals, building materials (e.g., sand and gravel, stone, gypsum, clays, lime, perlite, pumice, and volcanic cinder) thereby increasing the economic base of the area and (b) improved access to remote areas of east central Nevada and west central Utah as a result of the M-X road network. Incorporation of these factors into the net impacts calculation involves the assumption of continuing operation and expansion of local quarrying and mining of building materials, with the M-X system as prime consumer in the 1980s. Improved access for mineral prospecting and exploration is a long-term benefit which will not accrue to the minerals and energy resources industry until completion of M-X construction activity.

The following statements are summarized from the Fugro (now Ertec) mineral report (Fugro National, Inc., January, 1981). This report was prepared for the land withdrawal application for the M-X project. The conclusions reached by the Fugro (Ertec) reports are basically similar to those reached in this ETR, but differ in the methodology and assignment of high potential mineral areas. The information in the Fugro report and the subsequent report Ertec Western, June, 1981 is incorporated by reference into the document.

The Basin and Range province, including the M-X Study Area, represents one of the most active exploration frontier areas in the United States at the present time. Hundreds of companies, groups, and individuals with thousands of exploration and operations personnel are currently investigating and developing mineral deposits, including oil and gas, within and adjacent to proven districts and in areas without known deposits within both range and valley portions of the study area.

Based on mineral occurrences (including oil and gas) and favorable geologic environments within the M-X Study Area, a large portion of the study area is interpreted to possess high, good, and speculative potential for new economic discoveries to the year 2000 and beyond. Potential for new discoveries is present in the ranges and valleys alike. Exploration by companies is going on in many of the areas designated by this report as possessing potential for new discoveries.

Mineral exploration and development activity is increasing, reflecting the expanding demand for mineral resources. Technological advances in exploration techniques and conventional and unconventional mining and metallurgical recovery methods facilitate these increasing activities.

Virtually all of the past metal mineral discoveries have been in the mountain ranges. It can be predicted, however, that many of the future discoveries for some commodities will be made in the valley areas, especially beneath the thin colluvial cover adjacent to known or suspected mineralized areas. Exploration will then continue working further away from the mountains into areas of thicker alluvial cover until the main valley or basin fault line is reached. At that point, valley bedrock may become too deep for economic mineral recovery.

The knowledge of the geologic setting of the mineral occurrences, including oil, gas, and geothermal, in the study area and surrounding environs, is continually expanding and evolving. As new data become available and a better understanding of the mineral occurrences and geologic setting is obtained, these data and interpretations will be applied to the search for new deposits. Exploration, like technology, is an evolutionary process requiring adequate time to show results. At least five to ten years of exploration may be required before the potential of even a small intensely explored area is reasonably well-known. The complex geologic setting within the M-X Mineral Resources Survey Study Area (for example, the Overthrust Belt with its oil and gas potential) will require years of industry

exploration before many of its mineral resources become evident.

The value of specific commodities to society is an important consideration that may change within a short time period. Recent increases in the use of molybdenum, beryllium, lithium, and particularly in a number of the industrial minerals, some of which occur in significant deposits within the study area, are examples. Growing demands for mineral commodities in the decades ahead seem certain to place increased emphasis on exploration and exploitation.

There are 19 metals that the United States imports for more than 50 percent of its needs for use by both the private and defense sectors. Eight of these metals occur and have been produced within the M-X Study Area as a principal, co-, or by-product commodity. These metals are manganese, aluminium, tin, potassium, mercury, zinc, tungsten, and gold.

The study area contains significant reserves of aluminum, potassium, and tungsten that are awaiting development. A considerable amount of tin will eventually be mined as a by-product to the mining of a large molybdenum deposit. Zinc occurs in many deposits as a by-product and will be produced along with lead, silver, copper, molybdenum, and tungsten. Much of the study area contains environments favorable for the Carlin-type stratiform gold occurrences, and exploration is intense with reported successes.

In addition to the above mentioned 19 minerals on the 50 percent plus U.S. Bureau of Mines import list, beryllium, bismuth, and fluorspar (acid and metallurgical grade) appear on the strategic mineral stock pile report to Congress (as of September 1979). Of these minerals, only beryllium and fluorspar are of common occurrence within the study area.

Known Mineral Resource Areas

There are 85 mining districts of varying size within the M-X Study Area that have produced metallic and nonmetallic commodities. In addition, there are two production centers which represent oil and gas fields. A number of other mining operations are planned for start-up in 1981 and later. In addition, recent exploration within and adjacent to districts has identified new mineral deposits, some of major size, for which production plans are underway. With the exception of oil and gas, uranium, beryllium, and some industrial minerals, the mining districts and production centers occur along the flanks and within the cores of the mountain ranges. Recent reported major metallic ore deposit discoveries at Hall

Mountain, Morey Peak, White Pine Range, and Fish Creek Range, Nevada; and at Pine Grove (Wah Wah Mountains), Simpson Mountain, and Drum Mountains, Utah, are in similar settings.

Exploration and mine development activities in the metal districts are accelerating with emphasis on deeper drilling and the development of extensions or projections of the districts. In response to increasing metal prices and improving mining and metallurgical recovery practices and usage of the new geologic interpretations, many deposits previously considered subeconomic are now being reactivated. Thus, the size of the many districts is being expanded.

In many of the districts, deeper drilling is being used to evaluate the known mineralized intrusive rocks and also to search for buried intrusive rocks that many contain disseminated, contact, vein, and replacement ore bodies of copper and molybdenum with co- or by-production lead, zinc, tungsten, silver, and gold. The intrusives commonly occur along the flanks of the ranges and beneath thin alluvial cover along or near the range front. The recent discoveries mentioned earlier in this section have resulted from sound geologic interpretations and deeper drilling of such occurrences of intrusive bodies. Such discoveries will continue to be made in both the ranges and the valleys. In addition to the metallic deposits, attention is also being given to nonmetallic commodities such as fluorspar and barite in many of the same districts.

Potential Mineral Resource Areas

In addition to the districts and deposits presently known and exploited, inferred ore deposit environments are present within the study area based on geologic analogies with adjacent areas of the Basin and Range Province. Continuing exploration to the year 2000 and beyond is expected to locate numerous, new economic deposits of metallics (precious, base, and ferrous metals), uranium, nonmetallics, industrial minerals, and oil and gas in both the ranges and valleys.

The types of potential resource environments and areas identified from the review of the mineral resources of the study area are as follows:

- o Deeper zones beneath known developed deposits in many of the identified districts;
- o Peripheral areas to identified districts based on geologic inferences;

- o Areas outside of identified districts at intersections of favorable geologic structures either within or outside the interpreted mineral belts;
- o Areas of favorable sedimentary lithofacies in conjunction with favorable structural setting and presence of indicator metals within ranges (in search of Carlin-type stratiform gold);
- o Projections of identified districts and deposits based on geological inferences into adjacent valleys beyond range fronts beneath thin (less than 600 meters) pediment alluvial cover;
- o Buried Paleozoic, Mesozoic, and Tertiary sediments underlying valley alluvial fill offer good to high potential for oil and gas occurrences throughout much of the study area because of the existence of favorable source and host rocks and the favorable degree of maturation of organic remains in the source rock; and
- o Valley sediments from the range fronts to the playa lake areas offer an environment for occurrence within the M-X deployment areas of a number of commodities including uranium, beryllium, precious metals, placer, various brines and evaporites (lithium, boron, gypsum-anhydrite, and salt), clays, and zeolites.

To estimate the interpreted degree of potential or favorability, a classification system with four categories (high, good, speculative, low) has been used instead of the U.S. Geological Survey and U.S. Bureau of Mines classification system (U.S. Geological Survey, 1976). ERTEC believes that the USGS classification system does not allow enough flexibility for interpretation of geologic parameters to project mineral potential into the future, and is designed to classify mineral resources as of a given date.

The potential classification is defined as follows:

High Potential - High potential is assigned to areas that contain or are extensions of active or inactive properties which show evidence of ore, mineralization, and favorable geologic characteristics. All producing properties fall within this category.

Good Potential - Good potential is assigned to areas with several geologic characteristics indicative of mineralization, relatively lower economic value of past production, and

similar environments but at greater distances from known ore and mineral occurrences. This category may include areas adjacent to known districts or in mineral belts.

Speculative Potential - Speculative potential is assigned to areas having some favorable geologic parameters and inferences based on geologic models and analogies to known favorable environments. Increasing depth of alluvial cover over areas of potential deposits is also a consideration in this category, except in the case of oil and gas potential.

Low Potential - Low potential is assigned to areas that are outside any construed favorable geologic and mineral trend projections or are buried by over 1,500 m of alluvium (except oil and gas).

The parameters that were considered in estimating the potential of areas include:

- o Locations of the mineral deposits and districts;
- o Past production history of the mineral district;
- o Locations of mineral belts;
- o Geologic phenomena relative to mineral occurrences:
 - Location of silicic igneous intrusives;
 - Location of silicic and intermediate volcanic rocks, centers, and calderas; and
 - Location of structural and tectonic trends;
- o Presence of geophysical (aeromagnetic) anomalies;
- o Depth of overburden cover to host rock;
- o Reported company exploration activity; and
- o Reported recent discoveries.

The confidence level is high in the determination of the classification of potential levels. This is particularly true when the full-scale of the potential classification can be demonstrated to be present in a given area and/or on a specific map.

The confidence level is not the same throughout the different minerals or mineral groups evaluated. A higher level of confidence rating is given to the precious, base, and ferrous metals because of the distribution and definition of the metal mining districts within mineral and geological belts. Part of the higher confidence level interpreted for the metals is because of the greater amount of data available in comparison with available data concerning uranium and certain industrial minerals and occurrences. The oil and gas potential evaluation is also considered to have a high confidence level because of the large amount of quality

investigative geologic work, both published and unpublished, utilized in compiling this report. Within the high and good potential classifications, there is strong likelihood that economic mineral and hydrocarbon deposits will be discovered. Discoveries in the speculative classification are less likely, but the presence of geologic parameters analogous to mineral and hydrocarbon concentration indicates that exploration activity in these areas will increase in the future. Within areas presently designated as low mineral and hydrocarbon potential, there appears to be limited potential for mineral activity.

Exploration within and adjacent to the metal districts situated near the range fronts is progressing into colluvial- and alluvial-covered valley areas between the range front and the major basin or valley fault zone. Between the range front and the major valley fault, the bedrock is generally at reasonable exploration depths. Beyond a major valley fault, exploration for minerals in bedrock becomes much more difficult because the host rock may have been dropped over 600 meters.

In this survey potential assigned to the valley areas takes into account the interpreted depth of alluvial cover over the bedrock. Mining of deposits with up to 600 m of cover is currently taking place worldwide, and this depth to bedrock has been chosen as a cut-off for the first level of exploration. For deposits in valley areas where 600 m to 1,500 m of overburden is likely, mining will probably result from following a known geologic structure from shallower depth, when depth to bedrock in the valley areas exceeds 600 m, therefore, the assigned potential was reduced one category (i.e., good to speculative), and all valley areas with over 1,500 m of alluvial cover were assigned low potential (excluding oil and gas potential).

Exploration for various stratiform metallic and non-metallic commodities is expected to increase over the long-term. Much of this exploration will be conducted throughout the valleys, depending upon the commodity being explored. Many of these deposits are blanket-like and tabular in form and, in some instances, cover many tens of square kilometers. Within M-X deployment areas, major size deposits could be economically recovered by open-pit methods to depths around 600 meters beneath the alluvial surface. Deeper deposits can be exploited by conventional underground mining methods if the rocks are competent. Some metallic and nonmetallic commodities can be recovered by underground leaching techniques.

High Potential Areas

The high potential metallic and nonmetallic areas delineated contain or are very likely to contain economically recoverable deposits. These areas are likely to be explored by industry in the immediate future (next five-year period). In many areas, exploration is already in progress. In the valley areas, bedrock beneath an overburden cover of 600 meters or less is extremely attractive for exploration if it is within a geologically favorable area. A significant discovery within such areas would likely be viable at today's economics. All producing properties fall within high potential areas.

High potential areas show abundant evidence of the presence of mineral deposits of various types, and access to these lands for discovery and development of these resources should be protected. These areas have more potential for resource discovery than most lands within the United States. The construction of the M-X system on such lands could seriously impair mineral resource development. Exclusion of these lands from M-X siting would provide adequate protection of these resources. Other administrative approaches could be explored to provide similarly adequate protection for mineral development. In addressing this problem, it should be remembered that decisions which introduce uncertainties as to the tenure and restrictions imposed on use or development of these lands, should mineral discoveries be made, are tantamount to withdrawing the lands from mineral entry.

A possible exception to this impairment would be the high potential areas outlined for oil and gas. The oil and gas industry may have greater flexibility in locating test drilling sites than the mining industry and could better accommodate the M-X system. However, there could be some negative impact from the M-X system should a major oil and gas field be outlined, with its requirements for a gathering network and related surface facilities, as well as power supply networks and road access in an M-X deployment area.

Good Potential Areas

As used in this survey good potential is assigned to areas with:

- o Several geologic characteristics indicative of mineralization;
- o Past production of significantly lesser value than areas assigned high potential;
- o Similar environments but greater distance from known ore occurrences; or

- o A combination of the above.

Such areas are likely to receive drilling-level exploration by industry in the near future. Mineral entry for lands with good potential is important and should be protected.

Speculative Potential Areas

Typically, areas of speculative potential have been less prospected and have fewer geologic data available than areas of good and high potential.

Speculative potential areas may fall within mineral belts, but are outside of known mining districts, generally farther away from known areas of mineralization, have lower magnitude geophysical indications of favorable geologic environments, and/or are covered by thicker alluvial accumulation. Their presence in a highly mineralized region, especially along projections of favorable belts and trends, makes it likely that they will receive some exploration over the next 20 years. Selected areas may receive significant exploration. Analysis of available data including satellite imagery, regional aeromagnetic and gravimetric surveys, state and county geologic maps, nonconfidential industry information, and selected field examination and literature verification do not suggest any specific areas of speculative potential where additional geologic studies are presently warranted. However, areas categorized as having speculative potential should remain available for future exploration.

Low Potential Areas

Low potential areas are areas where the geologic environment suggests low favorability for mineralization. Until new geologic knowledge indicates that low potential areas be reassessed, the commitment to additional studies cannot be justified. Areas categorized as having low potential should remain available for future exploration.

Supply-Demand Implication for Mineral Commodities

Mineral commodities known or likely to occur within the study area reflect various levels of domestic availability. Only ten metallic and nonmetallic commodities currently on the list of strategic commodities are known to occur within the study area. In terms of net importance to the United States, more than 50 percent of these ten strategic mineral commodities are currently derived from foreign countries.

These commodities identified within the study area are:

- | | | | |
|---|-----------|---|-----------|
| o | manganese | o | zinc |
| o | aluminum | o | tungsten |
| o | tin | o | gold |
| o | potassium | o | beryllium |
| o | mercury | o | fluorspar |

Supply-demand relationships are self-evident. Estimates of the future supply and demand for these and other commodities suggest that new deposits will have to be discovered, particularly if the United States is to decrease its reliance on foreign sources. Portions of the study area offer significant potential for the discovery of such deposits.

Impact of the M-X System on Mining

The implementation of the M-X system will have many direct and indirect effects on the mining and oil and gas industries. As described earlier, the M-X Study Area is, and is expected to continue to be, a part of one of the premier active exploration areas in the United States.

The M-X system may adversely affect a number of aspects of exploration and mining activities in the study area. The earliest impact of the M-X missile system will be a dampening effect on industry exploration as companies postpone current and future exploration in a "wait and see" posture until withdrawals, construction, and overall impact of land status can be assigned. Correspondence with companies indicates that such deferrals have already begun to occur. Persons or companies holding mineral leases or mining claims in conflict with M-X withdrawal areas will be directly impacted by M-X deployment.

The ability of industry to conduct significant exploration and development within the deployment areas is likely to be impaired. Limitations on exploration activities, such as detonations for seismic surveys, electrical input, or induced potential surveys are a concern of the mining and petroleum industries. The compatibility of high yield, open-pit blasting or underground block-caving between or near deployment sites and the movement of large trucks on and across the M-X transporter road system is also of major concern to the industry.

During the life of the M-X system, large open-pit mining operations in valley margins or within the central portions of the valleys will probably be in conflict where missile cluster sites and connecting roads are built.

Both open pits and underground mines require hundreds or thousands of acres for facilities. Even when the mines

themselves may not be in conflict with cluster siting, conflicts may develop for acreage for mill site and tailings ponds, service and support facilities, and mine dumps. Gathering systems for oil and gas production, storage, and transport could also be affected.

Road access to mining operation in both valley and range areas could be impaired by the M-X system principally during construction phases. New roads may have to be constructed along the margins of the impacted valleys to ensure adequate haulage access to operations in adjacent ranges.

During the construction period, the M-X project will create local, if not regional competition with the mining industry for:

- o Specific space for operations;
- o Supplies of water;
- o Supplies of aggregate material necessary for mining and milling operations;
- o Fabricated materials;
- o Construction equipment;
- o Labor, with or without consideration of pay salary differentials that may result; and
- o Housing.

Implementation of the M-X system would spur the development and mining of aggregate and stone materials to be utilized in the production of concrete and cement for construction and base materials for roads, foundations, etc. A positive result of the M-X system will be a substantial increase in the number of roads within each valley, provided that access to these roads is maintained. The availability of additional water for mining activities following M-X construction is also considered a positive factor.

Following construction of the M-X system, the principal impact on the mineral industry will be the competition for land to explore and develop.

The proposed Air Force mineral policy states that they will avoid high potential mineral areas. Adherence to that policy, and guarantees of continued access to the M-X deployment areas for mineral exploration and development, could mitigate the impact of M-X on the mineral industry.

LAND WITHDRAWAL (3.3.1)

Identification of the impacts of the M-X system on mining claims was accomplished by overlaying the proposed system on a map of mining claims (Figure 3.3.1-1). Potentially significant impacts were determined to occur where the proposed system overlapped large concentrations of claims.

Withdrawal of land presently held in mineral claims could limit future mineral development in the deployment area. This might result in a valuable ore deposit located in bedrock under the valleyfill could not being developed because of the overlying M-X components. This would be especially true if open pit methods were to be used. In addition to claims indicating the presence of large-scale mineral deposits, many claims are held by individuals and worked on a part-time basis as recreation or income supplement. Withdrawal of land already occupied by claims would impact these individuals. This will be addressed in subsequent final decisionmaking. Non-M-X projects, being confined to a single site, can more easily avoid mining and mining claim conflicts. In fact, many of the non-M-X projects in the study area are producing mines, the logical extension of mining claim activity.

Mining development is a long-term resource commitment. From the discovery of a mineral deposit to production may take 7 to 10 years or longer. The economic life of a deposit may be 30 to 50 years. The location of M-X over a potential mining area could preclude the development of new mines for the duration of the M-X system.

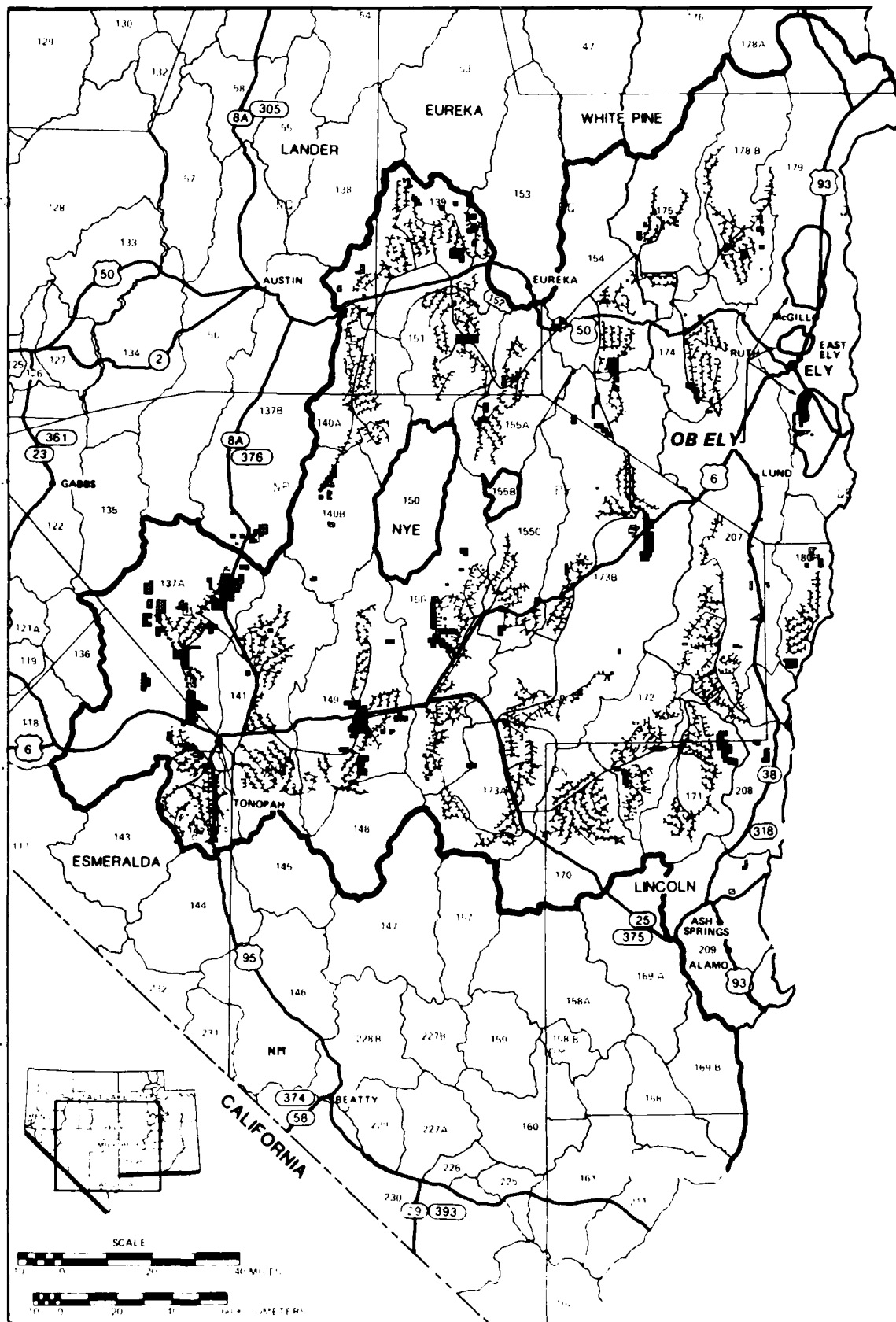
Most of the developed metallic mineral resources in the M-X deployment area occur in the mountain ranges which are not being considered for withdrawal. Other minerals, especially nonmetallic, are concentrated in the playas, which are also not being considered for withdrawal. Much of the area being considered is covered by oil, gas, or geothermal leases, and portions of the deployment area adjacent to known mineral deposits contain unpatented mining claims. Future discoveries may occur in the deployment area as extensions of known deposits or mineral belts.

Acquisition of land for the deployment of the M-X system would not directly impact any operating mine. The areas of high mineral interest that could be affected by the project are located along the mountain fronts where there is a possibility of basinward extensions of mineralization. These would be areas of shallow alluvial cover so recovery of minerals would be economical. Many of these areas are already covered by mineral claims and are actively being explored. By avoiding these claims, the M-X system would minimize potential impacts to future mining concerns. If the M-X system were to occupy land over unknown mineral deposits, these deposits could be precluded from development during the life of the project. However, the proposed Air Force Policy on minerals will minimize this conflict.

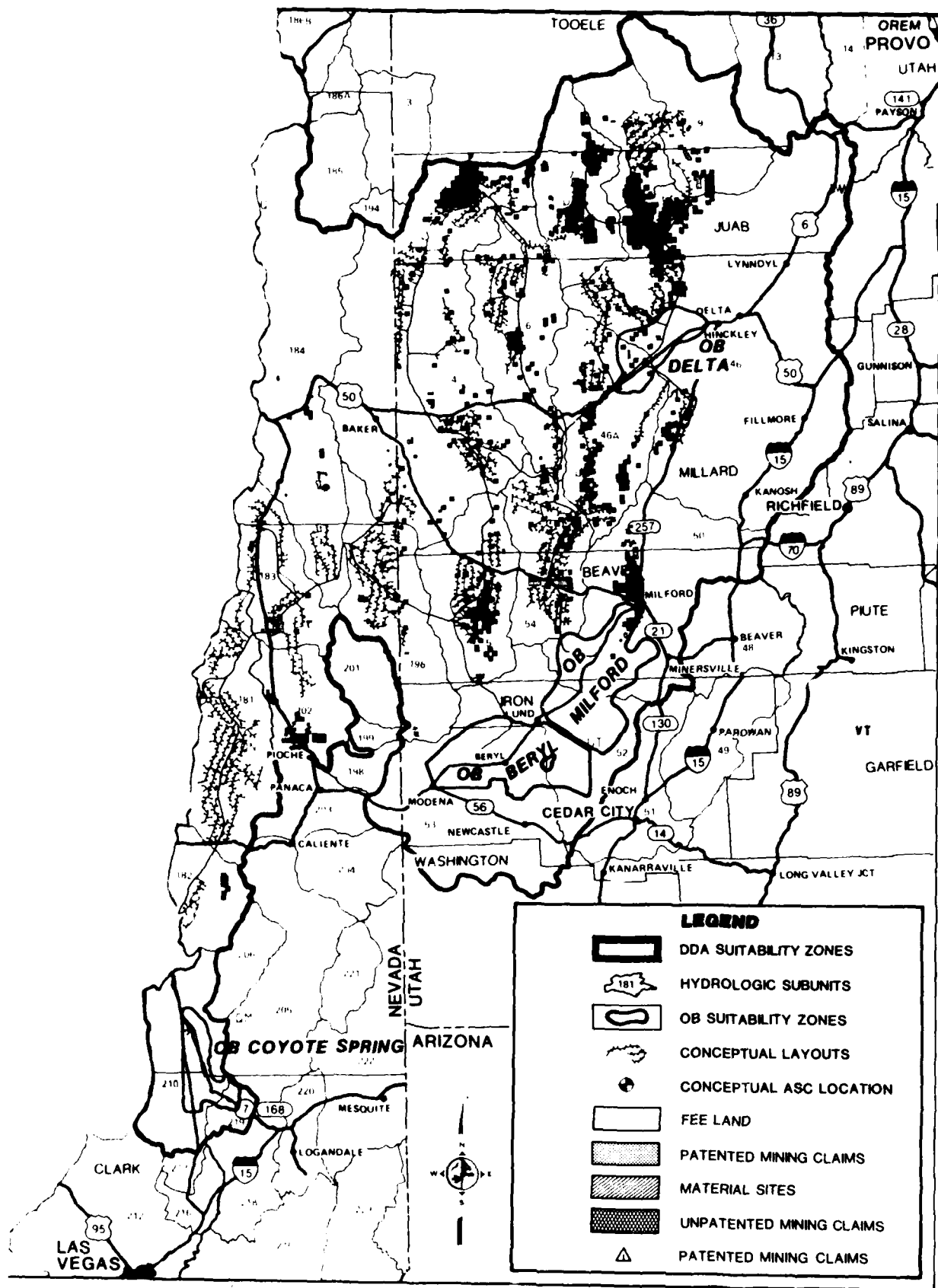
The areas of high resource value, whether mineral, oil and gas, or geothermal, with which the M-X project could conflict are listed below for the valleys affected by M-X.

Nevada (3.3.1.1)

1. Railroad Valley. The west central part of this valley (T.9N., R.56 & 57E.) features Nevada's only two producing oil fields. The entire valley has been much explored. The fields are not large (total Eagle Springs field production from 1954-1970 was 2.5 million barrels or 397,250 cu m. Moreover, given the extremely chaotic and complex geology of Nevada, there is no assurance that a favorable petroleum "trap" extends for any great distance beneath the valley's alluvial cover. Nonetheless, as petroleum is such a vital resource, it would not be in the country's interest to prevent new discoveries.
2. Hot Creek and Reveille valleys. A geothermal potential exists in T7-8N, R50-51E.
3. Big Smoky Valley. High industrial process heat geothermal potential is found in the west central part of this valley, T11-14N, R43E.
4. Penoyer Valley. There would be a total exclusion of right-of-way Crossing T35-56E, Sections 16, 17, 18, 21, 23, and 24 and for vital tailing and water pipeline areas for Emerson Mine, total of 4,160 acres (1,681 ha).
5. Crescent Valley. Project overlaps at McDarmott Mine (Mercury), Cortez mine (Au), Placer Amex (B0438-0-001).
6. Coal Valley. Overlaps exist at T2N, R60E, Sections 1 and 12, R60E, T3N, Section 18; T2N, R61E, Sections 6, 7, 8, 9, 16, 17, 18, 19, 20, 30, 31, 32, 33; T3N, R61E, Sections 28, 29, 31, 32 for a total of 10,240 ac (4,137 ha). With concentrations of unpatented mining claims along the valley border.
7. Cave Valley. Overlaps exist at T5N, R63E, Sections 7, 8, 9, 10, 15, 16, 17, 18, 20, 21, 22, 28. Total of 7,360 acres, with concentrations of mining claims at the south end of Cave Valley.
8. Lake Valley. All the area from Bristol Pass Road west of Highway 93 to the north boundary of 1N, extending across 67E overlaps the project. Included in the recommendation is the small valley lying along the easterly side of T1-82N and R69E. Total acreage is 25,600 (10,342 ha). This is an area of concentrated mining claims of good potential. Further, it is close to the town of Pioche, Nevada. The small valley area contains the community of Ursine with a population of approximately 35.
9. Spring Valley. The northern four tiers of sections covering the end of a valley are in T11N, R67E. Total acreage is 7,040 (2,844 ha). Approximately half the area is covered by fee lands and patented mining claims.
10. Monitor Valley. Northumberland Mining District Barite production (B0839-8-001).



3230-D-1



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Figure 3.3.1-1. Distribution of patented and unpatented mining claims and the Proposed Action conceptual project layout.

11. Spring Valley. T7N, R68E, Sections 9, 10, 15 and 16. Total acreage is 1,920 (766 ha). This area is vitally important to a major operating mine and has a strong recommendation for exclusion.
12. Hot Creek Valley. 115 claims are in T7N, R50E. This is adjacent to Tybo mining district (silver, lead, zinc, gold, and mercury). This combines with the geothermal potential previously mentioned.
13. Steptoe Valley. 153 claims are in T14N, R63E and is adjacent to Ward silver, lead, and zinc mining district.
14. Tonopah Area. South end Big Smoky Valley, T5N, R41-42E. Anaconda is developing a large molybdenum deposit for production.

Utah (3.3.1.2)

1. Escalante Desert. This is an area of high geothermal potential and exploration activity and it is reported that there may be a potential for electric power generation. To avoid interference with geothermal development, the Escalante desert areas south of T25S and/or east of R10W should be avoided.
2. Black Rock Desert. Like the Escalante Desert, this is an area of recent vulcanism, high heat flow, and much geothermal leasing and exploration activity.
3. Sevier Desert. The part of the Sevier Desert in west central Juab County is bordered on the north by heavily mineralized mountain ranges. The Key Mountains on the west have been the site of much uranium exploration activity. The Sheeprock Mountains to the north have extensive precious and base metal mineralization. The townships with the heaviest mining claim activity include those bordering on the Key Mountains (T13S, R9W, 430 claims; T14S, R9W, 160 claims) and those bordering the Erickson, East Erickson, and Blue Bell mining districts in the Sheeprock Mountains (T11S, R6W, 534 claims; T11S, R7W, 359 claims).
4. Dugway Valley. Located between the Key Mountains on the east and the mineral storehouse of the Thomas Range on the west, Dugway Valley has extensive claim activity. The Thomas Mountains have the world's largest beryllium deposit, large fluorite reserves, and the largest uranium deposit in the Great Basin at the Yellow Chief Mine. Because of the stratabound nature of the Yellow Chief deposit, it is entirely possible that it may extend basinward. Townships with heavy claim activity include T13S, R10W (947 claims); T14S, R10W (364 claims); T12S, R11W, (190 claims); and T14S, R11W (179 claims).
5. Fish Springs Flat. T13S, R11W is immediately south of the rich uranium-beryllium-topaz mineralization of the Thomas Range, and contains 62 claims. T12-13S and R12-13W are areas of considerable geothermal interest and leasing activity.

6. Sevier Lake Valley. The east side of Sevier Lake, R11W, T20-22S, has extensive evaporate deposits, including potash. Over 100 claims and a state mining lease have been filed on these saline deposits.
7. Pine Valley. A large molybdenum deposit (Pine Grove Project) is currently being explored for possible future development.

Table 3.3.1-1 indicates the potential conflicts between M-X required land uses including safety zones and lands subject to possessory uses. This assumes an even distribution of possessory uses throughout the deployment area. The table indicates potential conflicts on 80,508 acres (32,525 ha) of federal land under geothermal, oil and gas leases and mining claims. This amounts to 2.6 percent of the project site requirements. Some uses will be permitted within the safety zone (Ref. COE Report).

From BLM figures, it is estimated that in the candidate sites there are 2,781 oil and gas leases, 127 geothermal leases, 10,260 valid unpatented mining claims and 354 patented mining claims. A possible effect of M-X siting is litigative acquisition actions, and the dollar value, plus court time represented. A rounded figure of \$49 million for real estate acquisition in the Great Basin (Nevada and Utah) area has been tendered by the Army Corps of Engineers (1980).

ACCESS CONFLICTS (3.3.2)

The deployment of the M-X system as currently designed does not directly preempt any working mine by acquisition of its location. However, the cluster and road network of three Utah counties (Juab, Millard, and Beaver), and four Nevada counties (Lincoln, White Pine, Nye, and Eureka) does infringe on individual mine workings and might easily interfere with access efficiency and ease of mine operation. The cluster and road network also intrudes on areas of potential mineral development, and during the M-X construction phase, geologic survey and exploration may be hindered. This inhibition of mineral development is difficult to quantify on a general basis since the potential output of individual deposits is subject to wide variation. In addition, the timing of minerals development is governed by economic considerations and is independent of land use developments.

Construction (3.3.2.1)

An estimation of the impact of M-X deployment on minerals industry growth is possible by assuming the impact is proportional to the share of BLM public lands preempted by M-X construction compared to the total area of BLM land directly impacted by the deployment. The ratios and proportions are approximate. Levels of impact range from less than 0.5 percent to nearly 1.5 percent. Projected growth of minerals output, to the year 2000, can accordingly be adjusted downward by these percentages. The rationale for these calculations is that future growth of minerals output is directly proportional to the amount of public lands available for exploration and development.

Operation (3.3.2.2)

If M-X siting is close to a large deposit--already blocked out, sampled, and known to contain large, valuable reserves--then revised deployment of the site

Table 3.3.1-1. Analysis of M-X land interests requirements.

Purpose	Required Total Acres	Required Non-Federal Acres = 6.7/2	Required Federal Acres Subject to Possessory Interests				Required Federal Acres With No Possessory Interests Outstanding
			Geothermal = 2/2	O & G + 57.2/2	Mining Claims + 6/2 x 40/3		
Exclusive Use	14,079 ¹	-	-	13,136	-	(282 + 8,053 + 338 ⁴)	= 4,463 (31.7%)
Right-of-Way	131,948 ¹	-	-	123,107	-	(0 + 0 + 3,167 ⁴)	= 119,940 (90.9%)
Safety	2,861,181 ¹	-	-	2,669,482	-	(0 + 0 + 68,668 ⁴)	= 2,600,814 (90.9%)
Totals	3,007,208	-	-	2,805,725	-	(282 + 8,053 + 72,173)	= 2,725,217 (90.6%)
T747/10-2-81							

T747/10-2-81

¹Supplied by BMO.

²Ratio of required acreage to total project acreage.

³Mineral consultant's estimate of valid portion of total claims in project area.

⁴Valid claims estimated to equal 6% X 40%, or 2.4% of required acreage.

Source: Army Corps of Engineers (1980).

would take place. The probabilities are that proven deposits of this nature are already known and basing criteria have excluded such locales. However, if an ore-body is known only through vein outcrops or through an abbreviated sampling program, in an area known to be geologically suitable to mineralization, then probable ore reserves may warrant further attention and exploratory work even with M-X basing already approved. In such event, revisions of facility locations in the deployment area would be addressed in subsequent tiered decisionmaking.

COMPETITION FOR LABOR (3.3.3)

The M-X project could affect the mining community through competition for the local labor pool. It is possible that many individuals living in the area affected by M-X development may elect to give up their present employment in favor of working on the construction of the M-X project.

Present mining operations such as Union Carbide in Alamo, Nevada and Anaconda Molybdenum near Tonopah, Nevada, operate under the umbrella of union organization. The likelihood of displacing employees from their present positions with longevity benefits, seniority, etc., may not be great.

It is assumed that a high priority federal project such as M-X will outbid local industry for resources (labor, materials, and services); that there are no insurmountable barriers to the free movement of labor from one sector to another; and that economic self interest is the prime motivation of the local labor force. Hence, it is possible that the mining industry of the area, paying lower wages to employees with transferable skills of value to M-X construction, will lose large numbers of these employees to the M-X project.

Table 3.3.3-1 shows an estimate of the proportion of mining employment in the Nevada/Utah deployment area that could be attracted by wage differentials to M-X related activity. Of the 43 percent of the labor force potentially subject to attraction to M-X employment, approximately 70 percent (30 percent of the total) are estimated to actually make the shift.

3.4 M-X IMPACTS--TEXAS/NEW MEXICO

The DDA for Texas/New Mexico is located on the surface of the High Plains. There is little mining activity in the area and no significant impacts are expected. There may be some minor locational conflicts with a new carbon dioxide gas field and distributory network in Union, Harding, and Quay counties, but these should be avoidable.

The Clovis operating base site is not located near any mining or potential mining activity. No impacts other than an increased use of sand and gravel are expected. Wind erosion damage is commented on frequently as impacting M-X construction and operations.

The Dalhart OB site is not located near any mining or potential mining activity. It is 15 to 20 mi west of the Hugoton gas field but no conflicts are expected. An increased demand for sand and gravel will accompany the OB construction.

Table 3.3.3-1. Percentage of mining labor force subject to attractions to M-X, by category.

Occupational Group	Percent of Employment ¹	Percent of Category Attracted	Percent of Total Attracted
Professional and technical	12.5	0	0
Managerial and administrative	8.8	0	0
Sales	0.4	0	0
Clerical	9.7	10	0.97
Craft and kindred workers	27.4	40	10.96
Operatives (except transport) ²	32.3	75	24.23
Transport equipment operatives	5.7	75	4.27
Nonfarm laborers	2.0	90	1.80
Service workers	1.2	90	1.08
Total			43.31

T2208/9-15-81

¹ 1977 breakdown of all U.S. mining employees.

² Assemblers, drillers, mine operatives n.e.c., welders.

3.5 MITIGATIONS

The major impacts to mining activity, toward which mitigations should be directed, would result from preemption of mining land use, interference with existing mining operations and competition for labor and resources.

AIR FORCE PROGRAMS (3.5.1)

During the siting of M-X facilities, areas of known high value mineral deposits will be identified and avoided. The Air Force will coordinate and cooperate with local mine operators to minimize disruption of mining operations. Where it is not practical to totally avoid a claim, impacted claim holders will be compensated in accordance with law. These mining conflicts will be settled on a case-by-case basis.

After the construction of shelters is completed, if a high value mineral resource is discovered and recovery is economically justified, the Air Force will advocate that Congress consider the abandonment or dismantling of affected shelter sites if it is necessary for mineral recovery.

OTHER MITIGATIONS UNDER CONSIDERATION (3.5.2)

Prior to construction of project facilities, a geologic survey of the entire deployment area could be undertaken to identify areas of potentially valuable mineral deposits. These would be a more detailed study than the literature survey already completed and would include field surveys. Where geologic evidence warrants it and geologic conditions make it practical, a limited drilling program could be instituted for confirmation of mineral values.

Project roads could be located in order to provide better access to existing or proposed mines. This could be beneficial to some mining operators who may otherwise have to construct new roads at considerable expense.

Mitigations for impacts and mining due to the increased demand for labor and resources are discussed in Section 3.15, Employment and Labor Force.

Additional discussion on mitigations is contained in ETR-38 "Mitigations".

4.0 SEISMICITY

4.1 INTRODUCTION

The following discussion considers seismicity, i.e., earthquakes and ground surface rupture, under the following categories:

1. How the project may have an effect on local seismic activity.
2. How seismicity affects the project feasibility.
3. How seismicity affects the new environment encompassing the project.

The relevance of these comments depends on the kind of facility that is being considered. Reference is made to several general kinds of facilities, however, the list is not complete. The term "critical facility" is used when public safety is an issue.

The few and exceptional cases of seismicity induced by man involves the alteration of fluid pore pressure at depth in proximity to pre-existing faults. The alteration of pore pressure may arise by either the introduction or withdrawal of fluids. Most seismic events created are of small magnitude, reflecting a generally low level of strain energy stored in rocks in the very shallow crust. Mechanically induced earthquakes are, however, similar to natural earthquakes, i.e., strain energy is released by slippage along a fault when stress exceeds the frictional resistance of the fault plane. However, in both injection and withdrawal, surface deformations are possible, with an increased potential for seismic release of strain along planes of weakness. Withdrawal of fluid from the ground generally decreases pore pressure and effectively increases resistance to fault slippage.

In terms of feasibility, seismicity affects the placement and design of a proposed facility. In addition to project location, facility design must consider cost and public safety. Seismicity, as a factor in the placement of the structure, may be weighed against the loss of economically and aesthetically valuable environmental features.

Seismic conditions can necessitate the construction of larger or different structures than would otherwise be built. Generally these factors would tend only to increase the visibility of structures but they may also require the withdrawal of larger parcels of land, or the acquisition of land with particular engineering characteristics not originally envisioned. Certain structures found sensitive to ground motions characteristic of deep alluvial fills might be moved to a location with a bedrock foundation.

The construction of numerous attendant project structures and facilities such as roads, towns, transmission lines, bridges, and communication cables should be considered in the above context, particularly since for some, seismicity may be an influence far from the principal elements of the project.

The magnitude of seismic hazards is generally known, and in most cases engineering design can eliminate, or contain within acceptable limits, structural

failure resulting from ground motion. Estimating the maximum credible earthquake for a region or location is a design input which will determine many specific features of the proposed structure, but it is also an environmental factor that will determine the probable magnitude of postulated environmental impacts. The return interval of the maximum earthquake which could affect an area is essential in predicting whether or not presumed impacts would occur during the life of the proposed facility. The M-X protective shelter is designed to survive and operate after a ground shock environment more severe in an attack than could ever be expected from natural seismic or earthquake type motions. Recognizing that the exact type of nuclear ground motions are somewhat different than natural earthquake induced ground motions, the M-X system is designed to withstand, at a minimum, the equivalent of a Richter 10 earthquake. The largest earthquake ever recorded was the Assam Earthquake in 1952 and measured 8.7 on the Richter scale. Ground motions induced by a nuclear weapon would be more powerful than a Richter 8.7 earthquake. Therefore, the M-X protective shelter will survive the most extreme natural seismic activity.

4.2 NEVADA/UTAH

TECTONIC SETTING (4.2.1)

Between Oligocene and Middle Miocene time the tectonic regime in the western United States shifted from one dominated by compression (e.g., during the Laramide orogeny) to one of extension. The Basin and Range Province, including Nevada and western Utah, became the site of a series of northerly trending, subparallel horsts and grabens bounded by normal faults. This block faulting has continued episodically to the present, with an apparent peak of activity during Pleistocene time when the whole region was uplifted. The Basin and Range is tectonically and seismically active at present. The Great Basin of Nevada and western Utah is characterized by the following features, which in association with late Cenozoic vulcanism and normal faulting, indicate a high level of tectonic activity: (1) high heat flow; (2) thin crust (about 30 km vs. 40-50 km in the Rocky Mountains); (3) low P_n velocities of 7.7-7.9 km/sec in the upper mantle; (4) high elevation; (5) high electrical conductivity (Thompson and Burke, 1974; Keller et al., 1975).

The deformation and seismicity of the Great Basin are the result of complex plate tectonic mechanisms operating in the area. Atwater (1970) characterized the area as a wide, soft zone that is accommodating oblique divergence between the Pacific and North America plates. This divergence is manifested by crustal extension in a WNW-ESE direction, that has produced approximately 128 to 192 km of displacement across the western Great Basin (Stewart et al., 1968). Subduction of the Pacific spreading center in Cenozoic time may have contributed to this extension and uplift (Smith and Sbar, 1974).

Much of the crustal extension is concentrated in seismically active zones that bound the relatively more stable subplates. There are four such zones surrounding the Great Basin subplate: (1) a northeast-southwest trending seismic zone in southwestern Utah and Nevada near the southern boundary; (2) the Owens Valley on the west; (3) the east-west trending Idaho seismic zone on the north; and (4) the Intermountain Seismic Belt (ISB) in Utah, forming the eastern boundary (Smith and Sbar, 1974; Walper, 1976). In addition to the bounding zones, the western Nevada seismic zone extends north-south into the west-central portion of the Great Basin.

SEISMIC SETTING (4.2.2)

Geographic Distribution of Seismicity (4.2.2.1)

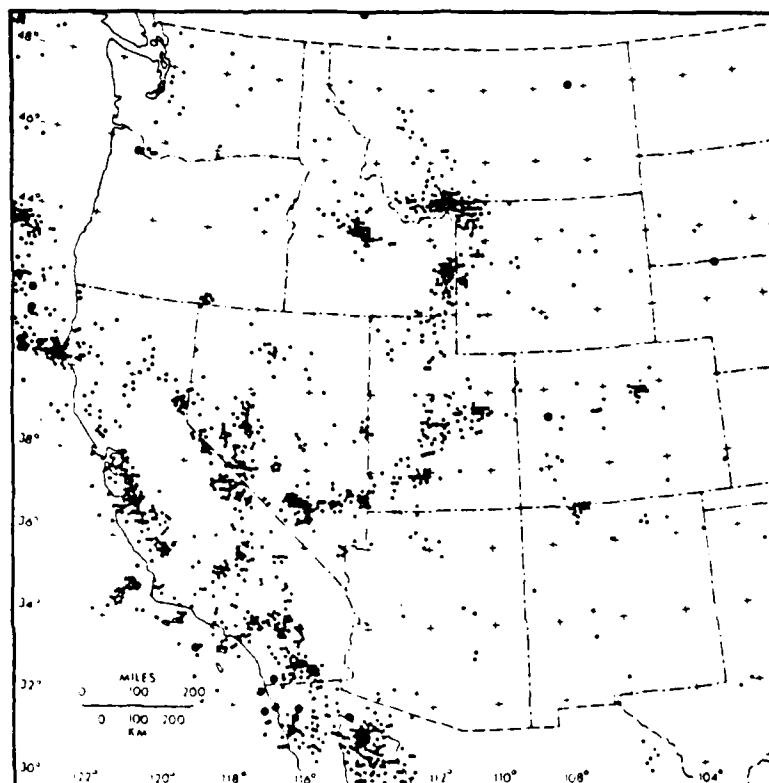
The distribution of magnitude (M) 3 to 5 earthquake epicenters (Figure 4.2.2-1) illustrates the distribution of recent seismic activity in the Great Basin. The epicenters are concentrated in broad zones (to 150 km wide) across west-central Nevada, the northern end of the Ventura-Winnemucca zone, and west-central Utah (ISB). There has been relatively little historic seismicity in the interior of the Great Basin (Smith and Sbar, 1974), and historic surface faulting has centered on the Ventura-Winnemucca seismic zone (Slemmons, unpublished report). Although earthquakes tend to cluster in areas of Tertiary and younger fault zones (Ryall, 1977; Sbar et al., 1972), many earthquake epicenters are widely scattered and cannot be associated with known faults (Smith, 1978). Most earthquake hypocenters in the Great Basin occur above a depth of 20 km. This generally corresponds to the crust above the low-velocity layer in the upper mantle.

Historic Seismicity (4.2.2.2)

Between 1934 and 1960, Nevada was one of the most seismically active area in the western conterminous United States (Slemmons et al., 1965; Wallace, 1977). During the period between 1952-1960, 1,173 earthquakes were recorded in Nevada and 586 of those were magnitude greater than 4 (Slemmons et al., 1965). Historic seismic activity in Nevada has been concentrated in the Dixie Valley-Fairview Peak, Pleasant Valley, and Cedar Mountain areas which comprise the northern portion of the Ventura-Winnemucca zone.

In Utah, between 1850 to 1962 413 earthquakes were recorded, while from June 1962, when the University of Utah seismograph began operation, to June 1978, 3,797 events were recorded. This seismic activity is concentrated along the ISB (Cook, 1967; Smith and Sbar, 1974). Ninety percent of the recorded earthquakes in Utah occurred in areas where fault zones are recognized (Cook, 1972).

