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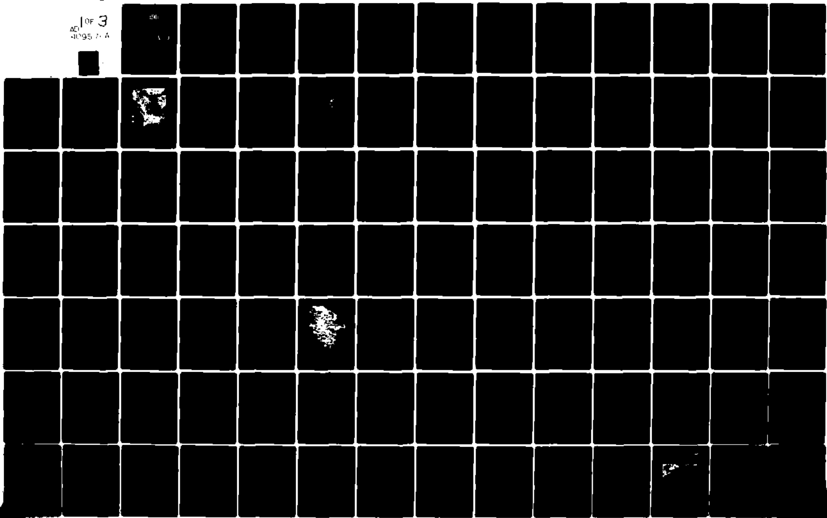

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TECHNICAL REPORT

ETR 11

GEOLOGY AND MINING

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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

HDR SCIENCES
Santa Barbara, California
22 December 1980

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ENVIRONMENTAL CHARACTERISTICS OF
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MINING AND GEOLOGY

1.0 INTRODUCTION

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

Geology, has varied affects on the M-X project. There are affects that the project would have on the geology or geologic processes of the siting area and there are locations in which the geology affects the placement of the project.

The project impacts 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 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 utilization of economic minerals.

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 earthquake 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 small, the excavation of shelters is not only difficult and uneconomic but effects the viability 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. Economic 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.

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

The suitable areas, following the application of the construction and operational screening criteria, in the Nevada/Utah siting region generally consist of long narrow valleys, which tend to run in a north-south direction. The mountain barriers between each suitable area act as a natural barrier and isolate the valleys from each other. The total available suitable area is approximately 16,000 mi^2 (41,600 square km) and was selected as 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 physical 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 the suitable area consists of large homogeneous areas of land which are bisected by the areas' transportation networks. The total available suitable area in Texas/New Mexico is approximately 8,000 mi^2 (20,800 sq. km), and is 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 consists of steep mountains bounded by northerly trending normal faults and separated by alluvium filled basins. The mountain ranges stand out from the valleys, with elevations of 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 a bajada that slopes from the foot of the mountains to the alluvial flood plains or playas in the center of the valley.

Slopes are strongly related to the physiographic features of the region. The mountains, alluvial fans, valley floors, and playas have distinctly different slopes. The mountains characteristically have slopes of 30 to 35 percent and some of 100 percent or greater. The alluvial fans and bajada form the transition between the steep mountain slopes and the valley floor. Slopes on the bajada 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.

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 altitude, but are slightly higher in southwestern Utah. Playas and alluvial flats are extensive and make up about 40 percent of the basin. The mountains cover almost one-fourth of the basin and alluvial fans cover the rest. Most drainage is to Utah 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. The siting region has only been examined at a scale of 1:250,000, so the coverage is somewhat general. As sites are chosen and examined at larger scales, additional details will become apparent. Areas with slopes greater than 10 percent, and 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-foot deep drainages (3 m) every 1,000 ft (300 m).

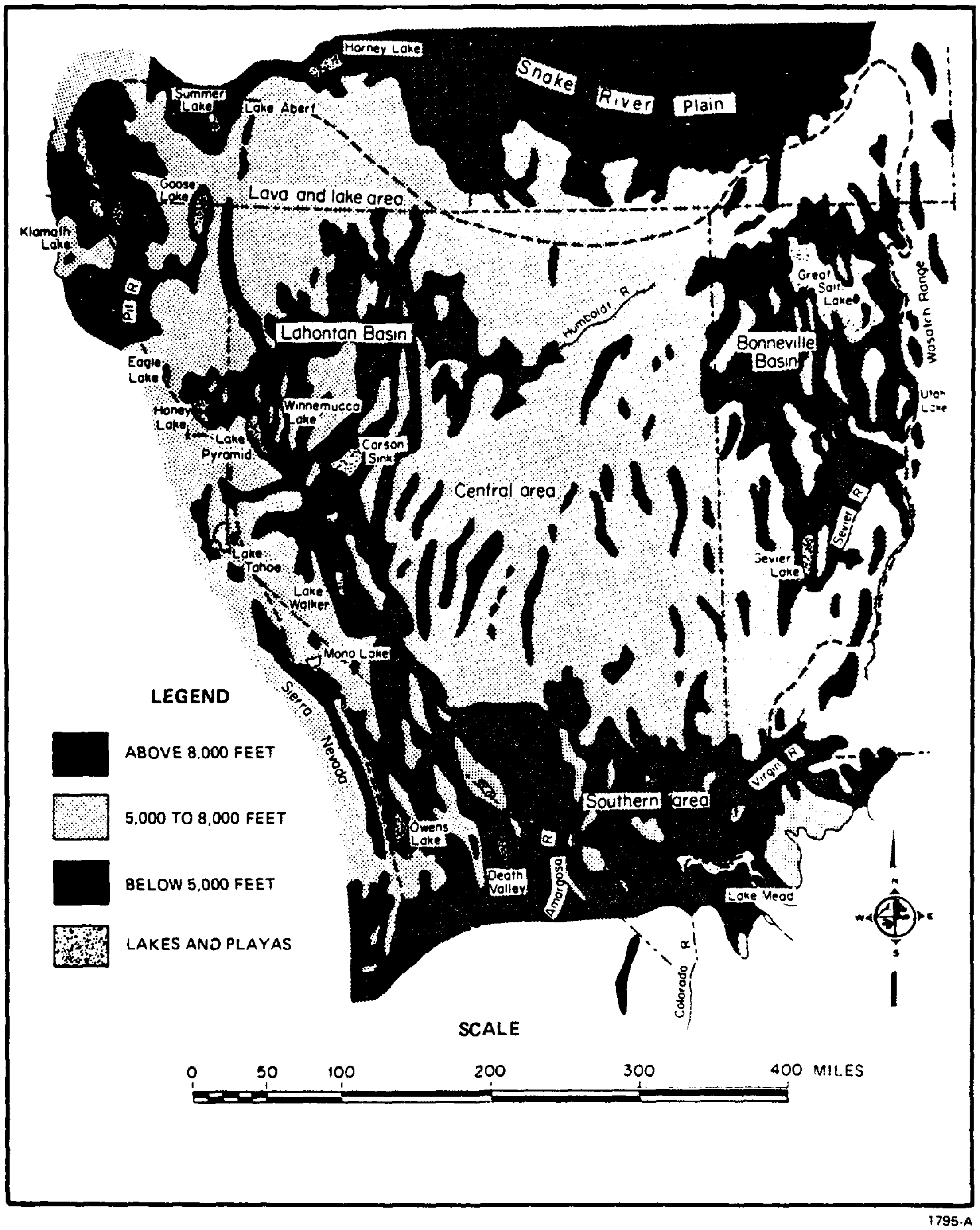

Figure 2.1.1-1. Physiographic regions of the Great Basin.

PHYSICAL DESCRIPTION (2.1.2)

The Great Basin region of the Basin and Region 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, parallel, 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 sediment deposits along the basin margins and (2) fine-grained playa and flood plain 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 km^2 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 km^2 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 high, 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. Rough broken 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 Rivers. 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, smooth-lying surface is broken only by a few drainageways and playas. Minor areas of sandy soils having undulating or dune-like topography exist, and rough broken 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 (DEIS, Chapter 3, Figure 3.3.2.1-1). 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 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. The Ogallala thins out to the south and is generally thickest where it was deposited in ancient river valleys.

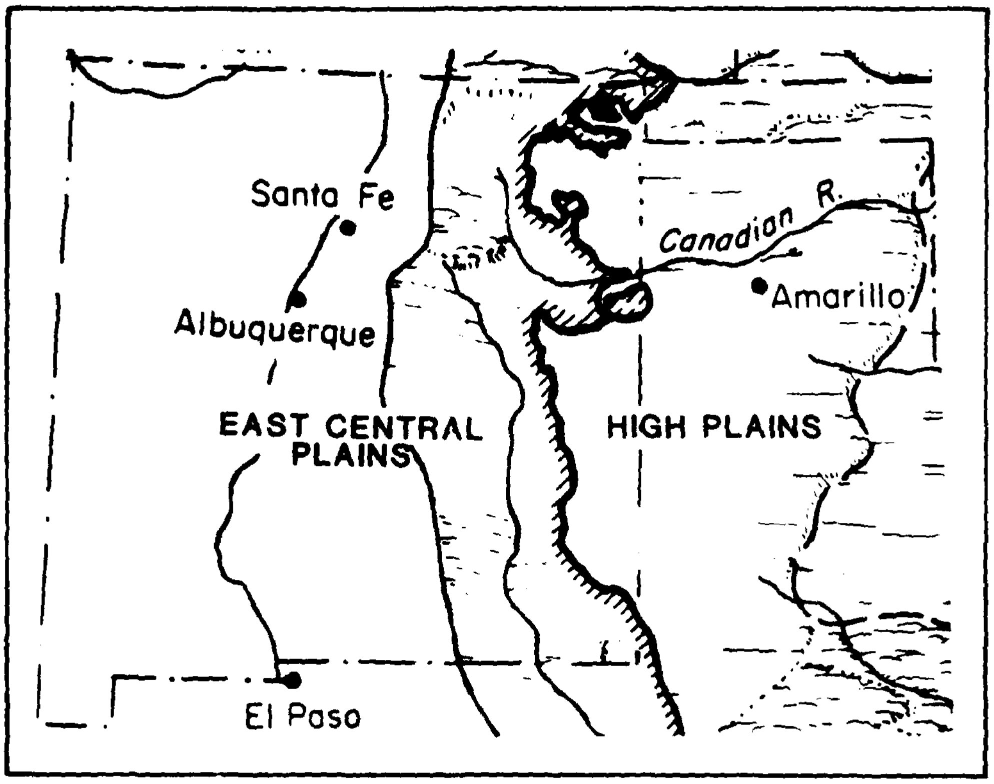

Figure 2.2.1-1. Major physiographic regions in the Texas-New Mexico deployment area.

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 surface of the Ogallala Formation is dotted with shallow depressions in which Pleistocene materials associated with the larger playas were deposited. During the Pleistocene, the present playas held permanent water bodies and today, water ponds on their surfaces only during the rainy season. 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 that have 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 are important source and reservoir rocks for oil and gas.

The absence in the High Plains of the extensive volcanic outpouring that characterized many areas in the Great Basin from Miocene time onward, particularly during the Pleistocene, has precluded the formation and deposition of the parent material for zeolitization, a process that is of some concern in Nevada/Utah.

3.0 MINING AND MINERALS

Some 100 minerals used in agriculture, manufacturing, defense and other basic industries are as critical to our life-style as fossil fuels. More than 2 billion tons of these minerals were consumed in this country in 1977 and the United States produced about one-fourth of the world's raw and processed minerals. The attendant mining and processing has resulted in locally adverse affects on land, air and water quality, and health. Between 1930 and 1970 over 3½ million acres were altered by surface mining. During this time Utah contributed about 40,000 acres to this total and Nevada 13,000 in the mining of copper alone.

Mining is an important issue in the Nevada/Utah siting region because of its position in the economy of the area. Mining 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 also rates high in Utah. In the siting area mining is most important, particularly in the vicinity of Tonopah, Ely, and Pioche. Any disruption of the mining industry would disturb a large portion of the regional economy.

Mining is also important when looked at in the national framework. Nevada is the nation's number one producer of barite, magnesite, and mercury and is second producer in gold. Utah is the leading producer of berylium and is second in copper, vanadium, and potash. With the rise in prices of most metals there has been an increased interest in mineral exploration using high technology. Deposits that were marginal are becoming economic to exploit.

The development of new mines occurs generally two to five years from the time of discovery. Old deposits could be reopened as the value of minerals increases past an economical threshold. 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. Mining, except for oil and gas extraction, is of minor economic importance in the Texas/New Mexico area. Some exploration for uranium is occurring in the area, 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 value products.

More than 200 economically valuable metallic and nonmetallic minerals are known to exist in Utah. Mineral 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 deposits are exposed and more readily discovered. Because the mineralization predates the formation of the basin and range, it is highly 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 presently 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. Figure 3.2.2.4-1, DEIS, Chapter 3 shows the locations of known mineral deposits and metal mining districts.

Nevada (3.1.1.1)

The value of Nevada's mineral output, including petroleum, dropped to $201.1 million in 1978, a decrease of 26 percent from that of 1977. The decreased output was primarily due to three major copper shutdowns, brought about by the depressed price of copper and the costs involved in complying with federal clean air regulations. 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 for 55 percent. Most of the mineral production came from the northern three-quarters of the state, with the southern quarter producing most of the 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 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 1978. 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. Carling 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.

The overall M-X development area in Nevada is conterminous with a substantial segment of the state's minerals industry. These six counties - Elko, Eureka, Lander, Lincoln, Nye, and White Pine - together accounted for 69 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 3.1.1-3. Copper, gold, and barite are the minerals of major economic value. There are also to be found plentiful supplies of stone, sand, and gravel for construction purposes.

Table 3.1.1-1. Nevada mineral production 1970-1978 in million dollars.

MINERAL	1970	PERCENT OF TOTAL	1977	PERCENT OF TOTAL	1978	PERCENT OF TOTAL
Copper	123.1	66.1	77.9	31.0	27.2	13.5
Gold	17.5	9.4	40.5	16.1	45.1	22.4
Barite	1.5	0.8	20.7	8.2	18.9	9.4
Sand & Gravel	9.8	5.3	22.1	8.8	23.0	11.4
Silver	1.3	0.7	2.2	0.9	1.9	1.0
Stone	2.7	1.4	4.4	1.8	5.8	2.9
All Other[(a)]	30.4	16.3	83.5	33.2	79.3	39.4
Total	186.3	100.0	251.3	100.0	201.2	100.0

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(a) Includes clays, gem stones, gypsum, iron ore, lead, petroleum, tungsten, zinc, diatomite, fluorspar, lime, lithium minerals, magnesite, mercury, molybdenum, perlite, pumice and salt.

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.

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

COUNTY	$000[1]	PERCENT OF TOTAL (STATE)
Elko	11,033	5.8
Eureka	29,681	15.5
Lander	27,728	14.5
Lincoln	5,350	2.8
Nye	21,595	11.3
White Pine	26,536	13.8
Study Area Total	121,923	63.6

088-1

[1]State total is 191,605.

Source: University of Nevada, Bureau of Business Economic Research, *Nevada Review of Business and Economics (Summer, 1978)*, p. 21 adapted.

Table 3.1.1-3. Minerals produced in Nevada study area counties.

COUNTY	MINERALS PRODUCED IN 1976, IN ORDER OF VALUE
Elko	Sand and gravel, barite, tungsten
Eureka	Gold, iron ore, stone, mercury
Lander	Copper, gold, barite, silver, lead, zinc
Lincoln	Stone, sand and gravel, perlite, zinc
Nye	Magnesite, petroleum, fluorspar, sand and gravel
White Pine	Copper, gold, lime, silver

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Source: Bureau of Mines, Minerals Yearbook, 1976; (reprint), p. 3.

Figure 3.1.1-2 presents a generalized geographic distribution of minerals industry activity in Nevada. Table 3.1.1-4 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 1978, production of copper, gold, silver, lead, and zinc was valued at $465 million, and accounted for almost 30 percent of the total value of Utah's mineral production (Table 3.1.1-5).

The production of copper exceeded that of all other metals, and in 1978 accounted for 23 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.

Tables 3.1.1-6 through 3.1.1-8 present the by county distribution of the minerals industry of Utah in terms of mining districts, mineral deposits, developed and undeveloped coal fields, oil and gas fields, and geothermal resources.

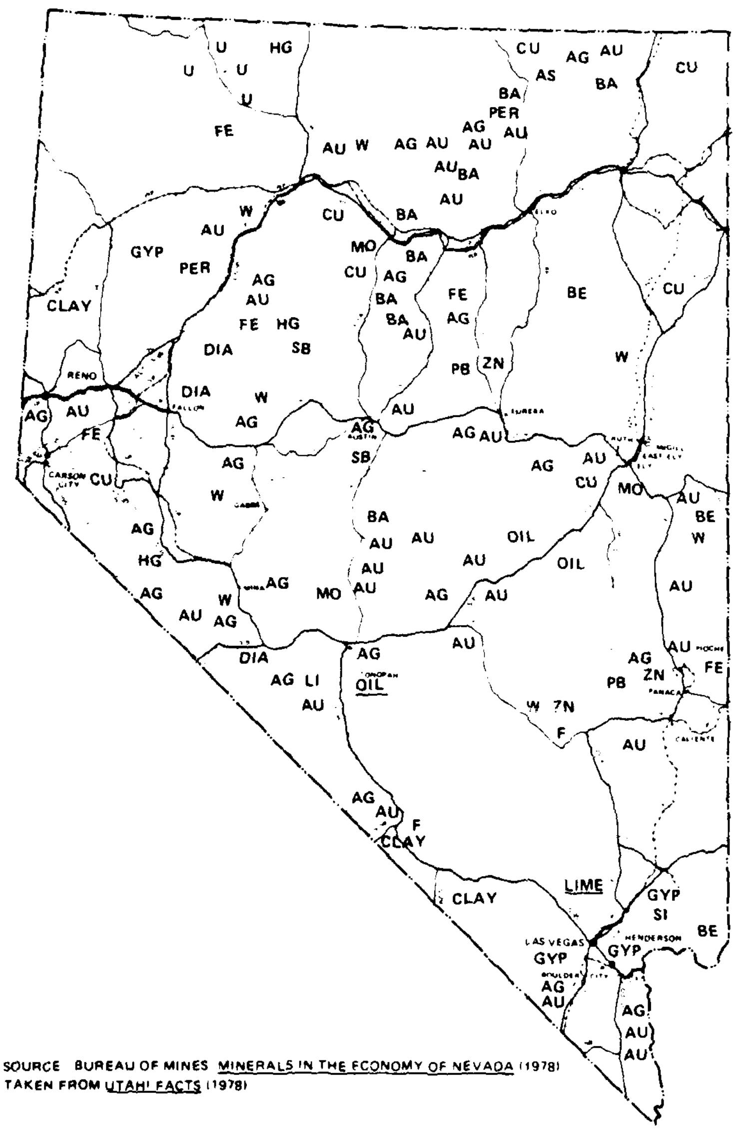
From this information it can be inferred that: (a) the proposed M-X deployment area in Utah falls outside the area of the state's coal, oil and gas fields, (b) there is considerable geothermal energy potential in the proposed deployment area, (c) the potential M-X deployment area is marked by undeveloped deposits of nonmetallic minerals, especially on the eastern and southern fringes, (d) Beaver, Juab, and Millard counties are minor contributors to the minerals output of Utah, and (e) 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 3.1.1-6)

The minerals produced in greatest quantity and value are nonmetallic. Table 3.1.1-7 presents mineral output in order of value for five counties in west-central Utah as of the mid-1970s. Table 3.1.1-8 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 to greater strength and stability



MINERAL SYMBOLS

AG	SILVER ORE
AU	GOLD ORE
AS	ARSENIC
BA	BARITE
BE	BERYLLIUM
CLAY	CLAY
CU	COPPER ORE
DIA	DIATOMITE
F	FLUORSPAR
FE	IRON ORE
GYP	GYPSUM
HG	MERCURY
LI	LITHIUM
LIME	LIME PLANT
MG	MAGNESIUM
MN	MANGANESE
MO	MOLYBDENUM
OIL	PETROLEUM, CRUDE
OIL	PETROLEUM PRODUCTS
PB	LEAD
PER	PERLITE
SB	ANTIMONY
SI	SILICA
U	URANIUM ORE
W	TUNGSTEN ORE
ZN	ZINC ORE

Figure 3.1.1-2. Geographic distribution on minerals industry activity in Nevada.

Table 3.1.1-4. 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 Chemical Products	D	White Pine
Dresser Industries	A	Lander			
FMC Corp.	A	Lander	MAGNESITE		
Milchem Inc.	A	Lander			
COPPER			Basic Inc.	A	Nye
Anaconda	B	Elko	PERLITE		
Duvall Corp.	B	Lander	DeLamar Perlite Co.	C	Lincoln
Kennecott Copper	B	White Pine	PETROLEUM		
FLUORSPAR			Ely Crude Oil	E	Nye
J. Irving Crowell, Jr.	C	Nye	Toiyabe Oil Inc.	E	Nye
GOLD			Western Oil Lands Inc.	E	Nye
Atlanta Gold Mine	B	Lincoln	PUMICE		
Carlin Gold Mining	A	Elko, Eureka	Cind-R-Lite Block Co.	A	Nye
Cortez Gold Mines	A	Lander	SAND AND GRAVEL		
IRON ORE			Stewart Brothers Co.	A	Nye
Nevada-Barth Co.	A	Eureka	Wells-Cargo Inc.	A	Nye
LEAD			W.M.K. Transit Mix Inc.	A	Nye
Pan American Mine	B	Lincoln			

090

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

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

Table 3.1.1-5. Mineral production in Utah, 1978.

MINERAL	VALUE OF PRODUCTION ($ IN MILLIONS)	PERCENTAGE OF TOTAL
Metals		
Copper	276.6	22.5
Gold	46.4	3.8
Iron Ore	22.5	1.8
Lead	1.9	negligible
Silver	15.6	1.3
Zinc	2.4	negligible
Uranium Ore	58.2	4.7
Non-Metals		
Clays	0.8	negligible
Gem Stones	0.1	negligible
Gypsum	2.0	negligible
Lime	8.1	0.7
Salt	13.4	1.1
Sand and Gravel	20.0	1.6
Stone	7.3	0.6
Mineral Fuels		
Coal	252.6	20.6
Natural Gas	32.6	2.7
Petroleum	345.6	28.2
Items Not Disclosed[1]	120.1	9.8
Total	1,226.2	100.0

091

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

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

Table 3.1.1-6. Value of mineral production in Utah study area counties (1975).

COUNTY	VALUE	
	$000	PERCENTAGE OF STATE
Beaver	176	negligible
Iron (1974)	14,727	1.5
Juab	627	negligible
Millard	*	negligible
Tooele	12,110	1.3
Study Area Total	27,640+	2.9
Utah Total	966,407	100.0

093

*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 3.1.1-7. Minerals produced in Utah study area counties (1975).

COUNTY	MINERALS PRODUCED, IN ORDER OF VALUE
Beaver	Sand and gravel
Iron	Iron ore, sand and gravel
Juab	Fluorspar, clays, gypsum, sand and gravel
Millard	Gypsum, stone, pumice, beryllium, sand and gravel
Tooele	Potassium salts, salt, lime, stone, sand and gravel

094

Source: U.S. Bureau of Mines, *Minerals Yearbook 1975: Volume II Area Reports, Domestic* (1978), p. 749.

Table 3.1.1-8. 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

095

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. Stockpiles in many instances 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 that 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, there were three highly important changes occurring: (1) prospecting techniques and mineralization concepts changed to become more sophisticated and more efficient, (2) roads and means of transportation improved greatly so that equipment could be brought in to isolated mining camps and ore taken out, (3) the extractive part of the mining industry acquired new ore-dressing, milling, and metallurgical technology.

One of the new metallurgical processes that had been invented was particularly adaptive to the lead and silver ores from Nevada, insuring 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, fewer values 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 ores that accounted for some of the deposits in the Great Basin of eastern Nevada and western Utah.

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 large deposits of low-grade copper ore at Ely and the Robinson District in eastern Nevada.

Utah, unlike Nevada, is primarily a manufacturing state. It is also physiographically divisible into regions other than the Great Basin shared with Nevada. Separated from the Basin and Range province by the Wasatch tectonic front and active fault line, 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.

Nevada calls itself "the Silver State," a reference to its former role as the leading producer of silver. One can easily recall the flamboyance of its transient boom towns and mining camps. Curiously enough, Nevada still enjoys that reputation, undoubtedly perpetuated by the continuing dependence on mining and the glitter of Las Vegas. Nevada has now gained the position nationally as the number two producer of gold and is pushing South Dakota for the number one spot. Utah, on the other hand, was developed by Mormon settlers who were staid, conservative people primarily interested in fostering their religious beliefs and in agricultural pursuits. The state never went through the "Boom Town" cycles that characterized mining in California and Nevada.

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

Nevada, with perhaps the overall size and breadth of Alaska to vie with it, is our most heavily mineralized state. By the very nature of its inherent geology, Nevada claims few locales that are not mineralized by significant metallic or nonmetallic deposits, or contain geothermal energy resources. The only exceptions are the fossil fuels; 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 manifestations of the hydrocarbons to warrant the expenditure of money for further drilling.

It has recently been estimated 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 gallons per 1,000 tons of ore treated and water consumption is 50,000 gallons per 1,000 tons. Heap-leaching, similar to leaching in situ, will have new water requirements of 600,000 gals/2,000 lbs of metal produced, and consumption for the same amount of metal.

In most cases, transmission lines, pipelines, supplies of oil and gas are scarce or nonexisting. Therefore, competition of the mining industry with M-X requirements for both water and power could mean delaying mining operations in some places.

Construction Resources. Another long-range development in the mineral history of Nevada and Utah was initiated shortly after the turn of the 20th century with the beginning of 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 purposes; and other nonmetals were mined for local consumption. However, developments following World War I were much more important because they were aimed primarily at wide markets, with California in particular.

The significance of industrial mineral deposits is such that they 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 short-lived. They do not pass through a cycle of boom and exhaustion in 25 years or less as some of the metallic deposits have been known to do, particularly in Nevada. Sand and gravel and other aggregates for concrete batching abound in the Great Basin. No shortages near proposed base locales should be expected with respect to M-X construction. The availability of cement is such that projected new plants in Utah may be able to supply project requirements with no significant dislocation of normal markets.

Non-Construction Resources. A complete list of active mines, claims, and ore-types for both Nevada and Utah can be found in the appendix of this report.

Mining Activity in Utah (3.1.2.2)

Within the M-X study area in central and southwestern Utah there is presently a high level of oil, gas, and uranium exploration. The Intermountain Power Project (IPP), already funded and sited in Lynndyl near Delta, is certain to increase coal demand.

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, three coal mines, three oil and gas developments, and five manufacturing plants. Development of energy and mineral resources are sure to increase 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.

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.

Production of bituminous coal in Utah has rapidly escalated and will continue to do so because of stockpiling and anticipation of demand for various projects, not the least of which is the Interstate Power Project (IPP). Current production of coal is of the order of 900,000 tons per month. The state ranks 16th within the 22 coal producing states.

Mining Activity in Nevada (3.1.2.3)

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 harvested with time and increased demand. The five counties comprising eastern Nevada (Elko, White Pine, Nye, Lincoln, and Clark) and the prime M-X study area are included, each with its own table.

The estimates taken from Bulletin 82, "Forecasts for the Future Minerals," of the Nevada Bureau of Mines and Geology, are valid prognosticators for increased mining production to the year 2020. However, by using 1970 dollars, the resulting values for future mineral output are diluted considerably.

Table 3.1.2-1. Estimated future mineral production statistics-Elko County (Page 1 of 5).

COMMODITY AND UNITS	NUMBER OF MINES	QUANTITY	NEW WATER REQUIREMENT MILLIONS OF GALLONS	WATER CONSUMED MILLIONS OF GALLONS	NUMBER OF PERSONS EMPLOYED	VALUE AT 197[illegible] PRICES THOUSANDS OF DOLLARS
[illegible]						
[illegible] Sand and Gravel*						
[illegible] Total	[illegible]		4	[illegible]	[illegible]	3[illegible]
[illegible]						
Copper, tons	[illegible]	[illegible]	[illegible],81[illegible]	[illegible]	[illegible]	[illegible]
Tungsten, tons	[illegible]	4[illegible]	[illegible]3	[illegible]	8	[illegible]80
Vanadium, tons	[illegible]	[illegible]	[illegible]4[illegible]	[illegible]	[illegible]	[illegible]
Barite, tons	[illegible]	[illegible]	[illegible]	4		[illegible]
Sand and Gravel, tons	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Total	[illegible]		4,[illegible]	[illegible]	39[illegible]	[illegible]44
[illegible]						
Beryllium, tons	[illegible]	[illegible]	4[illegible]	[illegible]	3	[illegible]
Copper, tons	[illegible]	[illegible]	[illegible]	[illegible],744	[illegible]4	[illegible]
Tungsten, tons	[illegible]	8[illegible]	26	[illegible]	[illegible]	[illegible]
Uranium, tons	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vanadium, tons	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]4
Barite, tons	3	15[illegible]	129	[illegible]	[illegible]	[illegible]
Sand, Industrial, tons	1	40[illegible]	16[illegible]	[illegible]	8[illegible]	[illegible]
Sand and Gravel, tons	[illegible]	44[illegible]	[illegible]	1[illegible]		44
Geothermal Power, MWH	[illegible]	16[illegible]	1[illegible]4	7[illegible]	3[illegible]	[illegible]
2000 Total	[illegible]		[illegible],64[illegible]	[illegible],43[illegible]	78[illegible]	[illegible]
2020						
Beryllium, tons	[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]
Gold and Silver, tons ore	[illegible]	[illegible]	4[illegible]4	[illegible]	[illegible]	[illegible]
Tungsten, tons	[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]
Uranium, tons [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vanadium, tons	1	[illegible],50[illegible]	91[illegible]	33[illegible]	12[illegible]	[illegible]
Barite, tons	4	4[illegible],00[illegible]	344	18[illegible]	2[illegible]	[illegible]
Sand, Industrial, tons	1	4[illegible],00[illegible]	16[illegible]	7[illegible]	8[illegible]	[illegible]
Sand and Gravel, tons	2	462,00[illegible]	4[illegible]	1[illegible]	[illegible]	4[illegible]
Stone, tons	2	[illegible]2[illegible],00[illegible]	11[illegible]	[illegible]	1	[illegible]
Geothermal Power, MWH	[illegible]	32[illegible],00[illegible]	2[illegible]8	[illegible]	[illegible]	[illegible]
2020 Total	1[illegible]		[illegible],4[illegible]	[illegible],1[illegible]	[illegible]	3[illegible]

[illegible]

*Statistics for individual items withheld to avoid disclosing confidential data

Table 3.1.2-1. (cont) Estimated future mineral production statistics - White Pine County (Page 2 of 5).

COMMODITY AND UNITS	NUMBER OF UNITS	QUANTITY	NEW WATER REQUIREMENT MILLIONS OF GALLONS	WATER CONSUMED MILLIONS OF GALLONS	NUMBER OF PERSONS EMPLOYED	VALUE AT 1970 PRICES THOUSANDS OF DOLLARS
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	[illegible]
Gold and Silver, tons ore	2	250,000	214	94	135	[illegible]
Lead and Zinc, tons	1	10,000	127	71	41	[illegible]
Sand and Gravel, tons	1	161,000	14	4	[illegible]	[illegible]
Stone, tons	1	74,000	10	[illegible]	[illegible]	[illegible]
Petroleum, barrels	1	100,000	4	[illegible]	[illegible]	[illegible]
1980 Total	9		5,459	[illegible]	[illegible]	[illegible]
2000						
Beryllium, tons	[illegible]	200	98	[illegible]	[illegible]	[illegible]
Copper, tons	[illegible]	60,000	6,705	[illegible]	[illegible]	[illegible]
Lead and Zinc, tons	1	10,000	127	[illegible]	41	[illegible]
Fluorspar, tons	[illegible]	[illegible]	18	[illegible]	[illegible]	[illegible]
Sand and Gravel, tons	[illegible]	160,000	24	4	[illegible]	[illegible]
Stone, tons	[illegible]	300,000	[illegible]	3	[illegible]	[illegible]
Petroleum, barrels	[illegible]	400,000	4	[illegible]	[illegible]	[illegible]
2000 Total	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
2020						
Beryllium, tons	[illegible]	300	[illegible]	[illegible]	[illegible]	[illegible]
Copper, tons	[illegible]	60,000	[illegible]	[illegible]	[illegible]	[illegible]
Lead and Zinc, tons	1	[illegible]	127	[illegible]	[illegible]	[illegible]
Tungsten, tons	2	800	260	[illegible]	[illegible]	[illegible]
Sand and Gravel, tons	[illegible]	146,000	14	4	[illegible]	[illegible]
Stone, tons	2	300,000	63	[illegible]	[illegible]	[illegible]
Geothermal Power, MWH	[illegible]	160,000	104	[illegible]	[illegible]	[illegible]
Petroleum, barrels	[illegible]	200,000	[illegible]	[illegible]	[illegible]	[illegible]
2020 Total	13		22,890	[illegible]	[illegible]	[illegible]

*Statistics for individual items withheld to avoid disclosing confidential data

Table 3.1.2-1. (cont) Estimated future mineral production statistics - Nye County (Page 3 of 5).

COMMODITY AND UNITS	NUMBER OF MINES	QUANTITY	NEW WATER REQUIREMENT MILLIONS OF GALLONS	WATER CONSUMED MILLIONS OF GALLONS	NUMBER OF PERSONS EMPLOYED	VALUE AT 1977 PRICES THOUSANDS OF DOLLARS
1970						
Flourspar, 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	2,5[illegible]
Iron Ore, long tons	1	200,000	76	36	51	[illegible]
Tungsten, tons	1	150	49	26	30	[illegible]
Barite, tons	3	150,000	129	68	75	[illegible],125
Fluorspar, tons	2	45,000	[illegible]	41	45	[illegible]
Refractories, tons	1	500,000	558	304	250	[illegible]
Sand and Gravel, tons	[illegible]	111,000	[illegible]	3	[illegible]	[illegible]
Stone, tons	1	50,000	[illegible]	3	[illegible]	15[illegible]
Gem and Semiprecious Stones, tons	[illegible]	--	--	--	1	[illegible]
Petroleum, barrels	[illegible]	150,000	19	17	6	450
1980 Total	14		1,478	792	690	12,141
[illegible]						
Gold and Silver, tons ore	2	450,000	381	168	24[illegible]	4,[illegible]
Iron Ore, long tons	1	200,000	76	36	51	[illegible]
Molybdenum, tons	1	4,500	952	529	315	15,480
Tungsten, tons	1	15	49	26	30	[illegible]
Barite, tons	3	300,000	258	136	[illegible]	[illegible]
Fluorspar, tons	[illegible]	50,000	86	45	5[illegible]	[illegible]
Refractories, tons	1	750,000	837	456	[illegible]	[illegible]
Sand and Gravel, tons	[illegible]	140,000	12	4	[illegible]	[illegible]4
Stone, tons	[illegible]	50,000	[illegible]	[illegible]	[illegible]	[illegible]
[illegible], tons	1	225,000	[illegible]	[illegible]	[illegible]	[illegible]
Gem and Semiprecious Stones, tons	[illegible]	[illegible]	--	--	[illegible]	[illegible]
Geothermal Power, MWH		[illegible]	52	38	[illegible]	[illegible]
[illegible] Total	[illegible]		2,832	1,506	[illegible],306	[illegible]
[illegible]						
[illegible], tons	[illegible]	[illegible]	[illegible]	38[illegible]	[illegible]	[illegible]
Gold and Silver, tons ore		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Molybdenum, tons	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible], tons	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Barite, tons	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fluorspar, tons	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Refractories, tons	[illegible]	[illegible]	[illegible]	456	[illegible]	[illegible]
Sand and Gravel, tons	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]
Stone, tons	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible], tons	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gem and Semiprecious Stones, tons		[illegible]				[illegible]
Geothermal Power, MWH		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Petroleum, barrels	[illegible]	[illegible]	[illegible]	14	[illegible]	[illegible]
Saline Playa Products, tons	[illegible]	[illegible]	[illegible]	46	[illegible]	[illegible]
[illegible] Total	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]

*Totals [illegible] for individual items withheld [illegible] confidential data

Table 3.1.2-1. (cont) Estimated future mineral production statistics - Lincoln County (Page 4 of 5).