A concern was raised that the various reports on number of events which have occurred for various time periods may be inconsistent. These may not be all the events that have occurred, but rather the ones recorded. These are reported events and therefore with the increase in detection capability, especially since 1962, a much more complete earthquake record is available. The increase in detection capability, however, may not account for all the variations. As is discussed by Arabasz et al. (1979), there are both spatial and temporal "seismic gaps" in the earthquake record which most likely represent either the post large earthquake stage (i.e., strain has been dissipated) or the preearthquake stage (i.e., strain is accumulated). The question therefore is, in a seismically active area, is the quiet zone the safe area or the most dangerous area. While Arabasz, et al. (1979), was referring specifically to the Wasatch Fault Zone the argument is equally valid throughout the DDA under our present level of knowledge of earthquake hazards. Therefore a conservative approach in determining seismic design values must be used.



Small dots represent epicenters of earthquakes of about M3-5; large dots, M>5.

Source: Thompson and Burke, 1974, p. 216

1723-A

Figure 4.2.2-1. Earthquake epicenters in western United States for the period 1961-1970.

Ventura-Winnemucca Seismic Zone

A 600-km-long seismic belt that extends from Ventura, California north-northeastward to Winnemucca, Nevada. The Ventura-Winnemucca zone is one of the most active seismic zones in the United States.

Although this zone includes several faults active in historic time, there is generally poor correlation of epicenters with known structural elements (Ryall et al., 1966). The seismic activity along this zone tends to shift with time; gaps in the seismic pattern are filled by successive large earthquakes (Ryall et al., 1966).

The Intermountain Seismic Belt

The Intermountain Seismic Belt (ISB) is one of the most active seismic zone in the United States (Smith and Sbar, 1974). The ISB is a 1300-km-long, 100-km-wide belt of earthquakes extending from Arizona northward into Montana, and it generally coincides with the boundary between the Basin and Range and the Colorado Plateau provinces (Smith and Sbar, 1974; Walper, 1976; Wechsler and Smith, 1978).

Seismicity along this zone is shallow; earthquake hypocenters are generally less than 20 km deep (Sbar et al., 1972). Fault motion in the Utah segment of the ISB is generally along steeply dipping (or vertical) fault planes (Sbar et al., 1972). The intensity of youthful activity along the ISB in Utah is demonstrated by the large amount of total vertical crustal displacement (3.5 km; Smith and Sbar, 1974) and by the large number of earthquakes that have been recorded along the zone (1,040 between 1850 and 1970 in Utah; Cook, 1972).

The ISB coincides with several major fault zones, the most important of which are the Wasatch Front, the Hurricane, Sevier, and Cache fault zones.

The Wasatch Front includes a large fault scarp along the western boundary of the Wasatch Mountains; evidence of Holocene normal faulting is present over much of the length of the scarp (Sbar et al., 1972; U.G.M.S., 1976). An unusual aspect of this fault is that, although it shows evidence of a great amount of past movement, the present-day microseismic activity is quite low (Sbar et al., 1972). Although there has been no historic faulting on the Wasatch fault, there is evidence of repeated moderate to large magnitude earthquakes ($M = 6.5-7.5$) during late Pleistocene and Holocene time (Swan et al., 1980). Most of this evidence is in the form of fresh scarps in Lake Bonneville shoreline alluvial fan deposits, and glacial moraines (Hamblin, 1976).

Quaternary faulting has apparently been episodic in nature along the Wasatch Front; this is suggested by three generations of faceted spurs separated by wide pediments along the mountain front near Salt Lake City (Hamblin, 1976; Hamblin and Best, 1978). Farther south, in the Spanish Fork area, eight such spur-pediment sequences represent the same time span; this indicates more closely spaced episodes of faulting on this section of the fault during late Cenozoic time than was the case near Salt Lake City (Hamblin, 1976).

There have been no large earthquakes along the Wasatch Front since settlement in the mid 1800s. Two faulting event within the past 1,580 $\pm$ 150 years have

been documented by Swan et al., (1978). Based on this very limited data, an average recurrence interval for the part of the zone studied appears to be in the range of 50 to 400 years for moderate magnitude earthquakes (Wallace, 1980; Swan et al., 1980). For magnitude greater than 7.0 earthquakes, the recurrence interval exceeds 1,000 years (Smith et al., 1976).

In contrast to the Salt Lake City area, the northern and southern parts of the Wasatch Front presently exhibit a lower rate of seismic activity. Average recurrence intervals for major earthquakes accompanied by surface rupture are about 500- 1,000 years for the area north of Salt Lake City (East Cache fault zone) and about 1,500-2,700 years for the area to the south of Salt Lake City (Hurricane and Sevier fault zones) (Swan et al., 1980; Wallace, 1980).

QUATERNARY FAULTS (4.2.3)

Identification and delineation of Quaternary faults is important in evaluating the potential seismic hazards of a region. Faults along which there is evidence of recent displacement may reasonably be expected to be seismic sources and to have future displacements (Bonilla, 1970; Albee and Smith, 1966). Recognition of Quaternary faults can be accomplished by utilizing historic, geophysical, seismic, geodetic, and geological evidence. Within the Great Basin, detailed information from most of these sources is sparse; therefore, identification of youthful faults and location is generally limited to faults with geomorphic expression, which is distinguishable by aerial reconnaissance or photogrammetric methods (Slemmons, 1967). Figure 4.2.3-1 shows some faults identified in the study area.

Nature of Faulting (4.2.3.1)

Analysis of fault plane solutions from historic seismicity within the Great Basin indicates that the predominate fault motion is normal dip slip caused by extensional tectonic movements within the crust. (Sbar et al., 1972) indicated that composite fault plane solutions of 120 microearthquakes clustered along the eastern boundary of the Great Basin in Utah show vertical motion on steeply dipping fault planes. Slemmons (1967) suggested that many of the faults in the Great Basin also have evidence of a horizontal component of displacement; the orientation of the fault determines the direction of lateral slip. Many northwest to north-south trending faults, on which there is evidence of a component of horizontal slip, have right-lateral displacement; north-south to northeast-southwest trending faults have left-lateral displacement.

There are several thousand Quaternary faults in the Great Basin, most of which are parallel or subparallel to the elongated north-south structural grain of the region. The faults are approximately equally spaced geographically and range in length from 1 km to more than 100 km. The major young faults are near range front bedrock-alluvium boundaries; relatively few major faults occur in to bedrock or mid-basin locations.

Because the majority of faults are near bedrock-alluvium contacts at mountain fronts, the faults are generally expressed geomorphically by a series of faceted bedrock spurs along the mountain front or as scarps truncating alluvial fan segments of different age.

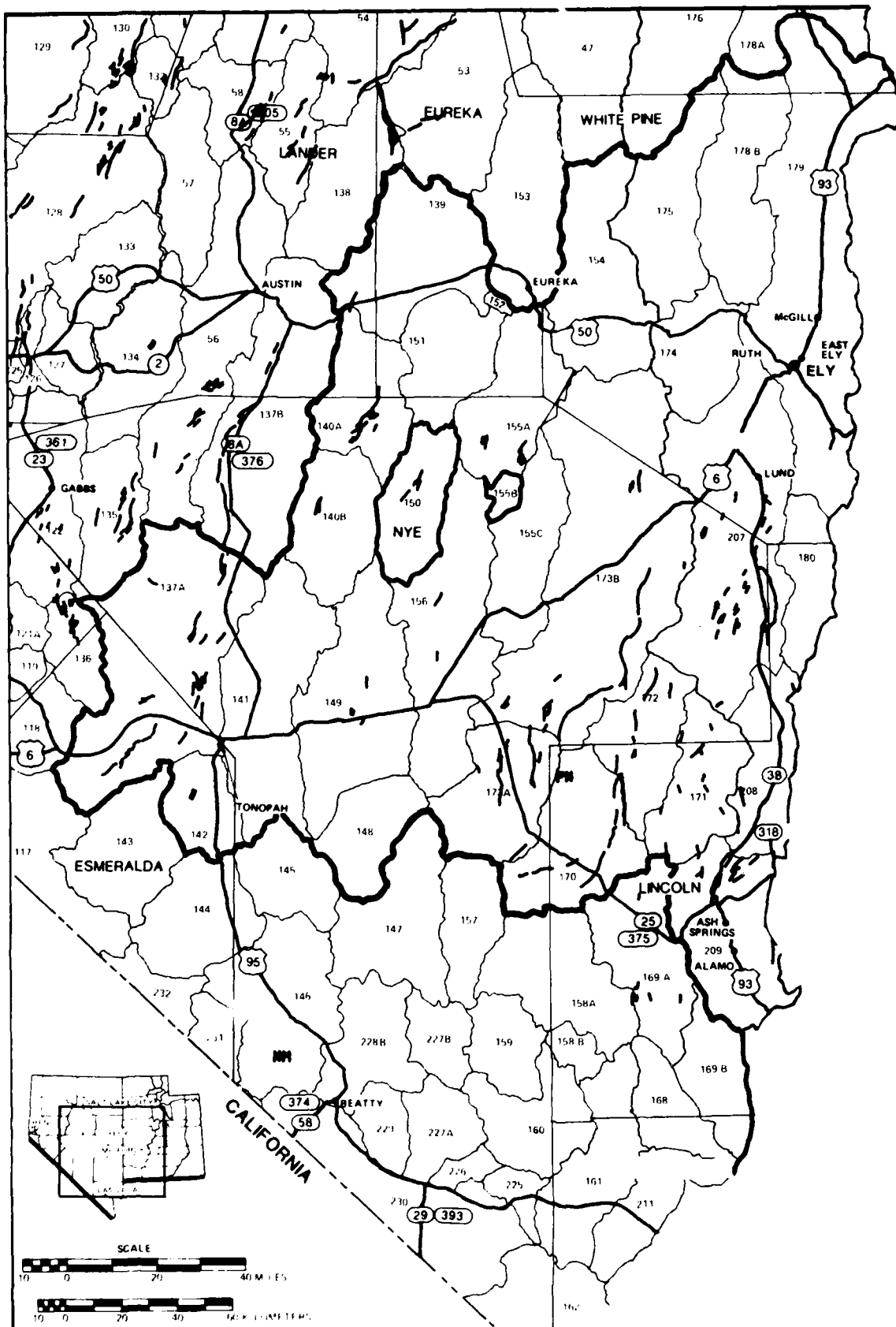
Some faults displace glacial moraines or lacustrine deposits and associated shoreline features, which may contain material that can be radiometrically dated. Segments of the Wasatch fault and faults associated with the Sierra Nevada frontal system are good examples of faults that displace late Pleistocene glacial moraines and pluvial lake shorelines. In these cases, absolute age dates can be used to bracket the age of faulting with some certainty. In most cases, relative age dating techniques are required. On unconsolidated alluvial fan deposits, the geomorphic characteristics of young fault scarps can be used to estimate the ages of fault displacement. Wallace (1977, 1980), Bucknam et al. (1979), and Slemmons (1967) have developed relative age-dating methods based on scarp morphologic characteristics such as scarp profile, scarp crest, debris slope, scarp face, and extent of dissection. Changes in these morphologic characteristics are related to aging or degradational processes. The succession of faceted spurs on alluvial fans along the Wasatch fault has been used by Hamblin (1976) and Hamblin and Best (1978) to study the recurrent nature of movement on the fault.

Spatial and Temporal Relationships

Faults in the Great Basin tend to cluster in time and in location. Although faults displaying evidence of Quaternary activity are fairly evenly distributed throughout the Great Basin, the occurrence of faults that display evidence of Holocene, and historic movement (Dixie Valley, Pleasant Valley, Cedar Mountain, etc.), is geographically limited (Figure 4.2.3-2). However, the historic pattern of faulting may not be representative of the long term. The recent clustering of faulting may be only an ephemeral and localized sequence of events in the recent geologic history of the Great Basin and future faulting may shift from the present zone to other Quaternary faults.

The historic fault pattern suggests, however, that for short intervals of geologic time, there may be some tendency for localized activity to continue along these zones. Wallace (1977) noted that sets of fault scarps in central Nevada appear to have been repeatedly active over certain time spans, but other faults along adjacent ranges exhibit no activity during those spans. Even along single fault scarps, some individual segments have had repeated offset while other parts were inactive. The Wasatch fault zone exhibits evidence of Holocene movement over much of its length (Anderson and Miller, 1979; Swan et al., 1978), but the Holocene activity on the Hurricane, Sevier, and southern Wasatch faults is unknown or very limited.

The average recurrence interval on most active faults in the United States is generally longer than 1,000 years (Wallace, 1980). In the Great Basin, the recurrence interval on individual faults and rates of large earthquakes varies with the geographic location (Swan, et. al., 1978). Wallace (1980) indicated that the recurrence interval on the individual segments of the Wasatch Fault is between 500 and 1,000 years but that the recurrence interval for the entire fault zone composed of 6 to 10 segments is between 50 and 400 years. In contrast, based on geologic studies, the average recurrence interval on individual fault zones in central Nevada was estimated to be approximately 10,000 years (Wallace, 1977) and some active faults may not show evidence of activity for several times that long. Ryall (1977) and Wallace (1977) suggested that, based on geomorphic studies, the recurrence interval for western and north central Nevada is on the order of 2,000-3,000 years.



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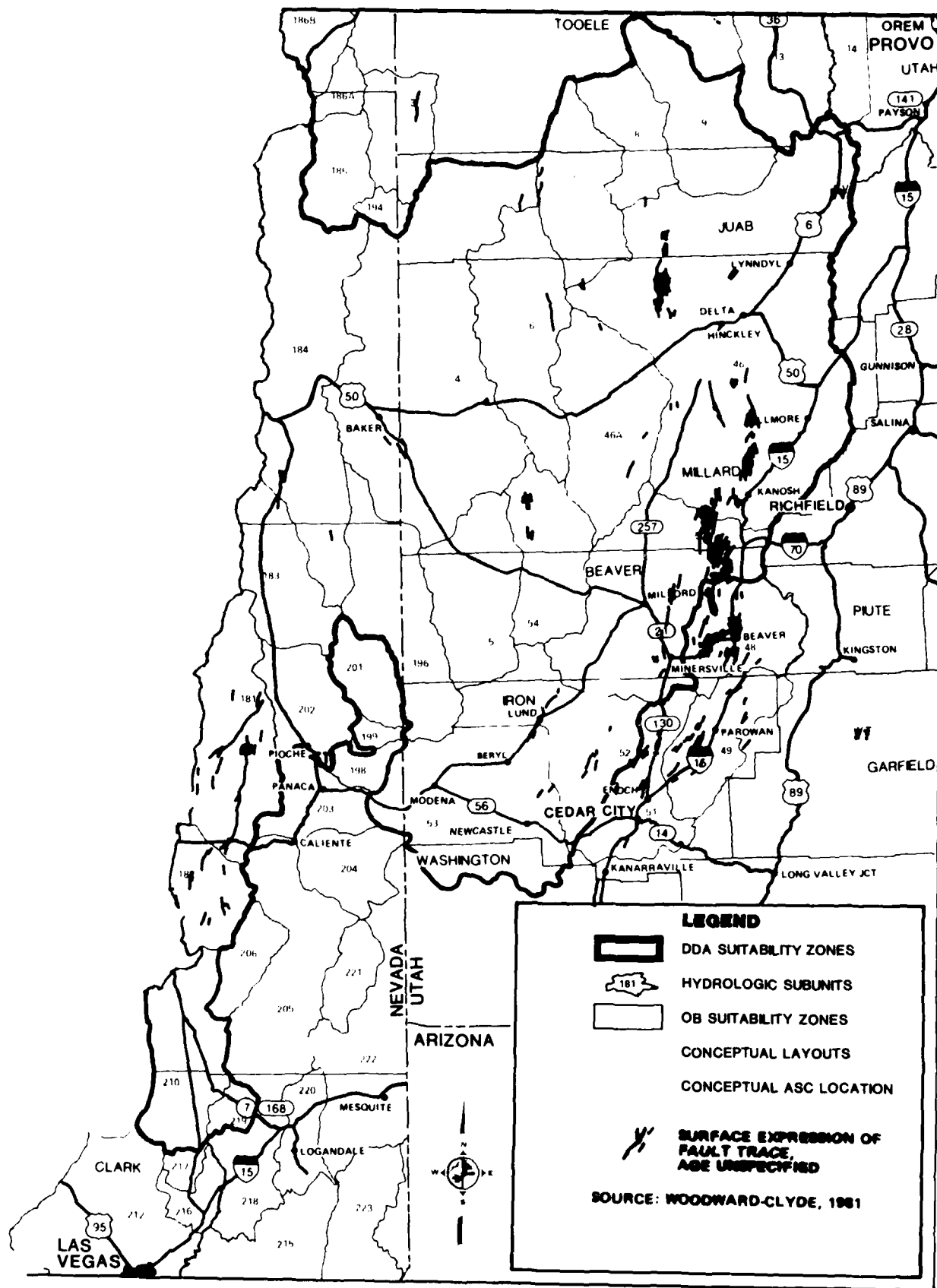
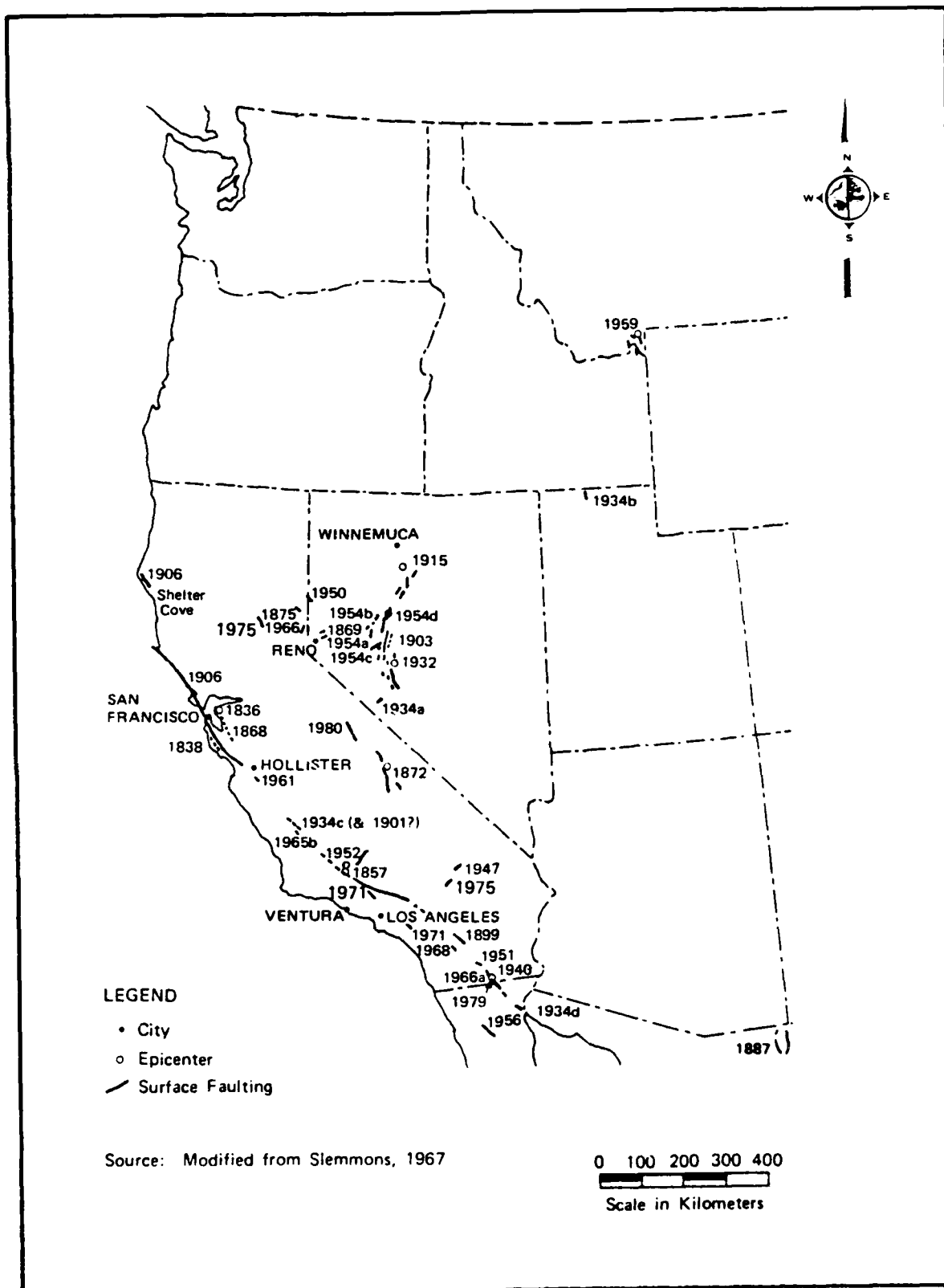


Figure 4.2.3-1. Faults in the vicinity of the Nevada/Utah study area.



1724-A

Figure 4.2.3-2. Historic surface fault ruptures.

HISTORIC EARTHQUAKES AND SURFACE RUPTURE (4.2.4)

Although many earthquakes occur in areas that cannot be assigned to a specific known fault, many major faults, particularly along the Ventura-Winnemucca zone and the eastern Great Basin boundary, have had historic earthquakes (Slemmons, 1967; Cook and Smith, 1967). Although the majority of earthquakes are not large enough to cause surface rupture, nearly half (13) of the historic earthquakes in the western conterminous United States that produced surface faulting are located in the Basin and Range (Slemmons, 1967), and seven are located in the Great Basin (Figures 4.2.3-2 and 4.2.4-1). Magnitudes for these earthquakes ranged from 5.5 to 7.75.

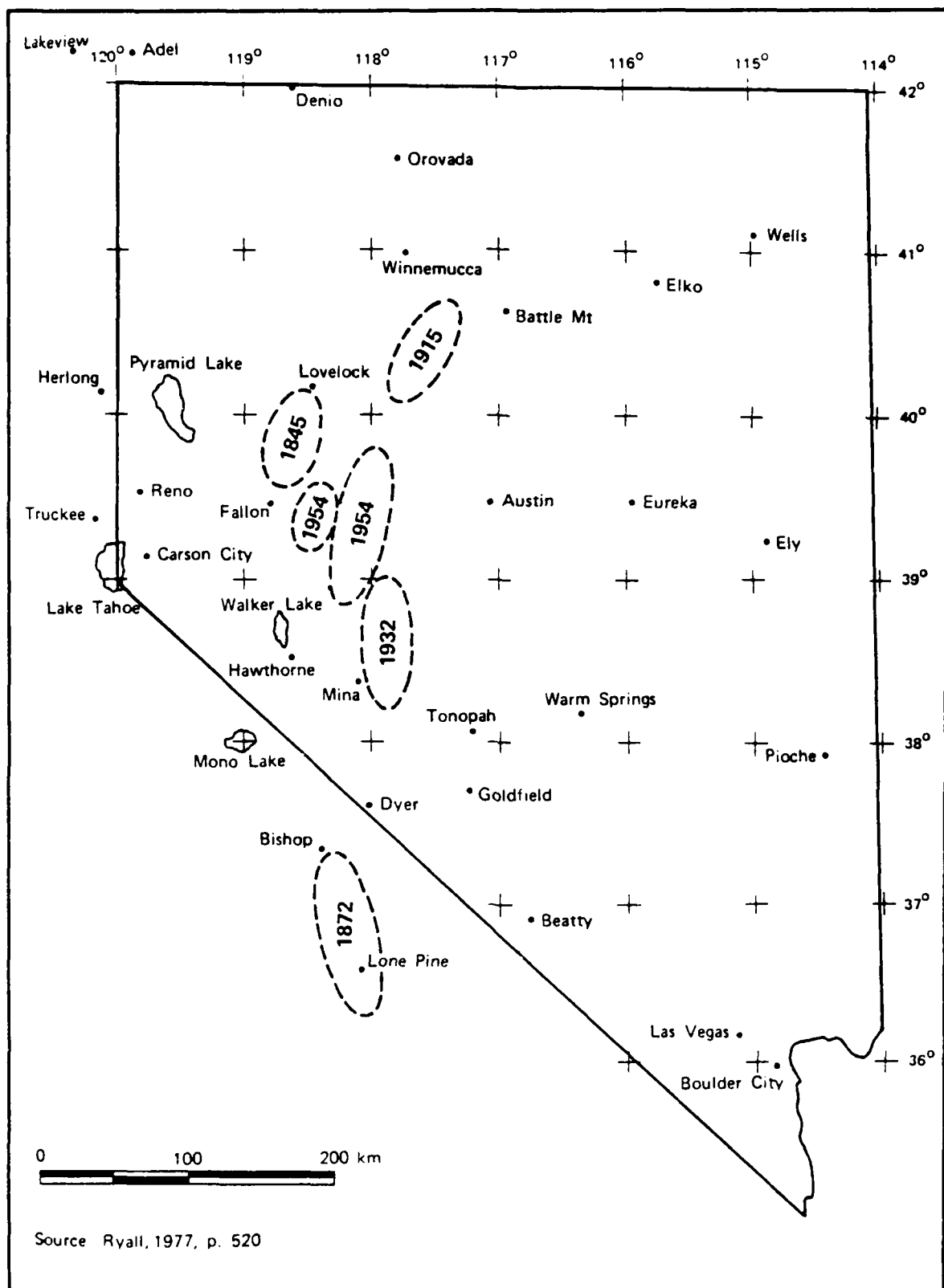
The number of faults associated with either historic seismicity or ground rupture during an earthquake is only a small percentage of the several thousand faults that appear to be potentially active. The numbers, in both cases, would probably be higher if it were not for the remoteness and small population of the area, the short historic time span of the area, and the short time interval in which seismographic recording networks have been in operation.

An example of typical Basin and Range faulting is the Dixie Valley-Fairview Peak event, which actually consisted of two earthquakes, four minutes apart. Surface rupture took place in two zones, both trending slightly east of north; the southern zone, the Fairview Peak rupture, was 50 km long and 10 km wide, and the northern Dixie Valley zone was 40 km long and 5 km wide. The faults were Basin and Range type normal faults at or near the alluvium-bedrock contact. The two fault zones were not connected by visible surface faulting or structural features, but they both apparently belong to the same general zone (Ventura-Winnemucca seismic zone) that connects the Pleasant Valley earthquake zone of 1915 to the Cedar Mountain zone of 1932. Geologic evidence indicated surface displacements on the Fairview Peak zone of 4 m of dip slip, with 4 m of dextral slip; the Dixie Valley fault zone showed 2.3 m of dip slip movement (Ryall, 1977; Slemmons, 1957, 1966). Geodetic retriangulation by the U.S. Coast and Geodetic Survey indicated regional right-lateral deformation across the Fairview Peak zone of about 3 m, with a maximum vertical offset of 2.3 m indicated by a maximum vertical displacement of 1.7 m.

Richter magnitudes for the Fairview Peak and Dixie Valley earthquakes were 7.3 and 6.9, respectively (Slemmons, 1966). Maximum ground accelerations from seismograph recordings 130 mi (208 km) away were 29 cm/sec², and at 470 mi (752 km) were 2 cm/sec/sec. The two events were felt over 200,000 sq mi (512,000 sq mi) and had a maximum modified Mercalli intensity of VII. Little property damage was reported because the region was so sparsely populated. At some distance from the epicentral area, significant structural damage due to movement of water within the structures was reported. Highways within the epicentral area had considerable damage from cracks and breaks, and from large rocks rolling onto the road. Water levels and rates of flow from wells increased temporarily in the epicentral area (Slemmons, 1957).

SEISMIC HAZARDS IN THE GREAT BASIN (4.2.5)

Damage from earthquakes may occur due to (1) surface fault rupture; (2) ground motion (shaking near a fault); and (3) ground failure (Cluff et al., 1970).



1725-A

Figure 4.2.4-1. Surface rupture zones of $M > 7$ earthquakes since 1840, western Great Basin.

The amount and type of damage are influenced by the magnitude of the earthquake, epicentral location, hypocentral depth, extent and magnitude of surface faulting, and intensity and duration of ground shaking.

The zone of surface fault rupture will vary in width depending on: (1) the attitude of the fault plane; (2) the amount of displacement along the fault; (3) the direction of fault movement; and (4) the surficial geology (Cluff et al., 1970). Damage to structures resulting from surface rupture will occur only where structures are located astride the fault trace; to avoid this hazard the position and width of the rupture zones must be identified.

Shaking can damage structures that are not designed and constructed to resist earthquake vibrations; the amount of damage may be influenced by the type of ground, earthquake-resistant design, quality of materials and construction, and the intensity and duration of strong ground motion.

Damage to structures resulting from ground failure will occur where structures are located on ground susceptible to landsliding, settlement, or liquefaction. Such damage can be avoided or minimized by locating structures away from susceptible areas, by special design, and/or by correcting the unfavorable ground condition.

Although major earthquakes in the Great Basin are not as yet predictable, there is a distinct pattern of seismicity associated with large events that helps to better understand them. Earthquakes of magnitude greater than 7 are generally preceded by several decades of moderately increasing seismicity (Ryall, 1977); after the main event, aftershocks occur for approximately a century. In the western Great Basin, aftershock occurrence rate is inversely proportional to the time after the main shock.

Another distinct pattern associated with large earthquakes is of spatial nature. Along plate boundaries Kelleher et al. (1973) found that great seismic gaps are probable sites of future earthquakes. It may be that in some regions, areas of unusually low seismicity that show evidence of having had previous large earthquakes, may be areas of highest probability of future large earthquakes (Smith and Sbar, 1974).

A possible example of a seismic gap in the Great Basin is the 75 km zone south of Salt Lake City, which appears to have a strain accumulation that is characteristic prior to a large earthquake. Similarly, large historic earthquakes have apparently been filling in gaps along the 500 km seismic belt in western Nevada (Ryall, 1977). Not only does this phenomenon help us to identify zones of high earthquake potential, it also suggests that zones of most recent ruptures may actually be safer than surrounding areas, at least for hundreds to thousands of years, depending on the length of the seismic cycle.

The Uniform Building Code indicates that most of the Ventura-Winnemucca and ISB zones and central Nevada are regions with potential for major destructive damage due to seismic activity (Zones 3 and 4); the remainder of the Great Basin area can expect moderate damage (Zone 2). More specifically, central and western Nevada have the potential for magnitude greater than 7-8 earthquakes while eastern Nevada and western Utah appear to have the potential for magnitude 6-7

earthquakes (Wallace, 1977). Lui and Fagel (1972) have a value of magnitude 6.7 for Utah as a whole and magnitude 8 for west-central Utah. Figure 4.2.5-1 summarizes the seismic constraints for broad sections of the Nevada/Utah potential deployment area.

Thus, it appears that the western Nevada region (Ventura-Winnemucca zone) and the central Utah region (ISB) are areas of highest seismic risk. However, because of the widespread nature of "active" faults throughout the entire Basin and Range region, it is likely that a major earthquake will occur at sometime in the future within a few tens of kilometers of almost any point in the area (Ryall, 1977). On a more local level, however, it is difficult to adequately evaluate the seismic risk because the historic record of earthquakes is so short compared to the length of the average recurrence interval.

4.3 TEXAS/NEW MEXICO

The threat of seismic hazards in the Texas/New Mexico development area is low. The nearest center of seismic activity is the Rio Grande rift zone, 200 mi to the west of the M-X Project and there's little to low earthquake impacts expected. The uniform building code places the study region in Zone 1 indicating that only minor damage can be expected to occur from distant earthquakes. No known active or potentially active faults occur in the deployment area.

4.4 M-X OPERATING BASES

Using the seven current candidate main bases (Beryl, Delta, and Milford in Utah, Ely and Coyote Spring in Nevada, Clovis in New Mexico, and Dalhart in Texas) as indexes, the following discussion will localize anticipated seismic risks for each operating base. The recommended levels of ground acceleration for design consideration are only coarse approximations based on published attenuation relationships.

BERYL (4.4.1)

The Beryl, Utah site is approximately 30 mi due west of the Hurricane Fault and is subject to moderate earthquake exposure. Because of the anticipated great thickness of basin fill at its site in the middle of the Escalante Desert, horizontal accelerations of about 0.5 g may be appropriate for structural design.

COYOTE SPRING (4.4.2)

A Quarternary fault runs along the southeast side of Kane Springs Valley, Nevada. The length of the fault is on the order of 32 mi and it is located northeast of the intended facility. In the past (tertiary), this fault may have had a strike-slip movement, but its most recent sense of movment (Late Quaternary) appears to be the usual Great Basin horst and graben dip-slip type. It has no evidence of ground rupture during Holocene time, but further field corroboration along its elongated northeastern trend is recommended. In the event of a moderate earthquake, ground shaking and lurching could result. Design of structures in the Coyote Spring OB should incorporate horizontal accelerations in the of 0.4 g range.

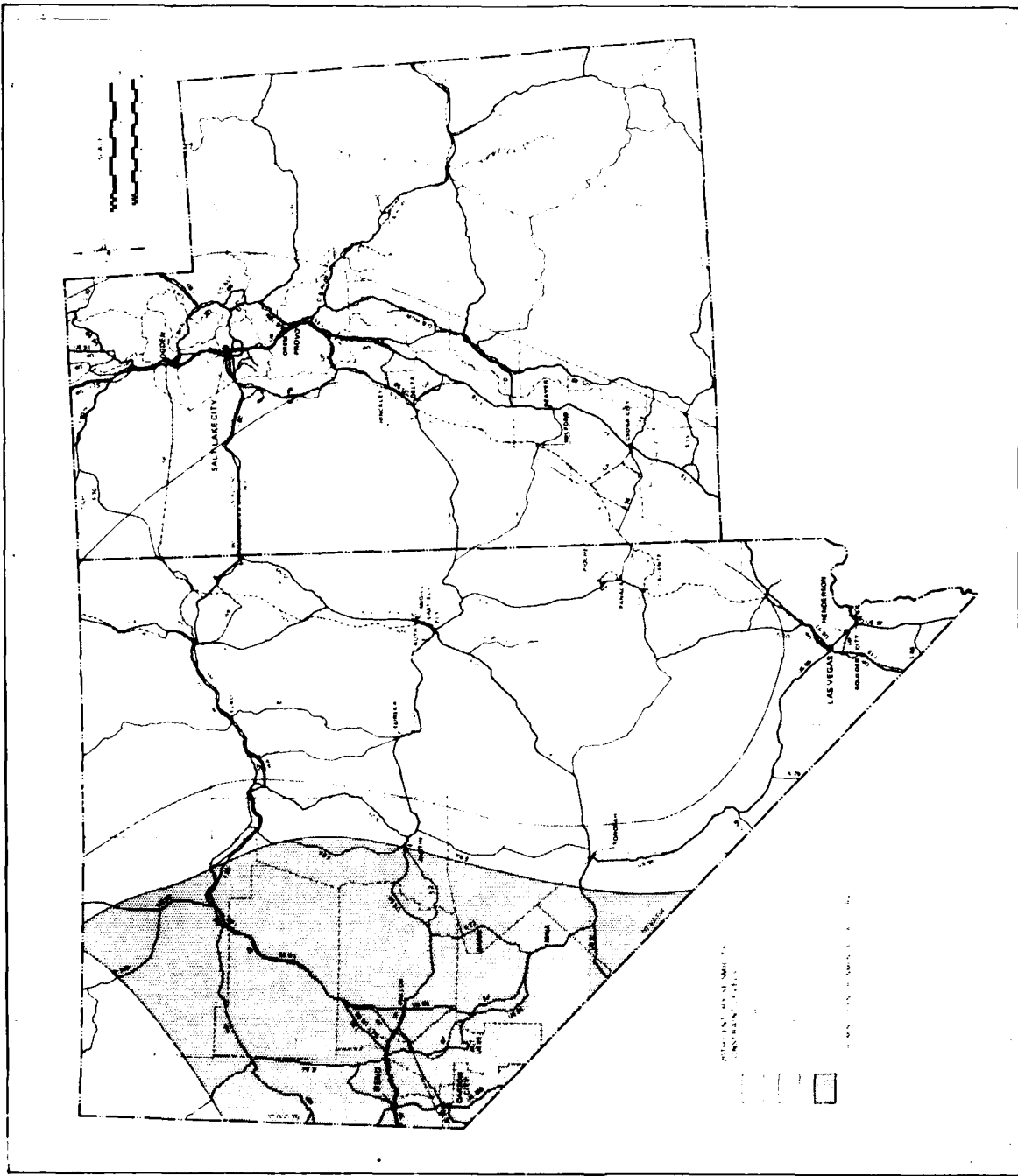


Figure 4.2.5-1. General seismic constraints in Nevada and Utah.

DELTA (4.4.3)

The physiographic and structural line of demarcation and which separates the Basin and Range Province from the Colorado Plateau is about 20 mi east of Delta. Tremors along the boundary are known to have a high order of periodicity, but seldom exceed 3.2 m on the Richter scale. Mild to moderate earthquakes have an historic trend towards becoming heavier by small increments, but engineering factors of safety can be incorporated in accordance with the state of the art in structural design. Earthquakes in this particular portion of the Wasatch fault could range to a magnitude of about 7.5 Richter. A design capable of withstanding about 0.5 g of ground motion (horizontal acceleration) will probably be required for earthquake resistant structures.

ELY (4.4.4)

The Ely basing area is located in southern Steptoe Valley in a currently quiescent seismic area. The area is located over 100 mi from known severe tremors of modern times. However, several late Quaternary faults in the valley alluvium incates that earthquakes have occurred repeatedly in this region during the Pleistocene. A possibility of recurrence of crustal re-adjustments in the area is remote, but it is recommended that structures be designed and built to resist a maximum ground motion equivalent to 0.3 g.

MILFORD (4.4.5)

Seismicity risk in the Milford (Utah) region is moderate to moderately severe. This basing area is located near the Western edge of the Intermountain Seismic Belt. The belt has been the locus of frequent historic small to moderate earthquakes although larger quakes are suggested from the geologic record. A mapped fault exhibiting movement during the Quaternary runs along the west side of Option 4 for a length of 8 mi. Several linear features seen in aerial photos could be faults. Earthquake engineering for building designs to withstand in the range of 0.5 g horizontal acceleration are suggested.

CLOVIS (4.4.6)

The Clovis area is in a zone of low seismic risk. Seismic hazards result only from large earthquakes on distant faults, the most likely being along the Rio Grande rift. Ground shaking is not expected to be greater than intensity VI on the modified Mercalli scale, and structures would have to be designed to resist only a low level of ground acceleration.

DALHART (4.4.7)

The Dalhart area is in a zone of low seismic risk. Seismic hazards result only from large earthquakes on distant faults, the most likely being along the Rio Grande rift. Ground shaking is not expected to exceed intensity VI on the modified Mercalli scale, and structures would have to be designed to resist only a low level of ground shaking.

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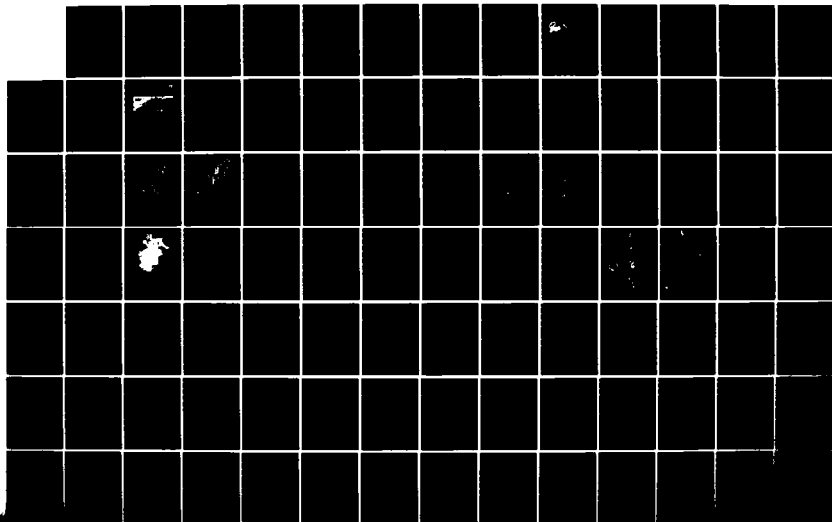
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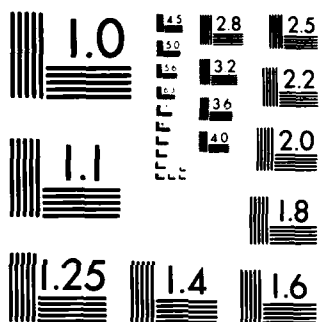
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4.5 MITIGATIONS

The effect being mitigated is not a change in the environment as such, but a change in the perceived environment brought about by the introduction of habitable structures into a seismically active area.

Since the project is being located over a wide area, it is subject to varying levels of seismic hazard. As detailed studies are completed, maximum expected ground accelerations will be determined. Design of structures will take into account the level of expected ground acceleration with an adequate safety margin depending on the sensitivity of the structure.

5.0 SOILS

5.1 INTRODUCTION

The study of soils in the M-X environmental impact analysis process is important from two perspectives. Forming the base of all construction activities, soils will directly affect the project; at the same time, the project will directly impact the soils.

Soils affect the project in terms of their relation to engineering and revegetation activities. Soil strength, permeability, texture, plasticity, erodibility, shrink-swell potentials and other soil properties ultimately affect the engineering design of all project facilities. Water erosion of the soil could potentially undercut the roads and plug culverts with sediment. Proper engineering design will mitigate but not eliminate these effects. Revegetation of the disturbed land surfaces requires a knowledge of soil characteristics, both chemical and physical. These will be direct input into the development of revegetation strategies.

The project could impact the soils in several different ways. Construction activities disturb the soil system making it more susceptible to wind and water erosion. Erosion causes the most productive surface layers of soil to be lost. In addition there are possible secondary effects: the degradation of the ambient air quality by dust, the silting of surface waters and fields, and the filling of highway and irrigation ditches with sediments. In addition to increasing erosion problems, construction activities have the potential for degrading soil characteristics so that revegetation or future agricultural pursuits are more difficult. Mechanical compaction of the surface soils by heavy construction equipment destroys the soil structure, possibly making revegetation more difficult and increasing the soil's susceptibility to erosion. During earthwork and excavation activities, subsoils of lower quality (containing high concentrations of salts, alkali, or other deleterious substances) could be brought to the surface in many areas. Mixed with the surface soils, these subsoils may reduce the soil to a lower level of productivity, again making revegetation more difficult.

General discussions of the Nevada/Utah and Texas/New Mexico regional soil characteristics are presented in addition to the soil characteristics of the seven potential operating base sites. The discussions represent summaries of material currently existing in the literature; in many cases, the information is very limited, especially for the Nevada/Utah study region. An extensive soils field program will be necessary to supplement the existing available information in order to determine site specific impacts. From the information that is currently available, potential impacts are predicted and presented along with a discussion of possible mitigating measures.

5.2 SOIL CHARACTERISTICS: NEVADA/UTAH STUDY REGION

PHYSICAL PROPERTIES (5.2.1)

Soil development in the Nevada/Utah study region has been strongly influenced by climatic, geologic, and topographic factors. Low rainfall has yielded a sparse vegetation cover and little humus accumulation with resulting light colors of the

soils. In addition, the limited rainfall of the region allows the soluble weathering products to be leached to only 12 to 36 in. (30 to 91 cm) below the surface (Buol et al., 1973). Accumulations of calcium carbonate in horizons (layers) below the surface are common and often take the form of hardened caliche layers. Silica accumulations sometimes cement subsurface horizons into a hardpan known as a duripan. Soils in some areas have loamy horizons of clay accumulation. Finally, when rainfall does occur in this region, it typically falls at high intensities. Water runs off the higher elevations causing sheet, rill and gully erosion of the soils on the alluvial fans. The runoff eventually accumulates in the valley bottoms. Soils in these periodically flooded areas have become sodium and/or salt affected as waters have evaporated off their surfaces.

The soils of the region formed primarily on alluvial fans, old lake bed deposits, and sedimentary and igneous bedrock. The topography of the region consists of the following physiographic features: (1) playas, (2) valley bottoms and floodplains, (3) alluvial fans and stream and lake terraces, and (4) uplands and mountains. Soil formation on each of these physiographic features has been influenced by a different set of factors. Therefore, each feature has certain general soil characteristics associated with it.

The playas and their associated soils consist of deposits that are light-colored, deep and clayey with very strong accumulations of salt and alkali. Any runoff from melting snow and summer thunderstorms usually ponds on their level surfaces. In general, their permeability and surface runoff are very slow and the erosion hazard is slight as long as the surface is undisturbed. When dry, repeated passes of vehicular traffic along the same path will powder the surface layer, creating a severe wind erosion hazard. When wet, such areas are generally sticky, have little bearing capacity and are virtually impassible to all wheeled vehicles and most animals. Salt crusting sometimes occurs during dry periods.

The valley bottoms and floodplains have smooth to gently undulating slopes (0 to 4 percent) with deep and moderate to very strongly alkaline and saline soils. The surface textures range from loams to silty clay loams, while the subsoils range from fine loam to fine silt. Permeability ranges from very slow to moderately rapid and the hazard of wind erosion of the disturbed soil is moderate throughout the bottom land areas.

The alluvial fans and stream and lake terraces make up the largest areas in the valleys. Slopes range from smooth to rolling (0 to 15 percent) and the soils are shallow to deep and mildly to strongly alkaline. The surface textures range from fine sands to gravelly sandy loams and silty clay loams, while the subsoils range from sands to loamy skeletal to fine loamy. In general, the gravel content of the deposits increases near mountain fronts. The permeability of these soils ranges from slow to rapid. Accumulations of calcium carbonate and silica at 12 to 36 in. (30 to 91 cm) below the surface often take the form of caliche layers and duripans (indurated, virtually impermeable layers that limit effective root penetration). During high intensity rainstorms, the soils of the alluvial fans will undergo sheet erosion and rill and gully formation.

The uplands and mountains have slopes ranging from steep to very steep (over 30 percent) and have shallow to deep, moderately alkaline to medium acid soils. Surface textures range from cobbly to sandy to gravelly loams, while the subsoils

range from loamy skeletal to clayey skeletal. These soils are often underlain by bedrock within 20 in. (51 cm).

Few engineering problems are encountered on the majority of the soils found in the Nevada/Utah study region. The shrink-swell potential of the soils is generally low except for areas underlain by fine-grained clayey playa deposits. In some areas, duripans and indurated caliche layers may impede excavation in building. Construction projects sited on the alluvial fans (especially roads sited across major drainages) will continuously be threatened by potential erosion and sedimentation problems during major storm events. Due to the general infrequency of rain however, wind erosion probably affects more land than does water erosion (Soil Conservation Service, August 1976). Plasticity of the soils in the valleys range from slight, for the silts and very fine sands (silty or clayey fine sands and clayey silts), to medium for the clays (gravelly clays, sandy clays, silty clays, and lean clays) (Woodward-Clyde Consultants, 1978).

A surface pavement of small and large rock fragments is present over many of the soils in the Nevada/Utah study region, protecting them from water and wind erosion. Much of this "desert pavement" has been produced by winds removing the finer soil particles from the surface. However, in some areas, it is believed that the gravel has been moved up to the surface by the action of entrapped air when the soil is wet by rain. In such instances, the surface pavement is underlain by a thin gravel-free layer of soil having vesicular structure (Buol, Hale, and McCracken, 1973). Removal of desert pavement during construction activities or disturbing it through off-road vehicle travel can significantly increase soil erodibility.

AGRONOMIC PROPERTIES (5.2.2)

The Nevada/Utah study region is covered by soils belonging predominantly to the Aridisols USDA taxonomic soil order. Aridisols are light colored soils that are low in organic matter, are never moist as long as three consecutive months and have accumulations of calcium carbonate, gypsum, silica, or clay in subsurface horizons (U.S.D.A. Soil Conservation Service, 1975). These soils are found primarily on the alluvial fans, lake terraces, and valley bottoms. Entisols, making up an order of young soils characteristically lacking developed subsurface horizons, are often found associated with Aridisols on the recent deposits of alluvium and on the actively eroding slopes. On the higher mountains surrounding the valleys, soils of the Mollisol order may be found associated with Aridisols. Mollisols are soils that have nearly black, organic-rich surface horizons.

The Aridisols, Entisols, and Mollisol orders have been divided into suborders, great groups, subgroups, families and series, each representing more specific categorical levels of soil characteristics. The Aridisols order has been divided into two suborders, both of which are represented in the Nevada/Utah study region; these are the Orthids and the Argids. Orthids are Aridisols that have accumulations of calcium carbonate, gypsum, or other salts more soluble than gypsum but have no horizon of clay accumulation. Argids are Aridisols that have a horizon in which clay has accumulated and may, in addition, have a calcic, petrocalcic, or natric horizon or a duripan. Both the Orthid and Argid suborders are divided into great groups and seven general associations of these and certain Mollisol and Entisol great groups are found in the Nevada/Utah study region (Soil Conservation Service, 1969).