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
1970						
Lead and Zinc, Fluorspar, Sand and Gravel, Stone*						
1970 Total	6		10	5	25	251
1980						
Lead and Zinc, tons	1	20,000	282	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
[illegible] Total	6		562	303	284	12,258
[illegible]						
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
[illegible] Total	6		651	340	411	15,020
[illegible]						
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
[illegible] Total	9		80[illegible]	4[illegible]	456	36,944

3378

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

Table 3.1.2-1. (cont) Estimated future mineral production statistics - Clark County (Page 5 of 5).

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
1970						
Industrial Sand, Sand and Gravel, Stone*						
1970 Total	12		472	146	341	[illegible]
1980						
Clay, tons	1	5,000	1	Nil	1	[illegible]
Sand, Industrial, tons	2	800,000	338	141	176	[illegible]
Sand and Gravel, tons	6	7,609,000	612	194	151	[illegible]
Stone, tons	7	2,307,000	322	161	441	[illegible]
1980 Total	15		1,273	496	765	18,591
2000						
Manganese, tons	1	45,000	120	45	45	2,250
Clay, tons	1	20,000	5	3	4	240
Sand, Industrial, tons	3	1,200,000	506	211	264	6,000
Sand and Gravel, tons	8	13,900,000	1,227	361	278	13,900
Stone, tons	10	3,701,000	756	378	740	11,103
Vermiculite, tons	1	50,000	129	68	75	1,000
Petroleum, barrels	1	500,000	4	2	[illegible]	1,500
Total-Rock Components, tons	1	400,000	165	103	52	8,000
2000 Total	26	2,912	1,17[illegible]	1,464	43,[illegible]	
2020						
Copper, tons	1	10,000	6,360	2,180	300	[illegible]
Lead and Zinc, tons	1	10,000	106	59	35	3,[illegible]
Molybdenum, tons	1	2,000	424	236	140	6,880
Sand, Industrial, tons	3	2,000,000	844	352	440	10,000
Sand and Gravel, tons	10	17,496,000	1,523	455	350	17,496
Stone, tons	13	4,580,000	1,040	520	900	13,740
Vermiculite, tons	1	100,000	258	136	150	2,000
Total-Rock Components, tons	1	1,000,000	414	232	130	20,000
2020 Total	31		10,969	4,170	2,445	84,816

3378

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

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. Projections to the mid-1980s do not foresee any significant employment growth (Nevada Employment Security Department, Nevada Statistical Abstract, 1977).

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 40 percent of mining 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 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 3.1.3-4).

Mining employment in the five west-central Utah counties potentially directly impacted by M-X deployment was less than 500 (see Table 3.1.3-5).

Proportion of personal income 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). (See Table 3.1.3-6).

MINING CLAIM AND LEASING ACTIVITY (3.1.4)

NEVADA. 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 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.

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.

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

YEAR	EMPLOYMENT ALL SECTORS (000)	EMPLOYMENT MINING (000)	PERCENT OF TOTAL EMPLOYMENT
1950	60.4	3.9	6.5
1960	109.1	4.6	4.2
1970	207.6	4.2	2.0
1977	307.5	3.4	1.1
1979 (June)	376.5	4.0	1.1

096

Sources: 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.

COUNTY	OPERATIONS		EMPLOYMENT	
	NUMBER	PERCENTAGE OF STATE	NUMBER	PERCENTAGE OF STATE
Elko	24	6.2	181	3.6
Eureka	13	3.3	335	6.7
Lander	34	8.7	714	14.3
Lincoln	15	3.8	379	7.6
Nye	29	7.4	652	13.1
White Pine	22	5.6	556	11.1
All Other Counties	232	59.5	2,159	43.4
Total Nevada	390	100.0	4,976	100.0

097

Source: State of Nevada Industrial Commission, *Directory of Nevada Mine Operations Active During Calendar Year 1978* (January 1979), p. 11.

Table 3.1.3-3. Mining personal income as a percentage of total personal income by selected counties (1977).

COUNTY	PERCENTAGE OF PERSONAL INCOME DERIVED FROM MINING
Elko	3.6
Eureka	62.4
Lander	55.1
Lincoln	18.5
Nye	10.6
White Pine	30.4
Nevada State	1.6

098

Source: Bureau of Economic Analysis, Regional Economics Information System (April 1979).

Table 3.1.3-4. Percentage of mining employment in Utah, 1960 - 1977.

YEAR	TOTAL NONAGRICULTURAL EMPLOYMENT (000)	TOTAL MINING EMPLOYMENT (000)	PERCENT SHARE
1960	264.4	13.8	5.2
1970	358.7	12.7	3.5
1977	486.6	15.0	3.1

099

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

Table 3.1.3-5. Employment in mining for selected Utah counties (1977).

COUNTY	TOTAL NONAGRICULTURAL EMPLOYMENT	MINING EMPLOYMENT	PERCENTAGE OF TOTAL/ ADMINISTRATIVE UNIT
Tooele	9,817	87	0.9
Juab	1,652	59	3.6
Millard	1,865	58	3.1
Beaver	1,134	29	2.6
Iron	5,295	217	4.1
All Other Counties	466,790	14,593	3.1
Utah Total	486,553	15,043	3.1

100

Sources: Utah Department of Employment Security; University of Utah, Bureau of Economic and Business Research, *Utah! Facts* (1978), p. IV-14.

Table 3.1.3-6. Mining personal income as a share of total income for selected counties (1977).

COUNTY	SHARE OF TOTAL PERSONAL INCOME DERIVED FROM MINING
Beaver	3.4
Iron	7.4
Juab	5.6 (1975)[1]
Millard	4.3
Tooele	negligible
Utah (All counties)	5.2

101

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

Source: Bureau of Economic Analysis, *Regional Economics Information System* (April 1979).

(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) Mineral Sale. Common sand, gravel, and other construction materials are available through material sale or for governmental agencies and non-profit 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 survey, the greater the potential for mineral industry growth. Geologic survey is constantly increasing industry knowledge of economically exploitable mineral deposits.

There were 6,315 active mineral leases and permits 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 permits 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 mineral leases and permits in effect in 1978 by mineral type.

Table 3.1.4-2 indicates the 1978 distribution of Nevada oil and gas leases by county. Table 3.1.4-3 presents the 1978 distribution of Nevada geothermal leases by county.

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

Nearly 20 million acres (8 million ha) 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.

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 mineral lease acreage. Table 3.1.4-4 presents the distribution by mineral commodity of outstanding leases and permits 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.

No commercial operation exists in the Nevada side. There may be one or two relatively small commercial sand and gravel operations serving the more populated areas along the eastern part of the Utah project.

Table 3.1.4-1. Mineral Leases and Permits 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	.67	1.2
Sodium	12	.02	negl.
Potassium	11	.02	negl.
Other (silica, sand and gravel)	6	.003	negl.
TOTALS	6.315	9.28	9.1

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

Table 3.1.4-2. Oil and gas leases in effect by county, 1978.

COUNTY	NUMBER OF LEASES	ACRES
Churchill	116	154,584
Clark	293	436,990
Elko	1,000	1,894,891
Esmeralda	9	8,783
Eureka	386	660,060
Humboldt	4	2,763
Lander	143	252,531
Lincoln	607	1,155,033
Mineral	10	9,217
Nye	1,803	1,929,000
Pershing	3	3,100
Washoe	1	1,155
White Pine	1,496	2,456,205
Totals	5,871	8,964,312

4167

Source: BLM, Nevada Statistics, 1978.

Table 3.1.4-3. Geothermal leases in effect by county, 1978.

COUNTY	NUMBER OF LEASES		ACREAGE	
	NON-COMPETITIVE	COMPETITIVE	NON-COMPETITIVE	COMPETITIVE
Churchill	103	33	171,595	56,669
Douglas	2	—	2,191	—
Elko	6	1	7,665	2,418
Esmeralda	16	1	28,688	2,546
Eureka	10	6	6,428	8,834
Humboldt	42	2	77,945	3,200
Lander	9	5	17,975	6,437
Lyon	10	10	9,126	13,682
Mineral	8	—	10,538	—
Nye	26	1	53,471	1,311
Pershing	60	14	86,912	28,546
Storey	1	—	543	—
Washoe	23	9	22,023	14,492
White Pine	17	—	39,079	—
Totals	333	82	534,179	138,135

4168

Source: BLM, Nevada Statistics, 1978.

Table 3.1.1.1. [illegible] Mineral [illegible]
and Permits [illegible]

MINERAL COMMODITY	NUMBER	[illegible]
Coal	[illegible]	
Potassium (Potash)	[illegible]	[illegible]
Phosphate	[illegible]	
Hard rock (a)	[illegible]	[illegible]
Gilsonite, Bituminous Sands, Asphalt	[illegible]	
Geothermal	[illegible]	[illegible]
Oil and Gas	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]

(a) "Any locatable or salable mineral [illegible] e.g. copper, gold, silver, [illegible]

Source: BLM, Facts and Figures for Utah [illegible]

Potential aggregate resources are available throughout the deployment area. Almost all alluvial fan deposits contain aggregate of some quality. Carbonate rock source areas for fan deposits would provide better quality aggregate than volcanic source areas. The best alluvial aggregate would come from well-graded channel deposits or lake shore gravels. The highest quality aggregate in the deployment area would come from Paleozoic quartzite deposits in the mountain ranges. These deposits are locatable on any detailed geologic map of the area. Cost of recovery of the quartzite aggregate 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 [illegible] (unpatented claims), amount to 13.3 percent of the state's M-X project area. The following Tables (3.1.4-5 and 3.1.4-6) show the distribution of unpatented and patented mining claims in relevant siting valleys and basins of both Nevada and Utah.

[illegible] resources inventory by county for Nevada and Utah indicating the [illegible] and current mining activity can be found in the appendix of this report. [illegible] and the total value of production through 1976 is [illegible] Nevada. Nonmetallic minerals, oil and [illegible] are also included as are locations of known aggregate [illegible].

3.2 TEXAS/NEW MEXICO EXISTING SETTING

MINERAL RESOURCES - TEXAS, NEW MEXICO AREA (3.2.1)

[illegible] interest are oil, natural gas, sand [illegible] Previous production of gypsum [illegible] there appears to be no current production. [illegible] potash, salt, high calcium limestone, [illegible] have been identified, but no production has been [illegible].

Industrial and Saline Minerals (3.2.1.1)

[illegible] have been identified in Tertiary and [illegible] associated deposits have been [illegible] for use in highway and railroad [illegible] aggregates [illegible] has been reported in [illegible] Other nonmetallic commodities [illegible].

[illegible] deposits [illegible] have been identified in the volcanic [illegible] County, New Mexico. Two [illegible] have had some production. Most of [illegible].

[illegible] deposits have been identified in Oldham [illegible] New Mexico. The gypsum occurs [illegible] interstratified with other rocks of the

Table 3.1.4-5. Unpatented mining claims.

VALLEY	NUMBER OF CLAIMS[1]	ACRES[2]
Hot Creek (Nevada)	149	2,882
Reveille	5	90
Little Smokey	7	126
Big Sand Springs	5	90
Railroad	69	1,242
Denoyer	91	1,838
Garden	86	1,548
Tickaboo	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
Lake	479	8,622
Spring	43	774
Snake (Utah)	169	2,704
Hamlin	11	176
Tule	500	8,000
Pine	406	6,496
Fish Springs Flat	2,614	41,824
Wah Wah	43	688
Whirlwind	115	1,840
Sevier Lake	300	4,800
Dugway	1,766	28,256
Escalante Desert	221	3,536
Sevier Desert	1,795	28,720
Black Rock Desert	33	528
TOTALS	9,917	159,620

2334

[1]Valid unpatented claims post 1953.

[2]18 acres per claim average for Nevada; 16 acres per claim average for Utah.

Table 3.1.4-6. Patented mining claims.

VALLEY	NUMBER OF CLAIMS	ACRES
Hot Creek (Nevada)	1	5
Reveille	-	-
Little Smokey	-	-
Big Sand Springs	-	-
Railroad	-	-
Denoyer	-	-
Garden	-	-
Tickaboo	-	-
White River	-	-
Coal	-	-
Pahroc	-	-
Steptoe	-	-
Cave	-	-
Muleshoe	-	-
Dry Lake	-	-
Delamar	17	330
Lake	167	2,674
Spring	20	318
Snake (Utah)	-	-
Hamlin	-	-
Tule	7	121
Pine	-	-
Fish Springs Flat	-	-
Wah Wah	2	30
Whirlwind	-	-
Sevier Lake	-	-
Escalante Desert	138	2,023
Sevier Desert	2	6
Black Rock Desert	-	-
TOTALS	354	5,510

2335

Table 3.2.1-1. Texas mineral productions in 1976 by county within the study area.

COUNTY	VALUE	MINERALS	PERCENT OF STATE TOTAL ($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 & Gravel	0.02
Parmer	W	Stone	
Sherman	$ 42,439,000	Petroleum, Natural Gas	0.2
Hartley	W	Natural Gas	
Deaf Smith	W	Limestone (Caliche)	

3221

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

Source: Minerals Yearbook, 1976.

Table 3.2.1-2. Value of mineral productions in New Mexico by county within study area (1976).

COUNTY	VALUE	MINERALS	PERCENT OF STATE TOTAL ($2.5 BILLION)
Chaves	$20,387,000	Petroleum, Natural Gas, Sand and Gravel, Stone	0.8
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
Union	W	Pumice, Sand and Gravel, Stone	

3222

W - Withheld to avoid disclosing proprietary data; state totals do not include county withheld values.

Source: Minerals Yearbook, 1976.

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 evaluation 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, but the salt beds have been evaluated as possible sites for high-level nuclear waste depositories.

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 evaluation area, but the area has high potential, however, no production has been recorded.

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 labor requirements of mining are obvious, large-scale mining operations require large numbers of employees. 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 currently occurring 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.

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. To take advantage of this labor force, the discovery of the mineral deposit would have to be made within the next two years and development plans begun soon thereafter.

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 missile system is based on three factors: 1) land preemption, 2) M-X proximity to minerals and energy activities, and 3) resource competition as a result of M-X activity.

The land 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 geologic deposits facilitates these calculations.

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 geologic 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.

A counterbalancing 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) 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 1980's. Improved access for geologic prospecting and survey is a long-term benefit which will not accrue to the minerals and energy resources industry until completion of M-X construction activity.

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). The mining claim map was provided by the Army Corps of Engineers (1980) and was incomplete with respect to the study area. A complete map of mining claims was requested of BLM but was not available for this study. Potentially significant impacts were determined to occur where the proposed system overlapped with large concentrations of claims.

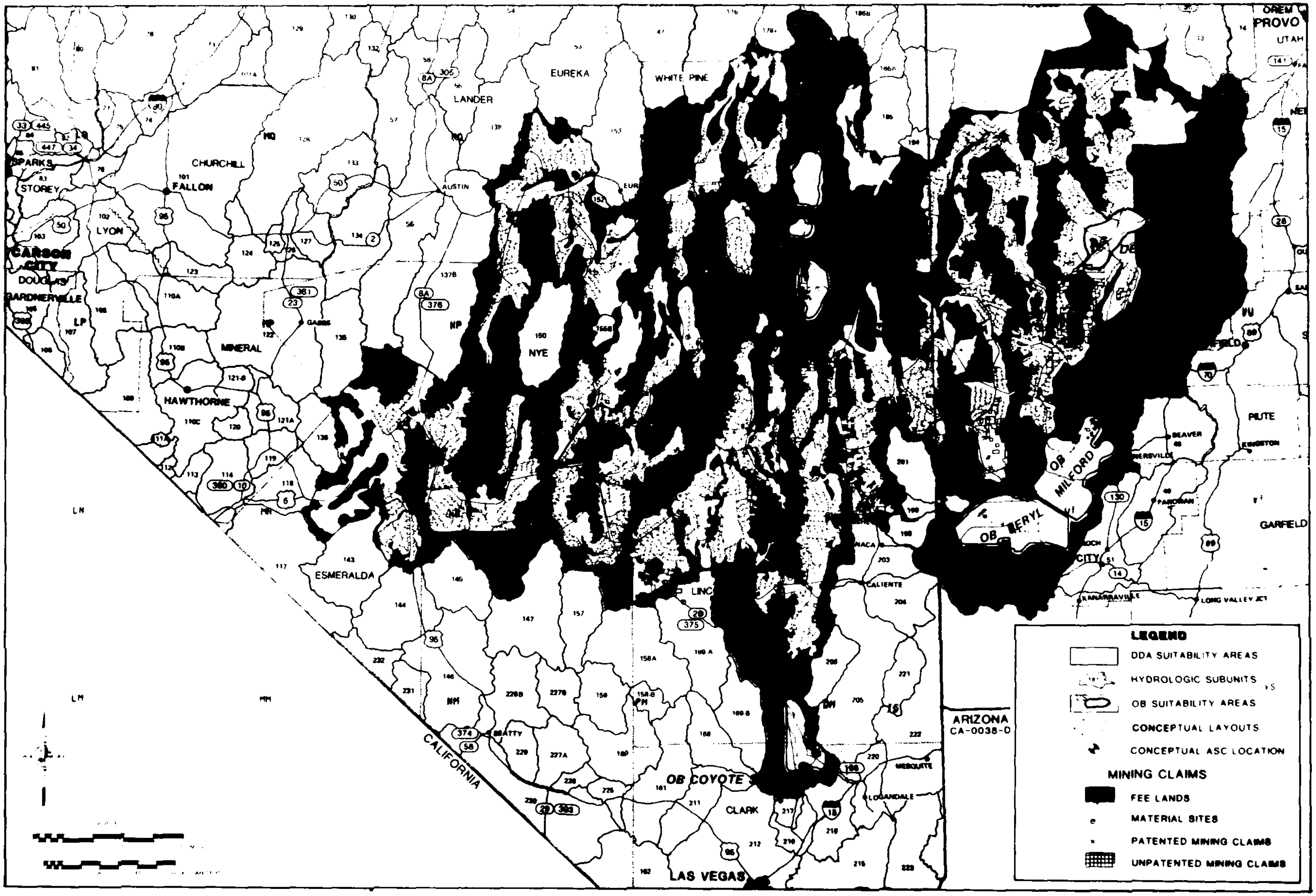


Figure 3.3.1-1. Distribution of patented and unpatented mining claims.

Withdrawal of land presently held in mineral claims has the potential of limiting future mineral development in the deployment area. The impact scenario would be that a valuable ore deposit located in bedrock under the valley fill could not be developed because of the overlying M-X components. This would be especially true if projected development were to be by open pit methods. In addition to claims that could indicate 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 will force the cessation or relocation of this activity. 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 mines, the logical extension of mining claim activity.

Mining development is a long-term resource commitment. From the date of discovery of a mineral deposit to the start of production may take as long as 7 to 10 years. 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 mines for the duration of the M-X system. In such an instance the benefits of the nuclear deterrent provided by M-X would have to be weighed against the long-term economic benefits of a mining operation, particularly if the mineral commodity were of strategic importance.

Most of the metallic mineral resources in the M-X deployment area occur in the mountain ranges which are not being considered for withdrawal. Other minerals are concentrated in the playas which also are not being considered for withdrawal. Much of the area that is 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.

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 have to be areas of shallow alluvial cover so recovery of mineral values would be economic. Many of these potential areas are already covered by concentrations of mineral claims. By avoiding these concentrations, the M-X system would minimize potential impacts to future mining concerns. If the M-X system were to occupy land over as yet unsuspected mineral deposits, these deposits would be precluded from development during the 20-year life of the project.

The areas of high resource value, whether metal, oil and gas, or geothermal, where the M-X project could conflict with known resources are listed below for the valleys affected by M-X, first in Nevada and then in Utah.

NEVADA

1. Railroad Valley. The west central part of this valley (T.9N., R.5G & 57E.) features Nevada's only two producing oil fields. The entire valley has seen much exploratory activity. The fields are not large (total Eagle Springs field production from 1954-1970 was 2.5 million barrels (397,250 m^3). Moreover, given the extremely chaotic and complex geology of Nevada, there is certainly no assurance that the 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 preempt any possibilities for new discoveries.

2. Hot Creek and Reveille Valleys. Geothermal potential exists in T.7 & 8N., R. 5051E.

3. Big Smoky Valley. High industrial process heat geothermal potential is found in the west central part of this valley, T. 11-14 N., R. 43E.

4. Penoyer Valley. Total exclusion of right-of-way Crossing Range 56E, T3s, Sections 16, 17, 18, 21, 23, and 24. Vital tailing and water pipeline areas for Emerson Mine, total of 4,160 acres (1,681 ha).

5. Coal Valley. R60E, T2N, Sections 1 and 12, R60E, T3N, Section 18; R61E, T2N, Sections 6, 7, 8, 9, 16, 17, 18, 19, 20, 30, 31, 32, 33; R61E, T3N, Sections 28, 29, 31, 32 for a total of 10,240 ac (4,137 ha). A concentration of unpatented mining claims along the valley border.

6. Cave Valley. R63E, T5N, Sections 7, 8, 9, 10, 15, 16, 17, 18, 20, 21, 22, 28. Total of 7,360 acres. A concentration of mining claims at the foot of Cave Valley.

7. Lake Valley. All the area from Bristol Pass Road west of Highway 93 to the north boundary of Township 1N, extending across Range 67E. Included in the recommendation is the small valley lying along the easterly side of R69E and T1 and 2N. 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.

8. Spring Valley. The northern four tiers of sections covering the end of a valley are in R67E, T11N. Total acreage is 7,040 (2,844 ha). Approximately half the area is covered by fee lands and patented mining claims.

9. Spring Valley. R68E, T7N, 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.

10. Hot Creek Valley. 115 claims in T7N, R.50E. Adjacent to Tybo mining district (silver, lead, zinc, gold, and mercury). This combines with the geothermal potential previously mentioned.

11. Steptoe Valley. 153 claims in T14N, R63E. Adjacent to Ward silver, lead, and zinc mining district.

12. Tonopah Area. South end Big Smoky Valley, T8N, R.41 & 42E. AMAX is developing a large molybdenum deposit area for production.

UTAH

1. Escalante Desert. This is an area of high geothermal potential and exploration activity and it is reported that there may be the potential for electric power generation. To avoid interference with geothermal development, the Escalante desert areas south of T.25S and/or east of R.10W 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 seen 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 boast 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. TS12 & 13S. & RS12 & 13W. are areas of considerable geothermal interest and leasing activity.

6. Sevier Lake Valley. The east side of Sevier Lake, R.11W., T.20-22S., has extensive evaporate deposits, including potash. Over 100 claims and a state mining lease have been filed on these saline deposits.

Table 3.3.1-1 indicates the potential conflicts between M-X required land uses and lands subject to possessory uses assuming an even distribution of possessory uses throughout the deployment area. The table indicates potential conflicts on 80,508 acres (32,525 ha) of land under geothermal, oil, and gas leases and mining claims. This amounts to 2.6 percent of the project site requirements.

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 potential effect of M-X siting, therefore, is possible 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 in a recent evaluation for the Air Force.

ACCESS CONFLICTS (3.3.2)

The deployment of the M-X missile 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

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	-	REQUIRED FEDERAL ACRES SUBJECT TO POSSESSORY INTERESTS: GEOTHERMAL 2%[2]	+	O & G 57.2%[2]	+	MINING CLAIMS 6%[2] X 40%[3]	=	REQUIRED FEDERAL ACRES WITH NO POSSESSORY INTERESTS OUTSTANDING
Exclusive Use	14,079[1]	-	943	=	13,136	-	(282	+	8,053	+	338[4]	=	4,463 (31.7%)
R/W	131,948[1]	-	8,841	=	123,107	-	(0	+	0	+	3,167[4]	=	119,940 (90.9%)
Safety	2,861,181[1]	-	191,699	=	2,669,482	-	(0	+	0	+	68,668[4]	=	2,600,814 (90.9%)
Totals	3,007,208	-	201,483	=	2,805,725	-	(282	+	8,053	+	72,173	=	2,725,217 (90.6%)

747

[1]Supplied by BMO.

[2]Ratio of required acreage to total project acreage.

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

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

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 other developments since the deposit will not go away.

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 one half of one percent to nearly one and one half 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 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, the probable ore reserves may warrant further attention and exploratory work even with M-X basing already approved. In such event, revisions in the deployment area would be justified and expedient.

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. This change of employment will not, in most cases, be from mining to M-X, but rather from other present service industries and businesses to M-X.

Present mining operations such as Union Carbide in Alamo, Nevada; Anaconda Copper, which is just starting an operation near Tonopah, Nevada, and other similar mining operations operate under the umbrella of union organization and the likelihood of displacing these individuals from their present employment, in many cases with longevity benefits, seniority, etc., will not be great.

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.

[illegible] of mining labor force subject to attractions to M-X, by category.

[illegible]	PERCENT OF EMPLOYMENT[a]	PERCENT OF CATEGORY ATTRACTED	PERCENT OF TOTAL ATTRACTED
[illegible]	[illegible]		[illegible]
[illegible]	[illegible]		[illegible]
[illegible]	[illegible].4		
[illegible]	[illegible]	1[illegible]	[illegible]
[illegible]	27.4	4[illegible]	[illegible]
[illegible]	[illegible]	7[illegible]	[illegible]
[illegible] equipment operatives	[illegible]	7[illegible]	4.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.2	9[illegible]	[illegible]
[illegible]			4[illegible]

[illegible]

[illegible] mining employees.

[illegible] mine operatives n.e.c., welders.

As employees quit mining for M-X construction opportunities, the smaller mining establishments will be most vulnerable. As establishment size increases, ability to survive M-X competition for resource will also increase. The larger firms although staying in the bidding for resources, will operate at higher costs.

3.4 M-X IMPACTS TEXAS/NEW MEXICO

The DDA for Texas/New Mexico is located on the surface of the High Plains in Texas and New Mexico. There is little mining activity in the area and no significant impacts are expected. There may be some minor location conflicts with a new CO_2 gas field in Union and Harding 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.

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.

3.5 MITIGATIONS

In an effort to mitigate adverse M-X deployment impacts on the minerals industry in the Nevada-Utah area:

a. geologic survey data should be incorporated in the site selection process to avoid land withdrawals which might adversely impact the exploitation of strategic mineral deposits and lead to possible litigation.

b. M-X sites should be deployed away from promising, significant mineral deposits.

c. easier access to workable strategic minerals deposits could be provided by means of the M-X road network.

d. locally quarried nonmetallic mineral building materials should be utilized to the maximum extent; e.g., stone, sand and gravel.

e. In order to reduce the potential for M-X to effect mining claims and potentially developable mineral deposits the project would avoid mining claims as much as possible. Where geologic evidence warrants it, and the overburden is shallow enough to allow economic development, a limited drilling program could be instituted for confirmation of mineral values.

4.0 SEISMICITY

4.1 INTRODUCTION

The following discussion considers seismicity, perceived here to comprise the occurrence of either, or both, earthquakes and ground surface rupture, in terms of the following categories:

1. How the project may affect seismicity.

2. How seismicity affects the project feasibility.

3. How seismicity affects the new environment encompassing the project.

The pertinence 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" pertains to those with which there is associated a major public safety 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 vents 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 exactly 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. Withdrawal of fluid from the ground could generally decrease pore pressure and effectively increase the resistance to fault slippage. However, in both injection and withdrawal, surface deformations are possible, with an increased potential for seismic release of strain along newly-formed planes of weakness.

In terms of feasibility, seismicity generates an environmental constraint affecting the placement and design of a proposed facility. In addition to project placement facility design may involve considerations of economic 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 thsee 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, transmisison lines, bridges, and communication cables should be considered in the above context, particularly since for some, seismicity may be an influence far from the principle 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, malfunctions 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.

4.2 NEVADA/UTAH

TECTONIC SETTING (4.2.1)

Beginning in Oligocene time, the tectonic regime of the central Cordillera 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, parallel horsts and grabens bounded by normal antithetic 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 demonstrate the high level of tectonic activity: (1) high heat flow (2HFU or more); (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; and (6) extensive late Cenozoic volcanism and normal faulting (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, with a strong right-lateral component that has produced approximately 128 to 192 km of displacement across the western Great Basin (Stewart et al., 1968). It appears that both a hot spot (mantle plume) in the Yellowstone area (Smith and Sbar, 1974) and the subduction of a rift zone in late Cenzoic time have led to this system of oblique extension and uplift. The mantle plume may also be the cause of the high heat flow and thin crust (Smith, 1978).

Most of the crustal movement is concentrated in seismically active zones that bound the relatively more stable subplates. These boundary zones are the result of lateral divergence in upper mantle flow. There are four such zones surrounding the Great Basin subplate: (1) an east-west trending seismic zone in southwestern Utah forming the southern boundary; (2) the north-south-trending Nevada seismic zone 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).

SEISMIC SETTING (4.2.2)

Geographic Distribution of Seismicity. Fault studies suggest that Quaternary seismicicty in the Great Basin was sporadic and that the foci of activity shifted with time (Slemmons, 1967). Wallace (1977) indicated that, for any given period of time, faults in some ranges were repeatedly active, while faults in nearby ranges were not. Even along a given fault or complex of faults, certain segments appear to have been repeatedly active, while adjacent segments had little or no activity.

The distribution of magnitude (M) 3-5 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 (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 microearthquakes tend to cluster along recognized Tertiary and younger fault zones (Ryall, 1977; Sbar et al., 1972), many scattered microearthquake epicenters 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 low-velocity crustal layer discussed previously.

Historic Seismicity. Between 1934 and 1960, Nevada was the most seismically active area in the western conterminous United States (Slemmons, 1965; Wallace, 1977). During the period between 1952-1960, 1,173 earthquakes were felt in Nevada and 586 of those were M 4 (Slemmons, 1965). Nevada seismic activity has been concentrated in the Ventura-Winnemucca zone.

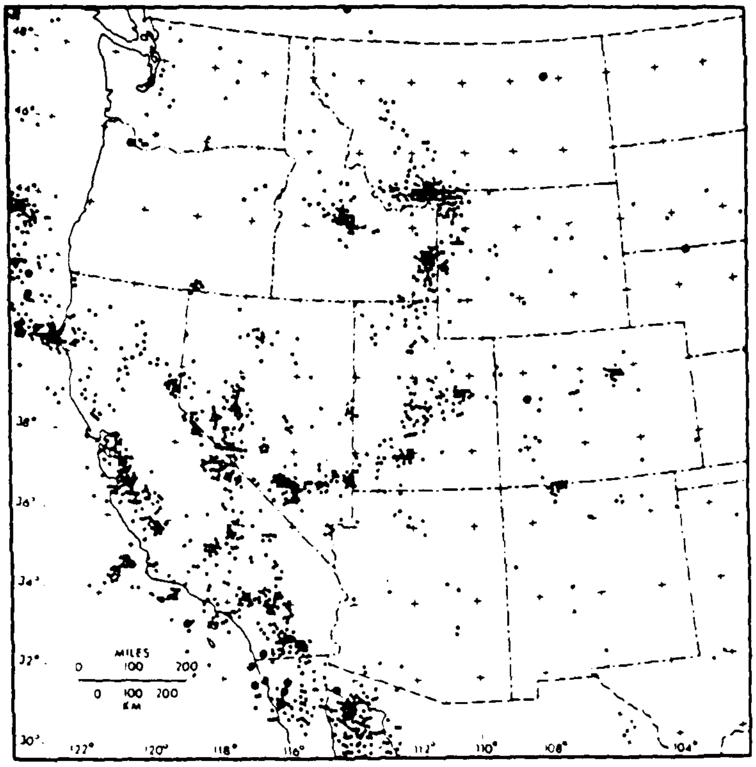
In Utah, where from 1850 to 1965 there were 609 earthquakes (38 produced damage to structures, 15 were M 6), historic seismic activity is concentrated along the ISM (Cook, 1967; Smith and Sbar, 1974). Ninety percent of the earthquakes in Utah occurred along recognized fault zones (Cook, 1972).

Ventura-Winnemucca Seismic Zone. The western boundary of the Great Basin is roughly defined by a 600-km-long seismic belt that extends from Ventura, California north-northeastward to Winnemucca, Nevada. The Ventura-Winnemucca zone is the most active seismic zone in the United States; the zone has almost twice as many M 4 earthquakes per year per 1,000 km^2 as the southern California zone (Ryall et al., 1966).

Although this zone includes a line of historic faulting, there is generally poor correlation of epicenters with known structural elements (Ryall et al., 1966). In fact, within the zone there are areas of little or no general historic seismic activity along which historic faulting has occurred. 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 Walker Lane shear zone is an active part of the Ventura-Winnemucca seismic zone (Ryall, 1966; Slemmons et al., 1979). This northwest-trending strike-slip fault zone, east of the Sierra Nevada, is near the western margin of the Basin and Range (Nielsen, 1965). Conjugate to the Walker Lane zone, the Olinghouse fault zone is a seismically active transcurrent fault in western Nevada (Sanders and Slemmons, 1979). In a general sense, the Death Valley-Furnace Creek zone, the Las Vegas shear zone, and the Genoa-Jack Valley fault zone are also within the Ventura-Winnemucca belt. An echelon right-lateral normal faulting is taking place along these active western Great Basin zones (Stewart, 1967).

The Intermountain Seismic Belt. The Intermountain Seismic Belt (ISB) is the third most active zone in the United States after the California and Nevada seismic zones (Smith and Sbar, 1974). The ISB is a 1300-km-long, 100-km-wide belt



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.

extending from Arizona northward into Montana, and it forms the transitional 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, 1972). Fault motion in the Utah segment of the ISB is 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 displacement (3.5 km; Smith and Sbar, 1974) and by the large number of earthquakes that have occurred along the zone (1,040 between 1850 and 1970 in Utah; Cook, 1972). Cook (1972) also estimated that about 20 earthquakes per year occurred along the ISB in Utah between 1950 and 1970.

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

The Wasatch Front includes an impressive 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 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 deposits and offsets on alluvial fans and morains (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 frequent 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 1847; the two most recent events of faulting occurred within the past 1,580 + 150 years (Swan et al., 1978). An average recurrence interval for the entire fault zone appears to be in the range of 50 to 400 years for moderate magnitude earthquakes (Wallace, 1980; Swan et al., 1980). For M 7.0 earthquakes, the recurrence interval exceeds 1,000 years (Smith et al., 1976).

Geographic variation characterizes the present-day seismic activity along the Wasatch Front. A zone of anomalously low seismicity is along the central Wasatch Front extending southward 75 m from Salt Lake City (Smith and Sbar, 1974; Smith et al., 1976). Scarps along this interval result from 15 m of displacement during Holocene time, but there is no record of any historic microearthquake activity in the area. The low seismicity in an area where Holocene faulting occurred may be explained either by (1) the possibility that the fault displacements were readjustments of the crust to the previous load of Lake Bonneville, (2) the buildup of strain prior to a large earthquake (Smith and Sbar, 1974), or (3) relief of built-up strain by a recent, but prehistoric large earthquake. If strain is accumulating, this area may be the site of a future large earthquake.

In contrast to the Salt Lake City area, the northern and southern parts of the Wasatch Front exhibit some seismic activity, albeit low. 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)

Faults are common geologic features in the Basin and Range Province and elsewhere in the western conterminous United States. Quaternary faults (faults that displace known or suspected geologic units of Quaternary age) are, however, generally restricted to tectonically active regions. The youthful faults reflect the tectonic stresses the region is undergoing.

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 faults identified in the study area.

Nature of Faulting. 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 subcrustal movements within the crust. (Sbar et al., 1972) indicated that composite fault plane solutions of 120 microearthquakes clustered along well-known fault zones on 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. Most 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 to 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 majority of faults are near range front bedrock-alluvium boundaries; relatively few are confined 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

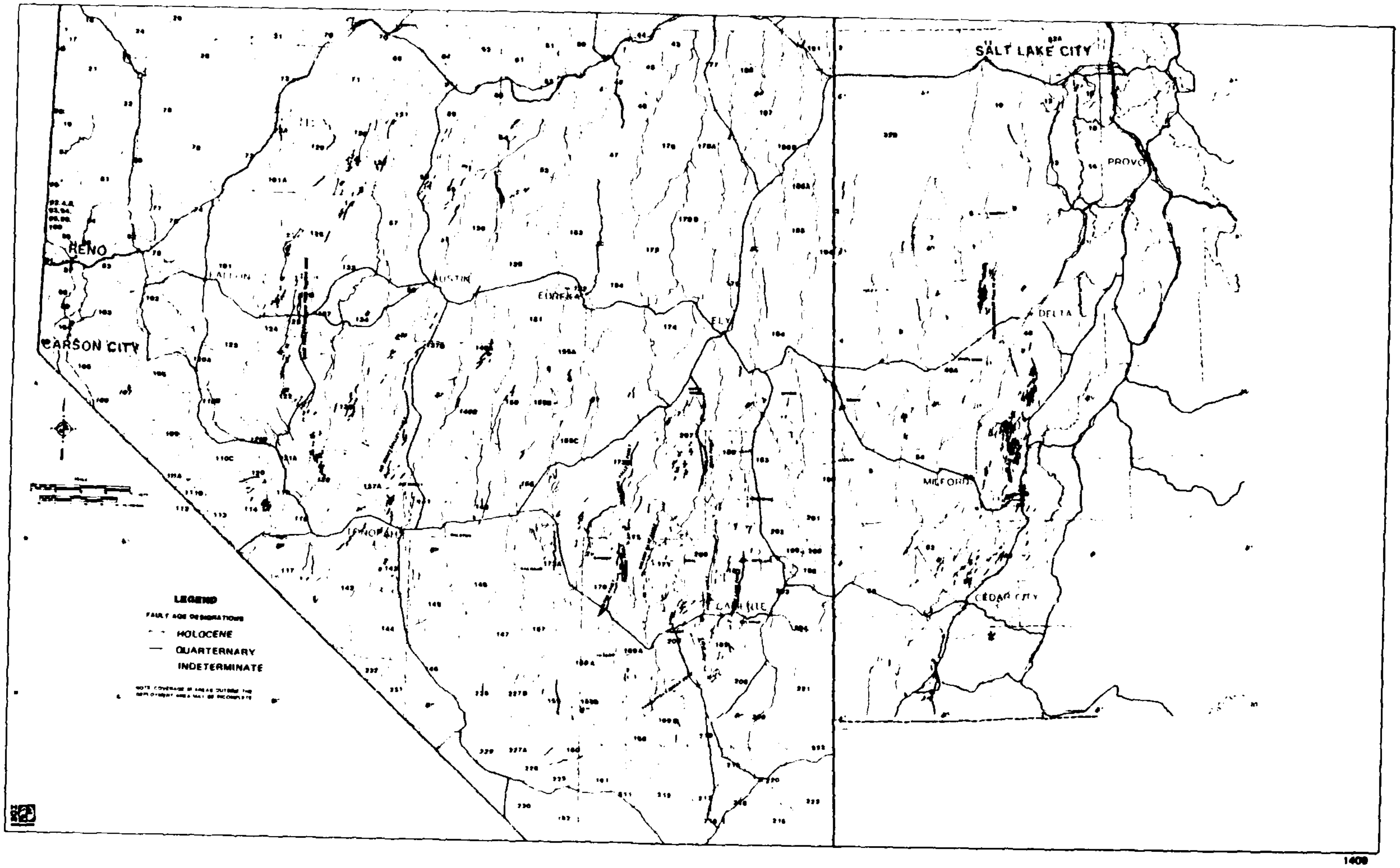


Figure 4.2.3-1. Faults in the vicinity of the Nevada/Utah study area.

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 and Anderson (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 space. 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 particularly historic movement (Ventura- Winnemucca zone), is geographically limited (Figure 4.2.3-2). However, the historic pattern of faulting is not representative of the long term. The recent clustering of faulting is 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 along the base of some ranges, but faults along adjacent ranges exhibit no activity or similar age. Even along single fault scarps, 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 faults, and southern Wasatch faults has been very limited.

Although some faults appera to have ruptured only once during the Quaternary and geologic evidence, as well as historical seismicity, document recurrent faulting along many existing fault lines. 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 are dependent upon the geographic location. 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.

HISTORIC EARTHQUAKES AND SURFACE RUPTURE (4.2.4)

The distribution of major fault zones, particularly faults suggested to be historic or Holocene, is strikingly similar to the belts of historic seismicity (Referto Figure 4.2.2-1). Although many earthquakes occur in areas that cannot be assigned to a specific known fault, many major faults, particularly along the

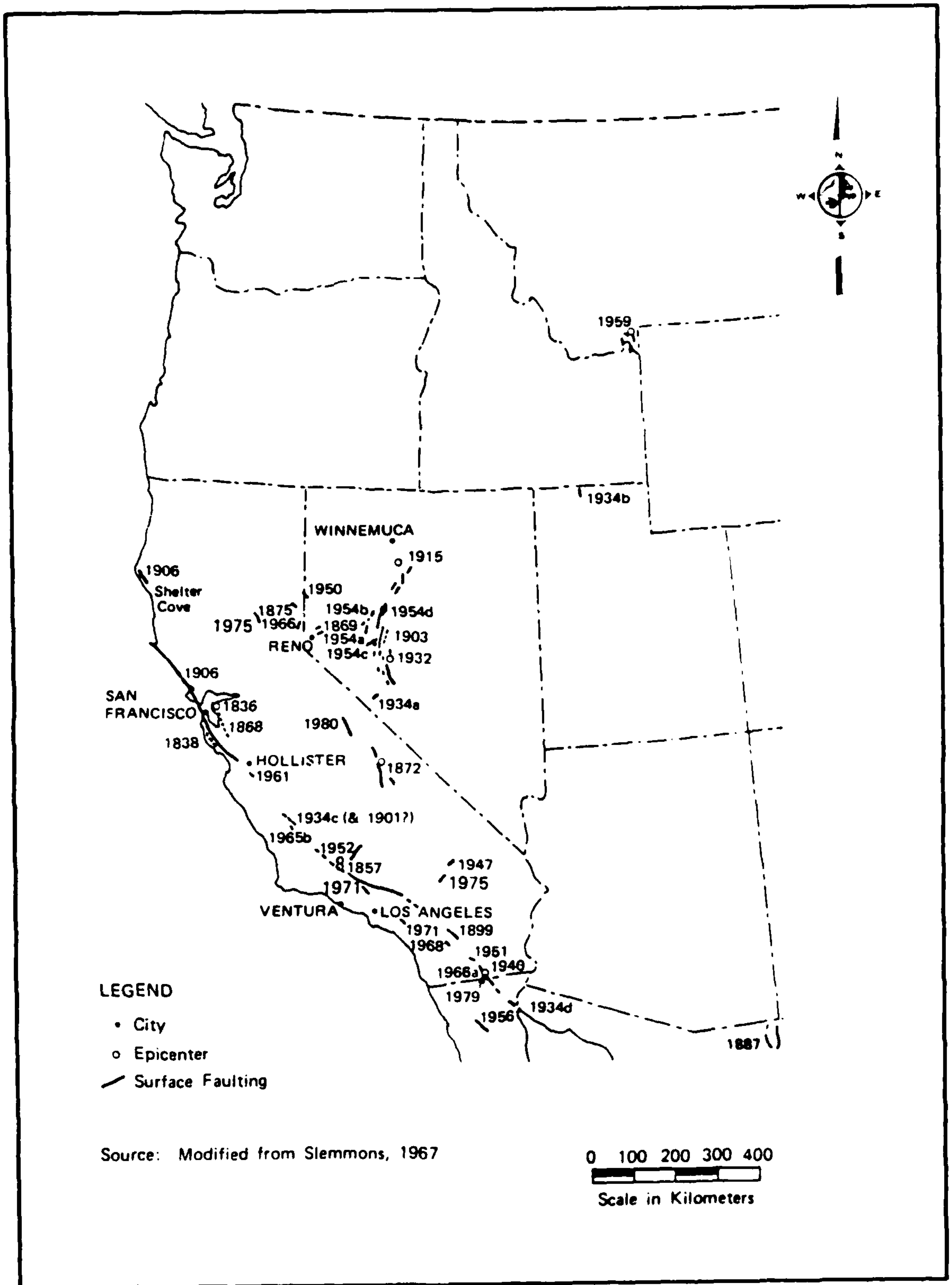


Figure 4.2.3-2. Historic surface fault ruptures.

Ventura-Winnemucca zone and the eastern Great Basin boundary, have had numerous 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 eqrthquakes 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 5-1/2 to 7-3/4.

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 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 contract. 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 showd 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/sec^2 and at 470 mi (752 km) were 2 cm/sec^2. The two events were felt over 200,000 mi^2 (512,000 km^2) 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). 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

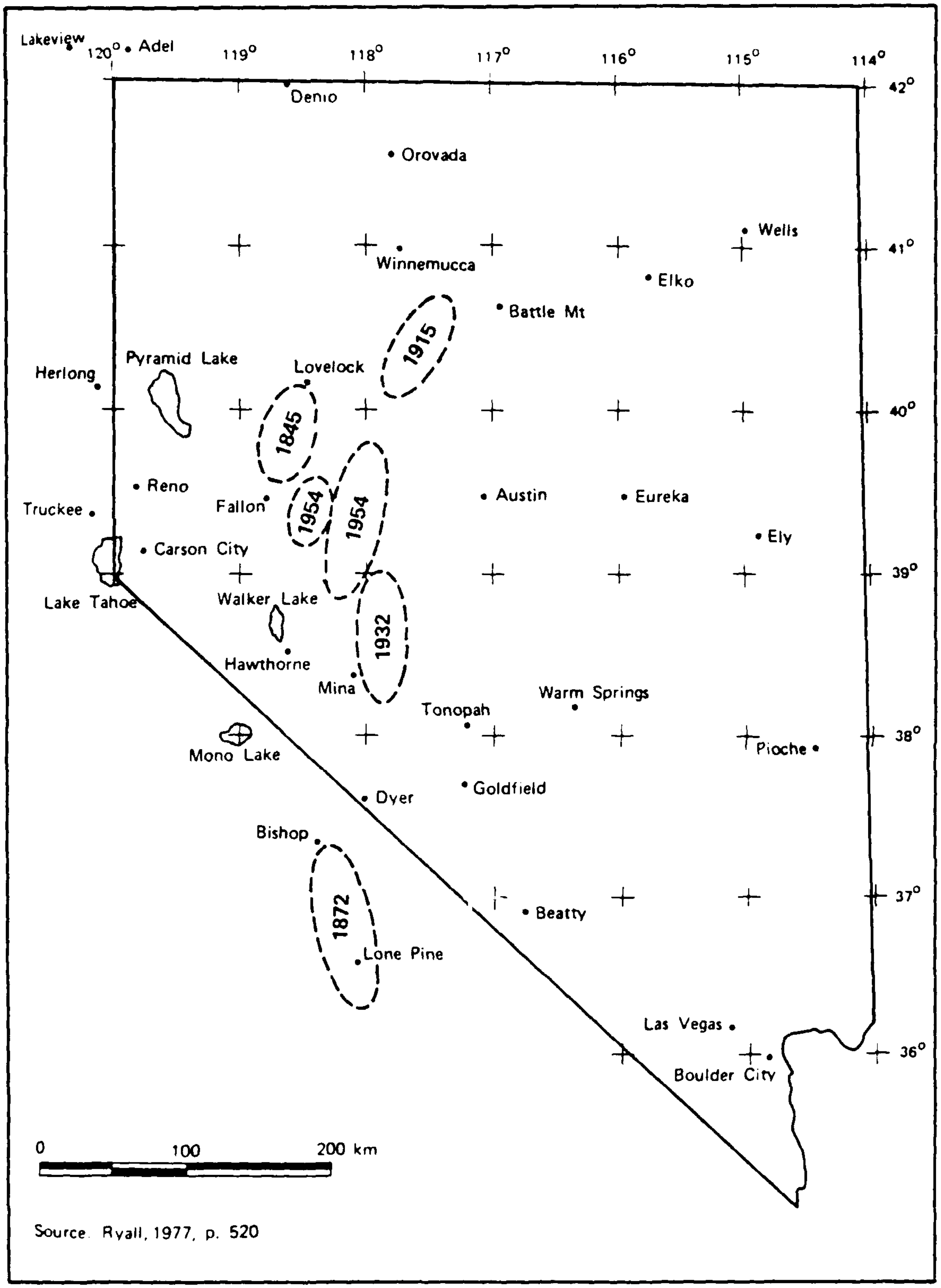


Figure 4.2.4-1. Surface rupture zones of M>7 earthquakes since 1840, western Great Basin.

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 one must identify the position and width of the rupture zones.

Damage resulting from shaking will occur to structures that are not designed and constructed to resist earthquake vibrations; the amount of damage is 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 M 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. In a worldwide study, Kelleher et al. (1973) found that seismic gaps are probable sites of future earthquakes. In fact, 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 M 7-8 earthquakes while eastern Nevada and western Utah appear to have the potential for M 6-7 earthquakes (Wallace, 1977). Lui and Fagel (1972) have a value of M 6.7 for Utah as a whole and M 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 ubiquitous 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).

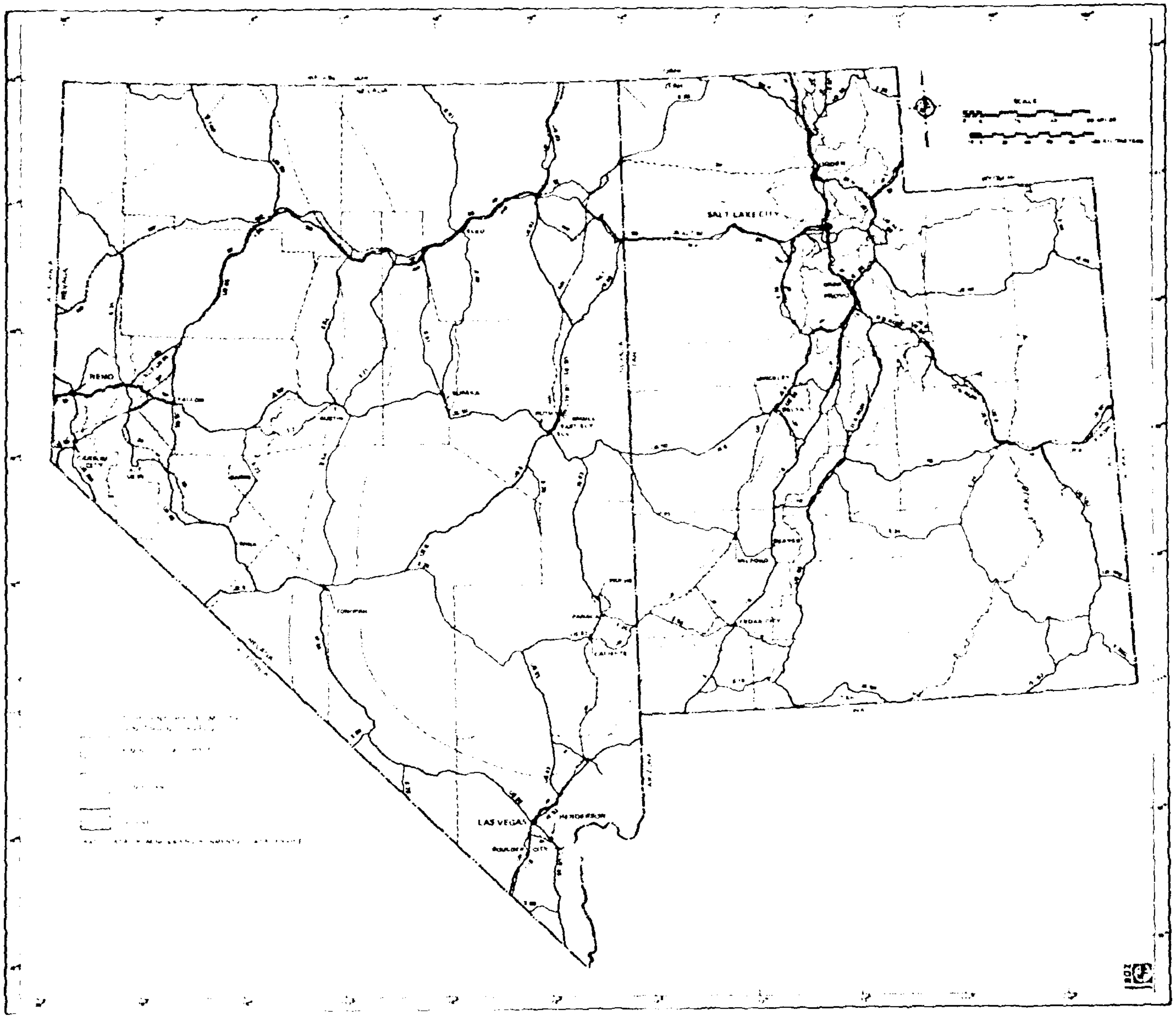


Figure 4.2.5-1. General seismic constraints in Nevada and Utah.

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 activity in the Texas/New Mexico development area stems from the Rio Grande lineament which is sufficiently removed to the west of the M-X Project so that it has little to low earthquake impact. The uniform building code places the study region in Zone 1, indicating that only minor damage can be expeted 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 Junction, Delta and Milford in Utah, Ely and Coyote Spring in Nevada, Clovis in New Mexico and Dalhart in Texas - as indices, the following discussion will localize anticipated seismic risks for each operating base.

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, however, a 0.5 g horizontal acceleration factor for structural design is recommended.

CLOVIS (4.4.2)

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 lineament. 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.

COYOTE SPRING (4.4.3)

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. A strike-slip movement characterizes this fault rather than the usual great Basin horst and graben dip-slip fault. It may or may not be indicative of ground rupture since Holocene time and it requires field corroboration along its elongated northeast-southwest trend. The Las Vegas Shear zone could conceivably transect it to the south. In the event of a moderate earthquake, ground shaking and lurching could result. The Las Vegas shear has not been historically active with any sense of strong motion, although it has reacted to nuclear blasts set off in the testing grounds to the west near Beatty, Nevada. Design of structures in the Coyote Spring OB is recommended to incorporate a horizontal acceleration factor of 0.4 g.

DALHART (4.4.4)

The Dalhart area is in a zone of low seismic risk. Siesmic hazards result only from large earthquakes on distant faults, the most likely being along the Rio Grande lineament. 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.

DELTA (4.4.5)

The Delta, Utah region is located in the seismic zone along the Wasatch Front. The physiographic and structural line of demarcation is only 20 mi east of Delta and separates the Basin and Range Province from the Colorado Plateau. Tremors here 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. The maximum credible earthquake in this particular portion of the Wasatch fault could range to a magnitude of 5.5 Richter. A design capable of withstanding 0.5 g of ground motion (horizontal acceleration) is recommended for MX OB construction.

ELY (4.4.6)

The Ely basing area is located in southern Steptoe Valley in a currently quiescent seismic area, although relatively strong earthquakes are believed to have struck in the Lehman Caves National Monument area to the east sometime during the Pleistocene. A mapped trace of a Quaternary fault on the westerly flanks of the Schell Creek Range indicates possible activity before the time of man. Historic seismic activity, however, is of low order. The area is located over 100 mi from known severe tremors of modern times. A possibility exists of recurrence of episodic re-adjustments in crustal tectonics in the area, but it is remote. For the sake of introducing a reasonable factor of safety, it is recommended that structures be designed and built to resist a maximum ground motion equivalent to 0.3 g.

MILFORD (4.4.7)

Seismicity risk in the Milford (Utah) region are moderate to moderately severe. This basing area is located within the Intermountain seismic belt associated with the Wasatch/Hurricane fault system. The belt is the locus of frequent historic small to moderate earthquakes although larger quakes are suggested from the historic 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 present in the area of the basing site. These are confirmed by a recent mapping of Quaternary faults in Utah. Earthquake engineering for building designs to withstand up to 0.59 horizontal acceleration are recommended.

4.5 MITIGATIONS

There are many faults throughout the Nevada/Utah siting area. The level of activity on most of the faults is unknown although it can be shown that many have moved during the Quarternary. It is recommended that no structures be located within 1,000 ft (300 m) of any known fault.

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 should 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 effect 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 effect 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 chemical and physical characteristics that is a 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 to a host of unacceptable 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, 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 in this report 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 inches (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 and soils in these periodically flooded areas have become sodium and/or salt effected as waters have evaporated off their surfaces.

The soils of the region formed primarily on alluvial fan outwash, old lake bed deposits and sedimentary and igneous bedrock. The topography of the region is made up of a series of valleys, consisting of the following physiographic features: (1) playas, (2) valley bottoms and flood plains, (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 free water 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 flood plains 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 inches (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 inches (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 precipitation events, however, wind erosion probably effects more land than does water erosion (U.S.D.A. 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 plasticity 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. Reformation of this protective surface may take decades.

AGRONOMIC PROPERTIES (5.2.2)

The Nevada/Utah study region is covered by soils belonging predominantly to the Aridisol 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, Soil Survey Staff, 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 Aridisol, Entisol, and Mollisol orders have been divided into suborders, great groups, subgroups, families and series, each representing more specific categorical levels of soil characteristics. The Aridisol 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 (U.S. 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 3.2.2.5-3, DEIS,

Table 5.2.2-1. Soil orders, suborders, and great groups predominating in the Nevada/Utah study region. (U.S.D.A. Soil Conservation Service, 1969 and 1975).

ORDERS	SUBORDERS	GREAT GROUPS	
Aridisols 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	Argids	Durargids:	silica cemented hardpan present within 40 in (1 m) of the surface
		Haplargids:	minimum horizon development with < 35 percent clay
		Natrargids:	subsurface horizon has over 15 percent of the cation exchange capacity (CEC) saturated with Na+
		Paleargids:	has a calcium carbonate cemented horizon or a horizon with >35 percent clay
	Orthids	Calciorthids:	has a mineral soil horizon of secondary calcium carbonate enrichment
		Camborthids:	has a mineral soil horizon that has a texture of loamy fine sand or finer, lacks cementation and induration and has little illuviation
		Durorthids:	silica cemented hardpan present within 40 in (1 m) of the surface
		Paleorthids:	has a horizon cemented with calcium carbonate within 40 in (1 m) of the surface
		Salorthids:	has a horizon of secondary soluble salt enrichment
Entisols Young soils characteristically lacking developed subsurface horizons	Orthents	Torriorthents:	loamy or clayey Entisols having a regular decrease in content of organic matter with depth
	Psamments	Torripsamments:	has textures of loamy fine sand or coarser
Mollisols Soils having dark, organic-rich (>1 percent organic matter) surfaces overlaying mineral material with a base saturation of 50 percent or more	Xerolls	Haploxerolls:	Mollisols with minimum horizon development and dry for more than 60 consecutive days

3770-1

Chapter 3 is a map showing 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 flood plains) are suitable for crops and pasture if water for irrigation becomes available (U.S.D.A. Soil Conservation Service, Preliminary Soil Survey Data, 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 potential 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, they 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 effected 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. However, the varying levels of information available for the individual sites produces a lack of consistency in the discussions.

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 (U.S.D.A. Soil Conservation Service, Sept. 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 inches (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 inches (30 to 61 cm). Below the caliche is a horizon of strongly calcareous sandy loam. Included with the Dixie-Neola association tion in the Beryl area are soils of the Zane series. The Zane soils are deep and well drained. They have a clay loam surface underlain by horizons of heavy clay loam, silt loam and fine sandy loam to depth of over 60 inches (152 cm).

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 (U.S. Dept. Int., BLM, Sept. 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 flood plains of Coyote Spring Valley 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. Playas are found throughout the area. The soils are generally deep, well-drained, strongly to very strongly saline and moderately to very strongly alkaline (U.S.D.A. Soil Conservation Service, May 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 inches (165 cm). 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 inches (150 cm). Permeability is moderately slow to the fine gravel at 18 inches (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 inches (150 cm). Permeability is moderate, runoff is slow and the erosion hazard is slight.

General engineering properties of the soils of this area include a high potential 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 (U.S.D.A. Soil Conservation Service, January 1976). A layer of soil cemented by silica and calcium carbonate, known as a duripan, may be found at about 20 inches (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 flood plains: 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 (from less than 1 percent up to 3 percent).

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 Torrifluvent-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 (from less than 1 percent to nearly 30 percent).

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 in place, on material weathered from the underlying sandstone and shale bedrock. Other soils have formed in material reworked from the eolian deposits. This includes soils formed in playa basins, valley fill 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 and 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 inches (50 to 150 cm) 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. Published U.S.D.A. soil surveys are available for most of the counties in the Texas/New Mexico study region; detailed, site specific soil information can be obtained from these (see bibliography).

Engineering properties of the soils of the Texas/New Mexico region vary widely. Permeabilities range from moderately slow (0.5 to 2.0 inches per hour) to rapid (greater than 5.0 inches per 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 U.S.D.A. soil taxonomic orders: Alfisols and Mollisols (U.S.D.A. 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 and are distributed as shown in Figure 3.3.2.5-2, DEIS, Chapter 3. 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 having 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 (soil blowing) 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 make dry-land farming difficult unless moisture conservation is practiced. Contour farming and terracing helps conserve moisture on the nearly level slopes and reduces 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 (U.S.D.A. Soil Conservation Service, September, 1958). Calcium carbonate, leached from the upper layers of these soils, has accumulated at depths of 24 to 60 inches (60 to 150 cm) 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 inches (107 to 150 cm). At depths below 60 inches (150 cm), a massive, strongly calcareous loam or sandy clav 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 inches (69 to 150 cm)).

Loamy and fine sandy loam Amarillo and Clovis soils are used primarily for dryland farming and are among the most productive soils in the country under dryland farming. 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.

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 (U.S.D.A. 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 inches (240 cm). The profile is calcareous below 35 inches (90 cm) with calcium carbonate reaching up to 30 percent between 50 to 60 inches (125 to 165 cm). 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 feet (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 inches (215 cm). Permeability is moderate as is the available water capacity. 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 M-X IMPACTS: NEVADA/UTAH

EROSION (5.4.1)

As the soil system is disturbed during clearing, leveling, earthwork and other construction activities, it becomes more susceptible to erosion. The natural vegetation cover and desert pavement, normally providing some protection against the erosive forces of wind and water, will be cleared or destroyed over large areas. Due to the slope requirements for finished roadways, considerable earthwork will be required. As a result, changes in the natural sheet drainage patterns and natural channels will encourage water erosion where it may not have occurred before. Heavy construction equipment operating on soil surfaces as well as repeated passes of smaller vehicles over soil surfaces will cause the soil to compact. The infiltration rates of compacted soils are low, resulting in increased runoff rates and water erosion. Wind erosion of the finer soil particles will result as vehicles drive across the dry soils and earthwork projects move them about.

If uncontrolled, water erosion will result in the undercutting of roads and widening and deepening of gullies. Eroding waters generally carry large amounts of fine soil particles with them, causing silting of surface waters and fields, filling of highway and irrigation ditches, plugging of culverts and other sedimentation problems. Wind erosion will result in the degradation of the ambient air quality until the soil surface is adequately reestabilized. Both types of erosion cause the more productive surface layers of soil to be removed, making revegetation and future agricultural development more difficult. Wind erosion impacts in the Nevada/Utah study region are discussed in further detail in ETR-13, (HDR Sciences, 1980).

Water Erosion. 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 hitting the surface. Rill erosion results from the scouring action of water running across the soil surface in the form of streamlets. Accelerated erosion of rills or other surface depressions tends to concentrate surface runoff, resulting in the formation of gullies or channels. The control of each of these types of erosion is necessary to protect the soil as a basic resource as well as to prevent damage to other resources by the sediments that are produced.

Although the Nevada/Utah study region is located within an arid climatic zone, water erosion has the potential for significantly impacting the environment as well as the project. Total rainfall in the region is very low, but typically that which does occur falls during high intensity storms. Rill and gully erosion are common in regions that experience such rainfall patterns. The disturbed, exposed land surfaces in combination with concentrated runoff during periods of high intensity rainfall will lead to an increase in rill and gully erosion during construction. Gully erosion, as shown in Figure 5.4.1-1, could be a significant problem after construction on the downslope side of roads as runoff is concentrated through culverts.

Quantification of Water Erosion. The best existing method for determining general 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 has been applied to construction sites and arid regions (Wischmeier and Smith, 1978). In order to assess water erosion impacts in the Nevada/Utah study region, the USLE was used to predict soil loss on a variety of representative small plots varying in soil, topography, rainfall and vegetation factors.

The equation is A = RKLSPC, where:

- A is the estimated average annual soil loss in tons per acre.
- R is the rainfall and runoff factor.
- K is the soil erodibility factor.
- LS is the topographic factor representing the length and steepness of slope.
- P is the supporting conservation treatment factor, such as terracing, strip cropping, or contouring.
- C is the cropping and management factor or native plant cover factor when the formula is used on non-cropland.

Guides for determining the values of these variables for the Nevada/Utah study region are presented in several studies; (USDA Soil Conservation Service, August 1976), (Wilson et al, March 1975) and (Clyde et al, June 1978). The rainfall factor, R in the USLE, takes into account the erosive forces of rainfall and its directly associated runoff, varying in value from less than 20 to over 500 across the United States. The factor in Nevada and Utah varies between 15 and 35; values of 20 and 30 were chosen as being representative of the study region. It is important to note that these values reflect average annual rainfall conditions and not those found during the high intensity rainfall events typical of this region. Because of this, the estimated average annual soil loss, A, that is calculated will probably be much less than if the specific intensity of individual storms were taken into account.

The soil erodibility factor, K, represents a soil's inherent susceptibility to erosion. The factor takes into account the physical characteristics of a soil,

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

including texture, structure, percent organic matter content and permeability, to obtain K values ranging from 0 to 1 (low erodibility to high erodibility). Typical K values for the soils in the study region are 0.2 (low erodibility), 0.32 (moderate erodibility) and 0.49 (high erodibility). K values for many of the soils in Nevada and Utah are not known and are subjects for future research.

Two values of the topographic factor, LS, were used to simulate proposed DTN effects. The slope was taken at 5 percent and the length was assumed to be 100 feet (the width of the right-of-way) for a road parallel to the slope and 435 feet for a road perpendicular to the slope. This does not take into account runoff being generated upslope from the disturbed area, which will certainly add to the erosion of the cleared areas. Additional, large cleared areas, such as those for protective structures, would have a longer slope length.

The value of the supporting conservation treatment factor, P, is taken to be 1 although for some construction practices the value is higher. The value of C, the native plant cover factor, is 1 for disturbed soils. For natural conditions consisting of a 50 percent canopy of brush and a 40 percent ground cover, C has a value of 0.13.

Table 5.4.1-1 presents the values determined by the USLE for the various conditions assumed. Values range from less than 1 ton per acre to more than 14 tons per acre. A soil loss of one ton per acre is the tolerable loss for Nevada as established by the Soil Conservation Service (USDA SCS, Soils Advisory #6, 1973); all disturbed conditions have values greater than one. It must also be stressed that the values of A are indicative of the average annual soil loss and do not represent losses from severe storm events. In addition, the values assume the disturbed area is at the top of the slope and do not account for runoff generated upslope. Finally, and most importantly, the values do not account for gulleying that would occur as a result of concentrated flow and culverts. Because of these factors, the values presented in Table 5.4.1-1 are much lower than those that potentially could occur. Soil erosion by water is considered a potentially significant impact in the Nevada/-Utah study region.

Valley-by-Valley Erosion Analysis. As it is not presently possible to apply the USLE over the vast Nevada/Utah project area, another more general approach was utilized to predict the relative degree of potential erosion impacts in each valley. This is a preliminary attempt to assess erosion impacts and will be modified and improved upon in the future. First, it was assumed that each valley has approximately the same rainfall patterns, general soil types, vegetation density and topographic features (slopes that are susceptible to erosion). Given this, potential erosion impacts were determined from three additional factors: 1) the number of miles of road construction planned per unit bajada and valley floor area (representing the relative degree of construction activity and soil disturbance per valley), 2) the number of roadway drainage crossings (project defined) planned per unit bajada and valley floor area (serving as an indicator of the level of disturbance to the natural drainage system) and 3) the average annual amount of surface water which flows from the mountains to the bajadas (amount of runoff).

The number of miles of road construction and the number of roadway drainage crossings per valley were defined and tabulated from the project layout (HDR Santa Barbara, Map 1843-E-A, July 1980) and are shown in Table 5.4.1-2. These figures

Table 5.4.1-1. Values of A, soil loss in tons per acre, for the Nevada/Utah study region. A = RKLSCP.

Case Number 1. 100 ft Slope at 5%, LS = 0.54

K (SOIL ERODIBILITY)

R (RAINFALL FACTOR)	0.2		0.32		0.49	
	N[1]	D[2]	N	D	N	D
20	0.28	2.16	0.45	3.47	0.69	5.29
30	0.52	3.24	0.67	5.18	1.03	7.94

[1] C = 0.13 (natural)

[2] C = 1.0 (disturbed)

Case Number 2. 435 ft Slope at 5%, LS = 1.0

K (SOIL ERODIBILITY)

R (RAINFALL FACTOR)	0.2		0.32		0.49	
	N[1]	D[2]	N	D	N	D
20	0.52	4	0.83	6.4	1.27	9.8
30	0.78	6	1.25	9.6	1.91	14.7

[1] C = 0.13 (natural)

[2] C = 1.0 (disturbed)

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Table 5.4.1-2. Natural and M-X project characteristics of the Nevada/Utah watersheds.