Table 5.2.2-1 lists and characterizes the Aridisol, Entisol and Mollisol great groups that predominate in the Nevada/Utah study region. Figure 5.2.2-1 shows the distribution of the seven great group associations that exist in the areas studied.

Although most of the soils of the Nevada/Utah study region are presently not being used for crop production, many of these soils are potentially arable. Of the predominant soil families in Dry Lake and Delamar valleys, Nevada, for example, the Delamar and Woolsey families (of the terrace and alluvial fans) and the Unionville and Penoyer families (of the valley bottoms and floodplains) are suitable for crops and pasture if water for irrigation becomes available (Soil Conservation Service, Nevada Survey Area 754). Railroad Valley, also in Nevada, has about 495,500 acres (100,200 ha) of potentially irrigable soils on the smooth alluvial plains (Nevada State Engineer's Office, May, 1971). In the state of Utah, there are about 5,630,000 acres (2,270,000 ha) of potentially arable land, much of which is located in the valleys of western Utah (Wilson et al., March 1975).

If the valleys of eastern Nevada and western Utah were developed for irrigated agriculture, they would still have continuing limitations. The soils of this region are generally low in their nitrogen content and would require fertilization. Micronutrients are usually abundant, although they may not be present in an available form due to the high pH present in the region. Other essential elements, however, are present in available forms, particularly potash from feldspars and mica. The low organic matter content and generally coarse soil textures produce low to moderate water holding capacities, which would have to be compensated for by proper irrigation system design. The silica and calcium carbonate cemented hardpans (duripans and petrocalcic layers) present in many areas are virtually impermeable, and limit effective root penetration. In addition, these hardpans can lead to problems of salinization and alkalization during irrigation, due to their restriction of internal drainage. Subsoil ripping is often necessary to disrupt these hard soil layers. Finally, those soils presently sodium- or salt-affected will require special treatment such as leaching and gypsum applications before being used to grow crops.

SOIL CHARACTERISTICS OF THE POTENTIAL OPERATING BASE SITES (5.2.3)

Site-specific soil characteristics are presented for each of the potential operating bases: Beryl, Coyote Spring, Delta, Ely and Milford.

Beryl, Utah (5.2.3.1)

The soils of the Beryl OB site formed primarily on very gently sloping to sloping (ranging up to approximately 7 percent) older alluvial fans and terraces. The Dixie-Neola series association predominates in this study area (Soil Conservation Service, 1960). These soils are generally shallow to moderately deep, over a hardened caliche horizon (a horizon in which calcium carbonate has accumulated), and are well drained. The Dixie soils have gravelly loam surfaces, underlain by a horizon of clay loam, and a weakly to strongly cemented caliche at 15 to 36 in. (38 to 91 cm). Below the caliche is a horizon of strongly calcareous, very gravelly, sandy loam. The Neola soils have sandy loam surfaces underlain by strongly cemented caliche at 12 to 24 in. (30 to 61 cm). Below the caliche is a horizon of strongly calcareous sandy loam. Included with the Dixie-Neola association in the Beryl area are soils of the Zane series. The Zane soils are deep and well drained.

Table 5.2.2-1. Soil orders, suborders, and great groups predominating in the Nevada/Utah study region (Page 1 of 2).

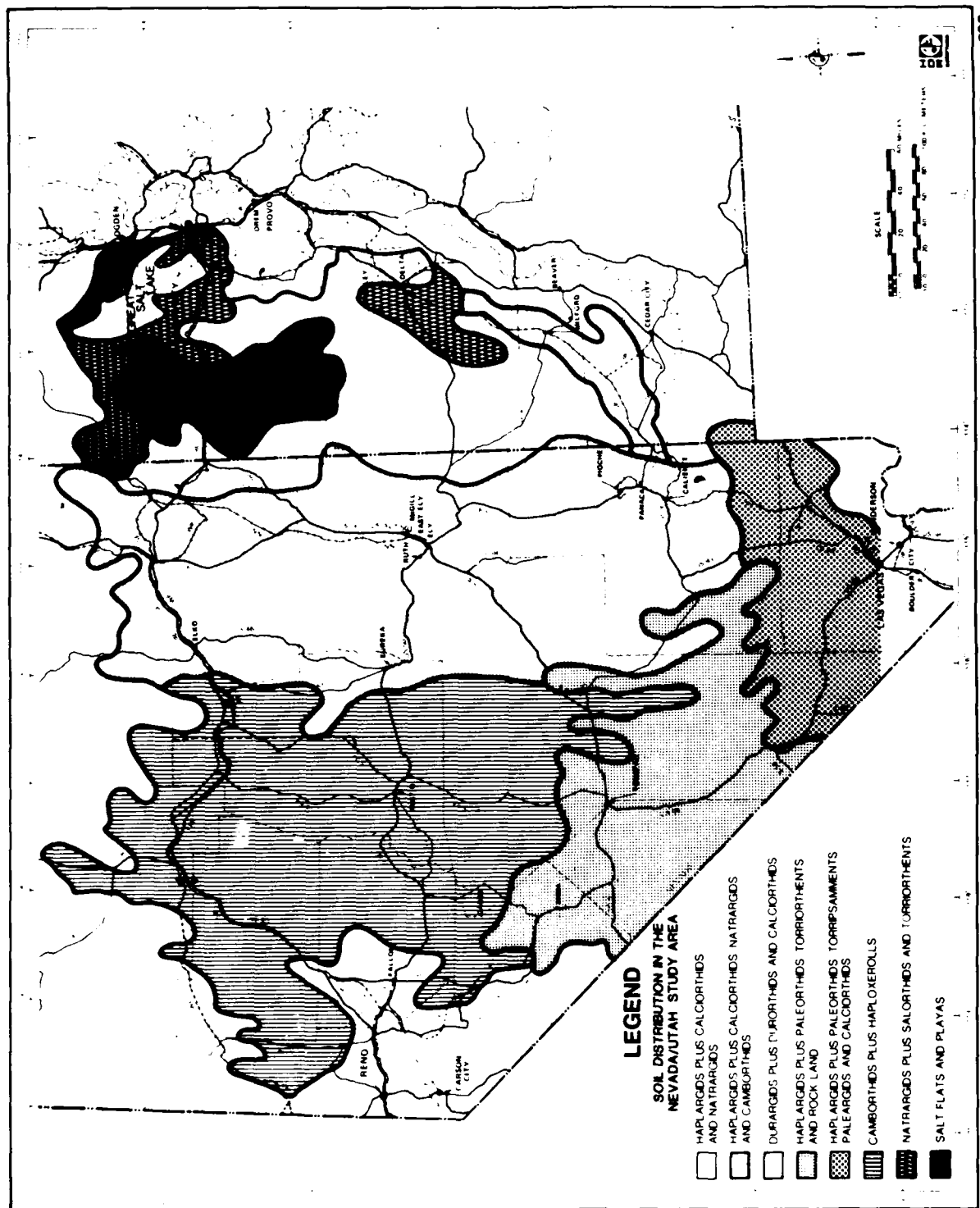
Orders	Suborders	Great Groups
<u>Aridisols</u> Light colored soils that are low in organic matter, are never moist as long as 3 consecutive months and have calcium carbonate, gypsum or clay in subsurface horizons	<u>Argids</u>	
	<u>Durargids:</u>	silica cemented hardpan present within 40 in (1 m) of the surface
	<u>Haplargids:</u>	minimum horizon development with more than 35 percent clay
	<u>Natrargids:</u>	subsurface horizon has over 15 percent of the cation exchange capacity (CEC) saturated with Na ⁺
	<u>Paleargids:</u>	has a calcium carbonate cemented horizon or a horizon with more than 35 percent clay
	<u>Orthids</u>	
	<u>Calciorthids:</u>	has a mineral soil horizon of secondary calcium carbonate enrichment
	<u>Camborthids:</u>	has a mineral soil horizon that has a texture of loamy fine sand or finer, lacks cementation and induration and has little illuviation
	<u>Durorthids:</u>	silica cemented hardpan present within 40 in (1 m) of the surface
	<u>Paleorthids:</u>	has a horizon cemented with calcium carbonate within 40 in (1 m) of the surface
	<u>Salorthids:</u>	has a horizon of secondary soluble salt enrichment

T 3770/10-2-81

Table 5.2.2-1. Soil orders, suborders, and great groups predominating in the Nevada/Utah study region (Page 2 of 2).

Orders	Suborders		Great Groups
<u>Entisols</u>			
Young soils characteristically lacking developed subsurface horizons	<u>Orthents</u>	<u>Torriorthents:</u>	loamy or clayey Entisols having a regular decrease in content of organic matter with depth
	<u>Psamments</u>	<u>Torripsamments:</u>	has textures of loamy fine sand or coarser
<u>Mollisols</u>			
Soils having dark, organic-rich (less than 1 percent organic matter) surface overlaying material with a base saturation of 50 percent or more	<u>Xerolls</u>	<u>Haploxerolls:</u>	Mollisols with minimum horizon development and dry for more than 60 consecutive days
T 3770/10-2-81			

Source: U.S.D.A. Soil Conservation Service, 1969 and 1975.



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Figure 5.2.2-1. Soil types of the Nevada/Utah study area.

They have a clay loam surface, underlain by horizons of heavy clay loam, silt loam, and fine sandy loam to a depth of over 60 in. (1.52 m).

The Dixie-Neola association is currently used almost entirely for range, the purpose to which it is best suited. Runoff is very slow to slow, and the erosion hazard is moderate to severe. The organic matter content and natural fertility of these soils are low, but they are free of toxic salts and alkali. In the Dixie and Neola soils, the available moisture holding capacity is low, and the effective root penetration is limited by the presence of cemented caliche horizons. In addition, the Neola soils need protection against wind erosion. In the Zane soils, the available water-holding capacity is high, and the effective rooting zone is deep. The Zane soils are potentially one of the best soils in the area for irrigation.

Coyote Spring, Nevada (5.2.3.2)

The soils of the potential OB site in Coyote Spring Valley are those found primarily on terraces and alluvial fans. The predominant great groups of soils present include Durorthids and Paleorthids (BLM, 1979). Durorthids are Aridisols that have a hardpan cemented with silica, while Paleorthids are Aridisols that have a hardpan cemented with carbonates. In general, the soils of this area are shallow to moderately deep, and on slopes of 2 to 15 percent. The water erosion hazard is moderate.

In the valley bottom and floodplains of Coyote Spring Valley there are moderately deep to very deep soils of the Torriorthent-Torrifluvent great group association. These soils are loamy or clayey Entisols, and lack developed subsurface horizons. Slopes range from 0 to 8 percent.

Delta, Utah (5.2.3.3)

The soils of the potential OB southwest of Delta developed on lake plains and terraces with slopes generally 0 to 2 percent. The soils are generally deep, well-drained, strongly to very strongly saline and moderately to very strongly alkaline (Soil Conservation Service, 1977). Surface textures range from silt loams to gravelly silt loams and runoff is slow to medium. These soils are used primarily for range, although they provide only limited grazing for livestock. These soils are potentially arable if water becomes available for leaching and irrigation. At the present, the water availability to plants is low due to the very high salt concentrations.

Several soil series are found in this region. Soils of the Uvada series predominate and have a surface horizon of light-gray silt loam underlain by horizons of silty clay loam, silty clay and silt loam to depths of over 65 in. (1.65 m). Salt content of the Uvada soils ranges from 0.65 percent to over 2.0 percent. Permeability is very slow, runoff is slow, and the hazard of erosion is slight.

Soils of the Goshute and Curdli series also occur in the Delta OB site. Goshute soils have a light-gray gravelly silt loam surface underlain by horizons of silty clay loam and fine gravel to over 60 in. (1.50 m). Permeability is moderately slow to the fine gravel at 18 in. (46 cm) where it then becomes very rapid. Runoff is medium and the hazard of erosion is moderate. The Curdli soils have a white loam surface

underlain by horizons of loam and heavy silt loam to greater than 60 in. (1.5 m). Permeability is moderate, runoff is slow and the erosion hazard is slight.

General engineering properties of the soils of this area include a high susceptibility to frost action, low to medium shear strength, and medium compressibility.

Ely, Nevada (5.2.3.4)

The soils of the potential OB site south of Ely formed on gently sloping (generally 3 to 5 percent) alluvial fans. They are calcareous, have loamy skeletal textures and are gray to very pale brown in color (Soil Conservation Service, 1976). A layer of soil cemented by silica and calcium carbonate, known as a duripan, may be found at about 20 in. (50cm) below the surface. The soils are well drained to the duripan, have moderately rapid permeability, low available water capacity, low quantities of organic matter and a low shrink-swell potential. Their erosion hazard is moderate. Severe limitations exist for these soils if used as septic tank absorption fields while moderate limitations exist if used for local roads and streets. The soils of this area belong primarily to the Durorthid great group of the USDA soil taxonomic system. Minor areas of soils belonging to the Torriorthent, Camborthid, and Haplargid great groups also exist.

Milford, Utah (5.2.3.5)

Several soil associations are present southwest of Milford in the area being considered as a potential OB site. A predominant association is made up of the Aridisols found on valley bottoms and floodplains: the Natrargids-Calciorthids association (Wilson et al, 1975). This association consists primarily of deep, moderately to very strongly alkaline soils. The surface layers are loams, silt loams, and silty clay loams, while the subsoils are fine and fine loamy. Permeability is moderately slow to very slow and slopes are smooth to gently undulating.

On the alluvial fans and low terraces, two soil associations are present which are made up of soils from the Aridisol and Entisol orders: the Calciorthid-Torriofluvent association and the Torriofluvent-Torriorthent association. These soils are deep and mildly to strongly alkaline. The surface layers are loams, silt loams, and sandy loams while the subsoils are loamy skeletal, fine loamy, fine silty and sandy. Slopes range from smooth to gently undulating to rolling.

5.3 SOIL CHARACTERISTICS: TEXAS/NEW MEXICO STUDY REGION

PHYSICAL PROPERTIES (5.3.1)

The soils of the Texas/New Mexico study region were formed in the geologic deposits of the High Plains region. For the most part, the upper portion of these deposits consists of layers of alluvial (stream deposited) and eolian (wind blown) sediments varying in texture and composition. The kind of soil that has developed at any given place on the High Plains appears to depend primarily on the particular layers that were exposed at the surface during soil formation (Lotspeich and Coover, 1962). In some places, however, the soils of this region have developed on material weathered from the underlying sandstone and shale bedrock. Other soils have formed in material reworked from the eolian deposits. This includes some of the

soils formed in playa basins, valleyfill and in materials recently deposited by streams. The general topography of the region ranges from nearly level to gently sloping. Strongly sloping and undulating topography exists adjacent to intermittent drainages.

In general, the soils of the Texas/New Mexico study region are deep to moderately deep and well drained. Surface textures range from clay loams, loams and fine sandy loams to loamy fine sands, while the subsoils are loamy to clayey (Maker et al., 1974). Calcium carbonate, leached from the upper horizons (layers), has accumulated at depths between 20 and 60 in. (0.50 to 1.5 m) in many of the soils. This zone may take the form of a pinkish-white soft caliche layer or an indurated caliche layer. Extensive areas of dune topography exist where the soils are predominantly deep, sandy and highly susceptible to wind erosion. Detailed, site specific soil information can be obtained from the U.S.D.A. soil surveys that are available for most of the counties in the Texas/New Mexico study region.

Engineering properties of the soils of the Texas/New Mexico region vary widely. Permeabilities range from moderately slow (0.5 to 2.0 in./hour) to rapid (greater than 5.0 in./hour). Shrink-swell potentials are low to moderate except for the highly expansive soils associated with the playas (Woodward-Clyde Consultants, 1978). Due to the nearly level topography, moderate to high wind velocities, and the loose consistency and dryness of many of the soils, soil erosion by wind has historically been a problem in agricultural areas where the soil surface is disturbed.

AGRONOMIC PROPERTIES (5.3.2)

The soils of the Texas/New Mexico study region differ from those of the Nevada/Utah region in that they developed on nearly level topography. They belong predominantly to two USDA soil taxonomic orders: Alfisols and Mollisols (Soil Conservation Service, 1969). Alfisols are soils that are medium to high in bases, have gray to brown surface horizons and have subsurface horizons of clay accumulation. Mollisols have nearly black, friable, organic-rich surface horizons high in bases. Aridisols occur in the Texas/New Mexico study region as a predominant soil order only in small areas on the western edge of the region.

The Alfisol and Mollisol orders have both been divided into suborders, great groups, subgroups, families, and series, each representing more specific categorical levels of soil characteristics. Several great groups predominate in the region. Haplustalfs, an Alfisol great group, are characterized by their reddish-brown color and thin subsurface horizon of clay accumulation. Argiustolls and Calciustolls are both Mollisol great groups. Argiustolls have subsurface accumulations of clay while Calciustolls have subsurface accumulations of calcium carbonate. Other important great groups are characterized by petrocalcic horizons cemented by carbonates (Paleustolls and Paleustalfs).

Most of the soils of the Texas/New Mexico study region are fertile and support irrigated crops, dryland farming of a few drought-tolerant grain crops, and rangeland. In many areas, the use of the soils as cropland mandates that rigorous wind erosion control practices are followed. Wind erosion is especially severe on the fine sandy loam, loamy fine sand and sandy soils. Irregular and often inadequate rainfall makes dry-land farming difficult unless moisture conservation is practiced. Contour farming and terracing help conserve moisture on the nearly level slopes and

reduce water erosion on the steeper slopes. Irrigated crops respond well to nitrogen and phosphorous fertilizers; nonirrigated crops are generally fertilized only when rainfall is above normal.

SOIL CHARACTERISTICS OF THE POTENTIAL OPERATING BASE SITES (5.3.3)

Clovis, New Mexico (5.3.3.1)

The soils of the potential Clovis OB site were formed from moderately sandy, calcareous materials on plains of nearly level to gently sloping and gently undulating relief. Slopes average less than 2 percent but may range up to 5 percent in some of the more undulating sections. The soils of this area belong primarily to the Amarillo-Clovis Series Association and are deep to moderately deep (Soil Conservation Service, September, 1958). Calcium carbonate, leached from the upper layers of these soils, has accumulated at depths of 24 to 60 in. (.60 to 1.5 m) and formed a lime-enriched zone. Areas of the soils of this association are locally called "sandy row-crop land."

Soils of the Amarillo series cover by far the largest acreage of land in the Clovis study area. The Amarillo series consists of loam, fine sandy loam, and loamy fine sand surfaces underlain by horizons of sandy clay loam, calcareous sandy clay loam and a white chalky zone of more than 50 percent calcium carbonate, occurring at depths of 42 to 60 in. (1.1 to 1.5 m). At depths below 60 in. (1.5 m), a massive, strongly calcareous loam or sandy clay loam layer often exists. The soils of the Clovis series occur to a much lesser extent than the Amarillo and differ primarily in that the chalky zone occurs at shallower depths (27 to 60 in. (.69 to 1.5 m)).

Loamy and fine sandy loam Amarillo and Clovis soils are used primarily for dryland farming and are among the most productive dryland farming soils in the country. When these soils are irrigated and fertilized, yields are generally high. The soils will be damaged by wind if they are not protected so a vegetative cover must be maintained during the windy season. Reference ETR-34 (Wind Erosion).

Loamy fine sand Amarillo and Clovis soils are also very productive under dryland farming, when there is enough rainfall. They are poorly suited to irrigation. If these soils are not protected, wind erosion can damage them severely. In general, these soils are best suited to permanent pastures.

Dalhart, Texas (5.3.3.2)

The soils of the potential OB site southwest of Dalhart were formed on nearly level to gently sloping and undulating upland plains. Slopes are generally 0 to 3 percent except on the more undulating and hummocky areas where they range from 3 to 8 percent. The soils of the Dalhart OB site are deep, noncalcareous to calcareous with surface textures ranging from fine sandy loams to loamy fine sands and fine sands (Soil Conservation Service, December 1977). Runoff is generally slow to medium. The soils of this area are subject to severe wind erosion effects.

Several soil series are present at the potential Dalhart OB site. The Dallam series predominates and consists of soils with brown loamy fine sand and fine sandy loam surfaces underlain by horizons of sandy clay loam and clay loam to a depth of 95 in. (2.40 m). The profile is calcareous below 35 in. (90 cm) with calcium

carbonate reaching up to 30 percent between 50 to 60 in. (1.25 to 1.65 m). Permeability is moderate, the hazard of water erosion is slight and the available water capacity is high. Soils of the Dallam series are generally well suited to crops and may be dry farmed or irrigated.

Soils of the Vingo series are found associated with soils of the Dallam series in areas of undulating and hummocky topography. In such places, slopes range from 3 to 8 percent with alternating ridges rising about 10 ft (3 m) above lower areas. Vingo soils occupy the level ridges while the lower areas are occupied by Dallam loamy fine sand. The Vingo soils are noncalcareous throughout and have brown loamy fine sand surfaces underlain by horizons of fine sandy loam and sandy clay loam to 85 in. (2.15 m). Permeability and available water capacity are moderate. The associated Dallam soils are loamy fine sands with characteristics as discussed in the preceding paragraph. The Dallam - Vingo Series Association is best suited to range.

Small areas of other soil series are found at the potential Dalhart OB site. Some of these include the Perico fine sandy loams and loamy fine sands, the Rickmore fine sandy loams and loamy fine sands, the Spurlock fine sandy loams, and the Valentine fine sand, duned soil.

5.4 WATER EROSION

INTRODUCTION (5.4.1)

Public comment has demonstrated a concern regarding the increased potential for water erosion related to operational activities and the construction of roads, shelters, and operating bases for the M-X missile project. Several comments concerned potential gullying and erosion due to off-road-vehicle use. The most frequent criticisms of the DEIS included lack of quantitative data regarding increased runoff, siltation, changes in surface drainage, revegetation, disruption of desert pavement, and lack of detailed mitigation measures.

Deployment of the M-X missile system will require the construction of 4,600 missile shelters and over 9,000 mi of roadway. As the soil system is disturbed during clearing, leveling, earthwork, and other M-X construction activities, it will become more susceptible to erosion. Soils surrounding DTN, cluster roads, and protective structures will also be disturbed through construction activities. Soils directly covered over by roads and protective structures will be lost for further production of range plants and crops. Adjacent soils disturbed during construction may become less productive as their physical and chemical characteristics are changed or degraded. Soil erosion causes the most valuable components of the soil - silts, clays, and organic matter - to be transported great distances, leaving the surface more coarsely textured and less fertile. The natural vegetation cover and desert pavement, which normally provide protection against the erosive forces of rainfall, runoff, and wind, will be removed or deteriorated over large areas. In addition, operation of heavy construction equipment, as well as repeated passes of smaller vehicles over soil surfaces, will cause soil compaction. Compacted soils are very difficult to vegetate without adequate treatment (see Section 5.8, Mitigations). The infiltration rates of compacted soils are low, resulting in increased runoff and changes in the natural drainage patterns. As a result of changes in the natural drainage patterns, water erosion will accelerate in many locations.

Accelerated water erosion from M-X construction activities could result in significant adverse impacts to project facilities and the surrounding environment. If uncontrolled, water erosion will result in the undercutting of roads and widening and deepening of gullies. Gully formation, as shown in Figure 5.4.1-1, could be a significant problem on the downslope side of roads as runoff is concentrated through an estimated 20,000 to 100,000 culverts. Sediment carried from construction sites can pollute streams, impacting much of the aquatic biota (see ETR-16, Aquatic Species), alter water quality (see ETR-12, Water Resources), block drainage and irrigation ditches, damage crops, and reduce the productivity of the adjacent natural areas (see ETR-14, Native Vegetation).

In general, water erosion takes three forms: (1) sheet, (2) rill, and (3) gully or channel erosion. Sheet erosion involves the uniform removal of soil layers through the detaching force of raindrops. Rill erosion results from the scouring action of water running across the soil surface which can develop into gully or channel erosion. The control of each type of erosion is necessary to protect the soil as a basic resource as well as to prevent damage to other resources from discharged sediments.



3221 A

Figure 5.4.1-1. Gully formation resulting from the concentrated flow of water through a culvert, Railroad Valley, Nevada.

THE UNIVERSAL SOIL LOSS EQUATION (5.4.2)

Estimates of potential water erosion impacts in the Nevada/Utah and Texas/New Mexico study regions were based on USDA's Universal Soil Loss Equation (USLE). Detailed discussions of the USLE and its application in this ETR are presented in Appendix F.

DETERMINATION OF WATER EROSION IMPACT RANKINGS (5.4.3)

DDA Impact Rankings (5.4.3.1)

Relative ratings, based on a 1 (low impact) to 5 (high impact) scale, were determined for each valley in the Nevada/Utah study region from three factors:

- (1) Intensity of the soil loss impact.
- (2) Magnitude of the soil loss impact.
- (3) Index to offsite disturbance (IOSD).

The intensity of the soil loss impact is the estimated annual soil loss from a valley's construction area divided by the tolerable soil loss for the area. The tolerable soil loss for Nevada soils is 1 ton/acre/year as established by the U.S.D.A. Soil Conservation Service (Septeer, 1979). The tolerable soil loss for the construction area in a valley is obtained by multiplying 1 ton/acre/year by the number of disturbed acres. The intensity values range from 1.4 (soil loss 1.4 times greater than tolerable) to 5.3 (soil loss 5.3 times greater than tolerable) as shown in Table 5.4.3-1.

A high intensity value for a valley results from unmitigated construction on areas of steep slopes and high soil erodibility, as expressed by high LS, K, C, and P factors in the Universal Soil Loss Equation (see Appendix Table F-5). The intensity, and therefore the total soil loss, can be reduced for each valley by employing practices that would result in a reduction in high values of LS, C, P, or K (see Appendix Tables F-1, F-2, and F-3 and Section 5.8 on Mitigations). The rainfall factor (R) is not under man's control.

The magnitude of the soil loss impact is the estimated annual soil loss from a valley's construction area minus the tolerable soil loss from the area. It is a measure of the estimated amount of soil loss that will be generated as a result of M-X construction activities. It also gives a relative sense of the amount of sediment that might be discharged from the construction area. The magnitude of the soil loss impact ranges from 700 tons/year to 33,500 tons/year as shown in Table 5.4.3-1.

The index to offsite disturbance (IOSD) equals the percent of the hydrologic subunit within 0.5 mi of its construction area. It provides a rough measure of the proportion of the valley to be affected by direct as well as indirect (sediments discharged offsite, gully advancement offsite) impacts. Based on planimetry from 1:250,000 scale maps of the project layout, IOSD values were found to vary from 1 to 59 (see ETR-14, Native Vegetation) and are listed in Table 5.4.3-1).

Table 5.4.3-1. Estimated potential water erosion (soil loss) impacts.

Unit No.	Hydrologic Subunit	(1)	(2)	Intensity of The Soil Loss (1) (2)	Magnitude of The Soil Loss Impact (1) - (2) (Tons/year)	Index To Off-Site Disturbance (IOSD)	Relative Potential Water Erosion Impact Rating ¹
		Estimated Annual Soil Loss From Construction Area (Tons/year)	Tolerable Annual Soil Loss From Construction Acre (Acres disturbed x 1 ton/acre/year) (Tons/year)				
4	Snake	44,300	10,800	4.1	33,500	23	4
5	Pine	13,400	4,100	3.3	9,300	28	4
6	White (Tule)	10,500	4,900	2.1	5,600	32	3
7	Fish Springs Flat	4,500	2,100	2.1	2,400	33	2
8	Dugway	2,800	2,000	1.4	800	37	2
9	Government Creek	2,500	600	4.2	1,900	8	2
46	Sevier Desert	17,600	5,800	3.0	11,800	14	4
46A	Sevier Lake	29,300	8,100	3.6	21,200	24	4
54	Wah Wah	20,700	5,800	3.6	14,900	51	5
137A	Big Smoky	7,000	3,300	2.1	3,700	2	2
139	Kobeh	9,200	5,000	1.8	4,200	38	4
140	Monitor	15,900	4,000	4.0	11,900	20	4
141	Ralston	12,900	6,400	2.0	6,500	38	4
142	Alkali Springs	7,400	3,300	2.2	4,100	59	4
148	Cactus Flat	See Stone Cabin					
149	Stone Cabin	6,700	4,600	1.5	2,100	28	2
151	Antelope	10,600	4,400	2.4	6,200	44	4
154	Newark	4,300	2,400	1.8	1,900	33	2
155	Little Smoky	11,600	5,000	2.3	6,600	11	2
156	Hot Creek	12,600	4,700	2.7	7,900	28	4
170	Penoyer	8,600	3,900	2.2	4,700	29	3
171	Coal	8,800	3,800	2.3	5,000	43	4
172	Garden	10,000	3,400	2.9	6,600	40	4
173A	Railroad	26,400	11,100	2.4	15,300	20	4
174	Jakes	5,600	3,100	1.8	2,500	35	2
175	Long	2,100	1,300	1.6	800	2	2
178B	Butte	7,700	3,400	2.3	4,300	18	3
179	Steptoe	2,600	500	5.2	2,100	1	2
180	Cave	7,000	2,000	3.5	5,000	28	4
181	Dry Lake	21,200	6,800	3.1	14,400	42	5
182	Delamar	4,900	2,000	2.4	2,900	36	3
183	Lake	12,200	3,100	3.9	9,100	35	4
184	Spring	3,000	1,400	2.1	1,600	5	2
196	Hamlin	12,200	4,100	3.0	8,100	56	5
202	Patterson	1,600	600	2.7	1,000	15	2
207	White River	18,700	4,200	4.4	14,500	17	4
208	Pahroc	1,600	300	5.3	1,300	7	2
209	Pahrnagat	1,300	600	2.2	700	4	2

T4609/9-16-81/F

¹ Rating Scale: 1 Low
 2 Moderately low
 3 Moderate
 4 Moderately high
 5 High

Source: HDR Sciences, 1981.

Relative ratings from 1 (low) to 3 (high) were assigned to each factor in every valley according to the ranges shown in Table 5.4.3-2. For example, Delamar Valley's (subunit 182) intensity value of 2.4 has an impact rating of 2, its magnitude value of 2,900 has an impact rating of 1 and its IOSD of 36 has an impact rating of 3. The average of the three ratings in each valley resulted in an estimated, relative overall valley water erosion impact rating (see Table 5.4.3-1) from 1 (low) to 5 (high) according to the distribution of averages shown in Table 5.4.3-2a. The average of Delamar Valley's three ratings $((2 + 1 + 3)/3)$ is equal to 2 which translates into an overall valley impact rating of 3 (moderate) (see Table 5.4.3-2b).

Relative potential water erosion impact ratings (low, moderate, high) were determined for each county in the Texas/New Mexico DDA. Because of the larger areas, generally less intense M-X activity for the overall analysis unit, and non-conformity between analysis unit boundaries (political) and environmental boundaries, a more generalized ranking approach was necessary. County impact rank was based on:

1. Estimated topographic factor (LS) for construction areas.
2. Estimated average rainfall factor (R) for the county.
3. Proportion of county area to be disturbed.

Discussions on the determination of LS and R values and their ranges in the Texas/New Mexico study region are presented in Appendix F.

OB Impact Rankings (5.4.3.2)

Water erosion impact ratings were assigned to the five Operating Base (OB) sites based on the site characteristics influencing erosion (Table 5.4.3-3). In particular, relative ratings, based on a 1 (low impact) to 5 (high impact) scale, were determined for each OB from the following:

- 1) The product of the rainfall factor, R, and the topographic factor, LS.
- 2) The erosion hazard ratings obtained from the literature.

The product of R and LS combines into one term to describe the influence of topography and rainfall on water erosion at the site. The erosion hazard rating tells something about the soil erodibility and the present erosion trends occurring within the area.

5.5 M-X IMPACTS: NEVADA/UTAH

Although the Nevada/Utah study region is located in an arid to semiarid climatic zone, it is not immune to water erosion. Southcentral Nevada (including Lincoln and Nye counties) has a mean annual valley precipitation of only 6.23 in. (Houghton et al., 1975), but up to 35 percent of all measurable rain is in the moderate to high precipitation class (0.25 in. or more). Most of this rainfall occurs in only 10-20 intense storms during the year. Because vegetative cover is sparse in this region, high intensity storms lead to increased water erosion and flooding problems. Northeastern Nevada (including White Pine and Eureka counties) has a

Table 5.4.3-2. Worksheet for determining relative overall valley impact rating.

a. Ranges for Factor Ratings

Factor	Range ¹ for 1 (Low) Rating	Range ¹ for 2 (Mod) Rating	Range ¹ for 3 (High) Rating
Intensity of soil loss impact (I)	I _ 1.5	1.5 I _ 2.5	I 2.5
Magnitude of soil loss impact (M)	M _ 4000 $\frac{\text{tons}}{\text{yr.}}$	4000 M _ 8000 $\frac{\text{tons}}{\text{yr.}}$	M 8000 $\frac{\text{tons}}{\text{yr.}}$
Index to offsite disturbance (ISOD)	ISOD _ 15	15 ISOD _ 35	ISOD 35

¹ Rating ranges based on analysis of entire range and distribution of individual values to arrive at 3 most appropriate groups.

b. Overall Valley Rating

Overall valley impact rating = average of the 3 factor ratings expanded to a 1 to 5 scale.

If:

1.00 average 1.25
1.25 average 1.75
1.75 average 2.25
2.25 average 2.75
2.75 average 3.00

Then overall impact rating is:

1 (low)
2 (moderately low)
3 (moderate)
4 (moderately high)
5 (high)

T4608/10-2-81/F

Source: HDR Sciences, 1981

Table 5.4.3-3. Estimated potential water erosion impacts at the operating base site.

Operating Base	Rainfall Factor (R)	Topographic Factor (LS)	(R) x (LS)	Erosion Hazard Rating From Literature	Potential Water Erosion ₁ Impact Rating
Beryl, Utah	22	0.34	7.48	Moderate to severe ²	3
Coyote Spring, Nevada	20	0.49	9.8	Moderate ³	4
Delta, Utah	14	0.14	1.96	Low ⁴	1
Ely, Nevada	16	0.22	3.52	Moderate ⁵	2
Milford, Utah	20	0.49	9.8	Not Available	4

T4639/9-16-81/F

¹Rating Scale: 1 Low
2 Moderately Low
3 Moderate
4 Moderately High
5 High

²USDA Soil Conservation Service, 1960.

³U.S. Department of Interior, Bureau of Land Management, 1979.

⁴USDA Soil Conservation Service, 1977.

⁵USDA Soil Conservation Service, 1976.

Source: HDR Sciences, 1981.

higher annual valley precipitation of 10.6 in. (Houghten et al., 1975). Natural erosion rates in regions receiving between 10 and 20 in. of rain annually are among the highest occurring anywhere (Stiller et al., 1980). The vegetative cover is still too sparse to provide adequate protection against water erosion due to the increased rainfall. In regions where the annual precipitation is greater than 20 in. the vegetative cover is dense enough to retard runoff and erosion.

Relative potential water erosion impact ratings were assigned to each valley containing M-X protective structures and DTN as a means of identifying problem areas and arriving at an overall DDA impact rating.

Thirty-eight percent of the valleys have a relative water erosion impact rating of moderately low; 11 percent have relative impact ratings of moderate; 43 percent have relative impact ratings of moderately high; and 8 percent have relative water erosion impact ratings of high (see Table 5.4.3-1). An overall DDA water erosion impact rating ranges between moderate and moderately high. The potential for water erosion impacts can be reduced using mitigation measures, whereas without mitigation, water erosion impacts would range from long term to permanent.

Table 5.4.3-3 presents relative water erosion impact ratings of the OB sites as follows: Delta rated low; Ely rated moderately low; Beryl rated moderate; and Milford and Coyote Spring rated moderately high. It should be noted that these ratings are based on a limited data base and additional site studies would allow for greater accuracy.

Extensive grazing lands currently exist in most of the valleys of eastern Nevada and western Utah. Cropland occupies much less acreage, but the potential for further development exists if water for irrigation becomes available. Assuming full basing in the Nevada/Utah study region, roughly 160,000 acres (see ETR-14, Native Vegetation) of soils will be potentially impacted. This includes soils directly covered by the DTN, cluster roads and protective structures as well as soils surrounding these facilities that are disturbed through construction.

The soils adjacent to the roads, DTN, and protective structures will be disturbed during construction and will have to be revegetated in order to control erosion and to maintain grazing land. However, construction activities may degrade these soils, making vegetation more difficult to reestablish. For example, construction of the 4,600 protective structures in Nevada and Utah will involve at each protective structure site excavations of up to 20 ft (6.1 m) deep or more and the deposition of the soil material at the surface. Earthwork activities during road construction will also disturb the vertical soil profile, although often to a shallower depth. Soil horizons below the surface often contain deleterious substances (salts, alkali, etc.) in concentrations that would restrict normal plant growth. For example, a representative soil profile of the Uvada series, predominating in some of the valleys in western Utah, has an electrical conductivity of 0.0031 mhos/cm at the surface and an electrical conductivity of 0.0567 mhos/cm at a depth of 65 in. (165 cm) (U.S.D.A. Soil Conservation Service, May, 1977). Mixing of such highly saline soil horizons with the surface horizon will result in a lower level of plant productivity at the surface. This will affect revegetation efforts as well as the quality of the land for future agricultural development. The chemistry of the underlying soil horizons in all areas of Nevada and Utah are generally not known in enough detail to determine the extent of this possible impact on soil productivity.

Excavation and earthwork activities may improve some characteristics of the soils of Nevada and Utah. Many of the soils of this area, including soils of the Durargid, Durorthid, Paleargid, and Paleorthid great groups, have hardpans cemented with silica and calcium carbonate at about 12 to 36 in. (30 to 91 cm) below the surface. Such hardpans limit effective root penetration, thereby restricting plant growth. Excavation and earthwork activities may serve to disrupt these hardpans and enhance plant reestablishment.

5.6 M-X IMPACTS: TEXAS/NEW MEXICO

The acceleration of water erosion as a result of M-X construction activities in the Texas/New Mexico study region could result in significant impacts to project facilities and the surrounding environment.

However, the magnitude of the water erosion impacts in the Texas/New Mexico study region is expected to be about the same as those in the Nevada/Utah study region based on the examination of the Universal Soil Loss Equation (see Appendix F).

Soils of the Texas/New Mexico study region will be directly impacted when they are covered by DTN, cluster roads and protective structures. These impacts are significant because soils of Texas and New Mexico are for the most part fertile and support, in addition to the natural vegetation, dryland farming, and irrigated crops and range. Furthermore, soil quality must be maintained at a productive level to support the necessary revegetation to control erosion of disturbed areas.

The soils of Texas and New Mexico will be impacted and degraded in several ways as a result of general construction activities. Soils of the Amarillo, Clovis, Dallam, and Sunray series are among those soils in this region that suffer severe erosion problems, but are also quite suitable for crops.

Construction of protective structures in Texas and New Mexico will involve excavations of 20 ft (6.1 m) deep or more at each protective structure site and the deposition of the soil material at the surface. Earthwork activities during road construction will also disturb the vertical soil profile although to a shallower depth. Different soil horizons below the surface often contain concentrations of certain minerals (calcium carbonate, gypsum, etc.) that would restrict normal plant growth. Mixing of these deeper soils with the productive upper layer will reduce plant productivity to a lower level. For example, in a representative profile of an Amarillo fine sandy loam (a major soil series in parts of the Texas/New Mexico study region), the upper 16 in. (41 cm) contains no calcium carbonate. However, horizons at 42 to 84 in. (107 to 214 cm) below the surface contain over 50 percent calcium carbonate (U.S.D.A. Soil Conservation Service, September, 1958). Mixing of such horizons may effect the necessary revegetation efforts as well as future agricultural activities.

5.7 FUTURE WATER EROSION IMPACTS WITHOUT M-X

Water erosion is a considerable problem throughout much of the Nevada/Utah study area due to sparse vegetation, high intensity storms, and terrain. Soils in much of the Texas/New Mexico study area are inherently less susceptible to water erosion, and the slopes generally are not as steep as those found in Nevada/Utah.

However, a larger number of storms in the Texas/New Mexico area result in water erosion impacts comparable to or greater than those in Nevada/Utah. Due to sparse population and generally low intensity of activity, future trends in impacts resulting from water erosion are anticipated to be similar to present conditions for both areas.

5.8 MITIGATIONS

AIR FORCE PROGRAMS (5.8.1)

The Air Force will establish an erosion control program including: selecting appropriate sites where drainage, topography, and soils are favorable for planned use; minimizing disturbed areas and the mixing of soils; controlling runoff; constructing sediment basins; revegetating disturbed areas; paving roads as early in the project life as practicable, and restricting off-road travel.

OTHER MITIGATION MEASURES UNDER CONSIDERATION (5.8.2)

Sound engineering and soil conservation practices could be employed both during and after construction in order to mitigate potential soil impacts due to water erosion, wind erosion, the mixing of surface soils with lower quality subsoils, and compaction.

Disturbance of the soil system is unavoidable if the M-X system is to be constructed. However, many of the adverse water erosion impacts associated with soil disturbance could be avoided or minimized in duration and magnitude through the mitigation measures discussed below (as condensed from "Guides for Erosion and Sediment Control in Nevada," USDA, SCS, Reno, Nevada, August, 1976).

Erosion and sediment could be controlled on construction sites if certain principles are followed in the use and treatment of land. These principles are: (1) using soils suited for the development, (2) leaving soil bare for the shortest possible time, (3) reducing the velocity and controlling the flow of runoff, (4) releasing runoff safely to downstream areas.

Combinations of the following practices have proved effective in applying the above principles:

1. Selecting land where drainage patterns, topography and soils are favorable for the development plan. Throughout the site selection process, it should be noted that steeper slopes increase the potential for water erosion, as expressed by the USLE topographic factors shown in Appendix Table F-1. The potential for soil erosion in any one of the valleys studied in this analysis could be reduced by moving the project to areas within the valley where the slope is less.
2. Fitting the development to the site and providing for erosion control in the development plan. Erosion control design measures that can be incorporated into site development plans are discussed in detail in various sources (Clyde et al., June, 1978; USDA Soil Conservation Service, August, 1976; U.S. Department of the Navy, October, 1979; and Technical Guides available at each of the field offices of the Soil Conservation Service).

3. Developing large tracts in small units to complete construction rapidly so large areas are not exposed to erosion.
4. Removing vegetation only from areas necessary and reducing grading to the minimum required.
5. Controlling runoff and conveying it to suitable outlets.
6. Protecting critical areas during construction with mulch, temporary seedings or mechanical measures. Appendix Table F-2 shows the reduction in soil erosion on construction sites due to application of mulches, temporary seedings and other protective ground covers.
7. Constructing sediment basins to detain runoff and trap sediment during construction.
8. Providing safe off-site disposal of runoff.
9. Establishing permanent vegetation and installing erosion control structures as soon as possible (see "Soil Handling Procedures to Maximize Revegetation Potential in the Nevada/Utah Candidate Siting Region for the M-X Missile System," Master, 1980).

The detrimental effects of erosion not only damage the soil resource but the eroded sediment may seriously damage land, waters, fisheries, or other resources downstream from the source (see ETR-16, Aquatic Species, and ETR-12, Water Resources). It follows that the most effective sediment control measure is the application of erosion control practices to minimize sediment production at the source. If successful erosion control is applied to the land in the watershed, sediment production can be reduced to levels which would cause negligible damage to lands and facilities below the source. When sediment yield is high enough to be a hazard to lands and facilities below, sediment control measures need to be applied.

An effective technique to handle the problem is to intercept and remove sediment from the watercourse at a point as close as possible to the source. A recommended measure for this is a debris basin. The debris basin is a small reservoir constructed with sufficient capacity to trap a large percentage of the sediment particles. The finer sediment particles that remain in suspension are carried on downstream. Debris basins could be constructed with sufficient capacity to hold the anticipated sediment delivery to the site. If circumstances preclude construction of a debris basin with adequate capacity, a smaller basin can be used if plans are included to clean it out periodically. If there is no suitable site for a debris basin near the sediment source, the sediment charged water could be directed downstream in a constructed channel or closed conduit to a site that is suitable for construction of a debris basin.

Revegetation of disturbed lands is one of the most important components of an erosion control strategy. The cost of revegetating disturbed lands is directly related to the area required to be revegetated, the amount of leveling and shaping required, and the effectiveness of precipitation received during the establishment period. In most areas of the Nevada/Utah study region and many areas of the Texas/New Mexico study region, revegetation will not be successful without irrigation. This

demand for the use of supplemental water will incur significant economic costs and will produce conflicts in the allocation of existing water resources. For more extensive information regarding the cost of supplemental water for irrigation, see ETR-12, Water Resources and ETR-14, Native Vegetation.

In some areas, higher quality surface soils are underlain by subsoils of poorer quality that contain potentially toxic concentrations of salts, alkali, and other deleterious substances. These areas could be determined and mapped so that revegetation strategies can be properly assessed. The extent of earthwork in such areas could be minimized to preserve the quality of the soil resource. If avoidance is not possible, surface soils could be selectively stockpiled during excavation and later replaced. These soil-revegetation-related mitigations are discussed in further detail in "Soil Handling Procedures to Maximize Revegetation Potential in the Nevada/Utah Candidate Siting Region for the M-X Missile System" (Master, 1980).

Soil compaction is best minimized by restricting off-road vehicle travel, especially on wet soils. In areas where compaction is inevitable, tilling could be done after construction to make revegetation less difficult and to decrease water erosion problems. Tilling loosens the compacted surface, making a suitable seed bed for revegetation. In addition, tilling, contour terracing, contour furrowing, contour trenching, mulching, deep chiseling and other activities, facilitate runoff intakes and water retention to achieve moisture conservation for revegetation and to help control runoff and erosion.

6.0 PALEONTOLOGY

Paleontological fossil resources are of scientific value throughout both siting regions. Fossils are protected by the Utah Antiquity Law and The National Antiquities Act of 1906 as objects of antiquity. These laws are presented in Appendix II. The combination of the National Environmental Policy Act (1969) as amended, the Federal Land Policy and Management Act (1976), and BLM Washington office instruction memorandum 79-111 (1978) as the applicable regulations require a paleontological survey as part of the environmental report on M-X (Fike, 1980).

Fossils exhibit a variety of uses that render them valuable to the scientific community. They are used to age date geologic formations, correlate formations in different areas, and to determine the environment and possibly the climate at the time of deposition. Fossils are also used to study phylogeny, evolution, dispersion and migration. In the Texas/New Mexico area, fossils are associated with paleo-Indian remains and are very valuable in the study of early man. Because of the different values the paleontological resources possess, it is important that any fossil remains encountered during the M-X construction be preserved for study. The M-X project has the potential for greatly expanding the knowledge of Great Basin or High Plains paleontology.

6.1 NEVADA/UTAH

Paleontological resources in the Nevada/Utah deployment region can be divided into two basic types: Those fossils of Paleozoic age (225 to 590 million years, found in the mountain ranges), and those of Cenozoic age (10,000 to 60,000,000 years, found mainly in valleys and along mountain fronts).

PALEOZOIC (6.1.1)

Paleozoic rocks have been well studied and many fossil locations are known. The detail of the studies in some areas is quite high because of the presence of mineral deposits. In other areas, Paleozoic rocks have been studied to determine the geologic history of the region. Even though the rocks are well exposed in the mountain ranges, the complex structure resulting from folding and thrust faulting makes the occurrence of zone fossils an important tool for deciphering the geologic history both within and between mountain ranges. Paleozoic rocks were deposited mostly under marine conditions. Generally, deposits in western Nevada consist of shale, chert, and greenstone deposited under deep water conditions; while those in eastern Nevada and western Utah are mainly limestone, dolomite, and sandstone deposited under shallow marine, near shore conditions. Fossils most commonly occur in the shales and limestones although they do occur in some of the other lithologies.

The most important occurrences of Paleozoic fossils are those associated with the "type section" of the individual formations (i.e., the place where the formation is described and named), measured sections in subsequent reports (areas of detailed study used to correlate with type sections), and areas with unique assemblages (bioherms, reefs, or an association of numerous species). Paleozoic fossils occur in most of the mountain ranges in Nevada and western Utah except in those made up of Cenozoic volcanic rocks and in the Snake Range, which is largely metamorphic.

CENOZOIC (6.1.2)

Cenozoic fossil locations are distributed mostly along the margins of the valleys and in the mountain ranges made up of the tertiary volcanic sequence. The volcanic rocks associated with secondary mineralization of economic importance are the most studied, but these rocks do not contain fossils. Probably the best studied Cenozoic formation is the Eocene Sheep Pass Formation associated with the oil and gas fields in Railroad Valley. Much of the Sheep Pass Formation is a lacustrine limestone and contains an assemblage of fresh water gastropods and mollusks. Other Cenozoic rocks containing fossils include aqueous tuffs, lake bed deposits, and conglomerates.