UNIT NO	HYDROLOGIC UNIT	BAJADA AND VALLEY BOTTOM AREA (Mi^2)	AREA ABOVE BAJADAS (Mi^2)	MILES OF CLUSTER RDS + DTN (Mi)	NO. OF DRAINAGE CROSSINGS Intermittent (Perennial)	ESTIMATED ANNUAL RUNOFF FROM MOUNTAINS 1000's of Acre-Ft
4	Snake	1296	1404	552	366(3)	51
5	Pine	479	251	220	230	No Data
6	White (Tule)	546	394	303	445	No Data
7	Fish Springs Flat	485	65	115	59	No Data
8	Dugway	341	88	110	69	No Data
9	Gov. Ck.	461		31	-	No Data
46	Sevier Desert	3642	328	467	33	No Data
46A	Sevier Lake			232	-	No Data
54	Wah Wah	367	233	293	316	7
137A	Big Smoky	855	748	182	59(6)	5
139	Kobeh	577	291	276	321	8
140	Monitor	494	544	210	33(29)	67
141	Ralston	588	329	338	54	10
142	Alkali Springs	269	44	277	-	Minor
149	Stone Cabin	519	466	244	40(12)	10
151	Antelope	274	170	225	49(27)	14
154	Newark	493	308	143	23	8
155	Little Smoky	342	816	259	36(10)	6
156	Hot Creek	481	555	264	42(8)	8
170	Penoyer (Sand Sp.)	694	6	207	28	2
171	Coal	321	139	197	28	Minor
172	Garden	326	167	184	31(14)	8
173	Railroad	1355	1397	591	83(23)	35
174	Jakes	218	204	157	9(16)	7
175	Long	318	339	133	24	4
178	Butte	446	564	185	43	12
180	Cave	207	155	103	38	10
181	Dry Lake	567	315	313	46(9(	5
182	Delamar	263	120	113	17(9)	4
183	Lake	405	172	183	21(12)	8
184	Spring	1051	610	78	6	90
196	Hamlin	316	97	225	6(21)	2
202	Patterson	327	89	31	-	3
207	White River	911	709	216	47(7)	27
208	Pahroc	379	99	35	9	1
209	Pahrangagat	372	414	45	-	1

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were normalized over the area of bajada and valley floor (total construction area) within each valley to get a density value representing the area impacted per total construction area (see Table 5.4.1-3). The average annual amount of surface water flowing from the mountains to the bajadas was obtained for the Nevada valleys from the "Water Resources and Inter-Basin Flows" map (Division of Water Resources, State of Nevada Engineers Office). The runoff values for Wah Wah Valley, Utah were obtained from a published source (Stephens, 1974); the runoff values for the other Utah valleys were not available. All runoff values were normalized over the area of the mountains from which they were flowing to the bajadas.

Relative ratings from 1 to 5 (low to high) were assigned to each of the three factors - road density, drainage crossing density, and runoff - based on the range and distribution of the individual values. The three ratings for each valley were equally weighted and averaged together to obtain an overall valley rating. This rating, tabulated in Table 5.4.1-3 and shown graphically in Figure 5.4.1-2 for each valley, represents the estimated degree of potential water erosion impacts. Of the valleys analyzed, 11 percent were predicted to have low potential erosion impacts (overall rating of 1), 60 percent were predicted to have moderate potential erosion impacts (overall ratings of 2 and 3) and 29 percent were predicted to have high potential erosion impacts (overall ratings of 4 and 5).

Loss and Degradation of Agricultural Lands (5.4.2)

Extensive grazing lands currently exist in most of the valleys of eastern Nevada and western Utah. Cropland presently 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 (HDR Sciences ETR-14) of soils will be potentially impacted. This includes soils directly covered by DTN, cluster roads and protective structures as well as soils surrounding these facilities that are disturbed through the normal course of construction activities. Soils directly covered over by roads and protective structures will be lost to all further production of range plants and potential future agricultural development.

The soils adjacent to the roads, DTN, and protective structures will be disturbed during construction and would have to be revegetated in order to control erosion and to maintain grazing land. However, construction activities may degrade these soils through several means, making revegetation more difficult to establish. For example, construction of the 4,600 protective structures in Nevada and Utah will involve excavations of up to 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 often to a shallower depth. Soil horizons below the surface often contain accumulations of 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 3.1 mmhos/cm at the surface and an electrical conductivity of 56.7 mmhos/cm at a depth of 65 in. (165 cm) (U.S.D.A. Soil Conservation Service, May, 1977). Exposing and mixing of such highly saline lower soil horizons with the surface horizon will result in the surface being reduced to a lower level of plant productivity. This will affect revegetation efforts as well as the quality of the land for future potential agricultural development. The chemistry of the underlying

Table 5.4.1-3. Valley ratings for predicting relative soil erosion impacts.

UNIT NO	HYDROLOGIC UNIT	ROAD DENSITY Mi/Sq Mi Bajada + Valley Floor	ROAD DENSITY RATING	DRAINAGE CROSSING DENSITY #/SQ Mi Bajada + Valley Floor	DRAINAGE DENSITY RATING	RUNOFF PER AREA ABOVE BAJADA Acre Ft/ Mi^2	RUNOFF RATING	OVERALL VALLEY IMPACT RATING[1]
4	Snake	0.43	3	0.28	5	36	3	4
5	Pine	0.46	4	0.48		No Data	N/A	4
6	White (Tule)	0.55	4	0.82	5	No Data	N/A	4
7	Fish Springs Flat	0.24	2	0.12	3	No Data	N/A	2
8	Dugway	0.32	3	0.20	4	No Data	N/A	3
9	Gov. Ck.	0.05	1	-		No Data	N/A	1
46	Sevier Desert	0.19	2			No Data	N/A	1
46A	Sevier Lake							
54	Wah Wah	0.80	5	0.86	5	30	2	4
137A	Big Smoky	0.21	2	0.08	2	7	1	2
139	Kobeh	0.48	4	0.56	5	27	2	4
140	Monitor	0.42	3	0.13	3	123	5	4
141	Ralston	0.57	4	0.09	2	30	2	3
142	Alkali Springs	1.03	5	-	1	Minor	1	2
149	Stone Cabin	0.47	4	0.10	2	21	2	3
151	Antelope	0.82	5	0.28	5	82	5	5
154	Newark	0.29	2	0.05	1	26	2	2
155	Little Smoky	0.76	5	0.13	3	7	1	3
156	Hot Creek	0.55	4	0.10	2	14	1	2
170	Penoyer (Sand Sp.)	0.30	2	0.04	1	333	5	3
171	Coal	0.61	5	0.09	2	Minor	1	3
172	Garden	0.56	4	0.14	3	48	4	4
173	Railroad	0.44	3	0.08	2	25	2	2
174	Jakes	0.72	5	0.11	3	34	3	4
175	Long	0.42	3	0.07	2	12	1	2
178	Butte	0.41	3	0.10	2	21	2	2
180	Cave	0.50	4	0.18	4	64	5	4
181	Dry Lake	0.55	4	0.10	2	16	2	3
182	Delamar	0.43	3	0.10	2	33	3	3
183	Lake	0.45	3	0.08	2	46	4	3
184	Spring	0.07	1	0.01	1	147	5	2
196	Hamlin	0.71	5	0.08	2	21	2	3
202	Patterson	0.09	1	-	-	34	3	2
207	White River	0.24	2	0.06	2	38	3	2
208	Pahroc	0.09	1	0.02	1	10	1	1
209	Pahranagat	0.12	1	-	-	2	1	1

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[1]Rating Scale:
1 Low
2 Mod Low
3 Moderate
4 Mod High
5 High

soil horizons of Nevada and Utah are generally not known in enough detail at the present to determine the extent of this possible impact on soil productivity.

Heavy construction equipment operating on moist soil surfaces as well as repeated passes of smaller vehicles over soil surfaces will cause the soil to compact and lose its structure. Compacted soils are very difficult to revegetate without adequate treatment. In addition, compacted soils have lower infiltration rates which leads to increased runoff rates and erosion.

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 inches (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.

5.5 M-X IMPACTS: TEXAS/NEW MEXICO

EROSION (5.5.1)

Water erosion impacts in the Texas/New Mexico study region are expected to be much less than those in the Nevada/Utah study region due primarily to the nearly level topography. As a means of comparison, representative values of soil loss in tons per acre were generated for the Texas/New Mexico study region using the Universal Soil Loss Equation described in Section 5.4.1. As shown in Table 5.5.1-1, various conditions were assumed, using a guide published by the Soil Conservation Service (U.S.D.A., July 1977) as well as the various published U.S.D.A. County Soil Surveys. The rainfall factor, R, varies between 75 and 125 in eastern New Mexico and western Texas. Typical K or soil erodibility factors for the soils in the study region are 0.2, 0.32 and 0.49. Two values of the topographic factor, LS, were used to simulate proposed DTN conditions. The slope was taken as 0.5 percent and the length was assumed to be 100 feet for a road parallel to the slope and 435 feet for a road perpendicular to the slope. The value of P, the supporting conservation treatment factor, is taken to be 1 although for some construction practices the value is higher. Finally, a natural vegetation cover of grasses is assumed for undisturbed conditions with a 75 percent canopy and a 60 percent ground cover; there the native plant factor, C, has a value of 0.032. For disturbed conditions during construction, C has a value of 1.0.

The values of soil loss, A, under the given assumed conditions are shown in Table 5.5.1-1 to vary from negligible to less than 8 tons per acre. In comparing these values with those obtained under the corresponding construction conditions in the Nevada/Utah study region, it can be seen that the Texas/New Mexico values are generally 50 percent or less.

Due to the nearly level topography, high wind velocities, and the loose consistency and dryness of many of the soils in the Texas/New Mexico study region, soil erosion by wind (soil blowing) has historically been a severe hazard for farmers in the area. As the soils are loosened and moved about during the M-X project construction, wind erosion will indeed be a problem. Wind erosion impacts are discussed in further detail in the technical report on Atmospheric Resources (HDR Sciences ETR-13, 1980).

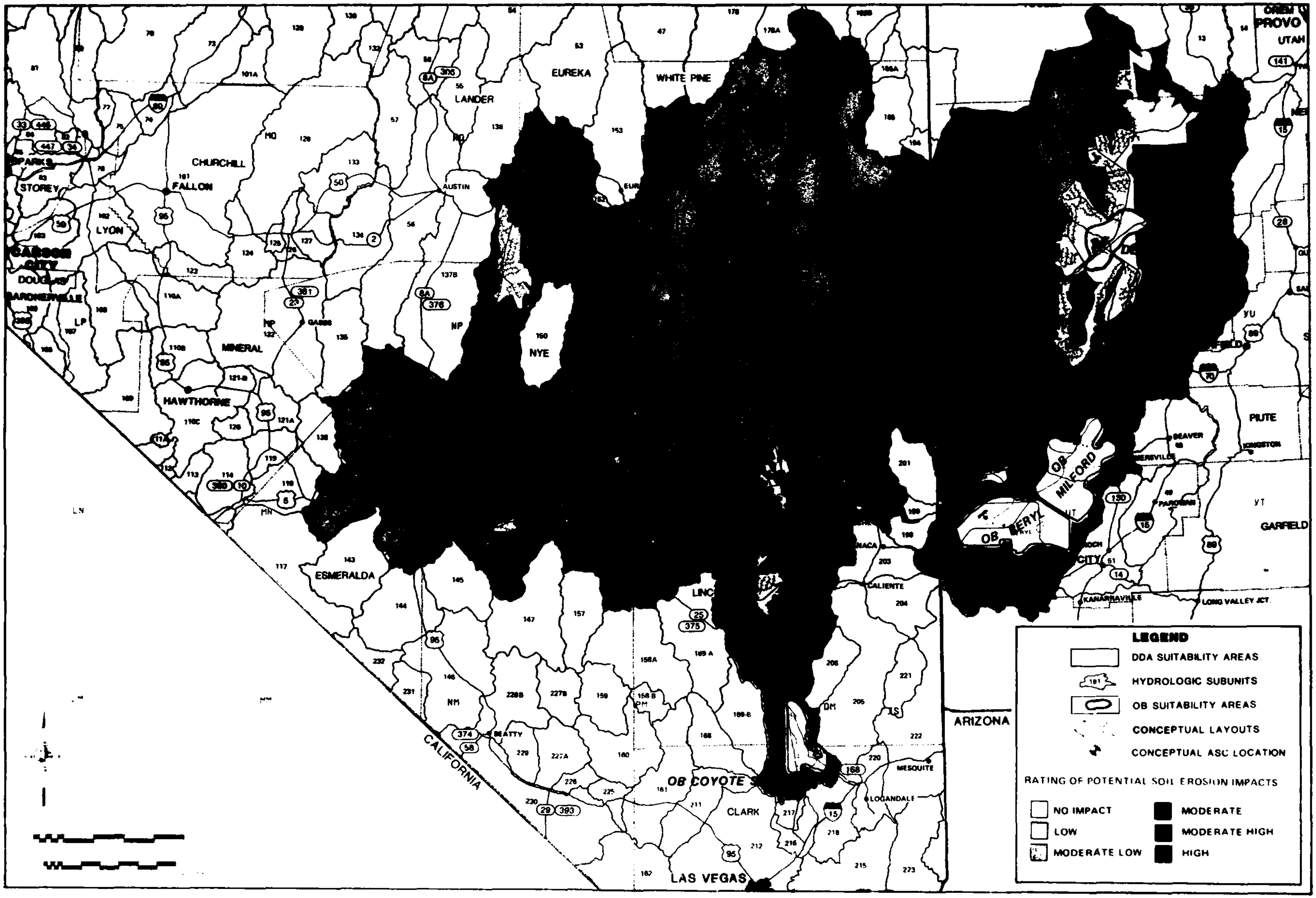

Figure 5.4.1-2. Estimated water erosion impacts for the watersheds in which M-X project elements would be deployed.

Table 5.5.1-1. Values of A, soil loss in tons per acre, for the Tecas/New Mexico study region. A = RKLSCP.

Case 1: 100 foot slope at 0.5%, LS = 0.096

K (Soil Erodibility)

R (Rainfall factor)	0.2		0.32		0.49	
	Natural C=0.032	Disturbed C = 1.0	Natural C=0.032	Disturbed C = 1.0	Natural C=0.032	Disturbed C = 1.0
75	0.05	1.4	0.07	2.3	0.11	3.5
125	0.08	2.4	0.12	3.8	0.19	5.9

Case 2: 435 foot slope at 0.5%, LS = 0.126

K (Soil Erodibility)

R (Rainfall factor)	0.2		0.32		0.49	
	Natural C=0.032	Disturbed C = 1.0	Natural C=0.032	Disturbed C = 1.0	Natural C=0.032	Disturbed C = 1.0
75	0.06	1.9	0.10	3.0	0.15	4.6
125	0.10	3.6	0.16	5.0	0.25	7.7

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LOSS AND DEGRADATION OF AGRICULTURAL LANDS (5.5.2)

Soils of the Texas/New Mexico study region will be directly impacted when they are covered by DTN, cluster roads and protective structures. Soils surrounding DTN, cluster roads and protective structures will be disturbed through the normal course of construction activities. Soils directly covered over by roads and protective structures will be lost to all further production of range plants and crops. Adjacent soils disturbed during construction may become less productive as their characteristics are changed or degraded. These impacts are significant in that the soils of Texas and New Mexico are for the most part fertile and support dryland farming, irrigated crops and range, in addition to the natural vegetation. Furthermore, their quality must be maintained at a certain level to support the revegetation efforts necessary to control erosion of the disturbed soils.

The soils of Texas and New Mexico will be impacted and degraded in several ways as a result of general construction activities. When the vegetation cover is removed and the soil is disturbed during construction, erosion will increase, as discussed in the preceding section. Soil erosion causes the finest and most valuable parts of the soil - silts, clays and organic matter - to be moved to great distances, leaving the surface more coarsely textured and less fertile. Soils of the Amarillo, Clovis, Dallam, and Sunray series are among those soils in this region that have severe wind 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 often to a shallower depth. Different soil horizons below the surface often contain accumulations of certain minerals (calcium carbonate, gypsum, etc.) in concentrations that would restrict normal plant growth. Mixing of these deeper soils with the productive upper layers will result in the surface being reduced to a lower level of plant productivity. 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 inches (41 cm) contains 0 percent calcium carbonate. However, horizons at 42 to 84 inches (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.

Heavy construction equipment operating on wet soil surfaces as well as repeated passes of smaller vehicles over soil surfaces will cause the soil to compact and lose its structure. Compacted soils are very difficult to revegetate without adequate treatment. In addition, compacted soils have lower infiltration rates which result in increased runoff rates and accelerated erosion.

5.6 MITIGATIONS

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

Wind Erosion. Several measures can be taken to help control wind erosion. Off-road travel should be restricted to reduce the disturbance of soil surfaces and natural vegetation. Potential fugutive dust areas should be wet down by water or covered by surface film binding agents or natural aggregates. The surface roughness of disturbed areas could be increased with graded ridges to reduce surface wind velocity. At the end of the construction period, the disturbed areas should be revegetated with the natural vegetation or erosion-preventing vegetation.

Water Erosion/Sedimentation. Several means are available to mitigate water erosion and sedimentation impacts. During construction, disturbance of the natural vegetation cover should be minimized. After construction, all disturbed areas should be revegetated with the natural vegetation or erosion-preventing vegetation.

During the rough grading process, provision must be made for transport of sheet drainage, intercepted by the roadway, to natural drainage channels. This is accomplished by graded ditches paralleling the roadway. Provision also must be made for erosion control in the roadside ditches when slopes exceed certain values, depending on soil characteristics and the quantity of water to be transported.

Natural drainage channels must be provided with roadway undercrossing, generally pipe or cast-in-place concrete box culverts. In some instances, rerouting of the natural drainage channels will be required. Drop structures and various erosion control measures will be required to protect the roadways and the culverts from damage due to erosion and undermining. Where natural drainage channels are rerouted and disturbed, erosion control structures are often required to stabilize and prevent eroding of the channel bed.

Roadway undercrossings are generally designed to handle the maximum runoff generated by "design" storms. Alternatives may be available for handling maximum runoffs. Where terrain permits, temporary ponding of peak flow may be possible, either integral with the roadway embankment and culvert or a control structure upstream of the undercrossing. Riprap may be required on some portions of the channel embankments for protection during high runoff. Another option which might be permitted where terrain is suitable, and sufficient bank protection can be provided, would be infrequent overtopping of the roadway by high storm flows.

Provisions must be made for maintaining surface water runoff during the road construction activities. This is generally accomplished by installation of drainage structures immediately prior to commencing the rough-grading phase. Temporary and minor relocation of the natural drainage channel may sometimes be desirable where the drainage structure is to be located in the natural channel. However, due to the arid climate and intermittent nature of the natural drainage ways, this requirement may be minimized.

The quantity and rate of runoff from the impervious surfaces will be greater than the relatively pervious soils existing prior to construction. This increased runoff will tend to increase erosion. If, due to topography, soil conditions, drainage channel instability or other problems, the increased runoff would create adverse effects that are not permissible, control measures can be implemented. An effective means of reducing the runoff rate from developed areas is to provide retention ponds with controlled release of the runoff. Other measures might include channel improvements and bank protection.

Soil Mixing. In some areas, higher quality surface soils are underlain by subsoils of poorer quality containing potentially toxic concentrations of salts, alkali and other deleterious substances. These areas should be determined through analysis and mapped so revegetation strategies can be properly assessed. Mixing of such soils during excavation should be minimized in order to maintain the more desirable qualities of the surface horizons. To avoid mixing, surface soils determined to be a distinctly higher quality than the underlying horizons should be selectively stockpiled during excavation and later replaced. Whenever possible, the extent of earthwork in such areas should be minimized. 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. Soil compaction is best minimized by restricting off-road vehicle travel, especially on wet soils. In areas where compaction is inevitable, thereby making revegetation more difficult and increasing water erosion problems, tillage practices can be employed after construction. Tillage loosens the compacted surface while preparing a suitable seed bed for revegetation. In addition, tillage, along with contour terracing, contour furrowing, contour trenching, mulching, deep chiseling and other activities, facilitates runoff intake and retention to achieve moisture conservation for revegetation and to help control runoff and erosion.

6.0 PALEONTOLOGY

Paleontologic fossil resources are of scientific value throughout both siting regions. Fossils are protected by state law in Utah and afforded some consideration under the National Antiquities Act (1906). The combination of the National Environmental Policy Act (1969) xxxxx, as amended the Federal Land Policy and Management Act of (1976), and BLM Washington office instruction memorandum 79-111 (1973) require a paleontologic survey as part of the environmental report on M-X.

Fossils exhibit a variety of uses that render them valuable to the scientific community. They are used to age date geologic formations, and correlate formations in different areas, or to determine the environment at the time of deposition and possibly the climate. Fossils are also used to study phylogen and evolution and 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 types of value the paleontologic resources possess, it is important that any fossil remains encountered during M-X construction be preserved for future study.

6.1 NEVADA/UTAH

Paleontology in Nevada/Utah region is 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 the valleys and along the mountain fronts).

PALEOZOIC (6.1.1)

The Paleozoic rocks have been well studied and many fossil localities are known. The level of detail of studies in some areas is quite high because of the presence of deposits of economic minerals. In other areas the 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 occurence of zone fossils an important tool for deciphering the geologic history both within and between mountain ranges. The 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. The shales and limestones most commonly contain fossils.

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 to type sections), and areas with unique asssemblages (bioherms, reefs, or an association of numerous species). Paleozoic fossils occur in most of the mountain ranges in Nevada and western Utah except those made up of Cenozoic volcanic rocks and 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 that are made up of the tertiary volcanic sequence. The volcanic rocks associated with secondary mineralization of economic importance are the most studied, but these rocks don't 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 that contain fossils include aqueous tuffs, lake bed deposits and conglomerates.

Cenozoic fossil occurrences are scatttered throughout the study area. Figure 3.2.3.10-2, DEIS, Chapter 3 shows some of the known localities and the areas as of Pleistocene lake beds. For the most part, Cenozoic fossils are 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 fossil locations, especially in the valleys, is the lack of exposure of the fossil bearing strata.

In reviewing the fossil occurrences throughout the Great Basin area, depositional environments associated with fossil locations are much more widespread than the known fossil localities. It can be projected that future discoveries of fossils will be made in the study area. Prime potential localities include late Pleistocene lake shorelines and lake and stream bed depositis. These types of deposits are found throughout the deployment area. There are two paleontologically significant areas in Nevada, both of which are west of the M-X deployment area. The areas are Ichythyosaur 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. Ichythyosaur State Park contains fossils of sea-going reptiles in Triassic age rocks. The proposed ACEC contains fossil insect fauna in a tuff of 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 roded through the Ogallala to the underlying Paleozoic or Traissic rocks.

In the New Mexico area, vertebrate remains are scarce, and the most common fosils are molluscs, gastropods, and seeds. Seeds are the most widespread fossils in the Ogallala in New Mexico and even those are uncommon. (Leonard and Frye, 1970). The only areas of paleontologic 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 Pliocene and early Pleistocene age. The presence of these localities should not constrain the placement of the operating bases.

6.3 M-X IMPACTS NEVADA/UTAH

DIRECT IMPACTS (6.3.1)

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

With the exact locations of the M-X facilities yet to be determined, impacts can only be discussed in general terms. Areas that are most likely to contain Cenozoic fossils include Pleistocene shore line deposits and lake bed deposits. The Pleistocene shore line deposits are located along the the circumference of those valleys that were topographically closed during the Pleistccene wet periods. Closed basins were of two types; those completely closed, and 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 excavation for the shelters.

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

INDIRECT IMPACTS (6.3.2)

Indirect impacts to fossil resources would accrue from the casual collection of fossils induced by the large number of people brought to the region by the project. Indirect impacts would affect Paleozoic fossil localities in the mountain ranges through the collection of unique fossils such as coilded ammonites or well preserved trilobites. Casual collection of important faunal constituents could destroy the scientific value of a deposit. Paleozoic fossils would only be affected indirectly by the potential increase in casual collection brought about by the increased population in the area. Almost every mountain range with Paleozoic outcrops could be effected. The most deleterious effects would be to areas with unique fossils that are easily collected, such as trilobites and coiled ammonites, or areas of scientific value, such as type sections or zone fossil localities

SIGNIFANCE ANALYSIS (6.3.3)

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

All potential fossil localities 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. (Madson, 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 paleontologic resources. The M-X program will also increase the population of the area and improve access which will lead to 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. Paleontologic resources are non -renewable and once destroyed or removed from context without cataloging, their value is destroyed.

Paleontologic resources are protected by state law in Utah and afforded some protection by the Federal Antiquities Act. Destruction of the resources is therefore against the law although the fossils do not have to be preserved in place; i.e., avoided. Salvaging the fossils encountered for future study is a viable alternative. Funding will have to be provided for monitoring the construction activity and salvaging and preserving any fossils encountered.

Coyote Spring OB

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

Milford OB

The Milford 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 to determine the possible presence of fossil material.

Beryl OB

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

The Delta OB

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

Ely OB

Along the edge of Steptoe Valley between Ely and the proposed operating base are outcrops of the 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.

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 couldbe encountered anywhere. The issues related to to paleontologic resources are the same as those discussed under the proposed action.

Clovis OB

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

Dalhart OB

The operating base at Dalhart is located 80 mi. (130 kilometers) west of the important vertebrate fauna localities 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 could also contain fossils.

By reducing to one half the size of the M-X project in each of the alternative areas, a decrease in the impacts to the paleontologic resources would be expected in each area. These would be accomplished not only by the reduction in the number of facilities but also by the increaed ease of avoidance siting. Some paleontologic sites could still be expected to be discovered but the ability to preserve the fossil material should be enhanced by the separation of the project into two areas. A decrease in the intensity of indirect impacts to the Paleozoic fossils in Nevada and Utah could be expected because of the decrease in imported poplation.

Impacts at the Coyote Spring Valley and Clovis OB sites have been discussed previously and do not change for this alternative.

6.4 M-X IMPACTS TEXAS/NEW MEXICO

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

6.5 MITIGATIONS

The ideal mitigation for impacts on paleontological resources is that of avoidance. No structure, roadway, or aggregate source area would be placed in an area of known or suspected fossil occurrence. Unformtunately, because of the widespread occurrence of potential fossil bearing sediments, and the desirability of some of the material for use as aggregate, complete avoidance is probably not feasible. partial avoidance, avoidance of the most important fossil localities, coupled with an extrapolation of the MX facilities most likely to encounter fossils, would allow for the operation of a program for monitoring and recovery of fossil material.

If the construction sites most likely to encounter fossil remains are identified before construction begins, a system for monitoring for fossil occurrences can be developed. This would be accomplished by periodic inspections of the construction sites by one or more qualified paleontologists, depending on the number of sites needing monitoring. If 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. A slight delay in construction may result but construction personnel could be diverted to nearby sites.

Vertebrate fossils would be the most important for preservation and as much vertebrate material as possible should be recovered. For invertebrate material such as an association of fresh water mollusks, a carefully collected and catalogued bulk sample could suffice.

Operational impacts on paleontology are limited to indirect effects of fossil collection by the increased population of the area. Mitigation of these effects would be very difficult. Areas of prime importance could be protected by designation as an Area of Critical Environmental Concern (ACEC). However, an ACEC requires development of a program for administration of the resource for which funds are not readily available. An attempt at education of the value of preserving the fossil resource in place can be made through the schools and organized rockhound clubs.

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/gas resources in both the Nevada and Utah Great Basin area, can be quickly drawn because of the paucity of known sites. The sole commercially producing area of oil and gas in Nevada thus far is 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 Trapp Springs near the town of Currant, share a total of some 18 producing wells. The low-gravity, high-sulphur 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 known shallow Nevada oil.

Excluding Great Salt Lake, where large quantities of tarry oil have been discovered, there is no oil/gas production in western Utah. However, good 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 liberally sprinkled 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.

Potentially, M-X siting may possibly restrict future oil/gas exploration and production. Presently, a deep, exploratory well is being completed by Mobil Oil on Morman Mesa in the Virgin River area of Clark County, Nevada. The indications are that significant quantities of 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 in 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. The relatively narrow strip of the Overthrust zone extends from Milford and Delta in Utah to Ely and Caliente in Nevada, then into northwest Arizona. Because of access and transportation requirements and the large blocks of "protection" land necessary to make a wildcat well project economically feasible, it

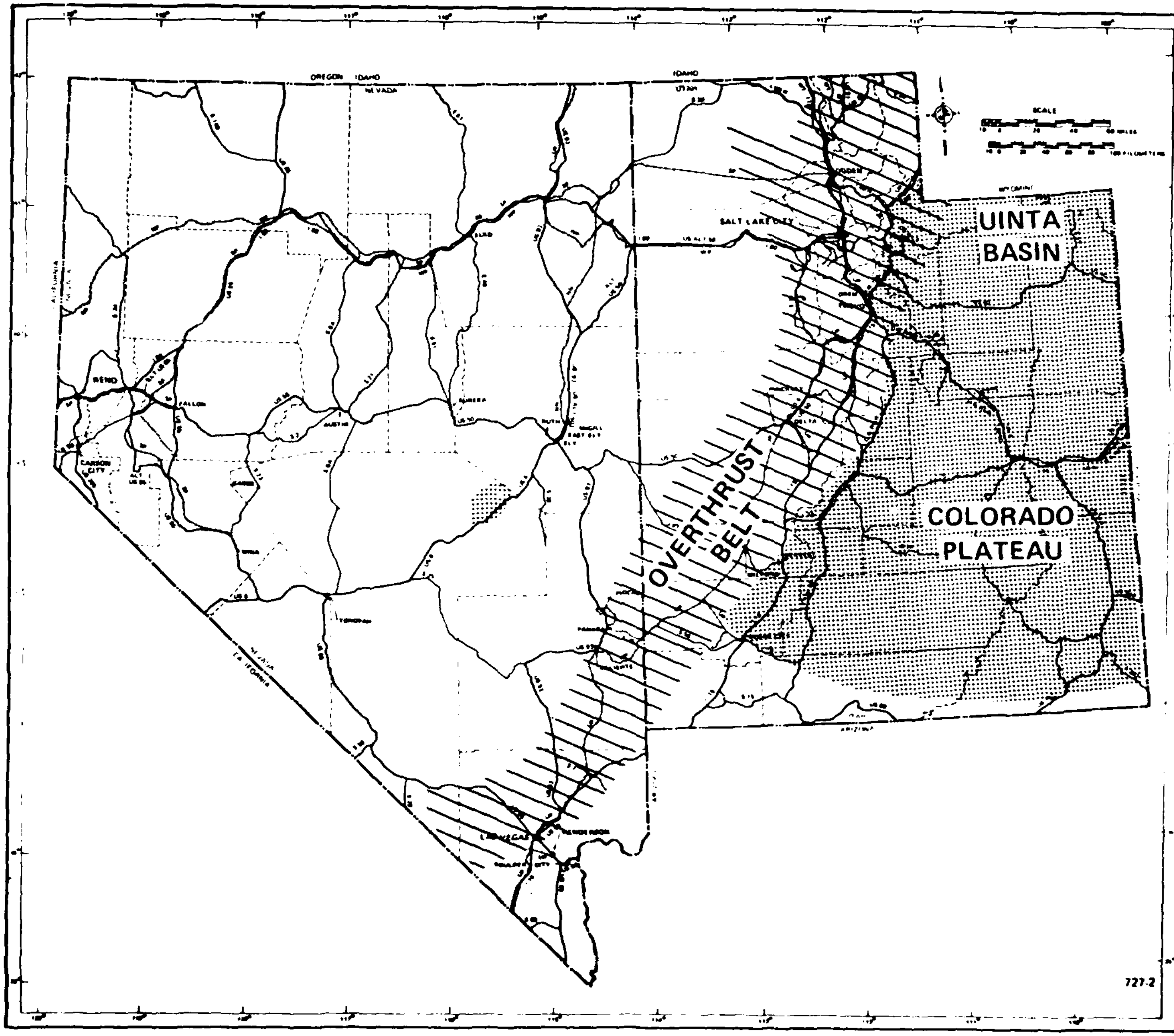

Figure 7.1-1. Energy resources in the vicinity of the Nevada/Utah study area.

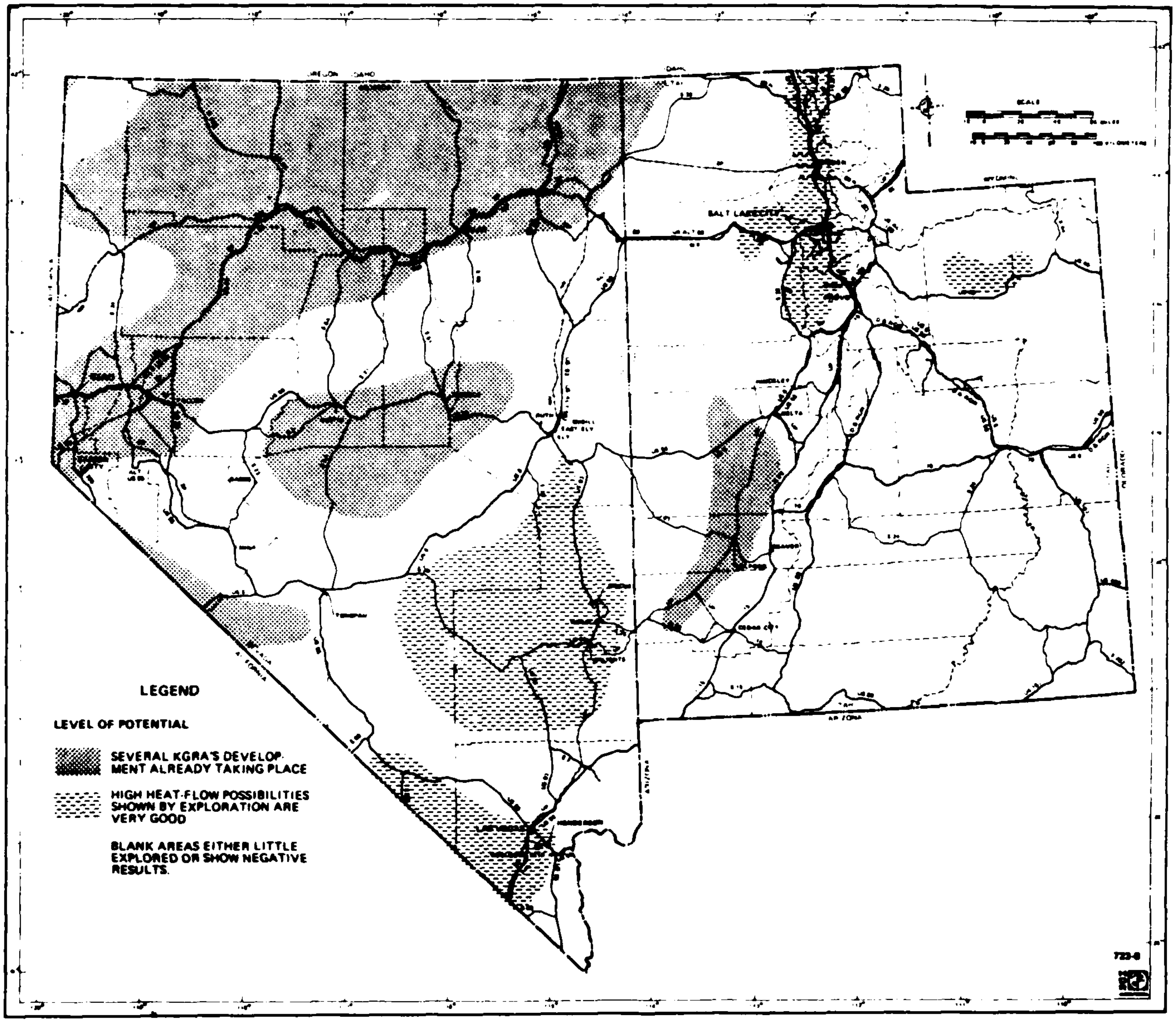

Figure 7.1-2. Geothermal resources in the vicinity of the Nevada/Utah study area.

can be appreciated that land withdrawal for M-X will interact directly with expanded energy development.

Oil and gas leasing cover approximately 3.9 million acres (1.6×10^6 ha) of the deployment area. Of the total 2.4 million acres (9.7×10^6 ha) are in Nevada, and 1.5 million acres (6.1×10^6 ha) are in Utah.

A possible 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 ($3.2 \times 10^6 m^3$) of oil. At $25 per bbl the fields will have yielded an income of $500 million.

GEOTHERMAL (7.1.2)

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

There are 13 to 225 acres (5.2 to 91 ha) of federal geothermal leases in the proposed M-X deployment area. It is forecast that 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.

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 Railroad Valley, Nye County. The Trap Springs Field in Railroad Valley is not yet fully developed. There is production within the vicinity of the deployment area and it could easily expand into the area. The Currant Fielc discovery well is a few miles north of the present production site. These resource areas are listed in Appendix I-A. Several firms have begun exploration activities in eastern Nevada, and nearly all public land in that part of the state 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, utilization of geothermal heat has not been intensive.

The potential for geothermal energy development in Nevada is great because of the widespread occurrence of geothermal resources. Known geothermal esource 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 areas of the west with 1978 production of coal, natural gas, and crude oil valued at more than $630 million -- up over

Table 7.1.3-1. Known geothermal resource areas in Nevada.

NAME	ACREAGE	NAME	ACREAGE
1. Baltazor	5,537.25	16. Moana Springs	5,210
2. Beowawe	12,712	17. Monte Neva	10,302
3. Brady-Hazen	98,446	18. Pinto Hot Springs	8,065
4. Colado	640	19. Ruby Valley Hot Spring	5,743
5. Darrough Hot Springs	8,398	20. Rye Patch	801
6. Dixie Valley	38,989	21. Salt Water Basin	19,232
7. Double Hot Springs	29,326.16	22. San Emidio Desert	7,678
8. Elko Hot Springs	8,960	23. Silver Peak	5,117
9. Fly Ranch	20,599.38	24. Soldier Meadow	5,966
10. Fly Ranch Northeast	7,680	25. Steamboat Springs	8,914
11. Gerlach	26,326	26. Stillwater-Soda Lake	225,211
12. Gerlach Northeast	7,971	27. Trego	7,013
13. Hot Spring Point	8,549	28. Wabuska	11,520
14. Kyle Hot Spring	2,561	29. Warm Springs	3,812
15. Leach Hot Springs	8,957	30. Wilson Hot Springs	1,294
			611,529.62

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

087-1

400 percent from the 1970 output. Ambitious projects are now underway and others are being planned for the further development of these 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 today 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.

In 1978, 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 ft^3. However, much of the potentially petroliferous area of Utah is still untested by drilling, and undiscovered oil and 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.

About 3,000 mi^2 (7,800 km^2) 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 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 of the 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.

Table 7.1.3-2. Identified remaining recoverable road reserves 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

092

[1]Includes measured, indicated, and inferred reserves.

Source: Utah Geological and Mineral Survey (1978).

Important, but largely undeveloped geothermal energy resources also exist throughout Utah (Table 7.1.3-3). The most significant thus far 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, and heat from the steam condensate can be used for lower temperature applications such as space heating, extending the plant growing season, pasteurizing milk, and many other uses. Unexplored 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 in Sevier County.

7.2 TEXAS/NEW MEXICO

The M-X candidate siting areas in New Mexico/Texas are unlike those in Nevada/Utah with regard to energy resources. Accounting for this in major part is their dissimilarity in terms of physiographic provinces, geologic structures and stratigraphy, and the general topographic changes form Basin and Range to the Great Plains. Figure 7.2-1 shows energy resources is 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 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 the foregoing bi-state county distribution within and about the environs of the M-X study area are crisscrossed with pipelines of varying diameters serving both oil and gas and refined petroleum products transmission.

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

4169

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

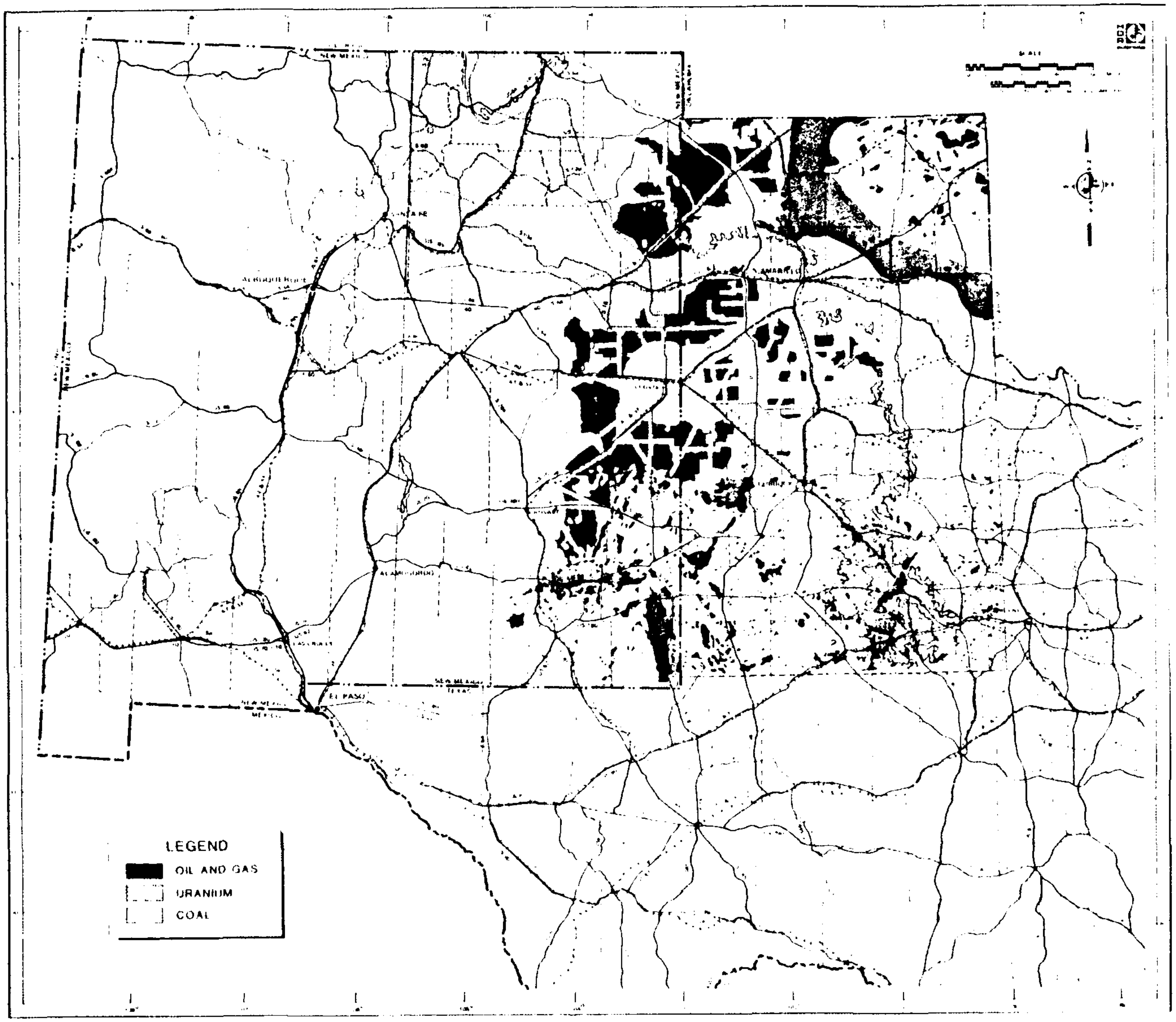

Figure 7.2-1. Energy resources in the Texas/New Mexico study area.

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

2200

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 and drilling and production technology. Secondary recovery techniques, water-drive, functionation, and acid wash, applied to oil fields are being supplemented by "Tertiary" recovery using thermal methods. 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. Oil and gas occur in the four-corners area (New Mexico, Colorado, Utah, and Arizona) and the Colorado Plateau. 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). Pipelines from the San Juan Basin exist for transmission of oil and gas.

URANIUM (7.2.3)

Uranium resources and some actual production are reported in San Miguel, Mora, Colfax, Harding, and Quay counties in northeastern New Mexico and in the Texas High Plains in Oldham, Potter, Randall, and Armstrong counties.

GEOTHERMAL (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. 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.

7.3 IMPACTS, NEVADA/UTAH

Oil and gas leasing is extensive throughout the M-X deployment area. Most of the leasing is 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 Morman Mesa discovered some shows. For the most part, the M-X project could be compatible with a producing oil field as 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. There is also new interest being generated by Mobil Oil's deep test well into the overthrust belt on Morman Mesa. It should be possible for the M-X system to coexist with active oil fields but some access problems may result. There could be indirect impacts resulting from competition for labor and materials if development of yet-to-be-discovered oil fields were 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 of the uranium deposits are sedimentary deposits occurring on the valley floors. 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.

Besides oil and gas, other energy resources include uranium in eastern New Mexico and the Texas High Plains. There are no known geothermal energy resources or areas of high heat flow within the M-X deployment area.

Uranium in New Mexico is widely found, particularly in the Grants area of the western-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

Were M-X deployment to be revised in the Great Basin, 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 Overthrust Belt.

8.0 GEOLOGIC FEATURES

Surficial geologic features of interest occur throughout the M-X deployment areas. Although the study of these features provides information for the analysis of recent geoogic history, many have been little studied to date and are not well understood. Siting M-X has the potential for disturbing the surficial features and complicates future analysis.

Because of the site specific nature of those geologic features no attempt has been made to locate and catalog them exactly. During the tier two analysis of the siting locations the kind of surface geologic features that will be taken into account include lake beds and shorelines, pluvial rivers, alluvial fans with unique characteristics, and desert pavement. In Texas/New Mexico the geologic features include the Ogallolu escarpment, Pleistocene lakebeds, and stream terraces.

9.0 ZEOLITES

9.1 INTRODUCTION

An association between the fibrous zeolites and various forms of lung disease is suspected on the basis of epidemiological studies in Turkey and because of the physical similarity between these zeolite species and asbestos. Attention has recently been drawn to the occurrence of zeolites in the Great Basin in the context of M-X deployment. The question of disease risk by construction workers and their families, Air Force personnel, and the indigenous population has manifested. This report defines the potential scope of this issue from geologic and air quality perspectives.

Although definition is an essential first step, it will ultimately be necessary to assess health risk in specific terms. Such assessment requires quantification of various geologic and medical factors that have yet to be accomplished judging from the published sources from which this report derives. Foremost among those factors obstructing the formulation of health risk conclusions relative to M-X deployment is the lack of knowledge pertaining to the specific distribution of zeolites in the Great Basin, and an equally serious absence of appropriate epidemiological studies in the United States. In the context of the latter, it is clear that the critical parameters relating ill health to biologic mechanisms and levels of zeolite exposure have not been determined. Professional conservatism dictates that intuitive assumptions to the effect that high level, long-term exposures are the only requisite conditions for the manifestation of disease be made. The contention that health risks from zeolites are eminent in the deployment of the M-X system is not justified either.

Zeolites are elsewhere considered under the category of mineral resources. Potentially these minerals are of great societal value stemming from 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 system as presently planned 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 treating worker and public exposure to zeolites. A sound public policy, governing encounters with zeolites might well anticipate and ameliorate most issues of concern.

9.2 GEOLOGIC OCCURRENCE AND NATURAL SYNTHESIS

Zeolites occur in a wide variety of geologic environments within metamorphic, sedimentary and volcanic rocks. They are formed from pre-existing minerals or mineraloids under conditions of geologically low pressure and low temperature in the presence of H_2O liquid or vapor. Zeolites find wide distribution in volcanic terrains, characterized by abundant pyroclastic rocks, and sedimentary deposits derived from volcanic rocks. Glass, the chief constituent of these rocks, tends to devitrify rapidly in hydrous, alkaline environments forming zeolites among other products.

9.3 CRYSTALLOGRAPHY, CHEMISTRY, PHYSICAL PROPERTIES AND USES

Zeolites are framework alumino-silicates characterized by having structural channels filled with exchangeable cations and water. Four oxygen atoms surround single silica or aluminum atoms to form tetrahedrans. Each oxygen atom is shared between two tetrahedra with tetrahedra linking together to form one of five secondary building units (see Figure 9.3-1).

1. a single, four-tetrahedran ring (S4R)
2. a six-tetrahedran ring, single or double (S6R, D6R)
3. a fibrous zeolite unit (4-1)
4. the mordenite-unit (5-1)
5. the stilbite-unit (4-4-1)

Groups of the same secondary building units come together in different ways to form larger frameworks with the characteristic structural channel systems. The larger frameworks may be differentiated further into subgroups of minerals based on differences in exchangeable cations and/or symmetries. The exchangeable cations or positively charged alkali and alkaline earth ions, are present in the channels to balance the net negative charge induced by the aluminum-centered tetrahedran. Water molecules are loosely bound to these cations as well as to the framework. The general chemical formula of a zeolite is:

$$M_x D_y \; Al_{x+2y} \; Si_{n-(x+2y)} \, O_{2n} \cdot mH_2O$$

where $M = Na^+, K^+$ or other monovalent cations

$D = Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}$ and other divalent cations.

Table 9.3-1 lists all of the natural zeolites according to their secondary building units and larger framework types.

The channels present in zeolites allow the cations to easily move around and pass in and out of the structure. The wider the channels are at their narrowest part, the larger the cation that can be introduced into the structure. Different zeolites have different channel widths, allowing ions to be selectively adsorbed or screened out depending on the zeolite. Some zeolites have openings large enough to admit organic molecules in addition to cations. In addition to their cation exchange properties, zeolites show excellent water adsorption capabilities. They can take up considerable quantities of water, filling up the channels in the lattice structure. Both of these properties have made zeolites attractive for a growing number of industrial and agricultural purposes.

Zeolites are high capacity, selective adsorbents. The commercial applications of zeolites are just now being realized and exploited. They can be used to remove radioactive molecules (e.g., strontium -90 and cesium 137) from streams of radioactive waste, nitrogen-containing compounds (e.g. ammonium), sulfur-containing compounds, and can serve as a catalyst in cracking crude petroleum to gasoline and other products. Zeolites are utilized in about 90 percent of the petroleum catalytic cracking installations and have greatly increased the recovery of gasoline. They may also find application in pollution control. Presuming no restrictions are placed on their use, the production and commercial use of zeolites will no doubt dramatically increase during the next decade.

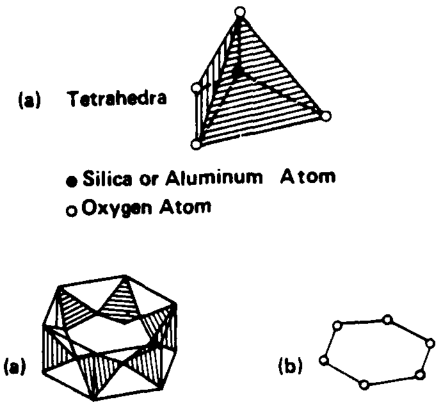

Fig. 1. (a) a single ring of six tetrahedra, (b) schematic drawing of the same ring showing the positions of Si-atoms only.

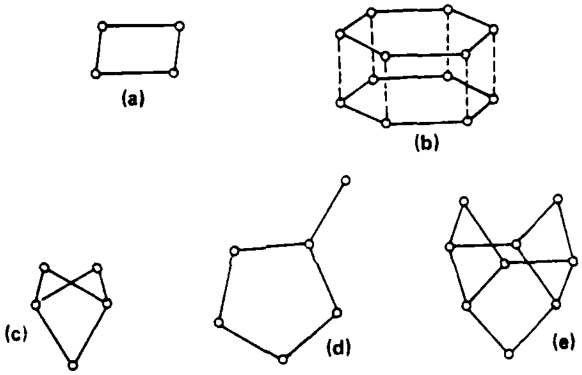

Fig. 2. The secondary building units (SBU) of the zeolite frameworks. (a) The single four-ring (S4R), (b) the six-ring, single or double (S6R and D6R), (c) the natrolite-unit (4-1), (d) the mordenite-unit (5-1), (e) the stilbite-unit (4-4-1).

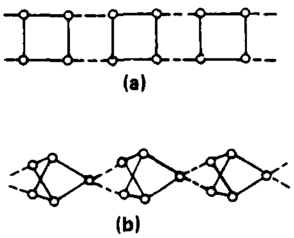

Fig. 3. Examples of interconnection of SBU. (a) The phillipsite ladder, as a connection of S4R, (b) the natrolite chain, as a connection of 4-1.

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Figure 9.3-1. Zeulite building units.
Source: Sand and Mumpton (1978)

Table 9.3-1. Zeolites.

GROUP (SBU)	FRAMEWORK TYPE	SPECIES NAME	TYPICAL UNIT CELL CONTENT	MOST ABUNDANT CATION
S4R	Phillipsite	Phillipsite	$(Ca_{0.8}Na,K)_6[Al_6Si_{10}O_{32}] \cdot 12H_2O$	Ca or Na or K
	Phillipsite	Harmotome	$Ba_2[Al_4Si_{12}O_{32}] \cdot 12H_2O$	Ba
	Gismondine	Gismondine	$Ca_4[Al_8Si_8O_{32}] \cdot 16H_2O$	Ca
	Gismondine	Garronite	$NaCa_{2.5}[Al_6Si_{10}O_{32}] \cdot 14H_2O$	Ca
	Leucite	Analcime	$Na_{16}[Al_{16}Si_{32}O_{96}] \cdot 16H_2O$	Na
	Leucite	Wairakite	$Ca_8[Al_{16}Si_{32}O_{96}] \cdot 16H_2O$	Ca
	Paulingite	Paulingite	$(K_2,Na_2,Ca,Ba)_{76}[Al_{152}Si_{525}O_{1354}] \cdot 700H_2O$	K
	Laumontite	Laumontite	$Ca_4[Al_8Si_{16}O_{48}] \cdot 16H_2O$	Ca
	Yugawaralite	Yugawaralite	$Ca_2[Al_4Si_{12}O_{32}] \cdot 8H_2O$	Ca
S6R and D6R	Chabazite	Chabazite	$Ca_2[Al_4Si_8O_{24}] \cdot 13H_2O$	Ca or Na
	Gmelinite	Gmelinite	$Na_8[Al_8Si_{16}O_{48}] \cdot 24H_2O$	Na or Ca
	Faujasite	Faujasite	$Na_{12}Ca_{12}Mg_{11}[Al_{59}Si_{133}O_{384}] \cdot 235H_2O$	Na
	Erionite	Erionite	$(K_2,Ca,Mg,Na_2)_{4.5}[Al_9Si_{27}O_{72}] \cdot 27H_2O$	Ca or Na or K
	Offretite	Offretite	$(K_2,Mg,Ca,Na_2)_{2.5}[Al_5Si_{13}O_{36}] \cdot 15H_2O$	Ca or Mg
	Levyne	Levyne	$Ca_3[Al_6Si_{12}O_{36}] \cdot 18H_2O$	Ca
	Mazzite	Mazzite	$K_2Mg_2Ca_{1.6}[Al_9Si_{27}O_{72}] \cdot 28H_2O$	Mg
4-1	Natrolite	Natrolite	$Na_{16}[Al_{16}Si_{24}O_{80}] \cdot 16H_2O$	Na
	Natrolite	Tetr. Natrolite	$Na_{16}[Al_{16}Si_{24}O_{80}] \cdot 16H_2O$	Na
	Natrolite	Mesolite	$Na_{16}Ca_{16}[Al_{48}Si_{72}O_{240}] \cdot 64H_2O$	Na or Ca
	Natrolite	Scolecite	$Ca_8[Al_{16}Si_{24}O_{80}] \cdot 24H_2O$	Ca
	Thomsonite	Thomsonite	$Na_4Ca_8[Al_{20}Si_{20}O_{80}] \cdot 24H_2O$	Ca
	Thomsonite	Gonardite	$Na_4Ca_2[Al_8Si_{12}O_{40}] \cdot 14H_2O$	Na
	Edingtonite	Edingtonite	$Ba_2[Al_4Si_6O_{20}] \cdot 8H_2O$	Ba
5-1	Mordenite	Mordenite	$Na_8[Al_8Si_{40}O_{96}] \cdot 24H_2O$	Ca or Na
	Dachiardite	Dachiardite	$Na_5[Al_5Si_{19}O_{48}] \cdot 12H_2O$	Ca or Na
	Ferrierite	Ferrierite	$Na_{1.5}Mg_2[Al_{5.5}Si_{30.5}O_{72}] \cdot 18H_2O$	Mg
	Epistilbite	Epistilbite	$Ca_3[Al_6Si_{18}O_{48}] \cdot 16H_2O$	Ca
4-4-1	Stellerite	Stellerite	$Ca_4[Al_8Si_{28}O_{72}] \cdot 28H_2O$	Ca
	Stellerite	Stilbite	$Na_2Ca_4[Al_{10}Si_{26}O_{72}] \cdot 34H_2O$	Ca or Na
	Stellerite	Barrerite	$Na_8[Al_8Si_{28}O_{72}] \cdot 26H_2O$	Na
	Brewsterite	Brewsterite	$Sr_2[Al_4Si_{12}O_{32}] \cdot 10H_2O$	Sr
	Heulandite	Heulandite	$Ca_4[Al_8Si_{28}O_{72}] \cdot 24H_2O$	Ca
	Heulandite	Clinoptilolite	$Na_6[Al_6Si_{30}O_{72}] \cdot 24H_2O$	Na

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Source: Sand and Mumrton (1978)

9.4 ASSOCIATION OF ZEOLITES WITH DISEASE

CASE STUDIES (9.4.1)

The scientific community was recently alerted to the potentially carcinogenic effects of zeolites by Professor Y. Izzettin Baris of the Division of Chest Diseases, Hacettepe University in Ankara, Turkey, who evaluated environmental chest disease in Turkey. Professor Baris searched for calcified pleural plaques, chronic fibrosing pleuritis, and diffuse malignant mesothelioma. He has evaluated several rural Turkish communities near commercial asbestos deposits finding all three diseases along with parenchymal fibrosis. He attributed this to both occupational and environmental exposure. Asbestos was utilized in the white stucco to plaster houses.

In the villages of Karain and Tuzkoy in the Nevsehir region there were much higher incidences of these chest diseases and mesothelioma appeared endemic. In Karain in 1974 there were 11 pleural mesotheliomas out of 18 deaths in a village of 604. Three of the other deaths were due to gastrointestinal cancer and may have been peritoneal mesothelioma. During 1970-1973, 13 of 37 deaths were due to pleural mesothelioma. This is an extemely high incidence for a rare cancer that is virtually nonexistent in the normal population. Karain is well known to tourists because of its picturesque rock dwellings called "fairy chimneys".

There was no asbestos deposit in the area nor has there been any processing of such material brought in from other parts of Turkey. The soil, rock, stucco, the material used for making the "sweet meal", and the airborne dust contained volcanic debris. The British Pneumoconiosis Research Unit in Cardiff has demonstrated many fibers of respirable sizes in the rock samples and street and field soils in Karain but not in control villages 4 and 7 km further up the valley. These fibers were found to be erionite-type zeolite by means of X-ray diffraction and analytic transmission electron microscopy. Professor Baris concluded that calcified pleural plaques, chronic fibrosing pleurisy, and malignant pleural mesothelioma may be caused by fibers other than asbestos. Up until recently it was believed that only asbestos caused mesothelioma.

SIMILARITY WITH ASBESTOS, FIBERGLASS, OTHERS (9.4.2)

Since these observations, pleural implantation of zeolites in experimental animals by Dr. Y. Suzuki (Mt. Sinai, New York) has demonstrated carcinogenicity, and electron microscopic size characterization by Drs. Wright, Rom and Moatamid (Rocky Mountain Center for Occupational and Environmental Health, University of Utah) have demonstrated fibers in erionite samples from the Intermountain area in Utah.

There is still controversy on the hazards to human health of working with fibrous material such as fiberglass. There is little question regarding the carcinogenic effect of asbestos or the likelihood of asbestiform zeolites having the same property to some degree. In the large family of the hydrous aluminum silicate minerals--zeolites--while they all share many physical characteristics, very few exhibit forms that are sufficiently lath-like or acicular in their electron-microscopic crystalline configuration to be termed asbestiform. The identified zeolite offenders seem to be erionite and mordenite, and these have to be ingested pleurally over long periods of time.

9.5 OCCURRENCE IN THE DEVELOPMENT AREA

PHYSICAL OCCURRENCE (9.5.1)

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 volcaniclastic 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, neither are they likely to be everywhere present 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 9.5.1-1. Unfortunately, other areas which might now, or in the future be commercialized, and still others that contain high but non-economic 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 negate the problem with respect to the locations shown in Figure 9.5.1-2. However, as previously discussed, the minimum level of zeolite exposure constituting a health hazard has not been determined, hence, in the same sense it is difficult to judge the corresponding minimum level of zeolite concentration in rocks and soils that could be associated with disease risk.

Zeolite as a detrital component of desert substrates has, to our knowledge, 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 go far in reducing further the chances of encountering large concentrations.

PREFERENTIAL SUSPENSION OF FIBERS IN DUST (9.5.2)

Just how concentrated zeolites must be to be a significant health risk is not known. The assumption that high exposure (the product of time and concentration) equals high risk has numerous precedents in the literature of toxic substances, but

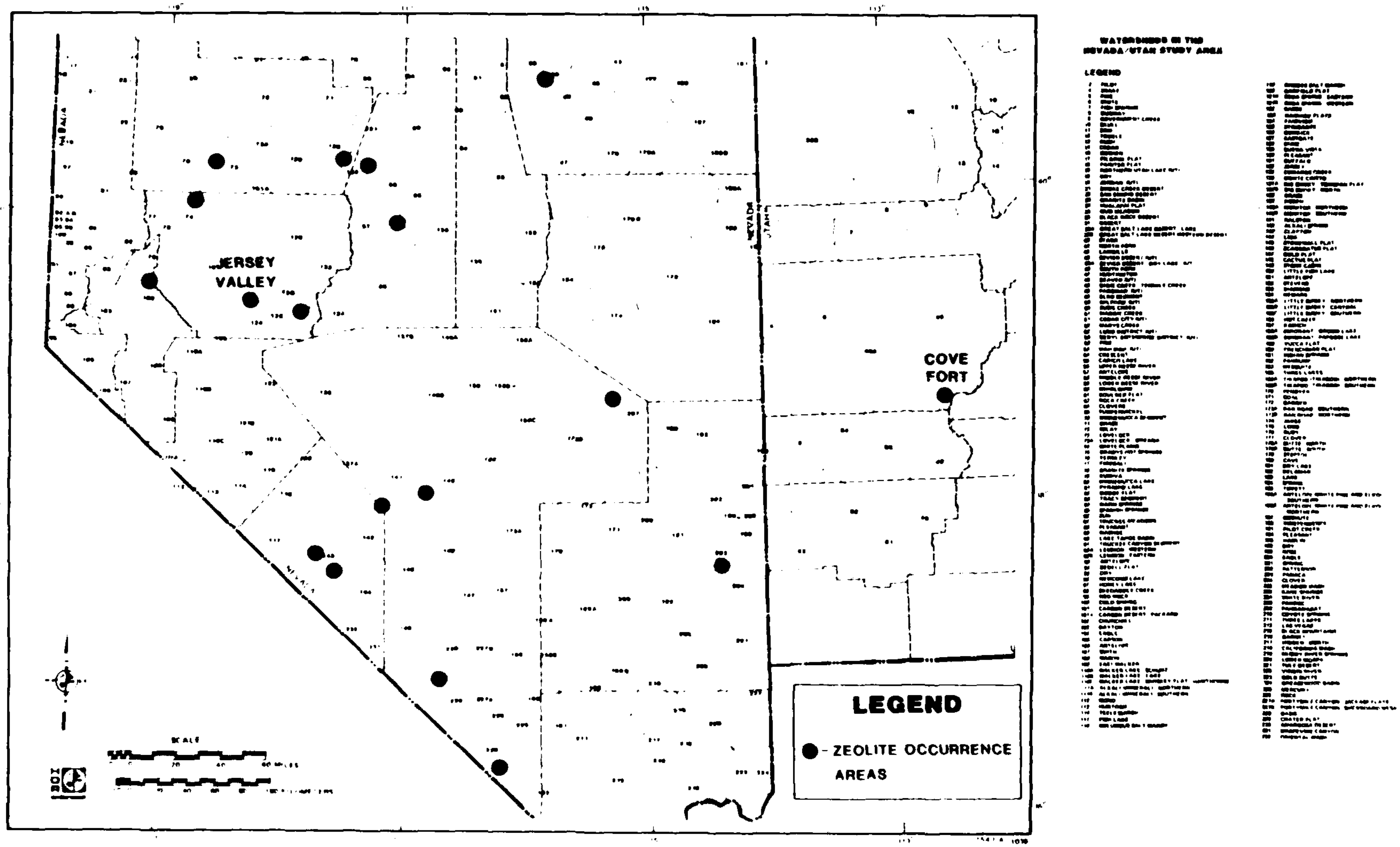

Figure 9.5.1-1. Locations of commercial interest for Zeolites.

this does not necessarily imply that there is inherent safety in low-level exposure. In any case, it is worthwhile to consider what the term concentration signifies and examine it in terms of what is currently known about asbestos. The state of Connecticut currently employs the following air quality standard for asbestos:

30,000 asbestos fibers of any size/m^3 (i.e., 3×10^4 fibers/m^3)

The standard relates specifically to the occurrence of asbestos-caused mesothelioma. No direct equivalence is suggested for zeolites but it is instructive to compare this standard with the number of potentially suspendible fibers that might exist in substrates containing relatively small amounts of zeolite. Figure 9.5.2-1 shows the number of zeolite particles per cubic meter of substrate as a function of the volume percent of zeolite in the substrate. Under the assumed conditions (Appendix IIA), 0.1 percent of zeolite by volume in 1 cm^3 of substrate would contain 1.27×10^8 potentially suspendible fibers with an average length of 10 microns. Not all potentially suspendible fibers would be suspended during disturbance of soil substrate by construction, nor is there a precise way of predicting emission rates from substrate to air, but it is reasonable to assume that of whatever particulates become airborne, the mass ratio of zeolite particles to other particles will be approximately the same in air as in the substrate. For a substrate containing 0.1 percent zeolite by volume, the number of zeolite fibers per m^3 of air will be equal to the total suspended load in micrograms/m^3 multiplied by the factor 5.1×10^2 particles of zeolite/micrograms of suspended load (Appendix IIA). Fugitive dust computations done elsewhere for standard air quality analyses estimate the total suspended loads to be on the order of 1.5×10^4 g/m^3 near the emission source; zeolite particulates could therefore number 7.7×10^3 per m^3. It is clear that it is possible for the numbers of zeolite particles in air to exceed the numerical value of one published asbestos standard. It should be stressed that no health risk equivalence is assumed between the Connecticut standard and these calculated zeolite particulate levels, yet it must be recognized that the possibility of equivalence exists and in this context it is noteworthy that the assumed standard may be exceeded by disturbance of substrate zeolite concentrations that are below the analytical detection level (about 2 - 3 percent of volume) by X-ray diffraction techniques. Levels of 0.1 percent by volume, moreover, are what could be expected as background concentrations in approximately 75 percent of the deployment area, judged solely by the distribution of volcanic deposits that typically host zeolites (Figure 9.5.1-2). This estimate, however, does not differentiate between kinds of zeolites, a factor that would greatly modify its significance. Additionally it does not include the percentage occurrence of erionite and mordenite in Nevada and Utah, which is not known.

It is well known that non-spherical particles will settle faster than spheres of equal volume in fluid regimes characterized as static or in laminar flow. Ignoring atmospheric turbulence for the moment, the settling behavior of zeolite and other particulates in air can be gauged from a single calculation of Stokes law (McKnown and Malaika, 1950). Figure 9.5.2-2 shows graphically that fiber shaped zeolite particles, in the size range of interest, have significantly lower settling velocities than zeolite spheres of equal volume and density, and similarly for quartz spheres of equal volume but higher density. The curves illustrate that a doubling of the fiber length from 5 micron to 10 microns does not appreciably alter settling velocities. The curves for spheres diverge markedly from the fiber curve at larger diameters with settling velocities for the spheres greater than those for fibers by factors equal to or greater than 1.4 and 1.8 in the 5 and 10 micron cases respectively.