Cenozoic fossil occurrences are scattered throughout the study area. Figure 6.1.2-1 shows some of the known locations and the areas of Pleistocene lake beds. Cenozoic fossils are usually found where Miocene to recent uplift and subsequent erosion have exposed the fossil bearing beds. Another type of exposure is that of man-made works such as gravel pits and roadways. A major reason for the relative scarcity of known fossil locations, especially in the valleys, is the lack of exposure of fossil bearing strata.

Depositional environments associated with fossil locations are much more widespread throughout the Great Basin area than known fossil locations. It is projected that future discoveries of fossils will be made in the study area. Prime locations include late Pleistocene lake shorelines and lake and stream bed deposits. These types of deposits are found throughout the deployment area. The two nearest paleontologically significant areas in Nevada are west of the M-X deployment area. These are Ichthyosaur State Park, east of Gabbs, and an area south of Gabbs being considered for designation as an Area of Critical Environmental Concern (ACEC) by the BLM. Ichthyosaur State Park contains fossils of sea-going reptiles in Triassic age rocks. The proposed ACEC contains fossil insect fauna in a tuff of the Miocene Age.

6.2 TEXAS/NEW MEXICO

Almost the entire deployment area in Texas and New Mexico is underlain by the Pliocene Ogallala Formation. There are occasional Pleistocene terrace deposits along the margins of the Ogallala and Pleistocene lake deposits on the surface. The Ogallala Formation is made up of alluvial deposits, channel gravels, silts and sands eroded from the Rocky Mountains. In places, river channels have eroded through the Ogallala to the underlying Paleozoic or Triassic rocks exposing some fossil bearing units.

In the New Mexico area, vertebrate remains are scarce. The most common fossils are mollusks, gastropods, and seeds. Seeds are the most widespread fossils in the Ogallala in New Mexico and even these are uncommon (Leonard and Frye, 1970). The only areas of paleontological significance near the M-X deployment area are in Donley and Hemphill counties, 60 to 80 mi east of the proposed location. The two areas are the type locales for vertebrate zone fossils of the Pliocene and the early Pleistocene age. The presence of these locations should not constrain the placement of the operating bases.

6.3 M-X IMPACTS--NEVADA/UTAH

DIRECT IMPACTS (6.3.1)

The M-X project has a high potential for the uncovering of currently undiscovered fossil deposits in the Cenozoic rocks of the siting valleys because of the vast amounts of earth movement required during the excavation of the shelters, the construction of roadways, and the excavation for aggregate. Since the system is located primarily in the valleys, the impacts to Paleozoic fossils in the mountain ranges will only be indirect, except along the DTN routes.

With the exact locations of the M-X facilities yet to be determined, impacts can only be discussed in general terms. Areas most likely to contain Cenozoic fossils include Pleistocene shore line deposits and lake bed deposits. The Pleistocene shore line deposits are located along the circumference of those valleys that were topographically closed during the Pleistocene wet periods. Closed basins were of two types: those completely closed, containing a sequence of shore line deposits depending on the water depth, and those partially closed that would fill to a certain level and then spill to the next lower basin, forming a single shore line at a certain elevation. The shore line deposits could be an important source of aggregate where they consist of well graded gravels. Lake bed deposits could be encountered on the valley floors during the excavation for the shelters.

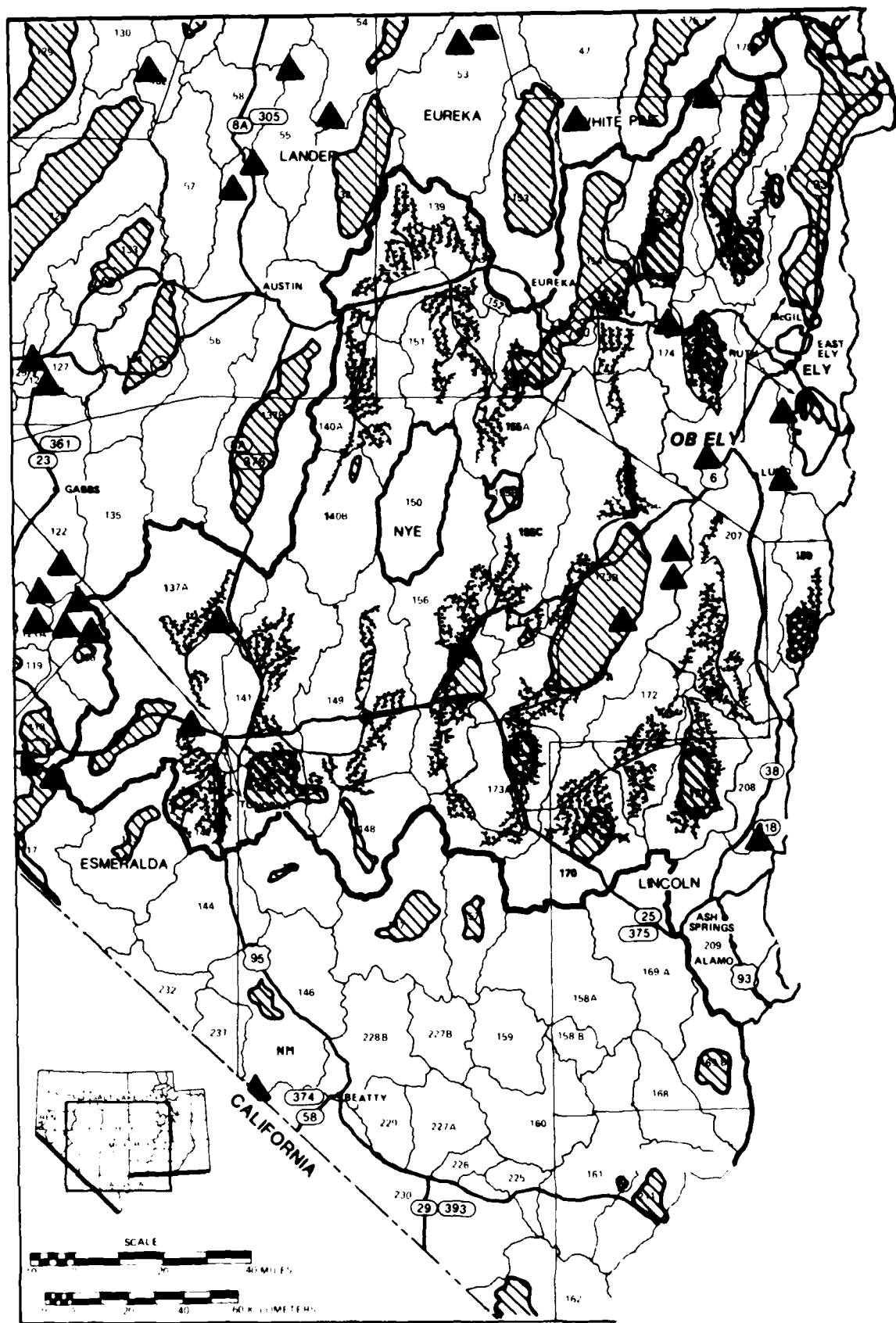
The actual discovery of Cenozoic fossil locations would not cause an adverse impact unless the fossils were destroyed. An increase in the number of Cenozoic fossil locations would have a positive effect if the fossils could be adequately preserved and studied. A conflict is possible between the preservation of fossil resources and the completion of construction on time. Sufficient advance planning will be performed to minimize such conflicts. The preservation of fossils for which there is no equivalent collection from other parts of the region would be more important than would the preservation of a fossil fauna that was equivalent to one already well studied.

INDIRECT IMPACTS (6.3.2)

Indirect impacts to fossil resources would be caused by the casual collection of fossils by the large number of people that the project will bring to the region. Indirect impacts would affect Paleozoic fossil locations in the mountain ranges through the collection of unique fossils such as coiled ammonites or well preserved trilobites. The casual collection of important faunal constituents could destroy the scientific value of a deposit. Almost every mountain range with Paleozoic outcrops could be affected. The most damaging effects would be to areas with unique easily collected fossils, such as trilobites and coiled ammonites, or areas of scientific value, such as type sections or zone fossil locations.

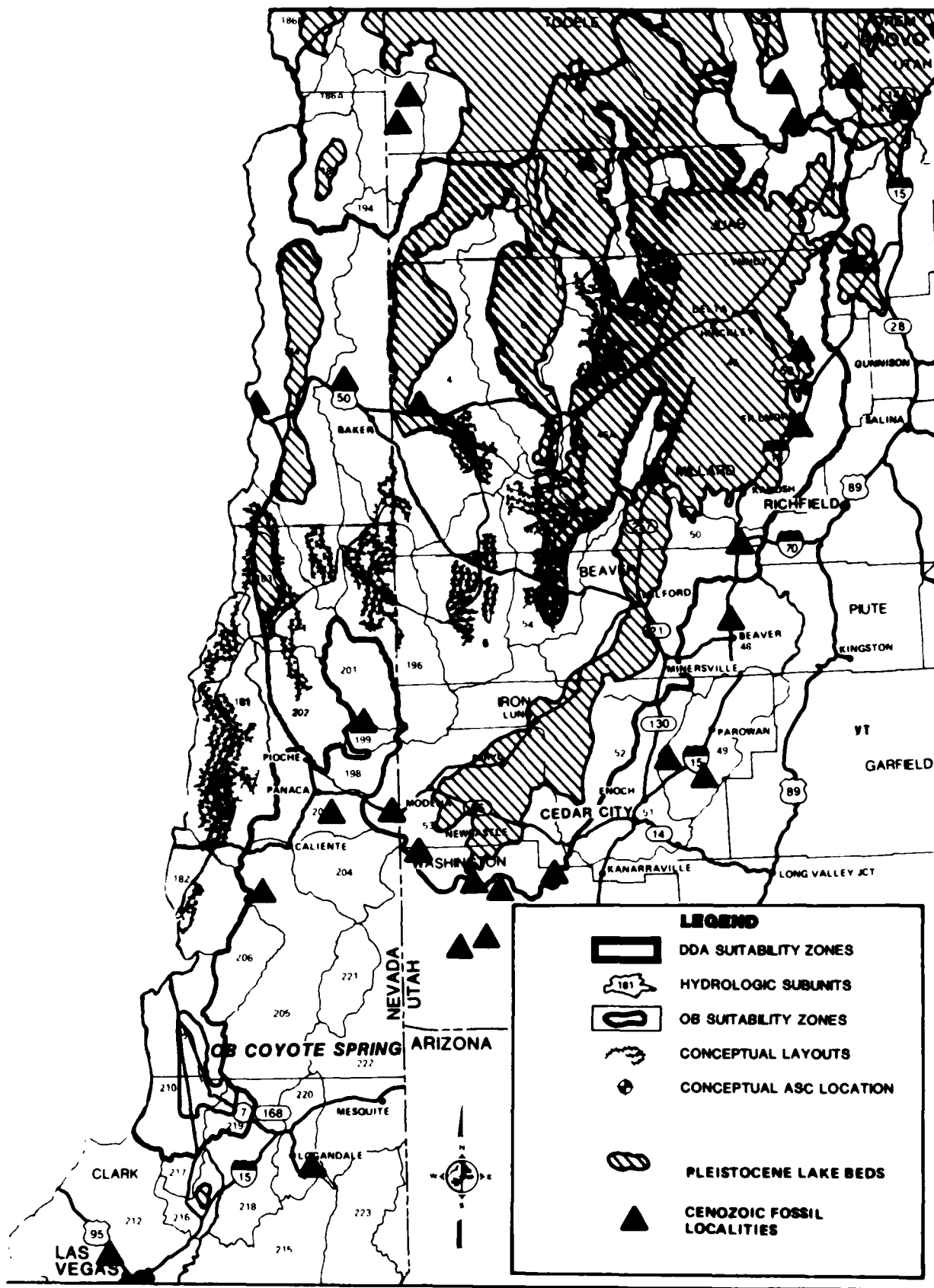
SIGNIFICANCE ANALYSIS (6.3.3)

To identify the impacts of the M-X program on paleontological resources it is necessary to identify locations where fossils would be expected to occur. This was done by a literature review and projections based upon the geologic features of known locations. Information is sparse on valley bottom occurrences, where most M-X disturbance takes place. It is assumed that valleys that contained Pleistocene lakes would be most likely to contain fossils, if other evidence is lacking.



3230-D-1

3218-C-1/1340-C-1



3218-C-1 / 1340-C-3201-D-1

Figure 6.1.2-1. Pleistocene lake beds and Cenozoic fossil locales and the Proposed Action conceptual project layout.

All potential fossil locations are significant because of the current lack of data and the value that any fossil find would have. Vertebrate fossils would have the most value because of their use in determining climate, correlation between valleys, age dating, dispersion patterns, and speciation (Madsen, 1980).

The Proposed Action is the excavation of 4,600 shelter sites and the construction of 10,000 mi of road. Any excavation and construction activity has the potential for destroying paleontological resources. The M-X program will also increase the population of the area and improve access, which would lead to the increased casual collection of fossils (Reppenning, 1980). Impacts from construction and excavation will occur only during the M-X construction period, while those of increased collection would accrue for the entire life of the project. Paleontological resources are nonrenewable--once they are destroyed or removed from their context without cataloging, their value is destroyed.

Paleontological resources are protected by the Utah Antiquity Law and by The Antiquities Act of 1906 as objects of antiquity. Destruction of the resources, therefore, is against the law. The fossils do not have to be preserved in place; (i.e. avoided). Salvaging, preserving, and cataloging the fossils for future study is a viable alternative. The construction sites will be examined prior to construction and monitored for fossil remains as part of the standard construction procedure. Fossils encountered will be salvaged and preserved.

Coyote Spring OB (6.3.3.1)

The Coyote Spring operating base is located near the channel of the ancestral White River. When the White River was flowing during the Pleistocene, it cut through deposits of older lake bed sediments in the bottom of Coyote Spring Valley. These sediments are potentially fossil-bearing although fossils have not yet been found. Just south of Coyote Spring Valley, the river bed cuts through the Muddy Creek formation that contains a vertebrate fauna near Moapa. The OB site is very close to this outcrop. Paleozoic rocks containing fossils outcrop in the mountains east and west of Coyote Spring Valley.

Beryl OB (6.3.3.2)

The Beryl OB siting area is located on alluvial valley fill in an area that at one time was inundated by Lake Bonneville. Lake Bonneville was a large lake that covered much of the Utah Basin and Range during the late Pleistocene, up to about 10,000 years ago. Important vertebrate fossils have been found in scattered locations in the Bonneville sediments. The disturbance of Bonneville sediments through excavation has the potential for destroying fossils contained in the sediment. Sites proposed for excavation or earth-moving activities will be examined prior to construction and monitored for fossil remains as part of the standard construction procedure. Fossils encountered will be salvaged and preserved.

Milford OB (6.3.3.3)

The Milford base site is located in an area that is geologically similar to the Beryl base site and the impacts are the same.

Delta OB (6.3.3.4)

The Delta OB is geologically similar to the Beryl base site and the impacts are the same.

Ely OB (6.3.3.5)

Along the edge of Steptoe Valley, between Ely and the proposed operating base, are outcrops of the Eocene Sheep Pass Formation. Some of these outcrops contain fossils, and one vertebrate fossil has been found. Paleozoic rocks outcropping in the mountain ranges east and west of the valley contain an assortment of fossils.

6.4 M-X IMPACTS TEXAS/NEW MEXICO

The DDA for Alternative 7 Texas/New Mexico full basing is located on the surface of the high plains. The surface is dotted with Pleistocene lake deposits that are known to contain fossils. The most important of these fossils are associated with the paleo-Indian artifacts and are very important in the study of fossil man. The Pleistocene deposits are scattered throughout the siting area and could be encountered anywhere. The issues related to paleontological resources are the same as those discussed under the Proposed Action.

The effects of the M-X project on the paleontological resources of the Texas/New Mexico area would be confined to possible disturbances from the excavation of shelters and aggregate source areas. Aggregate source areas are most likely to produce fossils because the aggregate would come from coarse grained deposits. Coarse grained deposits in the Ogallala Formation frequently contain vertebrate faunal remains. The importance of fossil finds would be greatest if the fauna differed either in age or constituents from those already known in the area. The best known faunas are located 60 to 80 mi (100 to 130 km) east of proposed siting areas.

CLOVIS OB (6.4.1)

The Clovis OB is located approximately 35 mi (55 km) from the western escarpment of the High Plains. Fossil occurrences along the western escarpment are not common and consist mostly of gastropods and seeds.

DALHART OB (6.4.2)

The operating base at Dalhart is located 80 mi (130 km) west of the important vertebrate fauna locations in Hemphill County. The Hemphillian fauna is found in the upper 150 ft of the Ogallala Formation and could be found in the Dalhart area. Pleistocene deposits on top of the Ogallala may also contain fossils.

6.5 MITIGATIONS

Impacts to paleontological resources resulting from M-X system deployment would be both direct and indirect in nature. A direct result of the project would be the potential for uncovering currently undiscovered fossil deposits in Cenozoic rocks in Nevada/Utah siting valleys during the excavation and construction phases of the project. Paleozoic fossils found in the area's mountain ranges would be affected indirectly by the potential increase in casual collection brought about by a project-induced population increase.

Because of the widespread occurrence of fossil bearing sediments and the desirability of some of the material for use as aggregate, the ideal mitigation, complete avoidance, is not feasible nor desirable. Partial avoidance, and avoidance of the most important fossil locations, coupled with a determination of the M-X facilities most likely to encounter fossils, would allow for the operation of a program for the monitoring and recovery of fossil material.

The Air Force program, as directed by the PMOA, will conduct an inventory of paleontological resources, evaluate their significance and avoid impacts through redesign where feasible. Construction activity will be monitored with data recovery and salvaging of fossils when impacts cannot be avoided.

The construction sites most likely to produce fossil remains will be identified before construction begins and a system for monitoring fossil occurrences instituted as part of the standard construction procedure. When fossils are encountered at a site, a recovery team, possibly made up of students from a nearby university under the supervision of a qualified paleontologist, could be sent to the site to recover as much of the fossil material as practicable. Scheduling coordination will be required of the construction agent to avoid delays in construction.

Indirect impacts, specifically increased casual fossil collection resulting from population growth within the area, will also be addressed. Development of educational and interpretative programs will be designed in an effort to enhance fossil preservation by minimizing indirect impacts.

A potential mitigation measure, with regard to indirect impacts, could be the establishment of areas of critical environmental concern. Areas of prime paleontological importance could be protected by designation as an Area of Critical Environmental Concern (ACEC). Providing funds for establishment of a program for administration of an ACEC should be considered.

7.0 ENERGY RESOURCES

Energy resources are important to the national economy. In the next decade, the increased development of energy resources and progress toward the goal of energy independence will be stressed. The M-X study areas contain potentially developable energy resources; the most important are geothermal in Nevada/Utah and oil and gas in Texas/New Mexico. Oil and gas exploration is occurring in the Nevada/Utah region and both areas have uranium potential. The M-X system has the potential for affecting exploration for and development of these energy resources.

7.1 NEVADA/UTAH

A summary of oil and gas resources in both the Nevada and Utah Great Basin area, can be quickly drawn because of the paucity of known sites. The only wells that are currently producing oil and gas commercially in Nevada are in the northern portion of Railroad Valley in northeast Nye County, as shown in Figure 7.1-1. Two small oil fields, Eagle Springs and Trap Spring (near the town of Currant), share a total of some 18 producing wells. The low-gravity, high-sulfur oil produced is shipped by tank trucks to a refinery in Tonopah. No petroleum fuel above fuel oil is extracted, thus excluding gasoline, kerosene, and diesel distillates from the known shallow Nevada oil.

Excluding Great Salt Lake, where large quantities of tarry oil have been discovered, there is no oil and gas production in western Utah. However, good oil and gas production (in addition to oil shale, tar, sand, and Gilsonite) is to be found in the Uinta Basin. Major production in Utah comes from the Four Corners area on the Colorado plateau.

Geothermal resources are abundant in both states, as shown in Figure 7.1-2. Known geothermal resource areas (KGRAs - USGS nomenclature) are found throughout most of the Nevada and western Utah. Within the Roosevelt Hot Springs area near Milford, Utah, for example, a pilot power plant using steam and hot water in a 2.5 Mw generating facility has proved successful. A similar facility in Churchill County, Nevada is being planned.

Presently, a deep, exploratory well is being completed by Mobil Oil on Mormon Mesa in the Virgin River area of Clark County, Nevada. The indications are that shows oil and gas in a critical part of the Overthrust Belt have been encountered. This information has already resulted in a widespread land-lease boom in areas of eastern Nevada. If the Mobil Oil well is confirmed to have a potential for large volumetric, commercial production, its energy importance will be great. The Overthrust Belt, from discoveries already made in southwest Wyoming and northeast Utah over the past five years, has become the most significant oil field prospect in the United States since the Alaskan north shore finds in Prudhoe Bay. Western Governors' Policy Office commented that the overall potential of the Overthrust Belt may be 1 - 15 billion barrels. The relatively narrow strip of the Overthrust zone in the M-X study area extends from Milford and Delta in Utah to Caliente in Nevada, then into northwest Arizona. Atlantic Richfield expressed the opinion that Millard County is, geologically, one of the more favorable counties in Utah for future oil and gas exploration. They are presently drilling one well and have scheduled

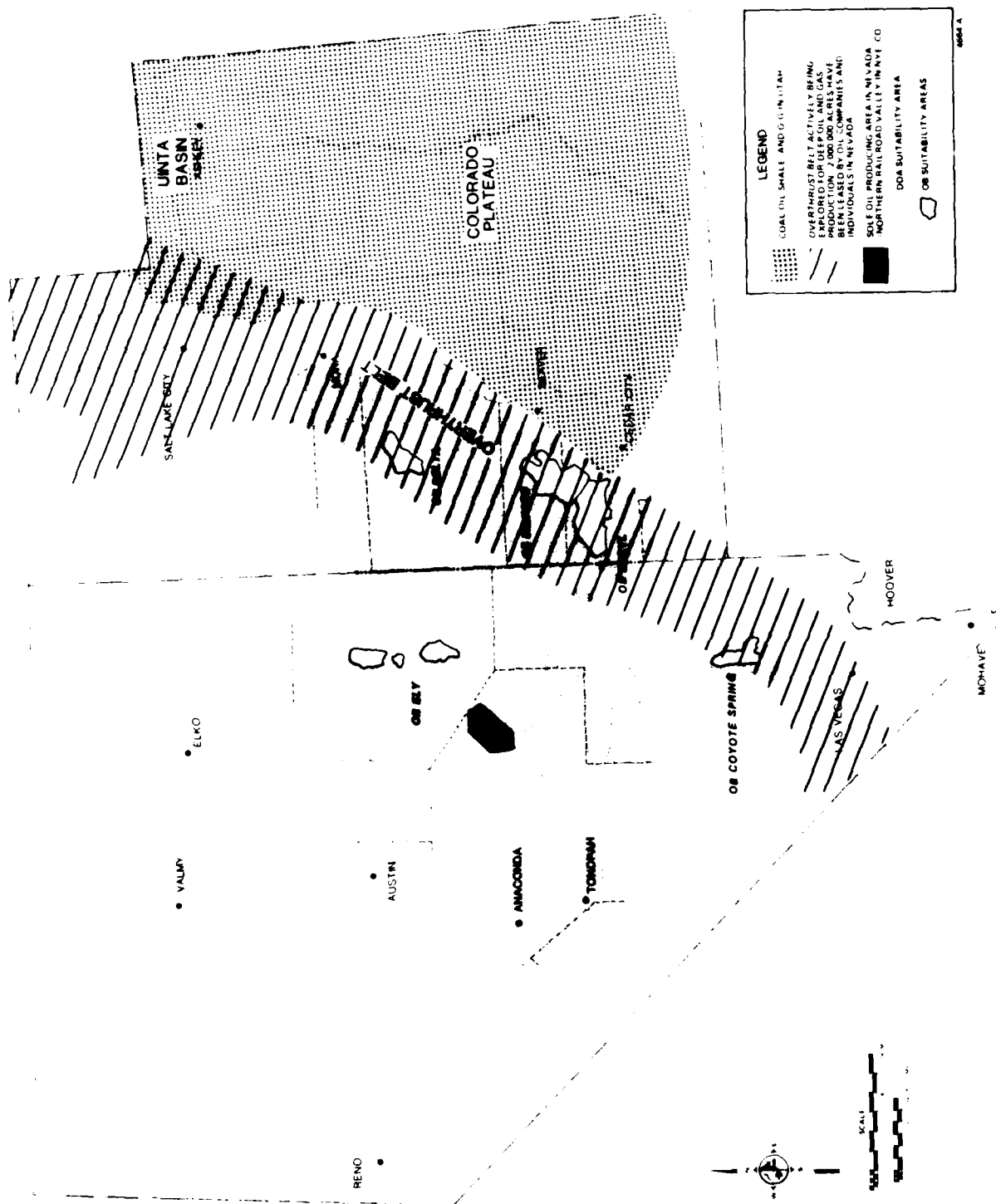


Figure 7.1-1. Oil/gas resource areas in Nevada/Utah.

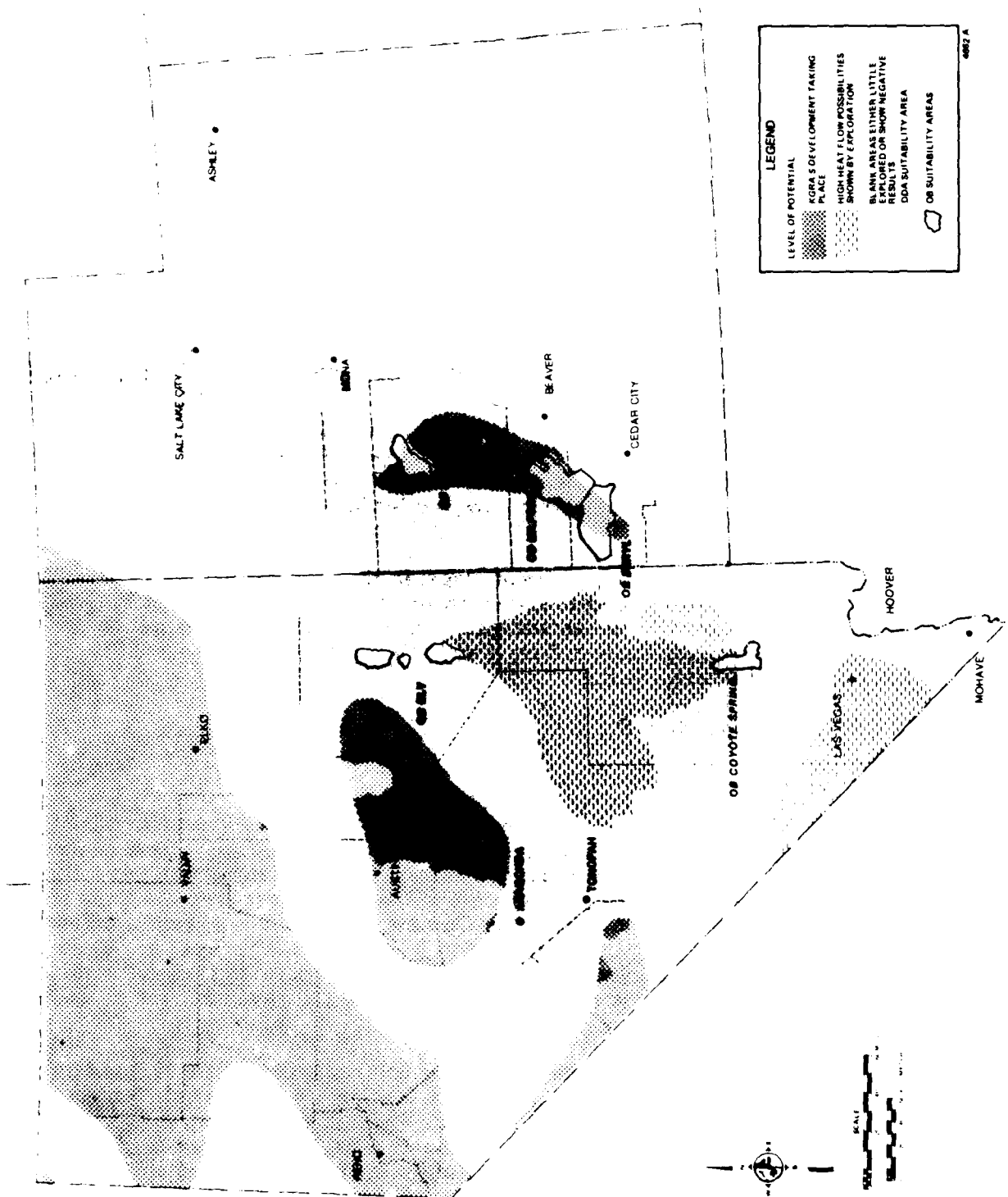


Figure 7.1-2. Geothermal resource areas in Nevada/Utah.

several others in the county. Because of access and transportation requirements and the large blocks of land necessary to make a production field economically feasible in remote areas, it can be expected that land withdrawal for M-X will interact directly with expanded energy development. However, mineral exploration or extraction employing drillholes is generally compatible with the M-X system since drilling requires little space and drill holes need not be directed straight down.

Oil and gas leasing cover approximately 3.9 million acres (1.6 million ha) of the deployment area. Of the total, 2.4 million acres (9.7 million ha) are in Nevada, and 1.5 million acres (6.1 million ha) are in Utah.

A conservative forecast is that by the year 2020 four fields will have been discovered within the deployment area and that they will have produced 20 million bbls (3.2 million cu m) of oil. At \$25 per bbl the fields will have yielded an income of \$500 million (Woodland, 1980).

GEOHERMAL (7.1.2)

Geothermal resources areas are fairly well defined in both states and do not require the same form of exploration as for oil and gas. A positive effect of M-X siting could be to produce funds for development of electrical-generating power from KGRAs for M-X facilities. Power not needed for M-X operations could be sold to communities.

There are several federal geothermal leases in the proposed M-X deployment area. If there is sufficient geothermal heat, there could be a 50 Mw plant in Utah and another in Nevada with an annual gross income each of \$8.76 million for 50 plant years - or a total income from both plants through the year 2020 of \$438,000 million (Woodland, 1980).

ENERGY PRODUCTION (7.1.3)

Nevada (7.1.3.1)

In 1978, 1.2 million barrels of crude oil were produced, valued at about \$6.7 million. Output is from two fields in Railroad Valley, Nye County. Most of the output is from the Eagle Springs field. The Trap Springs Field is not yet fully developed. These production areas are adjacent to the deployment area and there is potential for expansion into the area. The Currant Field discovery well is a few miles north of Eagle Springs, but no production is planned at the present. These resource areas are listed in Appendix A. Several firms have begun exploration activities in eastern Nevada, and nearly all public land that is available for oil and gas leases has been taken.

Presently, utilization of Nevada's geothermal resources is fairly limited. Space heating, domestic water heating, and pool heating are thus far the primary uses of geothermal heat, and most of these uses have been concentrated in the Truckee Meadows of Washoe County. Outside of this area, there has not been much utilization of geothermal heat. Most resource areas are remote from potential user areas.

The potential for geothermal energy development in Nevada is great because of the widespread occurrence of geothermal resources. Known geothermal resource areas comprised a total of 611,530 acres (244,612 ha) of land in the mid 1970s. These resource areas are listed in Table 7.1.3-1.

Utah (7.1.3.2)

Utah is one of the most energy-rich states of the west with 1978 production of coal, natural gas, and crude oil valued at more than \$630 million - an increase of 400 percent from the 1970 output. Ambitious projects are now underway and others are being planned for further development of these and other energy resources.

Utah's coal production during 1978 was about 10 million short tons (9,070,000 tonnes), highest in the state's history. The state's coal industry currently is in the midst of expansion. Public utilities and high energy-consuming industries in the Midwest and even in Japan have negotiated contracts for Utah coal. The national trend toward increased use of coal has given rise to projections of 1985 production ranging from 20 to 35 million tons (18 to 32 million tonnes).

Estimated recoverable reserves of Utah coal total almost 23.4 billion tons (21.2 billion tonnes), most of it in two main regions: in the center of the state are the Wasatch Plateau, Book Cliffs, and Emery Fields located in Carbon, Emery, Sevier, Sanpete, and Grand counties. In the southern region are the Kaiparowits Plateau, Alton, and Kolob coal fields of Coyote, Fairfield, Iron, and Washington counties.

Historically, the central region fields have accounted for the bulk of Utah's production with 97 percent of the cumulative output coming from Carbon and Emery counties alone. Although nearly 41 percent of the state's identified reserves are located in the Kaiparowits and Kolob fields, environmental concerns as well as the high cost of recovery have prevented large-scale development in this area to date. Table 7.1.3-2 indicates the remaining known reserves in the state.

According to the U.S. Bureau of Mines, Utah's marketed production of natural gas was 57.9 billion cubic feet, with a total value of \$32.6 million. Proved reserves of natural gas in the state are estimated at between 250 and 400 billion cu ft. However, much of the potentially petroliferous area of Utah is still untested and undiscovered gas reserves are considered to be very large.

Utah's 1978 production of crude petroleum totaled 32.3 million barrels and was valued at over \$345 million. Proved reserves of crude oil in Utah are estimated at 274 million barrels. Most of this is located in four large fields: Altamount/Bluebell and Great Red Wash Fields on the upper Uinta Basin; the Pineview Field in Summit County; and the Greater Aneth Field in the Four Corners region of southeastern Utah. In 1976, some 82 percent of Utah crude came from these four fields. Thus the bulk of Utah's petroleum production and reserves lie outside of the proposed M-X deployment area.

About 3,000 sq mi (7,800 sq km) in the Uinta Basin in northeastern Utah is underlain by oil shale 15 ft (4.5 m) thick and averaging at least 15 gallons of oil per ton. Gross oil in place in this overall area is estimated at 320 billion barrels. Oil

Table 7.1.3-1. Known geothermal areas in Nevada.

Name	Acreage
1. Baltazor	5,537.25
2. Beowawe	12,712
3. Brady-Hazen	98,446
4. Colado	640
5. Darrough Hot Springs	8,398
6. Dixie Valley	38,989
7. Double Hot Springs	29,326.16
8. Elko Hot Springs	8,960
9. Fly Ranch	20,599.38
10. Fly Ranch Northeast	7,680
11. Gerlach	26,326
12. Gerlach Northeast	7,971
13. Hot Spring Point	8,549
14. Kyle Hot Spring	2,561
15. Leach Hot Springs	8,957
16. Moana Springs	5,210
17. Monte Neva	10,302
18. Pinto Hot Springs	8,065
19. Ruby Valley Hot Spring	5,743
20. Rye Patch	801
21. Salt Water Basin	19,232
22. San Emidio Desert	7,678
23. Silver Peak	5,117
24. Soldier Meadow	5,966
25. Steamboat Springs	8,914
26. Stillwater-Soda Lake	225,211
27. Trego	7,013
28. Wabuska	11,520
29. Warm Springs	3,812
30. Wilson Hot Springs	1,294
Total	611,529.79

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Source: Mendive, D.L., Energy in Nevada, 1976,
p. 68.

Table 7.1.3-2. Identified remaining recoverable road reserves¹
in Utah; selected coal fields.

Coal Field	Remaining Reserves (Millions of Tons)	Percentage of Total
Kaiparowits Plateau	7,848	33.7
Wasatch Plateau	6,047	25.9
Book Cliffs	3,071	13.1
Kolob	2,012	8.6
Alton	1,509	6.5
Emery	1,425	6.1
Other Fields	1,447	6.2
Utah Total	23,389	100.0

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¹Includes measured, indicated, and inferred reserves.

Source: Utah Geological and Mineral Survey, 1978.

shale in the Uinta Basin is estimated to contain about nine times the current estimated United States reserves of crude oil.

Utah's reserve of oil in bituminous sandstone ("tar sand") is more than 90 percent of the United States measured total. The largest Utah deposits are in the Oil Shale Triangle just west of Canyonlands National Park and on the Asphalt Ridge near Vernal in Uintah County. According to the Utah Geological and Mineral Survey, it is estimated that there are 12 to 16 billion barrels in place in the Asphalt Ridge deposits. To date, recovery of petroleum from oil shale and bituminous sandstone has been minimal, due largely to environmental constraints, lack of a national energy policy, and the high costs of production with current technology.

Important, but largely undeveloped geothermal energy resources also exist throughout Utah (Table 7.1.3-3). So far, the most significant appear to be those located in the Roosevelt Hot Springs area, about 15 mi (24 km) northeast of Milford in Beaver County. Here, groundwater at temperatures as great as 240°C (465°F) has been found by Phillips Petroleum Company, Thermal Power Company, and others involved in deep drilling. This hot water flashes partly to wet steam as it flows up the drill hole to the surface, and the steam can be separated from the remaining water to power a turbine electrical generator.

It is anticipated that the Roosevelt Springs area northeast of Milford in Beaver County may ultimately produce 500,000 kilowatts or more of electrical power. Plans for construction of the first power-generating plant in the area were announced early in 1978 by Rogers International of San Francisco. A 55 Mw plant is proposed to begin operations in 1982. The power is to be purchased by Utah Power and Light Company.

Heat from the portion of geothermal fluid that does not flash to steam as well as heat from the steam condensate can be used for lower temperature applications such as space heating, greenhouse horticulture, pasteurizing milk, and many other uses. Undeveloped areas of Utah which have the potential for this type of geothermal development are Cove Fort and Thermo in west-central Utah.

Lower temperature (20° - 120°C) water issuing from springs or from drill holes is found at a number of locations in the state. In this category are the geothermal resources near Monroe (Crater Springs KGRA) in Sevier County.

7.2 TEXAS/NEW MEXICO

The possible M-X siting areas in Texas/New Mexico are unlike those in Nevada/Utah with regard to energy resources. This is mainly due to the dissimilarity of physiographic provinces, geologic structures and stratigraphy, and the general topographic changes from Basin and Range to the Great Plains. Figure 7.2-1 shows energy resources in the Texas/New Mexico study area. Energy Resources are also discussed in Section 3.2.

OIL AND GAS (7.2.1)

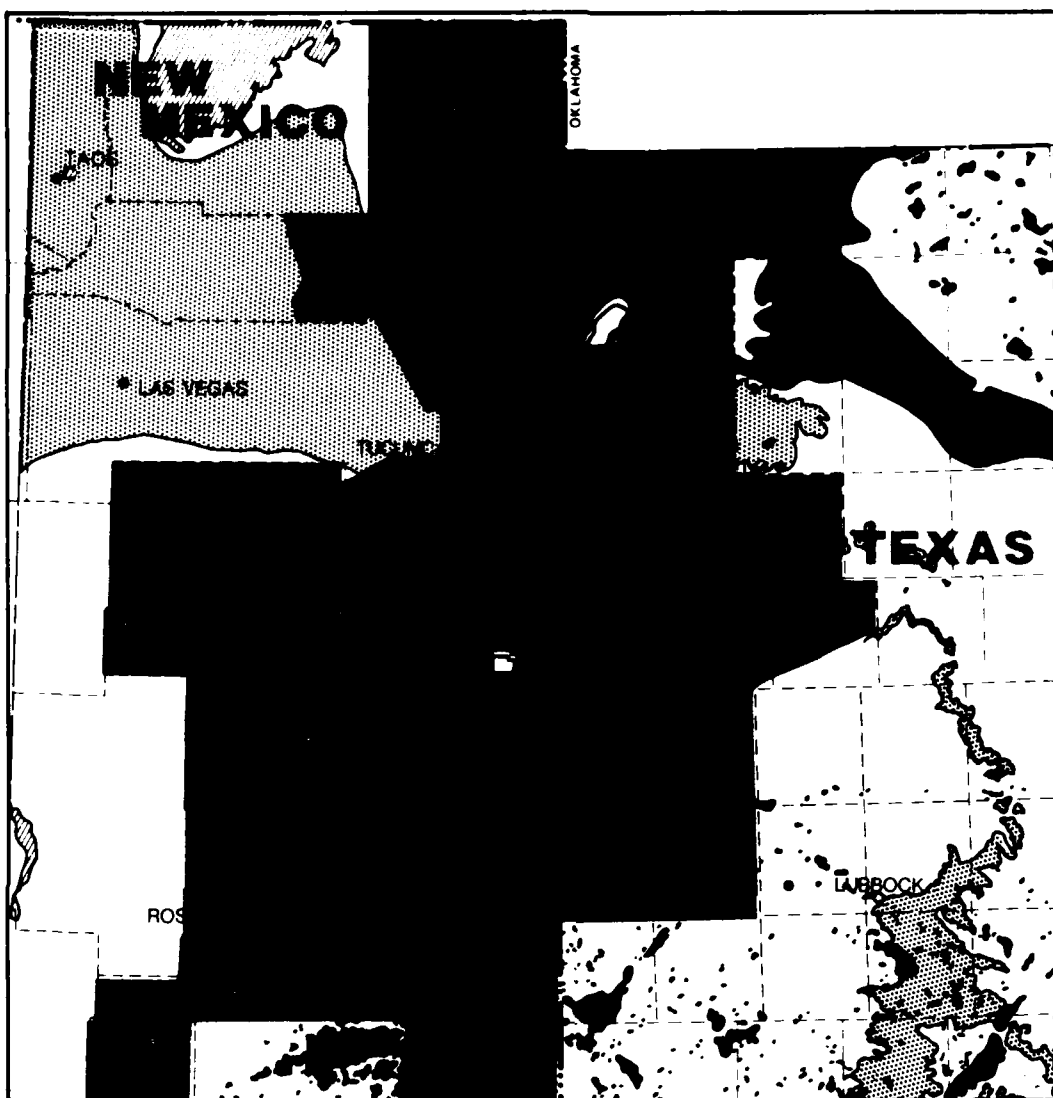
Of the four energy resources considered -- oil and gas, coal, geothermal, and U_3O_8 -- the first is the most readily available. Production facilities for hydrocarbons in sufficient supply to power M-X siting facilities are close to the siting areas

Table 7.1.3-3. Geothermal energy in Utah study area.

Sites	Acreage
Cedar City (211)	128,000
Milford (210)	640,000
Roosevelt Hot Springs (209)	768,000
Cove Fort (208) (207) (206)	896,000
Delta (205)	128,000
Total	2,560,000

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Note: Identifying numbers refer to individual hydrothermal connection systems for which thermal energies are listed in USGS Circular No. 770.



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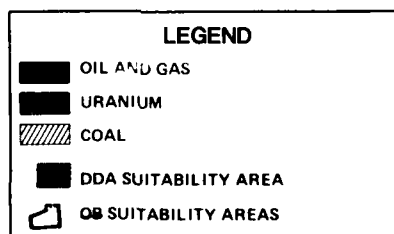
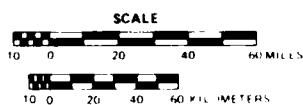


Figure 7.2-1. Energy resources in the Texas/New Mexico study area.

in eastern New Mexico and the Texas Panhandle. Natural gas and petroleum in the New Mexico portion of the study area are available in the following counties: Mora, Roosevelt, Chaves, Lea, and Eddy; in the Texas portion, Dallam, Hartley, Oldham, Sherman, Hansford, Ochiltree, Moore, Hutchinson, Roberts, Potter, Carson, Gray, Donley, Lamb, Hale, Motley, Cochran, Hockley, Lubbock, Dickens, Yoakum, Terry, Lynn, Garga, Kent, Gaines, Dawson, Borden, Andrews, Martin, and others in the Permian Basin. The Cimarron strip of Oklahoma, spreading over into fields in Kansas, presents further sources of oil and gas. Table 7.2.1-1 indicates the current level of activity within the study area.

The petroleum fields in this bistate county distribution within and surrounding the M-X study area are crisscrossed with pipelines of varying diameters transmitting both oil and gas and refined petroleum products.

In the proven oilfields of eastern New Mexico and the Texas Panhandle around Randall, Clovis, Amaville, and Dalhart there is a high potential for increased future production of hydrocarbons. Advances are being made in the improvement of oil-field equipment as well as drilling and production technology. Secondary recovery techniques applied to oil fields such as water-drive, functionation, and acid wash, are being supplemented by tertiary recovery using thermal methods and gas pressurization with carbon dioxide. These will increase production from known fields. Improvements in exploration techniques are leading to the discovery of new fields. The potential for new fields is good in parts of the study area.

COAL (7.2.2)

Coal as a source of energy is found in the siting areas of New Mexico and Texas and in the Raton field, extending into Colorado. Additional good coal in volume is found farther away in the San Juan Basin of New Mexico. Transportation of coal to power plants in the siting areas would require rail lines or other facilities to be built (i.e., pipeline transmission in slurry form).

URANIUM (7.2.3)

In the study area, uranium resources and some minor production (less than 200 lb) are reported in San Miguel, Harding, and Quay counties in northeastern New Mexico and in the Texas High Plains in Oldham, Potter, Randall, Deaf Smith, and Armstrong counties.

GEOHERMAL (7.2.4)

Geothermal energy sources are not sufficiently close to the M-X siting areas in eastern New Mexico and the Texas High Plains to be viable sources of direct power. The nature of this source of power requires a close site for direct use because of rapid heat losses. However, there are several known geothermal resource areas (KGRAs) and fields (KGRFs) in western New Mexico large enough to warrant serious consideration for possible power plant construction if sufficient heat is present. They could serve as a valuable supplement to existing gas and oil power supplies. The best known of the KGRAs in New Mexico are Jemez Mountain, Socorro Peak, Lightning Dock, and Kilbourne Hole. The Texas High Plains area does not have any exploitable geothermal energy potential.

Table 7.2.1-1. Current activity and future oil and gas development in the Texas/New Mexico study area.

County	Current Exploration Activity	Potential for Future Discovery
Texas		
Sherman	High	Moderate
Dallam	Moderate to High	Moderate
Hartley	Moderate to High	Moderate
Oldham	High	High
Deaf Smith	Low to Moderate	Low to Moderate
Parmer	Low to Moderate	Low to Moderate
Bailey	Low to Moderate	Low to Moderate
Cochran	High	Moderate
New Mexico		
Union	Low	Low
Harding	Low	Low
Quay	Low	Low
Curry	Low	Low
DeBaca	Low	Low
Roosevelt	Moderate	Moderate
Chaves	Moderate	Moderate

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Source: Woodward - Clyde, 1980.

7.3 IMPACTS, NEVADA/UTAH

Oil and gas leasing is extensive throughout the M-X deployment area. Most of the leasing is in areas of low potential. However, there is a high interest in potentially deep oil fields in the Overthrust Belt. The Overthrust Belt is producing oil and gas north of the project area in northern Utah and there are indications that the Mobil Oil deep test well on Mormon Mesa contained some shows. For the most part, the M-X project could be compatible with a producing oil field since only 2.5 acre parcels would be withdrawn. The additional road network could improve access to well fields. During construction there could be some access conflicts.

The effect of full deployment of the M-X project on the energy resources of Nevada and Utah is difficult to establish. A large percentage of the geotechnically suitable area is held in oil and gas leases. It should be possible for the M-X system to coexist with active oil fields but some access problems may result. There may be some conflicts between M-X operation and some petroleum exploration techniques. There could be indirect impacts resulting from competition for labor and materials if development of yet-to-be-discovered oil fields was to take place concurrently with M-X construction.

Uranium deposits have been discovered in the project area and much exploration work is currently being done. Some uranium is contained in sedimentary deposits occurring in the valley fill. Depending on the extraction technique, some conflicts with M-X siting could ensue.

Geothermal resources are scattered throughout the M-X deployment area. The geothermal resource areas in the deployment area are currently avoided by M-X siting. There is thus no impact on potential development of geothermal resources. It is possible that the M-X project could provide an impetus for accelerated development of the geothermal resources.

7.4 IMPACTS, TEXAS/NEW MEXICO

New Mexico's main oil- and gas-producing area lies in the southeast quarter of the state. Except for a few scattered, small fields just east of Roswell, the M-X siting areas avoid any large scale production areas.

The contiguous Texas High Plains do include a northward extension of the west Texas Permian Basin. However, except for a few small oil-producing patches, northwest of Lubbock, there is little impact created by M-X.

The Western Oil and Gas Association has adopted the following policy for Nevada and Utah and the same precepts can be extended to the Texas/New Mexico region.

PUBLIC COMMENTS ON THE DRAFT EIS:

"WHEREAS, the United States Air Force proposes to establish the M-X Missile System in the states of Nevada and Utah, and "WHEREAS, the system as presently contemplated, could close approximately 136,000 acres of public lands to oil and gas exploration and leasing in the

establishment of 200 linear mode systems, each containing 23 shelters of 2-1/2 acres each to conceal an M-X Missile, plus three support bases, each encompassing 7,000 acres of lands, and "WHEREAS, the United States Air Force is agreeable to the conduct of exploration, drilling and production activities around and between each of the 2-1/2 acre shelters which will be located 5,200 ft from one another and will allow industry use of the extensive road network which will be constructed in support of the M-X Missile System. "NOW, THEREFORE, BE IT RESOLVED that this Board of Directors strongly supports the multiple use of the public lands and believes that adequate oil and gas exploration can co-exist with the M-X Missile System as presently proposed by the Air Force." (A0051-2-001)

Atlantic Richfield expressed an opposite view on the impacts on the oil and gas industry. They stated that there is extensive hydrocarbon production at this time in eastern New Mexico and west Texas, and there are several counties in this area that have a high potential for hydrocarbons. The counties in New Mexico in which the proposed system would be located are active areas of exploration and development of oil and gas and are expected to remain so. In Texas, Cochran, and Hockley counties are long time producers; development work and production operations are expected to continue for many years. The remaining M-X study area is in the Palo Duro Basin where exploration and development activities could have a serious impact on future production. Of particular concern is the likelihood that delays would be caused by special permits or additional reporting requirements (including project environmental impact statements) that might be required.

Another concern expressed by Atlantic Richfield was the impact to the carbon dioxide field in Union and Harding counties, New Mexico. Carbon dioxide will be used to increase recovery in older fields and is anticipated to increase recovery 10 to 30 percent they envision serious conflict with M-X deployment and carbon dioxide pipelines through the area.

Uranium in New Mexico is widely found, particularly in the Grants area of the west-central part of the state. There are also known occurrences in the northeast quarter of the state, but M-X siting areas skirt the limits of the known deposits and thus have no direct impact. A possibility exists that there could be unexplored extensions of uranium mineralization into the study area which could be excluded by M-X siting. Edges of a large east-west uranium mineralized belt west and southwest of Amarillo are within the M-X deployment area.

7.5 MITIGATIONS

If M-X deployment was revised in the Nevada/Utah, there could be important changes in the impacts with regard to energy resources. If valley or basin accommodation changes in M-X siting were to adjust to petroleum exploration and production needs, there could be little curtailment in the development of potentially discoverable hydrocarbons in the Great Basin.

8.0 ZEOLITES

8.1 INTRODUCTION

Zeolites are considered elsewhere under the category of mineral resources. Potentially, these minerals are of great societal value due to their versatile use in industrial and environmental processes. The demand for zeolites will increase in the future as will the number of their applications. Inevitably, the exploitation of these resources will bear on the issue of health risk assessment. M-X deployment may be a potential factor in zeolite mining activities inasmuch as the presently-planned system is, in part, located within geologic environments favorable to the occurrence of economic zeolite deposits. With or without formal definition of the degree of health risk, it seems probable that in the future, pertinent governmental agencies will promulgate policies about worker and public exposure to zeolites. A sound public policy governing encounters with zeolites might well anticipate and ameliorate most issues of concern.

8.2 GEOLOGIC OCCURRENCE AND NATURAL SYNTHESIS

Zeolites occur in a wide variety of geologic environments within metamorphic, sedimentary, and volcanic rocks. They are formed from preexisting minerals or mineraloids under conditions of low pressure and low temperature in the presence of water liquid or vapor. Zeolites find wide distribution in volcanic terrains, characterized by abundant pyroclastic rocks and sedimentary deposits derived from volcanic rocks. Glass, major constituent of these rocks, tends to devitrify rapidly in hydrous, alkaline environments, forming zeolites among other products.

8.3 OCCURRENCE IN THE DEVELOPMENT AREA

PHYSICAL OCCURRENCE (8.3.1)

On the basis of their association with volcanic deposits and in view of the requisite conditions for natural synthesis, several inferences are possible concerning zeolite occurrence in the various geologic environments common to the Great Basin. In general, the occurrence of voluminous pyroclastic and volcanoclastic rocks in the M-X deployment area suggests that zeolites may also be very widespread. Zeolites are undoubtedly more common than would be supposed from the published record alone, given the difficulties of field identification and the lack of past emphasis on their development. However, they are not likely to be present everywhere in high abundance, much less in economic quantities.

Areas of zeolite occurrence that have attracted commercial interest, regardless of whether significant production ensued, are shown on Figure 8.3.1-1. Unfortunately, other areas which might now, or in the future, be commercialized, and still others that contain high but noneconomic concentrations of zeolites are impossible to identify from the published sources at hand. On the tentative assumption that the highest degree of potential health hazard is generally related to high zeolite concentration, a policy of simple avoidance of large deposits would appear to reduce the problem in the locations shown in Figure 8.3.1-2. However, the minimum level of zeolite exposure constituting a health hazard has not been determined, hence, it is difficult to judge the corresponding minimum level of zeolite concentration in rocks and soils that could be associated with disease risk.

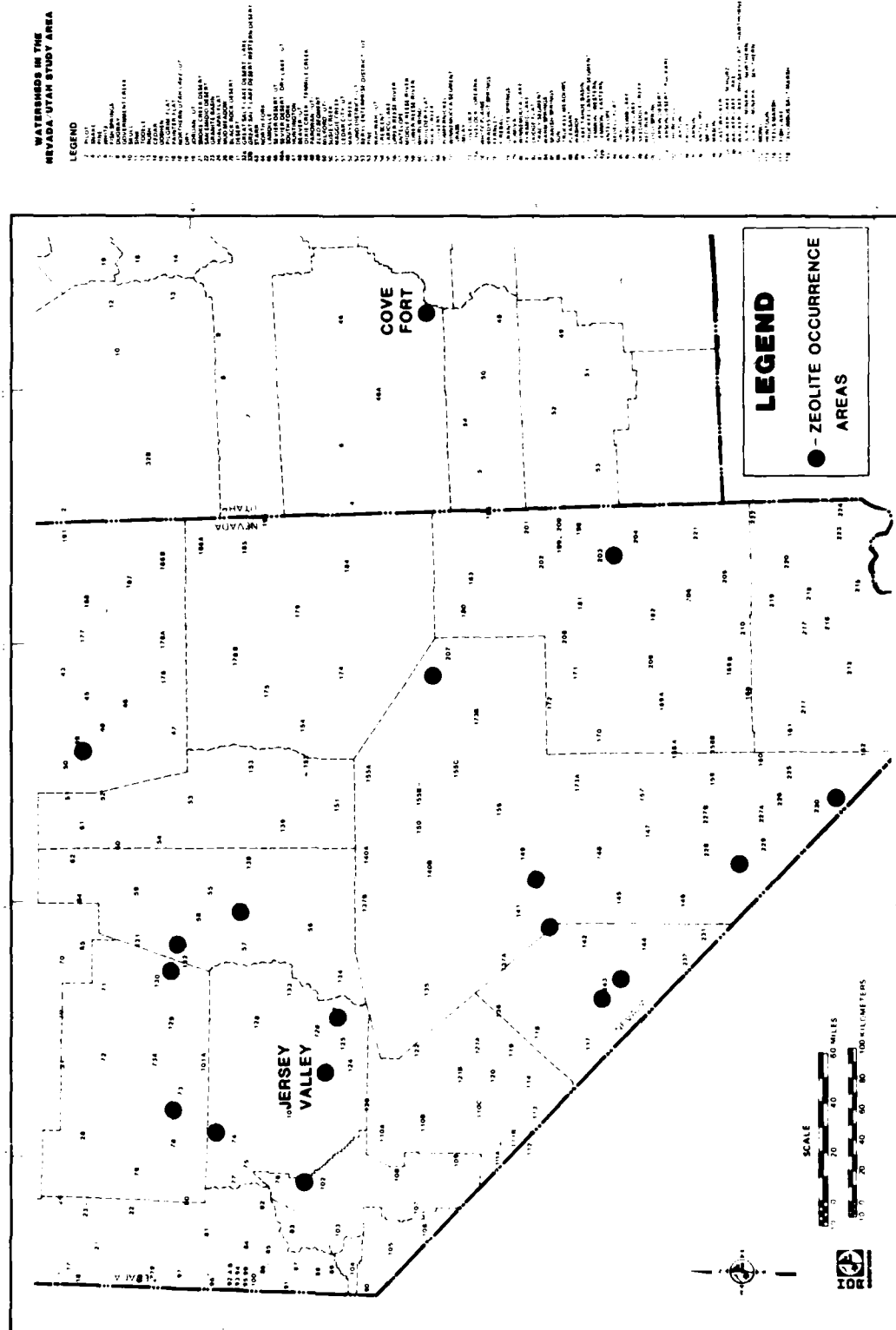


Figure 8.3.1-1. Locations of commercial interest in zeolites.

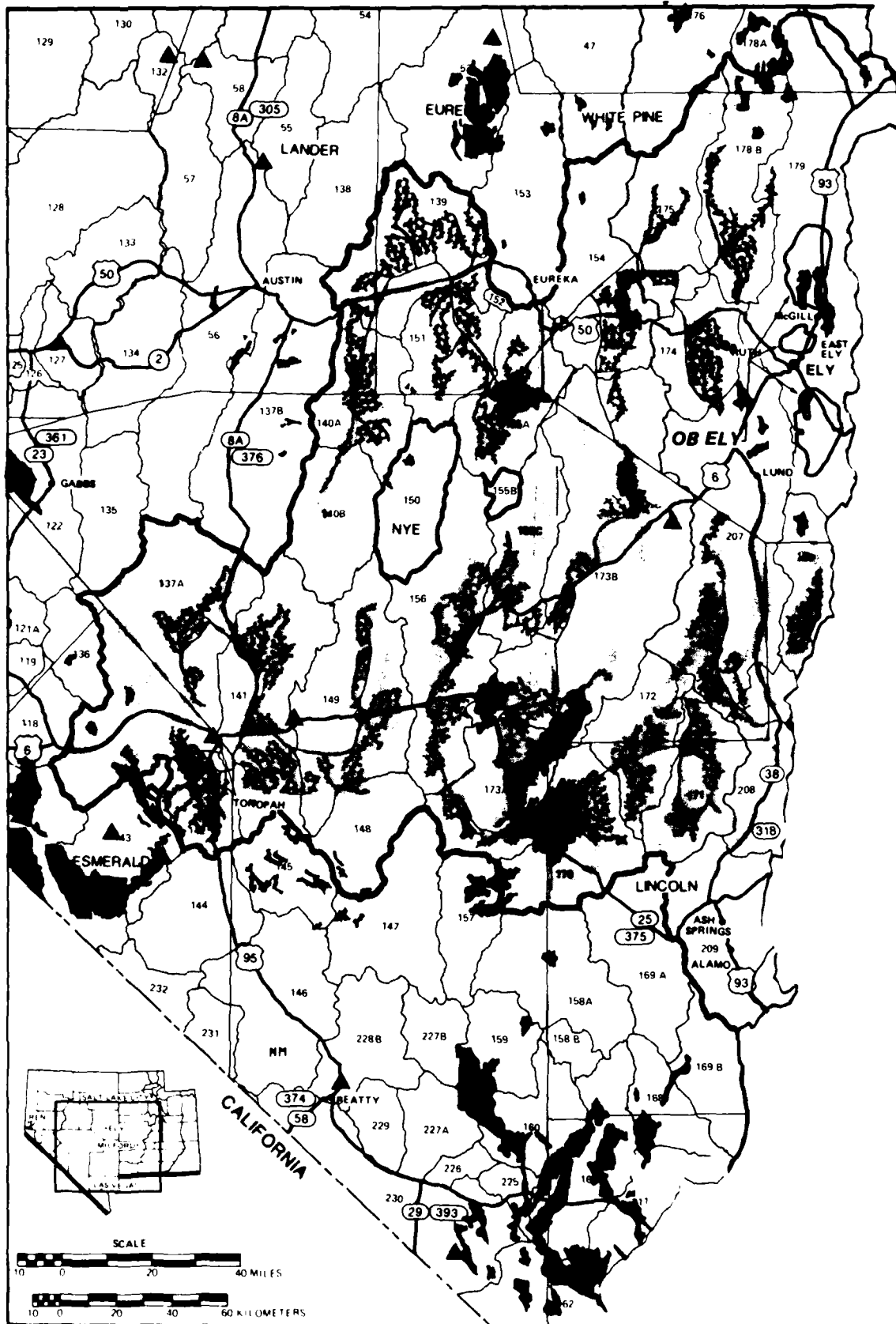
Zeolite as a detrital component of desert substrates has, not been widely discussed in the literature and the extent of its possible concentration within fluvial systems is unknown. Where greatly diluted by non-zeolite detritus, it ceases to be a significant factor in health terms. Locally, however, some drainages may tap zeolite-rich sources, in which case some parts of the local fluvial system may be zeolite-rich, or, depending on the mechanics of deposition, concentrated by size and density.

Most of the presently known economic deposits come from exposed sections of lake beds older than the formation of the playas. This is important in relation to M-X deployment because the system layout presently occupies the terrain between the playas and the mountain blocks in which these older lake bed sections are most likely to exist.

It seems inevitable that zeolites will be encountered during M-X construction but it is by no means certain or even highly probable that any encounter will necessarily involve large abundances. The simple expedient of conducting reconnaissance geologic surveys well in advance of an engineering design layout would be very helpful in further reducing the chances of encountering large concentrations.

FUTURE EXPLORATION AND DEVELOPMENT (8.3.2)

Given the current status of zeolite mining and exploration in the deployment area, the placement of M-X personnel within it could be done with little or no conflict with these mining activities and presumably without exposing such personnel to excessive zeolite exposure. If zeolite development increases in the future, however, a potential for increased exposure exists. Mining operations may degrade air quality, and populations downwind of these locations could be exposed to increases in airborne zeolites and other particulates. Population centers built over presently unknown zeolite deposits or which use drainage systems tapping zeolite-rich deposits may be subjected to higher levels of exposure. See Public Health and Safety ETR for a discussion of how zeolites affect health issues.



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9.0 BIBLIOGRAPHY OF CITED AND SUPPLEMENTARY LITERATURE

CHAPTER 2.0 REFERENCES

- Dott, R. H., Jr., and R. L. Batten, 1976. Evolution of the Earth, Second Edition. New York: McGraw-Hill.
- Flint, R. F., 1971. Glacial and Quaternary Geology. New York: John Wiley.
- Thornbury, W. D., 1965. Regional Geomorphology of the United States. New York: John Wiley.

CHAPTER 3.0 REFERENCES - GREAT BASIN

- Albers, J. P., and J. H. Steward, 1972. "Geology and Mineral Deposits of Esmeralda County, Nevada," Nevada Bureau Mines Bull. 78.
- Baker, Sachbold, and Stoll, 1972.
- Baker III, Arthur, N. L. Archbold, and W. J. Stoll, 1973. "Forecasts for the future - Minerals," Nevada Bureau Mines Bull. 82.
- Bryan, D. P., and K. G. Papke, 1980. "Industrial Minerals of Nevada," Soc. Mng. Engrs. Meeting Pre-print.
- Cornwall, H. R., 1972. "Geology and Mineral Deposits of Southern Nye County, Nevada," Nevada Bureau Mines Bull. 77.
- Ertec, Western Inc., 1981. "Mineral Resources Survey: Seven Additional Valleys Nevada/Utah Siting Area."
- Garner, 1979.
- Garside, L. J., 1973. "Radioactive Mineral Occurrences in Nevada," Nevada Bureau Mines Bull. 81.
- Granger, A. E., M. M. Bell, G. C. Simmons, and Florence Lee, 1957. "Geology and Mineral Resources of Elko County, Nevada," Nevada Bureau Mines Bull. 54.
- Horton, R. C., 1962. "Barite Occurrences in Nevada," Nevada Bureau Mines Map No. 6.
- Hose, R. K., M. C. Blake, Jr., and R. M. Smith, 1976. "Geology and Mineral Resources of White Pine County, Nevada," Nevada Bureau Mines Bull. 85.
- Fugro National, Inc., 1981. "MX Mineral Resources Survey: Nevada/Utah Siting Area."
- Jerome, S. E., and D. R. Cook, 1967. "Relation of some Metal Mining Districts in the Western United States to Regional Tectonic Environments and Igneous Activity," Nevada Bureau Mines Bull. 69.
- Johnson, M. G., 1977. "Geology and Mineral Deposits of Pershing County, Nevada," Nevada Bureau Mines Bull. 89.
- Kral, V. E., 1950. "Mineral Resources of Nye County, Nevada," Nevada Bureau Mines Bull. 50.
- Koschmann, A. H., and M. H. Bergendahl, 1968. "Principal Gold-Producing Districts of the United States," Geological Survey.
- Larson, L. T. et al., 1978. "Great Basin Geologic Framework and Uranium Favorability," Bendix Field Engineering Corporation for U.S. Department of Energy.

Lawrence, E. F., and R. V. Wilson, 1962. "Mercury Occurrences in Nevada," Nevada Bureau Mines Map No. 7.

Longwell, C. R., E. J. Pampeyan, Ben Bowyer, and R. J. Roberts, 1965. "Geology and Mineral Deposits of Clark County, Nevada," Nevada Bureau Mines Bull. 62.

McQuiston, Jr., F. W., and R. S. Shoemaker, 1975. "Gold and Silver Cyanidation Plant Practice," Society of Mining Engineers (AIME).

Nevada Employment Security Department, 1977. Nevada Statistical Abstract.

Nevada Employment Security Department and University of Nevada, Bureau of Business and Economic Research, Nevada Review of Business and Economics, Summer 1978, p. 14; Fall 1979, p. 20.

Papke, K. G., 1979. "Fluorspar in Nevada," Nevada Bureau of Mines Bull. 93.

Roberts, R. J., K. M. Montgomery, and R. E. Lehner, 1967. "Geology and Mineral Resources of Eureka County, Nevada," Nevada Bureau Mines Bull. 64.

Ross, D. C., 1961. "Geology and Mineral Deposits of Mineral County, Nevada," Nevada Bureau of Mines Bull. 58.

Shawe, D. R., 1978. "Guidebook to Mineral Deposits of the Central Great Basin," Nevada Bureau of Mines Report 32.

Schilling, J. H., 1962. "Molybdenum Occurrences in Nevada," Nevada Bureau Mines Map No. 8.

_____. 1962. "Vanadium Occurrences in Nevada," Nevada Bureau Mines Map No. 10.

State of Nevada Industrial Commission, 1979. Directory of Nevada Mine Operations Active During Calendar Year 1978.

_____. 1980. Directory of Nevada Mine Operations Active During Calendar Year 1979.

_____. 1981. Director of Nevada Mine Operations Active During Calendar Year 1980.

Stewart, J. H., E. E. McKee, and H. K. Stager, 1977. "Geology and Mineral Deposits of Lander County, Nevada," Nevada Bureau Mines Bull. 68.

Tschanz, C. M., and E. H. Pampeyan, 1970. "Geology and Mineral Deposits of Lincoln County, Nevada," Nevada Bureau Mines Bull. 73.

U.S. Army Corps of Engineers, 1980. Real Estate Planning Report: MX Advanced ICBM Program: Great Basin Candidate Siting Province: Nevada and Utah.

U.S. Bureau of Economic Analysis, 1979. Regional Economics Information System, April.

U.S. Bureau of Land Management, 1977. Facts and Figures for Utah, p. 26

U.S. Geological Survey, 1976.

U.S. Bureau of Mines, 1976. Minerals Yearbook.

Utah Department of Employment Security, 1978. Utah! Facts, II:21,22, University of Utah, Bureau of Economic and Business Research.

Willden, Ronald, 1964. "Geology and Mineral Deposits of Humboldt County, Nevada," Nevada Bureau Mines Bull. 59.

Willden, Ronald, and R. C. Speed, 1974. "Geology and Mineral Deposits of Churchill County, Nevada," Nevada Bureau Mines Bull. 83.

Woodward, W. M., 1980. Mining Engineering Study: M-X Great Basin Candidate Site, Nevada-Utah.

_____ and AIM, 1978. Mineral Appraisal Report: MX Great Basin Candidate Site: Nevada and Utah.

CHAPTER 3.0 REFERENCES - TEXAS/NEW MEXICO

- Adams, S. S., 1969. "Bromine in the Salado Formation, Carlsbad Potash District New Mexico," New Mexico Bureau of Mines and Min. Res., Bull. 93.
- Anderson, E. C., 1954. "Occurrences of Uranium Ores in New Mexico," New Mexico Bureau of Mines and Min. Res. Cir. 29.
- _____. 1959. "Carbon Dioxide in New Mexico," New Mexico Bureau of Mines and Min., Res., Cir. 32.
- Baker, C. L., 1931. "Volcanic Ash in Texas," Texas Bureau of Econ. Geology, Min. Res. Cir. No. 2.
- _____. 1932. "Barite in Texas," Texas Bureau of Econ. Geology, Min. Res. Cir. No. 4.
- _____. 1932. "Fuller's Earth and Bentonite in Texas," Texas Bureau of Economic Geology, Min. Res. Cir. No. 3.
- _____. 1932. "Gold in Texas," Texas Bureau of Econ. Geology, Min. Res. Cir. No. 5.
- _____. 1935. "Sulphur in Texas," Texas Bureau of Econ. Geology, Min. Res. Cir. No. 6.
- Butler, A. P., W. I. Finch, and W. S. Twenhofel, 1962. "Epigenetic Uranium in the United States," U.S. Geological Survey Min. Inv. Res. Map MR-21.
- Byrd, M. F., 1955. "Potash Occurrences in the United States," U.S. Geology Survey, Min. Inv. Res. Map MR-3.
- Clippinger, D. M., 1946. "Building Blocks from Natural Lightweight Materials of New Mexico," New Mexico Bureau of Mines and Min. Res., Bull. 24.
- Clippinger, D. M., and W. E. Gay, 1947. "Pumice Aggregate in New Mexico, Its Uses and Potential," New Mexico Bureau of Mines and Min. Res., Bull. 28.
- Dorfman, M., and R. O. Kehle, 1974. "Potential Geothermal Resource of Texas," Texas Bureau of Economic Geol. Cir. 74-4.
- Eargle, D. H., 1956. "Some Uranium Occurrences in West Texas," Texas Bureau of Economic Geol., Rep. Inv. No. 27.
- Ellison, Jr., S. P., 1971. "Sulfur in Texas," Texas Bureau of Economic Geol., Handbook No. 2.
- Evans, G. L., (nd), "Strontium Mineral in Texas," Texas Bureau of Econ. Geo., Min. Res. Sur. Cir. No. 46.
- File, L. A., 1965. "Directory of Mines of New Mexico," New Mexico Bureau of Mines and Min. Res., Cir. 77.

- Garner, L. E., A. E. St. Clair, and T. J. Evans, 1979. "Mineral Resources of Texas," Texas Bureau of Econ. Geol., Map.
- Garner, L. E., R. D. Sharpe, and M. E. McClelland, 1980. "Computer-Generated List of Texas Mineral Producers (Exclusive of Oil and Gas)."
- Girard, R., 1970. "Texas Mineral Producers," Texas Bureau of Econ., Geol..
- Horley, G. T., 1940. "The Geology and Ore Deposits of Northeastern New Mexico," New Mexico Bureau of Mines and Min. Res., Bull. No. 15.
- Hawkins, M. E., and T. J. Evans, 1975. "The Mineral Industry of Texas in 1975," Texas Bureau of Econ. Geology, Min. Res. Cir. No. 60.
- Kottowski, F. E., 1962. "Reconnaissance of Commercial High Calcium Limestones in New Mexico," New Mexico Bureau of Mines and Min. Res., Cir. 60.
- McAnulty, Sr., W. N., 1974. "Fluorspar in Texas," Texas Bureau of Econ. Geol. Handbook 3.
- Mendive, D. L., 1976.
- New Mexico Bureau of Mines and Min. Res., 1965. "Mineral and Water Resources of New Mexico," (report to U.S. Senate).
- Redfield, R. C., 1942. "Bauxite and Aluminum," Texas Bureau of Econ. Geol., Min. Res. Cir. No. 18.
- Schnabel, R. W., 1955. "The Uranium Deposits of the United States," U.S. Geological Survey, Min. Inv. Res. Map MR-2.
- Sellards, E. H., 1930. "Graphite in Texas," Texas Bureau of Econ. Geol. Min. Res. Cir. No. 1.
- Sellards, E. H., and G. L. Evans, 1944. "Index to Mineral Resources of Texas of Counties," Texas Bureau of Econ. Geol., Min. Res. Cir. No. 29.
- Siemers, W. T., and G. S. Austin, 1979. "Active Mines and Processing Plants in New Mexico," New Mexico Bureau of Mines and Min. Res., Map 9.
- Stotelmeyer, R. B., 1969. "New Mexico's 1967 Mineral Production by Counties," New Mexico Bureau of Mines and Min. Res., Min. Res. Rep. 1.
- Talmage, S. B., and T. P. Wootton, 1937. "The Non-Metallic Mineral Resources of New Mexico and Their Economic Features," New Mexico Bureau of Mines and Min. Res., Bull. No. 12.
- U.S. Geological Survey, 1965. "Uranium in Texas," Map.
- Weber, R. H., and F. E. Kottowski, 1959. "Gypsum Resources of New Mexico," New Mexico Bureau of Mines and Min. Res., Bull. 68.

Whithington, C. F., 1962. "Gypsum and Anhydrite in the United States," U.S. Geological Survey, Min. Inv. Res. Map MR-33.

Woodland, 1980.

Zimmerman, J. B., and E. Thomas, 1969. "Sulfur in West Texas: Its Geology and Economics," Texas Bureau of Econ. Geol. Cir. 69-2.

CHAPTER 4.0 REFERENCES

- Albee, A. L., and J. L. Smith, 1966. "Earthquake characteristics and fault activity in southern California," Lung, R., and R. Proctor, eds., Engineering Geology in Southern California. Association of Engineering Geologists, Los Angeles Section, Special Publication: Glendale, California, p. 9-34.
- Albers, J. P., 1967. "Belt of Sigmoidal bending and right-lateral faulting in the western Great Basin," Geological Society of America Bulletin, 78, p. 143-156.
- Anderson, L. W., and D. G. Miller, 1979. "Quaternary fault map of Utah," Long Beach, California: Fugro, Inc.
- Anderson, R. E., 1973. "Large-magnitude late Tertiary strike-slip faulting, north of Lake Mead, Nevada" (abstract), U.S. Geological Survey Professional Paper 794.
- Anderson, R. E., R. C. Buckman, and R. E. Wallace, 1978. "Seismotectonics of Utah and Nevada" (abstract), U.S. Geological Survey Professional Paper, p. 259-260.
- Anderson, R. E., E. B. Ekren, and L. Wright, 1977. "Late Cenozoic fault patterns and stress fields in the Great Basin and westward displacement of the Sierra Nevada Block," Geology, 5, 7, p. 388-392.
- Arabasz, W. J., R. B. Smith, and W. D. Richins, 1979. "Earthquake Studies in Utah 1850 to 1978," University of Utah Seismograph Stations. Department of Geology and Geophysics, University of Utah.
- Armstrong, R. L., 1972. "Low-angle (denudation) faults, Hinterland of the Sevier Orogenic Belt, eastern Nevada and western Utah," Geological Society of America Bulletin, 83, (6), p. 1729-1754.
- Artem'yev, M. Ye, I. M. Rotvayn, A. M. Sadovskiy, and V. I. Keylis-Borok, 1977. "Recognized places of intense earthquake formation; Part VII, using Bouguer gravity anomalies for California and neighboring regions," Vychis. Seismol., 10, p. 19-31.
- Atwater, T., 1970. "Implications of plate tectonics for the Cenozoic tectonic evolution of western North America," Geological Society of America Bulletin, 81, p. 3513-3536.
- Bateman, P. C., 1961. "Willard D. Johnson and the strike-slip component of fault movement in the Owens Valley, California, earthquake of 1872," Seismological Society of America Bulletin, 51, (4), p. 483-493.
- Bayer, K. C., 1974a. "A preliminary seismicity study of the southern Nevada region, quarterly report, April-June 1973," U.S. Geological Survey, Branch Seismicity Eng., Las Vegas.
- Bayer, K. C., 1974b. "Seismic data report southern Nevada region, December 1971-December 1972," International Journal of Rock Mechanics and Mineral Science, 11, (3), p. 55A.

- Bechtold, I. C., M. A. Liggett, and J. F. Childs, 1973a. "Regional tectonic control of Tertiary mineralization and recent faulting in the southern Basin-Range Province, an application of ERTS-1 data," U.S. National Aeronautical Space Administration, Symposium on significant results obtained from the Earth Resources Technology Satellite-1, v. I, Technical Presentations, Special Publications 327, p. 425-432.
- _____. 1973b. "Remote sensing reconnaissance of faulting in alluvium, Lake Mead to Lake Havasu," Geology, Seismicity, and Environmental Impact, Associated Engineering Geologists, p. 157-161.
- Beck, P. J., 1970. "The southern Nevada-Utah border earthquakes, August to December, 1966," Master's thesis, University of Utah.
- Bell, E. J., C. O. Sanders, and D. B. Slemmons, 1978. "Geologic and geometric analysis of conjugate strike-slip faults and regional strain in the western Basin and Range Province," Geological Society of America, Abstracts with Programs, 10, (3), p. 95.
- Bell, E. J., and D. B. Slemmons, 1979. "Recent crustal movements in the central Sierra Nevada-Walker Lane region of California-Nevada, Part II, The Pyramid Lake right-slip fault zone segment of the Walker Lane," Whitten, C. A., Green, R., Meade, B. K., eds., Recent crustal movements: Tectonophysics, 52, (1-4), p. 571-583.
- Bell, E. J., and D. T. Trexler, 1979. "Structural and tectonic analysis of the Dixie Valley fault zone, northeastern Dixie Valley, Nevada," Geological Society of America, Cordilleran Section, 75th Annual Meeting, San Jose, California, Abstracts with Programs, 11, (3), p. 69.
- Bell, J. W., 1979. "Origin of prehistoric faulting in Las Vegas Valley, Nevada," Geological Society of America, Cordilleran Section, 75th Annual Meeting, San Jose, California, Abstracts with Programs 11, (3).
- _____. 1980. "Subsidence in Las Vegas Valley," Nevada Bureau of Mines and Geology Bulletin 95.
- Behrman, P. G., 1979. "Features of the Melones fault zone, central Sierra Nevada foothills, California," Geological Society of America, Cordilleran Section, 75th Annual Meeting, San Jose, California, Abstracts with Programs, 11, (3), p. 68-69.
- Berg, J. W., Jr., K. L. Cook, H. D. Narans, Jr., and W. M. Dolan, 1960. "Seismic investigation of crustal structure in the eastern part of the Basin and Range province," Seismological Society of America Bulletin, 50, p. 511-535.
- Berger, B. R., and B. E. Taylor, 1974. "Pre-Cenozoic age for "basin-range" faulting, Osgood Mountains, north-central Nevada," Geological Society of America Abstract, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, 6, (3), p. 145.

- Bingler, E. C., 1975. "Geologic and geophysical studies for seismic microzonation of the Reno area," Geological Society of America Abstracts with Programs, 7, (3), p. 299.
- Birkeland, P. W., 1968. "Correlation of Quaternary stratigraphy of the Sierra Nevada with that of the Lake Lahontan area," in Morrison, R. B., and Wright, H. E., Jr., eds., Means of correlation of Quaternary successions, IAQR proceedings, 8, Salt Lake City, University of Utah Press, p. 469-500.
- Blackwelder, Eliot, 1931. "Pleistocene glaciation in the Sierra and Basin Ranges," Geological Society of America Bulletin, 42, p. 865-922.
- Bohannon, R. G., 1978. "Strike-slip faults in Lake Mead area of southern Nevada" (abstract), U.S. Geological Survey Professional Paper, p. 71.
- Bohannon, R. G. and R. E. Anderson, 1978. "Tertiary tectonic history of the eastern Basin and Range Province in the vicinity of Lake Mead in southern Nevada and western Arizona," Geological Society of America Abstracts with Programs, 10, (3), p. 96-97.
- Bohannon, R. G., 1979. "Strike-slip faults of the Lake Mead region of southern Nevada," Armentrout, J. M., ed., Cenozoic paleogeography of the western United States, Pacific Coast Paleogeographical Symposium, (3), p. 129-139.
- Bonilla, M. G., "Surface faulting and related effects," Wiegel, R. L., ed., Earthquake engineering: New York: Prentice-Hall, p. 47-74.
- Bonilla, M. G. and J. M. Buchanan, 1970. "Interim report on worldwide historic surface faulting," U.S. Geological Survey Open-File Report.
- Braile, L. N., et al., 1974. "Crustal structure across the Wasatch Front from detailed seismic refraction studies," Journal of Geophysical Research, 79, (17).
- Briggs, Peter, Frank Pren, and S. A. Guberman, 1977. "Pattern recognition applied to earthquake epicenters in California and Nevada," Geological Society of America Bulletin, 88, p. 161-173.
- Bucknam, R. C., 1980. "Characteristics of active faults in the Great Basin," Summaries of Technical Reports, v. IX., National Earthquake Hazards Reduction Program: U.S. Geological Survey Open-File Report 80-6, p. 94-95.
- Bucknam, R. C., S. T. Algermissen, and R. E. Anderson, 1979. "Late Quaternary faulting in western Utah and the implication in earthquake hazard evaluation," Geological Society of America Cordilleran Section 75th Annual Meeting, Abstracts with Programs, 11, (3), p. 71-72.
- Buje, C. G., K. G. Poetzi, A. F. Shakal, and D. E. Willis, 1973. "Seismicity of the Nevada Test Site and adjacent areas," Earthquake Notes, 44, (1-2), p. 62.
- Burchfiel, B. C., P. J. Pelton, and J. Sutter, 1970. "An early Mesozoic deformation belt in south-central Nevada, south-eastern California," Geological Society of America Bulletin, 81, p. 211-215.

- Burke, D. B., and E. H. McKee, 1973. "Mid-Cenozoic volcano-tectonic features in central Nevada," Geological Society of America, Cordilleran Section, 69th Annual Meeting, Abstracts with Programs, 5, (1), p. 18.
- California State University, 1975. "A field guide to Cenozoic deformation along the Sierra Nevada Province and Basin and Range Province boundary," California Geology, 28, (5), p. 99-119.
- Carr, W. J., 1979. "Possible paleoseismic belt in Nevada Test Site region" (abstract), U.S. Geological Survey Professional Paper 1150, p. 82.
- Christiansen, R. L., and E. H. McKee, 1978. "Late Cenozoic volcanic and tectonic evolution of the Great Basin and Columbia Intermountain regions," Smith, R. B., and Easton, G. P., eds., Cenozoic tectonics and regional geophysics of the western Cordillera, Geological Society of America Memoirs 152, p. 283-311.
- Cloud, W. K., 1956. "Intensity distribution and strong-motion seismograph results, Nevada earthquakes of July 6, 1954, and August 23, 1954," Seismological Society of America Bulletin, p. 34-40.
- Cluff, L. S., D. B. Slemmons, and F. B. Waggoner, 1970. "Active fault zone hazards and related problems of siting works of man," 4th Symposium on Earthquake Engineering, University of Roorkee, India, Proceedings, p. 401-410.
- Cluff, L. S., C. E. Glass, and G. E. Brogan, 1974. "Investigation and evaluation of the Wasatch fault north of Brigham City and Cache valley faults, Utah and Idaho," prepared for the U.S. Geological Survey, Menlo Park, by Woodward-Lundgren and Associates, Oakland, California.
- Cluff, L. S., L. F. Hintze, G. E. Brogan, and C. E. Glass, 1975. "Recent activity of the Wasatch fault, north-western Utah, U.S.A.," Tectonophysics, 29, p. 161-168.
- Cluff, L. S., K. J. Patwardhan, and K. J. Coppersmith, 1980. "Estimating the probability of occurrence of surface faulting earthquake on the Wasatch Fault zone, Utah," Seismological Society of America Bulletin.
- Coats, R. R., 1979. "Southward-directed thrusting of Mesozoic age in northeastern Nevada" (abstract), U.S. Geological Survey Professional Paper 1150, p. 81.
- Cook, K. L., 1967. "Earthquake hazards in Utah," draft of paper presented in 1967, p. 23-27.
- Cook, K. L., 1972. "Earthquakes along the Wasatch front, Utah--The record and the outlook;" Utah Geological Association Publication I-H, p. H1-H29.
- Cook, K. L., and J. R. Montgomery, 1974. "Crustal structure and east-west transverse structural trends in eastern Basin and Range Province as indicated by gravity data," Geological Society of America, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, 6, (3), p. 158.

- Cook, K. L., and Smith, R. B., 1967. "Seismicity in Utah," 1850 through June 1965, Seismological Society of America Bulletin, 57, p. 689-718.
- Cordova, Tommy, 1969. "Active faults in Quaternary alluvium, and seismic regionalization, in a portion of the Mount Rose quadrangle, Nevada," Masters thesis, University of Nevada.
- Cross, T. A., and R. H. Pilger, Jr., 1978. "Constraints on absolute motion and plate interaction inferred from Cenozoic igneous activity in the western United States," American Journal of Science, 278, (7), p. 865-902.
- Davis, G. A., 1973. "Relations between the Keystone and Red Spring thrust faults, eastern Spring Mountains, Nevada," Geological Society of America Bulletin, 84, p. 3709-3716.
- Davis, J. R., 1978. "Quaternary faulting in Clayton Valley in southwestern Nevada," (abstract): U.S. Geological Survey Professional Paper 1100, p. 69-70.
- _____. 1979. "Quaternary faulting in Clayton and Big Smokey valleys, Nevada," Geological Society of America, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, 11, (3), p. 74.
- Dewey, J. W., W. H. Dillinger, J. Taggart, and S. T. Algermissen, 1972. "A technique for seismic zoning, analysis of earthquake locations and mechanisms in northern Utah, Wyoming, Idaho and Montana," International Conference on Microzonation for Safer Construction, Research and Application, University of Washington, Seattle, Proceedings, 2, p. 879-895.
- Dickinson, W. R., 1979. "Cenozoic plate tectonic setting of the Cordilleran region in the United States," in Cenozoic Paleogeography of the western United States: Pacific Coast Paleogeography Symposium 3, p. 1-13.
- Dodge, R. L., and L. T. Grose, 1979. "Seismotectonic and geomorphic evolution of a typical Basin and Range normal fault, the Holocene Black Rock fault, northwestern Nevada," Geological Society of America, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, 11, (3), p. 75.
- Dott, R. H., Jr., and R. L. Batten, 1976. Evolution of the earth (2nd ed.), New York: McGraw-Hill.
- Douglas, B. M., and Alan Ryall, 1972. "Spectral characteristics and stress drop for microearthquakes near Fairview Peak, Nevada," Journal of Geophysical Research, 77, (2), p. 351-359.
- Douglas, B. M., and Alan Ryall, 1975. "Return periods for rock acceleration in western Nevada," American Geophysical Union Transactions, 56, (12), p. 1024.
- Douglas, B. M., Alan Ryall, and W. U. Savage, 1972. "Source mechanisms and stress drop for microearthquakes in the Excelsior Mountains area, western Nevada," Geological Society of America, Cordilleran Section, 68th Annual Meeting, Abstracts with Programs, 4, (3), p. 149.

- Eardley, A. J., 1939. "Structure of the Wasatch-Great Basin region," Geological Society of America Bulletin, 50, (8), p. 1277-1310.
- Eaton, G. P., 1978. "Tectonic environment of late Cenozoic Great Basin volcanism," American Geophysical Union Transactions, 59, (4), p. 248.
- Ekren, E. B., G. D. Bath, and G. L. Dixon, 1974. "Tertiary history of Little Fish Lake Valley, Nye County, Nevada, and implications as to the origin of the Great Basin," U.S. Geological Survey, Journal of Research, 2, (1), p. 105-118.
- Ekren, E. K., R. C. Bucknam, W. J. Carr, G. L. Dixon, and W. D. Quinlivan, 1976. "East-trending structural lineaments in central Nevada," U.S. Geological Survey Professional Paper 986.
- Eppley, R. A., 1965. "Earthquake history of the United States, Part I, Stronger earthquakes of the United States," U.S. Government Printing Office.
- Fischer, F. G., P. J. Papanek, and R. M. Hamilton, 1972. "The Massachusetts Mountain earthquake of 5 August 1971 and its aftershocks, Nevada test site," U.S. Geological Survey.
- Flint, R. F., 1971, Glacial and Quaternary geology, New York: John Wiley.
- George, G. D., 1974. "Investigation of spatial and temporal migration of seismic activity in the California/Nevada area," Masters thesis, University of Wisconsin, Milwaukee.
- Gilbert, G. K., 1890. "Lake Bonneville," U.S. Geological Survey Monograph 1.
- Glass, C. E., and D. B. Slemmons, 1978. "State-of-the-art for assessing earthquake hazards in the United States," Report 2, imagery in earthquake analysis; Office, Chief of Engineers, U.S. Army, Miscellaneous Paper S-73-1.
- Grannell, R. B., and D. C. Noble, 1977. "A detailed analysis of Basin and Range faulting, Grass Valley area, north-central Nevada," Geological Society of America, Abstracts with Programs, 9, (4), p. 424-425.
- Gumper, F. J., and Christopher Scholz, 1971. "Microseismicity and tectonics of the Nevada seismic zone," Seismological Society of America Bulletin, 61, (5), p. 1413-1432.
- Hamblin, W. K., 1976. "Patterns of displacement along the Wasatch fault," Geology, 4, p. 619-622.
- Hamblin, W. K., and M. G. Best, 1978, "Patterns and rates of recurrent movement along the Wasatch-Hurricane-Sevier fault zone, Utah, during late Cenozoic time," U.S. Geological Survey, National Earthquake Hazards Reduction Program, Summaries of Geotechnical Report, 5.
- Hamilton, R. M., B. E. Smith, F. G. Fischer, and P. J. Papanek, 1971. "Seismicity of the Pahute mesa area, Nevada test site, 8 December 1968 through 31 December 1970," U.S. Geological Survey, Menlo Park, California.

- _____. 1972. "Earthquakes caused by underground nuclear explosions on Pahute mesa, Nevada test site," Seismological Society of America Bulletin, 62, (5), p. 1319-1341.
- Hamilton, Warren, and W. B. Myers, 1966. "Cenozoic tectonics of the western United States," Canada Geological Survey Paper 66-14, The World Rift system--International Upper Mantle Comm. Symposium, Ottawa, 1965, p. 291-306.
- Hardyman, R. F., E. B. Ekren, and F. M. Byers, Jr., 1975. "Cenozoic strike-slip, normal, and detachment faults in northern part of Walker Lane," Geological Society of America, Abstracts with Programs, 7, (7), p. 1100.
- Haynes, C. V. Jr., 1968. "Geochronology of late Quaternary alluvium," in Morrison, R. B., and Wright, H. E., Jr., eds., Means of correlation of Quaternary successions, IAQR proceedings, v. 8, Salt Lake City, University of Utah Press, p. 591-631.
- Hintze, L. F., 1976. "Attenuation faulting in the Fish Springs and House ranges, western Utah," Geological Society of America, Abstracts with Programs, 8, (6), p. 918-919.
- Holzer, T. L., 1978. "Potential surface faulting related to ground-water withdrawal in Las Vegas Valley, Nevada," (abstract), U.S. Geological Survey Professional Paper 1100, p. 292.
- _____. 1979. "Leveling data, Eglinton fault scarp, Las Vegas Valley, Nevada," U.S. Geological Survey Open-File Report 79-950, 7 p.
- Howard, E. L., 1976. "New paleostructural interpretation of Basin and Range Province, Nevada and western Utah," American Association of Petroleum Geologists Bulletin, 60, (8), p. 1399.
- Howell, B. F., 1974. "Seismic regionalization in North America based on average regional seismic hazard index," Seismological Society of America Bulletin, 64, (5), p. 1509-1528.
- International Conference of Building Officials, 1979. Uniform Building Code, Whittier, California.
- Jones, J. C., 1915. "The Pleasant Valley, Nevada, earthquake of October 2, 1915," Seismological Society of America Bulletin, 5, p. 190-205.
- Kelleher et al., 1973.
- Keller, G. R., R. B. Smith, and L. H. Braile, 1975. "Crustal structure along the Great Basin-Colorado plateau transition from seismic refraction studies," Journal of Geophysical Research, 80, (8), p. 1093-1098.
- King, P. B., 1959. The evolution of North America, Princeton: Princeton University Press.
- _____. 1969. "The tectonics of North America--a discussion to accompany the tectonic map of North America," U.S. Geological Survey Professional Paper 628.

- Kumamoto, L., and G. V. Keller, 1978. "Microearthquake survey in the Gerlach-Fly Ranch area of northwestern Nevada," in Grose, L. T., ed., Studies of a geothermal system in northwestern Nevada, Part 1: Colorado School of Mines, 73, (3), p. 45-64.
- Larsen, N. W., 1979. "Chronology of late Cenozoic basaltic volcanism, the tectonic implications along a segment of the Sierra Nevada and Basin and Range province boundary," Ph.D. dissertation, Brigham Young University, Provo, Utah.
- Larson, L. T., L. H. Beal, D. E. Cornwall, and C. D. Sanders, 1977. "Bibliography, Great Basin geologic framework and uranium favorability Part I, Citation by author," report prepared for Bendix Field Engineering Corporation, Grand Junction, Colorado, by Mackay School of Mines, Reno, Nevada.
- Larson, L. T. et al, 1977. "Great Basin geologic framework and uranium favorability," Report prepared for Bendix Field Engineering Corporation, Grand Junction, Colorado, by Mackay School of Mines, Reno, Nevada.
- Lee, D. E., R. F. Marvin, and H. H. Mehnert, 1978. "New data on modification of K-Ar ages by Tertiary thrust faulting in eastern Nevada," (abstract), U.S. Geological Survey Professional Paper 1100, p. 185.
- Levandowski, D. W., T. V. Jennings, and W. T. Lehman, 1976. "Relations between ERTS lineaments, aeromagnetic anomalies and geological structures in north-central Nevada," Utah Geological Association Publication 5, 1st International Conference on New Basement Tectonics, Proceedings, p. 106-117.
- Liaw, A. L., and T. V. McEvilly, 1979. "Microseisms in geothermal exploration, studies in Grass Valley, Nevada," Geophysics, 44, (6), p. 1097-1115.
- Liu, S. C., and L. W. Fagel, 1972. "Earthquake environment for physical design, a statistical analysis," Geotechnical Journal, November, p. 1959-1960.
- Livaccari, R. F., 1979. "Late Cenozoic tectonic evolution of the western United States," Geology, 7, (2), p. 72-75.
- Locke, A. P., Billingsley, and E. B. Mayo, 1940. "Sierra Nevada tectonic pattern," Geological Society of America Bulletin, 51, p. 513-540.
- Lockwood, J. P., and J. G. Moore, 1979. "Regional deformation of the Sierra Nevada, California, on conjugate microfault sets," Journal of Geophysical Research, 84, (B11), p. 6051-6049.
- Longwell, C. R., 1974. "Large-scale lateral faulting in southern Nevada," Geological Society of America, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, 6, (3), p. 209.
- Loring, A. K., 1972. "Temporal and spatial distribution of Basin-Range faulting in Nevada and Utah," Masters thesis, University of Southern California.
- _____. 1976. "Distribution in time and space of late Phanerozoic normal faulting in Nevada and Utah," Utah Geology, 3, (2), p. 97-107.