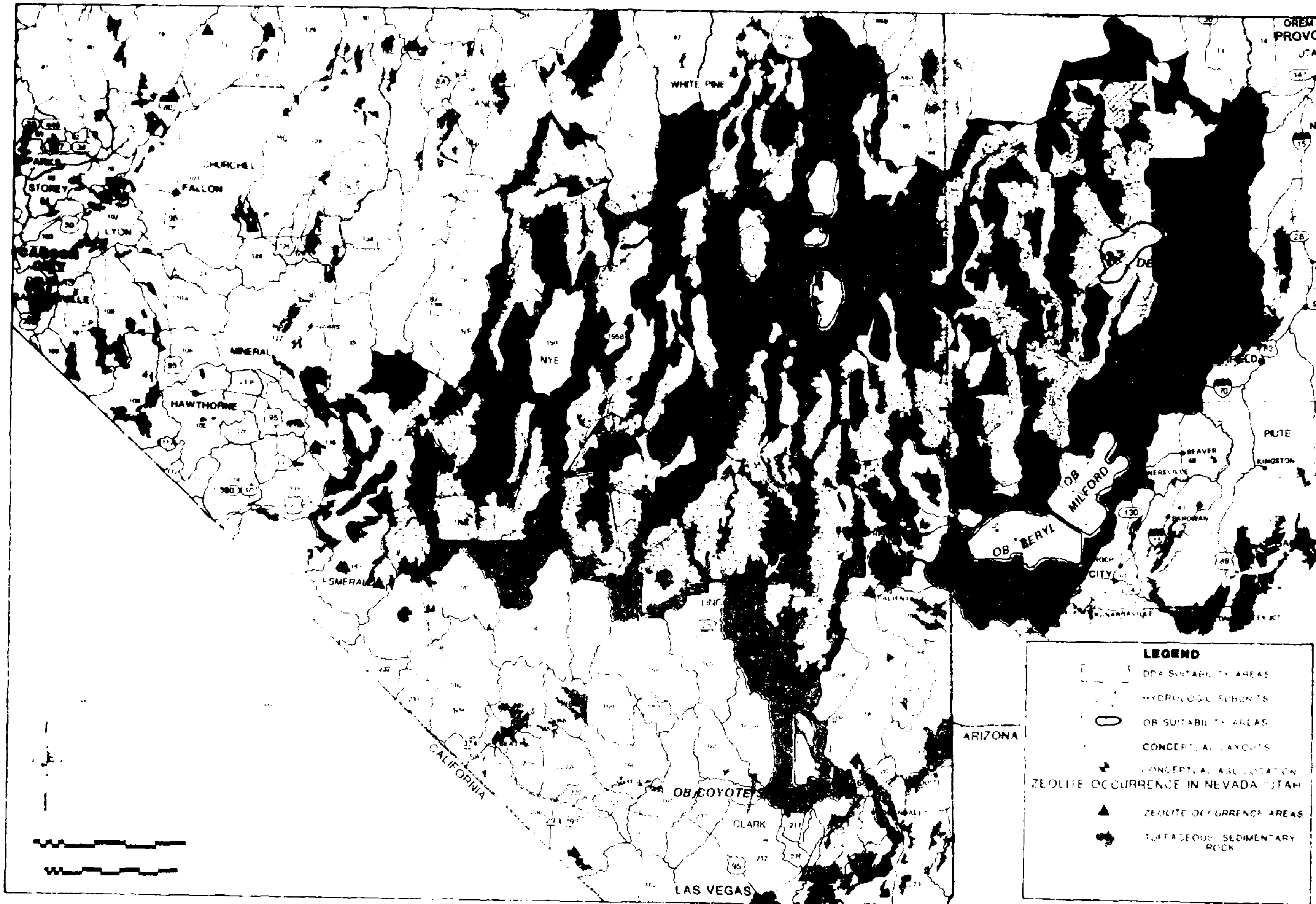

Figure 9.5.1-2. Areas of possible Zeolite occurrence in Nevada and Utah.

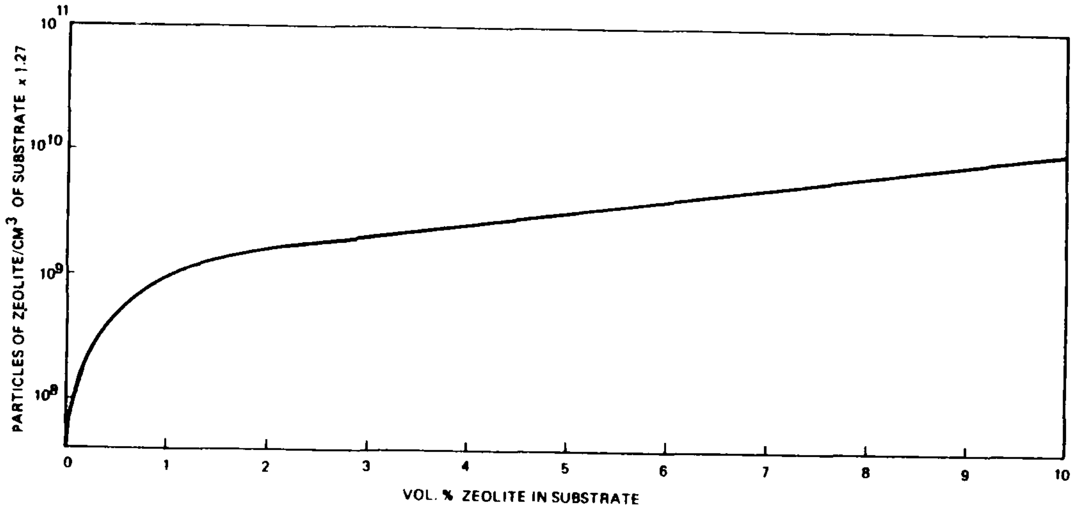

Figure 9.5.2-1. Number of particles of zeolite as a functional percent volume.

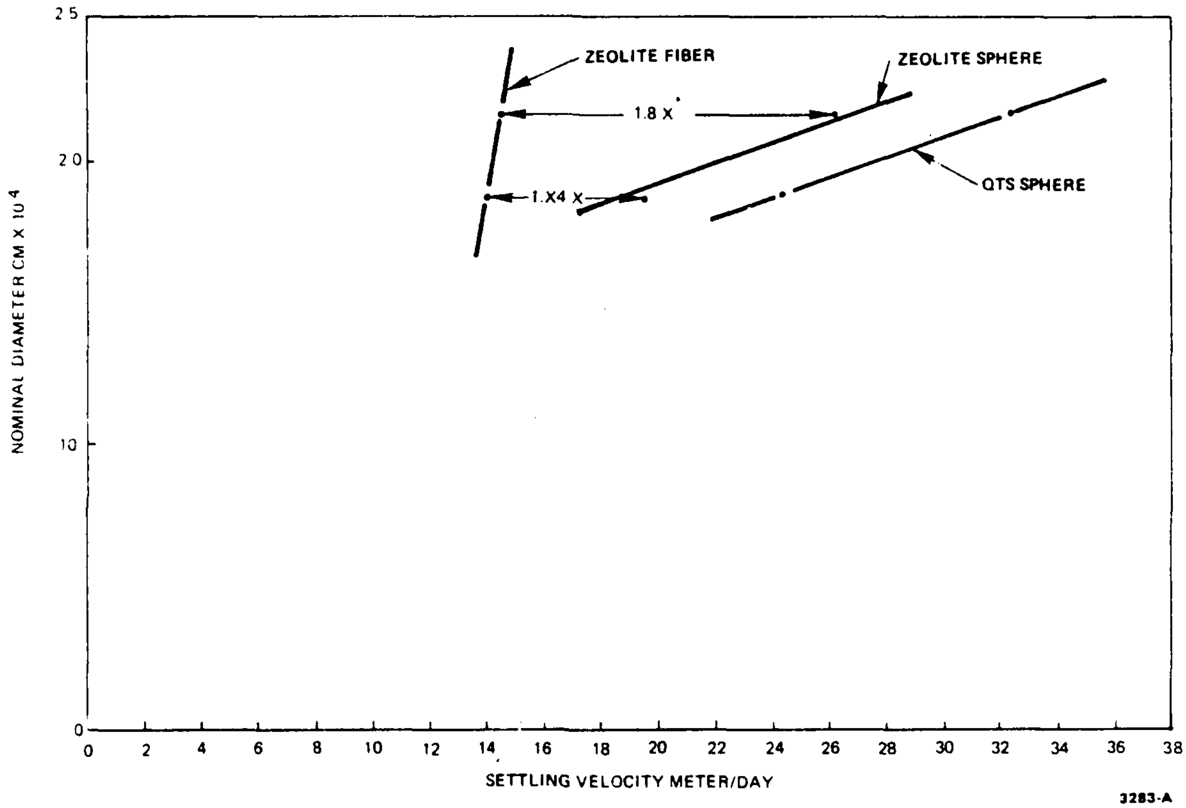

Figure 9.5.2-2. Zeolite settling velocities.

These results suggest that fibrous zeolites may be selectively suspended in the air beyond the duration of normal particulates. Over time the airborne zeolite concentration may therefore be increased over the original proportion of zeolite in the suspended load inherited from the substrate concentration. The effect of turbulence, not accounted for in the calculations, would mainly be to enhance the suspension of all particulates but it would not negate the preferential suspension of fibrous particulates.

It would appear therefore that a viable mechanism exists which would raise airborne zeolite concentrations above substrate concentrations once the material has become airborne.

9.6 OTHER FACTORS

POSSIBLE/PROBABLE INCLUSION OF ZEOLITES IN NESHAPS (9.6.1)

If further medical studies firmly establish a link between airborne zeolite dust and lung disease, it is possible that the fibrous zeolites will ultimately be included in the Environmental Protection Agencies (EPA) regulations on National Emission Standards for Hazardous Air Pollutants (NESHAPS). If the physical similarity between zeolites and asbestos translates to disease risk equivalence, the federal regulations governing exposure to these substances may be the same or similar. The federal standard for asbestos, in the general case, calls for "no visible emissions." This may be considered a rather liberal guideline since emission levels of asbestos in the non-visible range can be quite high, still constituting a health risk. It is possible, and perhaps likely in relation to the M-X project, that stricter standards would be set by the state governments. The Connecticut standard for asbestos, for example, is 200 times more conservative than the OSHA standard of U.S. Department of Labor as of 1977 (Bruckman et al, 1977). In turn, the OSHA standard is far stricter than the EPA standard. With the passage of conservative state regulations, in 2 or 3 years, M-X construction activities would come wholly or in part under environmental guidelines and mitigation procedures not now defined. It may be possible, however, to anticipate the nature of these regulations and institute similar internal M-X policies. Moreover, it may be possible to contribute directly in the formulation of governmental policy.

FUTURE EXPLORATION AND DEVELOPMENT (9.6.2)

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 zeolite 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 within drainage systems tapping zeolite-rich deposits may be subjected to higher levels of exposure.

9.7 CONCLUSIONS AND RECOMMENDATIONS

The difficulty in analyzing the severity of the zeolite problem is two-fold: 1) there is the problem of analyzing the zeolite content of the soil at any given locality for the specific zeolites that may be cancer-causing, and 2) there is the problem of determining the level and length of exposure that would cause a health problem. The first difficulty can be overcome by geologic field study of the deployment area. The second problem is more difficult to resolve and it may not be possible to determine the hazardous exposure level for several years.

The following conclusions and recommendations are suggested to answer the questions of direct effect to the M-X program.

1. Delineate the zeolite mineralized limits by a definitive survey and sampling program.

2. Analyze the mineral samples and identify the types of zeolites present. Initial steps have already been discussed with Dr. William Rom, Director of the Rocky Mountain Center for Occupational and Environmental Health, University of Utah, to conduct these studies.

3. Guided by the definitively surveyed limits of any zeolite deposit, care will be exercised in avoiding construction of the M-X building appurtenances on or proximal to the zone.

4. If the mineralized zone is small, excavation under controlled grading conditions can be implemented. Then, restoration of grade elevations can effectively be done by importing zeolite-free soil, placing and compacting it to ASTM 90 percent of maximum density specifications.

5. It is recognized that road building, construction of drainage structures--such as culverts and check dams--may transect a zeolitized zone or cut across tuffaceous sediments which may contain zeolites. In such event, fugitive dust can be controlled by surface treatment with water. Where open-face cuts have been made, they can subsequently be united. Level expanses can be stabilized by spreading soil cement with subsequent watering to form a duricrust.

6. As a final measure, if it should happen that grading for construction is directly in the midst of a proved or suspected zeolitized belt, working crews should be required to use ordinary, lightweight face respirators. Health professionals and a professional geologist, conversant with zeolites, their form, nature, and occurrence should be on hand to assist in overseeing such cases.

7. Epidemiologic Studies. Morbidity evaluations should be conducted on all zeolite miners from Jersey Valley, Nevada, Rome, Oregon, Bowie, Arizona, and Hector, California to look for calcified pleural plaques, chronic fibrosing pleurisy, and malignant pleural mesothelioma. The surveys shown include respiratory symptom questionnaires, residential and occupational histories, pulmonary function, sputum evaluations, chest radiographs and other standard medical evaluations required for such studies.

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- 2.2 Texas/New Mexico
  - 2.2.1 Slope and Topography
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10.0 BIBLIOGRAPHY OF CITED AND SUPPLEMENTARY LITERATURE

CHAPTER 2.0 REFERENCES

Dott, R. H., Jr., and Batten, R. L. 1976. Evolution of the Earth, Second Edition. New York: McGraw-Hill 504 p.

Flint, R. F. 1971. Glacial and Quaternary Geology. New York: John Wiley. 892 p.

Thornbury, W. D. 1965. Regional Geomorphology of the United States. New York: John Wiley, 609 p.

CHAPTER 3.0 REFERENCES - GREAT BASIN

Albers, J. P. and Steward, J. H., 1972, Geology and Mineral Deposits of Esmeralda County, Nevada: Nevada Bureau Mines Bull. 78.

Baker III, Arthur, Archbold, N. L., and Stoll, W. J., 1973, Forecasts for the future - Minerals: Nevada Bureau Mines Bull. 82.

Bryan, D. P. and Papke, K. G., 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.

Garside, L. J., 1973, Radioactive Mineral Occurrences in Nevada: Nevada Bureau Mines Bull. 81.

Granger, A. E., Bell, M. M. Simmons, G. C., and Lee, Florence, 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., Blake, Jr., M. C., and Smith, R. M., 1976, Geology and Mineral Resources of White Pine County, Nevada: Nevada Bureau Mines Bull. 85.

Jerome, S. E. and Cook, D. R., 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 Bergendahl, M. H., 1968, Principal Gold-Producing Districts of the United States· Geological Survey pp. 610.

Larson, L. T., and others, 1978, Great Basin Geologic Framework and Uranium Favorability: Bendix Field Engineering Corporation <u>for</u> U.S. Department of Energy.

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

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

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

Papke, K. G., 1979, Fluospar in Nevada: Nevada Bureau of Mines Bull. 93.

Roberts, R. J., Montgomery, K. M., and Lehner, R. E., 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, Molyboenum Occurrences in Nevada: Nevada Bureau Mines Map No. 8.

____, 1962, Vanadium Occurrences in Nevada: Nevada Bureau Mines Map No. 15.

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

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

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

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

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, 122 p.

Anderson, E. C., 1959, Carbon Dioxide in New Mexico, New Mexico Bureau of Mines and Min., Res., Cir. 32, 24 p.

Anderson, E. C., 1954, Occurrences of Uranium Ores in New Mexico, New Mexico Bureau of Mines and Min. Res. Cir. 29, 26 p.

Baker, C. L., 1931. Volcanic Ash in Texas, Texas Bureau of Econ. Geology, Min. Res. Cir. No. 2, 4 p.

_____, 1932, Fuller's Earth and Bentonite in Texas, Texas Bureau of Economic Geology, Min. Res. Cir. No. 3, 7 p.

_____, 1932, Gold in Texas, Texas Bureau of Econ. Geology, Min. Res. Cir. No. 5, 6 p.

_____, 1932, Barite in Texas, Texas Bureau of Econ. Geology, Min. Res. Cir. No. 4, 5 p.

_____, 1935, Sulphur in Texas, Texas Bureau of Econ. Geology, Min. Res. Cir. No. 6, 5 p.

Butler, A. P., Finch, W. I., and Twenhofel, W. S., 1962, Epigentic 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, 35 p.

Clippinger, D. M. and Gay, W. E., 1947, Pumice Aggregate in New Mexico, Its Uses and Potential, New Mexico Bureau of Mines and Min. Res., Bull. 28, 50 p.

Dorfman, M. and Kehle, R. O., 1974, Potential Geothermal Resource of Texas, Texas Bureau of Economic Geol. Cir. 74-4, 33 p.

Eargle, D. H., 1956, Some Uranium Occurrences in West Texas, Texas Bureau of Economic Geol., Rep. Inv. No. 27, 23 p.

Ellison, Jr., S. P., 1971, Sulfur in Texas, Texas Bureau of Economic Geol., Handbook No. 2, 48 p.

Evans, G. L., ____, Strontium Mineral in Texas, Texas Bureau of Econ. Geo., Min. Res. Sur. Cir. No. 46, 26 p.

File, L. A., 1965, Directory of Mines of New Mexico, New Mexico Bureau of Mines and Min. Res., Cir. 77, 188 p.

Garner, L. E., St. Clair, A. E., and Evans, T. J., 1979, Mineral Resources of Texas, Texas Bureau of Econ. Geol., Map.

Garner, L. E., Sharpe, R. D., and McClelland, M. E., 1980, Computer-Generated List of Texas Mineral Producers (Exclusive of Oil and Gas), arranged alphabetically by county.

Girard, R., 1970, Texas Mineral Producers, Texas Bureau of Econ., Geol., 62 p.

Horley, G. T., 1940. The Geology and Ore Deposits of Northeastern New Mexico, New Mexico Bureau of Mines and Min. Res., Bull. No. 15, 104 p.

Hawkins, M. E., and Evans, T. J., 1975, The Mineral Industry of Texas in 1975, Texas Bureau of Econ. Geology, Min. Res. Cir. No. 60, 40 p.

Kottowski, F. E., 1962, Reconnaissance of Commercial High Calcium Limestones in New Mexico, New Mexico Bureau of Mines and Min. Res., Cir. 60, 77 p.

McAnulty, Sr., W. N., 1974, Fluospar in Texas, Texas Bureau of Econ. Geol. Handbook 3, 31 p.

New Mexico Bureau of Mines and Min. Res., 1965, Mineral and Water Resources of New Mexico, (report of U.S. Senate), 437 p.

Redfield, R. C., 1942, Bauxite and Aluminum, Texas Bureau of Econ. Geol., Min. Res. Cir. No. 18, 19 p.

Schnabel, R. W., 1955. The Uranium Deposits of the United States, U.S. Geological Survey, Min. Inv. Res. Map MR-2.

Sellards, E. H. and Evans, G. L., 1944, Index to Mineral Resources of Texas of Counties, Texas Bureau of Econ. Geol., Min. Res. Cir. No. 29, 21 p.

Sellards, E. H., 1930, Graphite in Texas, Texas Bureau of Econ. Geol. Min. Res. Cir. No. 1, 3 p.

Siemers, W. T. and Austin, G. S., 1979, Active Mines and Processing Plants in New Mexico, New Mexico Bureau of Mines and Min. Res., 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, 23 p.

Talmage, S. B. and Wootton, T. P., 1937, The Non-Metallic Mineral Resources of New Mexico and Their Economic Features, New Mexico Bureau of Mines and Min. Res., Bull. No. 12, 159 p.

U.S. Geological Survey, 1965, Uranium in Texas, Map.

Weber, R. H. and Kottlowski, F. E., 1959, Gypsum Resources of New Mexico, New Mexico Bureau of Mines and Min. Res., Bull. 68, 68 p.

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

Zimmerman, J. B. and Thomas, E., 1969, Sulfur in West Texas: Its Geology and Economics, Texas Bureau of Econ. Geol. Cir. 69-2, 35 p.

CHAPTER 4.0 REFERENCES

Albee, A. L., and Smith, J. L., 1966, Earthquake characteristics and fault activity in southern California, in Lung, R., and Proctor, R., 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, v. 78, p. 143-156.

Anderson, L. W., and Miller, D. G., 1979, Quaternary fault map of Utah: Fugro, Inc., Long Beach, California, 35 p.

Anderson, R. E., 1973, Large-magnitude late Tertitary strike-slip faulting, north of Lake Mead, Nevada (abstract): U.S. Geological Survey Professional Paper 794, 18 p.

Anderson, R. E., Bucknam, R. C., and Wallace, R. E., 1978, Seismotectonics of Utah and Nevada (abstract): U.S. Geological Survey Professional Paper, p. 259-260.

Anderson, R. E., Ekren, E. B., and Wright, L. 1977, Late Cenozoic fault patterns and stress fields in the Great Basin and westward displacement of the Sierra Nevada Block: Geology, v. 5, no. 7, p. 388-392.

Armstrong, R. L., 1972, Low-angle (denudation) faults, Hinterland of the Sevier Orogenic Belt, eastern Nevada and western Utah: Geological Society of America Bulletin, v. 83, no. 6, p. 1729-1754.

Artem'yev, M. Ye, Rotvayn, I. M., Sadovskiy, A. M., and Keylis-Borok, V. I., 1977, Recognized places of intense earthquake formation; Part VII, using Bouguer gravity anomalies for California and neighboring regions: Vychis. Seismol., no. 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, v. 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, v. 51, no. 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, 29 p.

Bayer, K. C., 1974b, Seismic data report southern Nevada region, December 1971-December 1972: International Journal of Rock Mechanics and Mineral Science, v. 11, no. 3, p. 55A.

Bechtoid, I. C., Liggett, M. A., and Childs, J. F., 1973a, Reigonal 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.

Bechtoid, I. C., Liggett, M. A., and Childs, J. F., 1973b, Remote sensing reconnaissance of faulting in alluvium, Lake Mead to Lake Havasu, in 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, 63 p.

Bell, E. J., Sanders, C. O., and Slemmons, D. B., 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, v. 10, no. 3, p. 95.

Bell, E. J., and Slemmons, D. B., 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, in Whitten, C. A., Green, R., Meade, B. K., eds., Recent crustal movements: Tectonophysics, v. 52, No. 1-4, p. 571-583.

Bell, J. W., 1980, Subsidence in Las Vegas Valley: Nevada Bureau of Mines and Geology Bulletin 95, 45 p. (in press).

Bell, E. J., and Trexler, D. T., 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, v. 11, no. 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 v. 11, no. 3, p. 69.

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, v. 11, no. 3, p. 68-69.

Berg, J. W., Jr., Cook, K. L., Narans, H. D., Jr., and Dolan, W. M., 1960, Seismic investigation of crustal structure in the eastern part of the Basin and Range province: Seismological Society of America Bulletin, v. 50, p. 511-535.

Berger, B. R., and Taylor, B. E., 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, v. 6, no. 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, v. 7, no. 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, v. 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, v. 42, p. 865-922.

Bohannon, R. G., 1978, Strike-slip faults in Lake Mead artea of southern Nevada (abstract): U.S. Geological Survey Professional Paper, p. 71.

Bohannon, R. G., and Anderson, R. E., 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, v. 10, no. 3, p. 96-97.

Bohannon, R. G., 1979, Strike-slip faults of the Lake Mead region of southern Nevada, in Armentrout, J. M., ed., Cenozoic paleogeography of the western United States: Pacific Coast Paleogeographical Symposium, no. 3, p. 129-139.

Bonilla, M. G., Surface faulting and related effects, in Wiegel, R. L., ed., Earthquake engineering: New York, Prentice-Hall, Inc., p. 47-74.

Bonilla, M. G., and Buchanan, J. M., 1970, Interim report on worldwide historic surface faulting: U.S. Geological Survey Open-File Report, 32 p.

Braile, L. N., Smith, R. B., Keller, G. R., Welch, R. M., and Meyer R. P., 1974, Crustal structure across the Wasatch Front from detailed seismic refraction studies: Journal of Geophysical Research, v. 79, no. 17.

Briggs, Peter, Pren, Frank, and Guberman, S. A., 1977, Pattern recognition applied to earthquake epicenters in California and Nevada: Geological Society of America Bulletin, v. 88, p. 161-173.

Bucknam, R. C., 1980, Characteristics of active faults in the Great Basin, in 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., Algermissen, S. T., and Anderson, R. E., 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, v. 11, no. 3, p. 71-72.

Buje, C. G., Poetzl, K. G., Shakal, A. F., and Willis, D. E., 1973, Seismicity of the Nevada Test Site and adjacent areas: Earthquake Notes, v. 44, no. 1-2, p. 62.

Burchfiel, B. C., Pelton, P. J., and Sutter, J., 1970, An early Mesozoic deformation belt in south-central Nevada, south-eastern California: Geological Society of America Bulletin, v. 81, p. 211-215.

Burke, D. B., and McKee, E. H., 1973, Mid-Cenozoic volcano-tectonic features in central Nevada: Geological Society of America, Cordilleran Section, 69th Annual Meeting, Abstracts with Programs, v. 5, no. 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, v. 28, no. 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 McKee, E. H., 1978, Late Cenozoic volcanic and tectonic evolution of the Great Basin and Columbia Intermountain regions, in 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., Hintze, L. F., Brogan, G. E., and Glass, C. E., 1975, Recent activity of the Wasatch fault, north-western Utah, U.S.A.: Tectonophysics, v. 29, p. 161-168.

Cluff, L. S., Glass, C. E., and Brogan, G. E., 1974, Investigation and evaluation of the Wasatch fault north of Brigham City and Cache valley faults, Utah and Idaho; a guide to land-use planning with recommendations for seismic safety: a report prepared for the U.S. Geological Survey, Menlo Park, by Woodward-Lundgren and Associates, Oakland, California, 26 figs, 25 maps, 143 p.

Cluff, L. S., Patwardhan, K. J., and Coppersmith, K. J., 1980, Estimating the probability of occurrence of surface faulting earthquake on the Wasatch Fault zone, Utah: Seismological Society of America Bulletin (in press).

Cluff, L. S., Slemmons, D. B., and Waggoner, F. B., 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.

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 1-H, p. H1-H29.

Cook, K. L., and Montgomery, J. R., 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, v. 6, no. 3, p. 158.

Cook, K. L., and Smith, R. B., 1967, Seismicity in Utah, 1850 through June 1965: Seismological Society of America Bulletin, v. 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, Nevada.

Cross, T. A., and Pilger, R. H., Jr., 1978, Constraints on absolute motion and plate interaction inferred from Cenozoic igneous activity in the western United States: American Journal of Science, v. 278, no. 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, v. 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.

Davis, J. R., 1979, Quaternary faulting in Clayton and Big Smokey valleys, Nevada: Geological Society of America, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, v. 11, no. 3, p. 74.

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 Grose, L.T., 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, v. 11, no. 3, p. 75.

Dott, R. H., Jr., and Batten, R. L., 1976, Evolution of the earth (2nd ed.): New York, McGraw-Hill, 504 p.

Douglas, B. M., and Ryall, Alan, 1972, Spectral characteristics and stress drop for microearthquakes near Fairview Peak, Nevada: Journal of Geophysical Research, v. 77, no. 2, p. 351-359.

Douglas, B. M., and Ryall, Alan, 1975, Return periods for rock acceleration in western Nevada: American Geophysical Union Transactions, v. 56, no. 12, p. 1024.

Douglas, B. M., Ryall, Alan, and Savage, W. U., 1972, Source mechanisms and stress drop for microearthquakes in the Excelsior Mountains area, western Nevada: Geological Society of America, Cordilleran Setion, 68th Annual Meeting, Abstracts with Programs, v. 4, no. 3, p. 149.

Dodge, R. L., and Grose, L. T., 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, v. 11, no. 3, p. 75.

Dott, R. H., Jr., and Batten, R. L., 1976, Evolution of the earth (2nd ed.): New York, McGraw-Hill, 504 p.

Douglas, B. M., and Ryall, Alan, 1972, Spectral characteristics and stress drop for microearthquakes near Fairview Peak, Nevada: Journal of Geophysical Research, v. 77, no. 2, p. 351-359.

Douglas, B. M., and Ryall, Alan., 1975, Return periods for rock acceleration in western Nevada: American Geophysical Union Transactions, v. 56, no. 12, p. 1024.

Douglas, B. M., Ryall, Alan, and Savage, W. U., 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, v. 4, no. 3, p. 149.

Dewey, J. W., Dillinger, W. H., Taggart, J., and Algermissen, S. T., 1972, A technique for seismic zoning, analysis of earthquake locations and mechanisms in northern Utah, Wyomnig, Idaho and Montana: International Conference on Microzonation for Safer Construction, Research and Application, University of Washington, Seattle, Proceedings, v. 2, p. 879-895.

Eardley, A. J., 1939, Structure of the Wasatch-Great Basin region: Geological Society of America Bulletin, v. 50, no. 8, p. 1277-1310.

Eaton, G. P., 1978, Tectonic environment of late Cenozoic Great Basin volcanism: American Geophysical Union Transactions, v. 59, no. 4, p. 248.

Ekren, E. B., Bath, G. D., and Dixon, G. L., 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, v. 2, no. 1, p. 105-118.

Ekren, E. K., Bucknam, R. C., Carr, W. J., Dixon, G. L., and Quinlivan, W. D., 1976, East-trending structural lineaments in central Nevada: U.S. Geological Survey Professional Paper 986, 16 p.

Eppley, R. A., 1965, Earthquake history of the United States, Part I, Stronger earthquakes of the United States: Washington, U.S. Government Printing Office, 120 p.

Fischer, F. G., Papanek, P. J., and Hamilton, R. M., 1972, The Massachusetts Mountain earthquake of 5 August 1971 and its aftershocks, Nevada test site: U.S. Geological Survey, 16 p.

Flint, R. F., 1971, Glacial and Quaternary geology: New York, John Wiley, 892 p.

George, G. D., 1974, Investigation of spatial and temporal migration of seismic activity in the California/Nevada area: Masters thesis, University of Wisconsin, Milwaukee, Wisconsin.

Gilbert, G. K., 1890, Lake Bonneville: U.S. Geological Survey Monograph 1, 438 p.

Glass, C. E., and Slemmons, D. B., 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, 221 p.

Grannell, R. B., and Noble, D. C., 1977, A detailed analysis of Basin and Range faulting, Grass Valley area, north-central Nevada: Geological Society of America, Abstracts with Programs, v. 9, no. 4, p. 424-425.

Gumper, F. J., and Scholz, Christopher, 1971, Microseismicity and tectonics of teh Nevada seismic zone: Seismological Society of America Bulletin, v. 61, no. 5, p. 1413-1432.

Hamblin, W. K., 1976, Patterns of displacement along the Wasatch fault: Geology, v. 4, p. 619-622.

Hamblin, W. K., and Best, M. G., 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, v. 5.

Hamilton, R. M., Smith, B. E., Fischer, F. G., and Papanek, P. J., 1971, Seismicity of the Pahute mesa area, Nevada test site, 8 December 1968 through 31 December 1970: U.S. Geological Survey, Menlo Park, California, 170 p.

Hamilton, R. M., Smith, B. E., Fischer, F. G., and Papanek, P. J., 1972, Earthquakes caused by underground nuclear explosions on Pahute mesa, Nevada test site: Seismological Society of America Bulltein, v. 62, no. 5, p. 1319-1341.

Hamilton, Warren, and Myers, W. B., 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., Ekren, E. B., and Byers, F. M., Jr., 1975, Cenozoic strike-slip, normal, and detachment faults in northern part of Walker Lane: Geological Society of America, Abstracts with Programs, v. 7, no. 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, v. 8, no. 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.

Holzer, T. L., 1979, Leveling data, Egligton 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, v. 60, no. 8., p. 1399.

Howell, B. F., 1974, Seismic regionalization in North America based on average regional seismic hazard index: Seismological Society of America Bulletin, v. 64, no. 5, p. 1509-1528.

International Conference of Building Officials, 1979, Uniform Building Code, 1979 ed.: Whittier, California, 734 p.

Jones, J. C., 1915, The Pleasant Valley, Nevada, earthquake of October 2, 1915: Seismological Society of America Bulletin, v. 5, p. 190-205.

Keller, G. R., Smith, R. B., and Braile, L. H., 1975, Crustal structure along the Great Basin-Colorado plateau transition from seismic refraction studies: Journal of Geophysical Research, v. 80, no. 8, p. 1093-1098.

King, P. B., 1959, The evolution of North America: Princeton, Princeton University Press, 189 p.

King, P. B., 1969, The tectonics of North America--a discussion to accompany the tectonic map of North America: U.S. Geological Survey Professional Paper 628, 94 p, scale 1:5,000,000.

Kumamoto, L., and Keller, G. V., 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, v. 73, no. 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, 101 p.

Larson, L. T., Beal, L. H., Cornwall, D. E., and Sanders, C. D., 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, 441 p.

Larson, L. T., Beal, L. H., Firby, J. R., Hibbard, M. J., Larson, E. R., Slemmons, D. B., and Sanders, C. D., 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, 226 p.

Lee, D. E. Marvin, R. F., and Mehnert, H. H., 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., Jennings, T. V., and Lehman, W. T., 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 McEvilly, T. V., 1979, Microseisms in geothermal exploration, studies in Grass Valley, Nevada: Geophysics, v. 44, no. 6, p. 1097-1115.

Liu, S. C., and Fagel, L. W., 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, v. 7, no. 2, p. 72-75.

Locke, A. P., Billingsley, and Mayo, E. B., 1940, Sierra Nevada tectonic pattern: Geological Society of America Bulletin, 51, p. 513-540.

Lockwood, J. P., and Moore, J. G.,1979, Regional deformation of the Sierra Nevada, California, on conjugate microfault sets: Journal of Geophysical Research, v. 84, no. 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, v. 6, no. 3, p. 209.

Loring, A. K., 1972, Temporal and spatial distribution of Basin-Range faulting in Nevada and Utah: Masters thesis, southern California.

Loring, A. K., 1976, Distribution in time and space of late Phanerozoic normal faulting in Nevada and Utah: Utah Geology, v. 3, no. 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, Nevada.

McKague, H. L., Grothaus, B., and Howard, N. W., 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, v. 11, no. 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, Abstraccts with Programs, v. 11, no. 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. Ryall, Alan, Brune, J. N., and Slemmons, D. B., 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, v. 43, p. 690-707.

Papanek, P. J., and Hamilton, R. M., 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, 37 p.

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, v. 11, no. 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, California.

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, v. 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, 41 p.

Reilinger, R., 1977, Vertical crustal movements from repeated leveling data in the Great Basin of Nevada and western Utah: American Geophysical Union Transactions, v. 58, no. 12, p. 1238.

Richins, W. D., 1975, Earthquake swarm near Denio, Nevada, February to April 1973: Masters thesis, University of Nevada, Reno, Nevada.

Richins, W. D., and Ryall, Alan, 1974, Earthquake swarm near Denio, Nevada, February to April, 1973: Geological Society of America, Cordilleran Section, 70th Annual Meeting, Abstracts with Programs, v. 6, no. 3, p. 308.

Richter, C. F., 1950, Elementary Seismology: San Francisco, W. H. Freeman and Company.

Rinehart, C. D., and Ross, D. C., 1964, Geology and mineral deposits of the Mount Morrison Quadrangle, Sierra Nevada, California: U.S. Geological Survey Professional Paper 385, 106 p.

Roberts, R. J., 1968, Tectonic framework of the Great Basin, in a coast to coast tectonic study of the United States: Umr. Journal, no. 1, p. 101-119.

Rogers, A. M., and Lee, W. H. K., 1976, Seismic study of earthquakes in the Lake Mead, Nevada-Arizona region: Seismological Society of America Bulletin, v. 66.

Rogers, A. H., Perkins, D. M., and McKeown, F. A., 1977, A preliminary assessment of the seismic hazard of the Nevada test site region: Seismological Society of America Bulletin, v. 67, no. 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, v. 6, no. 3, p. 246.

Ryall, Alan, 1977, Earthquake hazard in the Nevada region: Seismological Society of America Bulletin, v. 67, no. 2, p. 517-532.

Ryall, Alan, Douglas, B. M., Malone, S. D., and Savage, W. U., 1972, Use of microearthquakes to determine mechanisms of faulting, stresses, and other source characteristics in the Nevada region: Physics Solid Earth, no. 12, p. 785-792.

Ryall, Alan, and Malone, S. D., 1971, Earthquake distribution and mechanism of faulting in the Rainbow Mountains, Aloe Valley, Fairview Peak area, central Nevada: Journal of Geophysical Research, v. 76, no. 29, p. 7241-7448.