- Lovejoy, E. M. P., 1964. Re-evaluation of geomorphic criteria of "Classical Basin Range Normal Block Faulting": Geological Society of America Special Paper 76, p. 282.
- Malone, S. D., 1972. "Earth strain measurements in Nevada and possible effects on seismicity due to the solid earth tides," Ph.D. dissertation, University of Nevada, Reno.
- McKague, H. L., B. Grothaus, and N. W. Howard, 1979. "Recognition of faults in Tertiary-Quaternary alluvium in northern Yucca Flat, Nevada," Geological Society of America, Cordilleran Section, 75th Annual Meeting, San Jose, California, Abstracts with Programs, 11, (3), p. 91.
- Nokleberg, W. J., 1979. "Accreted microplates in the central Sierra Nevada, California," Geological Society of America, Cordilleran Section, 75th Annual Meeting, San Jose, California, Abstracts with Programs, 11, (3), p. 120.
- Nolan, T. B., 1943. "The Basin and Range province in Utah, Nevada, and California," U.S. Geological Survey Professional Paper 197-D, p. 141-196.
- Oliver, J., Alan Ryall, J. N. Brune, and D. B. Slemmons, 1966. "Micro-earthquake activity recorded by portable seismographs of high sensitivity," Seismological Society of America Bulletin 56, p. 899-924.
- Page, B. M., 1934. "Basin-Range faulting of 1915 in Pleasant Valley, Nevada," Journal of Geology, 43, p. 690-707.
- Papanek, P. J., and R. M. Hamilton, 1972. "A seismicity study along the northern Death Valley Furnace Creek fault zone," U.S. Geological Survey, National Center of Earthquake Research, Menlo Park, California.
- Pease, R. C., 1979. "Fault scarp degradation in alluvium near Carson City, Nevada," Geological Society of America, Cordilleran Section, 75th Annual Meeting, San Jose, California, Abstracts with Programs, 11, (3), p. 121.
- Proffett, J., Jr., 1973. "Nature, age and origin of Cenozoic faulting and volcanism in the Basin and Range Province," (with specific reference to the Yerrington District, Nevada), Ph.D. dissertation, University of California, Berkeley.
- Proffett, J., Jr., 1977. "Cenozoic geology of the Yerrington district, Nevada, and implications for the nature and origin of Basin and Range faulting," Geological Society of America Bulletin, 88, p. 247-266.
- Racine, D., 1979. "A seismicity study of the Pacific northwest region of the United States," Teledyne Geotechnical, Alexandria, Virginia, Report No. NUREG/CR-0926.
- Reiinger, R., 1977. "Vertical crustal movements from repeated leveling data in the Great Basin of Nevada and western Utah," American Geophysical Union Transactions, 58, (12), p. 1238.
- Richins, W. D., 1975. "Earthquake swarm near Denio, Nevada, February to April 1973," Masters thesis, University of Nevada, Reno.

- Richins, W. D., and Alan Ryall, 1974. "Earthquake swarm near Denio, Nevada, February to April, 1973," Geological Society of America, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, 6, (3), p. 308.
- Richter, C. F., 1950. Elementary Seismology, San Francisco: W. H. Freeman.
- Rinehart, C. D., and D. C. Ross, 1964. "Geology and mineral deposits of the Mount Morrison Quadrangle, Sierra Nevada, California," U.S. Geological Survey Professional Paper 385.
- Roberts, R. J., 1968. "Tectonic framework of the Great Basin, in a coast to coast tectonic study of the United States," Umr. Journal, 1, p. 101-119.
- Rogers, A. M., and W. H. K. Lee, 1976. "Seismic study of earthquakes in the Lake Mead, Nevada-Arizona region," Seismological Society of America Bulletin, 66.
- Rogers, A. H., D. M. Perkins, and F. A. McKeown, 1977. "A preliminary assessment of the seismic hazard of the Nevada test site region," Seismological Society of America Bulletin, 67, (6), p. 1589-1606.
- Romney, C., 1957. "The Dixie Valley-Fairview Peak, Nevada, earthquakes of December 16, 1954, seismic waves," Seismological Society of America Bulletin 47, p. 301-320.
- Ryall, Alan, 1974. "Seismology of the western Basin and Range Province," Geological Society of America, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, 6, (3), p. 246.
- _____. 1977. "Earthquake hazard in the Nevada region," Seismological Society of America Bulletin, 67, (2), p. 517-532.
- Ryall, Alan, B. M. Douglas, S. D. Malone, and W. U. Savage, 1972. "Use of microearthquakes to determine mechanisms of faulting, stresses, and other source characteristics in the Nevada region," Physics Solid Earth, 12, p. 785-792.
- Ryall, Alan, and S. D. Malone, 1971. "Earthquake distribution and mechanism of faulting in the Rainbow Mountains, Aloe Valley, Fairview Peak area, central Nevada," Journal of Geophysical Research, 76, (29), p. 7241-7448.
- Ryall, Alan, and Keith Priestley, 1975. "Seismicity, secular strain, and maximum magnitude in the Excelsior Mountains area, western Nevada and eastern California," Geological Society of America Bulletin, 86, (11), p. 1585-1592.
- Ryall, Alan, K. F. Priestly, W. U. Savage, and C. J. Koizumi, 1973. "Cenozoic tectonics related to a paleosubduction zone under northern Nevada," Earthquake Notes, 44, (1-2), p. 77.
- Ryall, Alan, W. U. Savage, and D. B. Slemmons, 1972. "Seismic potential in the western Basin and Range/eastern Sierra Nevada region, Nevada and California," American Geophysical Union Transactions, 53, (4), p. 442.

- Ryall, Alan, D. B. Slemmons, and L. D. Gedney, 1966. "Seismicity, tectonism, and surface faulting in the western United States during historic time," Seismological Society of America Bulletin, 56, (5), p. 1105-1135.
- Sanders, C.O., and D. B. Slemmons, 1979. "Recent crustal movements in the central Sierra Nevada-Walker Lane region of California-Nevada, Part III, the Olinghouse fault zone,," in Whitten, C. A., Green, R., Meade, B. K., eds., Recent crustal movements: Tectonophysics, 52, (1-4), p. 585-597.
- Savage, J. C., and J. P. Church, 1974. "Evidence for postearthquake slip in the Fairview Peak, Dixie Valley, and Rainbow Mountain fault areas of Nevada," Seismological Society of America Bulletin, 64, (3), part 1, p. 687-698.
- Sbar, M. L., M. Barazangi, J. Dorman, C. N. Scholz, and R. B. Smith, 1972. "Tectonics of the intermountain seismic belt, western United States; micro-earthquake seismicity and composite fault plane solutions," Geological Society of America Bulletin, 83, p. 13-28.
- Scholz, C. H., M. Barazangi, and M. L. Sbar, 1971. "Late Cenozoic evolution of the Great Basin, western United States as an ensialic inter-arc basin," Geological Society of America Bulletin, 82, p. 2979-2990.
- Schwartz, D. P., F. H. Swan, III, K. L. Hanson, P. L. Knuepfer, and L. S. Cluff, 1979. "Recurrence of surface faulting and large magnitude earthquakes along the Wasatch fault zone near Provo, Utah," Geological Society of America, Abstracts with Programs, 11, (6), p. 301.
- Shawe, D. R., 1965. "Strike-slip control of Basin-Range structure indicated by historical faults in western Nevada," Geological Society of America Bulletin, 76, p. 1361-1378.
- Sheridan, M. F., 1978. "Owens Valley; a major rift between the Sierra Nevada Batholith and Basin and Range province, U.S.A.," in Rambert, I. B., and Neumann, E. R., eds., Tectonics and geophysics of continental rifts: NATO Advanced Study Institute Paleorift Systems, Arizona State University, Proceedings, 37, p. 81-88.
- Sill, W. R., W. Wilson, J. Bodell, S. Ward, and D. S. Chapman, 1977. "Heat flow measurements in southern Utah and the northern Basin and Range-Colorado Plateau transition," American Geophysical Union Transactions, 58, (12), p. 1237-1238.
- Slemmons, D. B., "Basin and Range active faults," Unpublished manuscript.
- _____. 1957. "Geological effects of the Dixie Valley Fairview Peak, Nevada earthquakes, December 16, 1954," Seismological Society of America Bulletin, 47, (4), p. 353-375.
- _____. 1959. "Geologic setting for the Fallon-Stillwater earthquakes of 1954," Seismological Society of America Bulletin, 46, p. 4-9.
- _____. ed., 1966. Guidebook for Nevada earthquake areas, Mackay School of Mines, University of Nevada.

- _____. 1966. "Dixie Valley--Fairview Peak earthquake areas, trip No. 1," in Slemmons, D. B., ed., Guidebook for Nevada earthquake areas, p. A1-A43.
- _____. 1967. "Pliocene and Quaternary crustal movements of the Basin-and-Range province, U.S.A.," Journal of Geoscience, Osaka City University, 10, p. 91-103.
- _____. 1977. "State-of-the-art for assessing earthquake hazards in the United States; Report 6," Faults and Earthquake magnitude, Miscellaneous Paper S-73-I, 120 p.
- Slemmons, D. B., and G. E. Brogan, 1973. "Preliminary microzonation for surface faulting in the Reno-Carson City area, part 1, Character and pattern of active faults," Earthquake Notes, 44, (1-2), p. 32-32.
- Slemmons, D. B., J. I. Gimlett, A. E. Jones, Roger Greensfelder, and James Koenig, 1964. "Earthquake epicenter map of Nevada," Nevada Bureau of Mines, Map 29, scale 1:1,000,000.
- Slemmons, D. B., A. E. Jones, and J. I. Gimlett, 1965. "Catalog of Nevada earthquakes, 1852-1960," Seismological Society of America Bulletin, 55, p. 537-583.
- Slemmons, D. B., and Alan Ryall, 1966. "Seismicity and prehistoric faulting of Nevada," (in preparation).
- Slemmons, D. B., et al., 1959. "Wonder, Nevada earthquake of 1903," Seismological Society of America Bulletin, 49, 3, p. 251-265.
- Slemmons, D. B., Douglas Van Wormer, E. J. Bell, and M. L. Silberman, 1979. "Recent crustal movements in the Sierra Nevada-Walker Lane region of California-Nevada, Part 1, rate and style of deformation," in Whitten, C. A., ed., Recent crustal movements: Tectonophysics, 52, (1-4), p. 561-570.
- Smith, B. E., J. M. Coakley, and R. M. Hamilton, 1972. "Distribution, focal mechanisms, and frequency of earthquakes in the Fairview Peak area, Nevada, near the time of the BENHAM explosion," Seismological Society of America Bulletin, 62, (5), p. 1223-1240.
- Smith G. I., 1968. "Late Quaternary geologic and climatic history of Searles Lake southeastern California," in Morrison, R. B., and Wright, H. E., Jr., eds., Means of correlation of Quaternary successions, v. 8, IAQR proceedings, Salt Lake City, University of Utah Press, p. 293-310.
- Smith, R. B., 1972. "Contemporary seismicity, seismic gaps, and earthquake recurrences of the Wasatch front," in Hilpert, L. S., ed., Environmental geology of the Wasatch Front, 1971, Utah Geological Association Publication 1, p. 11-19.
- _____. 1975. "Seismicity, crustal structure, and contemporary tectonics of the Basin-Range Rocky Mountains and Colorado Plateau," American Geophysical Union Transactions, 56, (12), p. 1058.

- _____. 1978. "Seismicity, crustal structure, and intraplate tectonics of the interior of the western Cordillera," in Smith, R. B., and Easton, G. P., eds., Cenozoic tectonics and regional geophysics of the western Cordillera: Geological Society of America Memoir 152, p. 111-114.
- Smith, R. B., and M. L. Sbar, 1974. "Contemporary tectonics and seismicity of the western United States with emphasis on the intermountain seismic belt," Geological Society of America Bulletin, 85, (8), p. 1205-1218.
- Smith, R. B., W. I. Arabasz, K. L. Cook, and W. D. Richine, 1976. "Detailed seismic monitoring of the Wasatch front, Utah," Seismological Society of America, 71st Annual Meeting, Abstracts with Programs 47, (2).
- Smith, R. B., and M. L. Sbar, 1974. "Contemporary tectonics and seismicity of the western United States with emphasis on the intermountain seismic belt," Geological Society of America Bulletin, 85, p. 1205-1218.
- Speed, R. C., 1976. "Mesozoic and Cenozoic tectonic evolution of the western Great Basin," Economic Geology and the Bulletin of the Society of Economic Geologists, Winter Meeting, 71, (3), p. 703.
- _____. 1979. "Extensional faulting in the Great Basin, kinematics and possible changes with depth," in Sharp, R. V., (convener), Analysis of actual fault zones in bedrock: U.S. Geological Survey Open-File Report No. 79-1239, p. 121-138.
- Speed, R. C., and D. B. Howell, 1978. "Paleogeographic and plate tectonic evolution of the early Mesozoic marine province of the western Great Basin," in Howell, D. G., and McDougall, K., eds., Mesozoic Paleogeography of the western United States: Pacific Coast Paleogeography Symposium 2, Sacramento, California, p. 253-270.
- Speed, R. C., and A. H. Cogbill, 1979. "Candeleria and other left-oblique dip faults of the Candeleria region, Nevada," Geological Society of America Bulletin, Part 1, 90, (2), p. 1149-1163.
- Stewart, J.H., 1967. "Possible large right-lateral displacement along fault and shear zones in the Death Valley-Las Vegas area, California and Nevada," Geological Society of America Bulletin, 78, p. 131-142.
- _____. 1971. "Basin and Range structure, a system of horsts and grabens produced by deep-seated extension," Geological Society of America Bulletin, 82, (4), p. 1019-1043.
- _____. 1975. "Origin of Basin and Range structure, a review," Geological Society of America, Abstracts with Programs, 7, (7), p. 1284.
- _____. 1979. "Regional tilt patterns of late Cenozoic Basin and Range fault blocks in the Great Basin," Geological Society of America, Cordilleran Section, 75th Annual Meeting, San Jose, California, Abstracts with Programs, 11, (3), p. 130.

- Stewart, J. H., J. P. Albers, and F. G. Poole, 1968. "Summary of regional evidence for right-lateral displacement in the western Great Basin," Geological Society of America Bulletin, 79, p. 1407-1414.
- Stubenrauch, A. L., 1977. "Seismicity of the Nevada Test Site, April 1, 1973 to October 1, 1975," Masters thesis, University of Wisconsin, Milwaukee, Wisconsin.
- Swan, F. H., III, D. P. Schwartz, and L. S. Cluff, 1980. "Recurrence of moderate to large magnitude earthquakes produced by surface faulting on the Wasatch fault zone, Utah," Seismological Society of America Bulletin, 70.
- Swan, F. H., III, et al., 1978. "Recurrence of surface faulting and large magnitude earthquakes along the Wasatch fault, Utah," (abstract): American Geophysical Union Transactions, 55, P. 1126.
- Swan, F. H., III, et al., 1980. "Study of earthquake recurrence intervals on the Wasatch fault, Utah," in Summaries of Technical Reports, Vol. IX, National Earthquake Hazards Reduction Program: U.S. Geological Survey Open-File Report 8--6, p. 123-124.
- Thompson, G. A., 1959. "Gravity measurements between Hazen and Austin, Nevada, a study of Basin and Range structure," Journal of Geophysical Research, 64, p. 217-229.
- Thompson, G. A., and D. B. Burke, 1973. "Rate and direction of spreading in Dixie Valley, Bain and Range province, Nevada," Geological Society of America Bulletin, 84, (2), p. 627-632.
- _____. 1974. "Regional geophysics of the Basin and Range province," Donath, F. A., Stehli, F. G., and Wetherill, G. W., eds., Annual Review of Earth and Planetary Sciences, 2, Palo Alto, California, p. 213-235.
- Thornbury, W. D., 1965. Regional geomorphology of the United States, New York: John Wiley.
- Tocher, Don, 1957. "The Dixie Valley-Fairvie Peak earthquakes of December 16, 1954, Introductions," Seismological Society of America Bulletin, 47, (4), p. 299-300.
- United Earth Sciences Division, United Electrodynamics, 1963. Long range seismic experiments, Cache Creek earthquake, Utah, 30 August 1962, Cache Creek aftershock, Utah, 5 September, 1962: Alexandria, Virginia.
- Utah Geological and Mineral Survey, 1976. "Earthquake fault map of a portion of Salt Lake County, Utah," Map 42, scale 1 inch = 2.5 miles.
- Van Wormer, D., 1978. "Microseismicity and tectonic deformation near Mina, Nevada," Seismological Society of America, 73rd Annual Meeting, Abstracts, 49, (1).

- Von Hake, C. A., 1974. "Earthquake history of Nevada," Earthquake Information Bulletin, 6, (6), p. 26-29.
- Wallace, R. E., 1975. "Fault scarp geomorphic and seismic history, north-central Nevada," Geological Society of America, Abstracts with Programs, 7, (3), p. 385.
- _____. 1976. "Seismicity of north-central Nevada on the basis of young fault scarps," Seismological Society of America, 71st Annual Meeting, Abstracts, 47, (2), p. 21.
- _____. 1977. "Fault scarps formed during the earthquakes of October 2, 1915, Pleasant Valley, Nevada," U. S. Geological Society Professional Paper.
- _____. 1977a. "Time-history analysis of fault scarps and fault tracers--a longer view of seismicity in ground motion, seismicity, seismic risk, and zone," 6th World Conference on Earthquake Engineering, New Dehli, India, 1977, Proceedings, p. 766-769.
- _____. 1977b. "Profiles and ages of young fault scarps, north-central Nevada," Geological Society of America Bulletin, 88, p. 1267-1281.
- _____. 1978a. "Geometry and rates of change of fault-generated range fronts, north-central Nevada," U.S. Geological Survey Journal of Research, 6, (5), p. 637-649.
- _____. 1978b. "Patterns of faulting and seismic gaps in the Great Basin province," in Conference VI, Methodology for identifying seismic gaps and soon-to-break gaps, May 25-27, 1978, Proceedings: U.S. Geological Survey Open-File Report 78-943, p. 858-868.
- _____. 1979a. "Map of young fault scarps related to earthquakes in north central Nevada," U.S. Geological Survey Open-File Report No. 79-1554, 2 sheets.
- _____. 1979b. "Strain pattern represented by scarps formed during the earthquakes of October 2, 1915, Pleasant Valley, Nevada," in Whitten, C. A., Green, R., and Meade, B. K., eds., Recent crustal movements: Tectonophysics, 52, (1-4), p. 559.
- _____. 1980. "Active faults, paleoseismicity, and earthquake hazards," Seventh World Conference on Earthquake Engineering, Istanbul, Turkey, September 1980, 8 p.
- Walper, 1976.
- Wechsler, D. S., and R. B. Smith, 1978. "Earthquake studies in the Basin and Range-Colorado plateau transition zone in southern Utah," Seismological Society of America, 74th Annual Meeting, Earthquake Notes, p. 21.
- Westphal, W. H., and A. L. Lange, 1966. "The distribution of earthquake aftershock foci, Cache Valley, Utah, September 1962," American Geophysical Union Transactions, 47, p. 428.

- Whitten, C. A., 1956a. "Geodetic measurements in the Dixie Valley area," Seismological Society of America Bulletin, p. 321-325.
- . 1956b. "Crustal movement in California and Nevada," American Geophysical Union Transactions 37, p. 393-398.
- Williams, J. S., and M. L. Tapper, 1953. "Earthquake history of Utah, 1850-1949," Seismological Society of America Bulletin, 43, p. 191-218.
- Woodward-McNeill and Associates, 1974. "Information concerning site characteristics, Vidal Nuclear generating station, Appendix 2.5," report prepared for Southern California Edison Company, Volumes II-IV.
- Woollard, G. P., 1958. "Areas of tectonic activity in the United States as indicated by earthquake epicenters," American Geophysical Union Transactions 39, p. 1135-1150.
- Wright, L., 1973. "Shallow-fault interpretation of Basin and Range structure, southwestern Great Basin," in Gravity and Tectonics, New York: John Wiley, p. 397-407.
- . 1976. "Late Cenozoic fault patterns and stress fields in the Great Basin and westward displacement of the Sierra Nevada block," Geology, 4, (8), p. 489-494.
- Zoback, M. L., 1978. "Mid-Miocene rifting in north-central Nevada, a detailed study of late Cenozoic deformation in the northern Basin and Range," Ph.D. dissertation, Stanford University, California.
- . 1979. "Direction and amount of late Cenozoic extension in north-central Nevada," Geological Society of America, Cordilleran Section, 75th Annual Meeting, San Jose, California, Abstracts with Programs 11, (3), p. 137.
- Zoback, M. L. and G. A. Thompson, 1976. "Evidence of left-lateral slip on Basin and Range faults," Geological Society of America, Abstracts with Programs, 8, (6), p. 1182.
- . 1978. "Basin and Range rifting in northern Nevada, clues from a mid-Miocene rift and its subsequent offsets," Geology, 6, (2), p. 111-116.
- Zoback, M. L., and M. D. Zoback, 1978. "Faulting patterns in north-central Nevada and strength of the crust," American Geophysical Union, Transactions, 59, (4), p. 385.
- Zones, C. P., 1957. "The Dixie Valley Fairview-Peak, Nevada, earthquakes of December 16, 1954, changes in hydrologic conditions," Seismological Society of American Bulletin, 47, (4), p. 387-396.

CHAPTER 5.0 REFERENCES

1. Literature Cited

- Buol, S.W., F.D. Hole, and R.J. McCracken, 1973. Soil Genesis and Classification. Ames: Iowa State University Press.
- Clyde, Calvin G., C.E. Israelsen, P.E. Packer, E.E. Farmer, J.E. Fletcher, E.K. Isradsen, F.W. Haws, N.V. Rao, and J. Hansen, 1978. Manual of Erosion Control Principles and Practices During Highway Construction. Hydraulics and Hydrology Series. Utah Water Research Laboratory. Utah State University, Logan, Utah.
- HDR Sciences, 1980. "Environmental Characteristics of Alternative Designated Deployment Areas: Atmospheric Resources." ETR-13, Santa Barbara, California.
- _____, 1980. "Environmental Characteristics of Alternative Designated Deployment Areas: Native Vegetation". ETR-14. Santa Barbara, California.
- Houghton, John G., Clarence M. Sakamoto, and Richard O. Gifford, 1975. Nevada's Weather and Climate. Special Publication 2, Nevada Bureau of Mines and Geology. McKay School of Mines, University of Nevada, Reno.
- Lotspeich, F.B., and Coover, J.R., 1962. "Soil Forming Factors on the Llano Estacado: Parent Material, Time and Topography," Tex. Journal of Sci., 14:7-17.
- Maker, H.J., H.E. Dregne, V.G. Link, and J.U. Anderson, 1974. Soils of New Mexico. Aricultural Experiment Station, Research Report 285. New Mexico State University, Las Cruces.
- Master, William A, 1980. "Soil Handling Procedures to Maximize Revegetation Potential in the Nevada/Utah Candidate Siting Region for the M-X Missile System." Technical Note ETN-099, Henningson, Durham and Richardson, Santa Barbara, California.
- Nevada State Engineer's Office, 1971. Water for Nevada: Reconnaissance Soil Survey, Railroad Valley. Water Planning Report, Nevada Department of Conservation and Natural Resoruces, Carson City, Nevada.
- Septeer, 1979.
- Stephens, Jerry C., 1974. Hydrologic Reconnaissance of the Wah Wah Valley Drainage Basin, Millard and Beaver Counties, Utah, Technical Publication No. 47, State of Utah, Dept. of Natural Resoruces.
- Stiller, D.M., G.L. Zimpfer, and M. Bishop, 1980. "Application of geomorphic principles to surface mine reclamation in the semiarid west." Journal of Soil and Water Conservation. 35:274-277.
- U.S.D.A. Soil Conservation Service, 1960. Soil Survey of the Beryl-Enterprise Area, Nevada. U.S. Government Printing Office.

U.S.D.A. Soil Conservation Service, September 1958. Soil Survey of Curry County, New Mexico. U.S. Government Printing Office.

_____. April 1968. Soil Survey of the Pahrangat-Penoyer Areas, Nevada. U.S. Government Printing Office.

_____. 1969. "Distribution of Principal Kinds of Soils: Orders, Suborders, and Great Groups." Map Sheet Nos. 85, 86, 1967. In National Atlas of the United States of America. Geological Survey, U.S. Dept. of the Interior.

_____, Soil Survey Staff, December 1975. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Agricultural Handbook No. 436. U.S. Government Printing Office.

_____. January 1976. "General Soil Map for White Pine County, Nevada." Reno, Nevada.

_____. August 1976. Guides for Erosion and Sediment Control in Nevada. Reno, Nevada.

_____. July 1977. Preliminary Guidance for Estimating Erosion on Areas Disturbed by Surface Mining Activities in the Interior Western United States. Interim Final Report. EPA-908/4-77-005.

_____. May 1977. Soil Survey of Delta Area, Utah: Part of Millard County. U.S. Government Printing Office.

_____. December 1977. Soil Survey of Hartley County, Texas. U. S. Government Printing Office.

_____. (nd). Preliminary Soil Survey Data. Lincoln County, southeast part, Nevada Survey Area 754 (including Delamar and Dry Lake Valleys). Unpublished, subject to revision. Obtained from the Soil Survey Party Office, Las Vegas, Nevada.

_____. February 1980. Soil Survey of Big Smoky Valley Area, Nevada: Part of Nye County. U.S. Government Printing Office.

U. S. Department of Interior, Bureau of Land Management, September 1979. Final Environmental Statement: Proposed Domestic Livestock Grazing Management Program for the Caliente area. Las Vegas District, Nevada.

U.S. Dept. of the Navy. Civil Engineering Design Manual: Soil Conservation. Design Manual 5.11. Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA, October, 1979.

Wilson, LeMoyne, Marvin E. Olsen, Theron B. Hutchings, Alvin R. Southard, and Austin J. Erickson, 1975. Soils of Utah. Agricultural Experiment Station, Bulletin 492, Utah State University, Logan, Utah. March

Wischmeier, W.H., and Smith, D.D., December 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. U.S. Dept. of Agriculture, Agriculture Handbook No. 537. U.S. Government Printing Office.

Woodward-Clyde Consultants, 1978. "Geologic and Hydraulic Comparison between Basing Modes," M-X Milestone II, Volume IV, Baseline-CES-Draft.

2. Supplementary Soils Literature of the Nevada/Utah Study Region

Blackburn, Wilbert H., 1973. Infiltration Rate and Sediment Production of Selected Plant Communities and Soils in Five Rangelands in Nevada. Agricultural Experiment Station, University of Nevada, Reno.

Chaffee, M. A., C. L. Forn, J. R. Hassemer, J. D. Hoffman, E. L. Mosier, J. M. Nishi, R. M. O'Leary, D. F. Siems, R. L. Turner, E. P. Welsch, and G. VanTrump, Jr., 1978. "Geochemical Analysis of Rock and Soil Samples, Eureka Mining District and Vicinity, Eureka and White Pine Counties, 32 Nevada." U.S. Geological survey, Open File Report No. 78-790.

Tueller, P. T. and D. T. Booth, 1975. "Large scale color photograph for erosion evaluations on rangeland watersheds in the Great Basin." Am. Soc. Photogramm., Fall Conv., Proc., Vol 1975. p. 708-731.

U.S.D.A. Soil Conservation Service, June 1959. Soil Survey of East Millard Area, Utah. U.S. Gov. Printing Office.

_____. May 1970. Soil Survey Laboratory Data and Descriptions for Some Soils of Nevada. Soil Survey Invest. Report No. 23.

_____. July 1970. Nevada Soil and Water Conservation Needs Inventory. Nevada Conservation Needs Committee, Reno, Nevada.

_____. 1970. Utah Conservation Needs Inventory Report. Utah Conservation Needs Committee.

_____. May 1976. Soil Survey of Beaver-Cove Fort Area, Utah: Parts of Beaver and Millard Counties. U.S. Government Printing Office.

3. Supplementary Soils Literature of the Texas/New Mexico Study Region

Goodfey, Curtis L., Gordon S. McKee, and Harvey Oaks, 1973. General Soil Map of Texas. Texas Agricultural Experiment Station, Texas A and M University.

Maker, H.J., V.G. Link, J.U. Anderson, and M.V. Hodson, June 1971. Soil Associations and Land Classification for Irrigation - Chaves County. Agricultural Experiment Station Research Report 192. New Mexico State University, Las Cruces, New Mexico.

Maker, H.J., V.G. Link, W.B. Gallman, and J.U. Anderson, October 1971. Soil Associations and Land Classification for Irrigation - DeBaca County. Agricultural Experiment Station Research Report 206, New Mexico State University, Las Cruces, New Mexico.

U.S.D.A. Soil Conservation Service, May 1960. Soil Survey of Southwest Quay Area, New Mexico. U.S. Government Printing Office.

- _____. 1962. Soil Survey of Lamb County, Texas. U.S. Government Printing Office.
- _____. 1963. Soil Survey of Bailey County, Texas. U.S. Government Printing Office.
- _____. 1964. Soil Survey of Cochran County, Texas. U.S. Government Printing Office.
- _____. 1965. Soil Survey of Armstrong County, Texas. U.S. Government Printing Office.
- _____. August 1965. Soil Survey of Hockley County, Texas. U.S. Government Printing Office.
- _____. March 1967. Soil Survey of Roosevelt County, New Mexico. U.S. Government Printing Office.
- _____. August 1968. Soil Survey of Deaf Smith County, Texas. U.S. Government Printing Office.
- _____. June 1970. Soil Survey of Randall County, Texas. U.S. Government Printing Office.
- _____. 1973. Soil Survey of Harding County, New Mexico. U.S. Government Printing Office.
- _____. 1974. Soil Survey of Castro County, Texas. U.S. Government Printing Office.
- _____. January 1974. Soil Survey of Lea County, New Mexico. U.S. Government Printing Office.
- _____. August 1974. Soil Survey of Hale County, Texas. U.S. Government Printing Office.
- _____. November 1974. Soil Survey of Tucumcari Area, New Mexico: Northern Quay County. U.S. Government Printing Office.
- _____. December 1974. Soil Survey of Swisher County, Texas. U.S. Government Printing Office.
- _____. July 1975. Soil Survey of Sherman County, Texas. U.S. Government Printing Office.
- _____. March 1975. Soil Survey of Dallam County, Texas. U.S. Government Printing Office.
- _____. March 1975. Soil Survey of Moore County, Texas. U.S. Government Printing Office.

_____. 1977. Soil Survey of Briscoe County, Texas. U.S. Government
Printing Office.

_____. May 1978. Soil Survey of Parmer County, Texas. U.S. Government
Printing Office.

_____. April 1979. Soil Survey of Lubbock County, Texas. U.S. Government
Printing Office.

_____. February 1980. Soil Survey of Potter County, Texas. U.S.
Government Printing Office.

CHAPTER 6.0 REFERENCES - NEVADA/UTAH

- Bissell, H. J., 1963. "Lake Bonneville: Geology of Southern Utah Valley, Utah," U.S. Geological Survey Prof. Paper 257-B.
- Bureau of Land Management, 1977. "Existing Data Inventory of Paleontological Resources in the Salt Lake District."
- Fike, R., 1980, Bureau of Land Management, Salt Lake City, written communication.
- Heylman, E. R., 1965. "Reconnaissance of the Tertiary sedimentary rocks in western Utah," Utah Geological and Mineralogical Survey, Bulletin 75.
- Hunt, C. B., H. O. Varnes, and H. E. Thomas, 1953. "Lake Bonneville: Geology of Northern Utah Valley, Utah," U.S. Geological Survey Prof. Paper 257-A.
- Madsen, J. H., 1980. State Paleontologist of Utah, written communication.
- Madsen, J. H. and W. E. Miller, 1979. "The Fossil Vertebrates of Utah, An Annotated Bibliography," Brigham Young University Geology Studies, Vol. 26, Part 4.
- Reppenning, 1980. U. S. Geological Survey, personal communication.
- Robison, S., 1977. "Paleontologic Inventory of Existing Data for the Moab District," Bureau of Land Management.
- _____, 1977. "Existing Data Inventory of Paleontological Resources in the Richfield District."
- _____, 1977. "Existing Data Inventory of Paleontological Resources in the Cedar City District."
- Williams, J. S., 1962. "Lake Bonneville: Geology of Southern Cache Valley, Utah," U.S. Geological Survey, Prof. Paper 257-C.

CHAPTER 6.0 REFERENCES - TEXAS/NEW MEXICO

- Evans, G. L., and G. E. Meade, 1945. "Quaternary of the Texas High Plains," University of Texas Publication 4401.
- Frye, I. C., and A. B. Leonard, 1964. "Relation of Ogallala Formation to the Southern High Plains of Texas," Bureau of Economic Geology, The University of Texas, Report of Investigations, No. 51.
- Leonard, A. B., and I. C. Frye, 1975. "Pliocene and Meistocene Deposits and Molluscan Faunas, East-Central New Mexico," New Mexico Bureau of Mines and Mineral Resources, Memoir 30.
- _____. 1978. "Paleontology of the Ogallala Formation, northeastern New Mexico," New Mexico Bureau of Mines and Mineral Resources, Circular 161.
- Savage, D. E., and C. S. Johnston, 1959. "A Survey of Various Late Cenozoic Vertebrate Faunas of the Panhandle of Texas." Part I: Introduction, Description of Localities, Preliminary Faunal Lists, University of California Publications in Geological Sciences, Vol. XXXI.
- Taylor, D. W., 1960. "Late Cenozoic Molluscan Faunas from the High Plains," U.S. Geological Survey Prof. Paper 337
- Thomaas, A.V., and J. L. Montgomery, 1976. "The Paleontological Resources of the Brazos River Basin," A Summary Statement, Department of Anthropology Texas Tech University.
- Wendorf F., ed., 1961. Paleontology of the Llano Estacado, Fort Burgwin Research Center, Number 1
- Wendorf F., and J. J. Hester, eds., 1975. Late Pleistocene Environments of the Southern High Plains, Fort Burgwin Research Center, Number 9.

CHAPTER 7.0 REFERENCES

See Chapter 3.0 References.

CHAPTER 8.0 REFERENCES

Geological Occurrences and Conditions for Natural Synthesis of Zeolites

- Adachi, H., 1977. "Green Tuff in the Yoshino District Yamagata Prefecture Japan with Special Reference to the Unconformity Problem," J. Geol Soc JPN, 83 (7), 411-424.
- Anderson, John J., 1971. "Geology of the Southwestern High Plateaus of Utah; Bear Valley Formation, an Oligocene-Miocene Volcanic Arenite," Geol. Soc. Am. Bull., 82, (5), p. 1179-1205.
- Baldar, N. A., and L. D. Whitting, 1968. "Occurrence and synthesis of soil zeolites." Soil Sci. Soc. Am. Proc. 32:235-238.
- Bradley, Wilmot Hyde, 1929. "The Occurrence and Origin of Analcite and Meerschaum Beds in the Green River Formation of Utah, Colorado, and Wyoming," U.S. Geol. Surv., Prof. Pap., (158), p. 1-7.
- Cook, H. E., and Hay, R. L., 1965. "Salinity Control of Zeolite Reaction Rates in Teels Marsh, Nevada (Abs.)," Geol. Soc. America Spec. Paper 82, p. 31-32.
- Glanzman, Richard K, M. J. Howard Jr, and James J. Rytuba, 1978. "Lithium in the McDermitt Caldera Nevada and Oregon," Energy (Oxford) V 3, N 3: Lithium--Needs and Resour., Proc. of a Symp, Corning, NY, Oct.12-14, 1977, p. 347-353.
- Glanzman, R. K., and Rytuba, J. J., 1979. "Zeolite-Clay Mineral Zonation of Volcaniclastic Sediments within the McDermitt Caldera Complex of Nevada and Oregon," U.S. Geol. Surv., Open-file Rep. No. 79-1668.
- Gorbundy, N. I., and A. V. Dobrovitskiy, 1973. "Distribution Genesis Structure and Properties of Zeolite," Sov Soil Sci, (Engl Transl Pochvovedenie), p. 351-360.
- Hay, Richard L., 1964. "Phillipsite of Saline Lakes and Soils," Am. Mineralogist, 49, (9-10), p. 1366-1387.
- Heiken, G. H., and M. L. Bevier, 1979. "Petrology of Tuff Units from the J-13 Drill Site, Jackass Flats, Nevada," Los Alamos Sci. Lab., Rpt. No. LA-7563-MS.
- Hoover, D. L., 1968. "Genesis of Zeolites, Nevada Test Site," in Nevada Test Site (E.B. Eckel, Ed.), Geol. Soc. Amer., Mem. No. 110, p. 275-284.
- Hoover, D. L., and A. D. Shepard, 1965. "Zeolite Zoning in Volcanic Rocks at the Nevada Test Site, Nye County, Nevada (Abs)," Am. Mineralogist, 50, (1-2), p. 287.
- Horstman, Arden William, 1966. "Correlation of the Lower and Lower Upper Cretaceous Rocks of a Part of Southwestern Wyoming, Utah, and Colorado (Abs.)," Dissert Abs., Sec. B., Sci. and Eng., 127, (4), p. 1187B.

- Mariner, R. H., and R. C. Surdam, 1970. "Alkalinity and formation of zeolites in saline alkaline lakes." Science 170:977-980.
- McNown and Malaika, 1950. Transitions, Am. Geophys. Union, 31, (1), p. 74-82.
- Moiola, Richard J., 1970. "Authigenic Zeolites and K-Feldspar in the Esmeralda Formation, Nevada," Am. Mineral, 55, (9-10), p. 1681-1691.
- Mumpton, F. A., 1973. "First reported occurrence of zeolites in sedimentary rocks of Mexico." Am. Mineral, 58:287-290.
- Mumpton, F. A., and R. A. Sheppard, 1972. "Zeolites," Geotimes. 17:16-17.
- Papke, K. G., 1972. "Erionite and other associated zeolites in Nevada." Nev. Bur. Mines and Geol. Bull. 79, 32 pp.
- Pitman, J. K., and T. D. Fouche, 1978. "Mineralogic Characteristics of Some Lower Tertiary Low-Permeability Reservoir Rocks, South-Central Uinta Basin, Utah (Abstr)," Am. Assoc. Pet. Geol., Bull. 62, (5), p. 891.
- Robinson, P. T., 1966. "Zeolite Diagenesis of Mio-Pliocene Rocks of the Silver Peak Range, Esmeralda County, Nevada," Jour. Sed. Petrology, 36, 4, p. 1007-1015.
- Sheppard, Richard A., 1973. "Zeolites in Sedimentary Rocks." U.S. Geol. Surv., Prof. Pap. No. 820:689-695.
- _____. 1976. "Zeolites in Sedimentary Deposits of the Northwestern United States--Potential Industrial Minerals," Mont. Bur Mines Geol, Spec Publ. (74), p. 69-84.
- Southard, A. R., and P. T. Kolesar, 1978. "An Exotic Source of Extractable Potassium in Some Soils of Northern Utah, USA," Soil Sci Soc Am J, 42, (3), p. 528-530.
- Stephens, J. D., and Eldon Bray, 1965. "Occurrence and Infrared Analysis of Unusual Zeolitic Minerals from Bingham, Utah (Abs)." Geol. Soc. America Spec. Paper 82, p. 195.
- _____. 1973. "Occurrence and Infrared Analysis of Unusual Zeolithis Minerals from Bingham, Utah," Mineral Rec. 4, 2, p. 67-72.
- Surdam, R. C., and R. A. Sheppard, 1976. "Zeolites in Saline Alkaline-Lake Deposits (in Zeolite '76; An International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites) (Abstract)," State Univ. Coll., Brockport, N.Y., p. 65-66.
- Surdam, Ronald C., and Robert H. Mariner, 1971. "The Genesis of Phillipsite in Recent Tuffs at Teels Marsh, Nevada (Abstr.)," Geol. Soc. Am., Abstr, 3, (7), p. 725.
- Travnikova, L. S., B. P. Gradusov, and N. P. Chizhikova. 1973. "Zeolites in some soils." Sov. Soil Sci, 5:251.

APPENDIX A

EARTH RESOURCES INVENTORY BY SELECTED COUNTIES FOR NEVADA

CHURCHILL COUNTY

I. Metallics

(Hydrologic

Unit No.) 1. Active Mines (as of 1976):

128 Vandenburg Mine (Sb) T22N, R37E

2. Metal Mining Districts

133 Alpine (Ag, Au) T19N, R36 & 37E (E)**

133 Tungsten Mountain (W) T21N, R38E (E)

** Letters refer to cumulative value of production through 1976. A = greater than \$1 billion; B = \$100 million - \$1 billion; C = \$10 million - \$100 million; D = \$1 million - \$10 million; E = less than \$1 million.

128 Wonder (Ag, Au, Cu) T18N, R35E (D)

128 Chalk Mountain (Pb, Ag, Au) T17N, R34E (E)

125 Westgate (Ag, Pb, Au) T17N, R35E (E)

124 Fairview (Ag, Au, Pb, Cu) T16N, R34E (E)

124 Sand Springs (Ag, Su, W) T16N, R32E (E)

II. Nonmetallic minerals

1. Active mines - none

2. Saline deposits

A. Commercial deposits - Sand Springs Marsh (NaCl) T16N, R31E

B. Playas

Fairview Valley

Edwards Creek Valley

III. Geothermal resource areas

1. No potential shown in M-X area

IV. Oil and gas fields - No exploratory wells in M-X area

ELKO COUNTY

I. Metallics

1. Active mines

186 Victoria mine (Cu) T28N, R66E

2. Metal mining districts

176 Valley View (W, Pb, Zn) T28N, R57 & 58E (D)

46 Lee (Cu) T30N, R57 & 58E (E)

176 Ruby Valley (W, Pb, Zn, Ag, Cu) T30N, R38E (E)

178A Mud Springs (Pb, Ag) T28N, R60E (E)

178A Delker (Cu) T29N, R62E (E)

188 Spruce Mountain (Pb, Ag, Zn, Cu, Au, W) T31N, R63E (D)

186 & 187 Dolly Varden (Cu, Pb, Ag, Au) T19N, R66E (C)

32 Ferguson Spring (Cu) T29N, R69E (E)

32 White Horse (Pb, Ag, Zn) T28N, R68E (E)

186 Kinsley (Cu, W, Au, Ag, Pb) T26N, R68E (E)

32 Ferber (Cu, Pb, Ag, Au) T27N, R70E (E)

II. Nonmetallics

1. Active mines - none

2. Saline deposits

Commercial deposits - none

Playas - Ruby Valley (176)

III. Geothermal resource areas

Ruby Valley - moderate industrial process heat potential; low residential space heating potential (176).

IV. Oil & gas fields - Two exploratory dry wells in M-X area.

EUREKA COUNTY

I. Metallics

1. Active mines

153 Mount Hope mine (Pb) T22N, R52E

153 Windfall mine (Au) T18N, R53E

2. Metal mining districts

153 Eureka (Pb, Au, Ag, Cu, Zn, Sb) T19N, R53E (B)

153 Alpha (Ag, Pb) T25N, R52E (E)

138 Roberts (Zn, Pb) T24N, R48E (E)

53 Antelope (Ag, Zn, Pb, Au, Cu) T23N, R50E (E)

153 Mount Hope T22N, R52E (E)

153 & 154 Diamond (Ag, Pb, Zn, Au, Cu) T22N, R54E (E)

139 Lone Mountain (Zn, Pb, Ag) T20N, R51E (E)

151 & 155 Fish Creek (Ag) T17N, R52E (E)

155 Gibellini (Mn) T15N, R52E (E)

II. Nonmetallic minerals

1. Active mines - none

2. Saline deposits

153 Williams Marsh (NaCl) T26N, R53E

153 Diamond Valley (NaSO₄) T24N, R54E

III. Geothermal resource areas

Moderate industrial process heat potential, low residential space heating potential shown in Antelope Valley, T18 & 19N, R50E.

IV. Oil and gas fields

One dry exploratory hole in M-X area

Heavy oil and gas leasing activity in Little Smoky Valley - T16N,
R53 & 54E; T15N, R52, 53, & 54E.

ESMERALDA COUNTY

- I. Metallics
 - 1. Active mines - None in M-X area
 - 2. Metal mining districts
 - 137A (Part of) Tonopah (Ag, Au, Pb, W, Cu) T2 & 3N, R42E (B)
 - 137A Crow Springs T5N, R39E (E)
 - 136 Gilbert (Au, Ag, Cu, Hg) T4N, R39E (E)
 - 143 Lone Mountain (Pb, Cu, Zn) T2N, R40W (E)
 - 137A Weepah (Au, Ag) T1N, R40W (D)
- II. Nonmetallic minerals
 - 1. Active mines - none
 - 2. Saline deposits
 - 142 Alkali Spring Valley (NaCl) T1S, R41E
 - 143 Silver-Peak Marsh (NaCl, Li) T1 & 2S, R40E
 - 3. Other playas
 - 136 T. S H, R37W (unnamed)
 - Big Smoky Playa, T2N, R38 & 39E
- III. Geothermal resource areas - Possible potential from Silver Peak (T25, R39E)
- IV. Oil and gas fields - none

LANDER COUNTY

- I. Metallics
 - 1. Active mines
 - 57 Thomas W. (Au, Ag) T20N, R30E
 - 57 Maren (Au) T20N, R40E

2. Metal mining districts

56 & 137B	Austin-Reese River (Au, Ag, U) T19N, R44E (C)
137B	Spencers Hot Spring (W) T17N, R46E (D)
137B	Ravenswood (Ag, Au) T22N, R42E (E)
56	Skookum (Ag, Au) T19N, R43E (E)
134	New Pass (Au, Mn, Ag, Pb) T20N, R40E (E)
56	Big Creek (Sb) T17N, R43E (D)
137B	Birch Creek (W, Au, Ag, U) T18N, R44E (E)
134	Gold Basins (Au, Ag) T16N, R38E (E)
137B	Kingston (Au, Ag) T16N, R43E (E)

II. Nonmetallic minerals

1. Active mines:

56	Allen mine (Barite) T21N, R42E
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2. Saline deposits - None commercially valuable

3. Other playas

Grass Valley (T23, 24, 25N, R47 & 48E)

Smith Creek Valley (T16 & 17N, R39 & 40E)

III. Geothermal resource areas

1. Moderate industrial process heat potential, low residential space heating potential shown in Smith Creek Valley (T17N, R39E)
2. Moderate industrial process heat potential, low residential space heating potential shown in N and Big Smoky Valley (T17N, R45E)

IV. Oil and gas fields - One dry exploratory well in M-X area

LINCOLN COUNTY

I. Metallics

1. Active mines

183	Atlanta mine (Ag-Au) T7N, R68E
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- 170 Tempiute mine (W) T3S, R56E
- 181 Pan American mine (Pb-Ag) T1S, R66E

2. Metal mining districts

- (Colo River) Pioche (An, Pb, Ag, Au, Mn, Cu, Fe) T1N, R67E (B)
- 183 Patterson (Ag, Au, Pb, Cu) T9N, R65E (E)
- 184 Atlanta (Au, Ag, U) T7N, R68E (E)
- 181 & Colo River Jack Rabbit (Cu, Ag, Pb, Mn, An, Au) T3N, R65 & 66E (C)
- 181 Lone Mountain (Ag) T1N, R65E (E)
- 181 Comet (Ag, Zn, Pb, Au, Cu, W) T1S, R66E (E)
- 53 Eagle Valley (Au, Ag, Pb, Cu) T1N, R70 & 71E (E)
- 172 Frierberg (Au, Ag, Pb, Zn) T1N, R57E (E)
- 170 Tempiute (W, Ag, Zn, Pb) T3 & 4S, R56 & 57E (C)
- (Colo River) Pahrnagat (Mn, Ag, Pb, Cu, Au) T3S, R39E (E)
- (Colo River) Chief (Au, Ag, Pb, Cu) T3S, R67E (E)
- 182 Delamar (Au, Ag) T5 & 6S, R64 & 65E (C)
- (Colo River) Vigo (Mn) T3S, R68F (E)
- (Colo River) Viola (Au, Ag, Cu, Pb) T10S, R69E (E)

II. Nonmetallic minerals

1. Active mines:

- 182 Mackie mine (Perlite) T4S, R62E

2. Saline deposits:

None commercially valuable

3. Other playas:

Cave Valley (T5 & 6N, R63E)

Dry Lake Valley (T2S, R64E)

Coal Valley (T1N & 1S, R59 & 60E)

Sand Spring Valley (T2 & 3S, R55E)

Delamar Playa (T7S, R62 & 63E)

III. Geothermal resource areas

1. Moderate industrial process heat potential, moderate residential space heating potential shown at Caliente (T3 & 4S, R67E)

IV. Oil and gas fields

1. None
2. Several dry exploratory holes in NW quarter of county
3. Oil and gas leasing activity:

Delamar Valley (R63E, T4, 6, & 7S; T4, 5, 6, and 7S)

Dry Lake Valley (R63E, T1 and 2S; T1N, 1, 2, & 3S; R65E, T1N, 1, 2, & 3S)

Lake Valley (R65E, T. 6, 7, 8 and 9 T3, 4, 5, 6, 7, 8 & 9N; R67E T2, 3, 4, 5, 6 & 6N; T1 & 2N)
Spring Valley (R67E, T9N; R68E, T9N)

Hamlin Valley (R69E, T7, 8, & 9N; T6, 7, 8, & 9N)

Muleshoe Valley (R63E, T4 & 5N; R64E, T5 & 6N; R64E, T5 & 6N; R65E, T5 & 6N)

Cave Valley (R63E, T6, 7, 8, & 9N; R64E, T6, 7, 8, & 9N)

White River Valley (R62E, T2, 3, 7, 8 & 9N)

Coal Valley (R59E, T1 & 2S, 1 & 2N, R60E, T1S, 1 & 2N)

Garden Valley (R57E, T1S, 1 & 2N; T1S, 1 & 2N)

Penoyer (Sand Spring) Valley (R54E, T3 & 4S; R55E, T. 1, 2, 3, & 4 S, T. 1N; R 56E, T. 1, 2, 3, & 4S, T. 1N; R 57E, T. 2 & 3 S)

Tikaboo Valley (R 56E, T. 5 S; R 57E, T. 4, 5, 6, & 7 S; R 58E, T. 4, 5, 6, & 7 S; R 59E, T. 7 S)

V. Sand and gravel sites

1. Delamar Valley - one site in T. 4 S, R 63E.
2. Pahroc Valley - one site in T. 3s, R 63E; one site in T. 3 S, R 62E; one site in T. 4 S, R 62E.

3. Lake Valley - one site in T. 1N, R 67E; one site in T. 2 N, R 67E; 4 sites in T. 3 N, R 66E; 2 sites in T. 4 N, R 66E; one site in T. 5 N, R 66E; one site in T. 6 N, R 66E; 2 sites in T. 9 N, R 85E.
4. Penoyer (Sand Spring) Valley - one site in T. 4 S, R 56E
5. Tikaboo Valley - one site in T. 4 S, R 56E; one site in T. 5 S, R 58E; one site in T. 6 S, R 58E.

VI. Mining claim activity

1. Delamar Valley

Patented claims - 3 patented claims in T. 5 S, R 64E

Unpatented claims. In T. 5 & 6 S, 64E

2. Dry Lake Valley. No known claim activity.

3. Lake Valley. South end of Lake Valley is adjacent to Pioche mining district.

Patented claims. In T. 1N, R 67E (adjacent to Pioche); in T. 3 N, R 66E (adjacent to Bristol Silver mine); in T. 7 N, R 68E

Unpatented claims. In T. 1N, R 66, 67, & 68E; T. 2 N, R 66 & 67E, T. 7 N, R 67E; T. 7 N, R 68E; T. 9 N, R 65E

4. Hamlin Valley

Patented claims. None known.

Unpatented claims. In T. 7 N, R 69E.

5. Cave Valley

Patented claims. None known.

Unpatented claims. In T. 9 N, R 63 & 64E; T. 5 N, R 63E.

6. Muleshoe Valley

Patented claims. None known.

Unpatented claims. In T. 6 N, R 64E.

7. White River Valley

Patented claims. None known.

Unpatented claims. In T. 8 N, R 62E; T. 2 N, R 62E.

8. Coal Valley

Patented claims. None known.

Unpatented claims. In T. 2 N, R 60 & 61E; T. 1N, R 60 & 61E.

9. Garden Valley

Patented claims. None known.

Unpatented claims. In T. 1N, R 57E.

10. Penoyer (Sand Spring) Valley

Patented claims. None known.

Unpatented claims. In T. 3 S, R 56E; T. 4 S, R 55E.

11. Tikaboo Valley

Patented claims. None known.

Unpatented claims. In T. 4 S, R 57E.

VII. Geothermal leasing activity. None known.

MINERAL COUNTY

I. Metallics

1. Active mines

122 Nevada Scheelite mine (W) T. 13 N, R 32E.

2. Metal mining districts

122, 123, 124 Leonard (W, Au, Pb, Ag) T. 13 & 14 N, R 32 & 33E (C)

122 Eagleville (Au, Ag, Sb) T. 14 N, R 34E (E)

123 Rawhide (Au, Ag, Cu, Pb, Sb) T. 13 & 14 N, R 31 & 32E (D)

122 Bell (Pb, Au, Ag, Zn, Cu, W, Hg) T. 8 N, R 36 & 37E (D)

II. Nonmetallic minerals

1. Active mines - none

2. Saline deposits - None commercially available

3. Other playas - Alkali flat, T. 12 N, R 33E

III. Geothermal resource areas

- 122 1. Areally limited occurrence on east side Alkali Flat, T. 12 N, R 33 & 34E; a spring 54 - 62° C, may represent potential for geothermal development.

IV. Oil and gas fields - None

NYE COUNTY

I. Metallics

1. Active mines

- 122 El Capitan mine (W) T. 13 N, R 36E.
134 Penelas mine (Au) T. 14 N, R 37E.
135 Catherine mine (Au) T. 13 N, R 39E.
135 Shamrock mine (Au) T. 13 N, R 39E.
137B Bobbie No. 4 mine (W) T. 13 N, R 42E.
137B Round Mountain mine (Au), T. 10 N, R 44E.
137B Shale Pit mine (Au) T. 9 N, R 43E.
137A Cannon mine (Au) T. 8 N, R 43E.
137A Nellie Grey Patent mine (Au) T. 8 N, R 43E.
137A Manhattan mine (Au), T. 8 N, R 44E.
140 Belmont mine (Au), T. 9 N, R 45E.
140 Barcelona mine (Ag), T. 9 N, R 45E.

2. Metal mining districts

- 137A San Antonio district (Mo, Ag, Au, Pb, Cu) T. 5 N, R 42E (E)
137A 15 mi (24 km) NNW of San Antonio district is the site of a large molybdenum mine to be opened by Anaconda within the next year or two.
Tonopah. Great bonanza district of early 1900s. (Ag, Au, Pb, W, Cu) T. 2 & 3 N, R 42 & 43E (B)

122	Quartz Mountain (Ag, Pb, Au) T. 14 N, R 36E (E)
122 & 134	Bruner (Au, Ag) T. 14 N, R 37E (E)
122	Lodi (W, Ag, Pb, Au) T. 14 N, R 37E (E)
122 & 134	Ellsworth (W, Au, Ag, Pb) T. 13 N, R 37E (E)
122	Gabbs (Mg, Fe, Pb, Ag, Hg, W) T. 11 & 12 N, R 36 & 37E (C)
135	Paradise Peak (W, Hg) T. 11 N, R 37E (E)
122	Fairplay (Ag, Au, Pb) T. 10 N, R 37E (E)
122	Athens (Au, Ag) T. 9 N, R 37E (E)
134	Jackson (Au, Ag, Pb) T. 14 & 15 N, R 39 & 40E (E)
135	North Union (Hg, Au, Ag, Pb, Zn, Cu) T. 11 & 12 N, R 39E (D)
135	South Union (Ag, Pb, Zn, Cu, Sb, Au, W) T. 11 N, R 39 & 40E (D)
137A	Cloverdale (Ag, Au, Pb) T. 7 & 8 N, R 39E (E)
137A	Royston (Ag, Pb, Cu) T. 6 N, R 40E (E)
56	Washington (Ag, Pb) T. 15 N, R 42 & 43E (E)
137B	Twin River (Au, Ag, W, Pb, Zn) T. 12 & 13 N, R 42E (D)
137A	Jett (Sb, Hg, Pb, Ag, W) T. 10 N, R 42E (E)
140	Northumberland (Au, Ag) T. 13 N, R 46E (D)
137B	Round Mountain (Au, Ag, W, Sb) T. 10 N, R 44E (C)
137A	Manhattan (Au, Ag, Sb) T. 8 N, R 44E (C)
140	Barcelona (Ag, Hg, Au, W) T. 9 N, R 45E (D)
140	Belmont (Ag, Au) T. 9 N, R 4E (D)
150	Danville (Ag, Au) T. 11 N, R 48E (E)
149	Longstreet (Au, Ag) T. 6 N, R 47E (E)
156	Morey (Ag, Au, Sb) T. 9 N, R 51E (E)
156	Tybo (Pb, Ag, Zn, Au, Hg, Cu, Sb) T. 6 & 7 N, R 49 & 50E (C)

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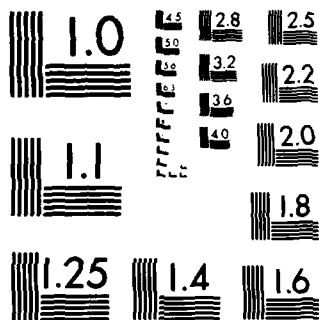
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ONE



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

173	Silverton (Ag), T. 8 N, R 54E (E)
173	Currant (Au, Ag) T. 11 N, R 59E (E)
173	Troy (W, Au, Zn, Ag, Pb) T. 6 N, R 57E (E)
172	Willow Creek (Au, Ag) T. 4 N, R 56E (E)
149	Hannapah (Ag, Au) T. 3 N, R 45E (E)
149	Ellendale (Au, Ag, Cu) T. 3 N, R 47E (E)
149 & 156	Clifford (Au, Ag) T. 3 N, R 49E (E)
156	Bellehelen (Ag, Au, Cu) T. 1 N, R 49 & 50E (E)
149	Golden Arrow (Ag, Au) T. 1 N, R 48E (E)
156	Eden (Au, Ag) T. 1N, R 50E (E)
148	Silver Bow (Ag, Au, Pb) T. 1N, R 49E (E)
173	Arrowhead (Au, Ag) T. 3 N, R 52E (E)
173	Reveille (Ag, Pb, Au, Sb, Cu, W) T. 2 N, R 51E (D)
170 & 173	Black Hawk (Hg) T. 2 S, R 54E

II. Nonmetallic minerals

1. Active mines

122	Gabbs (Magnesite): T. 12 N, R 37E
137B	P & S (Barite): T. 13 N, R 45E
140	Northumberland (Barite): T. 12 N, R 46E

2. Saline deposits

Commercially valuable deposits

Spaulding Marsh (NaCl) T. 14 N, R 43 & 44E. Located at the north end of Big Smoky Playa (T. 13 & 14 N, R 43 & 44E).

Railroad Valley (NaCl) T. 8 N, R 56E.

Railroad Valley (Na₂CO₃) T. 7 N, R 56E.

Other playas

Monitor Valley T. 13 N, R 47E.

Little Smoky Valley T. 12 N, R 53E.

Pancake Range playa T. 6 N, R 53E.

Mud Lake T. 1 S, R 43 & 44E.

South Railroad Valley T. 1 & 2 N, R 53E.

III. Geothermal resource areas

- 122
1. Moderate industrial process heat potential, moderate residential space heating potential indicated in Gabbs area, T. 11 - 13 N, R 36E.
 2. High industrial process heat potential, low residential space heating potential along west side of central Big Smoky Valley, T. 11 - 14 N, R 43E.
 3. Moderate industrial process heat potential, low residential space heating potential in central Monitor Valley, T. 7 & 8 N, R 49, 50, & 51E.
 4. Moderate industrial process heat potential, low residential space heating potential in central Hot Creek Range and Hot Creek Valley, T. 7 & 8 N, R 49, 50, & 51E.
 5. Moderate industrial process heat potential, low residential space heating potential indicated on west side of central Railroad Valley, T. 6, 7, 8, & 9 N, R 54 & 55E.

IV. Oil and gas fields

1. Nevada's only commercial oil fields, to date.

Eagle Springs field, Railroad Valley, T. 9 N, R 57E.

Currant or Trap Spring field, Railroad Valley, T. 9 N, R 56E.

Eagle Springs field production to 1970 (1954 - 1970 cumulative): 2.5 million barrels (397,250 m³).

2. Oil and gas leasing activity:

White River Valley (T. 11 N, R 60E; T. 10 N, R 60, 61, & 62E; T. 9 N, R 60, 61, & 62E; T. 8 N, R 60, 61, & 62E; T. 7 N, R 59, 60, 61, & 62E; T. 6 N, R 59, 60, 61, & 62E; T. 4 N, R 60 & 61E; T. 3 N, R 61 & 62E; T. 2 N, R 62E).

Coal Valley (T. 3 N, R 59 & 60E; T. 2 N, R 59 & 60E).

Garden Valley (T. 5 N, R 58 & 59E; T. 4 N, R 58 & 59E; T. 3 N, R 57 & 58E; T. 1 N, R 47 & 58E).

Railroad Valley: (T. 14 N, R 55, 55½, & 56E; T. 13 N, R 55, 55½, & 56E; T. 12 N, R 55, 55½, 56, & 57E; T. 11 N, R 55, 55½, 56, 57, & 58E; T. 10 N, R 55, 56, 57, & 58E; T. 9N, R 55 & 56E; T. 8 N, R 55E; T. 7 N, R 54 & 55E; T. 6 N, R 54, 55, 56, & 57E; T. 5 N, R 53, 54, 55, 56, & 57E; T. 4 N, R 52, 53, 54, & 55E; T. 3 N, R 52, 53, & 54E; T. 2 N, R 52, 53, & 54E; T. 1N, R 52, 53, & 54E; T. 1S, R 53E, T. 2S, R 52 & 53E).

Little Smoky Valley (T. 15 N, R 52, 53, & 54E; T. 14 N, R 52 & 53E; T. 13½ N, R 52 & 53E; T. 13 N, R 52 & 53E; T. 12 N, R 52 & 53E; T. 13 N, R 52 & 53E).

Big Sand Springs Valley (T. 13 N, R 54E; T. 12 N, R 53 & 54E; T. 11 N, R 53, 54, & 55E; T. 10 N, R 53 & 54E; T. 9 N, R 52, 53, & 54E; T. 8 N, R 52 & 53E; T. 7 N, R 52 & 53E).

Hot Creek Valley (T. 9 N, R 51E; T. 8 N, R 50, 51, & 52E; T. 7 N, R 50 & 51E; T. 6 N, R 50 & 51E; T. 5 N, R 50 & 51E; T. 4 N, R 50E).

Reveille Valley (T. 4 N, R 50 & 51E; T. 3 N, R 50 & 51E; T. 2 N, R 50 & 51E, T. 1N, R 51 & 51½E; T. 1S, R 51E).

V. Sand and gravel sites

1. White River Valley. 6 sites in T. 6 N, R 62E; 1 site in T. 5 N, R 62E.
2. Railroad Valley. 1 site in T. 11 N, R 57E; 1 site in T. 10 N, R 58E; 3 sites in T. 8 N, R 57E; 1 site in T. 1N, R 53E; 1 site in T. 1S, R 53E; 1 site in T. 2 S, R 54E.
3. Penoyer Valley. 1 site in T. 2 S, R 54E.
4. Hot Creek Valley. 1 site in T. 7 N, R 52E; 5 sites in T. 6 N, R 51E; 1 site in T. 4 N, R 50E.
5. Reveille Valley. 1 site in T. 4 N, R 50E.

VI. Mining claim activity

1. White River Valley - Unpatented claims in T. 2 N, R 62E.
2. Coal Valley - Unpatented claims in T. 2 N, R 60 & 61E, and in T. 3 N, R 60 & 61E.

3. Railroad Valley - Unpatented claims in T. 10 & 11 N, R 58E (Current district); T 9 N, R 55E; T. 3 N, R 53E; T. 2 N, R 52E; T. 1 N, R 52E.
4. Little Smoky Valley - Unpatented claims in T. 14 N, R 52E.
5. Big Sand Springs Valley - Unpatented claims in T. 7 N, R 53E.
6. Hot Creek Valley - Unpatented claims in T. 10 N, R 51E; T. 9 N, R 51E; T. 7 N, R 50E; T. 6 N, R 50E.
7. Reveille Valley - Unpatented claims in T. 2 N, R 51½E.

VII. Geothermal Leasing Activity

1. Railroad Valley. Geothermal leases in N½, T. 7 N, R 55E.
2. Hot Creek Valley. Geothermal leases in T. 4 N, R 50E.
3. Reveille Valley. Geothermal leases in T. 4 N, R 50E.

WHITE PINE COUNTY

I. Metallics

1. Active mines

- | | |
|-----|--|
| 154 | High Point mine (Pb, Ag) T. 18 N, R 55E. |
| 179 | Ruth Pit (Cu) T. 16 N, R 62E. |
| 179 | Aultman mine (Au, Ag) T. 18 N, R 63E |
| 179 | Ward Mountain mine (Pb, Ag) T. 14 N, R 63E |
| 4 | Taylor mine (Au placer) T. 15 N, R 67E |
| 184 | Sullivan mine (Au placer) T. 14 N, R 67E |
| 4 | Osceola mine (Au placer) T. 14 N, R 67E |
| 4 | Lexington mine (W) T. 11 N, R 69E |

2. Metal mining districts

- | | |
|-----|---|
| 179 | Ely (Cu, Au, Ag, Mo, Zn, Pb, Mn) T. 16 N, R 62 & 63E.
One of the world's greatest copper pits and the only Nevada district to be rated <u>A</u> - over \$1 billion produced. |
| 176 | Bald Mountain (W, Cu, Au, Ag, Sb) T. 24 N, R 57E (E) |

154	Newark (W, Ag, Au, Pb) T. 19 N, R 55E (D)
154 & 173	White Pine (Pb, Ag, Au, Cu, Zn, W) T. 16 N, R 57E (C)
179	Cherry Creek (W, Ag, Au, Pb, Cu) T. 23 & 24 N, R 62E (C)
179	Granite (Pb, Au, Ag) T. 21 N, R 62 & 63E (E)
179	Hunter (Ag, Pb) T. 20 N, R 62E (E)
179	Ward (Ag, Au, Pb, Cu, Zn) T. 14 N, R 63E (D)
179	Duck Creek (Pb, Ag, Au, Cu, Zn) T. 17 N, R 64E (E)
179	Nevada (Mn, Ag, Au) T. 14 & 15 N, R 64E (D)
184	Taylor (Ag, Au, Sb, Pb) T. 14 N, R 65E (D)
184	North Aurum (W) T. 23 N, R 65E (E)
184	Middle Aurum (Zn, Ag, Cu, Pb, Mn, Au) T. 21 & 22 N, R 65E (D)
184	South Aurum (Ag, Pb, Cu, Au) T. 20 N, R 66E (E)
185	Red Hills (Pb, Ag, Au, Cu) T. 21 N, R 67E (E)
194	Tungstonice (W, Au, Ag, Pb, Cu, Zn) T. 21 N, R 68E (E)
4	Black Horse (Ag, W, Au, Pb) T. 15 N, R 68E (E)
4	Osceola (Au, Ag, W, Pb) T. 14 N, R 67 & 68E (D)
4	Tungsten (W, Ag) T. 12 & 13 N, R 68E (E)
4	Lincoln (W, Ag, Pb) T. 12 N, R 68E (E)
183 & 196	Minerva (W, Ag) T. 11 N, R 68E (D)
4	Lexington, T. 11 N, R 69E (E)
4	Snake (W, Ag) T. 12 N, R 69 & 70E (E)

II. Nonmetallic minerals

I. Active mines

179	McGill mine (limestone) T. 18 N, R 64E
	Much of production used in McGill copper smelter

2. Saline deposits

Commercially valuable deposits

Spring Valley (NaCl) T. 17 N, R 67E

Other playas

Long Valley (T. 21 N, R 58E)

Jakes Valley (T. 16 N, R 59 & 60E)

South end of Spring Valley (T. 11 N, R 67E)

III. Geothermal resource areas

Moderate industrial process heat potential, low residential space heating potential at Cherry Creek in Central Steptoe Valley (T. 23 N, R 63E) and Warm Springs in Central Steptoe Valley (T. 21 N, R 63E). It is possible that these two areas are connected in an 18 mi (29 km) long favorable zone.

IV. Oil and gas fields

The eastern half of White Pine County, White River, Butte, Jakes, Long, Newark, and upper Railroad valleys is close to the Nye County production in southern Railroad Valley. This, together with similar favorable geology, has encouraged the drilling of 29 test holes. None were commercially productive, although 5 encountered oil and gas shows.

3. Oil and gas leasing activity

Snake Valley (T. 18 N, R 70E; T. 15 N, R 70 & 71E; T. 14 N, R 69, 70, and 71E; T. 13 N, R 69 & 70E)

Hamlin Valley (T. 11 N, R 70E; T. 10 N, R 70E)

Spring Valley (T. 11 N, R 66, 67, & 68E; T. 10 N, R 66, 67, & 68E)

Lake Valley (T. 10 N, R 65 & 66E)

Steptoe Valley (T. 15 N, R 63 & 64E; T. 14 N, R 63 & 64E; T. 13 N, R 63, 64, & 65E)

White River Valley (T. 11 N, R 60, 61, & 62E; T. 10 N, R 62E)

Railroad Valley (T. 14 N, R 55, 56, & 57E; T. 13 N, R 67E)

Little Smoky Valley (T. 16 N, R 54E; T. 15 N, R 54E)

V. Sand gravel sites

1. Snake Valley. One site in T. 14 N, R 69E; one site in T. 13 N, R 70E.
2. Spring Valley. One site in T. 11 N, R 66E.
3. Lake Valley. Two sites in T. 10 N, R 65E; one site in T. 10 N, R 66E.
4. Steptoe Valley. One site in T. 15 N, R 64E; one site in T. 14 N, R 64E.
5. White River Valley. One site in T. 11 N, R 62E; one site in T. 11 N, R 62E.

VI. Mining claim activity

1. Spring Valley

No unpatented claims known

2. Cave Valley

Unpatented claims in SW $\frac{1}{4}$ T. 10 N, R 64E.

3. Steptoe Valley

Unpatented claims in SE $\frac{1}{4}$ T. 15 N, R 63E; NE $\frac{1}{4}$ T. 14 N, R 63E; NW $\frac{1}{4}$ T. 14 N, R 64E.

VII. Geothermal leasing activity - None known

APPENDIX B

EARTH RESOURCES INVENTORY BY COUNTY FOR UTAH

BEAVER COUNTY

I. Metallics.

(Watershed
No.)

1. Metal mining districts.

5 & 196	Indian Peak (Ag, Pb, CaF ₂) T. 28 S., R. 16 & 19 S.
54	Pine Grove (Pb, Fe, U) T. 28 S., R. 15 W.
54	Sterling T. 27 S., R. 15 W.
50	Star and North Star (Ag, Pb, Cu, Zn, W, Mo, CaF ₂) T. 28 S., R. 11 & 12 W.
50 & 54	San Francisco (Ag, Cu, Zn, Sb, Au, Pb, W) T. 27 S., R. 13 W.
50	Pruess (Cu, Au, Pb) T. 26 S., R. 13 W.
50	Beaver Lake (Cu) T. 26 S., R. 11 & 12 W.
50	Rocky (Cu, W) T. 27 S., R. 11 W.
50	Antelope (Pb, Cu) T. 26 S., R. 8 & 9 W.
50 & 48	Granite and North Granite (Au, Ag, Cu, Pb, Zn, Mo, W, Th, RE) T. 27 S., R. 8 & 9 W.
50	Bradshaw (Ag, Au, Cu, Pb, Fe, W, Zn) T. 29 S., R. 9 & 10 W.
48	Lincoln (Cu, Pb, Ag, W, Zn) T. 29 S., R. 9 W.
48	Fortuna (Au) T. 27 S., R. 7 W.

II. Nonmetallic minerals.

52	1. Sulfur. Found in Sulphur Mining District, T. 30 S., R. 15 W.
50	2. Alunite. At White Mountain, T. 29 S., R. 12 & 13 W. Zone 5 mi (9 km) long.
50	3. Barite. At Horn Silver Mine, San Francisco district; T. 27 S., R. 13 W. 1000 tons produced.

- 50 4. Fluorite. At Indian Peak district (5) T. 28 S., R. 18 & 19 W.; Pine Grove district, T. 28 S., R. 15 W.; and at Star district, T. 28 S., R. 11 & 12 W., approximately 5000 tons produced. Estimated reserves of 50,000 tons 40% CaF_2 .
- 50 5. Aggregate. Perlite in San Francisco Mountains, T. 26 S., R. 13 E. Perlite on west side Mineral Mountains, T. 28 S., R. 9 W. and T. 27 S., R. 8 W. Pumice and pumicite in some locations on west side Mineral Mountains. Diatomaceous earth on north side Black Mountains, T. 30 S., R. 11 W.
- 50 6. Magnesite. Reported from San Francisco Mountains, T. 26 S., R. 13 W.
- 50 7. Marble. Reported from San Francisco Mountains.

III. Geothermal Resources.

1. The Escalante Desert in the Milford vicinity is recognized as a "hot" prospect, with potential for industrial process heating, space heating, and possibly even electric power. Several major companies, with Phillips Petroleum in the lead, have been engaged in active drilling, leasing, and geophysical exploration here for the past several years.
2. Geothermal leasing activity.

Escalante Desert (T. 26 S., R. 8, 9, 10, & 11 W.; T. 27 S., R. 9, 10, 11 & 12 W.; T. 28 S., R. 9, 10, 11, 12 & 13 W.; T. 29 S., R. 11 & 12 W.).

Wah Wah Valley (T. 27 S., R. 13 W.; T. 28 S., R. 13 W.).

IV. Petroleum Resources.

1. Just west of southern overthrust Belt - "last petroleum frontier in 48 states."
2. Oil and gas field - none.
3. Oil and gas leasing activity:

Escalante Desert (T. 26 S., R. 8, 9, 10, 11 & 12 W.; T. 27 S., R. 9, 10, 11 & 12 W.; T. 28 S., R. 9, 10, 11 & 12 W.; T. 29 S., R. 10, 11 & 12 W.; T. 30 S., R. 9 & 10 W.).

Wah Wah Valley (T. 26 S., R. 13 & 14 W.; T. 27 S., R. 13, 14 & 15 W.; T. 28 S., R. 13, 14 & 15 W.).

Pine Valley (T. 26 S., R. 16, 17 & 18 W.; T. 27 S., R. 16, 17 & 18 W.; T. 28 S., R. 16, 17 & 18 W.; T. 29 S., R. 16 & 17 W.; T. 30 S., R. 16 & 17 W.).

Hamlin Valley (T. 26 S., R. 19 & 20 W.; T. 27 S., R. 20 W.;
T. 28 S., R. 19 & 20 W.).

V. Sand and Gravel Sites.

1. Pine Valley. 1 site in T. 26 S., R. 16 W.

VI. Mining Claim Activity.

1. Escalante Desert.

Unpatented claims in T. 26 S., R. 12 W.; T. 27 S., R. 11
& 12 W.; T. 28 S., R. 9, 11 & 12 W.; T. 29 S., R. 10 & 11 W.

Patented claims in T. 26 S., R. 11 W.; T. 27 S., R. 11 &
12 W.; T. 28 S., R. 11 W.; T. 29 S., R. 9 & 10 W.

2. Wah Wah Valley.

No unpatented claims known.

Patented claims in T. 27 S., R. 13 W.

3. Pine Valley.

Unpatented claims in T. 27 S., R. 16 & 17 W.; T. 28 S., R. 16
& 17 W.; T. 29 S., R. 16 & 17 W.; T. 30 S., R. 16 & 17 W.

IRON COUNTY (NW CORNER)

I. Metallics.

(Hydrologic Unit
No.)

1. Metal mining districts.

196 Stateline (Ag, Au, Hg, Fe) T. 31 S., R. 19 E.

196 Gold Springs (Ag, Au, Hg) T. 32 S., R. 19 E.

II. Nonmetallic Minerals.

5 Sulfur. Found (along with some mercury) at Cina Mine, T. 31 S.,
R. 18 W.

III. Geothermal Resources. None known.

IV. Petroleum Resources.

1. Oil and gas fields - none.
2. Oil and gas leasing activity:

Pine Valley. 4 scattered sections in T. 31 S., R. 16 & 17 W.

V. Sand and Gravel Sites. None known.

VI. Mining Claim Activity. None known.

JUAB COUNTY

I. Metallics.

(Watershed
No.)

1. Metal mining districts.

- | | |
|-------|---|
| 4 | Spring Creek (Cu, Pb, Be) T. 12 S., R. 19 W. |
| 4 | Trout Creek (Au, Zn, W) T. 12 S., R. 18 W. |
| 4 | Fish Springs (Pb, Ag, Cu, Zn) T. 11 S., R. 14 W. |
| 7 & 8 | Detroit (Cu, Ag, Au, Pb, Mn) T. 14 S., R. 11 W. |
| 46 | Deseret (Pb, Cu) T. 12 S., R. 6 & 7 W. |
| 46 | West Tintic (Pb, Cu, Fe, Au, W, Zn) T. 11 S., R. 4 & 5 W. |

2. Other important metallic deposits.

Spor Mountain (T. 12 & 13 S., R. 12 W.).

Uranium. Very widely distributed uranium in vein deposits -- low temperature hydrothermal veins. Carnotite with quartz, fluorite, opal.

Beryllium. World's largest beryllium deposit (millions of tons). Finely divided beryllium mineralization is disseminated in an extensive blanket of altered rhyolitic tuff with an average content of about 1/2 percent BeO.

Thomas Range (T. 13 S., R. 12 W.).

Uranium. Yellow Chief deposit. Uranium mineralization disseminated in a Tertiary tuffaceous sandstone. Over 10,000 tons (9,000 tonnes) ore mined.

II. Nonmetallic Minerals.

- | | |
|---|--|
| 8 | 1. Topaz. Largest topaz deposits in U.S. at Topaz Mountain (T. 13 S., R. 11 ???). Prime gemstone area. |
| 4 | 2. Barite. Garrick Mine (T. 13 S., R. 16 W.). |

- 7 & 8 3. Fluorspar. Thomas Range (T. 12 & 13 S., R. 11 & 12 W.) is Utah's largest fluorite producer. Fluorite occurs as pipes and veins in dolomite. 12 mines have produced 144,000 tons (130,600 tonnes) from 1943 - 1962. 62,000 tons indicated (56,000 tonnes) and 300,000 tons (270,000 tonnes) estimates reserves.
- 7 4. Magnesite. Very small production from Fish Springs Range (T. 11 S., R. 14 W.).

III. Geothermal Resources.

- 1. Some potential in Fish Springs Flat (west-central part of county) although not quite as "hot" an area as Beaver and Millard counties to the south.

- 2. Geothermal leasing activity:

Sevier Desert. Few scattered sections in T. 13 & 14 S., R. 9 W.

Fish Springs Flat. T. 11 S., R. 14 W.; T. 12 S., R. 13 W.; T. 13 S., R. 12 & 13 W.

Tule Valley. Few scattered sections in T. 11 S., R. 15 & 16 W.; T. 12 S., R. 15 W.; T. 13 S., R. 15 & 16 W.

IV. Petroleum Resources.

- 1. Oil and gas fields - none.

- 2. Oil and gas leasing activity:

Sevier Desert. T. 11 S., R. 6, 7, 8 & 9 W. (few scattered sections); T. 12 S., R. 6, 7 & 8 W.; T. 13 S., R. 6, 7, 8, 9, & 10 W.; T. 14 S., R. 9 W. (3 scattered sections). Oil well locations reported in the center of the E 1/2 T. 15 S., R 7 E.

Dugway Valley. T. 11 S., R. 10 W. (scattered sections); T. 12 S., R. 10 W.; scattered sections in R. 11 W., T. 13 S., R. 10 W.; 2 sections in T. 14 S., R. 10 ???.

Fish Springs Flat. T. 11 S., R. 12 & 13 W. (scattered sections); T. 12 S., R. 13 & 14 W. (scattered sections); T. 13 S., R. 12, 13 & 14 W.; T. 14 S., R. 13 & 14 ???

Tule Valley. T. 11 S., R. 15 W. (1 section) & 16 ???; T. 12 S., R. 15 W. (2 sections) & 16 W.; T. 13 S., T. 14 S., R. 14, 15, 16 & 17 W.

Snake Valley. T. 12 S., R. 17 W. (1 section) & ??? ???; T. 13 S., R. 17, 18, and 1 section in 19 W.; T. ??? ???, R. 17, 18, 19 & 20 W.

V. Sand and Gravel Sites.

1. No organized material sites known or identified.

VI. Mining Claim Activity.

1. Sevier Desert (Heavy Mining Claim Activity).

Unpatented claims in T. 11 S., R. 6 & 7 W.; T. 12 S., R. 6, 7 & 8 W.; T. 13 S., R. 6, 7, 8, 9 & 10 W.; T. 14 S., R. 9 & 10 W.

2. Dugway Valley (Heavy Mining Claim Activity).

Unpatented claims in SW 1/4 T. 11 S., R. 10 W.; T. 12 S., R. 10 W. (NW 1/4) & T. 12 S., T. 11 W.; T. 13 S., R. 10 & 11 W.; T. 14 S., R. 10 & 11 W.

3. Fish Springs Flat (Heavy Mining Claim Activity).

Unpatented claims in T. 11 S., R. 12 W.; T. 12 S., R. 12 & 13 W. & SE 1/4 R. 14 W.; T. 13 S., R. 11, 12 & 13 W.; T. 14 S., R. 12 W.

4. Tule Valley.

Unpatented claims in T. 11 S., R. 14 & 15 W. & SE 1/4 T. 16 W.; T. 12 S., R. 15 W. (NE 1/4); T. 13 S., R. 15 W. (NW 1/4) & R. 16 W. (NE 1/4); T. 14 S., R. 14 W. (E 1/2).

Patented claims in SW 1/4 T. 11 S., R. 14 W.

5. Snake Valley.

Unpatented claims in T. 12 S., R. 17 W. (SW 1/4) & T. 12 S., R. 18 W. (SE 1/4).

MILLARD COUNTY

I. Metallics.

(Watershed
No.)

1. Metal mining districts.

7 & 46

Detroit (Little Drum) (district extends north into Juab County). (Cu, Mn, Bi) T. 15 S., R. 10 & 11 W.

46A

Saw Back (Cu, Pb, Mo) T. 22 S., R. 13 W.

Gordon (Fe) T. 25 S., R. 6 W.

2. Other important metallic deposits.

- 50 Tungsten. South of Marjum Pass in House Range (T. 13 S., R. 14 W.). Roughly 10,000 tons (9,000 tonnes) ore produced.

II. Nonmetallic Minerals.

- 50 1. Fluorspar. Minor production from Rainbow mine, near Cove Fort (T. 25 S., T. 6 W.).

- 47 2. Gypsum. In gypsum sand dunes and evaporite beds approximately 8 miles (13 km) west of Fillmore (T. 21 S., R. 6 W.).

3. Aggregate.

Perlite. In Escalante Desert (T. 24 S., R. 9 W.); Black Rock Desert (T. 22 S., R. 9 W.); and Cricket Mountains (T. 21 S., R. 10 W.).

Pumice. In Escalante Desert (T. 24 S., R. 9 W.).

- 47 Volcanic cinders. At Black Rock Volcano, Black Rock Desert (T. 23 S., R. 6 W.); 10 miles (16 km) west of Fillmore (T. 21 S., R. 6 W.); Pawant Butte (T. 19 S., R. 6 W.); and Whirlwind Valley southwest of Delta (T. 18 & 19 S., R. 8 W.).

- 46A Diatomaceous earth. Low-grade deposit south of Sevier Lake (T. 24 S., R. 12 W.).

4. Limestone. Cricket Limestone and Dolomite Company quarry, Cricket Mountains (T. 23 S., R. 10 W.).

5. Saline deposits.

Sevier Lake, Saline sink of the Sevier River.

Other playas:

Tule Valley

Snake Valley (salt marsh at north end, T. 15 S., R. 18 W.).

North end of Wah Wah Valley.

6. Sulfur deposits.

Sulphurdale or Gordon district, T. 25 S., R. 6 W. Largest deposits in Utah. Pipes, veins, and impregnations in rhyolite tuff and andesite. Only significant production to date in Beaver country to south.

III. Geothermal Resources.

1. Escalante Desert and Black Rock Desert areas, roughly between I-15 and the Union Pacific Railroad, are recognized as areas of recent vulcanism, high heat flow, and high potential. Phillips Petroleum has been especially aggressive in exploring the Roosevelt area, in the southern Black Rock Desert about 25 mi (40 km) southwest of Fillmore.

2. Geothermal leasing activity:

Whirlwind Valley. T. 15 S., R. 9 W. (1 section); T. 17 S., R. 9 W. (1-1/2 sections).

Black Rock Desert. T. 19 S., R. 9 W. (1 section); T. 20 S., R. 8 & 9 W.; T. 21 S., R. 8 & 9 W.; T. 23 S., R. 7 & 8 W., T. 24 S., R. 7 & 8 W.

Escalante Desert. SE 1/4 T. 24 S., R. 9 W.; T. 25 S., R. 8 & 9 W.; T. 26 S., R. 8 & 9 W. and 1 section in NE 1/4 R. 11 W.

IV. Petroleum Resources.

1. Oil and gas fields - none.
2. Oil and gas leasing activity:

Whirlwind Valley. T. 15 S., R. 9 W.; 1 section in R. 10 W.; R. 12 W. T. 16 S., R. 9 W., 3 sections in R. 10 W., scattered sections in R. 11 W., R. 12 W.; T. 17 S., R. 9 & 10 W.; scattered sections in 11 & 12 W.; T. 18 S., R. 9 & 10 W.; scattered sections in 11 W., 12 W.; T. 19 S., R. 9, 10 & 12 W.; T. 20 S., R. 12 W.

Black Rock Desert. T. 20 S., R. 7, 8 & 9 W.; T. 21 S., R. 7, 8 & 9 W.; T. 22 S., R. 7, 8 & 9 W.; T. 23 S., R. 7, 8, 9 & 10 W.; T. 24 S., R. 7, 8 & 9 W.

Escalante Desert. T. 23 S., R. 10 W (1 section); T. 24 S., R. 8, 9, 10 & 1 section in 11 ???; T. 25 S., R. 8, 9, 2 half-sections in 10, 11 & 1 section in 12 W.; T. 26 S., R. 8, 9, 11 & 12 W.

Sevier Lake. T. 19 S., R. 10 & 11 W.; T. 20 S., R. 10, 11, 12 & 13 W.; T. 21 S., 2 sections in R. 10, 11, 12 & 13 W.; T. 22 S., R. 11, 12 & 13 W.; T. 23 S., R. 11, 12, and scattered sections in 13 W.; T. 24 S., WNW 1/4 R. 11, R. 12 & 13 W.; T. 25 S., R. 12 & NE 1/4 13 W.

Wah Wah Valley. T. 24 S., R. 13 & 14 W.; T. 25 S., R. 13 & 14 W.; 1/2 section in R. 15 W.; T. 26 S., R. 13 & 14 W.

Tule Valley. T. 15 S., R. 14, 15, 16 & NE 1/4 17 W.; T. 15-1/2 S., R. 14, 15, 16 W.; T. 16 S., R. 14, 15, 16 W.; T. 17 S., R. 14, 15, 16 W.; T. 18 S., NW 1/4 R. 14, R. 15, & SE 1/4 R. 16 W.; T. 19 S., 3 sections in R. 15 W., 1/2 section in R. 16 W.; T. 20 S., 1-1/2 sections in R. 15 W.; T. 21 S., scattered sections in R. 14 W., 1/2 section in SE 1/4 R. 15 W.; T. 22 S., WNW 1/4 R. 13 W., 3 sections in R. 14 W.; T. 23 S., 2 sections in NW 1/4 R. 13 W., R. 14 W., SE 1/4 R. 15 W.; T. 24 S., R. 14 & 15 W.

Snake Valley. T. 15 S., R. 17, 18, 19 & 20 W.; T. 16 S., R. 17, 18, 19 & 20 W.; T. 17 S., R. 17, 18, 19 & 20 W.; T. 18 S., R. 17, 18, 19 & 20 W.; T. 19 S., R. 16 (SW 1/4), R. 17, 18, 19 & 20 W.; T. 20 S., R. 16, 17, 18, & NW section of 19 W.; T. 21 S., R. 16, 17, 18 & 19 S.; T. 22 S., R. 15 W., scattered sections in 16 W., R. 17, 18, 19 & 20 W.; T. 23 S., scattered sections in 16 & 17 W., R. 18 W.; T. 24 S., R. 18 & 19 W.; T. 25 S., R. 18 & 19 W. Exploratory well in SW 1/4 T. 17 S., R. 18 W. Being drilled by Amerada - 7,782 ft deep (January 1980).

Pine Valley. T. 23 S. 1/2 section in SW 1/4 R. 16 W.; T. 24 S., R. 16 W.; T. 25 S., R. 16 W.; T. 26 S., R. 16, 17 & 18 W.

Hamlin Valley. T. 22 S., R. 19 & 20 W.; T. 23 S., R. 18, 19 & 20 W.; T. 24 S., R. 18, 19 & 20 W.; T. 25 S., R. 18, 19 & 20 W.; T. 26 S., R. 20 W.

V. Sand and Gravel Sites.

1. Black Rock Desert. 1 site 1.5 mi (2.5 km) southwest of Pawant Butte (T. 19 S., R. 6 W.).
2. Snake Valley. 1 site in T. 25 S., R. 18 W.

VI. Mining Claim Activity.

1. Whirlwind Valley.

Unpatented claims in N 1/2 T. 15 S., R. 9 W.; T. 16 S., R. 9 W.; W 1/2 T. 17 S., R. 10 W.; E 1/2 T. 18 S., R. 13 W.; S 1/2 T. 19 S., R. 12 W.

2. Black Rock Desert.

Unpatented claims in W 1/2 T. 21 S., R. 9 W.; S 1/2 T. 23 S., R. 8 W.

3. Escalante Desert.

Unpatented claims in T. 25 S., R. 9 W.

4. Sevier Lake (Heavy Claim Activity).

Unpatented claims in T. 20 S., R. 10, 11 & 12 W.; T. 21 S., R. 10, 11, 12 & 13 W.; T. 22 S., R. 11, 12 & 13 W.; T. 23 S., R. 11, 12 & 13 W.; T. 24 S., R. 11, 12 & NE 1/4 R. 13 W.; T. 25 S., N 1/2 R. 12 W.

5. Tule Valley.

Unpatented claims in T. 15 S., W 1/2 of R. 14 W.; T. 16 S., N 1/2 R. 15 W.; T. 17 S., N 1/2 R. 14 W., R. 15 W.; T. 18 S., N 1/2 R. 15 W.; T. 19 S., W 1/2 R. 14 W.; T. 20 S., E 1/2 R. 14 W., N 1/2 R. 15 W.; T. 21 S., N 1/2 R. 14 W.; T. 23 S., N 1/2 R. 14 W.

6. Wah Wah Valley.

Unpatented claims in T. 24 S., S 1/2 of R. 13 W.; T. 25 S., R. 13 W.

7. Snake Valley.

Unpatented claims in T. 19 S., S 1/2 R. 17 W., & W 1/2 R. 19 W.; T. 20 S., NW 1/4 R. 18 W.

TOOELE COUNTY

I. Metallics.

(Watershed
No.)

1. Metal mining districts.

- | | |
|--------|--|
| 3 | Gold Hill (Au, Cu, Pb, Bi, W, Zn, Be, As) T. 8 S., R. 17 & 18 W. |
| 3 & 32 | Willow Springs (Cu, Pb) T. 10 S., R. 18 W. |
| 7 & 32 | Granite Mountains (Au, Cu, Pb, Be) T. * S., R. 13 W. |
| 7 & 8 | Dugway (Ag, Pb, Au, Cu, Zn) T. 9 & 10 S., R. 12 W. |
| 9 | Erickson (Ag, Pb, Zn, Cu, Mn) T. 10 S., R. 7 W. |
| 9 | East Erickson (Cu, Pb, Zn, W, Au, U) T. 10 S., R. 6 W. |
| 13 | Columbia (Ag, Pb, Zn, Au) T. 9 S., R. 6 W. |
| 9 & 13 | Blue Bell (Ag, Pb, Zn, Bi, Fe, Be) T. 10 S., R. 6 W. |

2. Other important metallic deposits.

- | | |
|---|--|
| 3 | Mercury Probert Mine (Camp Floyd district, Deep Creek Mountains, T. 10 S., R. 18 W.) Utah's largest producer. 3,000 flasks Hg between 1903 and exhaustion in 1907. |
|---|--|

II. Nonmetallic Minerals.

1. Barite. Found as an accessory mineral in Blue Bell, Clifton, and Dugway districts and in Probert (Hg) mine.
- 7 2. Fluorspar. Potential producing deposit in Dugway district.
- 32B 3. Vermiculite. Deposit of unknown quality and extent reported at north end of Deep Creek Mountains (T. 8 S., R. 18 W.).
- 32B 4. Andalusite. Deposit reported at north end of Deep Creek Range (T. 8 S., R. 18 W.).
- 32B 5. Salines. The Great Salt Lake Desert, the southern extremity of which abuts on the M-X area, is, of course, one of the world's greatest salt deposits.

III. Geothermal Resources.

1. None known in area.

IV. Petroleum Resources.

1. Oil and gas fields - none.
2. Oil and gas leasing activity:

Dugway Valley. T. 9 S., R. 9 & 10 W. (four scattered sections);
T. 10 S., R. 9 & 10 W. (five scattered sections).

Sevier Desert. T. 9 S., R. 6 & 7 W. (2 scattered sections).

V. Sand and Gravel Sites.

1. None known.

VI. Mining Claim Activity.

1. Fish Springs Flat.

Unpatented claims in T. 9 S., R. 12 W.; T. 10 S., R. 12 S.

2. Sevier Desert.

Unpatented claims in T. 10 S., R. 6 & 7 W.

Patented claims in SW 1/4 T. 10 S., R. 6 W.

APPENDIX C

MINING CLAIMS BY COUNTY IN NEVADA

(All claims most probably for metals)

Reference: "Woodward Report", 1980

I. Eureka County. None known in valleys.

II. Lincoln County.

1. Spring Valley.

T. 7N, R. 68E. 65 claims; (45 pre-1955, 20 newer)
In Secs. 2, 3, 10, 1.

2. Lake Valley.

T. 9N, R. 65E. 4 claims. Secs. 28 & 33.
T. 1N, R. 66E. 48 claims (42 pre-1955). Secs. 1, 11, 12.
T. 2N, R. 66E. 4 claims (2 pre-1955). Sec. 36.
T. 3N, R. 66E. 13 claims (64 pre-1955). Secs. 18, 19, 20, 28,
29, 33.
T. 1N, R. 67E. 229 claims (158 pre-1955) Secs. 1, 3, 4, 5, 6,
7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18.
T. 2N, R. 67E. 7 claims. Secs. 8, 16, 17.
T. 5N, R. 67E. 1 claims. Sec. 5.
T. 9N, R. 67E. 1 claims. Sec. 27.

3. Cave Valley.

T. 9N, R. 63E. 35 claims. Secs. 13, 14, 23, & 24.
T. 9N, R. 64E. 8 claims. Secs. 9 & 16.
T. 5N, R. 63E. 227 claims. Secs. 8, 9, 10, 11, 14, 15, 16, 17,
21, 22, 27.