Ryall, Alan, and Priestley, Keith, 1975, Seismicity, secular strain, and maximum magnitude in the Excelsior Mountains area, western Nevada and eastern California: Geological Society of America Bulletin, v. 86, no. 11, p. 1585-1592.

Ryall, Alan, Priestly, K. F., Savage, W. U., and Koizumi, C. J., 1973, Cenozoic tectonics related to a paleosubduction zone under northern Nevada: Earth quake Notes, v. 44, no. 1-2, p. 77.

Ryall, Alan, Savage, W. U., and Slemmons, D. B., 1972, Seismic potential in the western Basin and Range/eastern Sierra Nevada region, Nevada and California: American Geophysical Union Transactions, v. 53, no.4, p. 442.

Ryall, Alan, Slemmons, D. B., and Gedney, L. D., 1966, Seismicity, tectonism, and surface faulting in the western United States during historic time: Seismological Society of America Bulletin, v. 56, no. 5, p. 1105-1135.

Sanders, C.O., and Slemmons, D. B., 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, v. 52, no. 1-4, p. 585-597.

Savage, J. C., and Church, J. P., 1974, Evidence for postearthquake slip in the Fairview Peak, Dixie Valley, and Rainbow Mountain fault areas of Nevada: Seismological Society of America Bulletin, v. 64, no. 3, part 1, p. 687-698.

Sbar, M. L., Barazangi, M., Dorman, J., Scholz, C. N., and Smith, R. B., 1972, Tectonics of the intermountain seismic belt, western United States; microearthquake seismicity and composite fault plane solutions: Geological Society of America Bulletin, v. 83, p. 13-28.

Scholz, C. H., Barazangi, M., and Sbar, M. L., 1971, Late Cenozoic evolution of the Great Basin, western United States as an ensialic inter-arc basin: Geological Society of America Bulletin, v. 82, p. 2979-2990.

Schwartz, D. P., Swan, F. H., III, Hanson, K. L., Knuepfer, P. L., and Cluff, L. S., 1979, Recurrence of surface faulting and large magnitude earthquakes along the Wasatch fault zone near Provo, Utah: Geological Society of America, Abstracts with Programs, v. 11, no. 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, v. 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, v. 37, p. 81-88.

Sill, W. R., Wilson, W., Bodell, J., Ward, S., and Chapman, D. S., 1977, Heat flow measurements in southern Utah and the northern Basin and Range-Colorado Plateau transition: American Geophysical Union Transactions, v. 58, no. 12, p. 1237-1238.

Slemmons, D. B., Basin and Range active faults: Unpublished manuscript.

Slemmons, D. B., 1957, Geological effects of the Dixie Valley Fairview Peak, Nevada earthquakes, December 16, 1954: Seismological Society of America Bulletin, v. 47, no. 4, p. 353-375.

Slemmons, D. B., 1959, Geologic setting for the Fallon-Stillwater earthquakes of 1954: Seismological Society of America Bulletin, v. 46, p. 4-9.

Slemmons, D. B., ed., 1966, Guidebook for Nevada earthquake areas: Mackay School of Mines, University of Nevada. Reno, 79 p.

Slemmons, D. B., 1966, Dixie Valley--Fairview Peak earthquake areas, trip No. 1, in Slemmons, D. B., ed., Guidebook for Nevada earthquake areas, p. A1-A43.

Slemmons, D. B., 1967, Pliocene and Quaternary crustal movements of the Basin-and-Range province, U.S.A.: Journal of Geoscience, Osaka City University, v. 10, p. 91-103.

Slemmons, D. B., 1977, State-of-the-art for assessing earthquake hazards in the United States; Report 6: Faults and Earthquake magnitude, Miscellaneous Paper S-73-1, 120 p.

Slemmons, D. B., and Brogan, G. E., 1973, Preliminary microzonation for surface faulting in the Reno-Carson City area, part 1, Character and pattern of active faults: Earthquake Notes, v. 44, no. 1-2, p. 32-32.

Slemmons, D. B., Gimlett, J. I., Jones, A. E., Greensfelder, Roger, and Koenig, James, 1964, Earthquake epicenter map of Nevada: Nevada Bureau of Mines, Map 29, scale 1:1,000,000.

Slemmons, D. B., Jones, A. E., and Gimlett, J. I., 1965, Catalog of Nevada earthquakes, 1852-1960: Seismological Society of America Bulletin, v. 55, p. 537-583.

Slemmons, D. B., and Ryall, Alan, 1966, Seismicity and prehistoric faulting of Nevada (in preparation).

Slemmons, D. B., Steinbrugge, K. V., Tocher, D., Oakeshott, G. B., and Gianella, V. P., 1959, Wonder, Nevada earthquake of 1903: Seismological Society of America Bulletin, v. 49, no. 3, p. 251-265.

Slemmons, D. B., Van Wormer, Douglas, Bell E. J., and Silberman, M. L., 1979, Recent crustal movements in the Sierra Nevada-Walker Lane region of California-Nevada, Part I, rate and style of deformation, in Whitten, C. A., ed., Recent crustal movements: Tectonophysics, v. 52, no. 1-4, p. 561-570.

Smith, B. E., Coakley, J. M., and Hamilton, R. M., 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, v. 62, no. 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.

Smith, R. B., 1975, Seismicity, crustal structure, and contemporary tectonics of the Basin-Range Rocky Mountains and Colordo Plateau: American Geophysical Union Transactions, v. 56, no. 12, p. 1058.

Smith, R. B., and Sbar, M. L., 1974, Contemporary tectonics and seismicity of the western United States with emphasis on the intermountain seismic belt: Geological Society of America Bulletin, v. 85, no. 8, p. 1205-1218.

Smith, R. B., 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., Arabase, W. I., Cook, K. L., and Richine, W. D., 1976, Detailed seismic monitoring of the Wasatch front, Utah: Seismological Society of America, 71st Annual Meeting, Abstracts with Programs v. 47, no. 2.

Smith, R. B., and Sbar, M. L., 1974, Contemporary tectonics and seismicity of the western United States with emphasis on the intermountain seismic belt: Geological Society of America Bulletin, v. 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, v. 71, no. 3, p. 703.

Speed, R. C., 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 Cogbill, A. H., 1979, Candeleria and other left-oblique dip faults of the Candeleria region, Nevada: Geological Society of America Bulletin, Part 1, v. 90, no. 2, p. 1149-1163.

Speed, R. C., and Howell, D. B., 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.

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, v. 78, p. 131-142.

Stewart, J. H., 1975, Origin of Basin and Range structure, a review: Geological Society of America, Abstracts with Programs, v. 7, no. 7, p. 1284.

Stewart, J. H., 1971, Basin and Range structure, a system of horsts and grabens produced by deep-seated extension: Geological Society of America Bulletin, v. 82, no. 4, p. 1019-1043.

Stewart, J. H., 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, v. 11, no. 3, p. 130.

Stewart, J. H., Albers, J. P., and Poole, F. G., 1968, Summary of regional evidence for right-lateral displacement in the western Great Basin: Geological Society of America Bulletin, v. 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, Schwartz, D. P., and Cluff, L. S., 1980, Recurrence of moderate to large magnitude earthquakes produced by surface faulting on the Wasatch fault zone, Utah: Seismological Society of America Bulletin, v. 70 (in press).

Swan, F. H., III, Schwartz, D. P., Cluff, L. S., Hanson, K. L., and Knuepfer, P. L., 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.

Swan, F. H., III, Schwartz, D. P., Hanson, K. L., Knuepfer, P. L., and Cluff, L. S., 1978, Recurrence of surface faulting and large magnitude earthquakes along the Wasatch fault, Utah (abstract): American Geophysical Union Transactions, V. 55, P. 1126.

Thompson, G. A., 1959, Gravity measurements between Hazen and Austin, Nevada, a study of Basin and Range structure: Journal of Geophysical Research, v. 64, p. 217-229.

Thompson, G. A., and Burke, D. B., 1973, Rate and direction of spreading in Dixie Valley, Bain and Range province, Nevada: Geological Society of America Bulletin, v. 84, no. 2, p. 627-632.

Thompson, G. A., and Burke, D. B., 1974, Regional geophysics of the Basin and Range province, in Donath, F. A., Stehli, F. G., and Wetherill, G. W., eds., Annual Review of Earth and Planetary Sciences: Palo Alto, California, v. 2, p. 213-235.

Thornbury, W. D., 1965, Regional geomorphology of the United States: New York, John Wiley, 609 p.

Tocher, Don, 1957, The Dixie Valley-Fairvie Peak earthquakes of December 16, 1954, Introductions: Seismological Society of America Bulletin, v. 47, no. 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, v. 49, no. 1.

Von Hake, C. A., 1974, Earthquake history of Nevada: Earthquake Information Bulletin, v. 6, no. 6, p. 26-29.

Wallace, R. E., 1977, Fault scarps formed during the earthquakes of October 2, 1915, Pleasant Valley, Nevada: U. S. Geological Society Professional Paper 49 p. (in press).

Wallace, R. E., 1976, Seismicity of north-central Nevada on the basis of young fault scarps: Seismological Society of America, 71st Annual Meeting, Abstracts, v. 47, no. 2, p. 21.

Wallace, R. E., 1975, Fault scarp geomorphic and seismic history, north-central Nevada: Geological Society of America, Abstracts with Programs, v. 7, no. 3, p. 385.

Wallace, R. E., 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.

Wallace, R. E., 1977b, Profiles and ages of young fault scarps, north-central Nevada: Geological Society of America Bulletin, v. 88, p. 1267-1281.

Wallace, R. E., 1978a, Geometry and rates of change of fault-generated range fronts, north-central Nevada: U.S. Geological Survey Journal of Research, v. 6, no. 5, p. 637-649.

Wallace, R. E., 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.

Wallace, R. E., 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.

Wallace, R. E., 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, v. 52, no. 1-4, p. 559.

Wallace, R. E., 1980, Active faults, paleoseismicity, and earthquake hazards: Seventh World Conference on Earthquake Engineering, Istanbul, Turkey, September 1980, 8 p.

Wechsler, D. S., and Smith, R. B., 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 Lange, A. L., 1966, The distribution of earthquake aftershock foci, Cache Valley, Utah, September 1962: American Geophysical Union Trasnactions, v. 47, p. 428.

Whitten, C. A., 1956a, Geodetic measurements in the Dixie Valley area: Bulletin Seismological Society of America, p. 321-325.

Whitten, C. A., 1956b, Crustal movement in California and Nevada: American Geophysical Union Transactions 37, p. 393-398.

Williams, J. S., and Tapper, M. L., 1953, Earthquake history of Utah, 1850-1949: Seismological Society of America Bulletin, v. 43, p. 191-218.

Woodward-McNeill and Associates, 1974, Information concerning site charateristics, 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 Geophysics 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.

Wright, L., 1976, Late Cenozoic fault patterns and stress fields in the Great Basin and westward displacement of the Sierra Nevada block: Geology, v. 4, no. 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, STanford, California, 259 p.

Zoback, M. L., 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 v. 11, no. 3, p. 137.

Zoback, M. L., and Thompson, G. A., 1976, Evidence of left-lateral slip on Basin and Range faults: Geological Society of America, Abstracts with Programs, v. 8, no. 6, p. 1182.

Zoback, M. L., and Thompson, G. A., 1978, Basin and Range rifting in northern Nevada, clues from a mid-Miocene rift and its subsequent offsets: Geology, v. 6, no. 2, p. 111-116.

Zoback, M. L., and Zoback, M. D., 1978, Faulting patterns in north-central Nevada and strength of the crust: American Geophysical Union, Transactions, v. 59, no. 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 America Bulletin, v. 47, no. 4, p. 387-396.

CHAPTER 5.0 REFERENCES

I. Literature Cited

Buol, S.W., F.D. Hole and R.J. McCracken. Soil Genesis and Classification. Ames: Iowa State University Press, 1973.

Clyde, Calvin G., C.E. Israelsen, P.E. Packer, E.E. Farmer, J.E. Fletcher, E.K. Israelsen, F.W. Haws, N.V. Rao and J. Hansen. Manual of Erosion Control Principles and Practices During Highway Construction. Hydraulics and Hydrology Series UWRL/H-78/02. Utah Water Research Laboratory. Utah State University, Logan, Utah. June 1978.

HDR Sciences. "Environmental Characteristics of Alternative Designated Deployment Areas: Atmospheric Resources." ETR-700, Santa Barbara, California. 1980.

HDR Sciences. "Environmental Characteristics of Alternative Designated Depolyment Areas: Vegetation". ETR-705. Santa Barbara, California. 1980.

Lotspeich, F.B. and Coover, J.R. "Soil Forming Factors on the Llano Estacado: Parent Material, Time and Topography," Tex. Journal of Sci., 14:7-17. 1962.

Maker, H.J., H.E. Dregne, V.G. Link, and J.U. Anderson. Soils of New Mexico. Agricultural Experiment Station, Research Report 285. New Mexico State University, Las Cruces, New Mexico, September, 1974.

Master, William A. "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. July 1980.

Nevada State Engineer's Office, 1971. Water for Nevada: Reconnaissance Soil Survey, Railroad Valley. Water Planning Report, Nevada Department of Conservation and Natural Resources, Carson City, Nevada.

Stephens, Jerry C. Hydrologic Reconnaissance of the Wah Wah Valley Drainage Basin, Millard and Beaver Counties, Utah, Technical Publication No. 47, State of Utah, Dept. of Natural Resources, 1974.

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

U.S. Soil Conservation Service. "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, 1969.

U.S.D.A. Soil Conservation Service. Advisory--SOILS--6. From Kenneth E. Grant, Administrator on Soil Erodibility and Soil Loss Tolerance in the Universal Soil Loss Equation. Feb. 6, 1973.

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

U.S.D.A. Soil Conservation Service. "General Soil Map for White Pien County, Nevada." Reno, Nevada. January, 1976.

U.S.D.A. Soil Conservation Service. Guides for Erosion and Sediment Control in Nevada. Reno, Nevada. August 1976.

U.S.D.A. Soil Conservation Service. 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. July 1977.

U.S.D.A. Soil Conservation Service. Soil Survey of Delta Area, Utah: Part of Millard County. U.S. Government Printing Office, Washington, D.C., May 1977.

U.S.D.A. Soil Conservation Service. Soil Survey of Hartley County, Texas. U. S. Government Printing Office, Washington, D.C. December, 1977.

U.S.D.A. Soil Conservation Service. 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.

U. S. Department of Interior, Bureau of Land Management. Final Environmental Statement: Proposed Domestic Livestock Grazing Management Program for the Caliente area. Las Vegas District, Nevada. September 1979. pp. 2-6 to 2-15.

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

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

Woodward-Clyde Consultants. "Geologic and Hydraulic Comparison between Basing Modes," M-X Milestone II, Volume IV, Baseline-CES-Draft, April 10, 1978.

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

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

Chaffee, M.A., Forn, C.L., Hassemer, J.R., Hoffman, J.D., Mosier, E.L., Nishi, J.M., O'Leary, R.M., Siems, D.F., Turner, R.L., Welsch, E.P., and VanTrump, G. Jr. "Geochemical Analysis of Rock and Soil Samples, Eureka Mining District and Vacinity, Eureka and White Pine Counties, 32 Nevada." U.S. Geological survey, Open File Report No. 78-790. 1978. 117 p.

HDR Sciences, Environmental Characteristics of Alternative Designated Deployment Areas: Atmospheric Resources, ETR-13, 1980.

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

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

U.S.D.A. Soil Conservation Service. Soil Survey of the Pahranagat-Penoyer Areas, Nevada. U.S. Government Printing Office, Washington, D.C. April 1968.

U.S.D.A. Soil Conservation Service. Soil Survey Laboratory Data and Descriptions for Some Soils of Nevada. Soil Survey Invest. Report No. 23. Washington D.C., May, 1970. 219 p.

U.S.D.A. Soil Conservation Service. Nevada Soil and Water Conservation Needs Inventory. Nevada Conservation Needs Committee, Reno, Nevada. July 1970.

U.S.D.A. Soil Conservation Service. Utah Conservation Needs Inventory Report. Utah Cosnervation Needs Committee. 1970.

U.S.D.A. Soil Conservation Service. Soil Survey of Beaver-Cove Fort Area, Utah: Parts of Beaver and Millard Counties. U.S. Government Printing Office, Washington, D.C. May 1976.

U.S.D.A. Soil Conservation Service. Soil Survey of Big Smokey Valley Area, Nevada: Part of Nye County. U.S. Government Printing Office, Washington, D.C. February 1980.

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

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

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

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

U.S.D.A. Soil Conservation Service. Soil Survey of Armstrong County, Texas. U.S. Government Printing Office, Washington, D.C. 1965.

U.S.D.A. Soil Conservation Service. Soil Survey of Bailey County, Texas. U.S. Government Printing Office, Washington, D.C. 1963.

U.S.D.A. Soil Conservation Service. Soil Survey of Briscoe County, Texas. U.S. Government Printing Office, Washington, D.C. 1977.

U.S.D.A. Soil Conservation Service. Soil Survey of Castro County, Texas. U.S. Government Printing Office, Washington, D.C. 1974.

U.S.D.A. Soil Conservation Service. Soil Survey of Cochran County, Texas. U.S. Government Printing Office, Washington, D.C. 1964.

U.S.D.A. Soil Conservation Service. Soil Survey of Dallam County, Texas. U.S. Government Printing Office, Washington, D.C. March 1975.

U.S.D.A. Soil Conservation Service. Soil Survey of Deaf Smith County, Texas. U.S. Government Printing Office, Washington, D.C. August 1968.

U.S.D.A. Soil Conservation Service. Soil Survey of Hale County, Texas. U.S. Government Printing Office, Washington, D.C. August 1974.

U.S.D.A. Soil Conservation Service, Washington, D.C. Soil Survey of Harding County, New Mexico. U.S. Government Printing Office, Washington, D.C., 1973.

U.S.D.A. Soil Conservation Service. Soil Survey of Hockley County, Texas. U.S. Government Printing Office, Washington, D.C. August 1965.

U.S.D.A. Soil Conservation Service. Soil Survey of Lamb County, Texas. U.S. Government Printing Office, Washington, D.C., 1962.

U.S.D.A. Soil Conservation Service. Soil Survey of Lea County, New Mexico. U.S. Government Printing Office, Washington, D.C., January 1974.

U.S.D.A. Soil Conservation Service. Soil Survey of Lubbock County, Texas. U.S. Government Printing Office, Washington, D.C. April 1979.

U.S.D.A. Soil Conservation Service. Soil Survey of Moore County, Texas. U.S. Government Printing Office, Washington, D.C., March 1975.

U.S.D.A. Soil Conservation Service. Soil Survey of Parmer County, Texas. U.S. Government Printing Office, Washington, D.C. May 1978.

U.S.D.A. Soil Conservation Service. Soil Survey of Potter County, Texas. U.S. Government Printing Office, Washington, D.C. February 1980.

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

U.S.D.A. Soil Conservation Service. Soil Survey of Tucumcari Area, New Mexico: Northern Quay County. U.S. Government Printing Office, Washington, D.C. November 1974.

U.S.D.A. Soil Conservation Service. Soil Survey of Randall County, Texas. U.S. Government Printing Office, Washington, D.C., June 1970.

U.S.D.A. Soil Conservation Service. Soil Survey of Roosevelt County, New Mexico. U.S. Government Printing Office, Washington, D.C. March 1967.

U.S.D.A. Soil Conservation Service, Soil Survey of Sherman County, Texas. U.S. Government Printing Office, Washington, D.C., July 1975.

U.S.D.A. Soil Conservation Service. Soil Survey of Swisher County, Texas. U.S. Government Printing Office, Washington, D.C. December 1974.

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.

Heylmun, E. R., 1965, Reconnaisance of the Tertiary sedimentary rocks in western Utah, Utah Geological and Minerological Survey, Bulletin 75.

Hunt, C. B., Varnes, H. O., and Thomas, H. E., 1953, Lake Bonneville: Geology of Northern Utah Valley, Utah, U.S. Geological Survey Prof. Paper 257-A.

Madsen, I. H., 1980, State Paleontologist of Utah, written communication

____, 1980, , personal communication

Madsen, I. 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 Meade, G. E., 1945, Quaternary of the Texas High Plains, University of Texas Publication 4401.

Frye, I. C., and Leonard A. B., 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 Frye, I. C., 1975, Pliocene and Meistocene Deposits and Molluscian Faunas, East-Central New Mexico, New Mexico Bureau of Mines and Mineral Resources, Memoir 30.

Leonard, A. B. and Frye, I. C., 1978, Paleontology of the Ogallala Formation, northeastern New Mexico, New Mexico Bureau of Mines and Mineral Resources, Circular 161.

Savage, D. E. and Johnston, C. S., 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 Montgomery, J. L., 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 Est____, Fort Burgwin Research Center, Number 1

Wendorf F., Hester, J. J., 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

None

CHAPTER 9.0 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., Vol. 82, No. 5, p. 11791205.

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., No. 158, p. 1-7.

Cook, H. E., 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; McCarthy J. Howard Jr; Rytuba, James J., 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., 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, 28 p.

Gorbundy, N. I., Dobrovitskiy, A. V., 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, V. 49, Nos. 9-10, p. 1366-1387.

Heiken, G. H., Bevier, M. L., 1979. "Petrology of Tuff Units from the J-13 Drill Site, Jackass Flats, Nevada," Los Alamos Sci. Lab., Rpt. No. LA-7563-MS, 55 p.

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., Shepard, A. D., 1965. "Zeolite Zoning in Volcanic Rocks at the Nevada Test Site, Nye County, Nevada (Abs), "Am. Mineralogist, V. 50, Nos. 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., V. 127, No. 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, vol. 31, no. 1, p. 74-82.

Moiola, Richard J., 1970. "Authigenic Zeolites and K-Feldspar in the Esmeralda Formation, Nevada," Am. Mineral, Vol. 55, No. 9-10, p. 1681-1691.

Mumpton, F. A., and R. A. Sheppard, 1972. "Zeolites," Geotimes. 17:16-17.

Mumpton, F. A., 1973. "First reported occurrence of zeolites in sedimentary rocks of Mexico." Am. Mineral, 58:287-290.

Papke, K. G., 1972. "Erionite and other associated zeolites in Nevada." Nev. Bur. Mines and Geol. Bull. 79, 32 pp.

Pitman, J. K., Fouche, T. D., 1978. "Mineralogic Characteristics of Some Lower Tertiary Low-Permeability Reservoir Rocks, South-Central Uinta Basin, Utah (Abstr)," Am. Assoc. Pet. Geol., Bull. Vol. 62, No. 5, p. 891.

Robinson, P. T., 1966. "Zeolite Diagenesis of Mio-Pliocene Rocks of the Silver Peak Range, Esmeralda County, Nevada," Jour. Sed. Petrology, V. 36, No. 4, p. 1007-1015.

Sheppard, Richard A., 1973. "Zeolites in Sedimentary Rocks." U.S. Geol. Surv., Prof. Pap. No. 820:689-695.

Sheppard, Richard A., 1976. "Zeolites in Sedimentary Deposits of the Northwestern United States--Potential Industrial Minerals," Mont. Bur Mines Geol, Spec Publ. No. 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., Bray, Eldon, 1973. "Occurrence and Infrared Analysis of Unusual Zeolithis Minerals from Bingham, Utah," Mineral Rec. Vol. 4, No. 2, p. 67-72.

Stephens, J. D., Bray, Eldon, 1965. "Occurrence and Infrared Analysis of Unusual Zeolitic Minerals from Bingham. Utah (Abs)." Geol. Soc. America Spec. Paper 82, p. 195.

Surdam, R. C., Sheppard, R. A., 1976. "Zeolites in Saline Alkaline-Lake Deposits (in Zeolite '76; An International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites) (Abstr)," State Univ. Coll., Brockport, N.Y., p. 65-66.

Surdam, Ronald C., Robert H. Mariner, 1971. "The Genesis of Phillipsite in Recent Tuffs at Teels Marsh, Nevada (Abstr.)," Geol. Soc. Am., Abstr, Vol. 3, No. 7, p. 725.

Travnikova, L. S., B. P. Gradusov, and N. P. Chizhikova. 1973. "Zeolites in some soils." Sov. Soil Sci, 5:251.

Association of Zeolites and other Minerals or Mineraloids with Disease

Anderson, H. A., Selikoff, I. J., 1978. "Pleural Reactions to Environmental Agents," Fed Proc, 37 (11). 2496-2500.

Artyinli, M., Baris, Y. I., 1979. "Malignant Mesotheliomas in a Small Village in the Anatolian Region of Turkey an Epidemiological Study," Dep. Chest Dis., Sci. Med., Hacettepe Univ., Ankara, Turk., J. Natl Cancer Inst. 63(1), p. 17-23.

Ataman, G., 1978. "Zeolitied Tuffs of Cappadocia and their Probable Link with Certain Types of Lung Cancer and Pleural Mesothelioma," C.R. Hebd Seances Acad Sci Ser D Sci Nat, 287 (4), 207-210.

Baris, I., 1979. "Environmental Mesothelioma in Cappadocia Turkey," Meeting of the Thoracic Societies of Great Britain and France, Paris, France, June 8-10, 1979. Thorax (Thora), 34 (5), p. 693.

Baris, I., Elmes, P.C., Pooley, F.D., and Sahin, A., 1978. "Mesotheliomas in Turkey," Thorax (Thora), 33(4). 538.

Baris, Y. I., Sahin, A. A., Ozesmi, M., Kerse, I., Ozen, E., Kolacan, B., Altinors, M., and Goktepeli, A., 1975. "An Outbreak of Pleural Mesothelioma and Chronic Fibrosing Pleurisy in the Village of Karain Urgup in Anatolia," Thorax (Thora), 33 (2). p. 181-192.

Becklake, M. R., 1976. "Asbestos Related Diseases of the Lung and Other organs, their Epidemiology and Implications for Clinical Practice," Am Rev Respir Dis, 114 (1), 187-227.

Bohlig, H., Hain, E., 1973. "Cancer in Relation to Environmental Exposure," Bogovski, P., et. al. (Ed.), IARC (International Agency for Research on Cancer), Scientific Publication, No. 8, Biological Effects of Asbestos. Proceedings of a Working Conference. Lyon, France, Oct. 2-6, 1972. 217-221.

Bruckman, L., Rubino, R. A., and Chrstine, B., 1977. "Asbestos and Mesothelioma Incidence in Connecticut USA," J Air Pollut Control Assoc, 27 (2), 121-126.

Cameron, J. D., 1977. "Man-made Mineral Fibers in the Lungs" Br J Dis Chest, 71 (1). 67-68.

Epstein, S. S. 1974. "Environmental Determinants of Human Cancer," Cancer Res, 34 (10). 2425-2435.

Eramyan, S. G., Dashtoyan, A. K., and Sunguryan, N. N., 1974. "Functional State of the External Respiration of Patients with Tuff-induced Pneumoconiosis," Gig Tr Prof Zabol, (4) 49-51.

Harington, J. S., 1976. "The Biolgoical Effects of Mineral Fibers, Especially Asbestos as seen from In-Vitro and In-Vivo Studies," Ann Anat Pathol, 21 (2), 155-198.

Hinds, M. W., 1978. "Mesothelioma in the USA Incidence in the 1970's," J. Occup Med, 20 (7), p. 469-471.

Heppleston, A. G., "The fibrogenic action of silica."Br. Med. Bull. 25, No. 3:282-87, 1969.

APPENDIX I-A

EARTH RESOURCES INVENTORY BY COUNTY FOR NEVADA

CHURCHILL COUNTY

I. Metallics

(Hydrologic Unit No.)		
	1.	Active Mines (as of 1976):
128		Vandenburg Mine (Sb) T. 22 N, R 37E
	2.	Metal Mining Districts
133		Alpine (Ag, Au) T. 19 N, R 36 & 37E (E)**
133		Tungsten Mountain (W) T. 21 N, R 38E (E)
128		Wonder (Ag, Au, Cu) T. 18 N, 4 35E (D)
128		Chalk Mountain (Pb, Ag, Au) T. 17 N, R34E (E)
125		Westgate (Ag, Pb, Au) T. 17 N, R 35E (E)
124		Fairview (Ag, Au, Pb, Cu) T. 16 N, R 34E (E)
124		Sand Springs (Ag, Av, W) T. 16 N, R 32E (E)

II. Nonmetallic minerals

1. Active mines - none
2. Saline deposits
   A. Commercial deposits - Sand Springs Marsh (NaCl) T. 16 N, R 31E
   B. Playas
      Fairview Valley
      Edwards Creek Valley

III. Geothermal resource areas

1. No potential shown in M-X area

** 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.

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

ELKO COUNTY

I. Metallics

1. Active mines

186 Victoria mine (Cu) T. 28 N, R 66E

2. Metal mining districts

176 Valley View (W, Pb, Zn) T. 28 N, R 57 & 58E (D)

46 Lee (Cu) T. 30 N, $ 57 & 58E (E)

176 Ruby Valley (W, Pb, Zn, Ag, Cu) T. 30 N, R 38E (E)

178A Mud Springs (Pb, Ag) T. 28 N, R 60E (E)

178A Delker (Cu) T. 29 N, R 62E (E)

188 Spruce Mountain (Pb, Ag, Zn, Cu, Au, W) T. 31 N, R 63E (D)

186 & 187 Dolly Varden (Cu, Pb, Ag, Au) T. 19 N - R 66E (C)

32 Ferguson Spring (Cu) T. 29 N - R 69E (E)

32 White Horse (Pb, Ag, Zn) T. 28 N - R 68E (E)

186 Kinsley (Cu, W, Au, Ag, Pb) T. 26 N - R 68E (E)

32 Ferber (Cu, Pb, Ag, Au) T. 27 N - R 70E (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) T. 22 N, R 52E

153 Windfall mine (Au) T. 18 N, R 53E

2. Metal mining districts

153 Eureka (Pb, Au, Ag, Cu, Zn, Sb) T. 19 N, R 53E (B)

153 Alpha (Ag, Pb) T., 25 N, R 52E (E)

138 Roberts (Zn, Pb) T. 24 N, R 48E (E)

53 Antelope (Ag, Zn, Pb, Au, Cu) T. 23 N, R 50E (E)

153 Mount Hope T. 22 N, R 52E (E)

153 & 154 Diamond (Ag, Pb, Zn, Au, Cu) T. 22 N, R 54E (E)

139 Lone Mountain (Zn, Pb, Ag) T. 20 N, R 51E (E)

151 & 155 Fish Creek (Ag) T. 17 N, R 52E (E)

155 Gibellini (Mn) T. 15 N, R 52E (E)

II. Nonmetallic minerals

1. Active mines - none

2. Saline deposits

153 Williams Marsh (NaCl) T. 26 N, R 53E

153 Diamond Valley ($NaSO_4$) T. 24 N, R 54E

III. Geothermal resource areas

Moderate industrial process heat potential, low residential space heating potential shown in Antelope Valley, T. 18 & 19 N, R 50E.

IV. Oil and gas fields

One dry exploratory hole in M-X area

Heavy oil and gas leasing activity in Little Smokey Valley - T. 16 N, R 53 & 54E; T. 15 N, R 52, 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, Cr) T. 2 & 3 N, R 42E (B)

137A Crow Springs T. S N, R. 39 E (E)

136 Gilbert (Au, Ag, Cu, Hg) T. 4 N, R 39E (E)

143 Lone Mountain (Pb, Cu, Zn) T. 2 N, R 40W (E)

137A Weepah (Au, Ag) T. I N, R 40W (D)

II. Nonmetallic minerals

1. Active mines - none

2. Saline deposits

142 Alkali Spring Valley (NaCl) T. IS, R 41E

143 Silver-Peak Marsh (NaCl, Li) T. 1 & 2S, R 40E

3. Other playas

136 T. S H, R 37W (unnamed)

Big Smoky Playa, T. 2 N, R 38 & 39E

III. Geothermal resource areas - Possible potential from Silver Peak (T. 25, R 39E)

IV. Oil and gas fields - none

LANDER COUNTY

I. Metallics

1. Active mines

57 Thomas W. (Au, Ag) T. 20 N, R 30E

57 Maren (Au) T. 20 N, R 40E

2. Metal mining districts

56 & 137B Austin-Reese River (Au, Ag, U) T. 19 N, R 44E (C)

137B Spencers Hot Spring (W) T. 17 N, R 46E (D)

137B Ravenswood (Ag, Au) T. 22 N, R 42E (E)

56 Skookum (Ag, Au) T. 19 N, R 43E (E)

134 New Pass (Au, Mn, Ag, Pb) T. 20 N, R 40E (E)

56 Big Creek (Sb) T. 17 N, R 43E (D)

137B Birch Creek (W, Au, Ag, U) T. 18 N, R 44E (E)

134 Gold Basins (Au, Ag) T. 16 N, R 38E (E)

137B Kingston (Au, Ag) T. 16 N, R 43E (E)

II. Nonmetallic minerals

1. Active mines:

56 Allen mine (Barite) T. 21 N, R 42E

2. Saline deposits - None commercially valuable

3. Other playas

Grass Valley (T. 23, 24, 25 N, R 47 & 48E)

Smith Creek Valley (T. 16 & 17 N, R 39 & 40E)

III. Geothermal resource areas

1. Moderate industrial process heat potential, low residential space heating potential shown in Smith Creek Valley (T. 17 N, R 39E)

2. Moderate industrial process heat potential, low residential space heating potential shown in N and Big Smokey Valley (T. 17 N, R 45E)

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) T. 7 N, R 68E

170 Tempiute mine (W) T. 3S, R 56E

181 Pan American mine (Pb-Ag) T. 1S, R 66E

2. Metal mining districts

(Colo River)	Pioche (An, Pb, Ag, Au, Mn, Cu, Fe) T. IN, R 67E (B)
183	Patterson (Ag, Au, Pb, Cu) T. 9N, R 65E (E)
184	Atlanta (Au, Ag, U) T. 7 N, R 68E (E)
181 & Colo River (C)	Jack Rabbit (Cu, Ag, Pb, Mn, An, Au) T. 3 N, R 65 & 66E
181	Lone Mountain (Ag) T. IN, R 65E (E)
181	Comet (Ag, Zn, Pb, Au, Cu, W) T. IS, R 66E (E)
53	Eagle Valley (Au, Ag, Pb, Cu) T. IN, R 70 & 71E (E)
172	Frieberg (Au, Ag, Pb, Zn) T. IN, R 57E (E)
170	Tem Piute (W, Ag, Zn, Pb) T. 3 & 4S, R 56 & 57E (C)
(Colo River)	Pahranagat (Mn, Ag, Pb, Cu, Au) T. 3S, R 39E (E)
(Colo River)	Chief (Au, Ag, Pb, Cu) T. 3S, R 67E (E)
182	Delamar (Au, Ag) T. 5 & ¢ S, R 64 & 65E (C)
(Colo River)	Vigo (Mn) T. 8 S, R 68F (E)
(Colo River)	Viola (Au, Ag, Cu, Pb) T. 10 S, R 69E (E)

II. Nonmetallic minerals

1. Active mines:

182 Mackie mine (Perlite) T. 4S, R 62E

2. Saline deposits:

None commercially valuable

3. Other playas:

Cave Valley (T. 5 & 6 N, R 63E)

Dry Lake Valley (T. 2S, R 64E)

Coal Valley (T. IN & IS, R 59 & 60E)

Sand Spring Valley (T. 2 & 3 S, R 55E)

Delamar Playa (T. 7S, R 62 & 63E)

III. Geothermal resource areas

1. Moderate industrial process heat potential, moderate residential space heating potential shown at Caliente (T. 3 & 4 S, R 67E)

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 (R 63E, T. 4, 6, & 7S; ???? T. 4, 5, 6, and 7S)

   Dry Lake Valley (R 63E, T. 1 and 2S; ???? T. IN, 1, 2, & 3S; R 65E, T. IN, 1, 2, & 3S)

   Lake Valley (R 65E, T. 6, 7, 8 and 9 ???? T. 3, 4, 5, 6, 7, 8 & 9 N; R 67E, T. 2, 3, 4, 5, 6 & 7 N; ???? T. 1 & 2 N)

   Spring Valley (R 67E, T. 9N; R 68E, T. 9N)

   Hamlin Valley (R 69E, T. 7, 8, & 9 N; ???? T. 6, 7, 8, & 9 N)

   Muleshoe Valley (R 63E, T. 4 & 5 N; R 64E, T. 5 & 6 N; R 64E, T. 5 & 6 N; R 65E, T. 5 & 6 N)

   Cave Valley (R 63E, T. 6, 7, 8, & 9 N; R 64E, T. 6, 7, 8, & 9 N)

   White River Valley (R 62E, T. 2, 3, 7, 8 & 9 N)

   Coal Valley (R 59E, T. 1 & 2S, 1 & 2 N, R 60E, T. IS, 1 & 2 N)

   Garden Valley (R 57E, T. IS, 1 & 2 N; ???? T. IS, 1 & 2 N)

   Penoyer (Sand Spring) Valley (R 54E, T. 3 & 4 S; R 55E, T. 1, 2, 3, & 4 S, T. IN; R 56E, T. 1, 2, 3, & 4S, T. IN; 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. IN, 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 know claim activity.