4. Muleshoe Valley.

T. 6N, R. 64E. 7 claims. Secs. 11 & 12.

5. Delamar Valley.

T. 5S, R. 64E. 16 claims. Secs. 14 & 15.
T. 6S, R. 64E. 3 claims. Secs. 3 & 10.

6. White River Valley.

T. 2N, R. 62E. 7 claims. Secs. 22, 27, 34, 35.

7. Coal Valley.

T. 3N, R. 60E. 18 claims. Sec. 36.

T. 1N, R. 61E. 312 claims. Secs. 5, 6, 7, 8, 9, 16, 17, 18, 19, 20, 30, 31, 33, 34.

T. 3N, R. 61E. 93 claims. Secs. 29, 31, 32, 33.

T. 2N, R. 60E. 37 claims. Secs. 1, 11, 12.

8. Garden Valley.

T. 1N, R. 57E. 47 claims (1 pre-1955). Secs. 7, 8, 16, 21.

9. Penoyer (Sand Spring) Valley.

T. 3S, R. 56E. 42 claims. Secs. 23 & 26.

III. Nye County.

1. White River Valley.

T. 2N, R. 62E. 7 claims. Secs. 7 & 8.

2. Railroad Valley.

T. 4N, R. 56E. 4 claims. Sec. 5.

T. 11N, R. 58E. 26 claims. Secs. 29, 32.

T. 10N, R. 58E. 33 claims. Secs. 5, 7, 8.

T. 14N, R. 55E. 16 claims. Sec. 15 (on W.P. Co. line).

T. 9N, R. 55E. 2 claims. Sec. 29.

T. 3N, R. 53E. 12 claims. Sec. 19.

T. 2N, R. 52E. 8 claims. Secs. 13, 24, 28.

T. 1N, R. 52E. 2 claims. Sec. 15.

3. Big Sand Springs Valley.

T. 7N, R. 53E. 8 claims. Sec. 6.

4. Little Smoky Valley.

T. 14N, R. 52E. 10 claims. Secs. 4 & 5.

5. Reveille Valley.

T. 4N, R. 50E. 5 claims. Sec. 30.

T. 2N, R. 52½E. 2 claims. Secs. 35 & 36.

6. Hot Creek Valley.

T. 6N, R. 50E. 24 claims. Secs. 9, 10, 15, 16, 17, 20, 21.

T. 7N, R. 50E. 115 claims. Secs. 4, 9, 16, 17, 20, 21, 28.

T. 9N, R. 51E. 77 claims. Secs. 3, 4, 9, 10.

T. 10N, R. 51E. 8 claims. Sec. 33.

IV. White Pine County.

1. Steptoe Valley.

T. 14N, R. 64E. 40 claims. Secs. 6, 7, 18.

T. 15N, R. 63E. 4 claims. Sec. 36.

T. 14N, R. 63E. 153 claims. Secs. 1, 11, 11, 13.

APPENDIX D

MINING CLAIMS BY COUNTY IN UTAH

Reference: "Woodward Report", 1980

UTAH

I. Beaver County

Escalante Desert

T. 28 S., R. 9W. 50 claims. Metals. Secs. 17, 19-21.

T. 29 S., R. 10W. 2 claims. Metals. Sec. 14.

II. Juab County

1. Sevier Desert.

T. 11 S., R. 6W. 534 claims. Metals & placer (?) mining claims. Secs. 4-10, 15, 17-21, 30, 31.

T. 12 S., R. 6W. 25 claims. Metals. Secs. 5-9, 17, 20, 21, 27-29, 33, 34.

T. 13 S., R. 6W. 10 claims. Metals. Secs. 4-9.

T. 11 S., R. 7W. 359 claims. Metals & placer (?). Secs. 1, 11-14, 22, 12, 25-36.

T. 12 S., R. 7W. 73 claims. Metals. Secs. 1, 3-10, 12, 15, 17-19, 26, 27, 30, 34, 35.

T. 12 S., R. 8W. 27 claims. Metals & uranium. Secs. 11-14, 23-26.

T. 13 S., R. 8W. 34 claims. Metals. Secs. 8, 17.

T. 13S., R. 9W. 430 claims. Metals & uranium. Secs. 5-8, 11-15, 17-20, 22-24, 29-31.

T. 14 S., R. 9W. 160 claims. Metals & placer (?). Secs. 6-9, 17, 28, 33, 34.

T. 13 S., R. 10W. 87 claims. Metals. Secs. 13, 24-26.

T. 14 S., R. 10W. 81 claims. Metals. Secs. 12, 13, 23, 24.

2. Dugway Valley.

T. 11 S., R. 10W. 40 claims. Metals & uranium. Sec. 31.

T. 12 S., R. 10W. 46 claims. Mostly uranium. Secs. 5, 6.

T. 13 S., R. 10W. 947 claims. Uranium, beryllium, and metals.
Secs. 1-11, 14, 15, 17-23, 27-36.

T. 14 S., R. 10W. 364 claims. Metals (uranium?). Secs. 4-6,
8, 9, 17-21, 28-30.

T. 11 S., R. 11W. 44 claims. Metals - beryllium - fluorite. Secs.
10, 11, 35.

T. 12 S., R. 11W. 190 claims. Beryllium - fluorite - topaz?.
Secs. 1, 10, 11, 14, 15, 21, 22, 33.

T. 13 S., R. 11W. 12 claims. Uranium - beryllium - topaz - fluor-
ite. Secs. 4, 24, 25.

T. 14 S., R. 11W. 179 claims. Metals - magnesite. Secs. 1, 2,
11-14, 23, 24.

3. Fish Springs Flat.

T. 13 S., R. 11W. 62 claims. Uranium - fluorite - beryllium -
topaz. Secs. 19, 20, 29, 30.

III. Millard County

1. Black Rock Desert.

T. 23 S., R. 8W. 20 claims. Metals - possibly also volcanic aggre-
gate. Sec. 26, 34, 36.

T. 21 S, R. 9W. 15 claims. Metals. Secs. 17-19, 30, 31.

2. Whirlwind Valley.

T. 16 S, R. 9W. 66 claims. Metals. Secs. 3, 4, 9, 10, 14, 15,
17, 20.

T. 17 S, R. 10W. 8 claims. Metals. Secs. 5, 29, 30.

T. 15 S, R. 9W. 35 claims. Metals. Secs. 3-7.

3. Sevier Lake Valley.

T. 20 S, R. 10W. 30 claims. Metals and/or salines. Secs. 8, 17-20,
29-31.

T. 21 S, R. 10W. 24 claims. Metals and/or salines. Secs. 5 & 6.

T. 20 S., R. 11W. 80 claims. Probably salines. Secs. 3-17, 21-27, 35, 36.

T. 21 S., R. 11W. 13 claims. Probably salines. Secs. 3-9 10, 10, 15, 20-22, 27-31, 33.

4. Escalante Desert.

T. 25 S., R. 9W. 28 claims. Metals. Secs. 14, 15, 21, 27, 35.

IV. Tooele County

Sevier Desert

T. 10 S, R. 6W. 56 claims. Metals. Secs. 29-31.

T. 10 S, 4, 7W. 4 claims. Metals. Secs. 25.

APPENDIX E

UTAH STATE LANDS CONTAINING MINERAL LEASES

Reference: "Woodward Report", 1980

BEAVER COUNTY

1. Escalante Desert.

- T. 26S, R. 10W. Sec. 36 (metal mining).
- T. 27S, R. 10W. Sec. 36 (metal mining).
- T. 28S, R. 10W. Secs. 20, 29, 30, 31 & 32 (metal mining).
- T. 29S, R. 10W. Secs. 2 & 36 (metal mining).
- T. 26S, R. 11W. Secs. 2, 16, 32, 36 (metal mining).
- T. 27S, R. 11W. Secs. 2, 16, 32, 36 (metal mining).
Sec. 36 (SE $\frac{1}{4}$) (sand & gravel)).
- T. 28S, R. 11W. Sec. 23, 24, 27, 34, 35 (metal mining).
- T. 29S, R. 11W. Sec. 4 (metal mining).
- T. 27S, R. 12W. Sec. 36 (sand & gravel).
- T. 28S, R. 12W. Sec. 16 (metal mining).

2. Wah-Wah Valley.

- T. 26S, R. 13W. Sec. 32 (metals).
- T. 27S, R. 13W. Sec. 32 (metals).
- T. 26S, R. 14W. Secs. 16, 32, 36 (metals).
- T. 27S, R. 14W. Secs. 2, 16, 32, 36 (metals).
- T. 28S, R. 14W. Secs. 2, 16 (metals).

3. Pine Valley.

- T. 16S, R. 16W. Secs. 32 & 36 (metals).
- T. 27S, R. 16W. Secs. 2, 16 & 32 (metals).
- T. 28S, R. 16W. Sec. 16 (metals).
- T. 29S, R. 16W. Sec. 32 (metals).
- T. 30S, R. 16W. Sec. 16 & 32 (metals).
- T. 26S, R. 17W. Sec. 32 & 36 (metals).
- T. 28S, R. 17W. Secs. 1, 2, 16, 32 & 36 (metals).
- T. 27S, R. 17W. Secs. 2, 16, 32, 36 (metals).
- T. 29S, R. 17W. Secs. 2, 16, 32, 36 (metals).
- T. 30S, R. 17W. Secs. 2, 16, 32, 36 (metals).

IRON COUNTY

1. Pine Valley.

T. 31S, R. 16W. Secs. 10, 16, 32 (metals).
T. 31S, R. 17W. Secs. 2, 16 (metals).

JAUB COUNTY

1. Sevier Desert (Uranium, base & precious metal area).

T. 11S, R. 6W. Sec. 32 (metals).
T. 12S, R. 6W. Sec. 16 & 32 (metals).
T. 11S, R. 7W. Sec. 2 & 36 (metals).
T. 12S, R. 7W. Sec. 16, 32 & 36 (metals).
T. 11S, R. 8W. Sec. 2 (metals).
T. 12S, R. 8W. Sec. 16 & 32 (metals).
T. 13S, R. 8W. Sec. 16 (metals).
T. 12S, R. 9W. Sec. 32 (metals).
T. 13S, R. 9W. Secs. 2, 16, 32, 36 (metals).
T. 14S, R. 9W. Secs. 2, 16 & 32 (metals).
T. 13S, R. 10W. Secs. 2 & 36 (metals).
T. 14S, R. 10W. Secs. 2 & 36 (metals).

2. Dugway Valley (Uranium - topaz - beryllium area)

T. 11S, R. 10W. Secs. 32 (metals).
T. 12S, R. 10W. Secs. 16 & 32 (metals).
T. 13S, R. 10W. Secs. 16 & 32 (metals).
T. 14S, R. 10W. Secs. 2 & 16 (metals).
T. 11S, R. 11W. Sec. 36 (metals).
T. 12S, R. 11W. Secs. 2 & 36 (metals).
T. 14S, R. 11W. Sec. 2 (metals).

3. Fish Springs Flat (Uranium - topaz - beryllium area to E).

T. 11S, R. 12W. Secs. 2, 16, 32 (metals).
T. 12S, R. 12W. Sec. 36 (metals).
T. 13S, R. 12W. Sec. 16, 32, 36 (metals).
T. 14S, R. 12W. Sec. 16 (metals).
T. 11S, R. 13W. Sec. 2 (metals).
T. 12S, R. 13W. Secs. 2, 36 (metals).
T. 13S, R. 13W. Secs. 2, 16, 36 (metals).
T. 14S, R. 14W. Sec. 2 (metals).

4. Tule Valley.

T. 12S, R. 15W. Sec. 32 (metals).
T. 13S, R. 15W. Sec. 16 (metals).
T. 11S, R. 16W. Sec. 36 (metals).
T. 13S, R. 16W. Sec. 2 (metals).

5. Snake Valley.

T. 12S, R. 18W. Sec. 36 (metals).

MILLARD COUNTY

1. Whirlwind Valley.
T. 16S, R. 9W. Sec. 16 (metals).
T. 15S, R. 10W. Sec. 2 (metals).
2. Sevier Lake.
T. 20S, R. 10W. Sec. 16 (metals).
T. 20S, R. 11W. Sec. 2 (metals).
T. 22S, R. 11W. Secs. 2, 16, 32 (metals).
T. 23S, R. 11W. Secs. 16 & 32 (metals).
T. 20S, R. 12W. Secs. 16 & 32 (metals).
Sec. 16 (potash).
T. 21S, R. 12W. Sec. 32 (metals).
T. 23S, R. 13W. Sec. 36 (limestone).
3. Escalante Desert.
T. 25S, R. 11W. Sec. 13 (metals).
T. 26S, R. 2W. Sec. 2 (metals).
4. WahWah Valley.
T. 25S, R. 13W. Sec. 16&32 (metals).
Sec. 16 & 32 (potash).
T. 26S, R. 14W. Sec. 2 (metals).
5. Tule Valley.
T. 15S, R. 14W. Sec. 2 (metals).
T. 17S, R. 14W. Sec. 16 (gypsum).
6. Snake Valley.
T. 19S, R. 18W. Sec. 32 (building stone).

TOOELE COUNTY

1. Fish Springs Flat.
T. 9S, R. 12W. Sec. 32 (metals).
Sec. 32 (fluorspar).

APPENDIX F

THE UNIVERSAL SOIL LOSS EQUATION (USLE)

The best method for determining soil loss from sheet and rill erosion is the application of the Universal Soil Loss Equation (USLE). The USLE was developed for use in determining soil loss from agricultural lands east of the Rockies, but it has been applied to construction sites and arid regions (Wischmeier and Smith, 1978; Clyde et al., 1978; U.S.D.A. Soil Conservation Service, August 1976). In order to assess water erosion impacts in the Nevada/Utah study region, the USLE was applied to each watershed where M-X project facilities are planned.

The Universal Soil Loss Equation is defined as follows:

$$A = R L S K C P$$

where

A is the estimated average annual soil loss in tons per acre.

R is the rainfall and runoff factor.

LS is the topographic factor representing the length and steepness of slope.

K is the soil erodibility factor.

C is the vegetative cover factor.

P is the erosion control practice factor.

These factors are discussed below in further detail as they apply to the Nevada/Utah and Texas/New Mexico study regions.

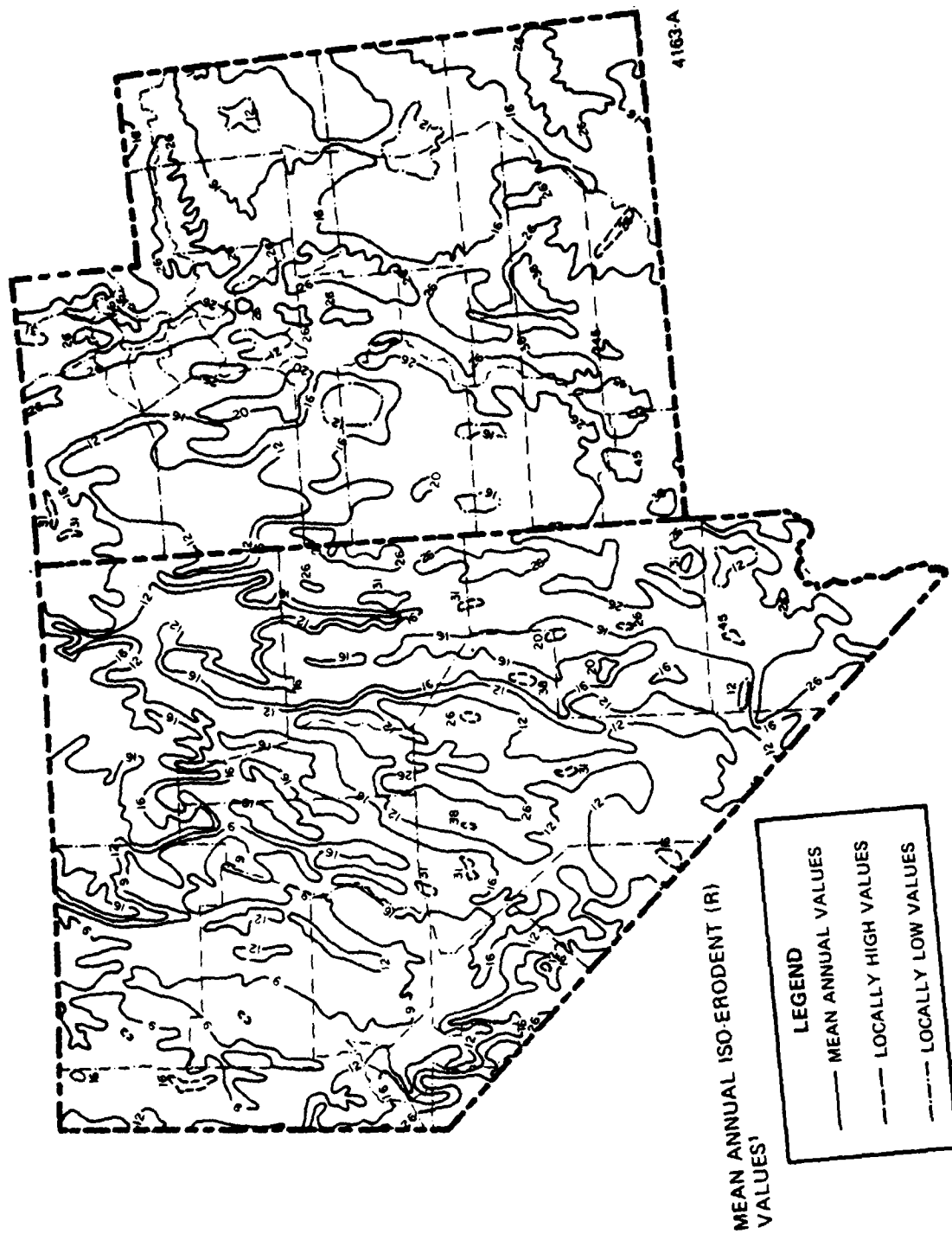
Rainfall Factor, R

The rainfall factor takes into account the erosive forces of rainfall and its directly associated runoff. The value of R for any location is the average annual sum of individual storm erosion index (EI) values for that location. The erosion index is a measure of the erosive force of a specific rainfall and equals the product of the total storm energy (E, measured in hundreds of foot-tons per acre) times the maximum 30-minute intensity (I30, measured in inches per hour).

Values of R range from less than 20 to over 500 across the United States. The R factors for the Nevada/Utah study region, interpolated from the isoerodent map shown in Figure F-1, range in value from 12 to 23. These values of R do not account for the effects of melting snow. In the Texas, New Mexico study region, R values are between 80 and 120 (Figure F-2).

Topographic Factor, LS

The topographic factor takes into account the effects of slope length and steepness. Soil erosion increases with percent slope and slope length, while runoff



¹FROM CLYDE ET AL, JUNE 1978

Figure F-1. R values for Nevada and Utah.

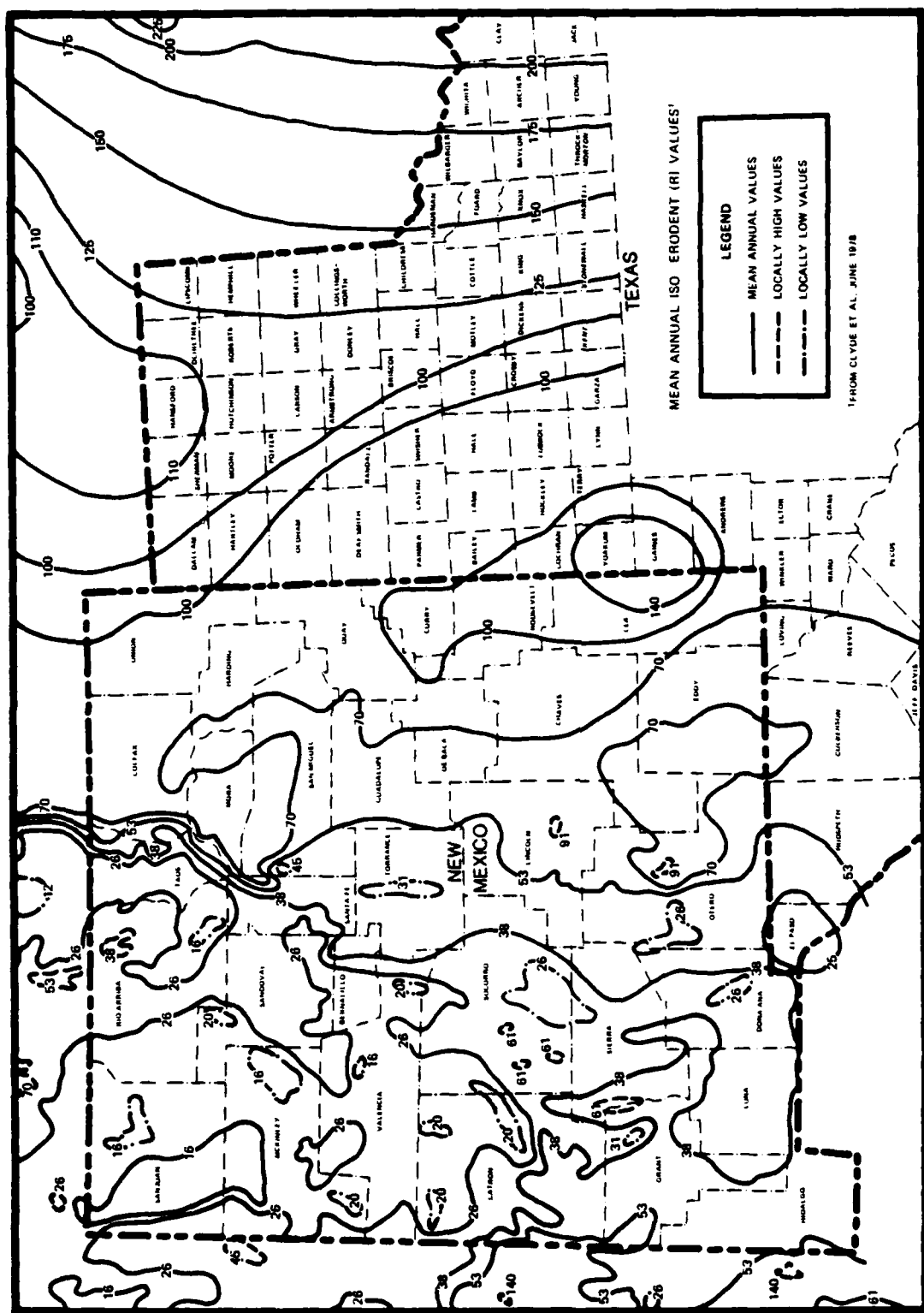


Figure F-2. R values for the Texas/New Mexico study region.

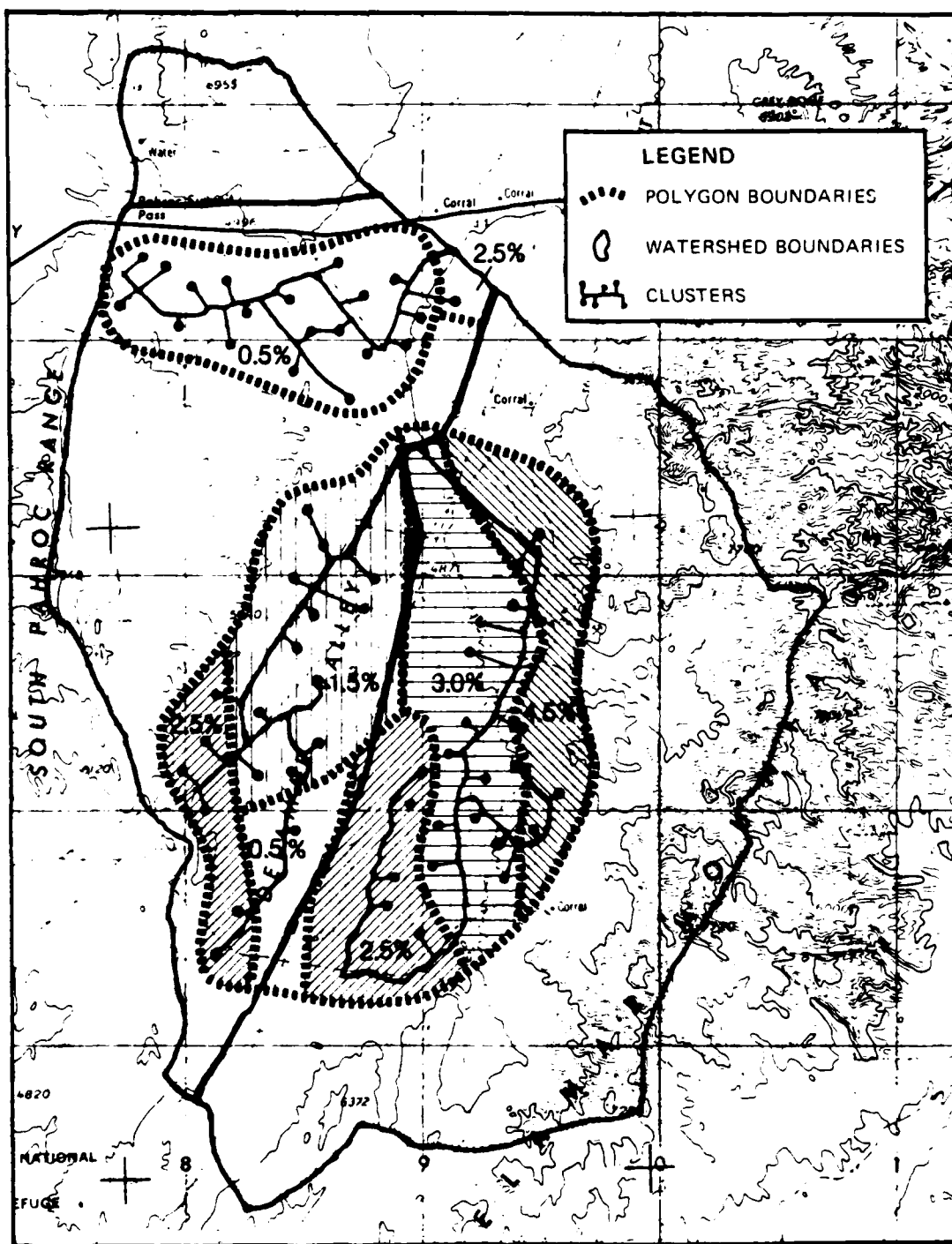


Figure F-3. Slope polygons for Delamar Valley, Nevada.

Table F-1. Values of the topographic factor, LS, for specific combinations of slope length and steepness¹.

Percent Slope	Slope Length (Ft)											
	25	50	75	100	150	200	300	400	500	600	800	1,000
0.2	0.060	0.069	0.075	0.080	0.086	0.092	0.099	0.105	0.110	0.114	0.121	0.126
0.5	.073	.083	.090	.096	.104	.110	.119	.126	.132	.137	.145	.152
0.8	.086	.098	.107	.113	.123	.130	.141	.149	.156	.162	.171	.179
2	.133	.163	.185	.201	.227	.248	.280	.305	.326	.344	.376	.402
3	.190	.233	.264	.287	.325	.354	.400	.437	.466	.492	.536	.573
4	.230	.303	.357	.400	.471	.528	.621	.697	.762	.820	.920	1.01
5	.268	.379	.464	.536	.656	.758	.928	1.07	1.20	1.31	1.52	1.69
6	.336	.476	.583	.673	.824	.952	1.17	1.35	1.50	1.65	1.90	2.13
8	.496	.701	.859	.992	1.21	1.41	1.72	1.98	2.22	2.43	2.81	3.14
10	.685	.968	1.19	1.37	1.68	1.94	2.37	2.74	3.06	3.36	3.87	4.33
12	.903	1.28	1.56	1.80	2.21	2.55	3.13	3.61	4.04	4.42	5.11	5.71
14	1.15	1.62	1.99	2.30	2.81	3.25	3.98	4.59	5.13	5.62	6.49	7.26
16	1.42	2.01	2.46	2.84	3.48	4.01	4.92	5.68	6.35	6.95	8.03	8.98
18	1.72	2.43	2.97	3.43	4.21	3.86	5.95	6.87	7.68	8.41	9.71	10.9
20	2.04	2.88	3.53	4.08	5.00	5.77	7.07	8.16	9.12	10.0	11.5	12.9

T4543/9-16-81/F

¹LS = $(W/72.6)^m (65.41 \sin^2 \theta + 4.56 \sin \theta + 0.065)$ where λ = slope length in feet; $m = 0.2$ for gradients 1 percent, 0.3 for 1 to 3 percent slopes, 0.4 for 3.5 to 4.5 percent slopes, 0.5 for 5 percent slopes and steeper; and θ = angle of slopes. (For other combinations of length and gradient, interpolate between adjacent values.)

Source: Wischmeier and Smith, 1978.

and erosion are retarded by interruptions in the slope length. The length of slope, L , for this analysis is assumed to be 600 ft., the length of the 7.5 ac clearing required for construction of each protective structure.

The percent slope, S , was determined using contour lines on 1:250,000 scale topographic maps. Construction areas were divided into polygons of constant slope, as shown in Figure F-3, and LS values (from Table F-1) were assigned to each polygon using a slope length of 600 ft. LS values ranged from 0.11 (for a 0-.2 percent slope) to 3.36 (for a 10 percent slope), for the Nevada/Utah study region which varies widely between valleys. Slopes of the Texas/New Mexico construction areas average between 0.2 and 0.8 percent, with corresponding topographic factors, LS , varying between 0.11 and 0.16. Both regions have areas of steeper slope. By using this technique, the calculated soil loss is a direct function of the project layout. Changes in the layout which move the project onto areas of differing slope and differing K values will change the magnitude of soil loss prediction.

Soil Erodibility Factor, K

The soil erodibility factor represents a soil's inherent susceptibility to erosion. The factor takes into account physical characteristics of a soil, including texture, structure, permeability, and percent of organic matter. K values range from 0.1 (low erodibility) to 0.7 (high erodibility). K values are generally assigned to soil series in conjunction with Soil Conservation Service second order soil surveys. The soil series map and a list of corresponding K values are necessary for accurate application of the soil loss equation. Only 2 of the 36 valleys in Nevada/Utah planned to contain M-X project facilities have published second order soil surveys. As a result of this severe data deficiency, K values for the construction areas in each valley had to be obtained through extrapolation of existing data.

Big Smoky and Penoyer valleys have published second order soil surveys (U.S.D.A. Soil Conservation Service, 1968 and 1980). A list of K values for the various soil series in these valleys was obtained from the U.S. Soil Conservation Service, Nevada State Office in Reno. This information, along with more general information (Wilson et al., 1975), was used to calculate three K values corresponding to three physiographic positions: (1) valley bottoms (slopes 1 percent or less); (2) gently sloping alluvial fans (slopes between 1 and 6 percent); and (3) moderate to steeply sloping alluvial fans (slopes greater than 6 percent).

The physiographic positions were related to slopes so that the K values could be used in conjunction with the slope polygon maps. Very fine sandy loam, silt loam, silty clay loam, and loam soils characterize the valley bottoms and floodplains in Penoyer and Big Smoky valleys, with K values ranging from 0.32 to 0.55. Thus an average K value of 0.40 was considered characteristic of all valley bottoms (slope polygons of 1 percent slope or less). Gravelly sandy loams, gravelly loams, sandy loams, fine sandy loams and loams predominate on the alluvial fans of Penoyer and Big Smoky valleys, with K values ranging from 0.10 to 0.37. K values of 0.25 were considered average for alluvial fans with slopes up to 6 percent. To allow for increases in gravel content and slope and the corresponding lower soil erodibility in gravelly soils generally located near mountain fronts, alluvial fans with slopes greater than 6 percent were assigned a K value of 0.20.

Although soil data for Texas/New Mexico were considerably more complete than for Nevada/Utah, the proportions and distributions of K values were not known in detail. However, K values ranged between 0.15 and 0.55, within the range of Nevada/Utah values. For comparison it was therefore assumed that, on the average, K values were about the same for the two regions.

Vegetative Cover Factor, C

The vegetative cover factor takes into consideration the protective effects of vegetation and other ground covers on the soil surface. C values for noncropland range from 0.003 for areas having a 95-100 percent ground cover of grasses to 1.0 for bare soil. For this analysis, C was assigned a value of 1.0, corresponding to the bare soil conditions which will occur during and after construction. As shown in Table F-2, the C factor can be reduced considerably if soil conservation practices are used during and after the construction period.

Erosion Control Practice Factor, P

The erosion control practice factor includes practices that will slow runoff water and thus reduce the amount of soil it can carry away. On cropland, such practices include contour tillage and contour strip-cropping, resulting in P values of less than 0.60 under good conditions. For construction projects, P is generally assumed to be 1, although values may vary between 0.8 and 1.3, as shown in Table F-3. In this analysis, a compacted, smooth surface was assumed to exist during construction. This corresponds to a P value between 1.2 and 1.3 (Table F-3). A mean value of 1.25 was used in this analysis.

Limitations of the USLE

Soil losses computed by the USLE are best available estimates, with several important limitations. The USLE does not account for gully erosion which could be significant during high intensity storms. In addition, the rainfall factor, R, based on average annual rainfall conditions and rainfall occurring at any one location during any one year, could be substantially above or below the average. A worst case study for rainfall is proposed for a later tier. The length of slope for this analysis was set at 600 ft; however, the USLE was developed for slope lengths of less than 400 ft, with values for longer slopes being obtained through extrapolation (Wischmeier and Smith, 1978). Computed soil loss values are most accurate for slopes of less than 400, where data exist to support the relationships expressed by the equation. Finally, it is recognized that a large margin of error exists in the choice of three constant K values used in the analysis.

Application of the USLE to the Nevada/Utah and Texas/New Mexico Study Regions

Since the USLE is a linear equation and K, C, and P are assumed to be approximately the same for the two regions, comparisons between Nevada/Utah and Texas/New Mexico can be made by multiplying average R factors and LS factors for average slopes (see Table F-1 for corresponding LS values). For the Texas/New study region:

$$\begin{aligned}\text{Soil Loss (tons/acre/year)} &= (KCP) (R) (\text{LS for 0.4-0.5 percent slope}) \\ &= (KCP) (100) (0.13) \\ &= (KCP) 13\end{aligned}$$

Table F-2. C factor values for construction sites¹.

Type of Cover	C Factor	Percent ²
None (fallow ground)	1.0	0.0
Temporary seedings (90 percent stand):		
Ryegrass (perennial type)	0.05	95
Ryegrass (annuals)	0.1	90
Smallgrain	0.05	95
Millet or sudan grass	0.05	95
Field brome grass	0.03	97
Permanent seedings (90 percent stand)	0.01	99
Mulch		
Hay rate of application tons per acre:		
1/2	0.25	75
1	0.13	87
1 1/2	0.07	93
2	0.02	98
Small grain straw 2	0.02	98
Wood chips 6	0.06	94
Wood cellulose 1 3/4	0.1	90
Fiberglass 1/2	0.05	95
Asphalt emulsion (1,250 gals/acre)	0.02	98

T4545/9-16-81/F

¹ Condensed from "Guides for Erosion and Sediment Control in Nevada," USDA, SCS, Reno, Nevada, August 1976.

² Percent soil loss reduction as compared with fallow ground.

Note: Fiber matting, excelsior, gravel, and stone may also be used as protective cover.

Table F-3. Practice factor P or surface condition
for construction sites¹

Surface Condition with No Cover	Factor P*
Compact and smooth, scraped with bulldozer or scraper up and down hill	1.3
Compact and smooth, scraped with bulldozer or scraper across the slope	1.2
Loose as a disced plow layer	1.0
Rough irregular surface equipment tracks in all directions	0.9
Loose with rough surface greater than 12" depth	0.8

T4544/9-16-81/F

*Values based on estimates.

¹Condensed from "Guides for Erosion and Sediment Control in Nevada", USDA, SCS, Reno, Nevada. August 1976.

For the Nevada/Utah study region:

$$\begin{aligned}\text{Soil Loss (tons/acre/year)} &= (\text{KCP}) (\text{R}) (\text{LS for 4 percent slope}) \\ &= (\text{KCP}) (20) (0.8) \\ &= (\text{KCP}) 16\end{aligned}$$

Since the product of R and LS across the United States can vary to over 100, the difference between the 13 value for the Texas/New Mexico study region and the 16 value for the Nevada/Utah study region is not significant. It should be noted, however, that the rainfall factors are based on average annual rainfall conditions and that rainfall occurring at any one location during any one year could be substantially above or below the average. Therefore, depending on the rainfall in any given year, annual soil loss between the two regions may be quite different.

Application of the USLE to Nevada/Utah valleys containing DTN and protective structures

Given the methods for obtaining appropriate values of R, LS, K, C and P, the potential soil loss per year was calculated for each valley containing DTN and protective structures (HDR project layout Map 1843-E-A). Calculations were tabulated for each valley on a Universal Soil Loss Equation data worksheet as illustrated in Table F-4. Column (1) on the worksheet is a listing of the slope polygons found in the valley. Column (2) is the number of protective structures found in each slope polygon. Protective structures were counted in order to estimate the acreage of land disturbed within a polygon. A value for the mean acres disturbed per protective structure was calculated for each watershed by dividing total acres disturbed within a polygon. A value for the mean acres disturbed per protective structure was calculated for each watershed by dividing total acres disturbed in the watershed (from DTN, cluster roads, protective structures, construction camps, and concrete plants) by the number of protective structures in the watershed. To obtain the acres of land disturbed within each polygon, the number of encircled protective structures was multiplied by the mean acres disturbed per protective structure. Column (3) in Table F-4 is the LS factor, Column (4) is the K factor and Column (5) is the product of $R \times C \times P$. The product of (3) $\times$ (4) $\times$ (5) yields the estimated A value in tons of soil loss per acre, per year for a particular slope polygon. This value, Column (6), is multiplied by the disturbed acres in that polygon, Column (7), to arrive at a value of tons of soil loss per year in that polygon, Column (8). This procedure is repeated for each slope polygon. The tons of soil loss per year from the entire disturbed acreage in the valley is the sum from each polygon, the sum of Column (8).

Table F-5 is a summary of the various soil loss equation factors for all of the valleys. The table presents average values for LS and K, weighted proportional to their occurrence, and the values of R, C, and P which are constant for the valley. The estimated annual soil loss from the total construction area in each watershed is presented in the final column of Table F-5. These soil loss values are derived from data for the slope polygons and cannot be calculated from the weighted averages presented in the Table.

Table F-4. Universal soil loss equation data worksheet for Delamar Valley,¹ Nevada.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Slope of Polygon (Percent)	Number of Protective Structures	LS	K	R x C x P	A ² (Tons/Acre/Yr)	Acres Disturbed	Tons Soil Loss/Year
0.5	20	0.14	0.40	26.25	1.47	640.0	941
1.5	13	0.28	0.25	26.25	1.84	416.0	764
2.5	12	0.41	0.25	26.25	2.69	384.0	1,033
3.0	12	0.49	0.25	26.25	3.21	384.0	1,235
4.5	5	0.93	0.25	26.25	6.10	160.0	976
Σ Column 8 = 4,949 tons/year							

T4546/6-18-81

¹ Hydrologic Subunit: Delamar; Subunit No. 182; Total No. of Protective Structures: 62; Total Acres of Disturbance: 1,984; Mean Acres Disturbed per Protective Structures: 32.0.

² Algorithms: Tons Soils Loss/Acre/Year = A = RLSKCP; Tons Soil Loss/Year = A x (Acres Disturbed); Acres Disturbed/Polygon = (No. of Protective Structures) x (32.0 Acres Disturbed/Protective Structures). Assumed constant over valley's construction area: R = Rainfall Factor = 21; C = Vegetative Cover Factor = 1; P = Erosion Control Practice Factor = 1.25; L = Length of Slope = 600 ft. Assumed variable over valley's construction area: K = Soil Erodibility Factor; LS = Topographic Factor.

Source: HDR Sciences, 1980.

Table F-5. Average USLE factors and estimated annual soil loss value (Page 1 of 2).

No.	Hydrologic Subunit Name	Rainfall Factor (R)	Topographic Factor (LS)	Soil Erodibility (K)	Vegetative Cover Factor (C) x Erosion Control Practice Factor (P) (C X P) ²	Area Disturbed During Construction (Acres)	Estimated Annual Soil Loss from Construction Area (Tons/Year)
4	Snake	21	0.67	0.26	1.25	10,800	44,300
5	Pine	16	0.63	0.27	1.25	4,100	13,400
6	White (Tule)	16	0.41	0.28	1.25	4,900	10,500
7	Fish Springs Flat	16	0.38	0.29	1.25	2,100	4,500
8	Dugway	18	0.20	0.35	1.25	2,000	2,800
9	Government Creek	16	0.92	0.29	1.25	600	2,500
46	Sevier Desert	21	0.44	0.29	1.25	5,800	17,600
46A	Sevier Lake	23	0.49	0.26	1.25	8,100	29,300
54	Wah Wah	21	0.57	0.28	1.25	5,800	20,700
137A	Big Smoky	14	0.45	0.29	1.25	3,300	7,000
139	Kobeh	16	0.30	0.33	1.25	5,000	9,200
140	Monitor	19	0.71	0.28	1.25	4,000	15,900
141	Ralston	16	0.35	0.34	1.25	6,400	12,900
142	Alkali Springs	12	0.61	0.29	1.25	3,300	7,400
148	Cactus Flat	12	0.34	0.25	1.25	See Stone Cabin	
149	Stone Cabin	12	0.36	0.29	1.25	4,600	6,700
151	Antelope	19	0.38	0.28	1.25	4,400	10,600
154	Newark	12	0.46	0.29	1.25	2,400	4,300
155	Little Smoky	19	0.37	0.29	1.25	5,000	11,600
156	Hot Creek	19	0.43	0.28	1.25	4,700	12,600
170	Penoyer	12	0.57	0.31	1.25	3,900	8,600
171	Coal	16	0.46	0.30	1.25	3,800	8,800
172	Garden		0.59	0.32	1.25	3,400	10,000

T0547/9-16-81/F

Table F-5. Average USLE factors and estimated annual soil loss value (Page 2 of 2).

No.	Hydrologic Subunit Name	Rainfall Factor (R)	Topographic Factor (LS) ¹	Soil Erodibility (K)	Vegetative Cover Factor (C) x Erosion Control Practice Factor (P) (C X P) ²	Area Disturbed During Construction (Acres)	Estimated Annual Soil Loss from Construction Area (Tons/Year)
173	Railroad	12	0.62	0.30	1.25	11,100	26,400
174	Takes	16	0.32	0.32	1.25	3,100	5,600
175	Long	16	0.25	0.36	1.25	1,300	2,100
178A	Butte	16	0.46	0.32	1.25	3,400	7,700
179	Steptoe		1.02	0.23	1.25	500	2,600
180	Cave	21	0.53	0.36	1.25	2,000	7,000
181	Dry Lake	21	0.43	0.32	1.25	6,800	21,200
182	Delamar	21	0.35	0.30	1.25	2,000	4,900
183	Lake	21	0.64	0.29	1.25	3,100	12,200
184	Spring	21	0.26	0.35	1.25	1,400	3,000
196	Hamblin	21	0.43	0.30	1.25	4,100	12,200
202	Patterson	23	0.37	0.25	1.25	600	1,600
207	White River	23	0.60	0.29	1.25	4,200	18,700
208	Pahroc	16	1.39	0.23	1.25	300	1,600
209	Pahranagat	16	0.41	0.25	1.25	600	1,300

T4547/9-16-81/F

¹ Average values weighted proportional to their occurrence.

² C is assumed to be 1 for every valley; P is assumed to be 1.25 for every valley.

³ Not the product of a straight multiplication of columns as explained in text.

Source: HDR Sciences, 1981.

Application of the USLE to Texas/New Mexico counties containing DTN and Protective Structures

In general, a relative potential water erosion impact rating can be assigned to each county in the Texas/New Mexico study region based on the degree of soil disturbance in the county. The $R \times LS$ value for each county varies between 11 and 19, making the area of disturbance the most important factor influencing water erosion impacts from county to county. Table F-6 shows the relative potential water erosion impact ratings assigned to each county.

Application of the USLE to Operating Base Sites

The Universal Soil Loss Equation was applied in a more general manner to the five Nevada/Utah Operating Base (OB) sites. Given that each site will have approximately the same acres of disturbance and the same value for the vegetative cover (C) and erosion control practice (P) factors, only the rainfall (R), topographic (LS), and soil erodibility (K) factors need to be examined to determine a potential for soil erosion.

The rainfall factor for each OB site was interpolated from the isoerodent map in Figure F-1. Values for all sites range from 14 to 22 (see Table F-7). A topographic factor was determined for each OB using an average slope for the site, estimated from 1:250,000 topographic maps, and a slope length of 600 ft. Average slopes varied between 0.5 percent and 3 percent, with corresponding LS values varying between 0.137 and 0.492. It should be noted that changes in the OB layout that move the various OB facilities onto areas of different slope will change the average slope and therefore the LS factor. (The OB layouts used in this analysis are those which were presented in Chapter 2 of the DEIS).

Soil erodibility factors were not available for all OB sites due to a data deficiency. Existing literature for four of the sites assigns an erosion hazard rating, or the relative susceptibility to erosion, for the predominating soils on the site. These ratings will be used as relative soil erodibility factors in this analysis. The Beryl OB site has a moderate to severe erosion hazard (U.S.D.A. Soil Conservation Service, 1960); the Coyote Spring OB site currently exhibits a moderate susceptibility to water erosion (U.S.D.I., BLM, 1979); the Delta OB site has a low erosion hazard (U.S.D.A. Soil Conservation Service, 1977), and the Ely OB site has a moderate erosion hazard (U.S.D.A. Soil Conservation Service, 1976). An erosion hazard rating for a Milford OB site was not found in literature covering the site (Wilson et al., 1975). Table F-7 presents the operating base characteristics which influence the water erosion potential of each site.

Table F-6. Water erosion data sheet for the Texas/New Mexico designated deployment area (DDA).

County	Average Construction Area Slopes (Percent)	Topographic Factor (LS) of Average Slope ¹	Average Rainfall Factor (R)	LS x R	County Area (Acres)	Area of Disturbance (Acres)	Relative Potential Water Erosion ² Impact Rating
Texas							
Bailey	0.2 - 0.4	0.12	100	12	534,400	3,500	M
Castro	0.2 - 0.3	0.12	100	12	563,200	3,900	M
Cochran	0.2 - 0.4	0.12	100 - 120	13	500,800	2,400	M
Dallam	0.2 - 0.7	0.13	100	13	945,200	20,000	H
Deaf Smith	0.2 - 0.4	0.12	100	12	966,400	16,400	H
Hartley	0.4 - 0.6	0.14	100	14	952,300	10,700	H
Hockley	0.3	0.12	100	12	See Lamb County		L
Lamb	0.3	0.12	100	12	654,100	2,200	L
Oldham	0.2 - 0.5	0.12	100	12	549,800	7,000	H
Randall	0.2 - 0.4	0.12	100	12	584,000	1,300	L
Shermand	0.3	0.12	105 - 110	13	586,000	700	L
Swisher	0.2	0.11	100	11	See Castro County		L
New Mexico							
Chaves	0.6	0.14	80 - 100	13	3,894,000	13,700	L
Curry	0.3	0.12	100	12	897,900	7,800	M
DeBaca	0.6 - 1.0	0.16	80 - 100	14	1,507,800	1,300	L
Harding	1.0	0.22	80 - 90	19	1,365,400	4,900	M
Lea	0.5	0.14	100	14	2,811,200	900	L
Quay	0.4 - 1.0	0.15	80 - 100	14	1,840,000	14,500	M
Roosevelt	0.2 - 1.0	0.14	90 - 100	13	1,570,800	18,500	H
Union	0.5 - 1.0	0.15	90 - 100	14	2,442,200	6,500	L

T4955/6-19-81

¹ Assume slope length of 600 feet.

² H = High Impact; M = Moderate Impact; L = Low Impact

Table F-7. Summary of operating base characteristics influencing water erosion potential.

Operating Base	Rainfall Factor (R)	Average Slope (%)	Average Topographic Factor (LS)	Erosion Hazard Rating From Literature
Beryl, Utah	22	2	0.34	Moderate ¹ to severe
Coyote Spring, Nevada	20	3	0.49	Moderate ²
Delta, Utah	14	0.5	0.14	Low ³
Ely, Nevada	16	1	0.22	Moderate ⁴
Milford, Utah	20	3	0.49	Not available

T4638/8-31-81

¹USDA Soil Conservation Service, 1960.

²U.S. Department of Interior, Bureau of Land Management, 1979.

³USDA Soil Conservation Service, 1977.

⁴USDA Soil Conservation Service, 1976.

Source: HDR Sciences, 1981.

APPENDIX G

LAWS PROTECTING PALEONTOLOGIC RESOURCES

Persons collected fossils in the State of Utah are cautioned against violating sections of Federal and State Laws dealing with the removal of objects of scientific interest from public lands.

FEDERAL REGULATIONS

In 1906 Congress enacted a law to preserve American antiquities. This law seeks to protect ruins or monuments and objects of antiquity situated on government lands.

If convicted, a person may be fined \$500.00, and be imprisoned up to 90 days for taking, digging up, injuring, or destroying ruins, monuments, or objects of antiquity.

Permits for examination of ruins, excavation of archaeological sites, and gathering of objectives of antiquity must be obtained from the respective secretary of the government department having jurisdiction over the land. Further, permission can be granted only to reputable museums, universities, colleges, or other recognized scientific or educational institutions to increase knowledge of the objects and for permanent preservation.

Most of the public lands under Federal jurisdiction and are administered by agencies of the Departments of Interior and Agriculture. These departments and their respective agencies were allowed to make regulations regarding the Antiquities Act -- that is, they grant the permits and spell out all the rules. Since these rules are subject to considerable change, one is advised to determine what regulations apply be corresponding with the agency having jurisdiction over the land involved.

STATE REGULATIONS

Utah Antiquity Law

63-11-2 (as of 1959) Protection of relics and scenic features -- Permits to explore, excavate, or remove --

Before any exploration or excavation in or on any prehistoric ruins, pictographs, hieroglyphs, or any other ancient marking or writing or archaeological or paleontological deposit in Utah on any public lands, either state or federal, shall be undertaken, a permits shall first be obtained from the State Park and Recreation Commission and from the Board of County Commissioners of the county wherein the same regulations as it may deem needful to protect from vandalism or injury the prehistoric ruins and relics and archaeological and paleontological deposits of the State, also all natural bridges and natural scenic features and formations. No persons shall remove from the State of Utah any part of any such ruins or deposit except with the consent of the State Park and Recreation Commission and of the Board of County Commissioners of the county wherein such ruins or deposits are found. Said commissions may require, as a condition to such consent, that such

portion of such relics, materials, or deposit, as said commissions shall require, shall remain the property of the State of Utah or said county. Any person violating this act or the rules and regulations promulgated by the State Park and Recreation Commission pursuant thereto shall be guilty of a misdemeanor and upon conviction thereof shall, in addition to any other penalties imposed, forfeit to the State all artifacts and materials discovered by or through his efforts. Punishments for misdemeanor -- Except in cases where a different punishment is prescribed by law, every offense declared to be a misdemeanor is punishable by imprisonment in a county jail not exceeding six months, or by a fine in any sum less than \$300.00, or both.

In all cases where a corporation is convicted of an offense for the commission of which a natural person would be punishable as for a misdemeanor and there is no other punishment prescribed by law, such corporation is punishable by a fine not exceeding \$1,000.00.

Source: Fossil Localities in Utah, Utah Geological and Mineral Survey, Circular 45, 1964.

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