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

    Patented claims. In T. IN, 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. IN, 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. IN, 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 AMAX within the next year or two, which is much bigger.
	Tonopah. Great bonanza district of early 1900's. (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)
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)

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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. IN, R 50E (E)

148 Silver Bow (Ag, Au, Pb) T. IN, 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 Smokey Playa (T. 13 & 14 N, R 43 & 44E).

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

Railroad Valley (Na_2CO_3) 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. IS, R 43 & 44E.

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

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)
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)

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 Springfield, Railroad Valley, T. 9 N, R 56E.

Eagle Springs field production to 1970 (1954 - 1970 cumulative): 2.5 million barrels (397,250 m^3).

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. 25, 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. IN, R 51 & 51½E; T. IS, 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. IN, R 53E; 1 site in T. IS, 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. IN, 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 A - 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

1. 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 SW¼ T. 10 N, R 64E.

3. Steptoe Valley

Unpatented claims in SE¼ T. 15 N, R 63E: NE¼ T. 14 N, R 63E; NW¼ T. 14 N, R 64E.

VII. Geothermal leasing activity - None known

APPENDIX I-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 & 9W.
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 miles (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. kSeveral 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 & 5 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.

Patended 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.

(Watershed 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.

(Watershed No.)	District
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 genstone 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 prodcued 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 #., 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. 18 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 Bever 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 expecially 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., 12W.; 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, 17, & NW section of 19W.; 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 Creeks, eroded from the Rocky Mountains. In places, river channels have roded through the Ogallala to the underlying Paleozoic or Traissic rocks.

In the New Mexico area, vertebrate remains are scarce, and the most common fosils are molluscs, gastropods, and seeds. Seeds are the most widespread fossils in the Ogallala in New Mexico and even those are uncommon. (Leonard and Frye, 1970). The only areas of paleontologic 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 Pliocene and early Pleistocene age. The presence of these localities should not constrain the placement of the operating bases.

6.3 M-X IMPACTS NEVADA/UTAH

DIRECT IMPACTS (6.3.1)

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

With the exact locations of the M-X facilities yet to be determined, impacts

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 I-C

MINING CLAIMS PER COUNTY IN NEVADA

(All claims most probably for metals)

Reference: "Woodward Report"

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 I-D

EARTH RESOURCES

MINING CLAIMS PER COUNTY IN UTAH

Reference: "Woodward Report"

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. 135., 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 - fluorite. 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 aggregate. 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. <u>Tooele County</u>

Sevier Desert

T. 10 S, R. 6W. 56 claims. Metals. Secs. 29-31.

T. 10 S, 4, 7W. 4 claims. Metals. Secs. 25.

APPENDIX I-E

EARTH RESOURCES INVENTORY

UTAH STATE LANDS CONTAINING MINERAL LEASES

Reference: "Woodward Report"

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 (SE¼) (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 - topza - 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. Wah-Wah 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).

T. 19S, R. 18W. Sec. 32 (building stone).

6. Snake Valley.

TOOELE COUNTY

1. Fish Springs Flat.

T. 9S, R. 12W. Sec. 32 (metals).
Sec. 32 (fluorspar).

APPENDIX II

Assume: 10% by volume of zeolite (5 in length) in substrate:

90% voids
plus
other particulates

10% zeolite

1 m^3 of substrate = $10^6 cm^3$;

Zeolite (per m^3 of substrate) = $10^6 cm^3 \times .10 = 1 \times 10^5 cm^3$

Assume average volume of zeolite particles is representable as follows:

$$\text{volume } (cm^3) = \quad r^2h = \quad \left(\frac{.0001}{2}\right)^2 (.001) = 7.85 \times 10^{-12} \ \frac{cm^3}{\text{particle}}$$

10
(.01 mm)
(.001 cm)

1
(.001 mm)
(.0001 cm)

<u>Number of zeolite particles/m^3 of substrate:</u>

$$\frac{1 \times 10^5 cm^3 \text{ zeolite}/m^3 \text{ substrate}}{7.85 \times 10^{-12} \ cm^3/\text{particle}} = 1.27 \times 10^{16} \ \frac{\text{particles of zeolite}}{m^3 \text{ substrate}}$$

Per cm^3 substrate:

$$1.27 \times 10^{16} \frac{p}{m^3} \times \frac{m^3}{10^6 cm^3} = 1.27 \times 10^{10} \ \frac{\text{particles zeolite}}{cm^3 \text{ substrate}}$$

Assume: 1% by volume of zeolite (5 length) in substrate:

Zeolite = $10^6 cm^3 \times .01 = 1 \times 10^4 cm^3$

$$\frac{1}{10^6} \times \frac{1 \times 10^4}{7.85 \times 10^{-12}} = 1.27 \times 10^9 \text{ particles zeolite/cm}^3 \text{ substrate}$$

Assume: 0.1% by volume zeolite (5 length) in substrate:

Zeolite = $10^6 cm^3 \times .001 = 1 \times 10^3 cm^3$

$$\frac{1}{10^6} \times \frac{1 \times 10^3}{7.85 \times 10^{-12}} = 1.27 \times 10^8 \text{ particles/cm}^3$$

For Air Quality Analysis

1) Mass ratio $\dfrac{\text{zeolites}}{\text{substrate}} = \dfrac{2.0 \text{ gm/cm}^3}{2.5 \text{ gm/cm}^3} \dfrac{\text{density of zeolite}}{\text{density of soil substrate}}$

2) for soil containing 1% zeolite by volume; 2.0×10^4 gm/m^3; mass of zeolite per volume of soil

3) m^3 soil = 2.5×10^6gm

4) mass ratio = $\dfrac{2.0 \times 10^4}{2.5 \times 10^6} = .008$

5) to convert gm/m^3 to # particles in air suspension for zeolites:

A) gm zeo/m^3 per = $\dfrac{\text{(reading)} \times .008}{10^6 \ \frac{g}{g}}$; reading = gm soil m^3 of air (i.e., concentration)

B) $$\text{cm}^3\ \text{zeo/m}^3 = \frac{\text{gm zeo}}{\text{m}^3} \times \frac{1\ \text{cm}^3}{2.0\ \text{gm}}$$

C) $$\#\ \frac{\text{particles}}{\text{m}^3} = \frac{\text{cm}^3\ \text{zeo}}{\text{m}^3} \times \frac{1\ \text{particle}}{7.85 \times 10^{-12}\ \text{cc zeo}}$$

$$\therefore\ \#\ \frac{\text{particles}}{\text{m}^3} = \frac{(\ )\ \text{g}}{\text{m}^3} \times 5.1 \times 10^2\ \frac{\text{particle}}{\text{g}}$$

So a dust concentration of 1000 g/m^3 yields a potential zeolite concentration of 510,000 particles/m^3 for a source substrate containing 1 percent zeolite by volume.

NATIVE AMERICANS: Ancestral/Sacred Sites and Areas

Consequences Which Are Specific to an Individual Environmental Variable

1. To what extent will the effect alter the carrying capacity of the environment for the resource?

1	2	3	4	5
no change in carrying capacity		some reduction in carrying capacity		major reduction in carrying capacity

N/A

2. What is the effect of the disturbance on the integrity of the resource?

1	2	3	4	5
no change in viability		some decrease in viability		major decrease in integrity

Due to the long temporal association of Native Americans with the deployment area, ancestral/scared sites have a broad and relatively dense distribution. It is projected that 80 percent of this cultural resource base will be lost as a result of project deployment. Approximately 35 percent of these sites will be disturbed during construction. The major disturbance will occur from indirect impacts during the life of the project, and beyond. Studies in the California desert indicate a 65-80 percent vandalism rate to such sites following the development of access routes to wilderness areas for recreational activities (i.e., ORV traffic).

3. **What is the effect of the disturbance on the quality of the resource?**

1	2	3	4	5
no loss in quality		some loss in quality		major loss in quality

Major loss in the quality of the resource will occur in two ways. First, direct impacts will result in the permanent loss of the resource, since these features are non-renewable. Second, indirect impacts associated with population influx will result in vandalism (secondary site loss through pot-hunting), and the defacement or partial disturbance of other sites. Quality from the Native American perspective refers to the extent to which such sites continue to function as a spiritual link to the ancestors, and as a resource for the preservation of traditional cultural systems. Quality from the perspective of the scientific community refers to the ability of the resource base to yield information about past and present cultural systems.

4. To what extant will the effect be masked by normal variation expressed by the resource?

1	2	3	4	5
completely masked		some masking		no masking

N/A

5. To what extent will the effect on the resource be masked by normal resource variability when the influence of potential future projects other than M-X are imposed?

1	2	3	4	5
completely masked		some masking		no masking

N/A

6. How rapidly will the resource recover from the disturbance effect if the effect is temporary?

1	2	3	4	5
rapid recovery		slow recovery		no recovery

N/A

7. How rapidly will the resource recover from the disturbance effect if the effect is permanent?

1	2	3	4	5
rapid recovery		slow recovery		no recovery

There is no recovery rate for ancestral/sacred sites. These resources are irretrievable, and the disturbance irreversible.

8. To what extent will the resource recover from the disturbance effect in a reasonable time period?

1	2	3	4	5
full recovery		moderate recovery		no recovery

N/A

9. To what extent will the resource recover from the effect when this effect is combined with other disturbances expected from M-X (cumulative effects)?

1	2	3	4	5
full recovery		moderate recovery		no recovery

N/A

10. How geographically widespread is the effect of the disturbance on the resource?

1	2	3	4	5
localized effect				widespread effect

Direct impacts resulting from ground disturbance will have a generalized local effect (Ranking of 2). The radius of disturbance is expected to average approximately one mile.

Indirect impacts are expected to affect regions far-removed from actual construction sites. The boundaries of this radius cannot be accurately predicted. Important variables include population in-migration and relative accessibility (proximity to new roadways, proximity to new or existing recreational facilities, compatibility of terrain with ORV activities, etc.). A ranking of 5 is appropriate to indirect impacts.

11. To what extent will the effect change the aesthetic value of the resource?

1	2	3	4	5
no change in aesthetic value		moderate decrease in aesthetic value		major decrease in aesthetic value

From the perspective of the Native American community, the proposed action will permanently mar the landscape and will destroy what are, in essence, the icons of their traditional religions. From the perspective of the scientific community and existing environmental laws which protect cultural resources, Disturbance or defacement of ancestral/sacred sites will destroy their dultural integrity, and thereby constitute a visual/aesthetic impact which must be mitigated. As indicated in Question 2 above, approximately 80 percent of the Native American cultural resource base is expected to be lost through direct and indirect impacts associated with the proposed action.

12. What is the scientific or intrinsic value of the resource?

1	2	3	4	5
low scientific or intrinsic value		moderate scientific or intrinsic value		high scientific or intrinsic value

Since very little is currently known about the prehistoric and early historic adaptations of Great Basin Indians, ancestral sites are extremely critical to accurate cultural and evolutionary reconstructions. The present integrity of this cultural resource base is high due to low population density and development in the study area. In addition, the continued use of sacred areas by contemporary Indians provides a critical data base for the development of cultural persistence theories in anthropology.

Issue 1
Competition for Resources

1. How does a change in the effect affect the viability of the resource?

1	2	3	4	5

N/A

2. To what extent will the resource continue to be usable with the same level of quality or capacity for renewal that it previously had?

1	2	3	4	5
no reduction in usefulness to humans		partial reduction in usefulness to humans		major reduction in usefulness to humans

Due to the anticipated 80 percent loss of ancestral/sacred sites over the long-term, a major reduction is projected. For Native Americans, usefulness applies to their access to sacred sites and sacred materials for religious rites (guaranteed under the American Indian Religious Freedom Act) and access to cultural resources for curation and display at tribal museums (probable competition with land management agencies for ownership of artifacts excavated in data recovery programs). Usefulness from a scientific perspective refers to distruption of the integrity of the cultural resource data base. Particularly with reference to indirect impacts, sites lost through vandalism represent an irretrievable loss of information vital to the reconstruction of past human adaptations.

3. What is the extent to which the resource will become limited to the point threatening the carrying capacity of the area or developmental trends which have already been in motion for some historic period of time.

1 2 3 4 5

N/A

Issue 2
Constraint on Future
Development Opportunities

1. Is the change in the effect observable relative to the potential variations in the baseline or trust or other competitors for these development opportunities.

1 2 3 4 5

N/A

2. To what extent does the change in the effect produce a developmental constraint that is observable?

1 2 3 4 5

N/A

3. To what extent does the change in the effect variable degrade the environmental resource which is or would be needed by other competitors?

1	2	3	4	5
no constraint on other future uses		moderate constraint on other future uses		major constraint on other future uses

see Issue 1, Question 2

4. To what extent does the change in the environmental variable when combined with competing opportunities cause a considerable stress on some portion of the environment which would not occur if the competition were not there or if constraints were imposed on the developmental directions for the various interested competitors.

1	2	3	4	5

N/A

5. To what extent is the change in the effect variable a significant modifier of other developmental actions which are planned to take place. For example, will it compete for the same space, will it cause that space to be unusable, will it require stress on limited resources, changes in transportation of goods, etc.?

1 2 3 4 5

N/A

Issue 3
Stress on Growing Communities

1. Is the change in the effect variable large or the same value as established standards for this particular effect?

1 2 3 4 5

N/A

2. Is there a reasonable opportunity for recovery from changes in this effect in a reasonable period of time?

1 2 3 4 5

N/A

3. Will the quality of the area necessarily have to be changed in order to accommodate the changes in these effects?

1 2 3 4 5

N/A

4. Will the change in these effects levels produce a permanent change in some sector of the environment and if so will that change be in total contrast with other induced changes already in process for the future development of the area or will these permanent changes be in concert with other expected changes?

1 2 3 4 5

N/A

5. Will the change in the effect level be significant within the context of the uncertainties of the growth pattern of the impacted regions? That is, if one assumes a 10 percent potential fluctuation in either the compositional structure of the demographics or in the absolute value of the population growth will the changes due to M-X be significantly larger or approximately the same amount of much smaller than this 10 percent absolute change?

1 2 3 4 5

N/A

6. Will growth trends in the area in terms of sectoral composition, population density, urban-rural transitions, and other uses of the land be modified significantly by M-X or will M-X's changes fit within the predicted trends for these areas?

1 2 3 4 5

N/A

7. Will planning for these areas require significant funding specifically for the properties and requirements of M-X or can they be included in umbrella types of funding which would include the future plans of the area and those requirements of M-X which add stress to the growing communities?

1 2 3 4 5

N/A

8. Will M-X require significant additional short-range planning or planning significantly accelerated relative to the planning required for the future development of the area?

1 2 3 4 5

N/A

9. To what extent will funding be required to mitigate the effect on the resource?

1	2	3	4	5
no funding required to mitigate		moderate funding required to mitigate		major funding required to mitigate

Mitigation for impacts to Native American cultural resources will take three major forms: (1) data recovery, (2) on-site preconstruction survey, and (3) compensation to local trib·l communities in the form of the return of artifacts and provision for curation and display. Preconstruction survey and data recovery programs are mandated under federal regulations, and formalized in the cultural resources Programmatic Memorandum of Agreement. The excavation of sites which cannot be avoided is by far the most costly procedure, both in terms of expenditure and construction delays. There is no way at present to estimate the cost of data recovery programs, since the number, size, and type of sites which require this procedure is unknown. In addition to excavation, the Air Force will be financially responsible for storage, processing, and analysis of all recovered artifacts. Finally, curation of artifacts may involve considerable funding for the construction of tribal museums on local reservations, with curation and display facilities which meet the requirements of existing cultural resource laws.

10. To what extent will the effect on the resource have significant economic or social consequences on communities within the study area?

1	2	3	4	5
no significant economic or social consequences				major significant economic or social consequences

The major social consequence of project deployment on Native American communities in terms of cultural resource impacts concerns the viability of traditional religions. The study area composes the Holy Lands of the Shoshone and Southern Paiute peoples. The endangered cultural resources which it contains are the icons of these religious systems, and the spiritual links of contemporary Indians with their ancestors and creator Gods. The projected long-term destruction of these features as a direct or indirect result of deployment will, from the Native American viewpoint, permanently sever the relationship of modern peoples with the "ancient ones," and thereby destroy traditional belief systems and values. Traditionalists believe that spiritual retribution may accompany this process, and that the Indian people themselves may perish.

Issue 4
Preservation of Biophysical and Cultural Resources

1. What is the legal status of the resources?

1	2	3	4	5
no legal status	state protected (game & nongame)	state protected rare or endangered	proposed federally protected	federally protected resources

Native American ancestral/sacred sites are protected by a number of federal laws. These include the National Environmental Policy Act (Section 101(b)(4)) and the Council on Environmental Quality regulations (40CFR1500-1508, Sections 1501.7(a)(1), 1506.6(3)(ii), 1508.8(b), and 1508.14); the National Historic Preservation Act, Executive Order 11593, and 36CFR800-Protection of Historic and Cultural Properties (36CFR800(a)(1) and 36CFR800.15); and the American Indian Religious Freedom Act (Public Law 95-341). Compliance procedures are also outlined in the cultural resources Programmatic Memorandum of Agreement.

2. Will the effect potentially indirectly affect those resources which are legally protected?

1	2	3	4	5
minimal likelihood of affecting a legally protected resource		moderate likelihood of affecting a legally protected resource		high likelihood of affecting a legally protected resource

The bulk of long-term or indirect impacts to Native American ancestral/sacred sites is expected to occur during the operations phase of the project, and beyond. The DTN system will open isolated areas to public access on a previously unparalleled scale. Studies in comparable environments, such as the Mohave Desert (Lyneis, Weide, and Warner 1980), indicate that recent public use of the area for recreation has resulted in extremely high vandalism rates to rock art (80%), ancestral habitation sites (74-78%), ceremonial sites or structures (66%), and battlefields (65%). A comparable level of indirect disturbance is predicted for DDA valleys.

3. Will a change in the effect require either behavioral modifications or changes in life patterns in order to preserve the specific cultural resources?

1 2 3 4 5

There is no known way to effectively eliminate or substantially reduce the destruction and vandalism of sites which accompanies increased public recreational use of wilderness areas. This problem relates to the difficulty of monitoring or policing very large areas. Certain measures have been suggested, however, which may result in a degree of behavioral modification. First, an effort may be made to educate the public regarding the importance of cultural resources, and the necessity for preservation of remaining sites. Section I.G of the Programmatic Memorandum of Agreement states: "The Air Force ... will ensure that its contractors and Air Force personnel and resident dependents are advised against illegal collection of historic and prehistoric materials, will encourage those with interests in such materials to participate in nondestructive activities . . ." A second method may be the creation of restricted areas, such as National Parks, where cultural resources are known to be concentrated in the vicinity of expected population in-migration. The presence of a permanent monitoring staff may help to reduce vandalism and pilfering. Arrow Canyon, for example, which is located close to the Coyote Springs OB site, and which contains many features sacred to the Southern Paiute people and valuable to the scientific community, may be so designated.

4. Will a change in the effect lead to a permanent degradation of some portion of the ecosystem which the cultural resources depends on?

1 2 3 4 5

Secondary ground disturbance associated with population in-migration may create additional indirect impacts to ancestral/sacred sites. ORV activities are linked with the disruption of natural vegetation and the eventual development of serious erosion problems. Erosion results in the washing-out and destruction of surface sites. A second disruption of the ecosystem associated with population influx is increased construction activity and development of commercial, residential, and recreational facilities in previously undisturbed areas.

5. Will a change in the environment effect lead to a degradation of some portion of the ecosystem which contains resources needed for the preservation of a cultural or biological resource?

1 2 3 4 5

Ancestral/sacred resources also include certain plant and animal species which are central to traditional religious rites, and fall under the protection of the American Indian Religious Freedom Act. If water depletion or critical vegetation depletion disrupts the natural habitats of sacred plant or animal species in certain deployment area valleys, this effect may seriously limit access by Native Americans to sacred materials.

6. Will a change in the effect level cause a degradation in the quality or aesthetics of the particular resource that is to be preserved, and will this be a major or a minor change in the aesthetic or quality feature?

1	2	3	4	5
no degradation of quality or aesthetics		moderate degradation of quality or aesthetics		major degradation of quality or aesthetics

The destruction or defacement of Native American cultural sites also results in the loss of the spiritual quality of the feature. An element of the traditional cosmology is thereby degraded or removed. Moreover, in traditional belief, disruption of grave sites may result in retaliatory actions by spirits of the dead on living peoples. From the perspective of the scientific community, both the integrity and environmental context of the cultural resource are essential to its quality as a data source. Sites partially or totally disturbed by vandalism become useless for scientific reconstruction of past human adaptations.

General Consequences

1. Are the consequences such that the portion of the resource base will not recover at all?

1	2	3	4	5
no likelihood of irreparable damage to ecosystem		moderate likelihood		certain irreparable damage to resource base

Native American ancestral/sacred sites are non-renewable resources. It is projected that approximately 80 percent of the resource base will be lost through direct and indirect impacts of the undertaking (see above, Consequences Which are Specific to an Individual Environmental Variable, Questions 2, 7, 10; and Issue 4, Question 2).

2. Are the consequences such that the impact may be large, but the recovery processes will overcome the damage in a reasonable period of time?

1	2	3	4	5
full recovery		partial recovery		no recovery

N/A

3. Are the deleterious effects measurable? Variable rankings depending on type of effect:

1	2	3	4	5
not measurable		measurable with difficulty		readily measurable

Readily measurable: Direct impacts to sites distrubed and mitigated during construction may be easily inventoried.

Measurable with difficulty: Indirect impacts to known sites outside the areas of direct disturbance may be monitored and measured through longitudinal studies (i.e., a series of surveys over time to record the integrity or disturbance of such sites).

Not measurable: Two types of effects are not measurable. First, indirect impacts to unrecorded sites cannot be inventoried. Since the majority of sites in the study area are not documented, impacts to the larger portion of the total resource base are not directly measurable. Indirect measures may be projected from longitudinal studies on known sites only. A second type of effect, namely the impact of cultural resource loss on the social, cultural, and psychological fabric of Native American communities, cannot be quantified. Longitudinal studies, however, may indicate general trends.

4. Will a change in the effect change the functional relationships existing within the ecosystem and will this cause a change in either the carrying capacity or other characteristics of viability associated with the system?

1	2	3	4	5
no change in functional relationships		moderate change in relationships		major change in relationships

N/A

5. Do these deleterious effects or consequences result in degradation of other measurable environmental variables?

1 2 3 4 5

N/A

6. Although the environmental effect itself may not be significant within the framework of the first five criteria, will it when measured in conjunction with certain other critical environmental variables produce changes that are observable within the framework of the criteria of the five standards?

1 2 3 4 5

N/A

Significance Analysis of the Native American Resource Water Accessibility and Agricultural Land.

2. What is the effect of the disturbance on the integrity of the resource?

1	2	3	4	5
no change		some decrease		major decrease

Water use, in the Nevada/Utah DDA and Coyote Springs OB site during construction and operation could significantly reduce the water and land use value of the Duckwater and Moapa Reservations holdings. Construction demands in Railroad North and South Valleys, and Little Smokey North and South Valleys (adjacent to Duckwater holdings) total 12,600 acre feet. (Table Pubs #2394.) Although water resources in Railroad Valley are probably sufficient to accomodate the 8,400 acre feet required there (State of Nevada Department of Reference Conservation and Natural Resource Water Resources - Water Reconnaissance Series Report 60), springs and wells on the Duckwater Reservation and its BLM permit grazing lands could be affected by local localized draw down, as could native pherophenic vegetation. Irrigation and stock watering could be at risk, for at least the short term. The Moapa reservation is dependent on groundwater flowing from the White River drainage system, discharging at Muddy River Springs. The annual discharge is 36,000 acre ft. of which fully 24% is issued on the Moapa Reservation (6.8 times state allotments (Eakins 1964, Facilitations Inc., 1980) construction water demands upstream could have extremely significant negative impact on the outflow of the Muddy River Springs - especially if that water use period corresponds with series of relatively dry years (Eakin 1966). Operation of an OB at Coyote Springs would require 4,000 acre feet annually over a 30 year period (Source: Table dealing with OB operations requirements). A withdrawal that would be reflected in a similar reduction in flow at the Muddy River Springs. For the perrenial yield of the lower White River drainage is the same as the discharge of the Muddy River Springs.

4. To what extent will the effect be masked by normal variation expressed by the resource?

1	2	3	4	5
masked		some masking		completely masked

Although some variation exists in Spring flows on Duckwater Reservation grazing lands, Native American's water resources are remarkably constant. Warm Springs at the Duckwater Reservation and the Muddy River Springs - the source of Moapa Reservation supplies - essentially have no variation in flow ((Eakin 1964:23, State of Nevada), Department of Conservation and Natural Resource, Groundwater Resources - Reconnaissance Series Report #25 and #60).

5. How rapidly will the resource recover from the disturbance effect if the effect is temporary?

1	2	3	4	5
rapid recovery		slow		no recovery

7. How rapidly will the resource recover from the disturbance effect if the effect is permanent?

1	2	3	4	5
rapid recovery		slow		no recovery

Assuming no permanent damage is done to the structure supplying Duckwater Reservation springs and wells by excessive draw down, recovery should be relatively quick (on the order of weeks or months). Excessive pumping for construction use in the White River Basin, that corresponds to a series of dry years, could have long term effects - not immediately felt - on the flow of the Muddy River Springs. OB pumping immediately upstream of the springs would diminish their flow for the life of the base.

12. What is the scientific or intrinsic value of the resource?

1	2	3	4	5
low		moderate		high

Native Americans in Nevada/Utah are economically depressed. Water is absolutely essential to bring land into production and provide a viable economic base. Future economic development is also dependent on adequate water supplies. Both to Duckwater and Moapa Reservations have plans to develop reservation expansions. Water accessibility has been identified by them as being a non-compensable resource.

3. What is the extent to which the resource will become limited to the point of threatening the carrying capacity of the area or developmental trends which have already been in motion for some historic period of time.

1	2	3	4	5
no limitations		limited		very limited

Water demands for construction in valleys surrounding the Duckwater Reservation will not threaten the carrying capacity of Duckwater Reservation land holdings unless permanent damage is done to the structure of springs and wells by excessive localized pumping. In the short term, during construction, existing stock watering sources and irrigation waters might be reduced to the point of a temporary reduction in productivity, again assuming excessive localized pumping for construction use access.

Reduction in water flow at Muddy River Springs, especially by OB operations at Coyote Springs, might jepordize present water demands at the Moapa Reservation (which are in 6-8 times excessive of Nevada State decrees) reducing the value of their cattle and horticultural operations. Such a reduction would limit development of the proposed 70,000 acre Moapa Reservation expansion which would be junior to the demands of other Muddy River water users for excess water.

5. To what extent is the change in the effect variable a significant modifier of other development actions which are planned to take place. For example, will it

compete for the same space, will it cause that space to be unusable, will it stress limited resources, changes in transportation of goods, etc.?

1	2	3	4	5
no constraint		constraint		high constraint

Reduction in the flow of the Muddy River Springs would hinder Moapa Reservation development plans on the existing reservation (expansion of intensive horticulture) and on the proposed 70,000 acre expansion.

10. To what extent will the effect on the resource have significant economic or social consequences on communities within the study area?

1	2	3	4	5
no consequences				major consequences

Temporary or permanent decrease in water supplies and therefore land use values on the Duckwater Reservation holdings would limit economic potential among an already poor people. Such economic decline could effect the integrity of the Duckwater as a distinct people.

Similarly, among the Moapa an economic decline as <u>a decrease in the rate of economic growth</u> would have negative effects on the persistance of the Moapa as a distinct people. The Moapa have stresses economic self-sufficiency and independence as the guiding principle of the reservation. Considerable economic growth has occurred and is planned - especially with the proposed 76,000 acre expansion - and a decrease in this growth or a retrenchment of these plans would stress the growing Moapa Reservation community.

1. Are the consequences such that the portion of the ecosystem or society will not recover at all?

1	2	3	4	5
no likelihood of damage				certain irreparable damage

The Duckwater Reservation has the capacity to recover from any temporary stress on its water resources. Although its growing population requires ever more waters and land to meet basic economic needs as well as future aspirations.

The Moapa could be extremely limited in their economic potential if an OB site at Coyote Springs reduced the flow of the Muddy River Springs. Given the growing population at the Moapa Reservation and their growing aspirations limits on their economic opportunities could be disasterous for their continuity as a distinct people.

3. Are the deleterious effects measurable?

1	2	3	4	5

not measurable measurable	measurable with difficulty	readily measurable

Given adequate economic and socio-cultural baseline data the effects of water accessibility limits on Native Americans could be measured.

4. To what extent will the effect be masked by normal variation expressed by the resource?

1	2	3	4	5
masked		some masking		no masking

Historically, Native Americans within the Great Basin were highly mobile making the rounds of accessible resources. Today, this tradition of mobility persists with movement for education, jobs, and visiting kin. Hard data are lacking on the actual amount and extent of migration for these purposes. There are four factors which support this finding in the absence of more detailed studies. (1) Population of enrolled members on reservations appears to grow with increased housing and economic opportunity (e.g., the Moapa Reservation). (2) A significant proportion of enrolled members live off reservation (e.g., Skull Valley Reservation: 87 members but only three families in residence; Goshiute Reservation: 602 members, three families on the Reservation; Fallon Reservation and Colony: 669 members, 529 in residence. (3) High rates of unemployment and underemployment (as measured by per capita income $1,500) is the rule among Great Basin Native Americans. (4) Native Americans freely living with relatives all over the Great Basin for the purposes of employment, education, or just visiting.

5. To what extent will the effect on the resource be masked by normal resource variability when the influence of potential future projects other than M-X are imposed?

1	2	3	4	5
masked		some masking		no masking

In the absence of hard data on the migration levels among Native Americans in the Great Basin and a model which predicts their movements toward new economic foci it can only be assumed that future projects would accelerate rates of migration already acceleratged by the economic opportunities provided by M-X.

10. How geographically widespread is the effect of the disturbance on the resource?

1	2	3	4	5
localized effect				widespread effect

Native Americans from all over the Great Basin are expected to move toward new economic foci. Those reservations and colonies situated near centers of M-X generated economic activities would be the recipients of the bulk of these migrants. The effects would be felt as a loss of population in distant reservations and colonies and a gain in population at central ones. Most at risk as a central receiving venue is the Duckwater Reservation, followed by the Ely Colony and Moapa Reservation.

2. To what extent does the change in the effect produce a developmental constraint that is observable?

1	2	3	4	5
low				high

Loss of population, especially of labor force members in outlying reservations and colonies will be demonstrated. There is a loss in productivity in those reservations as the most skilled people move toward more reservation work. In receiving reservations, increases in population will be demonstrated through increased crowding, in housing, and a decrease in services as government funds are usually assigned to reservations on the basis of enrolled resident members.

3. To what extent does the change in the effect variable degrade the environmental resource which is or would be needed by other competitors?

1	2	3	4	5
no constraint		moderate constraint		major constraint

Labor force out-migration would inhibit the economic integrity outlying reservations and due to the inability to compete with high wages remove skilled persons from participation in future development plans.

Labor force in-migration would stress local resources on centralized reservations and colonies and these in-migrations would compete with local residents for existing as well as M-X generated employment.

2. Is there a reasonable opportunity for recovery from changes in this effect in a reasonable period of time?

1	2	3	4	5
short time				long time

Any population movement generated by boom conditions will have short-term consequences in responses to localized population decline on growth. The bust following booming growth will provide even more difficulties as local residents in previous boom areas migrate to maintain their newly established standards of living. The population decline post M-X could seriously hinder development plans in the centralized reservations.

9. To what extent will funding be required to mitigate the effect on the resource?

1	2	3	4	5
none required				major funding

Funding to provide meaningful economic opportunities on outlying reservations during the boom years of M-X construction and on centralized reservations after the bust would act to slow down labor force migration, maintain development trajectories and provide a secure economic base for Native Americans in the Great Basin.

10. To what extent will the effect on the resource have significant economic or social consequences on communities within the study area?

1	2	3	4	5
no consequences				major consequences

Labor migration within the Great Basin would stress both supplying and receiving reservations. In receiving reservations competition for jobs, crowding in housing and schools, and dilution of other available services would occur. Existing social relationships would be modified in reservations either supplying or receiving migrants. In receiving reservations a large influx of migrants could lead to an increase in antisocial behavior and intrareservation hostility.

1. Are the consequences such that the portion of the ecosystem or society will not recover at all?

1	2	3	4	5
no likelihood		moderate likelihood		certain irreparable damage

Massive Native American migrations following the M-X construction boom and bust would probably effect permanent changes in the Native American communities at risk. In the absence of hard data on migration and other socioeconomic variables, it is impossible to precisely judge either the nature of potential damage or its possible extent.

3. Are the deleterious effects measurable?

1	2	3	4	5
not measurable		measurable with difficulty		readily measurable

If adequate baseline data on migration are collected, then the extent of migration, its causes and its effects can be monitored and the consequences perhaps mitigated.

5. Do these deleterious effects or consequence result in degradation of other measurable environmental variables?

1	2	3	4	5
no				yes

Native American community infrastructure and services will be considerably stressed under heavy in-migration. Reservation experiencing out-migration during construction on following the end of construction would experience a decline in economic growth, and perhaps an absolute decline in their economic base. More detailed data are required to make more precise predictions.

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